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Challenging the One-hour Sepsis Bundle

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In April 2018, the Surviving Sepsis Campaign (SSC) released an updated sepsis bundle, which combines directives previously listed in the three-hour and six-hour bundles. The authors discussed the reasoning and evidence supporting these changes. However, there are data that suggest these recommendations may be contrary to the best available evidence. Our purpose here is to highlight the areas where evidence is only as strong as the methodological constructs of the research used. This article is a narrative review of the available, limited evidence on which the one-hour bundle was based. [West J Emerg Med. 2019;20(2)185-190.]

INTRODUCTION

In April 2018, the Surviving Sepsis Campaign (SSC) released an updated sepsis bundle (Table 1), which combines directives previously listed in the three-hour and six-hour bundles. In this update the authors noted that "when they [the bundles] were introduced, the bundle elements were designed to be updated as indicated by new evidence and have evolved accordingly."[1] Yet, some of the studies included in these recommendations are of poor quality and have methodological issues, making it dangerous to draw dogmatic conclusions about generalizability to all septic patients. Additionally, the one-hour bundle makes recommendations that are still shrouded in unresolved controversies. Furthermore, the exact sepsis definitions used within the article are nebulous, and the definition of time zero (i.e., at triage) may not allow successful implementation of the bundle. The one-hour bundle may have a bigger implication with regard to future hospital reimbursements and, most importantly, patient care. This article addresses these challenges and a few others in greater detail.

Challenge 1: Definition of Sepsis

Before discussing the individual elements of the bundle, we must first address the fact that there is no single, clear definition of sepsis currently being used to screen for these patients. Clinicians practicing in the United States have three options from which to choose when defining patients presenting with a sepsis spectral illness: the Sepsis 2.0 definitions, the Centers for Medicare and Medicaid Services (CMS) definitions, or the Sepsis 3.0 definitions. Each is listed in Table 2.

The 2018 SCC one-hour bundle paper refers to the 2016 SSC guidelines "for further discussion and evidence related to each element and to sepsis management as a whole." Does this mean we should refer to the 2016 guidelines regarding sepsis definitions? If we do, there are no clinical parameters within this document. With regard to verbal definitions, the 2016 SSC iteration accepted some of the Sepsis-3.0 proposals and eliminated severe sepsis as a category. The SSC also accepted the proposed verbal definitions for sepsis and septic shock. However, qSOFA (quick sequential organ failure assessment) was not accepted or recommended as best practice, and systematic inflammatory response (SIRS) along with all other specific clinical parameters of end organ dysfunction were eliminated from the recommendations.[6]

There are no defined elements of sepsis offered to clinicians in order to determine which patient population requires application of the one-hour bundles. Are we using Sepsis 2.0, Sepsis 3.0, or the CMS definitions? If it is Sepsis 3.0, the sensitivity of qSOFA is too low for emergency department (ED) application and patients will be missed.[7-16] Additionally, multiple national organizations have not accepted the Sepsis 3.0

Table 1. Surviving Sepsis Campaign one-hour bundle.

Bundle element	Grade of recommendation and level of evidence
Measure lactate. Re-measure if initial lactate > 2 mmol/L.	Weak recommendation. Low quality of evidence.
Obtain blood cultures prior to administration of antibiotics.	Best practice statement.
Administer broad-spectrum antibiotics.	Strong recommendation. Moderate quality of evidence.
Rapidly administer 30 ml/kg crystalloid for hypotension or lactate ≥4 mmol/L.	Strong recommendation. Low quality of evidence.
Apply vasopressors if patient is hypotensive during or after fluid resuscitation to maintain MAP ≥ 65 mm Hg.	Strong recommendation. Moderate quality of evidence.

mmol/L, millimoles per liter; *ml/kg*, milliliters per kilogram; *mmHg*, millimeters of mercury; *MAP*, mean arterial pressure.

Table 2. Various definitions for sepsis spectral illnesses.

	Sepsis 2.0[2,3]	CMS[4]	Sepsis-3.0[5]	2016 SCC Guidelines[6]
SIRS	Temperature > 38°C or < 36°C Heart rate > 90 bpm Respiratory rate > 20 or $PaCO_2$ < 32 mmHg White blood cell count > 12,000/cu mm, < 4,000/cu mm or > 10% bands	No change	Eliminated. qSOFA introduced Respiratory rate > 22 Altered mental status Systolic blood pressure < 90 mmHg	No SIRS. No qSOFA.
Sepsis	Infection and two or more SIRS	No change	Infection and two qSOFA criteria	Infection and end organ dysfunction. No clinical criteria offered.
Severe Sepsis	Sepsis and end organ dysfunction defined as: • Sepsis-induced hypotension • Lactate above upper limits of laboratory normal • Urine output < 0.5 ml/kg/hr x two hours • PaO_2/FiO_2< 250 in absence of pneumonia • PaO_2/FiO_2< 200 in presence of pneumonia • Creatinine > 2.0 mg/dL • Bilirubin > 2 mg/dL • Platelet count < 100,000/uL • INR > 1.5	Sepsis and end organ dysfunction. Lactate > 2	Eliminated	Eliminated
Septic Shock	Sepsis and a SBP < 90 mmHg or a reduction of 40 mm Hg from baseline or evidence of low perfusion after adequate fluid bolus.	Initial lactate > 4 or SBP < 90 mm Hg after 30 mL/kg fluid bolus	SBP < 90 mmHg AND lactate > 2 after adequate fluid resuscitation	Subset of sepsis with circulatory and cellular/metabolic dysfunction associated with a higher risk of mortality. No clinical criteria offered

SIRS, systemic inflammatory response syndrome; *CMS*, Centers for Medicare and Medicaid Services; *SCC*, Surviving Sepsis Campaign; *bpm*, beats per minute; *cu mm*, cubic millimeter; *qSOFA*, quick sequential organ failure assessment; *ml/kg/hr*, milliliter per kilogram per hour; *PaO_2*, partial pressure of oxygen; *FiO_2*, fraction of inspired oxygen; *INR*, international normalized ratio; *mg/dL*, milligram per deciliter; *MAP*, mean arterial pressure; *SBP*, systolic blood pressure.
*All lactate levels in millimoles per liter values.

definitions. There is no gold standard definition established to trigger any resuscitative cascade.[17] The exact definitions with corresponding clinical parameters must be clearly defined in the 2018 recommendations, and they must be evidence based.

Challenge 2: Bundle Compliance and Protocolized Sepsis Care

The authors of the one-hour bundle state, "The compelling nature of the evidence in the literature … has demonstrated an association between compliance with bundles and improved survival in patients with sepsis and septic shock …."[1] Patients with sepsis and those with septic shock are two very different patient populations. The SSC one-hour bundle paper cites a retrospective review by Seymour et al. that demonstrated improved mortality outcomes in patients with septic shock who received the three-hour bundle. There was no survival benefit in patients who were not in septic shock.[18]

This evidence does not support the application of these bundles to patients with sepsis. With regard to patients with septic shock, three large, randomized control trials – ARISE, ProMISe and ProCESS – all demonstrated no significant difference in patient mortalities who were treated via usual care vs protocols.[19-21] There are no definitive data to support that bundle compliance improves mortalities in septic patients, and the data are mixed regarding improved survival in patients with septic shock.

Challenge 3: Time Zero and Emergency Medicine

The 2018 SSC bundle states, "Consistent with previous iterations of the SSC sepsis bundles, 'time zero' or 'time of presentation' is defined as the time of triage in the ED or if referred from another location, from the earliest chart annotation consistent with all elements of sepsis (formerly severe sepsis) or septic shock ascertained through chart review."[1] Up to 53% of patients will not demonstrate evidence of severe sepsis or septic shock at time of triage.[22] In the SSC one-hour bundle paper, authors compared the care of patients presenting with polytrauma, acute myocardial infarction (MI) and cerebrovascular accident to those presenting with sepsis. Unlike sepsis, these other conditions have very distinct pathophysiologic causes, consistent clinical effects and rapid screening processes.

Sepsis presentations are dependent on causative organisms, patient comorbidities and other confounding factors. Many times there is no indication that patients are severely ill upon initial evaluation. Some data collected in laboratory tests suggested a higher degree of illness, but these values rarely are resulted rapidly enough to identify and initiate treatment within one hour of patient arrival. Traumas, MIs, and strokes do not require laboratory values for screening and identification.

Because the definitions are not identified, it is unclear which patients require rapid assessment at time zero. Many patients present to the ED with SIRS criteria, which can be due to a variety of conditions other than infection and sepsis. The differential diagnosis of a tachycardic patient presenting with abdominal pain encompasses a nonemergent diagnosis of pain from gastritis all the way to impending septic shock due to a perforated viscous. Very few EDs have the capability to make the exact diagnosis and initiate resuscitative efforts from triage. Unless the patient presents with other signs and symptoms suggesting a more emergent diagnosis, treatment will begin later than one hour after triage.

The one-hour bundle challenges providers to send nearly every SIRS-positive patient through a rapid sepsis screening process, which is not feasible or compatible within the daily operations of the ED.[23] Time zero should not be time of triage. It should be time of physician suspicion of infection.

Finally, while all the authors of the one-hour SSC bundle are well-respected intensivists, unfortunately they are unfamiliar with the challenges of the ED. For most patients, this first hour of resuscitation will occur in the ED. Inclusion of an emergency physician, who has knowledge and experience of ED operations, would allow for better collaboration and success in implementation of care bundles and for exclusion of recommendations that may not be feasible to implement in the ED and may also cause harm.[24]

Challenge 4: Lactate

The authors state there is "low quality of evidence" for initial measurement of lactate with repeat measurements for lactate >2 millimoles per liter (mmol/L).[1] While there is evidence that elevated lactates are associated with an increased mortality and lactate clearance is associated with lower mortality,[25-27] the exact lactate level that should trigger aggressive resuscitative effort remains unknown. Traditionally, most studies used a lactate of greater than 4 mmol/L.[19-21,25,28] Since 2005, researchers have studied varying lactate levels and associated mortality rates.

Shapiro and colleagues performed a prospective cohort study demonstrating a 4.9% mortality for patients with an initial lactate of 0-2.4 mmol/L, 9.0% mortality for patients with initial lactates between 2.5 and 3.9 mmol/L and a 28.4% mortality for patients with an initial lactate >4 mmol/L.[29] In 2009, Mikkelsen et al. risk-stratified patient mortality according to varying lactate levels and found patients without evidence of shock had an 8.7% mortality rate with lactate levels <2 mmol/L, a 16.4% mortality rate with lactate levels 2-3.9 mmol/L and 31.8% with lactate levels >4 mmol/L. In patients with shock, corresponding mortality rates were 15.4%, 37.3% and 46.9%.[30] In 2015, Bhat et al. conducted a retrospective review that revealed 28-day mortalities were 12.7% for patients with an initial lactate <2 mmol/L, 19.5% for patients with an initial lactate between 2.0 and 4 mmol/L and 24.6% for those with lactates >4.0 mmol/L.[26] None of the studies demonstrated a consistent, clear delineation in which an intermediate lactate level was associated with a sudden increase in mortality,[26,29,30] yet we are provided with the cut-off value of 2 mmol/L.

Challenge 5: Fluids

The authors state there is "low quality of evidence" for the administration of 30 milliliters per kilogram (ml/kg) of crystalloid fluids.[1] With regard to fluid resuscitation, multiple studies have demonstrated aggressive fluid resuscitation and positive fluid balances are harmful and increase mortality.[31-36] In the Seymour et al. study discussed above, there was no association between improved survival rates and fluid administration.[18] Yet the fluid component has been moved to begin within one hour. Additionally, the exact quantity of fluid that defines a fluid bolus varies in different studies.[19-21,37-39] A prescriptive fluid bolus amount that does not consider individual patient needs and comorbidities is potentially deleterious. Clinicians should have the opportunity to judge and determine the amount of fluids that his/her patient requires.

Challenge 6: Timing of Antibiotics

In 2006, Kumar et al. published results from a retrospective study demonstrating an average increase in mortality by 7.6% for every one-hour delay in the administration of antibiotics in patients presenting with septic shock.[40] These data were incorporated into the 2008 SSC guidelines[41] and extrapolated to the treatment of patients presenting with severe sepsis as well, even though this was not the patient population studied in Kumar's paper. Several follow-up studies were performed to evaluate associations between mortality and timing of antibiotic administration. A cohort analysis from the EMSHOCKNET study found no association between in-hospital mortality and the time from ED triage to administration of antibiotics during the first six hours of resuscitation, but did find an increased risk of death if antibiotics were delayed until after the recognition of shock.[42]

In a 2015 systemic review and meta-analysis, authors demonstrated no significant survival benefit of administering antibiotics within three hours of ED triage or within one hour of septic shock recognition in severe sepsis and septic shock.[43] Seymour et al. demonstrated improved survival rates in patients receiving antibiotics within three hours, but they did not extend this to within one hour and noted that the improved survival rates appeared to be stronger among patients receiving vasopressors than among those who were not.[18] Most recently, the PHANTASi (Prehospital ANTbiotics Against Sepsis) trial demonstrated no differences in 28-day or 90-day mortality between sepsis, severe sepsis or septic shock patients receiving antibiotics in the ambulance en route to the hospital vs those patients who received usual care and were administered antibiotics after arrival to the hospital.[44]

Lastly, analysis of the SSC registry demonstrated that approximately one-third of septic shock patients do not receive broad-spectrum antibiotics within three hours of ED presentation,[45] yet the time window was decreased to one hour. The evidence does not support this strict timeline on antibiotic administration to all septic patients. Additionally, antibiotics are not without harm. Increased use contributes to increased microbial resistance, the potential to increase *Clostridium difficile* colitis, as well as other adverse events. Administration of antibiotics to meet a timeline that is not evidence based will result in an increase of inappropriate antibiotic use.

What Does This All Mean?

As history has a way of repeating itself, it is highly likely that this proposed one-hour bundle will be used as a marker of quality by CMS. The downstream effects of this decision will result in hospital reimbursement cuts in an already fiscally-narrow existence. Additionally, once these measures are required for reimbursement, hospital administrators will pressure clinicians to meet these broadly applied, checked items. This has several implications and the potential for deleterious outcomes.

As discussed above, up to 53% of patients diagnosed with severe sepsis and septic shock do not present with evidence of such in triage. As it takes time to evaluate these patients, make a diagnosis and initiate treatment, many will not meet initiation of the one-hour bundle in time. In an effort to meet the bundle, patients will receive antibiotics unnecessarily or will receive inappropriate antibiotics because the diagnosis has yet to be made in a setting where the risk does not outweigh the benefit. Some patients will receive intravenous fluids in amounts that are harmful, resulting in higher morbidities and mortalities.

Forcing a physician to practice recommendations that are not backed by high-quality evidence will unnecessarily harm patients and put the very people we are to care for at high risk of poor outcomes. In its current form, the one-hour bundle faces many challenges and requires several revisions. This bundle should be revised to state: "*We suggest that these bundles should be initiated within one hour of physician suspicion of infection causing hypotension or lactate greater than 4 mmol/L. A fluid bolus of 30ml/kg should be administered to patients when it is safe to administer such a volume*." Until this bundle is updated to include this statement, it is not appropriate or ready for bedside application in the ED setting. We, practicing emergency physicians, should have the ability to choose the components that are applicable to our patients.

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Pertussis: The Identify, Isolate, Inform Tool Applied to a Re-emerging Respiratory Illness

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Pertussis, commonly referred to as "whooping cough," is a highly contagious acute respiratory infection that has exhibited cyclical outbreaks throughout the last century. Although vaccines have provided some immunity, many populations, including infants and pregnant women, remain at risk for serious illness. Through the use of the novel "Identify, Isolate, Inform" (3I) tool, emergency department (ED) providers can readily recognize key symptoms of the disease and risk factors for exposure, thus curbing its transmission through early initiation of antimicrobial therapy and post-exposure prophylaxis. The three classic stages of pertussis include an initial catarrhal stage, characterized by nonspecific upper respiratory infection symptoms, which may advance to the paroxysmal stage, revealing the distinctive "whooping cough." This cough can persist for weeks to months leading into the convalescent stage. Household contacts of patients with suspected pertussis or other asymptomatic, high-risk populations (infants, pregnant women in their third trimester, and childcare workers) may benefit from post-exposure prophylactic therapy. The Pertussis 3I tool can also alert healthcare professionals to the proper respiratory droplet precautions during contact with a symptomatic patient, as well as isolation practices until antimicrobial treatment is in progress. ED personnel should then inform local public health departments of any suspected cases. All of these actions will ultimately aid public health in controlling the incidence of pertussis cases, thus ensuring the protection of the general public from this re-emerging respiratory illness. [West J Emerg Med. 2019;20(2)191–197.]

INTRODUCTION

Pertussis, commonly referred to as "whooping cough," is an acute respiratory illness that is highly contagious. *Bordetella pertussis,* a Gram-negative bacterium, travels via respiratory droplets infecting human hosts.[1] Worldwide epidemics have occurred throughout history, prompting study and control measures, including the development of vaccines.[1] However, even in vaccinated populations, pertussis demonstrates periodic outbreaks. For example, in 2010 California experienced a large outbreak that reached the highest incidence rates of the disease since 1947. This outbreak involved over 9,000 individuals and led to 10 infant deaths.[2,3] In 2017 there were over 15,000 cases in the United States, with California reporting the highest number at 1,742 cases.[4]

Given this background, and following on previous work for Ebola virus disease, measles, Middle East Respiratory Syndrome, Zika, mumps, and hepatitis A, investigators developed a novel Pertussis Identify, Isolate, Inform (3I) tool for use by healthcare

workers in the assessment and treatment of patients who may have pertussis (Figure).[5-10] After an overview of the disease and critical information pertaining to transmission and treatment, we explain and present here the Pertussis 3I tool.

The presentation of pertussis varies widely, and can be affected by factors such as vaccination status and age. It is classically described as having three stages.[11-14] After an initial incubation period of 7-10 days, the disease begins with the catarrhal stage, which has a duration of one to two weeks. This manifests as a mild cough with lacrimation and rhinorrhea. There may also be a low-grade fever. After the catarrhal stage, the patient may advance to the paroxysmal stage, which lasts two to four weeks. This is where the characteristic paroxysmal or "whooping cough" may occur, described as a grouping of multiple short coughs followed by a single, forceful inspiratory "whoop." An audio example of this signature cough is available here: http://www.pkids.org/diseases/pertussis.html. This cough may be associated with emesis, cyanosis or even apnea.[15] The third or convalescent stage is characterized by a persistent cough that can last from four weeks up to several months. This is why pertussis is known as the "100-day cough" in China.[16]

Older children, adolescents, and adults may report a nonproductive cough that is worse at night or feelings of a choking sensation. They likely will be asymptomatic between coughing episodes.[11] Presenting symptoms may be nonspecific in both infants and older patients. Young infants may initially be afebrile with mild symptoms that rapidly progress to respiratory distress/apnea, hypoxia or seizures.[12]

Population Health Research Capsule

What do we already know about this issue?
Pertussis, or whooping cough, a highly contagious respiratory illness, presents in cyclical outbreaks every few years.

What was the research question?
Investigators sought to modify the "Identify, Isolate, Inform" (3I) Tool for use in the identification and management of pertussis.

What was the major finding of the study?
A novel Pertussis 3I Tool is created for real-time application in managing patients presenting to the emergency department (ED).

How does this improve population health?
The 3I Tool aids ED providers who play an essential role in identifying and treating this vaccine-preventable disease.

Risk Factors

Unvaccinated individuals, or those who have not yet completed the vaccine series, are the most at risk. This includes infants <six months of age, who are also at the highest risk for severe outcomes.[17] However, even persons who have received the vaccine series lose their immune status within six to eight years of their last injection or 15 years after infection.[13] Thus, remaining up to date with vaccination is imperative, especially when traveling abroad to areas with increased disease incidence.[18] Additionally, household contacts and those considered high risk, who have known exposure, should receive treatment in the form of post-exposure prophylaxis (PEP) (see "Treatment" section).

Diagnosis

Nasopharyngeal cultures, polymerase chain reaction (PCR) testing and serologic studies are available to confirm an infection with *Bordetella pertussis*, the causative organism.[11] However, these tests offer varying levels of sensitivity and may not be obtainable in a timely fashion to confirm cases in the acute setting. Furthermore, other laboratory studies, such as a complete blood count (CBC), may be helpful in distinguishing causes for cough, but only in certain age groups (see "Differential Diagnosis" section). Imaging studies also provide limited information, as patients often do not demonstrate significant findings on chest radiograph. However, chest imaging may be helpful in assessing for superinfection.

Complications and Special Populations

Severe and sometimes fatal pertussis-related complications can occur in certain groups. These include infants <12 months of age, particularly those <four months, as well as pregnant women who are also at risk of transmitting the disease to their newborn children.[17,19] Often, patients become secondarily infected with another bacterial or viral infection. Neonates are especially at risk for apnea and hemodynamic instability (i.e., bradycardia, hypotension). Although rare, seizures and encephalopathy can also occur.[12,17,19]

Transmission and Personal Protective Equipment

Pertussis has no known animal or environmental hosts.[1] It travels from human to human via respiratory droplets from a cough or sneeze. Patients who have not yet started or completed the initial vaccine series are at greatest risk of becoming infected. If there is concern that a patient has pertussis, healthcare workers should place the patient in isolation and don personal protective gear for respiratory droplet precautions.[20]

Prevention

In addition to protective measures to avert disease transmission, the most important preventative measure is

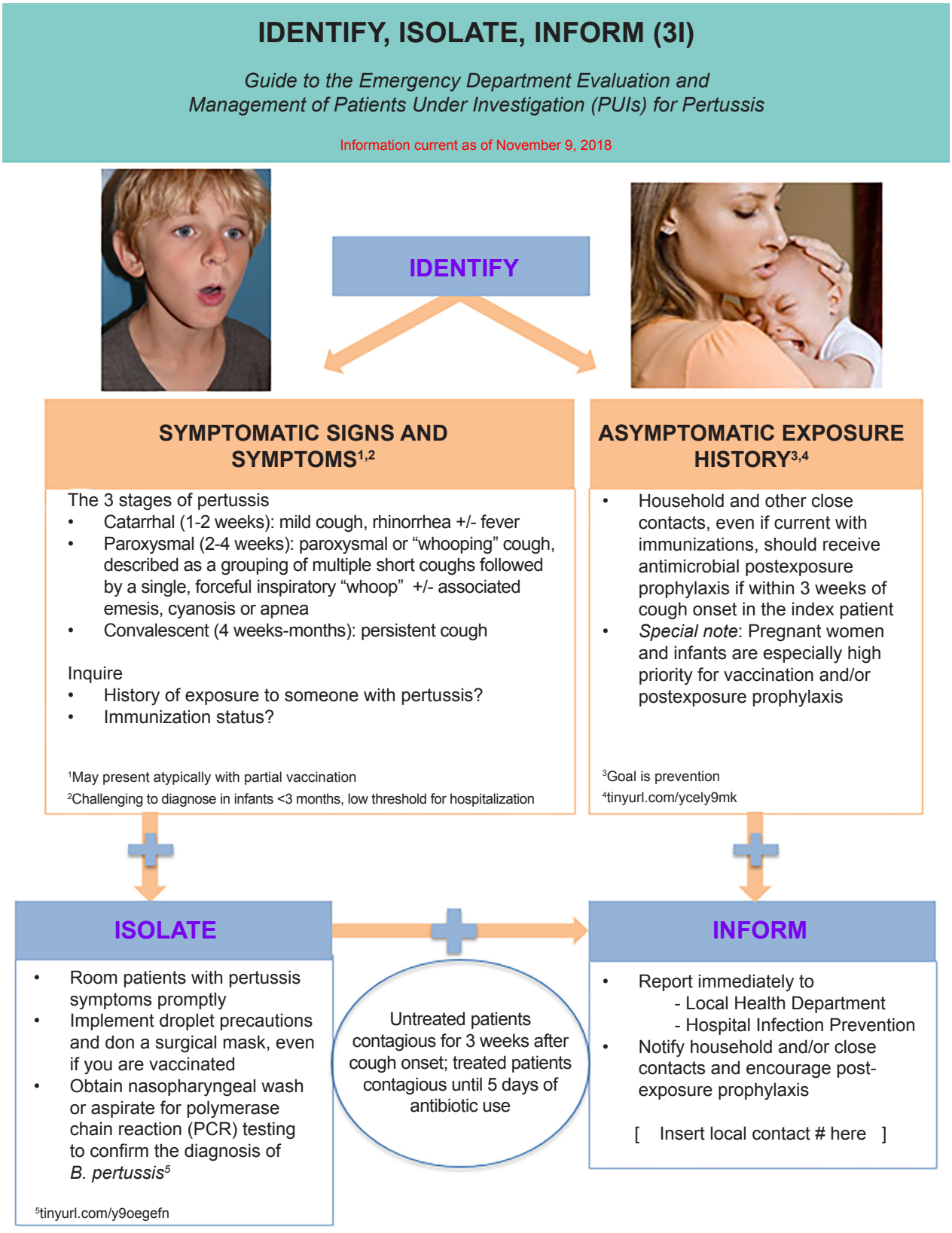

Figure. The Identify, Isolate, Inform 3I Tool for Pertussis.
The Identify, Isolate, Inform 3I Tool was conceived by Dr. Kristi L. Koenig, County of San Diego EMS Medical Director & Professor Emerita, UC Irvine.

vaccination. In 2018, the Centers for Disease Control (CDC) and Prevention's Advisory Committee on Immunization Practices published the following vaccine recommendations:[21]

- Infants and young children: five-dose series of diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccines, with one adolescent booster dose of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine
- Adults: booster dose of Tdap (regardless of vaccine status)
- Pregnant Women: one-dose Tdap to be administered sometime during 27-36 weeks gestation (third trimester), regardless of previous receipt of Tdap
- Persons >11 years with close contacts of infants (e.g., parents, siblings, grandparents, child care providers, and healthcare providers): administer a single dose of Tdap if they have not previously received Tdap
- Healthcare personnel: administer a single dose of Tdap if they have not previously received Tdap

Differential Diagnosis

Given the nonspecific nature of presenting symptoms, diagnosing pertussis can be challenging. In addition, the characteristic "whooping" cough is only appreciated in a minority of patients.[13] Thus, other causes for similar complaints must also be considered, including upper respiratory infections or pneumonia. Clinicians should also contemplate asthma, bronchiolitis (respiratory syncytial virus) or adenovirus in the differential diagnosis for children.[13] Of special note, in infants nearly all fatal cases of pertussis present with an extreme leukocytosis with lymphocytosis.[17] Thus, obtaining a CBC may be helpful to distinguish between causes of cough in pediatric patients; however, its utility remains limited. Adults presenting with cough may have non-infectious causes for their symptoms such as chronic obstructive pulmonary disease, congestive heart failure, or gastroesophageal reflux disease.[22] Foreign body aspiration is also possible in patients presenting with cough and is sometimes associated with cyanosis or apnea.

Treatment

Suctioning and other airway management is a mainstay of management. As with other conditions, in the presence of hypoxia or respiratory distress, supplemental oxygen should be applied. Intravenous fluids may also be needed for treatment of dehydration.[19,23] In addition to supportive care, antimicrobial treatment is recommended. Macrolides are the preferred treatment, which include azithromycin, clarithromycin or erythromycin.[19,23,24] For infants <one month of age, azithromycin is the preferred antibiotic.[14,19] For patients who cannot tolerate these medications, and are >two months of age, trimethoprim/sulfamethoxazole is recommended.[19,23,24]

PEP is limited to certain groups (Table).[25] These include household contacts of a pertussis case and high-risk populations. With regard to household exposures, even if these contacts are asymptomatic and/or current with immunizations, it is recommended they receive antimicrobial treatment within 21 days of cough onset in the index patient. High-risk groups include infants, women in their third trimester of pregnancy, caregivers or household contacts of infants, and anyone who works in or attends a childcare setting.[25] Antibiotic selection and duration of treatment for either PEP or a confirmed case of pertussis are identical. Depending on the patient's age and therapy of choice, treatment includes a 5-14 day course of a macrolide, with the treatment duration dependent on the macrolide chosen. In cases of PEP, treatment should be initiated within 21 days of exposure.[19, 23]

Disposition

Although dependent on provider judgment, patients with mild to moderate disease can be safely discharged home to undergo antibiotic treatment, with careful attention noted to household contacts or other possibly exposed individuals. Hospital admission is recommended for neonates because they are at risk for apnea.[19] Additionally, admission is recommended for patients <six months of age or who have a history of prematurity. Other symptoms to consider when determining need for hospitalization include inability to tolerate fluids or persistent dependence on supplemental oxygen.[13,19,23] Admitted patients should be maintained in respiratory droplet isolation.[20]

IDENTIFY, ISOLATE, INFORM

Identify

Identification of two groups of patients is important: those who are symptomatic, and those who are asymptomatic but have been exposed. Both groups may benefit from treatment. Symptomatic individuals may present in any one of the three classic stages of pertussis, as discussed above. Some may be in the initial catarrhal phase, reporting mild upper respiratory symptoms, and others may have progressed into the paroxysmal phase, exhibiting the classic "whooping cough." Other symptoms

Table. Candidates for pertussis post-exposure prophylaxis.

Household contacts	High-risk individuals
Even if asymptomatic and/or current with immunizations, should receive antimicrobial treatment within 21 days of cough onset in the index patient	• Infants • Women in their third trimester of pregnancy • Caregivers or household contacts of infants • Anyone who works in or attends a childcare setting

commonly reported include post-tussive emesis, cyanosis and apnea. Patients who have had a persistent cough for weeks, and perhaps months, may be in the convalescent phase. All of the aforementioned presentations may represent a patient with pertussis, making careful reviews of exposure history and immunization status essential. Importantly, those with previous vaccinations may present atypically and not exhibit classic features of pertussis.

Another important group to consider are those who deny symptoms, but report having been exposed to a person with confirmed pertussis. Pregnant women and infants are especially at risk; thus, review of this type of exposure is critical when deciding whether to initiate treatment. Patients are considered most contagious three weeks after the onset of the paroxysmal phase, where coughing spells are most prevalent. Thus, asking exposed patients when they were with the source patient could aid in assessing their individual risks.

Isolate

If a symptomatic, and thus potentially contagious, patient has been identified, he or she should immediately be placed in droplet isolation.[20] Healthcare personnel should also don personal protective gear for respiratory droplet precautions, irrespective of their own vaccine status. This includes donning a standard surgical mask. Patients are considered infectious from the beginning of the catarrhal stage until three weeks after the onset of the paroxysmal stage.[24] Thus, isolation may be needed during this length of time. However, evidence suggests that those undergoing antibiotic treatment may no longer be contagious five days after initiating treatment.[24,26]

This timeline is even more important when one considers returning to school or work. With the former, the CDC and the American Academy of Pediatrics recommend children with pertussis refrain from attending school until they have completed five days of antibiotic treatment.[25] However, since pertussis is often not definitively diagnosed, it's unclear as to the true benefit of this exclusion, leading some public health authorities to adopt a more liberal policy of allowing children who have started, but perhaps have not yet completed, their antibiotic course to attend school.[25] Consultation with one's local health department may assist with this decision. In summary, discretion must be taken when a patient is undergoing either inpatient or outpatient treatment, particularly when close contacts include infants or pregnant women.

Diagnosis should be confirmed with nasopharyngeal cultures, PCR testing and/or serologic studies. Test selection is based on the timeframe of symptoms.[27] If the patient reports a cough of less than two weeks duration, both a culture and PCR should be performed. If the cough has been present for between two and four weeks, culture becomes less reliable, and thus PCR is recommended. Serology is the only reliable diagnostic tool after four weeks of symptoms. However, serology measures pertussis antibodies, and these levels may be affected by stage of the disease and vaccination status.[11] Therefore, providers should consider these confounding factors when interpreting serologic studies.

Practitioners must pay close attention to use of the proper technique for obtaining a nasopharyngeal specimen, whether it is for culture or PCR testing. *B. pertussis* resides in the posterior nasopharynx. Therefore, the swab must be inserted past the anterior nare to ensure optimal collection.[11] Cotton-tipped or rayon swabs should not be used, as they contain chemicals that can alter results; rather, a calcium alginate or polyester (e.g., dacron) swab affixed to a long metal shaft is indicated.[11] A video depicting the proper technique for specimen collection is available on the CDC website at https://www.cdc.gov/pertussis/clinical/diagnostic-testing/specimen-collection.html.[28]

Inform

If a pertussis case is suspected, healthcare workers should contact their local health department, as well as their hospital infection prevention department.[29] Clinicians should also assess for household or other close contacts and provide them with appropriate education and follow up. Contacting public health agencies can occur through a number of channels, and may depend on local public health department policies. Providers should notify their local public health agency of any cases of suspected pertussis. This may include patients with paroxysms of cough, the classic inspiratory "whoop," post-tussive emesis and/or apnea (for infants less than one year old).[29] Laboratories who identify confirmatory tests for pertussis should also report to local public health authorities. Local public health agencies can then forward their findings to state agencies, which will then share this information with the CDC through the National Notifiable Diseases Surveillance System (NNDSS).[30] This chain of reported information allows for further investigation. Given the limitations of confirmatory testing, it becomes even more essential for healthcare workers to report clinically suspected cases of pertussis, so that health officials can conduct continued surveillance.

CONCLUSION

CDC reports suggest the incidence of pertussis exhibits cyclical rises and falls.[31] Therefore, there is an imminent need to routinely educate healthcare workers on its clinical features and epidemiologic properties so that they can promptly detect and appropriately manage pertussis cases. The novel Pertussis Identify, Isolate, Inform (3I) tool can aid emergency department staff in readily recognizing key symptoms of the disease and risk factors for exposure. The Pertussis 3I tool can also alert the healthcare workforce to the appropriate isolation protocols for use during contact with a symptomatic patient. With this added knowledge, healthcare workers can protect both themselves and others (especially infants and pregnant women) from contracting disease. Further, they can educate patients, in addition to exposed individuals, on the importance of early

antimicrobial therapy as well as notify the appropriate hospital and public health agencies. All of these actions will ultimately aid public health in controlling the incidence of pertussis cases, thus ensuring the protection of the general public from this re-emerging respiratory illness.

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Stewarding Recovery from the Opioid Crisis Through Health System Initiatives

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As the consequences of liberal opioid prescribing have become apparent, efforts to address the role of the health care system in supporting more balanced opioid use and the prevention and treatment of opioid use disorder have increased. Developing a unified and multidisciplinary approach can lead to an integrated care model that emphasizes primary prevention, harm reduction, and transition to life-sustaining treatment while also maintaining attentiveness to effective pain management. A model for this, which follows the nomenclature in proscribing antimicrobial use, is the development of an opioid stewardship program. Such programs allow for the integration of diverse perspectives and new mandates and uses a patient-centered approach with an iterative evaluation process. We describe a group of adoptable efforts that have been utilized successfully at our institutions and may be adapted and optimized to the needs and resources of other hospitals and health care systems.[West J Emerg Med. 2019;2(2)198-202.]

The tragic opioid epidemic in the United States (U.S.) claimed 115 lives a day in 2016.[1] Multiple factors have contributed to the escalating opioid death toll, particularly a rapid and substantial increase in fentanyl-related deaths.[2] Hidden in the well-publicized, escalating fentanyl fatality data is the fact that prescription opioid deaths also continue to rise, albeit more slowly.[3] Furthermore, opioid prescribing, with its associated consequences of long-term opioid use including addiction, has fallen only modestly despite significant efforts.[4] Mitigation of the prescription opioid epidemic will only be achieved when analgesic-prescribing pathways minimize opioid initiation, patients prescribed opioids are carefully monitored, and patients with existing opioid use disorder (OUD) are ushered into treatment. We believe that hospitals and health systems are essential components of the solution and describe a framework to create a comprehensive opioid stewardship program that can improve patient outcomes, quality of care, and regulatory compliance. Such a program aligns with the shifting societal attitudes and awareness of the risk and consequences of opioid addiction and the role of health systems in health promotion in their communities.

To date, some large health systems such as the Veterans Administration, have developed systematic approaches to pain management that balance the public and regulatory pressures to standardize opioid prescribing while addressing patient goals and safety.[5] Recommendations from the Joint Commission that went into effect January 1, 2018, mandate that all healthcare facilities now implement leadership teams and performance improvement processes to address safe opioid prescribing.[6] The National Quality Forum released guidelines to measure and respond to new changes in opioid management in March 2018.[7] We highlight the initiatives implemented in our health systems to meet these new mandates. We recommend organizing and expanding these efforts into a formal opioid stewardship program (OSP), a term mirroring the infectious disease platforms promoting judicious antibiotic use. OSPs provide the necessary framework to identify gaps in quality and develop and implement a tripartite change of culture and practice: 1) encourage use of

non-opioids as first-line treatment for pain; 2) provide pathways to safer opioid use when opioids are indicated; and 3) identify and engage patients with OUD into treatment. These are described in more detail below as well as in Table 1.

The three authors, who have collaborated extensively on the mitigation of opioid-related consequences, have gained valuable insights following implementation of OSPs at their academic institutions. Through shared experiences and an iterative process, each has developed a successful OSP that addresses the needs of their respective institutions. A successful OSP requires executive support and rigorous project management, oversight by key clinical leaders, and integration of multidisciplinary stakeholders as shown in Table 2. Although the program can be directed by a number of specialties, our experiences as emergency physicians show that we are well suited to the task because of our experience treating patients with acute and chronic pain, as well as OUD. Being hospital based, the emergency department (ED) is well integrated into the administrative structure and routinely interacts with the other clinical services.

The ability to use information technology (IT) resources was critical to provide benchmarking of opioid use, collect timely metrics, and build best practice, clinical decision support tools. Dissemination of new pathways and protocols across the institution was addressed by the authors through academic detailing (e.g., individual meetings, grand rounds) to departments and creation of an institutional OSP website (e.g., bcore.brighamandwomens.org).

Limiting Opioid Initiation: Keep Opioid-naïve Patients Opioid Naïve When Possible

We individually developed pain management pathways and order sets that deemphasize opioid use using an iterative consensus process by engaged providers starting with specialties with high utilization (e.g., primary care, emergency medicine). For procedure-focused specialties such as orthopedics and general surgery, direct, procedure-specific modifications in pre- and post-procedure prescribing were similarly created. Patient feedback, both obtained during deliberate rounding and through direct post-procedure assessments at three to seven days suggested opportunities to "right size" the number of pills prescribed while still assuring the provision of adequate pain management. Certain states (e.g., Massachusetts. New York, New Jersey) have placed regulatory controls on initial opioid prescribing that dovetailed with the implementation of the OSP guidelines.

The recently modified pain questions in the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) are an attempt to shift the focus from pain management outcomes, which are often medication-centered, toward adequacy of pain assessment.[8] To support this, institution-specific multidisciplinary education modules emphasizing the role of opioid alternatives can be created, aligning with the U.S. Food and Drug Administration's 2017 blueprint for the treatment of patients with pain.[9] Programs should highlight the significant risk for developing long-term opioid use and the recognition that our ability to predict who may develop an OUD following even minimal (one-day) opioid exposure is limited.[10] Electronic health record (EHR) decision support can prioritize non-opioid and non-pharmacologic pain management options and redirect providers who have been trained to practice using opioids as a first-line pain relief option.

Using Opioids When, and Only When, an Opioid is Indicated

OSPs identified resources from local, state, and federal governmental agencies and professional organizations to guide appropriate and safe opioid use when indicated. Such guidance addressed various aspects of pain, such as in the post-operative setting or managing acute severe pain in the ED and were adopted or modified to be institution or procedure specific.[11] Guidelines were implemented with corresponding outcome measurements to allow incremental standardization of opioid prescribing practices. Monitoring outcomes highlights success, such as a recent pilot in Colorado designed to reduce ED opioid prescribing by 15% through implementation of standardized alternative pain-management strategies that exceeded expectation (36% reduction).[12] They similarly allow for assessment of adverse outcomes, as noted by an effort to use evidence-based, postoperative prescribing guidelines led to a 63% reduction in opioid prescribing,[13] and lowering the EHR default reduced opioid prescribing by about one-third,[14] both without an increase in requests for medication refills.

Attention to the frequent use of opioids for the treatment of chronic pain is of paramount importance given the increasingly recognized role of hyperalgesia in perpetuating continued use. In accordance with Centers for Disease Control and Prevention guidelines, health systems can facilitate compliance with opioid use agreements, urine drug monitoring for both compliance (e.g., diversion) and prohibited drug use, prevent benzodiazepine co-prescribing, and performance of functional outcome assessments. Safe-use education should become part of opioid-specific discharge instructions including emphasis on appropriate storage and disposal of remaining medication. For those patients already managed on high-dose opioids for their chronic pain, we encouraged the creation of pathways for dose reduction to the recommended dose of 90 morphine milligram equivalents (MME).[11] For patients unable or unwilling to undergo gradual dose tapering, they were cautiously maintained on their dose and the recommendations of existing pain-management guidelines for monitoring were followed.

OSPs can leverage EHRs to develop dashboards of opioid-use patterns by department or prescriber with the goal of reducing variability as a marker of quality care. OSPs can provide oversight of regulatory changes and evolving state laws affecting prescribing, such as mandatory prescription drug monitoring program (PDMP) queries, consent for minors for opioid prescriptions, and prompts for the initiation of controlled medication agreements. Providing decision support, order sets,

Table 1. Roadmap to the implementation of an opioid stewardship program (OSP).

The leadership team:

Multidisciplinary stakeholder input: representatives from primary care, anesthesiology, emergency medicine, psychiatry, surgery, and pharmacy with executive support from the chief medical officer, chief quality officer, and chief nursing officer.

Potential task forces/subcommittees:

- Guidelines and pathways
- Education and outreach
- Legal and compliance
- Information technology

The missions:

Limit opioid initiation

- Rationalize expectations among patients for pain and pain relief
- Create prescribing guidelines
- Standardize order sets emphasizing non-opioid approaches as first and second line
- Education and best practice alerts about non-opioid and non-pharmacologic (multimodal) therapies
- Community intervention/education programs to discourage diversion and non-medical use

Improve the safety of opioid use

Leverage the electronic health record

- Best practice alerts for compliance with safe opioid treatment guidelines and state/federal regulations.
- Integrate prescription drug monitoring program access
- Track and nudge providers and departments using dashboards and e-alerts following compliance trends.
- Default formulations (immediate release), doses, and schedules for opioid orders and prescriptions
- Prompt at discharge to educate patients about safe storage, appropriate disposal and naloxone

Create pain management strategies

- Standardize short-term dosing based on common diagnoses and procedures
- Compliance with state regulations and documentation requirements
- Create monitoring parameters for patients receiving high-dose opioids
- Develop systems or registries to check for presence of opioid use agreements, urine drug- screen results, maximum morphine equivalent dosing, and rates of co-prescribed benzodiazepines
- Create endpoints for acceptable opioid use (e.g., maximum of 90 morphine milligram equivalents/day) and exit strategies such as weaning

Other activities

- Disseminate educational modules on pain assessment and opioid stewardship to meet Joint Commission recommendations
- Integrate clinical pharmacists into medication management

Treating patients with opioid use disorder

Operationalize addiction management

- Increase screening for opioid use disorder at admission and in primary care practices
- Reduce barriers for the use of buprenorphine or methadone to mitigate opioid withdrawal in hospitalized patients
- Organize resources to improve hand-offs to settings that provide opioid agonist therapy

Implement harm reduction strategies

- Naloxone distribution or prescribing
- Certified recovery specialists/peer navigators and other social services
- Family and community engagement processes
- Safe practices (clean syringes, counsel about risk of infection)

Table 2. An example organizational structure for an academic health center opioid stewardship program.

- Steering committee
  - Chair or co-chairs
    - Chair of anesthesiology (or designee)
    - Chair of emergency medicine (or designee)
    - Chair of internal medicine (or designee)
    - Chair of psychiatry (or designee)
    - Chair of surgery (or designee)
    - Chief medical officer
    - Chief nursing officer
    - Chief information office
    - Graduate medical education director/designated institutional official
    - Pharmacy director
    - Project manager
    - Quality/safety
  - Tasks
    - Prioritize efforts
    - Populate task forces
      - Develop initial expectations and metrics
      - Guide committee efforts with periodic meetings and oversight
      - Evaluate metrics and suggest improvements
- Guidelines and pathways/pain management
  - Chair or co-chairs
  - One representative from each:
    - Ambulatory care/primary care
    - Emergency medicine
    - Hospice/palliative care
    - Internal medicine/hospitalist
    - Nursing
    - Oncology
    - Orthopedic surgery
    - Pain medicine/anesthesia
    - Pediatrics
    - Pharmacy
    - Rheumatology
    - Surgery
  - Tasks
    - Assessment of current state
    - Benchmarking of progress
    - Guideline development for pain management
    - Implementation
- Addiction and harm reduction committee
  - Chair or co-chairs
  - One representative from each:
    - Addiction psychiatry/addiction medicine
    - Ambulatory care/primary care
    - Emergency medicine
    - Internal medicine/hospitalist
    - Nursing
    - Pain medicine/anesthesia
    - Pharmacy
    - Social work
    - Surgery
  - Tasks
    - Benchmarking current status
    - Capacity development
    - Process improvement
    - Implement harm reduction efforts
- Quality and information technology
  - Chair or co-chairs:
    - Chief medical information officer
    - Quality/safety leader
    - Information technology
    - Physician leader
    - Nurse leader
    - Pharmacy leader
    - Other committee chairs
  - Tasks
    - Define the scope of the problem
    - Develop and implement recommendation with other committees
    - Analyze capacity for addiction treatment
    - Process improvement for addiction management
    - Assess rates of hospitalized patients with opioid use disorder who leave against medical advice as these are missed opportunities to improve withdrawal care
    - Provide strategies for opioid withdrawal management with buprenorphine and methadone
- Education and outreach
  - Chair or co-chairs
    - Physician leader
    - Nursing leader
    - Pharmacy leader
    - Graduate medical education representative
  - Tasks
    - Implement an awareness campaign
    - Implement a continuing education program
    - Collect feedback from constituencies

prescribing defaults, maximum MMEs, and using nudges, reminders, and best practice alerts are efforts that helped reduce the initiation of opioids or limit the dose and duration provided.[15]

Treating Patients with Opioid Use Disorder

OSPs must expand recognition and timely management of patients with OUD. Compassionate care of hospitalized patients suffering from complications of illicit opioid use (e.g., endocarditis, abscess) emphasizing opioid agonist therapy to

mitigate opioid withdrawal, reduce premature self-discharge and readmission, enhance opportunities to transition to methadone or buprenorphine, and improve other medication adherence such as antibiotic therapy is essential.

Additionally, resources should be allocated for "warm handoffs" to addiction treatment programs using hospital-based substance use disorder clinics and peer recovery coaches to engage patients into treatment. A comprehensive approach to mitigating opioid harm includes naloxone prescribing and distribution programs for at-risk individuals. Primary care providers should be supported to integrate buprenorphine prescribing into their practices to expand capacity for referrals and allow patients to find evidence-based treatment within the health system home.[16]

These concepts broaden existing new mandates to address multiple, intertwined morbidities associated with opioid use. They implement best practices and necessary resources to guide health systems tasked with this challenging work. The severity of the crisis and the rapidly changing regulatory and public health landscape dictate that sensible change must start immediately. Although the mandate for action is national, a substantial component of the solution is local. Hospitals and health systems are uniquely poised to create an integrated care model that emphasizes primary prevention, harm reduction, and transition to life-sustaining treatment. OSPs provide a specific mechanism to integrate many perspectives and requirements into a process to reduce consequences of excessive and inappropriate opioid use, and assure that those in pain receive safe and effective care.

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Approach to the Diagnosis and Management of Subarachnoid Hemorrhage

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Headache is one of the most common reasons for presentation to the emergency department (ED), seen in up to 2% of patients.[1] Most are benign, but it is imperative to understand and discern the life-threatening causes of headache when they present. Headache caused by a subarachnoid hemorrhage (SAH) from a ruptured aneurysm is one of the most deadly, with a median case-fatality of 27-44%.[2] Fortunately, it is also rare, comprising only 1% of all headaches presenting to the ED.[3] On initial presentation, the one-year mortality of untreated SAH is up to 65%.[4] With appropriate diagnosis and treatment, mortality can be reduced to 18%.[5] The implications are profound: Our careful assessment leading to the detection of a SAH as the cause of headache can significantly decrease our patients' mortality. If this were an easy task, the 12% reported rate of missed diagnosis would not exist.[6] We have multiple tools and strategies to evaluate the patient with severe headache and must understand the strengths and limitations of each tool. Herein we will describe the available strategies, as well as the ED management of the patient with SAH. [West J Emerg Med. 2019;20(2)203-211.]

INTRODUCTION

A 50-year-old female was preparing her children for school when she experienced a headache severe enough to make her lie down on the sofa. She managed to get the children off to school, but the headache did not abate. She was used to headaches, as she had migraines periodically that were controlled with over-the-counter medications, but this one was different and much more intense. She took a couple of acetaminophen, and when the pain was not relieved she brought herself to the emergency department (ED).

Headache is one of the most common reasons for presentation to the ED, seen in up to 2% of patients.[1] Most are benign, but it is imperative to understand and discern the life-threatening causes of headache when they present. Headache caused by a subarachnoid hematoma (SAH) from a ruptured aneurysm is one of the most deadly, with a median case-fatality of 27-44%.[2] Fortunately, it is also rare, comprising only 1% of all headaches presenting to the ED.[3] On initial presentation, the one-year mortality of *untreated* SAH is up to 65%.[4] With appropriate diagnosis and treatment, mortality can be reduced to 18%.[5]

The implications are profound: Our careful assessment leading to the detection of a SAH as the cause of headache can significantly decrease our patients' mortality. If this were an easy task, the 12% misdiagnosis rate would not exist.[6] We have multiple tools and strategies to evaluate the patient with severe headache, and must understand the strengths and limitations of each tool.

Pathophysiology

Eighty-five percent of cases of atraumatic SAH result from a ruptured aneurysm.[7] Alternate etiologies include perimesencephalic hemorrhage, which has a benign course, as well as arteriovenous malformations, dural arteriovenous fistula, arterial dissection, mycotic aneurysm, and cocaine abuse. The prevalence of aneurysms in the general population is roughly 2-5%,[8] greater in those with family history of aneurysms, and/or personal history of Ehlers-Danlos or polycystic kidney disease. Not all aneurysms are dangerous. Factors associated with the risk of rupture include hypertension, tobacco use, excessive alcohol use, sympathomimetic drugs, Black race, Hispanic ethnicity, and aneurysmal size > 10 millimeters (mm).[9] Aneurysmal SAH is more common in women and in patients 40-60 years old.

Aneurysms typically present at cerebral artery bifurcation points in both anterior or posterior regions. Aneurysmal

pathophysiology has been theorized to involve congenital weakness in the vessel wall, or degenerative changes resulting in destruction of elasticity of the vessel wall at points of high turbulence such as bifurcations.[10]

Classification

There are several systems of classification for SAH. The Hunt and Hess score and World Federation of Neurological Surgeons grading system are both used to predict patient outcome, and the Fisher grade helps to predict vasospasm. Given the retrospective derivation of these scales and little if any assessment of intra- and interobserver variability, no single scale can be recommended over others.[11] In terms of patient-centered outcomes and prognosis, specific scores were not seen to perform any better than the Glasgow Coma Scale (GCS).[12]

The classification systems do, however, help highlight an important concept of *spectrum bias*. As we delve into the diagnosis of SAH, it is important to note that some patients with SAH, for example Hunt and Hess grades I and II patients, are more commonly missed because symptoms are milder, and they may have smaller aneurysms with less subarachnoid blood. These patients do *not* necessarily do better or have less morbidity with rupture or re-rupture.

Diagnosis

The diagnosis of SAH should be considered in any patient with a severe and sudden onset or rapidly escalating headache. With such a large number of patients presenting to the ED with a chief complaint of headache, differentiating those with a benign cause from those with an emergent etiology such as SAH can be difficult. Deciding which patients require a workup for SAH is often the most challenging part of the emergency physician's care, in part due to the low frequency and high acuity of the illness.

Classic teaching characterizes the headache of SAH as a "thunderclap headache," which is defined as a sudden, severe headache often described as the worst of the patient's life.[14] The headache is typically a sudden onset, which is commonly characterized as occurring within a few minutes, although research parameters include headache that reaches maximum intensity within one hour. Symptoms that increase the likelihood of a subarachnoid bleed as the cause of headache include exertional onset, syncope, vomiting, neck pain, and seizures.[15] Focal neurologic deficits, meningismus, and/or retinal hemorrhage may be present, but up to 50% of SAH patients have a normal neurologic exam.[16] Recent research has attempted to shed light on which elements of the history and physical exam are correlated with and discriminating for the diagnosis of SAH.

Perry et. al published the Ottawa SAH Rule in 2013 after prospectively assessing 2131 adult patients with a non-traumatic headache that reached maximum intensity within one hour (Figure 1).[17] Subjects were excluded if they had a pattern of similar headaches, had papilledema, or focal neurologic deficits on exam, or had a prior history of aneurysm, SAH, neoplasm, or hydrocephalus. Of the 2,131 patients investigated, 132 were ultimately diagnosed with SAH, giving a prevalence of 6.2%. The authors describe a decision rule with 100% sensitivity, although the specificity is at best 15% (Table). By this rule, any one criterion suggests that the patient should get a full workup. The low specificity, however, can have the deleterious effect of increasing the number of patients who undergo full workups, and are subsequently exposed to unnecessary radiation, procedures, and perhaps invasive procedures. While the merits of the Ottawa decision rule can be argued, it has helped delineate which historical elements, signs, and symptoms are statistically correlated with a confirmed diagnosis of SAH. Given that one of the most difficult elements of a SAH diagnosis is determining in whom a workup is needed, these data can inform the clinician's process of determining pretest probability, even if the rule is not used in its entirety.

Inclusion criteria: alert, adult (>15 years old) patients with new, severe, non-traumatic headache reaching maximal intensity within one hour
Exclusion criteria: new neurologic deficits, prior history of aneurysm, subarachnoid hematoma, or brain tumor, or history of recurrent headaches (≥ 3 episodes in ≥ 6 months)
Age ≥ 40
Neck pain/stiffness
Witnessed loss of consciousness
Onset with exertion
Instantly peaking/thunderclap headache
Limited neck flexion

Figure 1. Ottawa subarachnoid hemorrhage decision rule.

Table. Hunt and Hess grading for subarachnoid hemorrhage.[13]

Grade	Criteria	Survival
I	Asymptomatic or mild headache with slight nuchal rigidity	70%
II	Moderate to severe headache, nuchal rigidity, no neurological deficit other than cranial nerve palsy	60%
III	Drowsiness, confusion, or mild focal deficit	50%
IV	Stupor, moderate to severe hemiparesis, possibly early decerebrate rigidity or vegetative disturbance	20%
V	Deep coma, decerebrate rigidity, moribund appearance	10%

Diagnostic Tools

Computed Topography

When a clinical suspicion for SAH exists based on history and physical exam, non-contrast computed tomography (CT) is the first diagnostic tool. It is also valuable in excluding other pathologies such as intracranial hemorrhage, malignancy, or abscess.

Timing of Computed Tomography

At the onset of the bleed, subarachnoid blood is the most readily visible on CT, but it becomes more difficult to appreciate as red blood cell (RBC) degradation progresses. Advances in neuroimaging have increased the sensitivity of non-contrast CT, raising questions regarding the need for lumbar puncture (LP) in the face of a negative CT.

A meta-analysis published in 2016 attempted to answer the question of CT sensitivity with relation to time from symptom onset.[18] The analysis, which included five studies, assessed patients with a thunderclap headache and normal neurologic exam. While the results carry many of the limitations of a meta-analysis, a conservative statistical analysis showed that a non-contrast CT completed within six hours of headache onset had a sensitivity of 98.7% with confidence intervals 97.1%-99.4%. The authors took into consideration the following criteria: patient must have a hematocrit > 30% and an isolated thunderclap headache without seizure, syncope, or neck pain; and the CT image must be third generation or newer, of high quality, read by an attending-level radiologist, and evaluated with the indication for imaging being thunderclap headache or concern for SAH. If these criteria are met, many consider a negative head CT within six hours to be a "rule-out" study given the sensitivity and confidence intervals.

Lumbar Puncture

If non-contrast head CT is not definitive (time to study, patient elements [i.e., severe anemia], interpretation limitations [i.e., trainee radiologist, motion artifact], etc) the next recommended diagnostic tool is the LP. In these instances the LP is looking for two elements that raise the concern for SAH: 1) RBCs; and 2) xanthochromia (bilirubin in cerebrospinal fluid [CSF]).

Given the sensitivity of the CT discussed above, shared decision-making should be conducted with regard to LP. In particular, with sensitivity of near 99% for an adequate study if completed within six hours, and meeting the criteria outlined above (Dubosh), patients should be made aware of the low diagnostic utility of LP if completed after a CT.[19] In this setting, risks (adverse events and false positives) generally outweigh benefits and LP is advised against. There are rare instances in which the clinical scenario so strongly suggests SAH that even an adequate negative CT completed within six hours is unable to rule out SAH and should be followed by LP. If the imaging is completed after the six-hour timeframe, the sensitivity of CT drops to 85.7%. In these cases, the diagnostic utility of LP increases as the probability of SAH after negative CT also increases. In such cases, LP is indicated. It should also be noted that, in keeping with the low prevalence of this disease, one recent study showed a roughly 0.4% of LPs revealed aneurysms.[20] Shared decision-making is still recommended, as with any invasive procedure.

Red Blood Cells

Intact RBCs will be seen early in the course of the disease and decrease as the cells break down and are resorbed. Fitting the pathophysiology, the presence of RBCs in the fourth tube of CSF is thought to represent SAH. Unfortunately, a LP is often a technically difficult procedure and rates of "traumatic tap," or introduction of erythrocytes by local trauma and needle manipulation can approach 30%.[21] This complicates the diagnosis of SAH by RBC results. Because differentiating between a true SAH and a traumatic tap is of the utmost clinical importance, authors have researched criteria to help differentiate the two.

Perry et al. published data comparing LP results in patients with SAH (by research gold-standard confirmation) to those without that final diagnosis, most notably patients with a traumatic tap without concurrent SAH.[21] In this analysis, the researchers found that setting a cutoff of 2,000 x 10^6 RBCs per liter (L) in the final CSF tube combined with no xanthochromia, irrespective of RBCs in the first tube, captured all patients with a final diagnosis of SAH while excluding most patients with a traumatic tap. Patients were considered to have a SAH if they had any of the following: CT head positive for blood in the subarachnoid space; xanthochromia on LP; or RBCs of 2,000 x 10^6 in the final tube of CSF with an aneurysm on CT angiography (CTA) that required neuro-intervention or resulted in death. To our knowledge, this fourth-tube cutoff for diagnosis of SAH has not yet been incorporated into professional society guidelines. Generally, it is believed that a traumatic tap produces a lower RBC count and possibly a more rapidly diminishing count from tube one to four.[22] Multiple authors have shown that the approach of comparing the first and fourth tubes is unreliable, in light of the fact that traumatic tap and SAH are independent entities.[21,23]

Xanthochromia

True xanthochromia is pathognomonic for SAH. This is valuable when there is high clinical suspicion and RBC count is not sufficiently elevated to differentiate from a traumatic tap diagnostic. Xanthochromia is detected either by visual inspection of the CSF tube vs a tube of water, or by spectrophotometry. RBCs that have shed into CSF from SAH will ultimately break down and release oxyhemoglobin, which then converts to bilirubin in vivo, interpreted as xanthochromia, or literally "yellow color." It should be noted that blood from a traumatic tap can produce oxyhemoglobin when exposed to natural light, which can produce a yellow

color, but since it is outside the body it will not produce bilirubin.[24] Protecting the specimen from light will minimize the conversion of RBCs to oxyhemoglobin. Alternatively, spectrophotometry can differentiate the oxyhemoglobin of traumatic tap from the bilirubin of SAH. Visual inspection, however, is still used in most institutions.

Timing

As with CT, controversy and practice variations exist with respect to timing of the LP. However, given the timing of RBC breakdown, the presence of any xanthochromia is delayed and most conservative estimates state an "up to 12 hours" timeframe.[25-27] In pursuit of xanthochromia, some have historically advocated a delayed LP approach, typically 12 hours from ictus, but the literature supporting this approach used spectrophotometry, which is not available in most labs in the United States.[28] No literature supports waiting for 12 hours to perform LP.[29] Given the flow of ED care and desire to expeditiously diagnose SAH, it is reasonable to obtain CT and then immediate LP (if needed), with attention to xanthochromia supplemented by the RBC cutoff criteria as needed. If the LP shows > 2000 x 10^6 RBCs in tube four, standard practice is to follow this with a CTA to assess for aneurysm. Conversely, if the cell count is < 2000 x 10^6/L and no xanthochromia is seen, then SAH is ruled out.

In the Perry study four out of five sites used visual inspection for xanthochromia, and 39% of all LPs were done within 12 hours of headache onset. Considering this, and the fact that results were confirmed with blood in subarachnoid space on CT, xanthochromia or RBCs in the final tube, and an aneurysm by cerebral angiography requiring neurovascular intervention or resulting in death, we believe that visual inspection is not only the most-often used modality to determine xanthochromia, but is reasonable for this purpose. Often, there is lack of clarity on exact time of ictus, and more importantly we have no pathophysiologic data showing a standard timeframe for the processes of RBC degradation into xanthochromia. Given the pathognomonic characteristics of xanthochromia, these authors (JH + EM) recommend that CSF samples be analyzed for both RBC count and xanthochromia regardless of timing of LP.

Computed Tomography Angiography

Over the last decade, CTA of the brain has become part of the discussion in ruling out SAH. As a non-invasive means of highlighting vascular anatomy and detecting aneurysms, CTA has many advantages. Much like non-contrast head CT, advances in neuroimaging have shown CTA to have a sensitivity of up to 98% and a specificity of 100% for aneurysms in patients with known SAH. These statistics are derived from a small data set (n= 65) where CTA results were compared to gold standards of digital subtraction angiography or surgical findings.[30,31]

Some propose CTA as an alternative to LP after a negative non-contrast CT.[19,31] With the prevalence of aneurysms estimated to be ~2-5% in the general population,[8] there is a concern for incidental findings and false positives. An aneurysm found on CTA may be incidental and unrelated to the cause of headache. For example, a patient with a moderate pretest probability of SAH on presentation at 12 hours of symptoms is generally not thought able to be ruled out by non-contrast head CT given its sensitivity of ~85%. Some advocate that if the patient has a CTA that is negative for aneurysm after a negative non-contrast head CT, this is accepted as being conclusively negative for SAH.[19] In addition, if it is not possible to perform LP for any reason, such as coagulopathy, the CTA could be used, with acknowledgment and consideration for its limitations.

Based on best available literature, a CTA without findings of aneurysm when coupled with a negative non-contrast head CT has a post-test probability of disease of < 1%.[31] This percentage is important because it falls below most clinicians' *test threshold*, which is the probability of disease below which no further investigation is required. However there is one confounding factor in this suggested algorithm (Figure 2). The sensitivity of CTA is 92.3% for aneurysms < 4mm,[32] and in contrast to pathologies where the size of the lesion correlates with the severity of disease (i.e., pulmonary embolus), a small, ruptured cerebral aneurysm can still lead to significant morbidity and mortality.

Collectively, for patients in whom a CT is completed at > 6 hours, a CT-CTA approach is pursued by some, but has limitations, most notably, the finding of incidental aneurysms and inability to detect small culprit aneurysms. If the CTA is positive for aneurysm, completing an LP at that time to determine incidental vs symptomatic could be considered. Limitations to this approach include radiation dose to patient, contrast dye exposure, and detriments to department flow of such an algorithm. As noted above, this approach of CT-CTA carries a low sensitivity for small but symptomatic aneurysms.[19] If this approach is used, the limitations and risk of false positive results should be discussed with the patient in a shared decision-making process.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) can be used to assess for SAH, with certain limitations. The challenge with using MRI for SAH is that the blood is combined with CSF that has a high oxygen concentration, thus delaying the transition of blood products to a deoxyhemoglobin state that is better imaged with MRI.[33] Since there are no data showing a discrete timeframe for the use of MRI, the decision to use MRI to assess for blood should be used in consultation with radiology and neurology or neurosurgery. The combination of fluid-attenuated inversion recovery and susceptibility-weighted imaging has been shown to be 100% sensitive for SAH, although most cases were imaged greater than 24 hours after the ictus of headache.[34] If MRI is negative for SAH, LP is still recommended.[1,35,36] Magnetic resonance angiogram is 95% sensitive for aneurysms

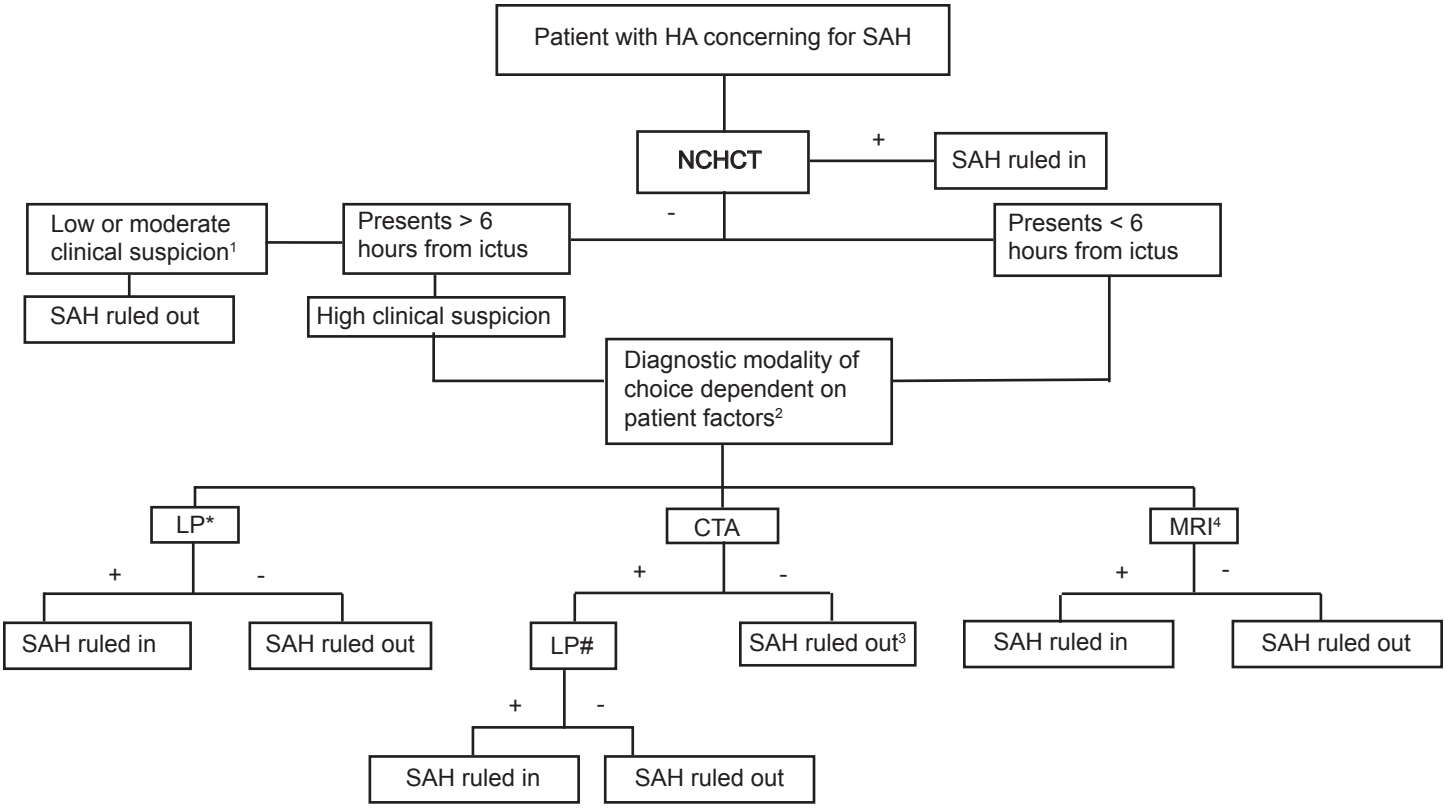

Figure 2. Algorithmic assessment for SAH in patient with sudden onset severe headache.
HA, headache; *SAH,* subarachnoid hemorrhage; *NCHCT,* non-contrast head computed tomagraphy; *LP,* lumbar puncture; *CTA,* computed tomography angiography; *MRI,* magnetic resonance imaging.
[1]With criteria met for Perry study [Perry et al. BMJ 2011][47]
[2]Patient factors include anticoagulation status, patient willingness to undergo LP, history of lumbar spinal fusion or other surgery, and time from ictus (with longer time favoring MRI)
[3]Caveat for this strategy includes the potential to miss aneurysms < 4 millimeters
[4]MRI is an acceptable diagnostic at > 24 hours from ictus, prior to this sensitivity is lacking.
*This is the recommended strategy by AHA/ASA, ACEP, and these authors
#Recommended to decrease the false positive rate of CTA.

> 3 mm.[37] With all of these limitations, MR imaging is not recommended as a primary imaging modality, but may be useful in certain atypical cases, in particular in patients with a long delay from ictus to presentation.

Summary of Available Diagnostic Tools

Many tools are available to assess for SAH including non-contrast CT, LP, CTA, and MRI. Understanding the potentially high mortality in the case of a missed SAH should mandate a diagnostic strategy with the highest sensitivity possible, which is currently accepted to be non-contrast CT followed, if negative, by LP.[1,31,34] This is the algorithm supported by both the American Heart Association (AHA) and American College of Emergency Physicians (ACEP). This strategy, of course, should take into account the previously described limitations of the LP. While CT/LP remains the most accepted rule-out method, other approaches do exist. Many practitioners have accepted the recent literature showing non-contrast CT to be an acceptable stand-alone study if completed within six hours.[18] If using any of the other tools described above, we must appreciate and work within the known limitations of each method.

ED Management

Once the diagnosis of SAH is established, the most important time-sensitive goals include confirmation of airway security and stabilization of hemodynamics. Intubation should be undertaken in the setting of low Glasgow Coma Scale Score or inability to protect the airway, but care should be taken to mitigate increases in mean arterial pressure (MAP) during the intubation process. This can be accomplished through careful choice of sedation agents for rapid sequence intubation and push-dose vasoactive agents if blood pressure does become elevated. Cardiac monitoring is important, as patients with devastating brain injury are at risk for neurocardiogenic stunning.[38]

The next priorities are to reduce systolic blood pressure (BP) and reverse anticoagulation to mitigate the risk of aneurysm re-rupture. Specific BP goals are unclear and need to be weighed against the risk of ischemia or infarction with hypotension. Guidelines recommend targeting BP < 160 systolic,[35] although many consider lower targets of 140-150. Nicardipine (5 milligrams per hour (mg/h) intravenous (IV), may increase by 2.5 mg/h q5-15 minutes (min); Max: 15 mg/h), labetalol (40-80 mg IV q10 min, start 20 mg IV x 1; Max 300 mg/total dose; Alt: 2 mg/min IV), and clevidipine (4-6 mg/h IV, start 1-2 mg/h IV, double rate q 90 seconds until near BP goal, then increase. By smaller increments q5-10 min; max:32 mg/h) are effective agents, often used in infusion form to avoid hypotension. In the setting of bradycardia, hydralazine may also be used. Nitroprusside and nitroglycerin should be avoided due to their significant vasodilatory effect and the risk of increasing intracranial pressure (ICP).

Reversing anticoagulation should be accomplished as soon as possible. Vitamin K antagonists can be reversed with phytonadione (vitamin K) and 4-factor prothrombin complex concentrate (PCC) or fresh frozen plasma. PCC is preferable as it has a more rapid onset, does not need to be thawed or blood-type matched, and can be infused rapidly with less volume and risk of fluid overload.[39] Antiplatelet agents should be reversed with platelet infusion, and desmopressin should be considered.[40] The utility of platelet administration has been questioned recently after a recent trial showed increased mortality with platelet infusion for patients taking antiplatelet therapy.[41] This trial, however, studied patients with spontaneous intracerebral hemorrhage, a different pathophysiology than SAH, and generalization of the results is not directly applicable.

Direct thrombin inhibitors such as dabigatran can be reversed with idarucizimab, which is United States Food and Drug Administration (FDA) approved and widely available. Andexanet alpha, an antidote for Factor Xa inhibitors (apixaban, edoxaban, rivaroxaban) is FDA approved for reversal of major bleeding with apixaban and rivaroxaban and available on a limited basis (Young).[39] If the patient with SAH is taking any Factor Xa inhibitor, including unfractionated heparin or fondaparinux, PCC is recommended as a first-line agent for reversal, unless Andexanet alpha is indicated and available.

Regardless of anticoagulation mechanism, a pre-approved institutional protocol should be in place for rapid utilization, with input from hematology, blood bank, emergency medicine, and neurosurgery in order to most efficiently reverse anticoagulation. Other strategies to reduce risk of aneurysmal re-rupture are targeted toward controlling pain, nausea, and valsalva effect by treatment with analgesics, antiemetics, and stool softeners as needed. Fentanyl is a very effective and easily titratable analgesic, and is quickly titrated off to facilitate neurologic exams. Nimodipine, a calcium channel blocker used to improve outcome in SAH patients can be started in the ED, with caution given to the patient's ability to swallow and the potential to inappropriately reduce BP.[35] Other best practices include arterial-line BP monitoring, crystalloid to target euvolemia, and head of bed at 30° to protect against aspiration and to allow jugular venous outflow for ICP protection.

Many patients with SAH will require ventriculostomy drainage, either for hydrocephalus or periprocedurally to help with ICP complications. Antiepileptic medications may be recommended if the neurologic exam is poor, or the amount of blood is significant, portending risk of clinical or subclinical seizure. There has not been a definitive study to recommend any specific antiepileptic agent, as each has therapeutic benefits and risks and is ideally tailored by the patient's profile. The most common agents are phenytoin (load 10-20mg/kilogram [kg] IV max: 50mg/min), fosphenytoin (10-20 phenytoin sodium equivalent (PE)/ kilogram (kg) IV; infuse slowly over 30 min; max: 150mg PE/min) and levetiracetam (15-20mg/kg over 30 min).

These therapeutic modalities should be discussed with the admitting neurointensivist or neurosurgery team. Continuous electroencephalogram (EEG) monitoring may be started in the intensive care unit (ICU).

The ultimate therapeutic goal, once a bleeding aneurysm is identified, is to secure it surgically by coiling or clipping. While coiling is the preferred method,[42] since it is less invasive than open surgical clipping, data are inconclusive as to whether long-term outcomes are better with either procedure, but guidelines suggest that coiling should be performed if both are possible.[43,44] In some cases, tortuous vascular anatomy or other contraindications to coiling make open surgery necessary. Earlier treatment and securing the aneurysm is associated with lower risk of rebleeding.[44] In the event that surgical treatment is delayed, antifibrinolytics such as aminocaproic acid may be used for a short period of time to mitigate the risk of re-rupture. Tranexamic acid and prothrombin complex concentrates have not been studied in this setting. This treatment modality is not backed by evidence, invokes risk of thrombosis, and is best discussed with the neurosurgery team.[44,45]

Once the aneurysm is secured, the greatest risk to patient outcome is that of vasospasm and delayed cerebral infarction (DCI). Many strategies are employed to assess for vasospasm, including hourly neurologic exam, strict euvolemia, continuous EEG, transcranial Doppler, permissive or induced hypertension, electrolyte monitoring and CT or direct angiography. If vasospasm is detected, timely treatment is paramount to decrease the risk of associated DCI. Treatment can be catheter-directed calcium channel blocker administration, such as nicardipine or verapamil, or vessel angioplasty.[46]

Our patient had a non-contrast CT 10 hours after onset

of headache, which was negative for blood but positive for mild hydrocephalus. Hydrocephalus presents in 20-30% of SAH patients, and is generally thought to be a result of fibrotic changes associated with inflammatory reaction to blood at the arachnoid granulation. This can be suggestive of a pathologic process but is not diagnostic of SAH. The patient then consented for a LP, which showed RBCs in tubes 1 (14,000x10^6) through tube 4 (13,500x10^6). She was started on a nicardipine infusion for BP management and was given fentanyl for pain control. Neurosurgery was consulted, and she was admitted to the neuro ICU for hourly neurologic examinations and preparation for coiling the next day.

Many centers have access to neurosurgical coiling capability, as part of a comprehensive stroke center designation, but in some areas surgical clipping may be the only available procedure. Coiling is typically preferred, having shown better outcomes in the long run, but in some cases patient anatomy (tortuous vessels or plaque in carotid arteries) may preclude this procedure and the patient may need to be transferred to another center.[42] Ventriculostomy placement prior to transfer will depend on the presence and severity of hydrocephalus, and should be discussed with the neurosurgery team.

The assessment and treatment of SAH is a dynamic and changing field, with the advent of advanced imaging, better understanding of pathophysiology and improved surgical techniques. SAH is rare but can be a devastating occurrence. Understanding the pathophysiology, demographics and risk factors helps to accurately evaluate the patient who presents to the ED with sudden-onset severe headache. The diagnostic strategy is key to decide which patients warrant full workup.

CT followed by LP is the standard diagnostic strategy, as per guidelines from ACEP, AHA and ASA, but many other advanced imaging options have come to the fore, making it important to understand the benefits and limitations of each diagnostic tool. Diagnostic sensitivity is critical, as a missed diagnosis of SAH can lead to increased mortality if the aneurysm re-bleeds. Shared decision-making can ensure that each patient understands risks and benefits. Disease recognition and prompt diagnosis is the primary responsibility of the emergency physician, while patient-specific management decisions are best made in a multi-disciplinary fashion.

CONCLUSION

Despite advances in the diagnosis and treatment of aneurysmal subarachnoid hemorrhage, mortality remains high. We are indebted to scholars who have contributed to the growing body of knowledge around aneurysmal SAH and appreciate that there is much more work to be done for this devastating disease.

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Push Notifications Reduce Emergency Department Response Times to Prehospital ST-segment Elevation Myocardial Infarction

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Introduction: Prehospital acquisition of electrocardiograms (ECG) has been consistently associated with reduced door-to-balloon times in the treatment of ST-segment myocardial infarction (STEMI). There is little evidence establishing best hospital practices once the ECG has been received by the emergency department (ED). This study evaluates the use of a push notification system to reduce delays in cardiac catheterization lab (CCL) activation for prehospital STEMI.

Methods: In this prospective before-and-after study, we collected prehospital ECGs with computer interpretation of STEMI from May 2012 to October 2013. Push notifications were implemented June 1, 2013. During the study period, we collected timestamps of when the prehospital ECG was received (email timestamp of receiving account), CCL team activation (timestamp in paging system), and patient arrival (timestamp in ED tracking board). When prehospital ECGs were received in the ED, an audible alert was played via the Vocera WiFi communication system, notifying nursing staff that an ECG was available for physician interpretation. We compared the time from receiving the ECG to activation of the CCL before and after the audible notification was implemented.

Results: Of the 56 cases received, we included 45 in our analysis (20 cases with pre-arrival CCL activation and 25 with post-arrival activation). For the pre-arrival group, the interval from ECG received to CCL activation prior to implementation was 9.1 minutes with a standard deviation (SD) of 5.7 minutes. After implementation, the interval was reduced to 3.33 minutes with a SD of 1.63 minutes. Delay was decreased by 5.8 minutes ($p < 0.01$). Post-implementation activation times were more consistent, demonstrated by a decrease in SD from 5.75 to 1.63 min ($p < 0.01$). For patients with CCL activation after arrival, there was no significant change in mean delay after implementation.

Conclusion: In this small, single-center observational study, we demonstrated that the use of push notifications to ED staff alerting that a prehospital STEMI ECG was received correlated with a small reduction in, and increased consistency of, ED CCL activation. [West J Emerg Med. 2019;20(2)212-218.]

INTRODUCTION

Prehospital acquisition of electrocardiograms (ECG) has been consistently associated with reductions in door-to-balloon (D2B) times for the treatment of ST-segment myocardial infarction (STEMI) ranging from 15 to 50 minutes.[1-10] The 2015 American Heart Association Guidelines for Emergency Cardiovascular Care made early acquisition of prehospital ECG a Class I recommendation.[11,12] Many emergency medical services (EMS) systems require transmission of the ECG for physician interpretation prior to cardiac catheterization lab (CCL) activation. There is no evidence establishing best practice after the ECG has been received at the hospital. Delays to physician interpretation can occur if test results are misplaced, forgotten, or overlooked in a busy emergency department (ED). We evaluated

the use of a push notification system to reduce delays in CCL activation for prehospital STEMI patients.

METHODS

This was a before-and-after comparison study conducted at a single, urban, academic center in Salt Lake City, Utah, with an annual census of 88,000 patient encounters. The receiving facility ED has 67 beds in three zones, with a minimum of double attending physician coverage 24 hours per day. Patients arrive from multiple EMS agencies in the region. Prehospital medical response and transports are either entirely fire department based, or fire department first response with third service ambulance contracted for patient transport. There are six STEMI receiving centers in the county, and suspected STEMI patients are transported by paramedics to the closest facility based on distance and knowledge of local traffic patterns.

Prehospital 12-lead ECGs are transmitted via email attachment using the ambulance's cardiac monitor. This is at the paramedic's discretion based on his or her own ECG interpretation or the computer interpretation of the ECG. Prior to implementation of push notifications, ED staff would only periodically check whether prehospital ECGs had arrived. As a result, most patients (even those who had an ECG available prior to arrival) had a 12-lead ECG acquired on hospital equipment upon arrival in the ED. The ECG was interpreted at bedside by the treating emergency physician (EP) who made the decision whether to activate the STEMI protocol. The ED charge nurse then called the "STEMI nurse" via the Vocera WiFi communication system (Vocera Inc., San Jose, California; Figure 1), who served as a single point of contact for CCL activation. The interventional cardiologist then arrived in the ED to assess the patient while the CCL team prepared for the procedure. Interventional cardiologists had the option to over-read the EP's interpretation before proceeding with the procedure, but this was left to provider preference.

Figure 1. Vocera WiFi communication badge.

Population Health Research Capsule

What do we already know about this issue?
ST-elevation myocardial infarction (STEMI) is a time sensitive diagnosis that has been shown to benefit from pre-arrival cardiac catheterization lab activation.

What was the research question?
Do push notifications indicating a pre-hospital electrocardiogram has been received in the emergency department (ED) reduce the time it takes the ED to activate the cardiac catheterization lab?

What was the major finding of the study?
Push notifications were associated with a reduction in the time ED staff took to activate the cardiac catheterization lab. Additionally, times were more consistent.

How does this improve population health?
Faster, more consistent cardiac catheterization activation for patients experiencing STEMI has been associated with improved mortality and possibly improved morbidity.

After implementation of push notifications, when prehospital ECGs were received in the ED an audible alert was played to the ED charge nurse via the text-to-speech function of the Vocera WiFi communication system saying, "ECG received, ECG received" (Figure 2). This notified nursing staff that an ECG was available for physician interpretation. The prehospital ECG was shown to an EP, and the same procedure for activating STEMI protocol was followed. If the CCL team indicated they were ready for the patient prior to his or her arrival, the patient was briefly assessed for stability by an EP on the ambulance gurney without being placed in a room and then taken directly to the CCL. If the CCL had not notified the ED they were ready for the patient or the patient was unstable, the patient was placed in an ED room and received any necessary stabilizing treatment until the CCL was ready.

We included adult patients (age ≥ 18 years) arriving from the field with a prehospital ECG consistent with STEMI received prior to patient arrival in the ED – ie, those who could have the CCL activated before arrival in the ED. For the before period, all prehospital ECGs received from the time ECG transmission was implemented until push notifications were implemented (from May 1, 2012, through May 30, 2013) were collected as

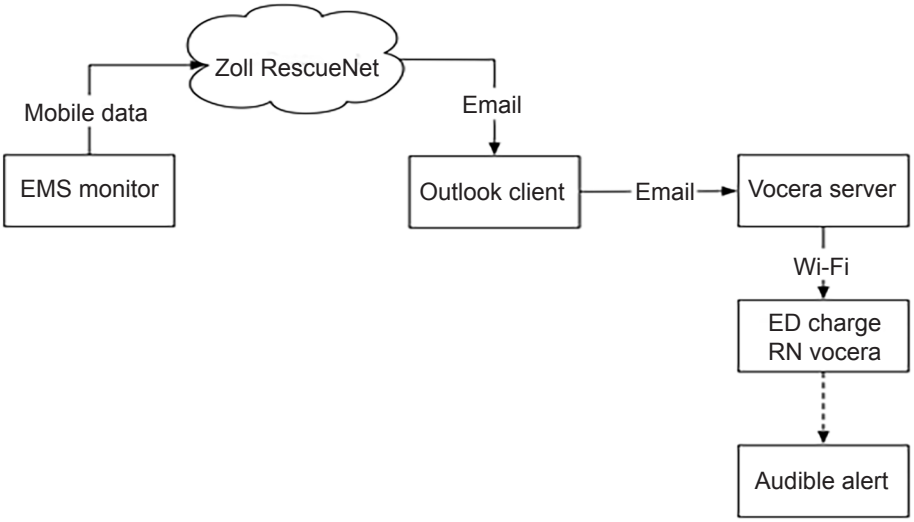

Figure 2. Diagram of a push notification system used to alert ED staff to the incoming transmission of a prehospital electrocardiogram. *EMS*, emergency medical services; *ED*, emergency department; *RN*, registered nurse.

a historical cohort and screened for enrollment. For the after period, all prehospital ECGs received after implementation were prospectively collected and screened (June 1, 2013 through September 31, 2013). All adult ECGs with a computer interpretation of STEMI were recorded in the data set. We excluded minors (age <18 years), inter-facility transfer patients, patients with ECGs that were transmitted to our facility in error, and ECGs that could not be matched to an ED patient. During the study period, we collected timestamps when the ECG was received, when the CCL team was activated, and when the patient arrived in the ED.

We calculated time intervals in decimal minutes. For patients where CCL activation occurred prior to ED arrival, "ED delay" was calculated as the time between when the prehospital ECG was received and the CCL was activated. For patients where CCL activation occurred after ED arrival, "ED delay" was calculated as the interval from ED arrival to CCL activation (Figure 3) under the assumption that an EP either did not see the prehospital ECG until the patient's arrival and wanted an ED-performed ECG, or that the EP wanted to examine the patient personally. These time intervals were treated as continuous data. Because a variety of factors outside

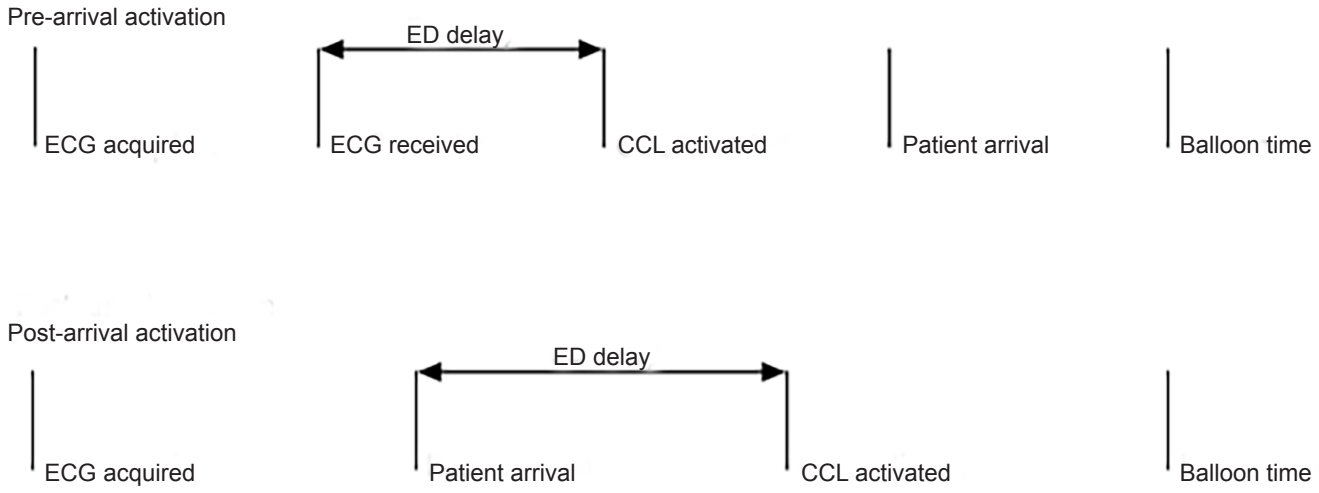

Figure 3. Timestamps used in the study to calculate emergency department delay. *ED*, emergency department; *ECG*, electrocardiogram; *CCL*, cardiac catheterization laboratory.

the ED's control affect CCL readiness, we used "ED delay" as our primary endpoint rather than D2B time. We believe this most accurately reflects the portion of D2B time for which the ED has influence. D2B was recorded as a secondary outcome.

We performed statistical analysis in SPSS Statistics (version 24; SPSS Inc., Chicago, Illinois). ED delay was compared using a Wilcox signed-rank test due to the non-parametric distribution of the data. We compared standard deviation (SD) of ED delay using a Mann-Whitney U test, also because of the non-parametric data distribution. D2B times were compared using an independent sample t-test because these data were normally distributed. Continuous demographic data (age) was compared using an independent sample t-test. We compared categorical demographic data (gender, race, risk factors, mortality) using Fisher's exact test. The proportion of cases activated prior to arrival was compared using Fisher's exact test. We obtained consent and privacy waivers from the Intermountain Healthcare Institutional Review Board, project # 1050432.

RESULTS

We collected 56 cases during the study period. Two were excluded as inter-facility transports, two were confirmed as received by our facility in error, and seven ECGs could not be matched to a patient arriving in our ED. The remaining 45 cases included in the analysis represent 43 unique patients. Two patients' medical record numbers could not be matched when we later performed a query for patient demographics, likely due to a typographic error in the original data entry. Patient demographics are summarized in Table 1.

Of these 45 cases, 32 were received before implementation of the push notification system and 13 were received after. Of the 32 "before" cases, 14 resulted in pre-arrival CCL activation. Of the 13 "after" cases, six resulted in pre-arrival CCL activation. In total, 20 cases were activated prior to the patient arriving in the ED and could be used for analysis of the intervention effect (Figure 4). Every pre-arrival activation continued on to the CCL and received an intervention.

The characteristics of ED delay before and after push notifications are summarized in Table 2. Before push notifications, the mean ED delay for pre-arrival activation was 9.13 minutes (SD 5.75 minutes) and median delay was 6.27 minutes. After implementation, the mean delay was 3.33 minutes (SD 1.63 minutes) and median delay was 3.00 minutes ($p<0.01$). Observed power for this difference was 82%. Times were also more consistent, demonstrated by a decrease in SD of 4.22 minutes ($p < 0.01$). For post-arrival patients, there was no significant change in mean; 2.5 minutes before vs 5.3 minutes after ($p = 0.55$), SD 3.99 before vs 8.57 after ($p= 0.44$), or median; 1.00 before vs 1.50 after ($p = 0.55$). There was no significant difference in the rate of pre-arrival activation ($p = 1.00$). There was a non-significant trend toward a reduction in D2B times for both pre-arrival (57.00 before vs 48.67 after, $p = 0.25$) and post-arrival activation groups (51.50 before vs 44.00 after, $p = 0.14$). In post-arrival activation cases, there were no significant differences in ED delay or D2B.

Table 1. Patient demographics compared before and after implementation of push notification.

	Before (n=32)	After (n=13)	P value
Age			0.900
Range	39.17-88.93	34.70-85.84	
Median	65.20	66.90	
IQR	16.70	19.80	
Gender			0.586
Male	22	7	
Female	9	5	
Unknown	1	1	
Race			0.218
Asian	1	0	
Hispanic	1	3	
Other	1	0	
White	28	9	
Unknown	1	1	
Risk factors			
CAD	15	1	0.017
HTN	22	6	0.287
HLD	20	4	0.091
DM	7	2	1.000
Smoker	9	4	1.000
30-day mortality	5	0	0.303

IQR, interquartile range; *CAD*, coronary artery disease; *HTN*, hypertension; *HLD*, hyperlipidemia; *DM*, diabetes mellitus.

DISCUSSION

Prehospital ECG transmission has been shown to reduce D2B times and increase the number of cases receiving treatment within 90 minutes. Accordingly, many guidelines for field operations encourage ECG transmission, but no best practices or guidelines examine the hospital's role in reducing D2B with prehospital ECG transmission – namely workflow – once the ECG is received. This study is novel in that it examines the effect of technology on ED workflow and CCL activation times for prehospital STEMI activations. We demonstrated a small but consistent reduction in ED delay that suggests push notifications may have a role in optimizing ED workflow for prehospital STEMI patients. Our observed reduction may not be clinically significant, but other facilities that currently have longer ED delay may see a larger effect size when implementing this intervention.

We found a non-significant trend toward improvement in D2B times for both groups after implementing push notifications. There are a number of factors outside the ED's control that affect CCL readiness, such as the time of day and procedures already

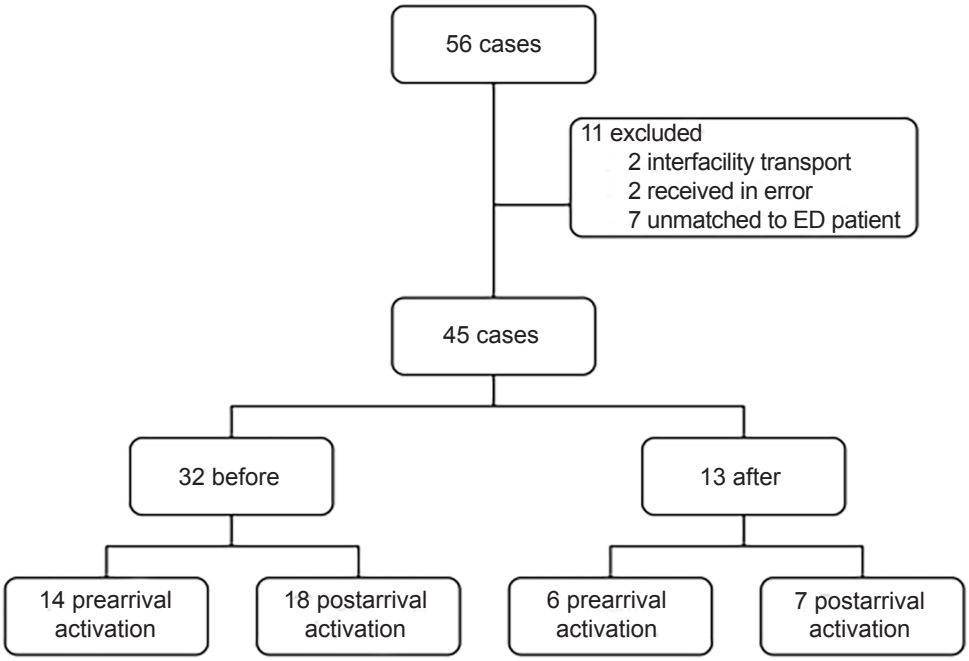

Figure 4. Breakdown of cases collected before and after implementation of push notifications.
ED, emergency department.

in progress. Either of these factors, which were not controlled for, may explain why ED delay improved significantly but D2B did not. Additionally, we found no difference in the fraction of prehospital ECGs activated prior to patient arrival. Facilities that have a lower pre-arrival CCL activation rate could see a significant effect when implementing this intervention. We saw several cases (nine) where a diagnostic ECG was received prior to patient arrival, but the CCL was not activated. These patients all continued on to CCL, but without the benefit of the pre-arrival activation they were eligible to receive. This may have occurred as a result of physician preference or other factors affecting the availability of ED staff to get the ECG read in a timely fashion.

There may be a variety of unintended consequences to implementing a push notification system. EPs are already interrupted at a staggering frequency during their shifts.[13–16] This notification process creates an additional source of interruptions for providers at all levels. The system also relies on the availability of other ED staff such as a charge nurse for the system to succeed. Having staff respond to push notifications may draw time and attention from other patient-care tasks with unintended ramifications. Alarm fatigue is also an issue. It is possible this system's success was due to its novelty and that over time staff could become less responsive. We chose to use the Vocera system because it was an existing technology at our facility and required no additional cost to integrate with our notification system. It is possible that other systems for notification such as text paging, alert lights, or computer pop-ups could have a similar effect depending on what another facility has available.

LIMITATIONS

This study is limited by its small sample size, single-site design, and use of a convenience sample. We only described the experience of our facility implementing one type of push notification. While we demonstrated limited benefit, it is difficult to generalize this to facilities whose STEMI processes differ from ours. Additionally, only prehospital ECGs with a computer interpretation of STEMI were collected. Any computer false negatives would have been missed, as well as any tracings that failed transmission for any technical reasons (poor wireless connectivity, monitor error, Bluetooth connectivity issue, etc.).

While the various agencies in our EMS system use different brands of cardiac monitors for acquiring 12-lead ECGs, there is significant heterogeneity in the test characteristics of computerized STEMI diagnosis between brands.[17–21] Transmission of the ECG was at the discretion of the treating paramedic. Further, differences in protocols between EMS agencies could also have affected the decision to transmit the ECG. These sources of variance likely affected the number of cases we received. We began collecting data when ECG transmission was first implemented in our region. Although EMS agencies used their existing cardiac monitors, difficulties with the initial implementation may have contributed to our small sample size.

Table 2. Summary of emergency department (ED) delay before and after implementation of a push notification system.

	Before	After	Difference
Pre-arrival activation	n=14	n=6	
ED delay			
Median	6.27	3.00	3.27 (p=0.005)
IQR	4.58-15.43	2.50-4.50	
D2B			
Mean±std dev	57.00±15.20	48.67±12.80	8.33 (p=0.253)
Post-arrival activation	n=18	n=7	
ED delay			
Median	1.00	1.50	0.50 (p=0.553)
IQR	0.00-4.00	0.00-10.75	
D2B			
Mean±std dev	51.50±16.40	44.00±5.66	7.5 (p=0.137)

IQR, interquartile range; *std dev*, standard deviation; *D2B*, door-to-balloon time.
All units are decimal minutes.

Our goal, however, was to look at effects after the ECG was received in the ED, which involved EP interpretation regardless of the reason for transmission. Thus, while paramedic discretion, computer algorithm accuracy, and differences in EMS protocols may have affected our sample size, it would not systematically bias our measured metric of time to CCL activation, as hospital providers were effectively blinded to these differences.

These results relied on nursing staff to get ECGs to a physician for interpretation and may not be externally valid for facilities that do not use EPs for ECG interpretation, or that use other technologies to send ECG results directly to physicians. If the top priority were solely speed of interpretation, relying on paramedic interpretation of STEMI would likely be fastest. However, this could come at the cost of increased false positives. As best practice evidence is lacking, the decision regarding who interprets the ECG is often made on a local level as a result of interdepartmental consensus.

Additionally, we did not examine downstream effects such as D2B times. While the use of prehospital ECGs has consistently been associated with reductions in D2B and increased proportion of cases receiving intervention within 90 minutes, previous research has failed to show an improvement in mortality when D2B time is reduced to less than 90 minutes.[22] Thus, the significance of any reduction in D2B depends on a facility's D2B characteristics prior to any process improvement. It should be noted that while there is no demonstrated mortality benefit of D2B below the 90-minute mark, it is possible there is a morbidity benefit in patient-oriented measures such as incidence of heart failure, exercise tolerance, or need for cardiac rehabilitation. Some evidence suggests that reduced D2B time is associated with increased false positives,[23] although we did not observe any false-positive CCL activations in this study.

CONCLUSION

In this small, single-center, before-and-after study, we demonstrated that implementing push notifications to alert ED staff to prehospital ECG reception correlated with a small, but significant, reduction in ED delay of activating the CCL. Additionally, times to CCL activation were more consistent. We did not observe a significant change in the proportion of cases that received pre-arrival activation. While future research is needed to determine the clinical significance, it is possible that push notifications have a role in optimizing ED workflow for prehospital STEMI patients.

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Machine Learning in Relation to Emergency Medicine Clinical and Operational Scenarios: An Overview

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Health informatics is a vital technology that holds great promise in the healthcare setting. We describe two prominent health informatics tools relevant to emergency care, as well as the historical background and the current state of informatics. We also identify recent research findings and practice changes. The recent advances in machine learning and natural language processing (NLP) are a prominent development in health informatics overall and relevant in emergency medicine (EM). A basic comprehension of machine-learning algorithms is the key to understand the recent usage of artificial intelligence in healthcare. We are using NLP more in clinical use for documentation. NLP has started to be used in research to identify clinically important diseases and conditions. Health informatics has the potential to benefit both healthcare providers and patients. We cover two powerful tools from health informatics for EM clinicians and researchers by describing the previous successes and challenges and conclude with their implications to emergency care. [West J Emerg Med. 2019;20(2)219–227.]

INTRODUCTION

Dr. Rob Procter, the editor of *Health Informatics Journal,* defined health informatics as "the interdisciplinary study of the design, development, adoption and application of information technology-based innovations in healthcare services delivery, management, and planning.[1]" The first digital computer was invented in the 1940s, and society was told that these new machines would soon be serving routinely as memory devices, assisting with calculations and information retrieval.[2] Within the next decade, healthcare providers had started to benefit from the dramatic effects of this technology.[2] Information technology has become so ingrained in modern medicine that contemporary practice depends on computational technology.

The recent advancement in health informatics has significant implications for biomedical research, as evidenced by searching PubMed for "Machine Learning" [Mesh] OR "Natural Language Processing" [Majr], which results in nearly 2400 publications related to machine learning and natural language processing (NLP) in 2017—up from 123 in 2010. This evolving technology also influences emergency care and research by aiding emergency medicine (EM) providers in several ways. First, it helps them to identify a high-risk condition by capturing data from available records or to prevent misdiagnoses by providing decision support.[3] Second, it improves workflow efficiency by providing integrated decision aids within the electronic health record (EHR).[4] Third, providers can maintain high-quality documentation in EHR in a high-tempo environment.[5]

We provide synopses of two clinically important health informatics applications: machine learning and NLP. These topics are diverse, and each of them is complex. Even in researching these areas, different researchers specialize in different sub-areas of machine learning or NLP. For example,

speech-recognition and machine translation from one language to another are two distinct sub-fields with their own bodies of work. Machine learning and NLP are closely intertwined within the evolving healthcare system. Together, these health informatics applications offer many benefits to improve the practice of EM. The purpose of this review is for EM providers and researchers to understand two tools of health informatics, namely machine learning and NLP.

Machine Learning

Definition

Machine learning is a computer science theory that often uses statistical techniques to give a computer, or artificial intelligence (AI), the ability to progressively improve performance on a given task based on the significant amount of data without any explicit program.[6]

Example

The use of machine learning has been integrated into our practice, for example, with automated white blood cell (WBC) differential count and computational electrocardiogram (ECG) analysis and interpretation.[7-9] Recently, biomedical research findings using machine-learning algorithms were reported in mammograms for breast cancer screenings and retinal scans for diabetic retinopathy, wherein researchers used artificial neuron networks (ANN) and found higher sensitivity and specificity compared to an expert clinician panel.[10,11] From EM literature, E-triage, a machine algorithm using random forest models, demonstrated superior predictability compared to the conventional Emergency Severity Index (ESI) triage.[12]

Basics of Machine Learning

Machine learning is designed to allow a program to infer patterns from three sets of data. First, the dataset used to adjust the weights on the learning algorithm (called the *classifier*) is the training set. The second data set is the *validation* data set. This dataset does not adjust the weights of the classifier but verifies that any increase in accuracy over the training dataset actually yields an increase in accuracy over a dataset that has not been shown to the classifier before, or at least the classifier hasn't trained on it (i.e., validation). The third dataset is the *testing* set. This dataset is used only for testing the final solution in order to confirm the actual predictive power of the classifier.

Glossary of Terms

Certain complex terminology associated with machine learning is described in this paragraph:

Supervised learning: These are input variables and output variables used to learn the mapping function from the input to output. In contrast, **unsupervised learning** does not provide any verification of output for the predictions. **Attribute** is a property or characteristic of an object that may vary, either from one object to another or from one time to another. Examples include the appearance of margins of a suspicious lesion in a chest radiograph and a suspected stroke in diffusion magnetic resonance imaging (MRI). **Class label** is a predefined category set as the goal to predict based on the attribute of computing the rules. Examples include abnormal ECGs, radiographs, and different types of WBCs in an automated differential count. **Classifier** is an algorithm that implements classifications, which involve the task of assigning objects to one of several predefined categories. Examples of classifiers include logistic regression, decision tree, and support vector machine (SVM). **Ensemble methods** constitute a combination of multiple, machine-learning algorithms to reduce the variance and bias and improve predictions.

Examples of Machine Learning

The training process of the dataset is unique in each machine-learning algorithm (Table). One example of this is **artificial neuron networks** (ANN). In this case, each node functions as an artificial neuron and is connected to another node, and the connection has a weight to facilitate the learning process— similar to the human brain's neuron network. The neurons are arranged in layers that function analogous to cells in the cerebral cortex and the retina. Figure 1 shows the diagram of an ANN that can predict the probability of a patient dying from a theoretical disease on the basis of the patient's age (xl) and sex (x2). Each circle represents a node, while each line represents a connection weight. (Actual weight values are shown.) The nodes of the network are arranged in three layers (input, hidden, output). A logistic activation function is used in both the hidden (h1, h2) and output nodes (o1); (hl and h2 are the activations of hidden nodes 1 and 2; o1 is the predicted output of the network.) At each hidden and output node, a weighted linear combination of the inputs is summed and then a logistic transformation is applied.[13]

A **decision tree** is an algorithm with a flowchart-like structure that recursively selects the best characteristics of an object to split the data (node) and expand the leaves. Figure 2 shows the example of decision trees for diabetes in men, including the predictor variables and the cut-off points for each predictor. It uses four variables (FPG = fasting plasma glucose, 2h-PCPG = 2-hour post-challenge plasma glucose, age and WHtR = waist-to-hip ratio) for classification and generated seven decision rules; each rule identifies a special subgroup with a certain probability of outcome (positive or negative) for each person in that subgroup. The FPG, located on the top of the tree, was the most important factor in the incidence of type 2 diabetes.[14] A random forest model is a grouped or "ensemble" method designed to combine the predictions made by multiple decision trees (Table). Many of these models, especially the general linear model and regression and discriminant analysis, were invented long before the term "machine learning" was coined.[15]

Table. Types and examples of machine-learning algorithms.

Study/year	Type of prediction model	Feature of model	Example
Nelder JA et al. 1972[15]	General linear model (GLM)	The technique used to obtain maximum likelihood estimates of the parameters with observations distributed according to some exponential family and systematic effects that can be made linear by a suitable transformation. A generalization of the analysis of variance is given for these models using log-likelihoods.[15]	The study aimed at forecasting daily emergency department (ED) visits using calendar variables and ambient temperature to compare the models in terms of forecasting accuracy.[16]
Lee E et al. 2012[17]	Discriminant analysis	A generalization of Fisher's linear discriminant, a method used in statistics, pattern recognition, and machine learning, to find a linear combination of features that characterizes or separates two or more classes of objects or events.	This study was done to develop a clinical tool capable of identifying discriminatory characteristics that can predict patients who will return within 72 hours to the pediatric emergency department. The investigator used a classification model to predict return visits based on factors extracted from patient demographic information, chief complaint, diagnosis, treatment, and a hospital real-time ED statistics census.[17]
Lee S et al. 2017[18]	Logistic regression	A type of supervised learning that groups the variable to be predicted into classes (presence or absence of disease, for example) by estimating the probabilities with a logistic function. It is intelligible, meaning it is interpretable by humans.	To derive a prediction rule to stratify ED anaphylaxis patients at risk of a biphasic reaction, the authors conducted an observational study of a cohort of patients presenting to an academic ED with signs and symptoms of anaphylaxis. Logistic regression analyses were conducted to identify predictors of biphasic reactions, and odds ratios (ORs) are reported.[18]
Peck JS et al. 2012[19]	Naïve Bayes	A learning algorithm for binary (0 or 1) or categorical (1, 2, 3, 4, for example) problems. The calculations of the probabilities of each hypothesis are simplified to make their calculation tractable and choose the highest posterior probability (example: post-test probability) from the prior probabilities (example: pre-test probability). It is based on the strong assumption that the predictor variables do not interact and are conditionally independent of each other.	The objectives were to evaluate three models that use information gathered during triage to predict the number of ED patients that will subsequently be admitted to a hospital inpatient unit (IU) and to introduce a new methodology for implementing these predictions in the hospital setting. Three simple methods were compared with each other in order to predict hospital admissions at ED triage: expert opinion, naïve Bayes conditional probability, and a generalized linear regression model with a logit link function (logit-linear). Predictors considered included patient age, primary complaint, provider, designation (ED or fast track), arrival mode, and urgency level (emergency severity index assigned at triage).[19]
Hao S et al. 2014[20]	Decision tree	Decision tree is a flow chart–like structure in which each internal node denotes a test on an attribute, each branch represents the outcome of a test, and each leaf node holds a class label,[4] which the model learns to predict. This algorithm works by recursively selecting the best attribute by which to split the node and expanding the leaf nodes of the tree until the stopping criterion is met.	A decision tree–based model with discriminant electronic medical record (EMR) features was developed and validated and estimated a patient ED 30-day revisit risk. A retrospective cohort was assembled with the associated patients' demographic information and one-year clinical histories before the discharge date as the inputs.[20]
Levin S et al. 2017.12	Random forest	A type of ensemble method designed for decision tree classifiers, which combines the prediction made by multiple decision trees, where each tree is generated based on the values of an independent set of random vectors.[21]	E-triage used the random forest model applied to triage data that predicts the need for critical care, an emergency procedure, and inpatient hospitalization in parallel and translates risk to triage level designations.[12]

Table. Continued.

Study/year	Type of prediction model	Feature of Model	Example
Son YJ et al. 2010[22]	Support vector machine (SVM)	A type of supervised learning models with associated learning algorithms that analyze data used for classifications and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a binary linear classifier. SVM is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall.	A study aims to identify predictors of medication adherence in heart failure patients. The investigators applied SVM for data classification. For a given set of training data, each marked as belonging to one of two categories. An SVM training algorithm develops a model by finding a hyperplane, which classifies the given data as accurately as possible by maximizing the distance between two data clusters. Data about medication adherence were collected from patients at a university hospital through a self-reported questionnaire.[22]
Wu Y et al. 1993[23]	Neural network	Information processing that derives meaning from complicated or imprecise data. Each node, functioning as an artificial neuron, is connected to another node, and the connection has weight to facilitate the learning process based on input and output, similar to the brain's neural network.	A study on developing a decision-making aid for radiologists in the analysis of mammographic data used an artificial neural network. The algorithm was trained based on the features extracted from experienced radiologists. The performance of the neural network was found to be higher than the average performance of the resident and staff physician alone, concluding that such networks may provide a potentially useful tool for distinguishing between benign and malignant lesions in mammograms.[23]

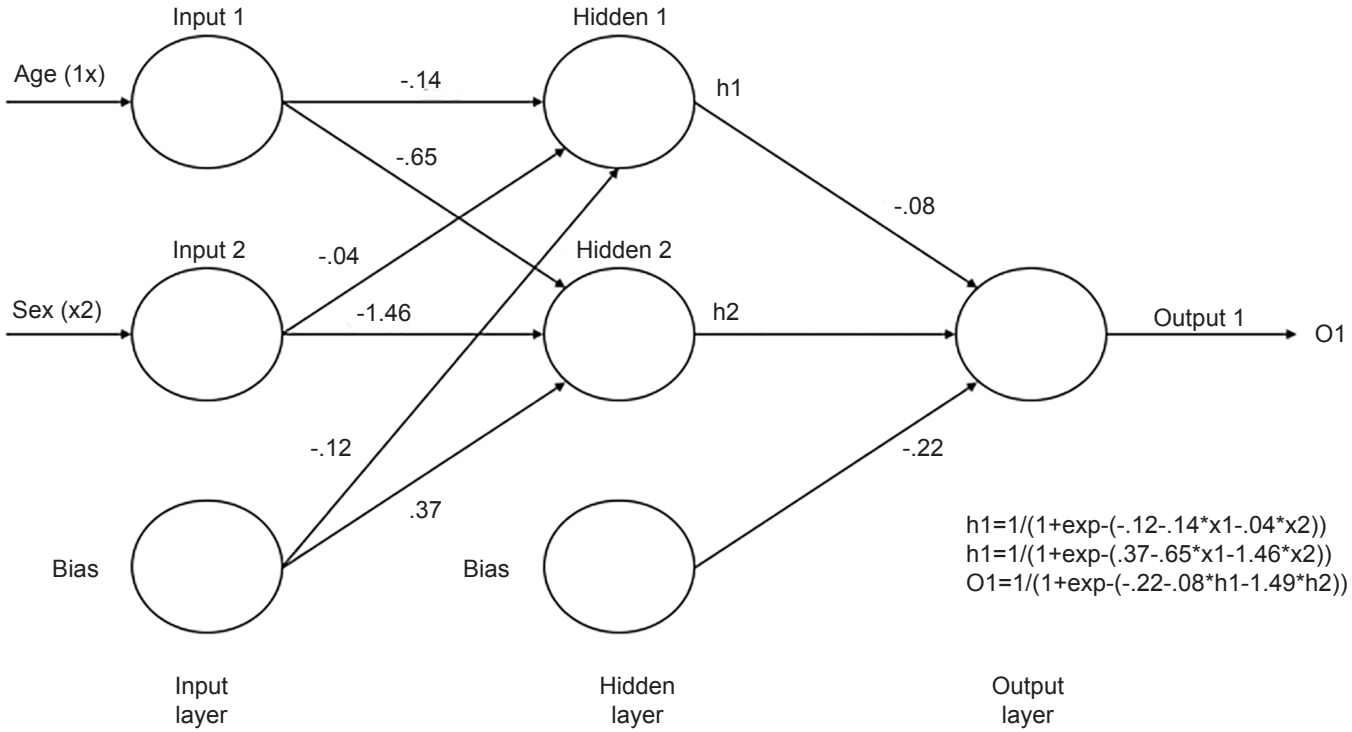

Figure 1. Diagram of artificial neuron networks.

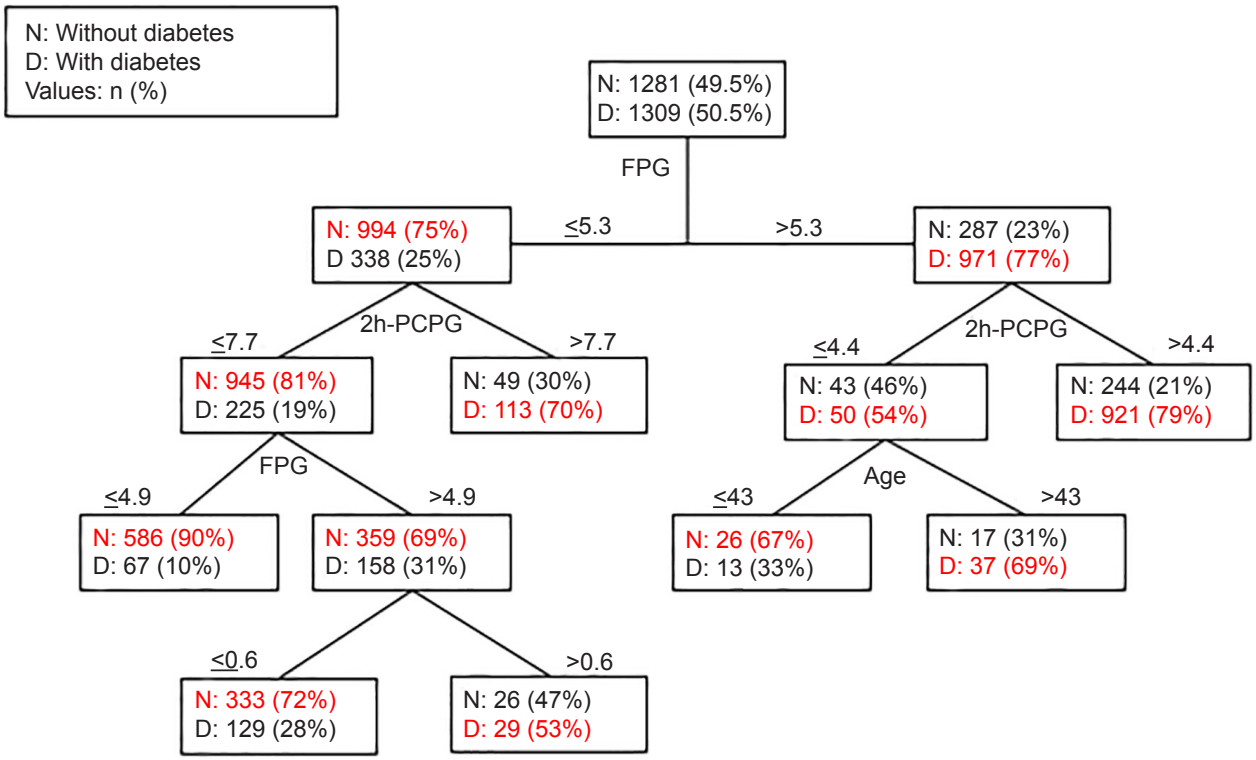

Figure 2. Diagram of decision tree.
The original figure was created by Ramezankhani et al.[14]; the link is https://bmjopen.bmj.com/content/6/12/e013336.long. The shading and formatting of the lines between tree nodes and the text font are modified.
FPG, Fasting Plasma Glucose; *PCPG*, Post Challenge Plasma Glucose.

Disadvantages of Machine Learning

There are several issues with machine-learning algorithms to consider when we apply these clinically. One is its problem with **overfitting**, which is a potential problem with any prediction model. Overfitting occurs when the learning algorithm recognizes the false signal or noise in the dataset as the signal and applies the prediction to the test dataset, resulting in poor performance on new data or an inability to externally validate the model. There are several approaches to address this issue. One way to recognize overfitting is that the accuracy changes drastically, for example, the accuracy of 99% on the training set drops down to 50% when the algorithm is applied to the new dataset. If the accuracy over the training dataset increases, but the accuracy over the validation dataset stays the same or decreases, then we should stop training. A statistical method, the *goodness of fit* test, can measure how closely the model's predicted values match the observed (true) values. Lastly, when we have several comparable algorithms, we can employ the simplest ones so that the added benefit of any complexity can be determined. This is the concept of **parsimony**, which favors a simpler model among others. The risk of overfitting can be minimized further by a sampling technique including cross-validation, which repeatedly partitions the example data randomly into training and validation sets to validate the model's predictions internally. The process of data partitioning, training, and validation is repeated multiple times, and the validation results are averaged across the training cycles[24] (Figure 3).

Another problem is that most clinicians and possibly some researchers are not made aware of what a machine-learning algorithm does to produce its output. A classic example is the study to explore the outcome of pneumonia-related hospitalization in the 1990s, in which asthma was reported as a protective factor against pneumonia in the study.[25] Most clinicians would know from their experience that comorbid asthma is not a protective factor. In any learning algorithm (later defined as classifier), such as a simple/multiple or logistic regression, if an independent variable is strongly associated with the outcome/output variable, then there are four possible interpretations: 1) the predictor causes the outcome; 2) the outcome causes the predictor; 3) there is a common (unconsidered) variable that is associated with both the predictor and outcome variable; and 4) the association is coincidental. It is important to note that correlation does not imply causation. The study employed the neural network (Table), an algorithm that is known not to be intelligible or difficult to interpret by humans. With simultaneous analyses using the same dataset, the authors confirmed that those who had pneumonia and comorbid asthma were more likely to be admitted to the intensive care unit and to receive better care,

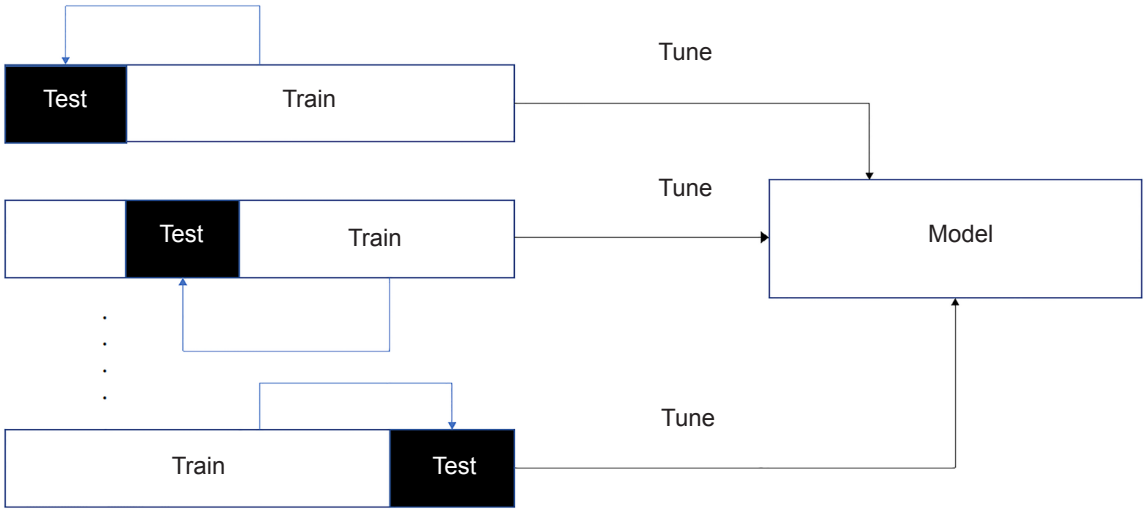

Figure 3. K-fold cross validation.*
*The datasets are divided into several, equally sized subsets. The model is trained on subsets (training sets). After the training process, the model is tested on the remaining subsets (test sets). According to the number of subsets partitioned, user tests k-fold cross-validation. In *ten*-fold cross-validation, for example, one may use *10* results of *10*-fold cross-validation.

which led to an improved pneumonia-related outcome. Although neural networks outperformed logistic regression (Table), a statistical model that is often believed to be the standard, the investigators concluded that the algorithm was too risky because the model was not intelligible.[26,27]

Miotto et al. published an article that showed the possibility of predicting future illnesses by applying a machine-learning algorithm to the EHR.[28] The algorithm was unique as it did not require the verification of the prediction or use of unsupervised learning. Responding to this, Will Knight wrote in *The Dark Secret at the Heart of AI*, "no one really knows how the most advanced algorithms do what they do. That could be a problem."[29] The real problem is that the final state of the internals of a neural network (a set of connections between nodes and the weight and sign of each connection) is not very meaningful in terms of understandability to a human domain expert. By contrast, the output of regression techniques and most other techniques is human-interpretable in terms of identifying the variables of importance. The lesson is that the validity of the machine-learning algorithm and its findings requires a careful interpretation, with particular attention on overfitting and caution with these prediction models, particularly when there is no external validation for the method to test the portability of the developed learning algorithm to another set of data.

Natural Language Processing (NLP)

Definition

NLP is an area of computer science and AI concerned with the interactions between computers and natural languages, particularly how to program computers to process and analyze large amounts of language data.[30]

Example

The advancement of NLP brought invaluable tools to clinical practice in day-to-day documentation, whether it is speech recognition software or macros and templates built into the EHR. Language modeling for automatic speech recognition uses a set of co-occurring words within a given window to find the most probable string of words out of candidate strings stored in the dataset.[31] Word-error rate and accuracy rate are used to evaluate speech- recognition systems.[32] Another example includes a statistical parser, which determines the most likely interpretation of a word or phrase in a sentence by using the conditional probability (a measure of the probability of an event given that another event has occurred).[33] Recent studies have used NLP to identify diseases and conditions that are difficult to diagnose by clinical gestalt alone. For example, a study used NLP to detect Kawasaki disease based on the ED chart, implying its potential as decision support.[3] Several other examples of using NLP for detection and prediction of disease and adverse events are reported in the literature.[34-38]

Development of NLP

NLP started in the 1950s as AI and linguistics crossed paths.[39] Early-stage NLP, described as a word-for-word translation, was defeated by the problem of *homographs*, meaning identically spelled words with different meanings. For example, "minute" could mean time or small size depending on the context. The next tool, hand-written rules, faced NLP's unrestricted volume and variations and encountered difficulty with extracting meaning from the text and poor handling of ungrammatical prose.[24] Statistical NLP emerged as the result of reorientation as simple, robust approximations replaced

deep analysis, evaluations became more rigorous, machine-learning methods using probabilities became prominent, and large, annotated bodies of text (corpora) were employed to train machine-learning algorithms— the annotation contained the correct answers and provided standards for evaluation.[40] Machine learning is the core of NLP due to the unique features described above.[41] Hand-written rules by humans have been largely replaced by machine learning for machine translation and speech recognition, and it is the driving force of contemporary NLP.[42,43]

Key Machine-learning Algorithms for NLP

Frequently used algorithms for natural NLP include the SVM and hidden Markov model (HMM). SVM classifies output such as words into categories that can be parts of speech from a variable or termed as a feature. The input is transformed to allow linear separation of the data points from different categories. Using the training data set, SVM identifies the hyperplane, a linearly separable boundary that divides the data into categories. HMM uses naïve Bayes, the algorithm based on the Bayes theorem (Table) as its core in that it applies conditional probability to sequential data (here, a sequence of words). HMM is the dominant algorithm used for speech recognition, which is used in radiology and pathology where semi-structured notes are used. The structure is imposed by templates, such as a chest radiograph report with normal findings in each system; and within each field, the contents are recorded as free text.

Real-world Application

Developing NLP algorithms to apply to real clinical problems is the next step in biomedical informatics. However, there are still crucial abstract data that cannot be acquired and stored in a way that allows for seamless decision-making practices. The text from a healthcare provider note is a great example of how data collection is influenced by provider-patient interactions. For example, a nurse may sense a patient's anxiety and aim to achieve maximum cooperation while minimizing harm to the patient in real life, yet the data itself may not truly reflect the nuances of the interaction. Electronic documentation, particularly free text, may provide this information, but notes cannot be translated and incorporated into the data. Johnson et al. proposed switching to a "hybrid approach that combines semi-structured data entry and NLP within a standards-based and computer-processible document structure."[44] With the use of NLP, recent research focused on text-mining techniques (a type of data extraction method from sentences) and has been incorporated into machine learning to develop prediction models. The previous example regarding Kawasaki disease also demonstrates that NLP's use of text from providers' notes does not work well when notes are too vague.[3]

Future of Machine Learning in Emergency Medicine

The concept of AI is not new but has made drastic progress since machine-learning algorithms have been developed in recent years. Other than machine learning for prediction and NLP, the areas where the practice of EM can adopt these technologies include machine vision (such as automatic interpretation of imaging studies to screen and triage rapidly); the use of text-mining to facilitate public health surveillance through automated analyses of emergency department documents, and algorithm-based warning systems for cardiovascular or neurological decline. Intelligible machine learning holds a promise in improving the practice of EM.

Limitations of this Review

We used unstructured search methods for this narrative review of selected articles. Since these are based on the authors' expertise, they may be biased.

CONCLUSION

We described two important health informatics-related topics that are relevant to emergency care and research: machine learning and NLP. Traditionally, the machine-learning model in healthcare has suffered from low external validity or poor portability between sites, but this seems to be changing with active employment of creative solutions. NLP is highly problem-specific, and the tools available are intended for use by programmers rather than end-users, except for speech recognition and machine translation (the use of software to translate text or speech from one language to another). NLP is being used more for research purposes, but there is no general purpose information-extraction tool because what one chooses to extract depends on the problem one is trying to solve. Computational artifacts are complex and hinder our ability to predict the performance of these tools. It is important to carefully evaluate these tools using both subjective and objective approaches. It is prime time for clinicians and researchers in emergency medicine to take full advantage of health informatics to improve patient care.

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Development of a Video Recording and Review Process for Trauma Resuscitation Quality and Education

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Video review for quality and education purposes has been a valued tool for decades. However, the use of this process dropped significantly after the development of the Health Insurance Portability and Accountability Act in the 1990s. Video review was recently reestablished at our institution. By working with our institutional legal counsel and risk management team, we have been able to create a video review process that complies with legal requirements. Literature on this subject has not described the process of obtaining video recordings. We aimed to review the process of obtaining high quality recordings in a secure manner. We hope that in the future, the data collected through our multidisciplinary review process will be helpful in improving quality of care for injured patients and providing coaching and feedback to learners, as well as improving our trauma education curriculum. [West J Emerg Med. 2019;20(2)228–231.]

INTRODUCTION

Video review for quality and performance improvement has been used in multiple fields since the 1960s.[1,2] Previous publications have discussed the benefits of using this information for resident education and quality improvement. Video review for trauma resuscitation is particularly valuable, as patient care in this area is protocol based and involves multiple providers as part of a team. Programs using video review have been able to show improved compliance with Advanced Trauma Life Support (ATLS) guidelines.[3] While publications are available regarding the benefits of performing video review, there is limited literature regarding development of this process. We aim to review the process of successfully reestablishing a robust video review process at our institution.

Obstacles to Video Review

Video review for resuscitation was common in the 1980s and 1990s. A survey of trauma centers in densely populated regions of the United States (U.S.) published in 1999 revealed 20% of trauma centers were using video review, the majority of which were designated Level I trauma centers. In the study, 34% of Level I trauma centers surveyed had a video process in place for trauma resuscitation. Of the hospitals discontinuing their video review programs and those that had never used videotaping, the primary issues were medicolegal concerns and inadequate support from personnel and staff. Interestingly, surveyed hospitals actively using video review reported no medicolegal issues.[4]

The enactment into law of the Health Insurance Portability and Accountability Act (HIPAA) in 1996 discouraged many institutions from continuing this practice due to concerns regarding patient privacy and legal implications. A survey of 125 trauma centers in the U.S. in the early 2000s revealed that only 15% used a video review process, while 40% had previously had a video review process that was no longer used. The majority of these institutions reported HIPAA compliance and scarce resources as reasons for discontinuing their process.[5]

At our institution, the video review process in place in the 1990s was discontinued when a state law on voyeurism was enacted in 2001, making it illegal to video record anyone in an undressed state without prior written informed consent.[6] This

regulation did not specifically address video recording for the purpose of medical care or quality improvement. In addition, The Joint Commission and the Center for Medicare and Medicaid Services (CMS) began requiring written informed consent for video recording in healthcare in the early 2000s.[7] Video recording and review was discontinued at our institution due to concerns regarding compliance with these regulations.

Recognizing its potential value for education and quality improvement, our institutional legal counsel and risk management developed solutions in 2015 to comply with state and federal regulations. Instrumental in this process was the language present in the Conditions of Admission (COA) form patients or their designees sign during the registration process. This document includes a section on video recording for the purpose of education and quality improvement. The consent form includes the following: "I consent to the recording, photography, closed circuit monitoring or filming for the purposes of treatment (will be in the medical record) or quality of care and teaching." The consent is valid for one year after signing.

When a patient is critically ill and cannot sign a COA, the patient may physically or verbally sign at a later time. A family member can also sign for the patient. It is rare that a COA is not obtained. This occurs in cases such as death occurring prior to obtaining a signature, the patient is unidentified, or no family is available. This process allows us to comply with state and national regulations and limits the risk assumed by providers, as they are considered protected by our hospital quality improvement process. Along with this new COA, the risk management team assisted in developing a secure process for recording and data keeping. Integral to this process is the choice of technology and software.

PROCESS DEVELOPMENT

Choice of Technology

Avigilon™ in-ceiling Micro Dome cameras (Vancouver, British Columbia) were installed in three of our four trauma resuscitation bays where all of our trauma team activation patients arrive. Cameras are positioned overhead to capture care and procedures. Recordings are manually activated by a set of pushbutton switches in the center of the room. Each resuscitation bed has an individual activation button and light indicator (red or green) to indicate whether recording is live.

We initially encountered challenges developing a process to ensure video recording was activated on patient arrival. This task was assigned to our trauma technicians. In addition, we added this task to our huddle checklist performed by our physician providers prior to patient arrival. The recorded cases are stored on an isolated computer using Avigilon software. The password-protected computer is located in a locked closet with access limited to the emergency department (ED) director. In addition, this computer has no connection to the internet or campus network. Total cost for the technology and installation was approximately $9,000.

Process of Obtaining Recordings (See Figure)

A weekly report of patients evaluated in the trauma resuscitation area is downloaded from the electronic health record (EHR). The report contains arrival time stamp, medical record number and chief complaint. The report is imported into a secured database created for case tracking and video review data collection. Cases with trauma-related chief complaints are selected for assessment of COA status in the EHR and ED disposition. In addition, cases identified through other venues are also identified as candidates for review (e.g., Trauma Process Improvement program, Trauma Surgery Case Conference, concerns or questions from individual team members). Patients with a COA on file within the prior 12 months will have the video recording computer checked for the presence of a recorded video. Recordings of non-trauma related cases or those without a COA on file are immediately destroyed prior to any review. Video recordings meeting requirements for consent are then downloaded onto an encrypted flash drive for subsequent review.

Recordings available on the computer are reviewed by either the ED director or the director of clinical operations to assess for quality. Those recordings lacking large portions of care or any sound or that have video quality issues are discarded. In addition, patients are excluded if they were discharged from the ED. Deaths occurring within the resuscitation bay are included if an active COA was on file from a previous encounter. All videos are discarded after 30 days.

Multidisciplinary Video Review Team

A multidisciplinary video review committee was created for quality review. This team includes designated faculty members from emergency medicine, trauma surgery and anesthesia. In addition, the trauma program manager, trauma performance improvement coordinator, ED nursing leadership, and the lead ED technician are also present.

Review Database Recording

A secure database was developed to keep records of the review process and assist with communication to the team regarding outcomes of reviews. In the database, patients are identified by a video number and medical record number. Review areas include general impression of the case and issues identified with members of the care team (faculty, resident physicians, nursing, techs, pharmacy and respiratory therapy). A section for overall learning points is provided. Finally, there is an area to list any issues identified and document a plan of action. The videos are then flagged if valuable for our monthly, multidisciplinary trauma conference. A case can also be flagged if issues arise requiring a formal quality review as part of the requirements set out by the American College of Surgeons Committee on Trauma (ACS-COT). For the purposes of education, mechanism of injury and any procedures recorded are documented.

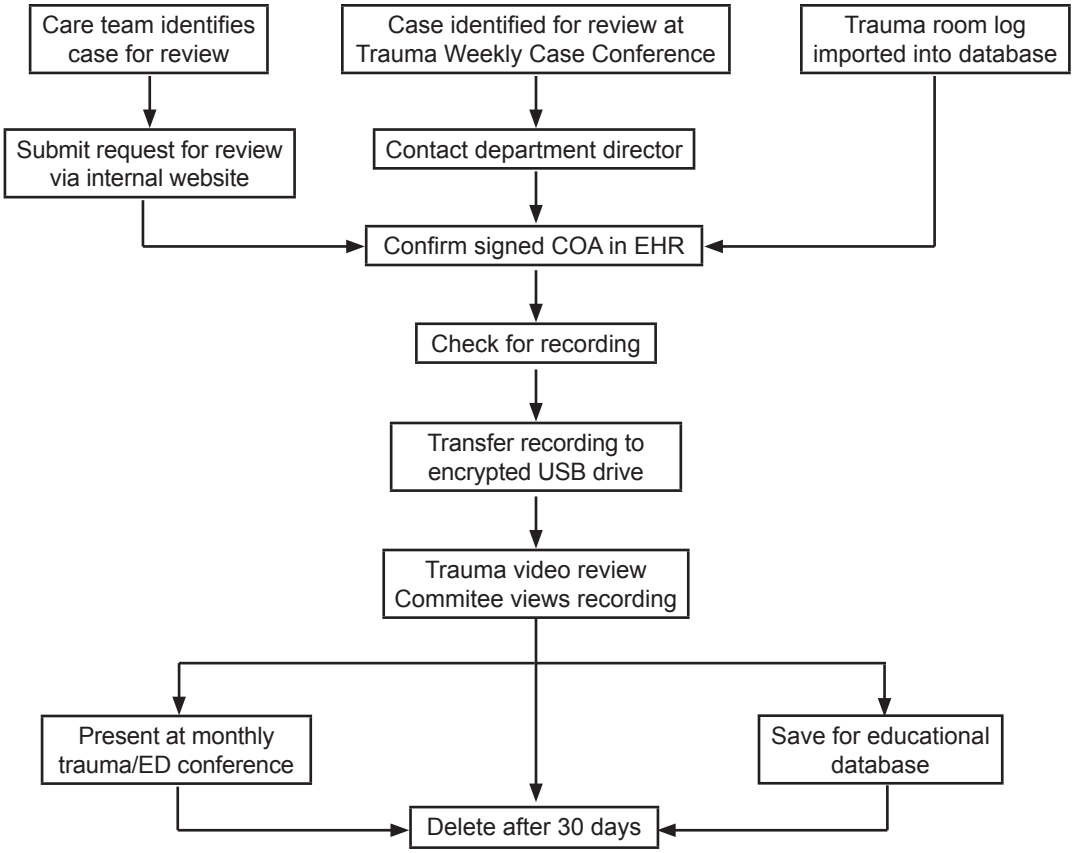

Figure. Our institutional video review process.
EHR, electronic health record; *COA*, Conditions of Admission; *ED*, emergency department.

Use of Videos for Education and Quality Improvement

Videos are used for training, education and coaching for physician providers and nursing. Recordings are integrated into a monthly, multidisciplinary emergency medicine/trauma conference. Videos considered to be of value demonstrate effective utilization of ATLS principles, as well as show the impact of deviation from these protocols. Videos demonstrating procedural technique, leadership skills and team dynamics are used for physician coaching. The video process allows the trauma medical director to address inefficiencies or gross deviations in policy and guideline performance issues with providers in a one-on-one setting. This is used to satisfy requirements in performance improvement set forth by ACS-COT. In addition, videos are also flagged for a nursing educational archive. Nurse management uses recordings for orientation training, procedure technique improvement, and direct feedback regarding team care of an injured patient.

CONCLUSION

Video recording for the purposes of quality improvement and education in medicine has been used for decades. The use of this process for trauma care in particular was widespread prior to the development of multiple federal and state privacy laws across the U.S. We recently began using this tool again at our institution. By working with our institution's legal counsel, we were able to reestablish trauma video recording within the guidelines of the established privacy laws. Ongoing data collection from this process will allow our group to assess its value for the purposes of process improvement and education.

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End-tidal CO_2 Monitoring is Available in Most Community Hospitals in a Rural State: A Health System Survey

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Introduction: Procedural sedation and analgesia (PSA) provides safe and effective relief for pain, anxiety and discomfort during procedures performed in the emergency department (ED). Our objective was to identify hospital-level factors associated with routine PSA capnography use in the ED.

Methods: This study was a cross-sectional telephone survey of ED nurse managers and designees in a Midwestern state. Respondents identified information about hospital infrastructure, physician staffing, family practice (FP) physicians only, board-certified emergency physicians (EPs) only (or both), and critical intervention capabilities. Additional characteristics including ED volume and hospital designation (i.e., rural-urban classification) were obtained from the Centers for Medicare and Medicaid Services and the state hospital association database, respectively. The primary outcome was reported use of PSA capnography. We conducted univariate analyses (relative risks, 95% confidence interval [CI]) to identify associations between hospital-level characteristics and PSA capnography use.

Results: We had an overall response rate of 98% (n=118 participating hospitals). The majority of EDs were in rural settings (78%), with a median of 5,057 visits per year (interquartile range 2,823-14,322). Nearly half of the EDs were staffed by FP physicians only, while 16% had board-certified EPs only. Nearly all hospitals (n=114, 97%), reported using continuous capnography for ventilated patients, and 74% reported use of capnography during PSA. Urban hospitals were more likely to use PSA capnography than critical access hospitals (relative risk 1.45; 95% CI, 1.22-1.73), and PSA capnography use increased with each ED volume quartile. Facilities with only EPs were 1.46 (95% CI, 1.15-1.87) times more likely to use PSA capnography than facilities with FP physicians only.

Conclusion: Continuous capnography was available in nearly all EDs, independent of size, location or patient volume. The implementation of capnography during PSA was less penetrant. Smaller, rural departments were less likely than their larger, urban counterparts to implement these national guidelines. Rurality and hospital size may be potential institutional barriers to capnography implementation. [West J Emerg Med. 2019;20(2)232–236.]

Throughout this paper, the authors use "BCEM" as an acronym/abbreviation for "Board-Certified in Emergency Medicine." This includes certification by the American Board of Emergency Medicine and the American Osteopathic Board of Emergency Medicine, both of which require completion of residency training in emergency medicine. This acronym does not refer to the American Board of Physician Specialties (ABPS) designation of "Board Certification in Emergency Medicine," which can be attained without residency training in emergency medicine.

INTRODUCTION

Procedural sedation and analgesia (PSA) has been shown to be a safe and effective relief for pain, anxiety and discomfort during procedures performed in the emergency department (ED).[1,2] Capnography is advocated to measure expired carbon dioxide and to assess ventilation adequacy.[3] In 2014, the American College of Emergency Physicians (ACEP) recommended routine use of capnography during PSA and issued a Level B recommendation, citing studies demonstrating capnography effectiveness in early detection of hypoventilation.[4] Despite widespread adoption in academic centers, the use of capnography in community hospitals has not been characterized. Quantifying the penetrance of this practice may lend insight into potential barriers to implementation of new technology advocated in national guidelines. We aimed to measure PSA capnography implementation in EDs within a Midwestern state, and to describe factors associated with PSA and continuous capnography adoption.

METHODS

Study Design and Population

This study was a cross-sectional telephone survey of ED nurse managers and designees in Iowa EDs from May 2017 to June 2017. We identified all Iowa facilities using the Iowa Hospital Association hospital database (n=121).[5] ED nurse managers, designees, and hospital recruiters were acquired through telephone interviews. Information regarding ED volume and a hospitals designation by the Centers for Medicare and Medicaid Services (CMS) was extracted from Iowa Hospital Association databases. The study was determined not to be human subjects research by the institutional review board.

Data Collection, Sources, and Definitions

The questionnaire and telephone prompts were designed by the study team, which included two board-certified emergency physicians (EP) with rural emergency medicine (EM) and health services research expertise. The questionnaire included hospital infrastructure, physician staffing, and critical intervention capabilities. We defined "capability/capable" as having the infrastructure, staffing and training necessary to perform a given intervention. The complete questionnaire can be found in the online supplemental Appendix. No validation study was conducted because elements of the survey instrument were objective facts.

We collected hospital-level variables from these Iowa Hospital Association datasets: *"Iowa Hospital Data"* and *"Services Directory"*.[5] "Hospital classification" is determined by the CMS based on an institution's bed volume, access to specialty services, and proximity to highway infrastructure and surrounding institutions. "Average ED volume" was calculated as the mean, self-reported annual ED census between 2013 and 2015, and were grouped into quartiles. Staffing models included whether EPs were board-certified in EM, family practice (FP), or both, and whether advanced practice providers (APPs, defined as physicians' assistants and nurse practitioners without a physician physically present) were used.

Outcome

The primary outcome was use of PSA capnography.

Analysis

We characterized PSA capnography use descriptively. We then conducted univariate analyses to measure the association of capnography use with hospital factors (e.g., CMS designation and rurality, ED volume quartile, and staffing models). Proportions, relative risks, and 95% confidence interval [CI] are reported. All analyses were completed using SAS version 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

Survey Results and Descriptive Analysis

A total of 118 hospitals of the 121 identified provided data (response rate = 98%), with staffing data acquired for 102 of these 118 hospitals (response rate = 86%). The majority of EDs in the state were rural (n= 93, 78%), with a median of 5,057 ED visits per year (interquartile range [IQR], 2,823-14,322). Median ED volumes ranged from 1,992 to 29,329 between the first and fourth quartiles, respectively. Approximately half of the hospitals had FP providers only, compared to 16% with board-certified EPs only (Table).

Nearly all hospitals (n=114, 97%) reported using continuous capnography for ventilated patients, and most (74%) reported use of capnography during PSA (n=87). Approximately 25% (n=29) reported using capnography exclusively for ventilated patients. Only two institutions reported use of PSA capnography without continuous capnography for ventilated patients. The distribution of staffing patterns and CMS designation class, stratified by PSA capnography use, is presented in the figure.

Univariate Analysis

Urban hospitals were more likely to use PSA capnography than critical access hospitals (relative risk ratio 1.45, 95% CI, 1.22-1.73). Use of PSA capnography increased with ED volume, as hospitals in the highest quartile were 1.44 times more likely to use this compared to those in the lowest quartile.

Table. Summary of hospital characteristics.

Characteristics	Overall (n=118)		Procedural capnography available (n=87)		Procedural capnography unavailable (n=31)		Relative risk	
	N	%	N	%	N	%	RR	95% CI
Centers for Medicare and Medicaid services designation and rurality								
Critical access hospital	80	67.8	53	60.9	27	87.1	Ref	
Rural referral hospital	6	5.1	4	4.6	2	6.5	1.01	0.56-1.81
Rural hospital	7	5.9	6	6.9	1	3.2	1.29	0.92-1.82
Urban location/hospital	25	21.2	24	27.6	1	3.2	1.45	1.22-1.73
Staffing[1]								
FP only	50	49.0	32	36.8	18	58.1	Ref	
BCEM only	16	15.7	15	17.2	1	3.2	1.46	1.15-1.87
Both FP and BCEM	36	35.3	27	31.0	9	29.0	1.17	0.89-1.55
APP in solo coverage	37	36.3	24	27.6	13	41.9	0.84	0.64-1.11
ED volume								
Lowest quartile	29	24.6	18	20.7	11	35.5	Ref	
2nd quartile	30	25.4	21	24.1	9	29.0	1.13	0.78-1.63
3rd quartile	30	25.4	22	25.3	8	25.8	1.18	0.83-1.69
Highest quartile	29	24.6	26	29.9	3	9.7	1.44	1.06-1.97

[1]Percents for staffing represent total within each category among hospitals with available data
FP, family practice; *BCEM*, board-certified emergency medicine; *APP*, advanced practice provider; *CI*, confidence interval; *ED*, emergency department; *RR*, relative risk.

When compared to facilities with FP providers only, those with board-certified EPs only were 1.46 (95% CI, 1.15-1.87) times more likely to use PSA capnography. There was no difference in PSA capnography use between facilities with both providers and those with only FP physicians.

DISCUSSION

At the hospital level, there are many factors that influence the decision-making process to adopt or reject a new professional policy. In a rural Midwestern state, where the majority of EDs are situated within small and financially vulnerable critical access hospitals, investment in new technology can take longer than it does in urban counterparts.[6] Comparing this with implementation of other new technologies [e.g., electronic health records (EHR)], may provide a useful theoretical framework to understand disparities.[7] For example, previous studies have demonstrated that the early adopters of EHR were typically large, private, urban and teaching hospitals, similar to our findings. In recent years rural facilities closed the gap in EHR implementation, but disparities remain when considering advanced measures of "meaningful use" of EHR, an advanced metric used by CMS to quantify the integration of EHR into healthcare delivery.[8] Similarly, nearly all hospitals (97%) in Iowa use continuous capnography to monitor intubated patients, and most (74%) used capnography for procedural sedation.

Although there are significant differences between implementing a new EHR system and a new monitoring technique, the principles behind the decision-making process are the same. Kruse's systematic review of EHR implementation included practical and theoretical considerations for or against adopting EHR systems.[7] From this, applicable factors to PSA capnography implementation may include patient volume/complexity, financial considerations, professional support, provider comfort, hospital location, and regional interdependence.

While our study cannot elucidate the importance of these factors on a facility's decision to implement capnography for PSA, our data demonstrate several supportive trends. Hospitals that exclusively hire board-certified emergency physicians, who may be more likely to have trained with these tools, were more likely to have access to capnography for PSA. Additionally, higher patient volume and urban centers were associated with increased capnography use. This may be due to management of higher acuity patients who may benefit the most from capnography monitoring. It is important to consider that there are likely collinear relationships between several of the variables measured; among facilities in the highest ED volume quartile, 93% had board-certified EP staff (48% board-certified EPs exclusively, 45% both board-certified EPs and FP physicians). As expected, Medicare class was highly correlated (r=0.74) with ED volumes.

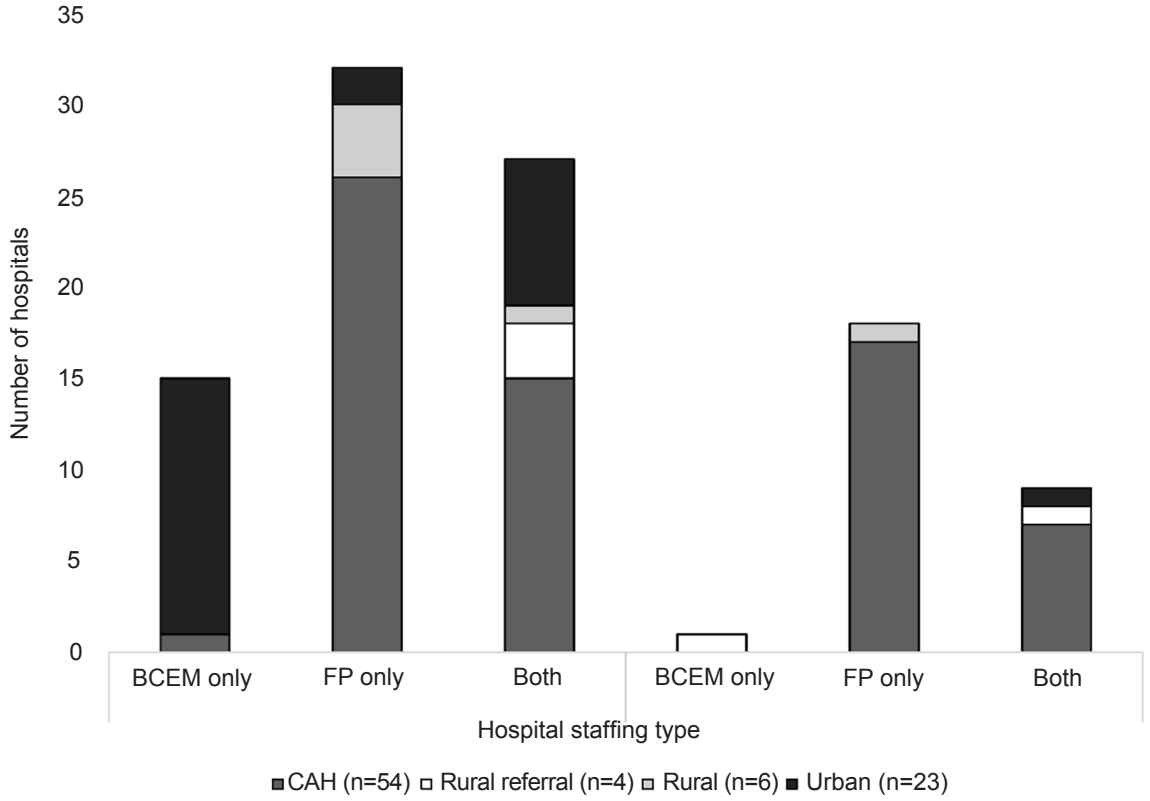

Figure. Distribution of PSA capnography use by staffing patterns and CMS classification scheme.
PSA, procedural sedation and analgesia; *CMS*, Centers for Medicare and Medicaid Services; *BCEM*, board-certified emergency medicine; *FP*, family practice; *CAH*, critical access hospital.

LIMITATIONS

While we were able to describe the availability of certain resources to an institution, this study was not designed to evaluate the frequency with which these resources were used and for what indications. For example, while sites may have indicated that physicians use capnography for PSA, there may have been variability with regard to the frequency of use (i.e., continuous vs intermittent), as well as variation in the physicians within the same facility. The focus of this study, however, was to identify availability of this procedure at a minimum. A cursory review of the existing literature yielded no substantive studies describing the prevalence of procedures requiring conscious sedation in rural and critical access hospitals. This study focuses on common characteristics of institutions across a state, and cannot be used to ascertain the rationale of an individual institution to adopt or not adopt a clinical practice.

CONCLUSION

Continuous capnography for the monitoring of ventilated patients is found in nearly all EDs, independent of size, location, patient volume, or staffing practice. Capnography for the use of PSA, however, is less likely to be found in smaller, rural departments. Future research is needed to describe the services provided by rural and critical access institutions to better understand the extent to which ACEP professional policies may be feasibly implemented within a rural setting.

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Barriers to Prompt Presentation to Emergency Departments in Colorado after Onset of Stroke Symptoms

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Introduction: Despite significant morbidity and mortality from stroke, patient delays to emergency department (ED) presentation following the onset of stroke symptoms are one of the main contraindications to treatment for acute ischemic stroke (AIS). Our objective was to identify patient and environmental factors associated with delayed presentations to the ED after onset of stroke symptoms.

Methods: This was a pre-planned secondary analysis of data from a multicenter, retrospective observational study at three hospitals in Colorado. We included consecutive adult patients if they were admitted to the hospital from the ED, and the ED diagnosed or initiated treatment for AIS. Patients were excluded if they were transferred from another hospital. Primary outcome was delayed presentation to the ED (> 3.5 hours) following onset stroke symptoms.

Results: Among 351 patients, 63% presented to the ED more than 3.5 hours after onset of stroke symptoms. Adjusted results show that patients who presented in the evening hours (odds ratio [OR] [0.45], 95% confidence interval [CI] [0.3-0.8]), as compared to daytime, were significantly less likely to have a delayed presentation. Speaking a language other than English (Spanish [OR 3.3, 95% CI 1.2-8.9] and "other" [OR 9.1, 95% CI 1.2-71.0]), having known cerebrovascular risk factors (>2 risk factors [OR 2.4, 95% CI 1.05-5.4] and 1-2 risk factors [OR 2.3, 95% CI 1.03-5.1], compared to zero risk factors), and presenting to a rural hospital (OR 2.2, 95% CI 1.2-4.2), compared to urban, were significantly associated with delayed presentation.

Conclusion: Important patient and environmental factors are significantly associated with delayed ED presentations following the onset of stroke symptoms. Identifying how best to educate patients on stroke risk and recognition remains critically important. [West J Emerg Med. 2019;20(2)237-243.]

INTRODUCTION

Cerebrovascular disease is the fourth leading cause of death in the United States (U.S.)[1] For patients who survive a stroke, daily functionality may be permanently affected resulting in severe disability.[2] Intravenous thrombolysis using tissue plasminogen activator (tPA) has the potential to improve morbidity in patients who present to an emergency department (ED) shortly after the onset of symptoms.[3] Despite significant morbidity and mortality from stroke, patient delays to ED presentation following the onset of stroke symptoms

continue to be the main contraindication to using tPA for acute ischemic stroke (AIS).[4] Our prior work examining variation in adherence to guideline recommendations for administration of tPA for AIS identified that most patients were not eligible for tPA because they presented to the ED well outside the recommended treatment window. Thus, our objective was to identify patient and environmental factors that may contribute to delays in presentation following the onset of stroke symptoms in our patient population.

Population Health Research Capsule

What do we already know about this issue?
Patient delays in presentation to an emergency department (ED) are one of the main contraindications to treatment for acute ischemic strokes.

What was the research question?
Our objective was to identify patient and environmental factors associated with delayed presentations to the ED.

What was the major finding of the study?
Time of day, patient language, cerebrovascular risk factors, and location of hospital were all significantly associated with delays in presentation.

How does this improve population health?
Identifying barriers to prompt presentation to an ED following the onset of stroke symptoms is the first step in identifying how to best educate patients on stroke risk and recognition.

METHODS

Study Design

We conducted a pre-planned, secondary analysis of data from a multicenter, retrospective observational study evaluating variation in ED adherence to cardiovascular and cerebrovascular guidelines, including systemic thrombolysis for AIS.[5] The institutional review boards at each participating hospital approved the study with a waiver of consent.

Setting

This study was performed at three acute care hospitals in Colorado, including an urban safety-net hospital, a suburban, academic tertiary-care hospital, and a rural community hospital. All three EDs were staffed by board-certified/eligible emergency physicians. Annual adult ED census ranged from 55,000 to 80,000 patients at each hospital. Only the academic tertiary-care hospital was a certified Joint Commission Stroke Center. The rural community ED had neurologists available for consultation only by video, whereas the two other EDs had 24/7 in-house neurology consultation.

Population and Assembly of the Study Cohort

Consecutive patients were identified retrospectively by any hospital-discharge implantable cardioverter-defibrillator ICD-9 code for acute ischemic stroke (434.xx).[6] Investigators at each site obtained a list of consecutive patients with the above ICD-9 codes, who were admitted from the ED beginning on December 31, 2012. From this initial cohort, each unique patient encounter was screened by a physician abstractor for inclusion using the following criteria: 1) a discharge diagnosis in the medical record of acute ischemic stroke; 2) admission to the hospital from the ED; and 3) diagnosis or initiated treatment for AIS in the ED. Exclusion criteria were age <18 years and patients transferred from another facility. Patient encounters were screened until we obtained a sufficient sample (n=117) at each institution.

Data Collection

Once the study cohort was established, structured medical record abstraction was performed using established, standard methodology.[7,8] Using a structured data abstraction form, abstractors documented the presence of pre-specified variables necessary to assess guideline adherence for tPA use in AIS, including time of symptom onset defined as last known normal (Appendix). In addition, patient sociodemographics, cerebrovascular comorbidities, stroke symptoms, arrival day and time were collected.[9-12] We stratified patients' stroke risk into one of three groups depending on the cumulative number of stroke comorbidities: none, 1-2, and > 2. Patient chief complaints were stratified into three groups related to how typical the complaint was for stroke: typical for stroke (focal weakness, numbness, or alteration in speech); associated with stroke (headache, ataxia, dizziness, fall, seizure, vision change, altered mental status); and other.

Outcomes

Our primary outcome was whether a patient arrived in the ED within the "presentation window" for tPA for AIS. Guidelines for the use of tPA in AIS require that it be initiated with 4.5 hours of symptom onset.[3,4] The American Heart Association/American Stroke Association (AHA/ASA) guidelines further recommend that tPA be initiated within 60 minutes of arrival to the ED.[4] Thus, patients who arrived within 3.5 hours of symptom onset were defined as having

arrived within the "presentation window" in which tPA could be expected to be initiated within 4.5 hours of symptom onset.

Data Management and Statistical Analyses

We performed all data management and statistical analysis using Statistical Analysis System (SAS) (SAS Institute, Inc., Cary, NC). Descriptive statistics were calculated for all variables. We reported continuous data as medians with interquartile ranges (IQR) and categorical variables as percentages with 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant. We assessed inter-rater reliability on the outcome variable using Cohen's kappa. A random sample of 15% of cases were re-abstracted with near-perfect agreement ($\kappa = 0.96$).

We used unadjusted logistic regression to estimate the association of each patient and environmental variable with patient presentation to the ED within the treatment window. Hierarchical multivariable logistic regression was used to estimate associations between patient and environmental factors and presentation to the ED within the treatment window. We assessed effect modification between gender and chief complaint as well as language and chief complaint. Significant collinearity was identified between race and insurance as well as language and insurance; thus, we removed insurance from the final multivariable model.

Sample Size Estimation

The parent study was powered to estimate adherence variation from an a priori-defined 95% adherence threshold.[5] The parent study included 117 patients with AIS from each hospital, for a total 351 patients.

RESULTS

Table 1 describes the sociodemographics, cerebrovascular comorbidities, and presenting characteristics of the 351 patients. The median time from symptom onset to presentation

Table 1. Characteristics of patients presenting with stroke symptoms.

	Combined cohort		Inside presentation window		Outside presentation window*	
	%	(n)	%	(95% CI)	%	(95% CI)
Cohort	100	(351)	36.8	(32-42)	63.2	(58-68)
Time since normal (median minutes, IQR)	420.0	(90-1020)	60.0	(30-120)	840.0	(480-2160)
Sociodemographics						
Age (median, IQR)	66.0	(57-78)	69.0	(57-80)	65.0	(57-77)
Gender						
Male	49.3	(173)	50.4	(42-59)	48.6	(42-55)
Female	50.7	(178)	49.6	(41-58)	51.4	(45-58)
Race/ethnicity						
Non-Hispanic White	54.4	(191)	52.7	(44-61)	55.4	(49-62)
Hispanic	25.9	(91)	28.7	(22-37)	24.3	(19-30)
Non-Hispanic Black	16.0	(56)	14.7	(10-22)	16.7	(12-22)
Other	3.7	(13)	3.9	(2-9)	3.7	(2-7)
Language						
English	86.9	(305)	90.7	(84-95)	84.7	(79-89)
Spanish	9.1	(32)	7.0	(4-13)	10.4	(7-15)
Other	4.0	(14)	2.3	(1-7)	5.0	(3-9)
Primary insurance						
Medicare	52.1	(183)	56.6	(48-65)	49.6	(43-56)
Medicaid	8.6	(30)	5.4	(3-11)	10.4	(7-15)
Commercial	16.0	(56)	17.8	(12-25)	14.9	(11-20)
Other source	16.8	(59)	16.3	(11-24)	17.1	(13-23)
Uninsured	6.6	(23)	3.9	(2-10)	8.1	(5-14)

CI, confidence interval; *IQR,* interquartile range.
*Presentation window defined as presenting in ≤ 210 minutes from onset of symptoms.

Table 1. Continued.

	Combined cohort		Inside presentation window		Outside presentation window*	
	%	(n)	%	(95% CI)	%	(95% CI)
Patient risk and complaint						
Comorbidities						
Atrial fibrillation	12.8	(45)	13.2	(8-20)	12.6	(9-18)
Cerebrovascular disease	26.5	(93)	24.0	(13-26)	27.9	(22-34)
Congestive heart failure	5.4	(19)	7.0	(3-11)	4.5	(2-8)
Coronary artery disease	18.5	(65)	21.7	(15-30)	16.7	(12-22)
Diabetes	30.5	(107)	27.1	(15-29)	32.4	(27-39)
Hypercholesterolemia	36.8	(129)	33.3	(26-42)	38.7	(33-45)
Hypertension	72.1	(253)	71.3	(63-78)	72.5	(66-78)
Tobacco use	31.9	(112)	28.7	(22-37)	33.8	(28-40)
Chief complaint						
Typical for stroke	68.4	(240)	68.2	(60-76)	68.5	(62-74)
Associated with stroke	27.4	(96)	26.4	(20-35)	27.9	(22-34)
Other	4.3	(15)	5.4	(3-11)	3.6	(2-7)
Environmental variables						
Time of presentation						
Day (7 AM -4:59 PM)	64.1	(225)	55.0	(46-63)	69.4	(63-75)
Evening (5 PM-11:59 PM)	27.6	(97)	36.4	(29-45)	22.5	(18-28)
Night (midnight-6:59 AM)	8.3	(29)	8.5	(5-15)	8.1	(5-12)
Day of week						
Weekday (Mon 7 AM-Fri 4:59 PM)	63.0	(221)	59.7	(51-68)	64.9	(58-71)
Weekend (Fri 5 PM-Mon 6:59 AM)	37.0	(130)	40.3	(32-49)	35.1	(29-42)
Hospital location						
Rural	33.3	(117)	37.2	(29-46)	31.1	(25-37)
Suburban	33.3	(117)	39.5	(32-48)	29.7	(24-36)
Urban	33.3	(117)	23.3	(17-31)	39.2	(33-46)

CI, confidence interval; *IQR,* interquartile ratio.
*Presentation window defined as presenting in ≤ 210 minutes from onset of symptoms.

to the ED was 420 minutes (IQR [90-1020]) (i.e., seven hours). Only 37% of patients presented to the ED within the treatment window. For patients arriving within the treatment window, the median time from symptom onset was 60 minutes (IQR [30-120]) as compared to 840 minutes (IQR [480-2160]) for patients who arrived outside the treatment window.

Table 2 describes both the unadjusted and adjusted associations between patient and environmental variables and delayed presentations to the ED after the onset of stroke symptoms. Adjusted results show that patients who presented in the evening hours were significantly less likely to have a delayed presentation as compared to patients who presented during daytime hours (odds ratio [OR] {0.45}, 95% CI [0.3-0.8]). Speaking a language other than English (Spanish [OR {3.3}, 95% CI {1.2-8.9}] and "other" [OR {9.1}, 95% CI {1.2-71.0}]), having known cerebrovascular risk factors (>two risk factors [OR 2.4, 95% CI {1.05-5.4}] and one to two risk factors [OR {2.3}, 95% CI {1.03-5.1}]), and presenting to a rural hospital (OR [2.2], 95% CI [1.2-4.2]) were significantly associated with delayed presentation.

DISCUSSION

Despite the significant effect of stroke on morbidity and mortality in the U.S., much of the literature for AIS focuses on the importance of minimizing treatment delays in patients who present to the ED within the tPA treatment window.[13-19]

Table 2. Bivariate and multivariate associations for late presentation (> 3.5 hours) to emergency department after onset of stroke symptoms.

	Unadjusted		Multivariable model	
	OR	(95% CI)	OR	(95% CI)
Sociodemographics				
Age	0.99	(0.98-1.01)	0.98	(0.97-1.00)
Gender				
Male	Ref		Ref	
Female	1.07	(0.70-1.65)	1.06	(0.66-1.70)
Race/Ethnicity				
Non-Hispanic White	Ref		Ref	
Hispanic	0.75	(0.45-1.26)	0.58	(0.30-1.11)
Non-Hispanic Black	0.99	(0.54-1.85)	1.16	(0.57-2.34)
Other	0.95	(0.30-3.24)	0.31	(0.05-1.94)
Language				
English	Ref		Ref	
Spanish	1.51	(0.71-3.43)	3.25	(1.20-8.88)
Other	2.51	(0.77-11.3)	9.13	(1.17-71.0)
Primary insurance*				
Medicare	Ref			
Medicaid	2.33	(1.00-6.13)		
Commercial	0.82	(0.45-1.50)		
Other source	1.20	(0.66-2.21)		
Uninsured	2.01	(0.80-5.79)		
Patient risk and complaint				
Number of stroke comorbidities				
None	Ref		Ref	
1-2	1.92	(0.90-4.09)	2.3	(1.03-5.14)
> 2	2.00	(0.93-4.32)	2.4	(1.05-5.44)
Chief complaint				
Typical for stroke	Ref		Ref	
Associated with stroke	1.01	(0.62-1.65)	1.05	(0.61-1.79)
Other	0.72	(0.25-2.13)	0.67	(0.22-2.07)
Environmental variables				
Time of presentation				
Day (7 AM-4:59 PM)	Ref		Ref	
Evening (5 PM-11:59 PM)	0.54	(0.33-0.88)	0.46	(0.27-0.77)
Night (midnight-6:59 AM)	0.87	(0.40-1.98)	0.66	(0.28-1.57)
Day of week				
Weekday (Mon 7 AM-Fri 4:59 PM)	Ref		Ref	
Weekend (Fri 5 PM–Mon 6:59 AM)	0.85	(0.54-1.32)	0.88	(0.54-1.44)
Hospital location				
Urban	Ref		Ref	
Rural	1.76	(1.03-3.04)	2.23	(1.18-4.20)
Suburban	0.84	(0.50-1.41)	0.76	(0.42-1.39)

OR, odds ratio; *CI,* confidence interval; *Ref*, reference value.
*Multicollinearity between race and insurance, and language and insurance.

As acknowledged in a statement from the AHA, the weak link in applying stroke treatments is patient delay in seeking care.[20] Unfortunately, our results mirror those reported in the literature over the past 30 years, which show that the vast majority of patients are excluded from treatment due to delays in presentation.[20-28]

We identified four possible barriers to prompt presentation to an ED in our cohort: primary language, stroke risk, time of day of ED presentation, and hospital location. Speaking a primary language other than English was significantly associated with delays in presentation to the ED. Two possible explanations for our finding include differences in knowledge and recognition of stroke symptoms, and reluctance to use emergency medical services (EMS) given a language barrier.[29,30] We expected patients with known stroke-risk factors to present to the ED promptly. However, we found the opposite, which contrasts with Lacy who showed no association.[31] Given that we treated all risk factors equally in our analysis, it is possible that patients with less-obvious stroke comorbidities were unaware of their personal risk for stroke.[32,33]

The association of time of day and timing of ED presentation is likely explained by the effect of nocturnal onset of symptoms. Patients presenting in the morning after awakening with symptoms are almost always outside the treatment window as their last known normal time was their bedtime.[34,35] While not specifically abstracted, we estimate that 12% of our cohort had "wake-up" strokes. Moreover, patients who presented in the evening hours were likely to have developed symptoms when family or co-workers were present to notice the symptoms. Lastly, it is not surprising that patients who present to a more rural hospital would have delays in presentation. While we do not have information on each patient regarding their exact distance traveled to each hospital in the study, it is reasonable to expect that patients presenting to more rural hospitals would have longer transport times than patients presenting to more urban hospitals.[36]

LIMITATIONS

The primary limitation of this study was its use of secondary data. While these data captured the appropriate population to address our study objective, important confounders were not measured, namely EMS use and stroke severity, both of which have been shown to be associated with timing of arrival to the ED.[25-27,37]

CONCLUSION

Important patient and environmental factors are significantly associated with delayed ED presentations following the onset of stroke symptoms. Identifying how best to educate patients on stroke risk and recognition remains critically important.

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Rethinking Intravenous Catheter Size and Location for Computed Tomography Pulmonary Angiography

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Introduction: Computed tomography pulmonary angiography (CTPA) is the test of choice for diagnosis of pulmonary embolism (PE) in the emergency department (ED), but this test may be indeterminate for technical reasons such as inadequate contrast filling of the pulmonary arteries. Many hospitals have requirements for intravenous (IV) catheter size or location for CTPA studies to reduce the chances of inadequate filling, but there is a lack of clinical data to support these requirements. The objective of this study was to determine if a certain size or location of IV catheter used for contrast for CTPA is associated with an increased chance of suboptimal CTPA.

Methods: This was a retrospective chart review of patients who underwent CTPA in the ED. A CTPA study was considered suboptimal if the radiology report indicated it was technically limited or inadequate to exclude a PE. The reason for the study being suboptimal, and the size and location of the IV catheter, were abstracted. We calculated the rate of inadequate contrast filling of the pulmonary vasculature and compared the rate for various IV catheter sizes and locations. In particular, we compared 20-gauge or larger IV catheters in the antecubital fossa or forearm to all other sizes and locations.

Results: A total of 19.3% of the 1500 CTPA reports reviewed met our criteria as suboptimal, and 51.6% of those were due to inadequate filling. Patients with a 20-gauge IV catheter or larger placed in the antecubital fossa or forearm had inadequate filling 9.2% of the time compared to 13.2% for patients who had smaller IVs or IVs in other locations (difference: 4.0% [95% confidence interval, -1.7%-9.7%]). There were also no statistically significant differences in the rates of inadequate filling when data were further stratified by IV catheter location and size.

Conclusion: We did not detect any statistically significant differences in the rate of inadequate contrast filling based on IV catheter locations or sizes. While small differences not detected in this study may exist, it seems prudent to proceed with CTPA in patients with difficult IV access who need emergent imaging even if they have a small or distally located IV. [West J Emerg Med. 2019;20(2)244-249.]

INTRODUCTION

Since the publication of the Prospective Investigation of Pulmonary Embolism Diagnosis II trial,[1] computed tomographic pulmonary angiography (CTPA) has become the test of choice for diagnosis of pulmonary embolism (PE) in the emergency department (ED).[2-3] The test characteristics of CTPA are reported to be quite good with sensitivity and specificity of 89% and 95%, respectively.[4] While CTPA can be highly accurate when performed with proper technique, the reported sensitivity and specificity do not account for

the times when CTPA is indeterminate because of technical factors such as motion artifact or inadequate filling of the pulmonary arteries.[5]

The American College of Radiology (ACR) recommends a 20-gauge or larger intravenous (IV) catheter in the antecubital fossa or forearm for CTPA.[6] The ACR recommendations do not provide supporting references, and a literature search did not reveal published clinical data supporting these recommendations. Nonetheless, many hospitals have policies that follow them. While these policies are designed to improve the quality of CTPA, in patients with difficult IV access these policies may result in significant delays in diagnosis while ED staff attempt to establish an IV that follows hospital policies.

Thus, we performed a retrospective chart review to assess if a certain location or size of the IV catheter used for a contrast bolus for CTPA is associated with an increased chance of inadequate filling of the pulmonary vasculature. In particular, we sought to determine if the ACR recommendation that a 20-gauge or larger IV catheter in the antecubital fossa or forearm is associated with decreased rates of inadequate filling of the pulmonary vasculature on CTPA compared to other IV catheter sizes and locations.

Population Health Research Capsule

What do we already know about this issue?
Many hospitals have requirements for intravenous (IV) catheter size or location for computed tomography pulmonary angiography (CTPA) studies to reduce the chances of a suboptimal study, but such requirements may result in delayed diagnosis.

What was the research question?
Is the size or location of an IV catheter used for CTPA associated with an increased chance of inadequate contrast filling?

What was the major finding of the study?
We did not find differences in the rate of inadequate contrast filling of CTPAs at various IV catheter locations or sizes.

How does this improve population health?
It may be prudent to proceed with CTPA in patients with difficult IV access who need emergent imaging even if they have a small or distally located IV.

METHODS

Study Design and Setting

This was a retrospective study performed at a single, large, urban, county hospital in Las Vegas, Nevada. The annual census of our adult ED is approximately 77,000. The CTPA studies from our adult ED are rapidly read 24 hours per day by a private group that currently employs 64 radiologists. The standard peripheral IV catheter used in our department is the 1.00-inch Becton Dickinson (BD) Insyte™ Autoguard™, which is available in sizes 16-gauge, 18-gauge, 20-gauge, and 22-gauge. In rare cases, a 2.5-inch, 18-gauge Introcan Safety® catheter is used for ultrasound-guided deep brachial IV lines or for placement in the internal jugular vein ("peripheral IJs").[7] This study received approval from our hospital's institutional review board, which waived full review.

We identified adult patients who underwent CTPA in the ED to evaluate for PE. We were able to identify these patients because our radiology image-viewing software system allows us to search for patients based upon imaging study type and date. Patients were excluded if they had undergone CTPA for any reason other than to rule out PE. Of the patients meeting the inclusion criteria and not meeting the exclusion criteria, we extracted additional patient data including basic demographics, whether or not the CTPA was suboptimal, why the CTPA was suboptimal (if applicable), and the size and location of the IV line.

Two premedical student research assistants functioned as data abstractors. They were blinded from the study objectives, and they used standardized data collection forms to perform chart reviews. Each data abstractor was trained through the review of 20 sample charts with a physician investigator. They assessed each final, attending radiology impression to determine if the CTPA met our definition of "suboptimal." We considered a CTPA suboptimal if the final radiology impression read any of the following: inadequate filling/suboptimal timing of the contrast bolus; motion artifact; or any case the radiology impression called the study technically limited or inadequate to exclude a PE. However, impressions stating inability to exclude subsegmental PE were not included as suboptimal, since subsegmental PEs may not need to be treated.[8] Note that our definition of "suboptimal" is consistent with prior literature on this topic.[9]

The data abstractors were periodically monitored, and a physician investigator audited 50 charts from each of the abstractors to assess for accuracy. Also, both abstractors reviewed a sample of 50 charts to assess the inter-rater reliability for the study.

All CTPA studies were performed on a 64-slice scanner (Siemens Medical Solutions USA Inc; Malvern, PA) with a standard CTPA protocol at the hospital where data were collected. This includes a localizer sequence through the carina followed by a timing bolus of 30-cubic centimeter (cc)

contrast bolus of Optiray 350 (Ioversol 74%; Guerbet LLC; Princeton, New Jersey) to localize the pulmonary arteries until the maximum Hounsfield unit is measured. A 90-cc bolus is then injected at 4-5 cc/sec both preceded and followed by a 50-cc saline flush given through a power injector. Continuous 0.6 millimeter (mm) axial slices are taken from above the apices to below the costophrenic angles with an inspiratory hold. Our hospital's protocol calls for 20-gauge IV access or greater at the antecubital fossa or forearm, but this can be overridden by the attending physician based on emergent indications. Pursuant to protocol, radiology technicians use a 10-cc normal saline flush to evaluate access prior to administration of contrast. Additional scanning parameters are as follows: 120 kilovolt peak (kVp), 2 x 2 mm reconstruction, pitch of 0.8-1.0, and coronal and sagittal multiplanar reformation of 3 x 3 mm.

Outcomes and Data Analysis

As discussed below, we decided to review a sample of 1500 CTPA studies. After review, we calculated the percentage of all CTPA studies that were suboptimal, and determined the fraction of those suboptimal studies that were due to inadequate filling of the pulmonary vasculature.

The primary outcome for the study was meant to assess the ACR's recommendations for IV size and location for CTPA. In particular, we aimed to measure the difference in the rate of inadequate filling of the pulmonary vasculature for 20-gauge or larger catheters in the antecubital fossa or forearm compared to the rate of inadequate filling for all other catheter size and location combinations.

Secondarily, the percentage of studies with inadequate filling of the pulmonary vasculature were stratified by IV catheter size and location. We compared the percentage of studies with inadequate filling when a 20-gauge or larger IV catheter was used to the percentage of studies with inadequate filling when smaller catheters were used. Also, the rate of inadequate filling was compared for IV catheters placed in the forearm or antecubital fossa to IV catheters placed at other locations.

Our initial choice of a sample size of 1500 was based on the size of a previously published study about suboptimal CTPAs[9] and gestalt that this would be sufficiently large. Since no prior study has evaluated the relationship between IV size or location and suboptimal CTPAs, we initially did not have sufficient information to perform a formal power calculation. However, with the knowledge of the results of this study, we can provide a post-hoc power analysis as follows: for the primary outcome, assuming that patients would have an IV catheter meeting the ACR recommendations six times as often as not, we found that at least 132 patients would be required in the group not meeting the ACR recommendations to find a 10% difference in the rate of inadequate contrast filling of the pulmonary vasculature with a power of 0.8 and an alpha of 0.05.

Data were collected and analyzed via Microsoft Excel (Version 15, Microsoft, Redmond, Washington). We performed statistical analysis using "R" (version 3.5.2, R Foundation, Vienna, Austria). The proportions for each group were compared using Fisher's exact test.

RESULTS

A total of 1500 consecutive CTPA studies to assess for PE in our ED from June 2016 to March 2017 were identified and included for analysis. The patients upon which these studies were performed were 48.2% female. The median age was 55 years (interquartile range [IQR]: 42-65), and the median body mass index was 28 (IQR: 24-34). The patients were 56.8% Caucasian, 23.7% African American, 12.8% Hispanic, and 5.0% Asian.

Of the 1500 studies, 289 (19.3% [95% confidence interval {CI}, 17.3-21.4%]) met our criteria for suboptimal. Of the suboptimal studies, 51.6% (147/289) were due to an inadequate filling of the pulmonary vasculature. Table 1 shows the reasons why the CTPA studies were considered suboptimal.

Table 1. Reasons for suboptimal CTPA studies.

Reason for suboptimal study	Percent of suboptimal studies
Motion artifact	54.3% (157/289)
Inadequate filling	51.6% (147/289)
Other	2.1% (6/289)
Multifactorial	11.4% (33/289)

CTPA, computed tomography pulmonary angiography.

Inter-rater reliability was determined based on the assessment of whether or not the CTPA was suboptimal from a sample of 50 charts, and Cohen's kappa was 0.92 between the two student abstractors. A physician auditor abstracted 100 charts (50 done by each abstractor) to assess the inter-rater reliability between the physician and each of the abstractors. The two additional Cohen's kappa values were calculated at 0.92 and 0.96.

Regarding the primary outcome, patients with a 20-gauge or larger IV catheter placed in the antecubital fossa or forearm (the ACR recommendations) had inadequate filling 9.2% of the time (81/883) compared to 13.2% (20/152) for patients who had smaller IVs or IVs in other locations. The difference of 4.0% (95% CI, -1.7%-9.7%) is not statistically significant.

When a patient had an IV catheter in the antecubital fossa or forearm, the rate of inadequate filling of the pulmonary vasculature was 9.3% (83/888), compared to 12.2% (18/147) in other IV locations. The difference between these groups was 2.9% (95% CI, -2.7%-8.5%), which is not statistically significant.

Only 13 patients had 22-gauge IV catheters for CTPA, but a comparison of the rate of inadequate filling for 22-gauge IV catheters (23.1 %) to larger catheters (9.7%) revealed a

difference of 13.4% (95% CI, -9.6%-36.4%).

Unfortunately, the IV catheter location used for CTPA was not specified in the chart in 465 of the 1500 studies, and in 464 cases the size of the IV catheter used was not recorded. In an attempt to assess for bias that may have been introduced into the study from the missing IV data, we performed an additional analysis and found that the rate of inadequate contrast filling was nearly identical for patients who had an IV size recorded (9.9%) compared to those with missing data (9.7%). Similarly, the rates of inadequate contrast filling were nearly equal for patients with an IV location recorded (9.8%) and those without an IV location recorded (9.9%).

The chance of inadequate filling of the pulmonary vasculature was determined for each IV catheter size and location, as listed in Tables 2 and 3.

Table 2. Intravenous (IV) catheter location and rate of inadequate pulmonary vasculature filling.

IV location	Total # (%)	Rate of inadequate filling
Antecubital	669 (64.6%)	62/669 (9.3%)
Forearm	219 (21.2%)	21/219 (9.6%)
Neck	38 (3.7%)	3/38 (7.9%)
Hand	38 (3.7%)	7/38 (18.4%)
Wrist	37 (3.6%)	4/37 (10.8%)
Upper arm	19 (1.8%)	2/19 (10.5%)
Central line	12 (1.2%)	2/12 (16.7%)
Leg	3 (0.3%)	0/3 (0%)

Table 3. Intravenous (IV) catheter size and rate of inadequate pulmonary vasculature filling.

IV size	Total # (%)	Rate of inadequate filling
16-gauge	3 (0.3%)	0/3 (0%)
18-gauge	316 (30.5%)	33/316 (10.4%)
20-gauge	704 (68.0%)	66/704 (9.4%)
22-gauge	13 (1.3%)	3/13 (23.1%)

DISCUSSION

To our knowledge, this is the largest study to evaluate the rate of suboptimal CTPA, and the only study to attempt to determine if a certain IV size or location is associated with an increased chance of inadequate filling of the pulmonary vasculature resulting in a suboptimal study. We found a fairly high rate of suboptimal CTPA, 19.3%. This number is substantially higher than the 4% found in a study by Bates et al. that used a similar definition of "suboptimal."[9] The chart review methods in that study were not as rigorous as ours, and we suspect the true suboptimal rate is higher than 4%.

While no other recent study has looked at the rate of suboptimal CTPA as it is defined in our study and the one by Bates et al, some other studies related to this issue are of note. For example, a study by Molaee et al. found that 7.9% of CTPA studies were of "unsatisfactory technique," such that they could not be adequately interpreted.[10] An older study from 2004 found that an artifact called "transient interruption of contrast" occurs in 37% of CTPA studies, limiting the radiologist's ability to interpret the study.[11] Additionally, another recent study related to this subject found that 9.5% of CTPA studies were "technically limited."[12] In the end, because of variations in local radiology practice styles, differences in technique for the execution of CTPA, and differences in equipment, the rate of suboptimal CTPA likely varies a bit from hospital to hospital.

Regardless of the exact rate of suboptimal CTPA, there is some consensus from previous studies[9-11] and this study that inadequate filling of the pulmonary vasculature accounts for a large portion of the suboptimal CTPAs. Since suboptimal CTPAs could lead to unnecessary anticoagulation and additional testing, it is important to minimize the chances of a suboptimal CTPA.

Thus, it makes sense to put forth recommendations about the IV size and location if these recommendations will reduce the frequency of suboptimal CTPA. While our study does show trends toward reductions in the rate of inadequate filling of the pulmonary vasculature when larger IVs in the antecubital fossa or forearm are used, the difference in the rates of inadequate filling for various IV sizes and locations appears to be small. Moreover, even patients with ideally located, 18-gauge IV catheters have inadequate filling of the pulmonary vasculature about one in 10 times, suggesting that factors other than the IV size and location affect the quality of the contrast bolus.

While our sample size for patients with 22-gauge IVs was very small, it is notable that 10 of 13 patients with these small IVs had CTPAs with completely adequate filling of the pulmonary vasculature. Interestingly, the packaging for a 22-gauge BD Insyte™ Autoguard™ catheter lists the maximum flow rate as 35 mL per minute, which should not allow for the standard rapid contrast bolus of 4-5 cc/second for a CTPA. However, through direct communication with BD Medical, we confirmed that the maximum listed flow rate is the gravity flow rate, and they claim that the BD Insyte™ Autoguard™ can be safely used for power injection as long as the pressure is limited to 300 pounds per square inch. Moreover, prior data suggests that 22-gauge peripheral IV catheters can tolerate the high flow rates from power injection without risking material damage.[13]

Thus, 22-gauge IV catheters can likely be safely and

adequately used for CTPA, and some data suggest that even intraosseous lines can be used for CT angiography. A tibial intraosseous line has been reported to have been used for successful administration of contrast for a CTPA study, with excellent opacification of the pulmonary arteries,[14] and a humeral intraosseous line been successfully used for a CT angiogram of the chest and abdomen.[15]

With regard to the use of unusual IV locations for CTPAs, the data we found for neck IVs are small but interesting. In these cases, neck IVs refer to external jugular vein IVs and peripheral IVs, and IVs in this location had very low rates of inadequate contrast filling of the pulmonary vasculature. Perhaps this is due to the nearly direct route from the external or internal jugular vein to the superior vena cava. A potential downside to the use of neck lines for CTPAs is that contrast extravasation may be more dangerous in the neck than in other locations of the body, but this was not assessed in our study.

The hospital where this study was performed allows the physician to proceed with CTPA even if the IV is smaller than recommended or not in the antecubital fossa or forearm in emergent situations. Based upon the results of our study, this appears to be a reasonable and important exception to the ACR recommendations for IV size and location. We hope that CTPA will not be delayed in an unstable patient with difficult IV access just because the IV size or location does not meet the recommendations. If the line is tested before contrast injection with a saline flush, there is no resistance, and there are no other easily obtainable IV access sites, it is reasonable to proceed with CTPA regardless of the IV size or location.

LIMITATIONS

Our study had several limitations. First, this was a retrospective study, which raises the possibility of confounders and unrecognized bias. Second, this was a single-center study with a single radiology group, which limits the external validity of the study. Additionally, while the study was adequately powered for the primary outcome, our sample sizes for some of the secondary outcomes were small. Thus, the data trends we observed may have become statistically significant with larger sample sizes.

Next, there was a fair amount of missing data in our IV size and location in analysis. However, our analysis of the missing data found that the rates of inadequate filling of the pulmonary vasculature were nearly identical for those patients with missing data compared to those with complete data for IV size and location. This suggests that the missing data would have been unlikely to have made a dramatic change to our results. Another issue related to missing data regards IV catheter length. Although the IV catheter length could be related to the rate of inadequate filling, the IV catheter length is generally not recorded in our electronic health record system. Therefore, we could not do a formal analysis of IV catheter length. However, central lines (which are, of course, longer than typical peripheral IV catheters) were separated out from the peripheral IVs in our analysis. Also, we know that the only available long IV catheter in our department is a 20-gauge, and this catheter is only used for upper arm and neck IV-line placement. With this information, the maximum possible number of long IV catheters was 23, making up only 2% of the total sample of 20-gauge or larger IV size group. Thus, variable IV catheter length was not much of a factor in our study.

CONCLUSION

Suboptimal CTPA reports occurred nearly 20% of the time in this study, more than half of which were due to inadequate filling of the pulmonary vasculature. While larger IVs in the antecubital fossa or forearm may slightly reduce the rate of inadequate contrast filling of the pulmonary arteries, we were unable to find any statistically significant differences in the rates of inadequate filling based on IV size or location. In emergent situations, the physician should proceed with CTPA even if an IV line meeting the ACR recommendations cannot be established.

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Using the Boston Syncope Observation Management Pathway to Reduce Hospital Admission and Adverse Outcomes

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Introduction: In an age of increasing scrutiny of each hospital admission, emergency department (ED) observation has been identified as a low-cost alternative. Prior studies have shown admission rates for syncope in the United States to be as high as 70%. However, the safety and utility of substituting ED observation unit (EDOU) syncope management has not been well studied. The objective of this study was to evaluate the safety of EDOU for the management of patients presenting to the ED with syncope and its efficacy in reducing hospital admissions.

Methods: This was a prospective before-and-after cohort study of consecutive patients presenting with syncope who were seen in an urban ED and were either admitted to the hospital, discharged, or placed in the EDOU. We first performed an observation study of syncope management and then implemented an ED observation-based management pathway. We identified critical interventions and 30-day outcomes. We compared proportions of admissions and adverse events rates with a chi-squared or Fisher's exact test.

Results: In the "before" phase, 570 patients were enrolled, with 334 (59%) admitted and 27 (5%) placed in the EDOU; 3% of patients discharged from the ED had critical interventions within 30 days and 10% returned. After the management pathway was introduced, 489 patients were enrolled; 34% ($p<0.001$) of pathway patients were admitted while 20% were placed in the EDOU; 3% ($p=0.99$) of discharged patients had critical interventions at 30 days and 3% returned ($p=0.001$).

Conclusion: A focused syncope management pathway effectively reduces hospital admissions and adverse events following discharge and returns to the ED. [West J Emerg Med. 2019;20(2)250–255.]

INTRODUCTION

Prior studies have shown admission rates for syncope in the United States (U.S.) to be as high as 70%, triggering at least 2% of hospital admissions from the emergency department (ED) and 460,000 hospitalizations annually.[1-3] Although emergency medicine has become more adept at distinguishing high-risk syncope from syncope of benign etiology and safety in ED discharge, there is a paucity of data addressing the care of patients once the ED recognizes a need for admission or further management.[4-17] Recent data note that a typical hospital admission in the U.S. for syncope averages $5,300 with a total cost of syncope-related admissions of over

$2 billion per year.[1-3, 16-21] These costs have been directly related to the broad diagnostic testing performed to discover the etiologies of syncope.[20] Not unexpectedly then, syncope was recently noted to be the leading diagnosis associated with payment denials by the Centers for Medicare and Medicaid Services.[22]

As short hospital-inpatient stays and hospital readmissions undergo increased scrutiny, ED observation units (EDOU) are increasingly being used as a low-cost alternative to inpatient hospitalization. While efforts to reduce unnecessary and expensive admission have generated clinical decision guidelines regarding the decision to admit, they have only begun to assess the value and yield of testing in syncope and have not fully assessed the utility of expedited care in an observation unit.[23-24] The safety of substituting ED observation for in-house care in syncope has not been well studied. The objective of this study was to evaluate the utility and safety of an ED observation-based management pathway for the evaluation of patients presenting to the ED following a syncopal event.

Population Health Research Capsule

What do we already know about this issue?
Although emergency department (ED) observation has been utilized for syncope, the safety and maximal utility of substituting ED observation for in-house care in syncope has not been well studied.

What was the research question?
This study aimed to evaluate the safety and effectiveness of an ED management Observation Pathway.

What was the major finding of the study?
A syncope management observation pathway reduced hospital admissions and adverse events, when compared to standard ED or inpatient care.

How does this improve population health?
With rising health care costs, hospital crowding, and increased ED boarding, a syncope management pathway is reliable, safe, and effective for ED patients.

METHODS

Study Design and Setting

This was a prospective cohort before-and-after study conducted in a large, urban teaching hospital with an annual ED census of 56,000 and an annual ED observation volume of approximately 6,000 visits. We performed an observational study of consecutive patients with syncope who were initially seen in the ED and were either admitted to the hospital, discharged or placed in an EDOU. We then implemented an ED-based, focused management pathway – the Boston Syncope Management Pathway (BSCMP) – to investigate the outcomes of these patients who presented to the ED with syncope (Figure). The BSCMP was derived by emergency physicians (EP) and cardiologists to create individualized workups for syncope based on presenting symptoms and comorbidities. The derivation used preexisting medical literature evaluating care of patients with syncope.[2, 9, 11-16] Institutional review board approval was obtained prior to initiation of the study.

Selection of Participants

Inclusion criteria were as follows: 1) age 18 years or older; and 2) ED patients presenting with syncope or near syncope and admitted by the ED team to either an inpatient ward or EDOU. We defined syncope as a sudden and transient (< five minutes) loss of consciousness producing a brief period of unresponsiveness and a loss of postural tone ultimately resulting in spontaneous recovery requiring no resuscitation measures.[9, 17] Near syncope was defined as "feeling like they were going to pass out" but without actual loss of consciousness. Exclusion criteria were patients discharged home directly from the ED without an observation stay, patients with persistent altered mental status, alcohol or illicit drug-related loss of consciousness, seizure, coma, hypoglycemia, or transient loss of consciousness caused by head trauma.

Outcome Measures

The primary outcome was the utility of the BSCMP for the management of patients presenting to the ED with syncope. Secondary outcomes looked at the efficacy of the pathway in reducing hospital admissions and improving patient disposition. We defined significant events, as has been defined previously, to include critical interventions such as pacemaker or defibrillator placement, percutaneous coronary intervention, surgery, blood transfusion, cardiopulmonary resuscitation, endoscopy and carotid artery interventions, or adverse outcomes such as death, pulmonary embolus, myocardial infarction, cerebrovascular accident, dysrhythmia, cardiac arrest, intracranial hemorrhage or sepsis.[6] We made secondary comparisons for patient demographics, comorbidities, and other features of their clinical presentation based on inpatient vs EDOU admission.

Data Collection and Processing

An electronic ED dashboard that interfaced with a commercially available healthcare information system automatically tracked all ED patients, identifying and flagging those with complaints of syncope, near syncope or loss

All patients should have orthostatic blood pressure measured*
All positive or equivocal tests should generate a cardiology consult or admission

I. Signs and symptoms of acute coronary syndrome
   a. Includes: Chest pain or shortness of breath of possible cardiac origin electrocardiogram or new (or not known to be old STT wave change, Ischemic ECG changes (ST elevation or deep [>0.1 mV] ST depression)
   b. Workup: Serian trigeminal neuralgia and stress testing (consider stress echo). If obvious ischemia then admit.
II. Worrisome cardiac history
   a. Includes: History of coronary artery disease, including deep q waves, hypotrophic or dialated cardiomyopathy. History of congestive heart failure or left ventrical dysfuntion, history of ventricular tachycardia/ventricular fibrillation, permanent pacemaker, implantable cardioverter-defibrillator, pre-hospital use of anti-dysrhythmic medication
   b. Workup: Echo (in none in the last six months) and telemetry
III. Family history of sudden death
   a. Includes: Family history (first degree relative) with sudden death, hypertrophic cardiomyopathy, Brugada's syndrome or long QT syndrome
   b. Workup: Echo, telemetry and ambulatory home monitoring
IV. Valvular heart disease
   a. Includes: Heart murmur noted in history or on emergency department (ED) examination not fully evaluated in the past six months
   b. Workup: Telemetry, echo, ambulatory monitoring
V. Signs of conduction disease
   a. Includes: Tachy or bradysrhythmias in ED, QT interval >500, Brugada, Wolff-Parkinson-White, multiple syncopal episodes within the last six months, palpations, syncope during exercise
   b. Workup:Telemetry, ambulatory monitoring, consider echo and stress testing
VI. Volume depletion
   a. Includes: Gastrointestinal bleeding by hemoccult or history, hematocrit <30, dehydration not corrected in the ED per treating physician discretion
   b. Workup: Follow gastrointestinal bleed pathway or hydrate and repeat complete blood count, electrolytes in the morning
VII. Persistent (>15 minutes) abnormal vital signs in the ED without need of concurrent interventions such as oxygen, pressors, temporary pacemakers
   a. Includes: Respiratory rate >24 beats/minute, blood pressure <90 mmHg, O_2 saturation <90%, sinus rate <50 beats/minute or sinus rate >100 beats/minute
   b. Workup: Telemetry and echo
VIII. CNS (excluding clear subarachnoid hemorrhage, transient ischemic attack, stroke) or similar concerns
   a. Includes: Headache, neuro symptoms, neuro deficit or anticoagulated
   b. Workup: Head computed tomography if positive-neuro or neurosurgery consult

*Orthostatic blood pressure
- Blood pressure and heart rate after patient quietly supine for five minutes and after one minute and three minutes of standing

Figure. Boston Syncope Pathway to guide the management of patients with syncope in the emergency department. This is a validated pathway for the management of syncope in the ED.[6]

of consciousness for provider enrollment. In addition, the investigators routinely reviewed daily patient logs to ensure appropriate pathway enrollment and identify missed patients. The ED dashboard does not allow for a physician to place a patient disposition without enrolling (with a written explanation) or declining pathway placement. A chart review was then performed of these patients reviewing their ED and EDOU or hospital course. Finally, we recorded outcomes at 30 days following initial presentation to the ED mainly via medical record reviews and a few through phone calls.

Primary Data Analysis

We entered data into a RedCap database. Categorical data was then analyzed using either chi-squared or Fisher's exact test. We analyzed continuous data using Student's t-test. Results are reported as percentages.

RESULTS

Patient demographics and comorbidities pre- and post-pathway are described in Table 1. These show a slightly older population in the post-pathway group with significantly fewer signs of acute coronary syndrome or signs of conduction disease; however, they indicated more worrisome cardiac history, valvular heart disease, and abnormal vital signs. As described in Table 2, prior to implementation of the BSCMP, of the 570 patients enrolled, 344 (58.6%) were fully admitted and 27 (4.7%) were placed in the EDOU. A total of 209 (36.7%) patients were discharged immediately following ED evaluation. After the pathway was introduced, 489 patients were enrolled. Of the 489 patients enrolled, 164 (33.5%) were admitted and 96 (19.6%) were placed in the EDOU. More patients were discharged directly from the ED to home in the post-pathway vs pre-pathway studies (36.7% vs 46.8%; $p<0.001$). The observation unit post-BSCMP

Table 1. Patient demographics and risk factors for adverse outcomes in syncope; pre and post-pathway.

	Pre-pathway	Post-pathway	P value
Number of patients	570	489	-
Age, mean (SD)	53.6 (24.2)	56.7 (22.8)	0.03
Male, % (n)			
Risk factors			
Signs of ACS (chest pain, ischemic, SOB, abnormal heart rhythm)	26.1% (149)	13.5% (66)	<0.001
Signs of conduction disease (recurrent syncope, palpitations, syncope with exercise, QT > 500 ms, heart block)	13.5% (77)	8.4% (41)	<0.01
Worrisome cardiac history (CAD, CHF, V-tach, pacemaker, ICD)	33% (188)	41% (201)	<0.01
Valvular heart disease (i.e. significant murmur)	4% (23)	7% (35)	0.03
Family history of sudden death	2% (11)	0.8% (4)	0.19
Persistent abnormal vital signs in ED (RR>24, O2<90, HR<50 or >100, SBP<90)	6.5% (37)	17% (83)	<0.001
Volume depletion (GIB, Hct < 30, profound dehydration)	6% (34)	8% (38)	0.24
Primary CNS event	1% (7)	2% (12)	0.17

SD, standard deviation; *ACS*, acute coronary syndrome; *SOB*, shortness of breath; *CAD*, coronary artery disease; *CHF*, congestive heart failure; *V-tach*, ventricular tachycardia; *ICD*, implantable cardioverter-defibrillator; *ED*, emergency department; *SBP*, systolic blood pressure; *HR*, heart rate; *GIB*, gastrointestinal bleed; *Hct*, hematocrit; *CNS*, central nervous system.

Table 2. Comparison of pre-pathway and post-pathway admission, emergency department observational (ED Obs), and discharged patients.

	Pre-pathway	Post-pathway	P value
Number of patients	570	489	-
Admitted	58.6%(334)	33.5% (164)	p<0.001
ED Obs	4.7% (27)	19.6% (96)	p<0.001
Discharged	36.7% (209)	46.8 (229)	p<0.001

Table 3. Return visits to the emergency department (ED) and 30-day adverse events (AE).

	Pre-pathway	Post-pathway	P value
Discharged	209	229	-
Return ED Visit	10% (21)	2.6% (6)	0.001
30-Day AE	3% (6)	3% (7)	p<0.99

managed 96 (19.6%) patients presenting to the ED for syncope vs 27 (4.7%) prior to pathway implementation (p<0.001). Of the patients placed in the EDOU, 11 (11.4%) were admitted from the EDOU.

As described in Table 3, of the 209 discharged patients from the ED, prior to the management pathway 21 (10%) returned to the ED for syncope. In comparison to the post-pathway cohort, only six (2.6%) re-presented to the ED for syncope after discharge (p=0.001). Although return visits decreased among discharged patients post pathway, 30-day adverse events were similar for these groups. Pre-pathway, 30-day adverse events were 3% (6/209) vs 3% (7/229; p=0.99) post-pathway. Table 4 describes the pre- and post-pathway 30-day return diagnoses post-discharge for syncope.

DISCUSSION

Our data suggest that a focused syncope management pathway may effectively reduce hospital admissions without increasing adverse events following discharge. EDOUs were designed to provide focused care in lieu of admission, with an expectation of discharge within 24 hours. The utility of ED observation has long been established for patients with diagnoses such as chest pain, asthma, congestive heart failure, and cellulitis, which in the past would often result in short hospital stays.[25-29] Like chest pain, syncope is a common presentation that uncommonly signifies a dangerous, underlying condition and should be amenable to this approach.

The BSCMP was designed to direct care and refocus EPs not only in differentiating life threats from less-dangerous causes of syncope but to enable the EP to selectively manage those patients with potential risk factors for adverse event. To do so, the pathway directs physicians toward testing in fixed circumstances and to discharge patients who are low risk based on the BSCMP.[6] Lastly, if neither the EDOU nor discharge is appropriate, the pathway recommends admission. This, in turn, likely reflects the broad spectrum of diseases that syncopal etiologies span, from potentially life-threatening to low-risk diagnoses.

Table 4. Description of return adverse events after discharge.

Pre-pathway (n=6/209) discharged	Post-pathway (n = 7/229) discharged
Myocardial infarction= 1	Anemia requiring transfusion= 1
PCI/surgery= 1	Vaginal bleed= 1
Ventricular dysrhythmia= 1	Ventricular tachycardia= 1
GI bleed=1	Death= 1
PE= 1	Surgery= 3
Sepsis= 1	

PCI, percutaneous coronary intervention; *GI*, gastrointestinal; *PE*, pulmonary embolism.

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A prior study comparing an ED observation syncope protocol and routine inpatient admission found that observation reduced admission rates and hospital length of stay with no differences in 30-day quality-of-life scores or patient satisfaction.[30,31] This study also suggested a reduction in hospital costs, with no difference in safety.[30] We believe the BSCMP takes this one step further, as our data suggest not only a reduction in admission rates but a significant decrease in the number of returns and readmissions to the hospital for syncope patients. Given the financial constraints involved in the current healthcare climate, this finding becomes increasingly significant.

While fewer than one-third of EDs currently have EDOUs, this number is growing and our ability to adequately care for these growing patient populations needs to be commensurate.

LIMITATIONS

There are a number of limitations in this study, including possible selection bias in assigning patients to observation units vs inpatient admission. Additionally, the demographics were different: The pre-pathway population was younger and had clearly different risk factors than the post-pathway group. We also used a single institution for a test site, where the use of the BSCMP is well engrained as a practice guideline. This results in a lack of generalizability of the conclusions of this study. The sample size of this study was small, and there was lack of long-term follow-up >30 days in these patients. For each adverse outcome that was reported, discerning an outcome as causative may not always be uniform.

CONCLUSION

A focused syncope management pathway may effectively reduce hospital admissions and, in turn, minimize adverse events following discharge and potentially decrease the total number of returns to the ED in the ensuing 30 days.

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Latent Class Analysis of Barriers to Care Among Emergency Department Patients

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Introduction: Emergency department (ED) patients experience a variety of barriers to care that can lead to unnecessary or repeated visits. By identifying the patterns of barriers experienced by subsets of the ED patient population, future researchers might effectively design interventions to circumvent these barriers and improve care. This study sought to identify classes of individuals with regard to perceived barriers to care.

Methods: Over a 10-week period, two medical students distributed surveys to eligible patients ≥18 years who presented to the ED. After consent, patients provided demographics data and rated their perceived access to care on nine specific items (scored 1-5). We used latent class analysis (LCA), a parametric clustering method, to determine patient groups. Demographic characteristics were then compared across classes.

Results: We enrolled a total of 637 patients. Results of the LCA indicated that a six-class solution fit best: 1) low barriers (60%); 2) "work responsibility" barriers (13%); 3) economic-related barriers (10%); 4) "appointment difficulty" barriers (8%); 5) "illness and care responsibilities" barriers (6%); and 6) diverse barriers (2%). Patients in the low-barriers class were the oldest across classes (p<.001). Individuals in the low-barriers class were also more likely to be White (p=.015) and have private insurance (p<.001) than those in the "appointment difficulty," "illness and care responsibilities," and diverse barriers classes.

Conclusion: LCA suggests there are six distinct classes of patients with regard to perceived access to care. These classes may be used as a potential starting point in designing targeted interventions for ED patients to improve continuity of care. [West J Emerg Med. 2019;20(2)256–261.]

INTRODUCTION

Overutilization of the emergency department (ED) has become a growing public health concern due to the burden placed on ED resources, space, and staff.[1] There is a need for clarification of factors contributing to ED overuse in order for successful intervention design and implementation to offset this burden. Insurance status alone was once commonly believed to be the root cause of most of the ED burden; however, empirical evidence has consistently been unable to demonstrate this correlation. Other individual- and healthcare system-level barriers to care have been identified, leading to consistent use of the ED as a main point of care.[2] Common barriers may include financial difficulties, logistical concerns associated with scheduling an appointment (e.g., transportation, work, or childcare responsibilities), and discomfort regarding interacting with providers.[2,3] These barriers, however, do not exist in a vacuum, as they often

cluster together within individual patients. Increasingly, studies have made use of latent class analysis (LCA), a parametric mixture modeling technique, to identify patterns of characteristics with which patients present as a way to better inform subsequent interventions.[4-7] A subset of this literature has focused on patterns of perceived barriers to care.[8-10]

Objective

Our goal was to build upon previous research by identifying classes of ED patients with differential patterns of perceived barriers to care. We then sought to examine differences across classes with regard to patient demographic characteristics. By identifying which patterns of perceived barriers are likely to occur within subsets of the ED population, a more-targeted intervention approach could be designed for the specific classes displaying elevated risk.

Population Health Research Capsule

What do we already know about this issue?
Patients presenting to the emergency department (ED) often lack continuity of care due to observed and/or perceived barriers.

What was the research question?
To what extent can we describe distinct subgroups of the ED patient population with differential patterns of barriers to care?

What was the major finding of the study?
There are six distinct patterns of barriers emerged: 1) low barriers; 2) working barriers; 3) financial barriers; 4) appointment concerns; 5) illness concerns; and 6) many barriers.

How does this improve population health?
Understanding subsets of the ED patient population that experience distinct barriers to care can help facilitate more effective tailored interventions.

METHODS

Study Design, Setting, and Population

This survey study, conducted between June-August 2015, involved the screening of a convenience sample of adult patients (>18 years) presenting to the ED at Strong Memorial Hospital (Rochester, New York).

Study Protocol

Two medical students were stationed in the ED for a total of ~70 hours per week for 10 weeks to recruit patients into the study. Representatives of the University of Rochester Medical Center (URMC)

The Emergency Department Research Associates (EDRA)[11] program first approached all eligible patients >18 years of age, broadly introduced the study, and asked if patients would be willing to learn more about it. Exclusion criteria included (a) an inability to communicate in English, (b) presentation to the psychiatric ED, (c) presentations for intoxication, suicide attempt, mental health arrest or overdose, and (d) patients who had an Emergency Severity Index score of 1 and/or were in the critical care bay. The medical students would then present the study in detail to those who agreed, use a formalized procedure to determine capacity to consent, obtain written informed consent from eligible patients, and administer a brief survey including demographics and perceived access to care. Participant responses were recorded directly into a secure online data collection website.[12] This study was approved by the Research Subjects Review Board at the URMC.

Measurements

Demographic Characteristics

Age was reported in three bins: 1) 18-26; 2) 27-65; and 3) 65 years or older. Participants self-reported their gender (male, female, or other), race (White, Black/African American, Asian, Native American, Native Hawaiian/Pacific Islander, multiracial, or other), ethnicity (Hispanic or non-Hispanic), insurance status (no insurance, private insurance, Medicaid, Medicare, or other), and presenting complaint.

Access to Care

Participants reported on the extent to which their ability to see a doctor in the prior year was limited by nine specific barriers.[13] Items asked about the following: a) taking care of others (such as caring for a spouse or grandchildren); b) lack of insurance; c) difficulty finding transportation; d) doctor, clinic, or hospital bills; e) work responsibilities; f) fear that the doctor would discover a serious illness; g) feeling that the doctor is not responsive to the patient's concerns; h) embarrassment about a potential illness; and i) confusion when trying to schedule an appointment. Response options were coded as 0 = "Not at All" and 1= "Very Little" to "A Whole Lot" (indicating some level of barrier). This measure has been previously used with ED populations.[14] For the purpose of this study, any value greater than zero was coded as endorsement of the barrier.

Data Analysis

We performed a series of LCAs using the set of barriers to care, with classes added until the best-fitting solution was identified. LCA is a clustering method whereby distinct unob-

served subgroups (i.e., latent classes) of a sample/population are identified based on a series of responses to categorical items. The resulting groups are relatively homogeneous with regard to their patterns of response to the indicator items. Importantly, LCA improves upon older clustering methods by providing statistical justification for the class solution chosen. Specifically, the minimum Akaike Information Criteria (AIC)[15] and Bayesian Information Criteria (BIC)[16] values across solutions (e.g., two classes, three classes, etc.) are indicative of the statistically best-fitting class structure. Substantively, model selection was also guided by the distinguishability of profiles (e.g., extent of substantive overlap between classes) and the ability to interpret the resulting model.[17] Once the best-fitting model was identified, we examined class differences in demographic characteristics using the auxiliary function in M*plus* v7.1, a latent variable modeling program (Muthén & Muthén, Los Angeles, California).[18]

RESULTS

Descriptive Analyses

The sample for this study was 636 consenting patients who completed a short survey. Patient characteristics are shown in Table 1. The gender distribution was fairly symmetrical, and age was normally distributed in this predominantly White sample (72%). More than half (55%) of the sample reported having private insurance. Overall, the most prevalent barriers reported in the sample were work responsibilities (23%), fear that a doctor would not be responsive to their concerns (20%), and transportation barriers (20%).

Table 1. Descriptive statistics of patients endorsing barriers to access of care.

	Frequency	%
Participant sex*		
Male	279	48%
Female	305	52%
Age		
18-26	122	19%
27-65	393	62%
65+	121	19%
Race		
White	455	72%
Black/African American	125	20%
Asian	7	1%
Native American	7	1%
Multi-racial	38	6%
Other	4	1%
Hispanic or Latino/Latina		
No	568	89%
Yes	68	11%
Insurance type		
Has private insurance	348	55%

*Based on non-missing data. The first 52 patients enrolled were not surveyed on their sex due to a coding error in the electronic survey.

Latent Class Analysis

When we conducted a binary LCA using M*plus*, we found discrepancy across the AIC and BIC with regard to the best-fitting model, as the AIC was lowest value in the six-class solution (5 class = 4518.60; 6 class = 4517.06; 7 class = 4517.12), while the BIC was lowest at the two-class solution (1 class = 4931.54; 2 class = 4659.02; 3 class = 4672.39). Given our goal of exploring potentially small subgroups of the ED population for whom unique patterns of barriers exist, we chose to follow the AIC and retain the six-class model. This choice was supported by the presence of highly distinguishable classes, as indicated by a model entropy value of 0.86. (Values greater than 0.80 indicate limited class overlap,)

The conditional probabilities of item endorsement for each of the six classes are presented in Figure, as are the overall probabilities of item endorsement. The majority of the sample (60%) fell into the low barriers class (class 1), citing minimal barriers to care. Class 2 (labeled the working barriers class, 13%) endorsed mainly issues concerning work responsibilities. Class 3 (the financial barriers class, 10%) was comprised of individuals who had primarily financial barriers, commonly endorsing items such as difficulty with hospital bills and lack of insurance. Class 4 (the appointment concerns class, 8%) was made up of individuals who had barriers pertaining to the actual appointment such as confusion scheduling the appointment, getting to the appointment, and feelings of doctor unresponsiveness at the appointment. Class 5 (the illness concerns class, 6%) was mainly concerned about other illnesses, as well as embarrassment over a potential illness. Class 6 (the many barriers class, 2%) represented a minority of participants, but it was the most extreme citing a large number of barriers prevalent in all class members including doctor, clinic or hospital bills, work responsibilities, fear of discovering another illness, and feelings that the doctor was not responsive to concerns. Embarrassment about potential illnesses was also highly reported (86%) among this class.

Comparing Classes on Covariates

We then compared classes on a set of demographic and care-related covariates to provide greater context for the observed groupings (see Table 2). Results demonstrate that participants in the low barriers class were significantly older than individuals in any of the other classes (each pairwise comparison $p<0.001$). Individuals in the low barriers class were also more likely to be White and have private insurance than those in the appointment concerns, illness concerns, and many barriers classes. The highest rates of White or privately insured patients were seen in the working barriers class.

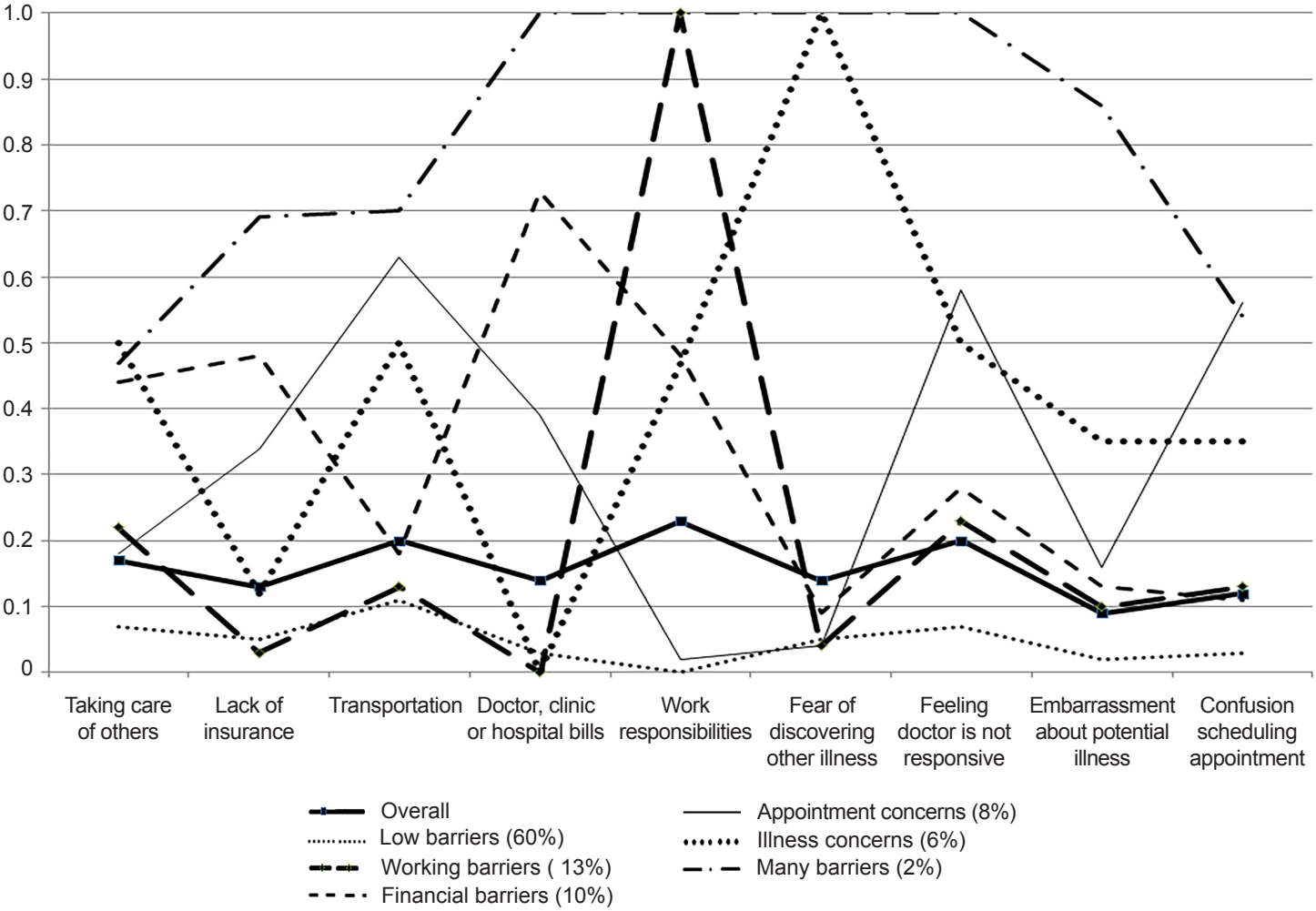

Figure. Conditional probabilities of endorsing barriers to care.

Table 2. Class means and percentages of covariates.

	Low barriers (60%)	Working barriers (13%)	Financial barriers (10%)	Appointment concerns (8%)	Illness concerns (6%)	Many barriers (2%)
% Female	50%	57%	57%	56%	57%	26%
χ^2 (1) = 5.82, p = 0.32						
Mean age (1 =18-26; 2 = 27-65; 3 = 65+)	2.13	1.73	1.89	1.91	1.79	1.39
χ^2 (1) = 65.65, p < 0.001						
% White	66%	74%	66%	47%	47%	31%
χ^2 (1) = 14.09, p = 0.015						
% Hispanic/Latino(a)	8%	9%	16%	10%	24%	46%
χ^2 (1) = 9.32, p = 0.097						
% with private insurance	58%	67%	58%	30%	35%	23%
χ^2 (1) = 22.99, p < 0.001						
% with a primary care provider	92%	84%	82%	81%	85%	85%
χ^2 (1) = 7.94, p = 0.16						

Note: χ^2 values represent overall class comparisons.

DISCUSSION

We sought to identify mutually exclusive patterns of perceived barriers to care among ED patients. Results of a series of LCAs revealed six distinct classes, with the majority of the sample reporting little difficulty accessing care (60%). The smallest class identified (2%) was also the most extreme, strongly endorsing a very broad set of barriers to care. Similar results were observed in a study by Thorpe and colleagues[8] where three latent classes were used to describe patterns of barriers to care among older adults: 1) a majority class (75%) endorsing low barriers; 2) a class largely reporting logistical barriers (18%); and 3) a minority class (2%) with high likelihood of endorsing many barriers to care (including financial barriers similar to the current study). Other studies among behavioral health patients have presented a two-class solution, with a majority class with few barriers and a minority class with moderately high probabilities of many barriers.[9,10]

The current findings extend previous work in two important ways. First, we performed this study using a different population of patients (i.e., ED patients) who tend to have elevated difficulties accessing appropriate care, as evidenced by the smaller proportion of the sample reporting minimal barriers in the current study than in the referenced previous work. Second, the current study was better able than previous work to specify distinct groups of patients with differential patterns of barriers. Specifically, our study may be of particular value because the findings within a six-class solution provide much more granularity with regard to description and practical implications compared to previous studies. A reliance on splitting a sample into low, moderate, and high difficulty accessing care classes makes it hard to design meaningful interventions to address those at risk, as the interventions would likely be too general and inefficient to effect change. By identifying and describing five distinct patterns of elevated barriers, subsequent researchers may be able to design tailored interventions to mitigate the specific concerns presented by each class of patient.

These potential tailored/targeted intervention efforts are further strengthened by the results of the covariate analyses performed. Specifically, these analyses provided a great deal of additional description, with regard to patient demographics, to the latent classes observed. For example, racial minority patients were more common in the three classes reporting elevated barriers (appointment concerns, illness concerns, many barriers) than in the minimal barriers class, particularly over-representing the many barriers class. These same three barriers classes are over-representative of the subsets of individuals without private insurance. A more thorough depiction of the latent classes identified will further enhance subsequent intervention efforts seeking to improve continuity of care for ED patients.

LIMITATIONS

There are several limitations to the current study that should be addressed. First, we relied on patient self-reports of perceptions of access to care, such that future research might seek to limit recall bias by using multiple methods of validating reports (e.g., confirmation using a separate screener; timeline follow-back of difficulties accessing care). Second, it is possible that this study may have underestimated the prevalence of several of the latent classes reporting barriers, particularly the many barriers class, as this is an ED sample in which those individuals with the most severe conditions, including severe psychiatric disturbances and substance use problems, may have been missed. These subsets of patients often experience significant difficulties accessing care. A related third concern is that the many barriers class was observed very infrequently, such that subsequent research is needed to better establish its validity. This concern is mitigated, however, by the previous work that has demonstrated a very similar class prevalence[8] and the presented covariate analyses that distinguished this class from several other latent classes.

Fourth, a large majority of the sample was White and had insurance coverage, such that subsequent multisite work with more diverse population may be needed to confirm the class structure observed. Furthermore, the use of a convenience sample, rather than a fully consecutive sample, limits generalizability of findings to patients with lower-acuity complaints without altered mental status or psychiatric concerns (e.g., intoxicated, suicidal ideation). Patients with more acute and/or behavioral health presentations may demonstrate differential patterns of barriers to care that should be identified in follow-up research.

CONCLUSION

The current study made use of advanced methods (ie, latent class analysis) to delineate six distinct patterns of barriers to care experienced by patients in the ED. By replicating these patterns in a more diverse sample of ED patients and effectively designing interventions to mitigate these specific patterns of barriers, researchers may be able to impact the continuity of care for the patients who present to the ED.

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Reconsidering the "Classic" Clinical History Associated with Subluxations of the Radial Head

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Introduction: The national burden of radial head subluxations in the United States (U.S.) population is poorly defined, and non-classical injury mechanisms have been increasingly reported in recent years. The purpose of this study is to report historical national estimates and demographic characteristics of patients presenting to U.S. emergency departments (ED) with subluxations of the radial head.

Methods: This cross-sectional, retrospective study analyzes the National Electronic Injury Surveillance System (NEISS) database (2001-2017) to identify patients ≤ 7 years of age presenting to U.S. EDs with subluxations of the radial head.

Results: Linear regression (R2 = 0.65; P < 0.01) demonstrated that the annual number of patients presenting to U.S. EDs with subluxations of the radial head increased significantly (P < 0.001) between 2001 (N=13,247; confidence interval [CI], 9,492-17,001) and 2010 (N=21,723; CI, 18,762-24,685), but did not change significantly between 2010 and 2017 (R2 < 0.01; P = 0.85). It also demonstrated that 51.0% (CI, 45.3%-56.6%) of injuries were either self-induced or spontaneous, whereas 36.8% (CI, 31.6%-42.0%) and 9.4% (CI, 8.0%-10.7%) were associated with parents/guardians or siblings, respectively. The majority of injuries occurred in patients who were the age of one (33.5%; CI, 32.1%-35.0%) and two (35.1%; CI, 33.7%-36.6%); females (57.8%; CI, 56.8%-58.9%) were more commonly injured than males.

Conclusion: Although the national burden of radial head subluxations may be less than previously reported, it still results in over 20,000 ED visits annually in the U.S. Given that over half of such injuries are actually self-induced or spontaneous, caretakers should be taught to recognize the clinical presentation of radial head subluxation, since the classically described history of a patient being lifted or pulled by the arm may simply have never occurred. [West J Emerg Med. 2019;20(2)262-268.]

INTRODUCTION

The most common pediatric upper-extremity injury is subluxation of the radial head, which may also be termed "pulled elbow" or "nursemaid's elbow."[1,2] Mechanistically, this occurs when traction forces act on the hand while the elbow is extended and the forearm is pronated, causing displacement of the annular ligament over the broader head of the radius; often, pain is sufficient to prevent patients from attempting to use their arm.[3] Injury incidence peaks in children 1-3 years of age, and are rare after age 6 due to thickening of the annular ligament.[2,4] Patients are classically at risk for subluxations of the radial head when being pulled by the arm to be lifted or to be prevented from falling.[5] In fact, patient histories are often sufficient to make a diagnosis, and treatment – namely, closed reduction of the joint – may be initiated without radiologic imaging as long as there is no clinical suspicion for fracture. However, non-classical injury mechanisms have been widely reported, ranging from falls onto elbows to even spontaneous events during sleep and accidentally

having the hands get stuck in fixtures.[6,7]

Despite its commonality, the national burden of radial head subluxations in the entire United States (U.S.) population is sparsely defined. Only two nationally representative studies have ever been conducted, to the best of our knowledge.[8,9] Our analysis makes use of more recently available data in order to investigate those studies' purported radial head subluxation injury trends over the past five years, as well as employing a novel methodology and more strict definition of radial head subluxation to better characterize epidemiological trends and identify new, important demographic characteristics related to the mechanism of injury.

The purpose of this study was, therefore, to report weighted national estimates and demographic characteristics of patients presenting to U.S. emergency departments (ED) between 2001 and 2017 with subluxations of the radial head. Our null, primary hypotheses were that annual national estimates of radial head subluxations have continued to rise in the most recently available data periods, and that injuries would be consistent with classically described mechanisms and histories.

Population Health Research Capsule

What do we already know about this issue?
Classically, clinical histories for patients sustaining radial head subluxations describe a child being pulled by the arm, displacing the annular ligament.

What was the research question?
Do patients sustaining radial head subluxations demonstrate classically described mechanisms and histories?

What was the major finding of the study?
Over half of radial head subluxations are self-induced or spontaneous, inconsistent with classical mechanisms.

How does this improve population health?
Our findings reduce the negative predictive value associated with non-classical radial head subluxation injury histories for both parents and providers.

METHODS

Data Collection

We performed a retrospective, cross-sectional analysis using the National Electronic Injury Surveillance System (NEISS) database of the U.S. Consumer Product Safety Commission (CPSC) between 2001 and 2017, which describes product- or activity-related injuries presenting to hospital emergency EDs in the U.S. The database is publicly available, de-identified, and published annually; hence, this study was exempt from institutional review board approval. Moreover, it is a nationally representative probability sample of U.S. EDs stratified by size and geographic location, from which reliable, weighted national estimates and sampling errors for queried injuries may be derived.[10,11]

Selection Criteria

In this study, we queried each yearly sample in the NEISS database between 2001 and 2017 for injuries specifically identified as elbow (Body Part Code: 32) dislocations (Diagnosis Code: 55) in patients ≤ 7 years of age. We identified 16,084 such elbow dislocations, translating to 413,198 weighted national estimates of ED visits. Next, we analyzed free-text case narratives for each of these 16,084 visits for explicit diagnoses of radial head subluxations (including "pulled elbow," "nursemaid's elbow"). After applying these criteria, 11,647 unique cases remained, amounting to 300,020 weighted national estimates of radial head subluxations presenting to U.S. EDs in patients ≤ 7 years of age during our study period. National estimates, standard errors, and 95% confidence intervals (CI) were derived in Stata/IC 15.1.[12] We determined significance of trends using adjusted Wald tests. P values < 0.05 (two-sided) were considered significant.

RESULTS

The annual number of pediatric patients presenting to U.S. EDs with diagnoses of radial head subluxations increased significantly (P < 0.001) between 2001 (N=13,247; CI, 9,492-17,001) and 2017 (N=24,614; CI, 18,782-30,445) (Table 1). This trend is illustrated graphically in Figure 1, demonstrating that the data best fit a linear regression function ($R^2 = 0.65$, p < 0.01) between 2001 and 2010; on average, subluxations of the radial head increased by 693 (CI, 279–1108) cases per year during this period. However, since 2010, there has been no significant change ($R^2 < 0.01$; P = 0.85) in the average number of subluxations of the radial head presenting to U.S. EDs annually (20,839; CI, 17,148-24,530).

The ages of patients presenting to U.S. EDs with subluxations of the radial head are shown in Figure 2 with 7.0% (CI, 6.0%-8.0%) of injuries occurring in patients ≤ 1 year of age. About one-third of cases (33.5%; CI, 32.1%-35.0%) occurred in patients who were one year old, and another roughly one-third occurred in those two years old (35.1%; CI, 33.7%-36.6%). Another 15.6% (CI, 14.4%-16.8%) of patients were three years old when sustaining subluxations of the radial head. After age three, the percentage of patients sustaining subluxations of the radial head drops off markedly from 5.7% (CI, 5.0%-6.3%) at age four to 2.1% (CI, 1.7%-2.5%) at age five. Merely 0.7% (CI, 0.4%-1.0%) of injuries occurred in patients six years old, with

an insignificant number of injuries occurring at age seven. Table 2 describes the overall demographic characteristics of pediatric patients diagnosed with subluxations of the radial head at a U.S. ED between 2001 and 2017.

The incidence of radial head subluxation was slightly but significantly higher in the summer (27.0%; CI, 26.0%-28.1%) and fall (27.1%; CI, 25.7%-28.5%) than in the winter (21.8%; CI, 20.7%-23.0%) or spring (24.0%; CI, 23.1%-24.9%) ($p < 0.001$). Importantly, in over half (51.0%; CI, 45.3%-56.6%) of cases, subluxations of the radial head were either self-induced or spontaneous. Additionally, more than one-third of cases (36.8%; CI, 31.6%-42.0%) were associated with parents or guardians handling the patient. Another 9.4% (CI, 8.0%-10.7%) of cases were associated with siblings interacting with the patient, whereas only 4.5% (3.7%-5.4%) of cases were associated with other relatives, caretakers, or friends interacting with the patient. Females (57.8%; CI, 56.8%-58.9%) were more commonly affected than males (42.2%; CI, 41.1%-43.2%). Almost two-thirds of radial head subluxations occurred at home (64.1%; CI, 57.0%-71.2%), while nearly one-quarter occurred in unknown locations (24.0%; CI, 16.7%-31.4%). Effectively all patients were treated in the ED and released from the hospital (99.7%; CI, 99.6%-99.9%).

Table 1. Weighted national estimates of pediatric patients presenting to United States emergency departments with subluxations of the radial head, 2001-2017.

Year	National cases	Standard error	95% Confidence interval
2017	24,614	2,934	18,782 - 30,445
2016	21,415	1,759	17,919 - 24,911
2015	16,553	1,399	13,773 - 19,334
2014	20,127	1,646	16,856 - 23,398
2013	20,460	1,689	17,103 - 23,817
2012	19,393	2,083	15,252 - 23,534
2011	22,426	1,855	18,739 - 26,114
2010	21,723	1,490	18,762 - 24,685
2009	17,337	1,382	14,590 - 20,083
2008	15,411	1,165	13,097 - 17,726
2007	15,030	1,274	12,497 - 17,562
2006	15,685	1,573	12,558 - 18,812
2005	14,736	1,413	11,927 - 17,545
2004	15,579	2,098	11,409 - 19,749
2003	12,184	1,671	8,864 - 15,505
2002	14,099	1,786	10,549 - 17,649
2001	13,247	1,889	9,492 - 17,001

DISCUSSION

Our study demonstrates that the national number of radial head subluxations presenting to U.S. EDs has not continued to increase since 2010. Between 2001 and 2010, radial head subluxations presenting to U.S. EDs rose by almost 700 cases per year. In contrast, over the past seven years, this number has steadied at about 21,000 cases per year. Moreover, we found that patients presenting to U.S. EDs with subluxations of the radial head were most often females between the ages of 1-3, with most injuries sustained at home. Lastly, we are the first to report that over half of radial head subluxations were self-induced or occurred spontaneously, rather than associated with parents, guardians, or other individuals handling patients, as is classically reported.

Our annual national estimates of radial head subluxations presenting to U.S. EDs were substantially lower than those previously reported. For example, Brown estimated that between 2005 and 2006, there were about 100,000 annual cases of radial head subluxation presenting to U.S. EDs.[9] In stark contrast, we found there were only about 15,000 diagnoses of radial head subluxation during these same years. Similarly, Welch, Chounthirath, and Smith found significantly higher estimates of radial head subluxations. In 2001, the authors reported over 20,000 cases presenting to U.S. EDs; in 2011, they reported over 30,000 such injuries.[8] For comparison, we only observed about 22,000 radial head subluxations presenting to U.S. EDs in 2011. This estimate gap is especially marked when considering that the later study only included patients ≤ 5 years of age, whereas we broadened our population to those ≤ 7 years of age, yet still identified fewer cases.

Given that Welch, Chounthirath, and Smith also queried the NEISS database, we ascribe their substantially higher estimates to two methodological decisions that may have resulted in an overly inclusive definition of injuries constituting radial head subluxations. First, the authors counted *any* patient ≤ 5 years of age sustaining an elbow dislocation as having a subluxation of the radial head.[8] Therefore, simple dislocations of the humeroulnar joint and mechanisms inconsistent with radial head subluxations are included in their investigation, which has previously been deemed a "common clinical mistake".[13-15] Second, they included non-dislocation diagnoses in their study if the narrative contained the term "nursemaid's elbow," potentially including complex elbow dislocations secondary to fracture – such as Monteggia fractures – inadvertently.[16] These assumptions may have led to the observed anomaly that, in most years, the authors estimated there were more radial head subluxations than there were total national elbow dislocations in their study population. For instance, in 2011 the authors estimated 30,616 national radial head subluxations in patients ≤ 5 years of age, yet the NEISS database reports only 29,091 total elbow dislocations for this age-matched population.[17] Therefore, it is likely that this value was inflated.

In contrast, our study excluded all cases for which definitive diagnoses of radial head subluxation were not explicitly made in the narrative sections of cases in which patients were both ≤ 7 years of age, and also coded as having an isolated elbow

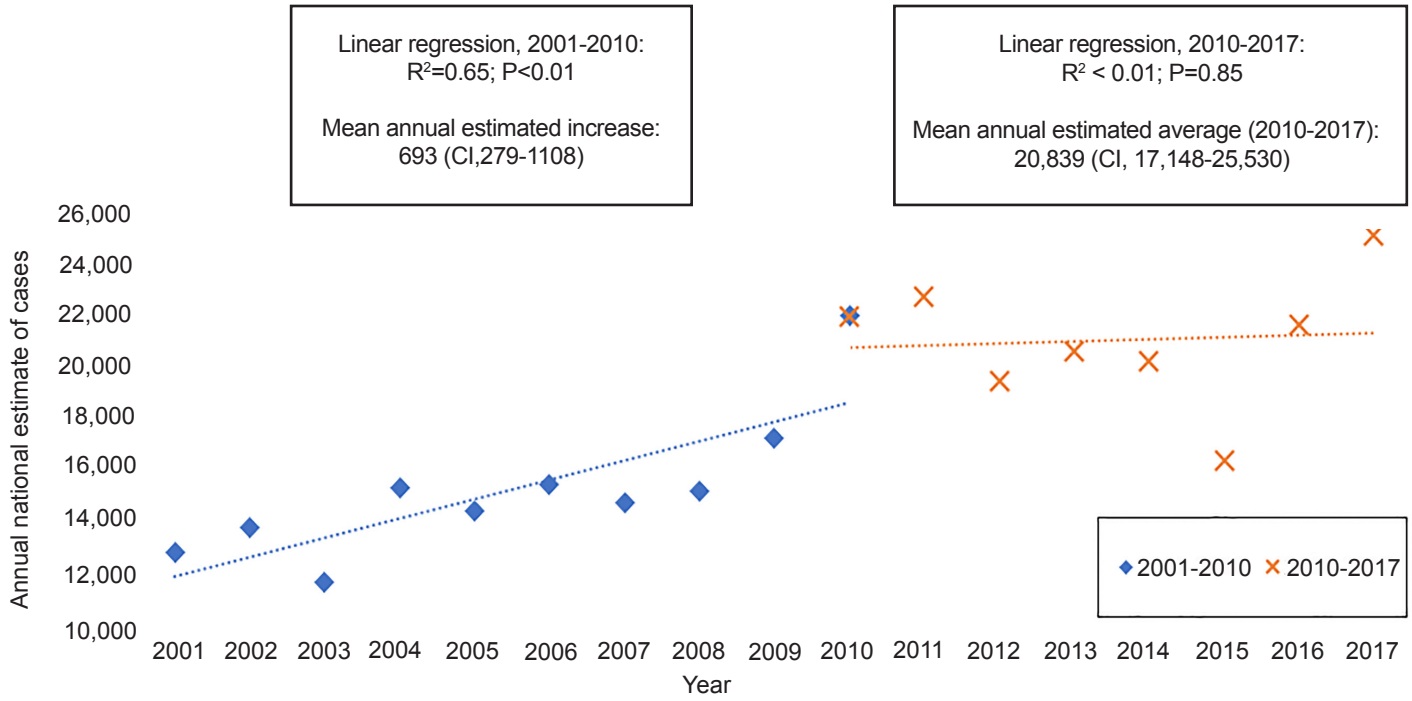

Figure 1. Weighted national estimates of pediatric patients presenting to U.S. emergency departments (EDs) with subluxations of the radial head, 2001-2017.
CI; confidence interval.
This figure overlays two linear regression models for the annual national estimate of radial head subluxations presenting to U.S. EDs between 2001 and 2017. The first linear regression model (blue, dotted line) uses annual national estimates (blue, filled diamonds) from 2001 to 2010 as inputs. The second linear regression model (orange, dotted line) uses annual national estimates (orange cross marks) from 2010 to 2017 as inputs. Results from the linear regression models are shown in the text boxes directly above each model.

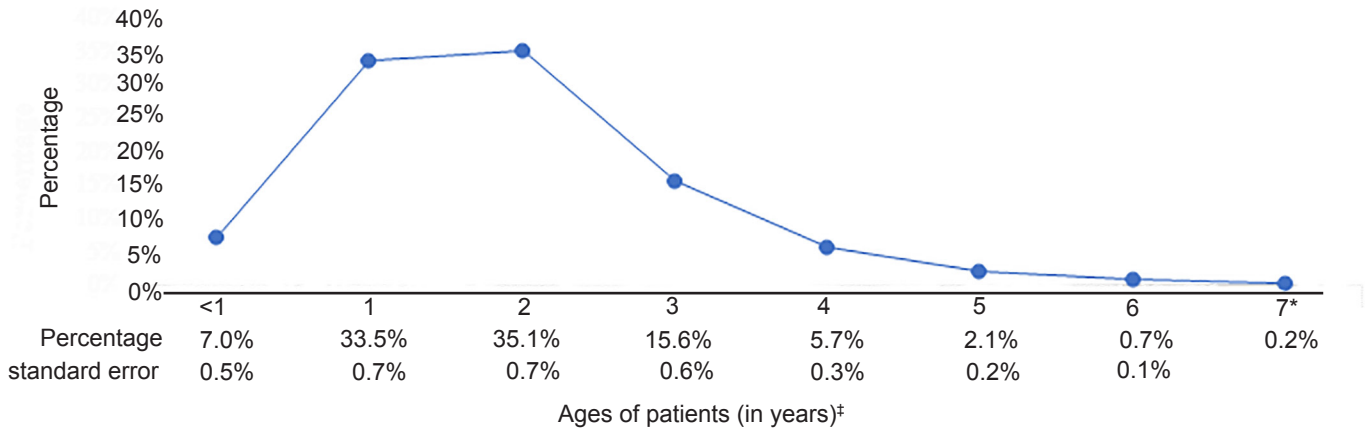

Figure 2. Ages of pediatric patients presenting to U.S. emergency departments with subluxations of the radial head, 2001-2017.
*The estimate is considered to be potentially unstable due to the number of unweighted cases from the sample frame totaling <20, the weighted national estimate totaling <1200, or coefficient of variation >33%. Therefore, no standard errors or confidence intervals are provided; the unstable percentage estimate is provided for reference purposes only. Variable results with sample frame totals <20 cases or percentages <0.1% were omitted from this table, resulting in percentage totals not necessarily summing to 100%.
‡Age groupings are based on "Age stages defined according to the Eunice Kennedy Shriver National Institute of Child Health and Human Development pediatric terminology" defined by Williams et al. (2012) in paper entitled, "Standard 6: age groups for pediatric trials."[18]

dislocation. As a result, we consider our findings to represent conservative estimates of radial head subluxation injuries presenting to U.S. EDs, with the advantage of incorporating over five years of recent data to show that the increased trends claimed by the aforementioned studies appear to have leveled off. Regardless, the pediatric health burden of radial head subluxations remains substantial, even under this best-case scenario. The magnitude of these findings implores the use of awareness interventions intended to educate parents, siblings, and other caretakers on safe ways to lift young children and prevent injuries during play. Namely, lifting or swinging young children by the hands and arms should be avoided to prevent primary and recurrent injury; instead, lifting underneath the arms and avoiding forceful "tugs" on the upper extremities can minimize the risk of sustaining a subluxation of the radial head.[6,19]

However, our study also suggests there is an equally important, added role for changing the way that parents and guardians are educated about avoiding radial head subluxation injuries in children. Specifically, parents and other caretakers must be taught to recognize the clinical entity of radial head subluxation in order to better determine when medical evaluation and treatment should be pursued, since over half of such injuries occur spontaneously or are self-induced. In other words, considering we found that radial head subluxations with classically described clinical histories – namely, where a parent or other caretaker recounts pulling on the arm of the patient and causing injury – comprise less than half of all cases, it is more likely that an adult may never actually witness the injury occurring; instead, they will have to rely on interpreting symptoms and other conspicuous clinical clues when deciding whether or not an ED visit is merited.[20] Likewise, these findings may play an important role in changing the way that clinicians in the ED evaluate and manage pediatric upper extremity injuries at the bedside. Our findings reduce the negative predictive value associated with previously non-classical radial head subluxation injury histories, thus maintaining heightened clinical suspicion for radial head subluxation in patients with certain demographic risk factors.

Moreover, our data corroborate previous epidemiological findings that those most at risk for sustaining subluxations of the radial head are often females ≤ 4 years of age, with almost two-thirds of injuries happening while the patient is at home.[4,5,21] Similarly, we showed that patients 1-2 years of age constitute the vast majority of those injured. Additionally, the sheer size of our sample allowed us to extend the age limit of our study population in order to calculate that only about 1% of radial head subluxations occurred in those over the age of 5; given the rarity of these injuries in older children, this result is frequently absent from single-institution studies.[22]

LIMITATIONS

This study has several limitations related to the nature of the NEISS database. First, the accuracy of our analyses depended on the correctness of the narrative sections, which are inherently prone to reporter bias. While such occurrences can never be entirely ruled out, the NEISS employs rigorous data collection methodologies that minimize misdiagnoses and coding errors.[10,11] Second, the NEISS database omits certain clinically relevant variables, including imaging results or the implementation of closed reduction techniques, and does not allow for the determination of primary vs recurrent injury. These variables may have provided information about the successes of various treatment strategies in both the short- and long-term while allowing for nuanced risk-stratification analyses. Most importantly, the dataset only includes injuries that presented to U.S. EDs, and therefore omits cases in which a patient first presented in an outpatient setting, such as a pediatrician's office or urgent care clinic.[20,23]

CONCLUSION

Subluxation of the radial head is a common early childhood injury of the upper extremity. Prior studies identified an upward trend in the annual number of radial head subluxations presenting to U.S. EDs through 2010, but our analyses show that these estimates may have been inflated and that said trends have largely leveled off in recent years. Even so, we find today that over 20,000 such injuries present to U.S. EDs each year. Furthermore, our study found that the majority of radial head subluxations are self-induced or spontaneous, and often occur at home in children 1-2 years of age. Therefore, it is especially important that caretakers recognize the clinical presentation of radial head subluxation: they may never directly observe the injury occur, and the age of the patient may preclude language skillsets from being developed sufficiently enough to communicate their experience with others. Thus, increased caretaker awareness of these injuries and their presentation may eventually play a substantial role in minimizing this national pediatric health burden.

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Table 2. Overall demographic characteristics of pediatric patients presenting to U.S. emergency departments with subluxations of the radial head, 2001-2017.

Demographic variable	Percentage	Standard error	95% Confidence interval
Season			
Summer	27.0%	0.5%	26.0% - 28.1%
Winter	21.8%	0.6%	20.7% - 23.0%
Fall	27.1%	0.7%	25.7% - 28.5%
Spring	24.0%	0.4%	23.1% - 24.9%
Person(s) associated with injury			
Patient (self-induced or spontaneous)	51.0%	2.9%	45.3% - 56.6%
Parent of guardian	36.8%	2.6%	31.6% - 45.0%
Sibling	9.4%	0.7%	8.0% - 10.7%
Other (i.e., relative, teacher, friend)	4.5%	0.4%	3.7% - 5.4%
Unspecified	1.6%	0.2%	1.2% - 2.0%
Sex			
Male	42.2%	0.5%	41.1% - 43.2%
Female	57.8%	0.5%	56.8% - 58.9%
Race			
White	48.5%	3.9%	40.8% - 56.2%
Black	10.3%	1.9%	6.5% - 14.1%
Other	3.0%	0.8%	1.4% - 4.6%
Asian[a]	1.7%		
Hispanic	9.2%	1.9%	5.4% - 13.0%
Race not specified	26.9%	4.2%	18.5% - 35.4%
Treated and released from hospital	99.7%	0.1%	99.6% - 99.9%
Location			
Unknown	24.0%	3.7%	16.7% - 31.4%
Home	64.1%	3.6%	57.0% - 71.2%
Street[a]	0.2%		
Public	4.0%	0.3%	3.4% - 4.5%
School	3.0%	0.2%	2.6% - 3.4%
Sports	4.7%	0.5%	3.7% - 5.6%

[a]The estimate is considered to be potentially unstable due to the number of unweighted cases from the sample frame totaling < 20, the weighted national estimate totaling < 1200, or coefficient of variation > 33%. Therefore, no standard errors or confidence intervals are provided; the unstable percentage estimate is provided for reference purposes only. Variable results with sample frame totals < 20 cases or percentages < 0.1% were omitted from this table, resulting in percentage totals not necessarily summing to 100%.

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The Prevalence of Modifiable Parental Behaviors Associated with Inadvertent Pediatric Medication Ingestions

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Introduction: Our aim was to examine potential risk factors and modifiable behaviors that could lead to pediatric poisonings. Our secondary objectives were to explore socioeconomic factors associated with caregiver (parent/guardian) safe medication storage and knowledge of poison control contact information.

Methods: We conducted a prospective, cross-sectional survey of caregivers of patients 2-10 years old presenting to an inner city pediatric emergency department. Caregiver and patient demographic data, prescription and nonprescription medication type, storage and when and where taken, were recorded. We used multivariable regression to explore factors associated with secure prescription medication storage and knowledge of poison control center contact information.

Results: Of 1457 caregivers, 29% took daily prescription and 17% took daily non-prescription medications. Only 25% of caregivers stored their prescription medications in a secure place, and <3% stored medications in a locked drawer or safe. Of demographic and socioeconomic factors, only income ≥$80,000 was associated with storage of prescription medication in a secure place (odds ratio [OR], 2.47; 95% confidence interval [CI], 1.27-4.81). When asked how they would access poison control in case of an ingestion, the majority, 86%, had an appropriate plan. In multivariable regression, the only factor associated with knowledge of poison control center contact information was college education in the caregiver (OR 1.6; 95% CI, 1.10-2.32).

Conclusion: A minority of caregivers store medications in a safe place and even fewer keep prescription medications under lock and key. The majority, however, were aware of how to contact a poison control center in case of ingestion. [West J Emerg Med. 2019;20(2)269-277.]

INTRODUCTION

In 2014, nearly 2.2 million human exposures were reported to United States poison control centers.[1] Approximately 61%, or 1.3 million, were in the pediatric population (age ≤ 19 years), 88 of which resulted in fatality. Children younger than six years of age accounted for approximately half (47.7%) of all these exposures, with 16 reported fatalities.[1] Nearly 70% of ingestions in children aged 12 years and younger were the result of inadvertently taking or being given someone else's medication.[1] Additionally, as a result of unintentional medication ingestions, approximately 70,000 children, with the peak incidence in two-year-olds, were evaluated in emergency departments (ED) annually, of whom approximately 12% required hospitalization.[2-6]

Several factors have been identified as contributing to inadvertent ingestions in the pediatric population. Supervision of young children by grandparents, use of containers for pills other than original prescription bottles, placement of medications in locations easily accessible to children (i.e., low storage areas, cabinets and refrigerators) and low socioeconomic status and education levels of the primary care giver(s) have all been implicated.[7,8] Most of the existing studies report data using cohorts of children who had documented accidental ingestions– either via poison control center reporting or from EDs where the children presented. Few, if any, studies have been conducted examining the prevalence of established, inadvertent-ingestion risk factors in a general pediatric ED population, particularly one that presents to an inner city ED.[5,8,9]

The objective of this study was to examine potential risk factors and modifiable behaviors of caregivers that may lead to inadvertent pediatric poisoning. We focused on caregivers of children aged 2-10 years of age, deemed to be at highest risk of unintentional ingestions.[2,9,10] Additionally, we sought to determine parental awareness of poison control centers, and whether caregivers had a meaningful plan to contact a poison control center in the event of an inadvertent pediatric ingestion.

Population Health Research Capsule

What do we already know about this issue?
Medication ingestions in children 12 years or younger are prevalent in the United States and are frequently inadvertent or accidental administration of someone else's medication.

What was the research question?
To determine potential risk factors and modifiable behaviors of caregivers that could lead to inadvertent pediatric poisoning.

What was the major finding of the study?
Parents frequently store and consume medications that are easy for children to access.

How does this improve population health?
The results of this study suggest that further outreach and education is necessary to improve medication storage to decrease opportunities for inadvertent pediatric ingestion.

METHODS

Study Design

This cross-sectional study was conducted over 13 months, from November 2013 to November 2014 in the pediatric ED of a large, inner-city university hospital. Written, informed consent was obtained from adult participants, and children aged 6-10 years provided verbal assent. Our institutional review board approved this study.

Setting and Selection of Participants

We conducted the study in the pediatric ED of a tertiary referral, university hospital ED, with an annual census of 78,000 total visits and 18,000 pediatric visits during the study period. The institution serves a catchment area of over two million people and is located in an inner city with one of the nation's highest poverty rates.[11] Patients were eligible for inclusion if they were between the ages of 2-10 and if the caregiver was primarily English speaking. We excluded children if they were critically ill or medically unstable. Caregivers were excluded if they were unable or unwilling to provide informed consent.

Methods and Measurements

We created a structured, data collection form that asked caregivers for demographic information about the child they accompanied as well as about the caregivers themselves. Additional data collected included annual income and highest level of education of the caregiver, the use of both prescription and nonprescription medications by the caregiver accompanying the child, where and when medications were taken, and the storage of these medications. Finally, participants were queried about their prior use or contact of a poison control center and, if they needed to access this service, how they would go about doing so.

Trained research assistants (RA) screened and enrolled eligible patients seven days a week, from 8:30 AM to 11 PM. These time periods coincided with peak pediatric ED volumes. Participants were given the option of having the survey read to them or completing it on their own. This allowed us to capture patients who had difficulty reading due to vision or literacy problems. The RAs checked all surveys for completion, and any skipped items were reviewed with the participant to ensure as complete a dataset as possible. A brief medical record review was also undertaken to determine the reason for the child's presentation to the ED (accidental ingestion [ingestion of a medication or another item] vs another chief complaint).

Outcome Measures

We report percentage of caregivers who took prescription and nonprescription medications, where these medications were taken and stored, and when they were taken. We also report caregiver knowledge of poison control center contact information. We used multivariable analysis to explore factors

associated with placement of prescription medications in a secure place. A secure place was defined as the following: above the countertop in the kitchen (not including above the refrigerator, as the size of appliances varies); in a medicine cabinet (above countertop height); or in a locked drawer or safe. Multivariable regression also explored factors associated with a reliable means of obtaining contact information for the poison control center. Obtaining this information from a bottle (either the medication bottle or a household product bottle) was not considered a viable method of contact. Likewise, contacting friends, neighbors or a family member were not considered appropriate resources. Contacting a healthcare provider, calling 911 or 411, referring to a poison control center magnet, a posted number, the internet, or the poison control center number added to phone memory were considered appropriate resources.

Data Analysis

We analyzed data using Statistical Package for the Social Sciences, version 20.0 (IBM Corporation, Armonk, New York). Continuous data are presented as means with standard deviations (SD) if normally distributed and medians with interquartile ranges (IQR) for nonparametric data. Categorical data are presented as frequency counts and percentages with 95% confidence intervals (CI). Univariate analysis of categorical variables was performed using chi-squared or Fisher's exact test, as appropriate. We conducted multivariable analysis to determine the following: 1) factors associated with placement of prescription medications in a secure place; and 2) factors associated with a reliable means of obtaining contact information for the poison control center contact information. Of note, a "secure" place was considered a cabinet above the counter or a locked drawer or safe. If a caregiver responded with multiple sites, and one site was not considered "secure," then this caregiver was categorized as placing prescription medications in a non-secure site. Variables explored for inclusion in the regression models were selected a priori and included more than one child in the household, caregiver age, annual household income, caregiver level of education, and number of prescription medications being taken by the caregiver. Odds ratios with 95% CIs are presented. All analyses were two-tailed and p values<0.05 were considered statistically significant.

RESULTS

Of 32,734 screened patients, 2007 were eligible based on age and 1495 participants were enrolled. Of the 512 who were not enrolled, 253 declined to participate or had no caregiver to provide informed consent, 136 were unable to provide informed consent due to limited English, and 123 were too ill. Characteristics of both children and their caregivers are provided in Table 1. For the majority of children, the caregiver accompanying them was the child's mother. The mean age of the child's caregiver was 31.1 years. In the course of the analysis, we determined that in a small percentage of cases children were brought in by a parent who did not live with the child– typically the father. For the remainder of the analysis, we only included adults who both accompanied the child and also reported living with the child, yielding a sample of 1457 children and their parents/guardians.

Nearly one-third (n=419) of the adults included in the analysis reported taking a prescription medication on a daily basis, and 251 reported taking an over-the-counter (OTC) medication on a daily basis. Of those taking a prescription medication, 70 (16.7%) reported that they did not know all the names of their medications. And when asked to list all prescription medications, 95 (22.7%) listed at least one medication as "unknown." The median number of prescription medications taken was 1.5 (IQR:2), with a range of 1-20. For those caregivers who were taking nonprescription medications, the median of nonprescription medications was one (IQR:1) with a range of 0-6. Prescription and nonprescription medications are presented in Table 2.

Storage of prescription and nonprescription medications is presented in Table 3. The places most commonly used for storage (open-ended question on our questionnaire) are noted here, with some caregivers noting more than one location. In addition to the sites noted in Table 3, other unique sites included "under the bed," "in the attic," and "on the couch" for prescription medications, and "all over the house," "no set place," "under the bed," "lunch bag," and "buy it and carry it on me" for nonprescription medications. Use of the original container in which the medication was dispensed was common for both prescription and nonprescription medications, and other containers used for storage are noted in Table 3. The majority of caregivers reported taking their prescription medications (n=316, 75.4%) and their nonprescription medications (n=144, 57.3%) around the same time every day. For those taking prescription medications, 149 (35.6%), 58 (13.8%), and 88 (21.0%) took their medications at breakfast, lunch and dinner, respectively. For those using nonprescription medications, 98 (39.0%), 45 (17.5%) and 56 (22.3%) took their medications at breakfast, lunch and dinner, respectively. Approximately half of both groups, 237 (56.6%) (prescription) and 124 (49.4%) (nonprescription) did not take their medications with a meal. Locations of where medications were administered are noted in Table 3, with some respondents noting more than one location.

Caregivers of children were also questioned about prior concerns of accidental ingestions and how these were managed. These responses are noted in Table 4. When asked how they would contact the poison control center in case of an accidental ingestion, the majority, 1,248 participants (85.7%), had an appropriate plan– they had the number posted, would call 911 or 411 or a healthcare provider, planned to use the internet to find the number, or had the poison control center number entered into their cellphone/telephone. The remainder were not

Table 1. Characteristics of participants (N=1,495).

	n (%)
Age of child, mean (SD)	*5.6 (2.7)
Male	783 (52.4)
Female	712 (47.6)
Race	
White	745 (49.8)
Black	700 (46.8)
Asian	22 (1.5)
Other	28 (1.9)
Hispanic	675 (45.2)
Child's primary caregiver	
Mother	1,301 (87.0)
Father	150 (10.0)
Grandmother	27 (1.8)
Aunt	5 (0.3)
Other	12 (0.8)
Person accompanying child	
Mother	1,266 (84.7)
Father	180 (12.0)
Grandmother	30 (2.0)
Aunt	7 (0.5)
Other	12 (0.8)
Mean age of person accompanying child (SD)	*31.1 (0.8)
Child lives with	
Mother only	711 (47.6)
Father only	24 (1.6)
Both mother and father	639 (42.7)
Grandmother	25 (1.7)
Mother and grandmother	3 (0.2)
Other	93 (6.2)
Child accompanied by someone who lives with him/her	1,457 (97.5)
Annual income of adult who accompanied the child and who also lives with child	(n=1,457)
≤$20,000	651 (44.7)
$20,001-$40,000	420 (28.8)
$40,001-$60,000	131 (9.0)
$60,001-$80,000	86 (5.9)
≥ $80,001	105 (7.2)
Declined to answer	64 (4.4)
Level of education of adult who accompanied child and who also lives with the child	(n=1,457)
Did not graduate high school	188 (12.9)
High school graduate	531 (36.4)
Vocational/ tech school graduate	92 (6.3)
Some college	378 (25.9)
College graduate	255 (17.5)
Declined to answer	13 (0.9)
Mean number of children who live in the home 18 years and younger (SD)	2.4 (1.2)

SD, standard deviation.
*years.

as organized: 116 (8%) planned to obtain the number from a medication bottle or from a household product bottle, and 93 (6.4%) participants either had no idea how to obtain the number or planned to ask a neighbor, family member or a friend.

Only 104 of 419 (24.8%) caregivers reported storing their prescription medications in a secure place. After multivariable regression, factors that remained associated with placing prescription medications in a secure place were age 30 years or older, income $80,000 or higher, and some college education or higher. Results of both univariate analyses (unadjusted) and multivariable analysis (adjusted for all five variables) are presented in Table 5. After multivariable regression, factors that remained associated with knowledge of poison control center contact information or a reliable method of obtaining it included age 30 years or older, income $80,000 or higher, and some college education or higher (Table 6).

We also examined our data to determine at what caregiver age we would reach a percentage level at which at least 35% of adults were using a prescription medication on a daily basis. At 30 years and older, 36.1% were using a prescription medication on a daily basis compared to only 20.9% of caregivers 29 years and younger ($p<0.0001$). For nonprescription medication use on a daily basis, the difference was not as pronounced, with 19.9% of caregivers 30 years and older vs 14.5% of caregivers aged 29 years and younger using a nonprescription medication on a daily basis ($p=0.007$). Finally, of all the children enrolled, 11 presented with a chief complaint of an accidental ingestion. Five children were brought in due to concerns about a potential or real ingestion of a medication, three children swallowed a toy, two swallowed a coin, and one swallowed a seed.

Table 2. Medications used by participants who live with the child (N=1,457).

	n (%)
Analgesics	
Acetaminophen	58 (4.0)
NSAIDs	64 (4.4)
Opiate analgesics	31 (2.1)
Aspirin	21 (1.4)
Tramadol	15 (1.0)
Cardiac and antihypertensive medications	
Beta blocker	26 (1.8)
Diuretic	25 (1.7)
ACE inhibitor/ARB	23 (1.6)
Calcium channel blocker	13 (0.9)
Angiotensin receptor blocker	7 (0.5)
Clonidine	1 (0.1)
Warfarin	1 (0.1)
Other blood thinners	1 (0.1)
Diphenhydramine	13 (0.9)
Diabetes medications	
Metformin	15 (1.0)
Sulfonylurea	5 (0.3)
Psychiatric medications	
TCAs	1 (0.1)
Antipsychotics	8 (0.5)
SSRIs	63 (4.3)
Seizure medication (excluding barbiturates)	30 (2.1)
Other controlled substances	
Benzodiazepines	21 (1.4)
Barbiturates	10 (0.7)
Supplements	
Multivitamin	147 (10.3)
Iron tablets	19 (1.3)
Fish oil	11 (0.8)

NSAID, non-steroidal anti-inflammatory drug; *ACE*, angiotensin-converting enzyme; *ARB*, angiotensin receptor blocker; *TCA*, tricyclic antidepressant; *SSRI*, selective serotonin reuptake inhibitor.

DISCUSSION

Our study sought to determine the prevalence of risky and modifiable behaviors of caregivers that could lead to inadvertent pediatric poisoning. Appropriate medication storage plays an important role in minimizing inadvertent ingestion, yet 11.9% of respondents reported keeping their prescription medications on a nightstand or bedroom dresser and 21% reported storing prescription medications in a pocketbook. Both of these storage methods could easily be accessed by a child and are unsafe. In contrast, only 2.9% of respondents reported storing prescription medications in a locked drawer or safe, likely the safest storage methods for prescription medications (Table 3). Our data replicate findings by McFee et al. in their study of children's inadvertent exposure to grandparents' medications, where medications were placed on tables or countertops (46%), low shelves (29%), and pocketbooks (17%).[5] While it was reassuring that the majority of our participants kept their medications in the original (presumably child-resistant) containers, this unfortunately does not appear to be a sufficient deterrent. Several studies have shown that child-resistant containers are almost as frequently involved in inadvertent pediatric poisoning as "easy open" containers.[3,5,8] It appears the location of the storage– easily accessible locations vs locked or elevated locations– may play a greater role in inadvertent pediatric ingestions.[5, 8]

A concerning finding was the location where caregivers ingested their medications. Over half were consumed in the kitchen or dining room, locations which could easily lead to inadvertent ingestion of a lost or misplaced pill by a child,

Table 3. Storage of medications and location where medications are taken by participants who live with the child.

	Prescription medications; n=419	Non-prescription medications; n=251
	n (%)	n (%)
Storage location		
Kitchen cabinet above counter	99 (23.6)	97 (38.6)
Medicine cabinet in bathroom	97 (23.2)	71 (28.3)
Pocketbook	88 (21.0)	20 (8.0)
On nightstand or dresser in bedroom	50 (11.9)	9 (3.6)
In bedroom in a drawer	42 (10.0)	20 (8.0)
In a closet	20 (4.8)	15 (6.0)
Locked drawer or safe	12 (2.9)	2 (0.8)
Kitchen cabinet below counter	7 (1.7)	7 (2.8)
Top of refrigerator	4 (1.0)	6 (2.4)
On countertop	6 (1.4)	3 (1.2)
In the refrigerator	4 (1.0)	2 (0.8)
In the car	3 (0.7)	1 (0.4)
Windowsill	1 (0.2)	2 (0.8)
Container storage		
Original bottle	411 (98.1)	238 (94.8)
Plastic dispenser or pill box	17 (4.1)	7 (2.8)
Loose	1 (0.2)	4 (2.0)
Plastic bag	2 (0.5)	1 (0.4)
Use of child-resistant cap for prescription medications	373 (89.0)	---
Location where medications are taken		
Kitchen	198 (47.3)	144 (57.4)
Bedroom	121 (28.9)	62 (24.7)
Bathroom	95 (22.7)	37 (14.7)
At work	42 (10.2)	20 (8.0)
Anywhere/on the go	30 (7.2)	9 (3.6)
Dining room	18 (4.3)	11 (4.4)
Car	19 (4.5)	5 (2.0)
Living room	15 (3.6)	5 (2.0)

simply due to the fact that there is a greater likelihood of children being present, allowing them to grab and ingest the caregiver's pills. This also proposes a new association to the child who is now visualizing a caregiver ingesting a pill in a location with which they associate mealtime and being instructed to eat.

An additional concerning finding was that over 10% of caregivers reported taking their medications "on the go" or in the car. This is problematic as distractions can easily interfere with proper oversight and storage of medications.

We found that potential medications that the children in our study could have been exposed to closely mirrored those found in other investigations of actual pediatric exposures.[2,4,5] Medications most commonly reported to be used by caregivers included analgesics, cardiovascular drugs, anticonvulsants, and psychotropic medications. All of these pharmaceuticals have the potential for significant morbidity and mortality if ingested by a small child. This presents an additional educational opportunity to provide to caregivers of small children. In addition to enforcing safe medication storage and avoidance of associating medication ingestion with mealtimes and locations of food consumption, introduction to the concept of high-risk medications and the fact that OTC medications can have devastating adverse effects is also important.

Other novel findings in our investigation included caregivers' reports of prior experiences with near or actual ingestions and their response to these. While nearly two-thirds appropriately managed their children, seeking care at the ED or from their

Table 4. Prior experience with near or actual ingestions (n=1,457).

	n (%)
Has this child ever put a pill in his/her mouth (not one that the child was intentionally given)?	
No	1,378 (95.1)
Yes, a prescription pill	38 (2.6)
Yes, an over-the-counter medication	31 (2.1)
Yes, both a prescription and an over-the-counter medication	1 (0.1)
Unsure	8 (0.5)
Were you ever worried that your child may have accidentally swallowed pills or a medication (but you were not sure or did not witness it)?	
No worries that my child swallowed a pill by accident	1,375 (94.4)
Yes, a prescription pill	33 (2.3)
Yes, an over-the-counter pill	38 (2.6)
Yes, worried about both prescription pill and an over-the- counter pill	9 (0.6)
Unsure	2 (0.1)
If you were concerned, what did you do?	(n=80)
Emergency department visit	29 (36.3)
Called poison control	18 (22.5)
Observed child at home (without medical guidance)	10 (12.5)
Called pediatrician	6 (7.5)
Did not do anything	4 (5.0)
Pediatrician visit	1 (1.3)
Called poison control for any possible ingestion for anyone?	212 (14.6)

pediatricians, over 15% did not seek any formal medical care or advice. Equally concerning was that 212 (12.6%) of caregivers reported having called a poison control center for a possible ingestion at some time. This suggests that, at least in our inner city population, there is a real risk of potential ingestion and, as others have recommended, additional parental education for both prevention and access to medical care/guidance is needed in the event of an ingestion.[2,4,5]

Lastly, we attempted to determine demographic characteristics associated with placing prescription medication in a safe place as well as with knowledge of poison control center contact information. Multivariable analysis determined that only annual income greater than $80,000 was associated with placing prescription medications in a safe place. In our second regression, only a higher level of education was significantly associated with knowledge of poison control center contact information. We expected older age and having more than one child (more mature, more life experience) and, especially, higher education level to be strongly associated with both factors. We are unsure why this relationship is

Table 5. Factors associated with placing prescription medications in a secure place (locked storage or above countertop). Multivariable analysis (n=419).

	Unadjusted odds ratio (95% CI)	P value	Adjusted odds ratio (95% CI)	P value
More than one child in family	1.74 (0.99-3.07)	0.55	-	-
Age 30 years and older	1.89 (1.15-3.12)	0.013	1.48 (0.87-2.51)	0.145
Income $80,000 or higher	3.28 (1.77-6.09)	<0.0001	2.47 (1.27-4.81)	0.008
Some college education or higher	1.89 (1.18-2.90)	0.007	1.40 (0.87-2.28)	0.170
Use of more than four prescription medications	1.79 (0.73-4.42)	0.21	-	-

CI, confidence interval.
Variables included in the multivariable regression model were selected if p<0.05 on unadjusted univariate analysis.

Table 6. Factors associated with knowledge of Poison Control Center contact information or a reliable method of obtaining it (n=1,457).

	Unadjusted odds ratio (95% CI)	P value	Adjusted odds ratio (95% CI)	P value
More than one child in family	0.97 (0.65-1.44)	0.88	-	-
Age 30 years and older	1.48 (1.05-2.09)	0.027	1.29 (0.90-1.83)	0.16
Income $80,000 or higher	4.05 (1.27-12.94)	0.018	2.82 (0.86-9.26)	0.88
Some college education or higher	1.83 (1.27-2.63)	0.001	1.6 (1.10-2.32)	0.01
Use of more than four prescription medications	1.45 (0.58-3.68)	0.43	-	-

CI, confidence interval.
Variables included in the multivariable regression model were selected if p<0.05 on unadjusted univariate analysis.

lacking. In their sample of parents of children aged 1-6 years admitted to the University of Puerto Rico Carolina Hospital pediatric ward, Gutierrez, et al. also demonstrated that educational level was not related to a lack of knowledge in how to contact a poison control center but did not offer any explanation for why this occurred.[9]

LIMITATIONS

This was a single-site investigation in an inner city ED, so our results may not be generalizable to other patient populations. The patient sample surveyed in this study was a convenience sample, with recruiting only when academic associates were present. However, as previously noted, this time encompassed the peak hours for pediatric ED visits. Given the nature of this questionnaire there may have been issues with social desirability bias, as we relied on self-report of where and how medications were stored. We also relied on self-report in caregivers remembering all medications they were taking and, furthermore, their impression of what is considered a medication. Likewise, the validity of self-reported knowledge of poison control center contact information may also have been biased. Caregivers may not have contact information posted or may not have input the number into their cellphones but may have responded as such.

Further, because this is a survey study based on previous behaviors, responder recall bias may be a substantial limitation. Finally, due to language constraints, we were not able to enroll many non-native English speakers, a population that may have its own unique characteristics with respect to risk factors for inadvertent pediatric ingestions. In our department, our non-English speaking patients are primarily Hispanic, and many are migrants or immigrants. Given the language barriers, socioeconomic constraints and unique cultural practices with home remedies (some of which incorporate lead), we suspect that this missed population is particularly vulnerable to accidental ingestions and at greater risk for adverse outcomes due to limited access to healthcare guidance and management.

CONCLUSION

In our inner city ED, parents continue to store and consume medications in locations that are easy for children to access. While many have an appropriate plan for reaching the poison control center in the case of an inadvertent ingestion, a sizable minority do not. This is of particular concern, since over 15% of our caregivers had already obtained poison control center assistance in the past, suggesting that the incidence of inadvertent ingestion is fairly high. Of those who actually were concerned about a potential inadvertent ingestion by a child, nearly 18% did not seek any medical advice or intervention. These data suggest that further outreach and education is necessary to improve medication storage by caregivers and increase poison control center awareness.

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Assessment of Physician Well-being, Part One: Burnout and Other Negative States

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Physician well-being is a complex and multifactorial issue. A large number of tools have been developed in an attempt to measure the nature, severity, and impact of both burnout and well-being in a range of clinical populations. This two-article series provides a review of relevant tools and offers guidance to clinical mentors and researchers in choosing the appropriate instrument to suit their needs, whether assessing mentees or testing interventions in the research setting. Part One begins with a discussion of burnout and focuses on assessment tools to measure burnout and other negative states. Part Two of the series examines the assessment of well-being, coping skills, and other positive states. [West J Emerg Med. 2019;20(2)278–290.]

INTRODUCTION

The word "burnout" was originally used by Herbert Freudenberger in 1974 to describe a state of emotional fatigue that was becoming more prevalent during the free clinic movement, attributed to the mismatch of resources to the needs of patients.[1] Thought to be a reaction to chronic emotional and interpersonal workplace stressors, it is a three-dimensional syndrome consisting of emotional exhaustion, depersonalization or cynicism, and a sense of reduced personal accomplishment.[2] Exhaustion from increased workloads and extended work hours combined with the stress of cognitive decision-making in the setting of emotionally-charged situations contribute to physician burnout.[3] These causes of physician burnout have, in recent years, been only exacerbated by increased clerical workload from electronic health records and reduced sense of work efficacy.[4]

The first national study of burnout in United States (U.S.) physicians was conducted in 2011 across all specialty disciplines. From a sample of over 7,000 physicians, approximately 46% reported at least one symptom of burnout and only 49% reported satisfaction with their work-life balance. Variability was noted across medical specialties, with the highest rates of burnout noted among physicians at the front lines of access to care, such as primary care and

emergency medicine (EM). This study further compared U.S. physicians to working adults in non-medical matched cohorts and concluded that physicians comparatively had both more symptoms of burnout and more job dissatisfaction than their non-physician peers.[5]

In 2014, rates of physician burnout and job dissatisfaction were compared with the results from 2011 and both were discovered to be on the rise, with 55% of physicians having reported one symptom of burnout and only 41% reporting satisfaction with work-life balance.[6] The U.S. adult working population had not seen the same increased rates of burnout and dissatisfaction in the same amount of time, thus further increasing this disparity between physicians and non-physician working adults. This pattern of burnout has not only been identified in attending physicians, but also in resident physicians and medical students.[7,8]

The prevalence of burnout in the physician population is significant when taken in consideration with the effects that it has upon physicians as individuals, the patient population that physicians serve, and the institution of medicine itself. Physicians who suffer from burnout have higher rates of substance abuse, personal relationship problems, anxiety, and depression.[9-11] These same physicians are more likely to self-report performing suboptimal patient care practices, such as admitting or discharging patients early, not offering options or answering questions, ordering more tests, not treating patients' pain, not communicating important handoffs, and not discussing plans with staff.[12] Burnout has additionally been identified as a risk factor for higher rates of medical errors, patient safety errors, and mortality ratios among hospitalized patients.[3,13,14] At the institutional level, physician burnout has been linked with reduction in clinical care hours, which threatens to intensify the projected shortage of physicians in the year 2025.[15,16]

As burnout is studied more, other variables such as depression, anxiety, and stress have been identified beyond emotional exhaustion, adding to the complexity of this syndrome. There is significant overlap in symptoms between burnout and depression and anxiety. Physicians reporting burnout are at greater risk for depression and anxiety. While there is an association, suffering from burnout does not equate to a clinical diagnosis of depression.[17] It is important to note that depression and anxiety remain mental disorders well-defined in the *Diagnostic and Statistical Manual of Mental Disorders,* fifth edition, (DSM-V) published by the American Psychiatric Association (APA) whereas burnout remains a work-related, non-DSM defined syndrome. Given that burnout is defined as a condition resulting from severe stress relative to one's own emotional and cognitive reserves, stress has been determined to be a considerable variable in burnout assessment. Stress arising from uncertainty, risk of poor outcomes, and high-stakes environments in medical practice often leads to anxiety, which in one study of emergency physicians (EP) was the greatest predictor of career burnout.[18]

Summary

Physician burnout is an increasingly prevalent crisis in our healthcare system, has become a focus of multiple medical organizations, and has been highlighted in both the popular media and the medical literature. The highest rates of burnout among physicians are among those specializing in primary care and EM. In the EM literature, research has shown that faculty have a poor ability to accurately identify burnout in trainees and that additional education is needed on methodology of trainee assessment.[19] Accurate measurement is key to conducting needs assessments, developing appropriate interventions to problems, and ongoing monitoring.[20]

Numerous assessment tools are available to the EP. The goal of the Assessment Tools Workgroup, a sub-committee of the Council of Emergency Medicine Residency Directors (CORD) Resilience Committee, was to research and summarize the various assessment tools available for burnout and related factors and compile them as a collated resource. This is the first resource available in this series and will focus on assessment tools to measure burnout and other negative states. For assessment tools related to well-being, resilience, and positive states, please refer to "Assessment of Physician Well-being Part Two: Beyond Burnout."

METHODS

The instruments included in this article are the result of a scoping review of English-language publications with abstracts indexed in PubMed, Web of Science, and MedEd Portal within the past 10 years. Searches were based on the main Medical Library Subject Heading (MeSH) terms "burnout," "anxiety," and "depression."

In addition to the search on the main term, subheadings included the following: each in quotes measurement, assessment, evaluation, diagnosis, education, etiology, trends, derivation, validation, tool, instrument, scale, measure, survey, or questionnaire and resident, residency, intern, internship, medical student, clerk, attending, physician, and clinician. A complete listing of search terms can be found in Appendix 1. This search was augmented by reviewing article reference lists and performing further citation searches. We did not include instruments cited only in abstracts or as reports of meetings.

Abstractors performed a comprehensive review of the identified assessment tools. Details of all scales and where they can be found are presented in Table and Appendix 2. The tools identified as most relevant, accessible, and practical in evaluating EP well-being were included for further review. The tools were selected by multiple abstractors. Abstractors worked in groups of two or three focused on one subject (e.g., burnout or depression). Discrepancies between abstractors were reviewed by either the first, second, or senior author. Consensus between at least two reviewers was required for an instrument to be included here.

Our primary inclusion criteria was use of the tool in a

Table. Burnout and other negative states assessment tools.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Source	Notes	Pros	Cons
Burnout								
Maslach Burnout Inventory- Health Services Survey (MBI-HSS)	Consists of three subscales: (1) emotional exhaustion (2) depersonalization (3) diminished personal accomplishment.	22 items	10 minutes	$15 per individual report $50 for the manual $250 add-on to calculate and summarize for a group of tests	http://www.mindgarden.com/117-maslach-burnout-inventory Accessed Jan 22, 2019	Wide variability in the interpretation of burnout scores using the MBI has been subject to recent debate. (Rotenstein LS, Torre M, Ramos MA, et al. Prevalence of Burnout Among Physicians: A Systematic Review. *JAMA*. 2018;320(11):1131-50.)	Widely used and well known Developed for human services, such as law enforcement, social work, clergy, and medical professionals	Cost (copyrighted and distributed by a commercial publisher) Variable interpretations of burnout scores
Single item measures of emotional exhaustion (EE) and depersonalization	Consists of only two of the full 22-item MBI questions: "I feel burned out from my work" and "I have become more callous towards people since I took this job." These questions represent the emotional exhaustion and the depersonalization domains of burnout as described in the MBI, respectively.	Two items	< Two minutes	Free	N/A	Likert Scale responses (1=never, 2=a few times a year, 3=a few times a month, 4=a few times a week 5=once a week, 6=a few times a week, 7=every day). The single scores for the two-item MBI (EE and depersonalization) are multiplied by 9 and 5, respectively.	Ultra-short Free Multiple validation studies	Reliability concerns related to ultra-short assessment tools
Copenhagen Burnout Inventory (CBI)	Consists of 3 sub-dimensions: personal burnout, work-related burnout, and client-related burnout.	19 items	10 minutes	Free	http://www.arbejdsmiljoforskning.dk/upload/cbi-scales.pdf Accessed Jan 22, 2019.	The CBI attempts to distinguish between perceived levels of burnout due to personal factors, work-related factors, and more specifically factors related to work with others.	Free to use Evaluates work-related and patient-related aspects of exhaustion	Single dimension of burnout

Table. Continued.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Source	Notes	Pros	Cons
Utrecht Work Engagement Scale (UWES)	"Work engagement" is considered to be the antipole of burnout. This scale measures work engagement and arises from the research in positive psychology.	17 items	10 minutes	Free for non-commercial educational and research purposes	https://www.wilmarschaufeli.nl/publications/Schaufeli/Test%20Manuals/Test_manual_UWES_English.pdf Accessed Jan 22, 2019.	Contrary to those who suffer burnout, engaged employees have a sense of energetic and effective connection with their work activities and they see themselves as able to deal well with the demands of their jobs.	Free to use Complements burnout screening	Normative values do not include the United States population
Jefferson Scale of Empathy-Health Professions (JSE-HP)	Measures empathy in healthcare providers and students.	20 items	10 minutes	Approximately $31 per person, scored $5000 for unlimited online use	https://www.jefferson.edu/university/skmc/research/research-medical-education/jefferson-scale-of-empathy.html Order form available: http://www.jefferson.edu/content/dam/university/skmc/research/centerResearch/OrderForm_2016.pdf Accessed Jan 22, 2019.	There are three official versions of the JSE: medical students (S-version), health professions (HP-version), and health professions students (HPS-version). The HP version can be administered to physicians and ALL other health professionals who are involved in patient care, such as nurses, dentists, pharmacists, clinical psychologists, etc.	Well validated Designed for physicians	Cost Indirect measure of wellness
Depression and anxiety								
Beck Depression Inventory-21 item (BDI-II)	Assesses the existence and severity of symptoms of depression; also screens for suicide risk.	21 items	Five minutes	$2.36 per form	http://www.pearsonclinical.com/psychology/products/100000159/beck-depression-inventoryii-bdi-ii.html Accessed Jan 22, 2019.	Assesses symptoms over the preceding two weeks.	Widely used Good psychometric properties	Cost
Center for Epidemiologic Studies Depression Scale (CES-D)	Assesses depression symptoms (utilizing DSM-V criteria) over the last week; also screens for suicide risk.	20 items	2-5 minutes	Free	cesd-r.com/ Accessed Jan 22, 2019.	Developed for use in studies of the epidemiology of depressive symptomatology in the general population.	Free Brief Scale and scoring available online	Reliability concerns

Table. Continued.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Source	Notes	Pros	Cons
Patient Health Questionnaire (PHQ-2)	Assesses depressive symptoms over the last 2 weeks.	Two items	< Two minutes	Free	http://www.phqscreeners.com/ Accessed Jan 22, 2019.	Derived from the full PHQ which contains the mood, anxiety, alcohol, eating, and somatoform modules.	Ultra-short Free	Reliability concerns related to ultra short assessment tools
Beck Anxiety Inventory (BAI)	Screens for anxiety and describes subjective, somatic, or panic-related symptoms of anxiety.	21 items	5-10 minutes	$2.36 per form	https://www.pearsonclinical.com/psychology/products/100000251/beck-anxiety-inventory-bai.html Accessed Jan 22, 2019.	The BAI has been found to discriminate well between anxious and non-anxious diagnostic groups in a variety of clinical populations.	Validated Good reliability	Costs Not widely studied in health professionals
State-Trait Anxiety Inventory (STAI)	Consists of two subscales, one for assessing State Anxiety (or questions about how one feels "right now") and one for assessing Trait Anxiety (or questions about how one generally feels).	40 items	10 minutes	$2.50 per form	http://www.mindgarden.com/145-state-trait-anxiety-inventory-for-adults Accessed Jan 22, 2019.	The T-Anxiety scale correlates more with other depression instruments than it does with other measures of anxiety.	Most widely researched and used measure of general anxiety	Cost Overlap with depression and depressive symptoms
Second victim syndrome								
Second Victim Experience Support Tool (SVEST)	Measures psychological distress, physical distress, types of support, and professional self-efficacy. Also measures intention to leave the specialty and absenteeism.	29 items	10-20 minutes	Free for non-commercial educational and research purposes	Burlison JD, et al. The Second Victim Experience and Support Tool. *J Patient Saf.* 2017;13(2):93-102.	Higher scores represent greater likelihood of experiencing second victim characteristics, which include a combination of psychological and physical distress and perceived levels of inadequate support or resources.	Free Novel	Limited studies, need more data on reliability and validity

physician population in the medical literature. Exclusion criteria included tools that either were not used in a physician population or were not cited in the medical literature relating to physicians more than 2-3 times. Excluded tools that did not meet these two criteria are referenced in Appendix 2. The figure illustrates the search algorithm and tool-selection process. The articles reviewed were organized by the subcategory of the tool (e.g., burnout tools), then by individual tool, and finally, by the populations for which the tool had been used.

A summary of the scale's purpose, structure, and evidence of its psychometric properties were derived from the original source references. Due to the varied psychometric properties of each tool, abstractors relied on the reported validity and reliability from the source manuscripts. Where available, published cutoff scores are provided for guidance, although their validity or utility in other clinical or research contexts should not be assumed. Where psychometric properties were not explicitly described in the primary sources, potential users may need to check for any subsequent information pertaining to reliability and validity.

The order of presentation is based on the following two subsections: Burnout Tools; and Depression and Anxiety Tools. The following comments and discussions should be read in conjunction with the details reported in Table and Appendix 2, as well as with the recommendations provided at the end of the review.

RESULTS

Burnout Tools

In the mid-1970s a group of researchers led by Christina Maslach began to seriously consider the complex and often difficult relationship that people in helping professions have with their work and the subsequent impact on their health and social networks. These researchers conceptualized burnout as a psychological syndrome in response to chronic interpersonal stressors on the job defined in three key dimensions: overwhelming exhaustion; feelings of cynicism and detachment from the job; and sense of ineffectiveness and lack of accomplishment.[21]

Maslach Burnout Inventory

The Maslach Burnout Inventory (MBI) is a self-assessment tool to measure experienced burnout in individuals. Across a wide range of demographics and occupations, the tool has demonstrated reliability, convergent validity, and discriminant validity.[2,22] The original and most widely used version of the MBI is known as the MBI-Human Services Survey (MBI-HSS). The MBI-HSS scores participants on three distinct but inter-related subscales: emotional exhaustion; depersonalization; and diminished personal accomplishment. While the authors of the MBI consider burnout as existing on a continuum rather than as a dichotomous state, they provide population norms for some groups as a benchmark for comparing scores. The MBI suggests burnout for professionals scoring in the high range on emotional exhaustion, in the high range for depersonalization, and in the low range for personal accomplishment. Official score reports also contain information on reducing burnout and resources for seeking help.[2]

Studies on physician burnout have almost exclusively used the MBI-HSS as a measurement tool due to the large body of literature supporting its reliability.[2,22] This includes many of the often-cited, population-based studies,[5,33,34] as well as studies in residents[23-25] and EPs.[25,26] Consequently, the MBI-HSS has in many ways become the preferred assessment tool for a wide variety of uses, such as evaluating the effectiveness of wellness programs, faculty and resident surveillance, and demographic trends.

While the MBI-HSS has a number of strengths, there are also some limitations to its use. The high cost of administration may limit access. Users of the MBI must also consider that burnout has clear discriminant validity.[2,22] In other words, it is truly a distinct phenomenon from other established constructs, such as depression and job dissatisfaction, and should not be used as a comprehensive catchall for determining individual or population mental health. It is important to note that the MBI was not normed on physicians-in-training. Attending physicians were sampled for the normative data. Finally, the MBI does not consider non-professional confounders of burnout, such as child care demands, the schedule and support of partners, life events, or financial concerns.[27]

Well-being is a complicated and multidimensional construct, and the simple absence of burnout as determined by the MBI does not necessarily equate overall well-being. Nevertheless, the MBI-HSS remains one of the most recognized, widely used, well-validated, and reputable tools in the toolbox for assessing occupational burnout in physicians and residents.

Single-Item Emotional Exhaustion and Depersonalization Scale

Because the MBI is a 22-item instrument, its use may be constrained by the time required for completion. To address this limitation, Shanafelt and colleagues created the single-item emotional exhaustion (EE) and depersonalization (DP) scale.[28] These authors used the following two questions from the MBI: "I feel burned out from my work," and "I have become more callous towards people since I took this job." Multiple studies have significantly correlated these two questions with the EE and DP subscales of the MBI, respectively.

The single-item EE and DP scale has been well-validated in physicians, medical students, and residents with very large sample sizes.[29] The scale is brief and free to use. However, some authors have raised concerns regarding the reliability of single-item surveys.[30] In general, however, models that used the single-item EE and DP scale did show consistency with those who used the full 22-item MBI.[29] This scale may be

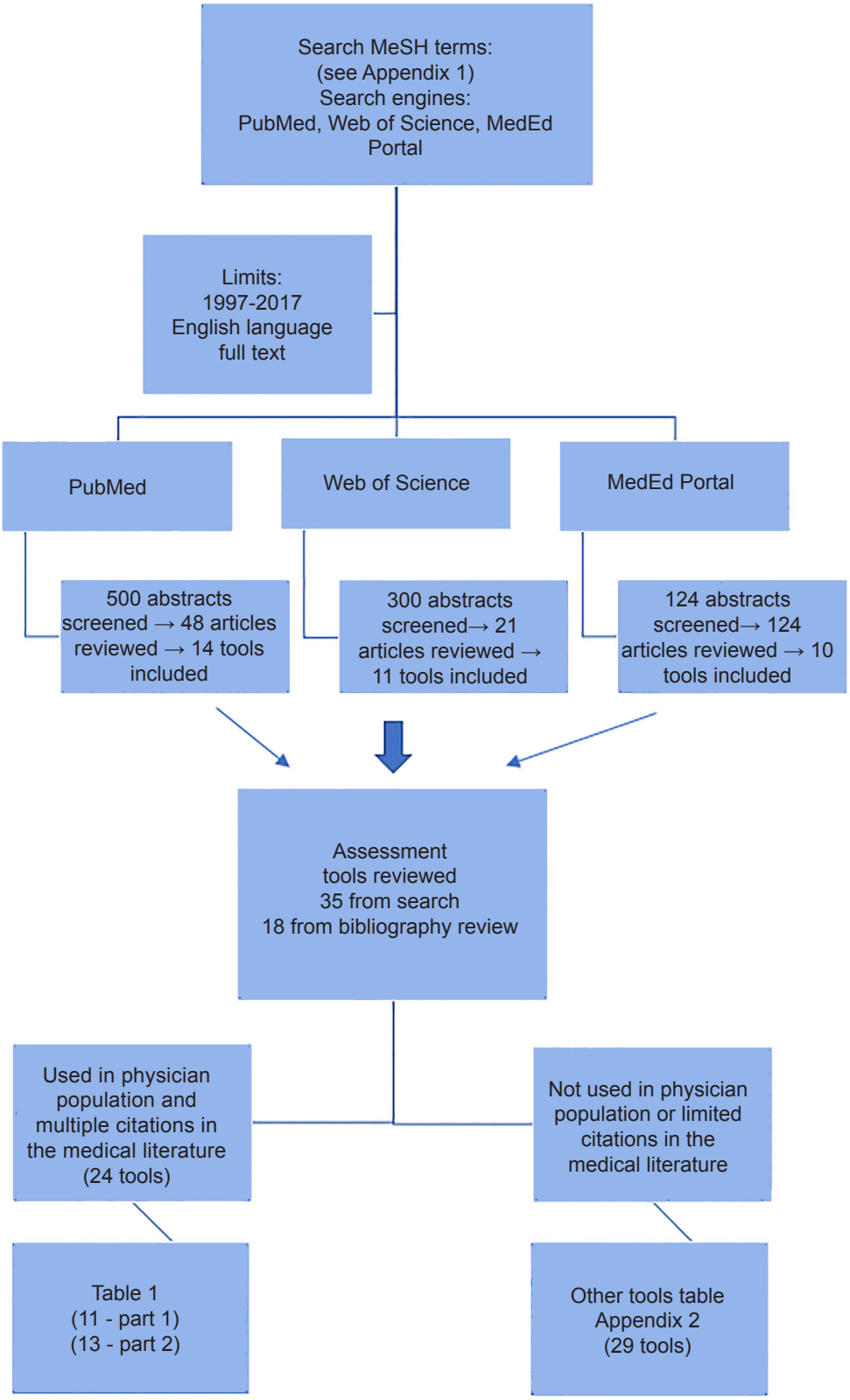

Figure. Flow diagram of literature search algorithm and assessment tool selection.

most useful for larger surveys in which only a few questions can be dedicated to burnout.

Copenhagen Burnout Inventory

The creators of the Copenhagen Burnout Inventory (CBI) felt the MBI could only apply to those who do "people work," and thus could not be extrapolated to those who do not explicitly work with clients. They reported that the personal burnout section of the CBI could be applied to anyone, regardless of whether they worked with people or were employed at all.[31] During their pilot in Danes, respondents reacted negatively toward phraseology of the MBI questions, some of which did not translate well into Danish, and the CBI creators thus sought to create a different tool altogether. The CBI was originally used in the human services sector with multiple professions, only one of which was hospital physicians. There have since been studies completed using the CBI in anesthesiologists and critical care physicians, as well as EPs. These have yielded consistent, valid, and reliable results measuring burnout.[32-34]

The personal burnout section asks how tired or exhausted the individual is on both physical and emotional levels, as well as how often an individual feels weak and susceptible to illness. The work-related burnout category asks to what degree an individual's physical and psychological fatigue and exhaustion are related to his or her work. The authors stressed that they were not looking at causality, but merely how much the respondent attributed his or her stress/burnout to work. Comparison of work-related burnout and personal burnout then allows causal assessment of an individual's burnout, be it due to work or other non-work factors such as family or health issues. The client-related burnout section determines if the respondent's burnout is due to people-oriented work focus.[31]

The CBI, unlike the MBI, is open access and free to use. Additionally, it performs very well in assessing burnout, and also has the added benefit of looking at burnout in different aspects of an individual's life. It has been translated into multiple languages and has been used in the physician population.[35] Like other tools for assessing burnout, it should not be used to measure depression or an individual's overall well-being as these are different and complex phenomena. Overall though, the CBI is a helpful tool for evaluating burnout and one that could easily be substituted for the MBI with the added benefit of being free to use.

Utrecht Work Engagement Scale

The Utrecht Work Engagement Scale (UWES) is derived from positive psychology – the study of human strength and optimal functioning. In contrast to the MBI, the UWES measures positive feelings such as vigor, dedication, and absorption in one's job.[36] The UWES attempts to measure burnout by measuring the opposite of burnout, with the underlying assumption that engaged workers have a positive, fulfilling, work-related state of mind. Multiple studies have demonstrated that work engagement is significantly inversely related to burnout.[37] It should be noted that the same group of researchers who developed the MBI also developed the UWES.

The UWES has been studied in very large populations and has been validated in non-U.S. physicians.[38-40] It is also available in multiple languages. However, the normative values are based on a general, Dutch, working population. The UWES is free, easy to use, and can be repeated to monitor progress. This scale could easily be combined with the MBI or the single-item EE and DP scale to measure both physician engagement as well as burnout in order to improve the work environment.

Jefferson Scale of Physician Empathy

Empathy is the ability to share and understand the feelings of another. Many neuroscientists believe that empathy is hardwired in human beings and essential to our survival.[41] Patients want genuine empathy from doctors and doctors want to provide it, but there is a tension in medicine between being able to maintain a healthy detachment from patients while still being able to connect with them.[42] One of the three key components of burnout is depersonalization, which is not only an inability to feel empathy for others but a loss of connection with oneself. Thus, the ability to measure and monitor empathy in healthcare professionals is important to assessing the degree of depersonalization, one of the major components of burnout.

The Jefferson Scale of Physician Empathy is a validated measure of empathy in healthcare professionals. If decreased empathy, in the form of depersonalization, is a hallmark of burnout, then the routine monitoring of the empathy of healthcare professionals could help to identify loss of compassion that could contribute to burnout.

Depression and Anxiety Tools

Compared to peers in other fields, medical students and residents experience significantly higher levels of depression. A large study of medical students and residents found that over half screened positive for depression and 8-9% screened positive for suicidal ideation within the prior 12 months.[23] Another systematic review of 54 studies involving resident physicians (n = 17,560) found that between 20.9% and 43.2% screened positive for depression. Although numerous studies have examined depressive symptoms among medical residents in various specialties, few studies have focused on EM specifically.[43]

Anxiety can be defined as an acute emotional response to stressful conditions (state anxiety), or as a personality characteristic (trait anxiety) that can also be thought of as a predisposition to respond to external threats in fixed ways. Beck's model of psychopathology suggests that anxiety and depression are separate but related constructs and can be measured independently. In Beck's definition, anxiety refers to negative feelings that are specific to certain situations, whereas depression involves more absolute and pervasive negative feelings.[44,45] As opposed to the assessments for burnout, the tools for measuring

depression and anxiety are validated diagnostic clinical tools widely used for the purpose of identifying DSM-V illnesses as defined by the APA. They are presented with a focus on prevalence and trends within physician populations.

Beck Depression Inventory II

The Beck Depression Inventory (BDI-II) is one of the most widely used, self-report measures of depression. The purpose of the BDI-II is to assess the existence and severity of symptoms of depression. Both the total BDI-II score and the single suicidal-ideation items have demonstrated accuracy in predicting suicide attempts and death by suicide.[46-50] The BDI-II has been used in several studies examining depressive symptoms among medical residents in the U.S. and other countries.[51-53]

Data from seven studies of resident physicians found the overall prevalence of depression to be 26.6% when using the BDI-II with a cutoff score of ≥ 10. Prevalence of depression was significantly lower among U.S. resident physicians (10.7%) compared to non-U.S. resident physicians (44.6%). The prevalence of depression was higher in more recent studies, and no association was found between prevalence and specialty or post-graduate year (PGY) training level.[54-60] Chronic sleep deprivation was associated with depression.[61]

Center for Epidemiologic Studies Depression Scale

The Center for Epidemiologic Studies Depression Scale (CES-D) is commonly used in clinical settings to screen for depression and in research studies with clinical and nonclinical samples.[62,63] Data from seven different studies of resident physicians found the overall prevalence of depression to be 25.6% when using the CES-D and a cutoff score of ≥ 16. Data from two other studies of resident physicians used a higher cutoff of ≥ 19 and found the prevalence to be 33.4%.[64-70] The CES-D is the only measure used in studies examining depressive symptoms of EM residents. A single-site study of 51 EM residents found the prevalence of depression to be 12.1% when using the CES-D and a cutoff of ≥ 15.[71,72] Depression was not associated with gender, rotation type, PGY level, or number of hours worked.[73]

Primary Care Evaluations of Mental Disorders: Patient Health Questionnaire and Generalized Anxiety Disorder Instrument

The full Primary Care Evaluation of Mental Disorders (PRIME-MD) and subsequent Patient Health Questionnaire (PHQ) and Generalized Anxiety Disorder Instrument (GAD) were developed as tools for primary care providers to screen for a range of psychiatric disorders, including depression and anxiety. A subsequent shorter version, the Public Health Questionnaire-9 (PHQ-9) is a self-report version of the PRIME-MD depression screen.[74,75] The GAD is the instrument designed to screen for generalized anxiety disorder.[76] All versions of the PHQ and GAD are considerably shorter and faster to administer than the original PRIME-MD.

The PHQ-9 was used in several studies examining depressive symptoms among residents. Data from four studies of resident physicians found the overall prevalence of depression to be 20.9% when using the PHQ-9. When using a slightly modified version of the PHQ-2 the prevalence of depression among resident physicians was 43.2 %.[77-80] Internal medicine residents who screened positive for depression were more likely to experience burnout[81] and to report making a medical error.[82]

The PHQ instruments are free and easy to use. With very little training and preparation, clinicians of all types can use these instruments to screen for common psychiatric disorders with relative accuracy. Reliability varies by form, and inter-rater reliability was established on the original PHQ by comparing the use of the instrument by a clinician with assessment of the patient by a mental health professional.[83] The PHQ instruments do measure depression and anxiety as disorders rather than responses to stress, making it a less favorable instrument for assessing across a physician population.

Beck Anxiety Inventory

The Beck Anxiety Inventory (BAI) is a self-report questionnaire that measures severity of anxiety in adults and adolescents. The instrument was specifically designed to "minimize confounding of symptoms of depression."[45] The BAI is relatively brief and easy to administer in a short period of time and is most effective as a measurement of somatic symptoms of anxiety.[84] The instrument does not assess other symptoms of anxiety such as worry or other cognitive aspects and thus may underestimate the presence of anxiety.[85] The reliability and validity evidence for this instrument has been widely studied; however, the BAI has not been widely studied in medical professional populations.[86,87]

State-Trait Anxiety Inventory

The State-Trait Anxiety Inventory (STAI) was derived from the Minnesota Multiphasic Personality Inventory (MMPI). The instrument is designed to measure the presence and severity of current symptoms of anxiety and a generalized propensity to be anxious. It is a self-report questionnaire containing two subscales, one for assessing state anxiety (S-Anxiety), questions about how one feels "right now," and one for assessing trait anxiety (T-Anxiety), questions about how one generally feels.[45,93] The STAI is one of the most widely researched and used measures of general anxiety. The instrument measures both S-anxiety, which is more likely to be prevalent in the emergency department, but it can also measure T-anxiety, illuminating patterns of response to anxiety that may be unhealthy. Because of the overlap of the T-anxiety scale with depression and depressive symptoms, this instrument is limited, having a difficult time achieving respectable levels of discriminant validity. In other words, the T-anxiety scale correlates more with other depression instruments than it does with other measures of anxiety.[94-97]

Second Victim Experience Support Tool

The Second Victim Experience Support Tool (SVEST) consists of seven subscales that measure psychological distress, physical distress, four types of support, and professional self-efficacy. SVEST also has two outcome measures related to the second victim's job: intention to leave and absenteeism. The phrase "second victim" refers to healthcare providers who experience an adverse event during the care of their patient, who may be considered the "first victim."[88] Medical errors or inadvertent injuries to the patient during care may cause the caregiver to suffer feelings of anxiety, stress, shame, or guilt as a result of adverse clinical event.[89-91] The only major study of the instrument's psychometric properties was conducted at a pediatric hospital with a very small physician sample.[92]

LIMITATIONS

There are an overwhelming number of assessment tools available in the literature that can be used to measure the different components of physician well-being. While our literature search was methodical and broad, we acknowledge that we may have missed some key assessment tools. At times, a single author determined the inclusion eligibility of the tools identified in our literature search strategy. However, consensus between at least two reviewers was required for an instrument to be included in this paper.

Assessment tools must be suitable for and validated in the population of interest. A majority of the tools that we found have been used in a physician population but have never been validated in this population. Many of the tools have been designed for and validated in special populations, and their applicability, reliability, and validity in a physician population is not clearly demonstrated in the medical literature. In the absence of independent validation, however, the results of these tools should be interpreted with caution.

Physician well-being is multifactorial, and it is difficult to divide these components purely by topic or sub-category as they have a complex interplay with one another. We have reviewed the tools based on the well-being topics that were most commonly found in the medical literature and that were of highest potential value. There are very few tools that were either designed for use in a physician population or have been validated in physicians. We have highlighted the tools from each topic that are most relevant for use in assessing an EP population.

CONCLUSION

Given the wide range of associated factors and the psychosocial impact of burnout, it seems unlikely that any one tool will be recognized as comprehensive for evaluating physician well-being. It is hoped that the present review will provide guidance on choosing between currently available instruments, whether assessing mentees or testing interventions in the research setting.

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Assessment of Physician Well-being, Part Two: Beyond Burnout

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Part One of this two-article series reviews assessment tools to measure burnout and other negative states. Physician well-being goes beyond merely the absence of burnout. Transient episodes of burnout are to be expected. Measuring burnout alone is shortsighted. Well-being includes being challenged, thriving, and achieving success in various aspects of personal and professional life. In this second part of the series, we identify and describe assessment tools related to wellness, quality of life, resilience, coping skills, and other positive states. [West J Emerg Med.2019;20(2)291-304.]

INTRODUCTION

In 2009, Shanafelt and colleagues proposed that "wellness goes beyond merely the absence of distress and includes being challenged, thriving, and achieving success in various aspects of personal and professional life."[1] Siedsma and Emle defined it as "the complex and multifaceted nature of physicians' physical, mental and emotional health, and well-being."[2] The American College of Emergency Physicians (ACEP) proposed a multidimensional wellness model in 2016, the components of which are the following: occupational, emotional, physical, financial, spiritual, social, and intellectual. When viewing this model, it is clear how these areas are interconnected and critical in a person's everyday life and that any approach to well-being must offer a holistic approach incorporating the different psychosocial aspects affecting the physician.[3,4] Despite these and other frameworks, no clear consensus definition of well-

being exists in the academic medical literature.[5] Well-being is comprised of multiple variables including work-life balance, quality of life, resilience, mindfulness, coping strategies, and mood. In this review we explore the tools that assess the positive states of physician well-being.

The importance of physician well-being has now been universally recognized, with calls to action made by virtually every major medical society, including the American Medical Association, the Association of American Medical Colleges, and the Accreditation Council for Graduate Medical Education and in emergency medicine (EM) by the Council of Residency Directors (CORD), ACEP, and the Society for Academic Emergency Medicine. Whether wellness and well-being can be taught remains to be determined, and there is no standard for assessment or improvement. Numerous studies have looked at various aspects, but either due to small or specific sample size or confounding factors that lacked consideration, interpretation of and extrapolation of the results of these interventions should be done with caution.[6]

Summary

Well-being is a complex and multifactorial topic. Accurate measurement is key to conducting needs assessments, developing appropriate interventions, and ongoing monitoring.[7] There are numerous tools available for assessment. The goal of the Assessment Tools Workgroup, a sub-committee of the CORD Resilience Committee, was to research and summarize the various assessment tools available on burnout, well-being, resilience, and related factors and compile them as a collated resource. This is the second resource available in this series; it focuses on assessment tools to measure well-being, resilience, and other positive states. For assessment tools related to burnout and negative states, please refer to "The Assessment of Physician Well-being, Part One: Burnout and Other Negative States."

METHODS

The instruments included in this article are the result of a scoping review of English-language publications with abstracts indexed in PubMed, Web of Science, and MedEd Portal within the past 10 years. Searches were based on the main Medical Library Subject Heading (MeSH) terms "resilience," "mindfulness," "mood," "personality," "well-being," "quality of life," and "stress." In addition to the search on the main term, subheadings included the following: measurement, assessment, evaluation, diagnosis, education, etiology, trends, derivation, validation, tool, instrument, scale, measure, survey, or questionnaire AND resident, residency, intern, internship, medical student, clerk, attending, physician and clinician. A complete listing of search terms can be found in Appendix 1. This search was augmented by reviewing article reference lists and performing further citation searches. We did not include instruments cited only in abstracts or as reports of meetings.

Abstractors performed a comprehensive review of the identified assessment tools. Details of all scales and where they can be found are presented in Table and Appendix 2. The tools identified as most relevant, accessible, and practical in evaluating emergency physician (EP) well-being were included for further review. The tools were selected by multiple abstractors. Abstractors worked in groups of two or three and focused on one subject (e.g., mindfulness or quality of life). Discrepancies between abstractors were reviewed by either the first, second, or last author on the manuscript. Consensus between at least two reviewers was required for an instrument to be included in this paper.

The primary inclusion criteria was use of the tool in a physician population in the medical literature. Exclusion criteria included tools that were not used in a physician population or were not cited in the medical literature relating to physicians more than two to three times. Tools that did not meet these two criteria are referenced in Appendix 2. The figure illustrates the search algorithm and tool selection process. The articles reviewed were organized by subcategory of the tool (e.g., mindfulness tools), then by individual tool, and finally, by the populations the tool had been used in.

A summary of the scale's purpose, structure, and evidence of its psychometric properties were derived from the original source references. Due to the varied psychometric properties of each tool, abstractors relied on the reported validity and reliability from the source manuscripts. Where available, published cutoff scores are provided for guidance, although their validity or utility in other clinical or research contexts should not be assumed. Where psychometric properties were not explicitly described in the primary sources, potential users may need to check for any subsequent information pertaining to reliability and validity.

The following comments and discussions should be read in conjunction with the details reported in Table and Appendix 2, as well as with the recommendations provided at the end of the review.

RESULTS

Well-being Factors and Quality of Life Tools

While the definition of job burnout is relatively clear,[8] well-being has been viewed through various domains[9] and used interchangeably with quality of life (QOL).[10] Higher perception of work-life imbalance negatively impacts work satisfaction and effect of work on QOL.[11] Several authors investigating well-being in physicians used instruments initially intended for the general population or patients,[10,12] while others derived instruments that specifically address the physician population.[13]

Physician Wellness Inventory

The Physician Wellness Inventory (PWI) is a measure of how happy and satisfied physicians are with their work. The PWI was piloted to assess attendings, residents and

Table. Positive state assessment tools.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Where to find it	Notes	Pros	Cons
Well-being and quality of life								
Physician Wellness Inventory	It has three scales: career purpose, cognitive flexibility and distress.	14 items	Two minutes	free	www.promoteyourwellness.com/PWI.docx	There are only two published studies using this instrument	Free Developed for physicians	Limited studies, need more data on reliability and validity
Physician Well Being Index (PWBI)	Used to: 1) stratify physician well-being in several important dimensions; and 2) identify physicians whose degree of distress may negatively impact their practice.	Seven Items	< Five minutes	Free for individuals Organizations: $10k license and $5k yearly fee	https://www.mededwebs.com/employee-well-being-index	Designed to measure burnout, provide valuable resources when people them the most, and track progress over time to promote self-awareness.	Short Externally validated Can be used for self-screening Provides self-directed learning resources	Costly More useful for screening than detailed testing
Quality of Life Linear Analog Scale Assessment (LASA)	LASA includes five simple items, each of which targets a specific domain of quality of life.	Five items	< Five minutes	Free	http://www.jpsmjournal.com/article/S0885-3924(07)00463-0/pdf	Specific domains include physical well-being (i.e., fatigue, activity level), emotional well-being (i.e., depression, anxiety, stress), spiritual well-being (i.e., sense of meaning, relationship with God), and intellectual well-being (i.e., ability to think clearly, concentrate).	Short Accessible Validated in multiple physician populations	Multiple forms exist
Professional Quality of Life Scale (ProQOL)	Self-report measure that asks the respondent to reflect on his or her experiences at work as a human service provider, both positive and negative, in the past 30 days.	30 items	5-10 minutes	Free, must credit the author	http://www.proqol.org/Home_Page.php	The ProQOL consists of three separate subscales: Compassion Satisfaction, Burnout, and Secondary Traumatic Stress. Standardized scores exist for all three (< 23 = low, 23-41 = average, > 41 = high). No composite score is available. It is recommended to complete the measure in its entirety rather than separate the questions into separate tests divided by subscale.	Free Validated Good reliability	Indirect measure of "wellness"

Table. Continued.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Where to find it	Notes	Pros	Cons
Epworth Sleepiness Scale (ESS)	Self-reported measure of how easily a person can fall asleep in different situations	Eight items	One minute	Free for individual use (Need a license for corporate use)	http://epworthsleepinessscale.com/about-the-ess/	The ESS specifically distinguishes reports of dozing behavior from feelings of fatigue and drowsiness/ sleepiness	Free Quick and easy to use	Subjective Risk for bias
Resilience and mindfulness								
Connor Davidson Resilience Scale (CD-RISC)	Used for clinical practice as a measure of stress and adaptability. Also used to evaluate response to clinical interventions.	25 items	5-10 minutes	Need agreement from authors with small fee Cost is dependent on type and extent of use	http://www.connordavidson-resiliencescale.com/index.php	The scale has been developed and tested as a measure of degree of resilience. The scale also has promise as a method to screen people for high, intermediate or low resilience.	Well validated	Small fee. Initial intent to use on patients with mental illness. Limit use in physicians.
Perceived Stress Scale (PSS)	Used to measure the perception of stress; measure of the degree to which situations in one's life are appraised as stressful; items are designed to tap how unpredictable, uncontrollable and overloaded respondents find their lives; direct queries of current experienced stress	14 items	10-15 minutes	Free	http://www.psy.cmu.edu/~scohen/scales.html	A psychometrically sound global measure of perceived stress that could provide valuable information about the relationship between stress and pathology (correlations between high perceived stress and burnout).	Free Short Easy to use	Not validated in health care providers
Coping Inventory for Stressful Situations (CISS)	The CISS measures three types of coping styles: task-oriented coping, emotion-oriented coping, and avoidance-oriented coping. It helps you determine the preferred coping style.	48 items	10 minutes	CISS Manual = $57 Quik Score Form (25/pkg)=$60	http://www.mhs.com	Offers precision in predicting preferred coping styles, and contributes to understanding the differential relationships between coping styles and other personality variables.	Reliable and valid Tests the interaction of stress, anxiety, and coping	Cost Not validated in a physician population

Table. Continued.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Where to find it	Notes	Pros	Cons
Ways of Coping Scale (WAYS)	The Ways of Coping Questionnaire is a 66-item instrument containing a wide range of thoughts and acts that people use to deal with the internal and/or external demands of specific stressful encounters.	66 items	10 minutes	$50 for the manual $2.50/license (50 surveys minimum)	http://www.mindgarden.com/158-ways-of-coping-questionnaire	An assessment of coping in relation to a specific stressful encounter. Not designed to be used as an assessment of coping styles or traits.	Well validated	Cost Length of instrument Not validated in a physician population.
The COPE Inventory (brief)	The COPE Inventory is a multidimensional coping inventory to assess the different ways in which people respond to stress.	28 items	15 minutes	Free	www.psy.miami.edu/faculty/ccarver/sclBrCOPE.html	Five scales (of four items each) measure conceptually distinct aspects of problem-focused coping (active coping, planning, suppression of competing activities, restraint coping, seeking of instrumental social support) Provides individual's insight into their typical coping response leading to increased mindfulness	Free Easy to use	Not validated in a physician population. Intended use is to provide insight into a typical coping response not a coping style.
Mood and personality								
Myers-Briggs Type Indicator (MBTI)	Introspective self-assessment tool that identifies psychological preferences in how people interact with their environments and make decisions.	93 items	15 minutes	$49.95 per user	https://www.cpp.com/products/mbti/index.aspx	Provides insight into an individual's personality traits, can help us identify weaknesses and be better communicators and decision makers	Widely used and highly regarded Validated Good reliability	Cost

Table. Continued.

Name of instrument	Brief description	Number of items	Time to complete	Cost	Where to find it	Notes	Pros	Cons
Profile of Mood States (POMS 2)	Self-report psychological rating scale use to assess transient, distinct mood states. Measures multiple dimensions of mood over a distinct period of time which include: Anger-Hostility, Confusion-Bewilderment, Depression-Dejection, Fatigue-Inertia, Tension-Anxiety, Vigor-Activity and Friendliness.	Full version: 65 items Short version: 35 items	Full version: 10 minutes Short version: five minutes	Manual $92, and Single full or short form $3.50	https://ecom.mhs.com(S(4sbwc3qmfsjjpo454qllycuj))/inventory.aspx?gr=cli&prod=poms2&id=pricing&RptGrpID=pmr	Provides insight into an individual's current mood state and how that may affect their performance at work and interaction with others.	Allows for real-time assessment of risks for burnout, second victim syndrome, etc.	Cost Not well validate in physician population
Thomas-Kilmann Conflict Mode Instrument (TKI)	Self-assessment tool that identifies individual conflict-handling styles, which are categorized into 5 "modes": competing, collaborating, compromising, avoiding, and accommodating	30 item	15 minutes	$18.95 each, $179 pack of 10	https://www.cpp.com/en/tkiitems.aspx?ic=4813	Provides a pragmatic, situational approach to conflict resolution, change management, leadership development, and communication	Relevant Validated in physician populations	Cost

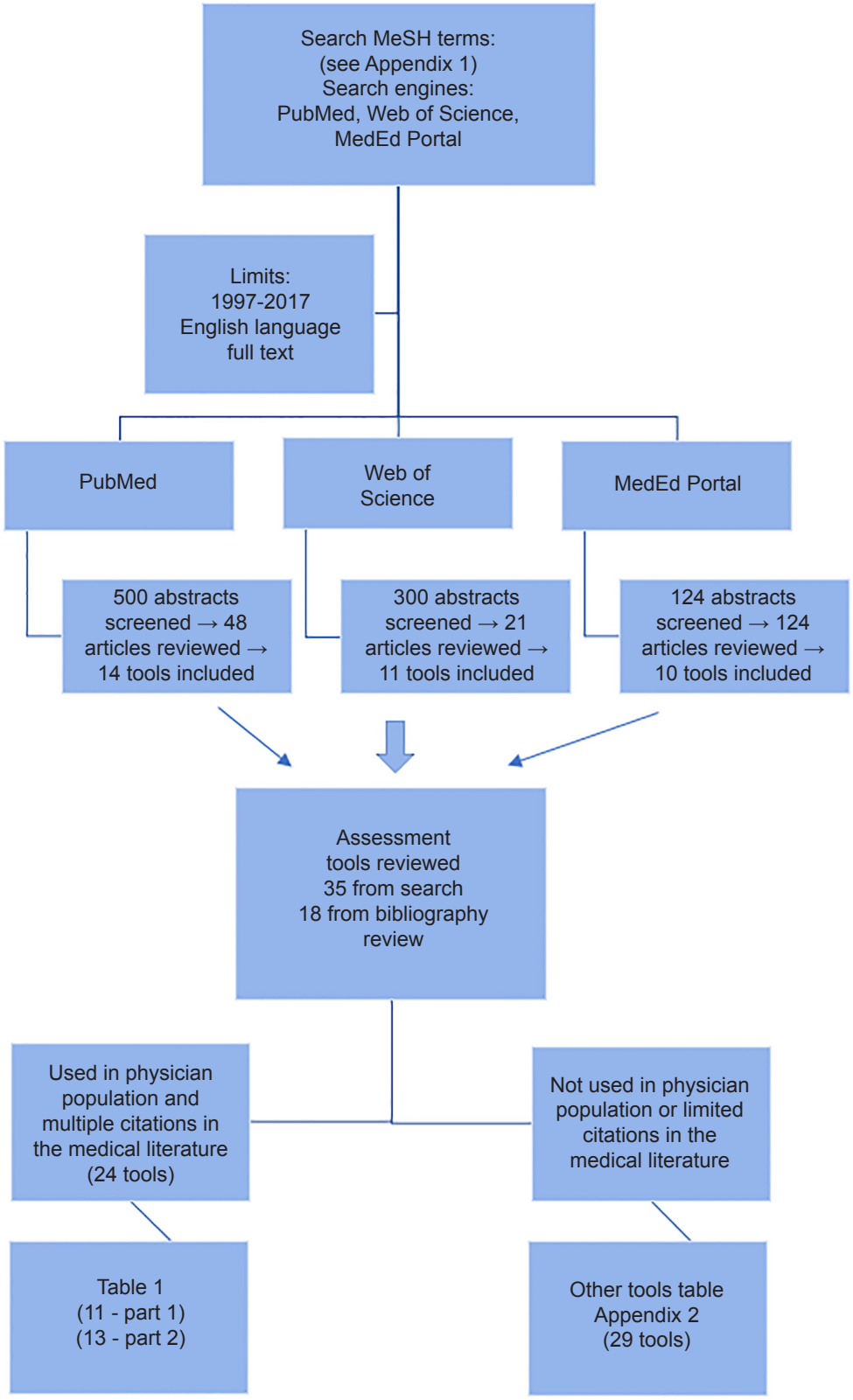

Figure 1. Flow diagram of literature search algorithm and assessment tool selection.

fellows from three academic centers in Michigan in 2010. The first and only study that used the PWI was performed in randomly selected full-time physician members of the American Academy of Family Physicians to assess the relationship between burnout and happiness. They found that career purpose was the strongest predictor of happiness.[14] No other studies have evaluated the reliability and validity of this instrument. The major advantage of the PWI is that it was developed for physicians, taking into consideration their work settings and relationship to patients.

Physician Well-being Index

The authors at the Mayo Clinic School of Medicine developed the Physician Well-Being Index (PWBI) specifically for medical professionals, including resident and medical student versions.[13,15,16] The purpose of the index is to stratify physician well-being in several important dimensions and to identify physicians whose degree of distress may negatively impact their practice (career satisfaction, intent to leave current position, medical errors). The seven-item survey includes domains of burnout, depression, stress, fatigue, and mental and physical QOL.

Quality of Life Linear Analog Self-assessment

The Quality of Life Linear Analog Self-Assessment (QOL LASA) scales have repeatedly been used in the literature to evaluate QOL in the cognitive, physical, emotional, social, or spiritual domains.[17] In medical oncologists, high QOL LASA scores were associated with higher work satisfaction.[18] One study employed the QOL LASA to measure the outcomes of a well-being initiative in a group of 40 internal medicine (IM) physicians who subsequently demonstrated a significant increase in QOL LASA scores post-intervention group.[60] QOL LASA scores have been shown to be negatively correlated with self-perceived error reporting in several studies.[19-21]

Professional Quality of Life Scale

The Professional Quality of Life Scale (ProQOL) is the current iteration of several previously developed scales related to compassion fatigue including the Compassion Fatigue Scale, the Compassion Fatigue Self-Test, and the Compassion Satisfaction and Compassion Fatigue Test. ProQOL is a well-validated, 30-item scale that consists of three separate subscales: compassion satisfaction; burnout; and secondary traumatic stress. There are over 650 citations related to ProQOL, and its previous iterations in the medical literature. Key literature can be found here: http://www.proqol.org/uploads/ProQOL_Concise_2ndEd_12-2010.pdf. The ProQOL scale allows for monitoring of both the negative consequences (e.g., burnout and secondary traumatic stress) and protective qualities (e.g., compassion and satisfaction) of being in a caring profession.

Epworth Sleepiness Scale

Fatigue has long been linked to well-being and QOL. Sleep loss and fatigue have a significant negative impact on resident quality of life and perception of well-being.[22] The Epworth Sleepiness Scale (ESS) is the most widely used tool to evaluate daytime sleepiness in a variety of populations and cultures. In multiple medical student studies, there were high rates of daytime sleepiness, higher levels of burnout, and academic performance.[23-28] Increased sleepiness has been shown to be related to an increase in motor vehicle accidents among IM residents,[29] with higher levels of stress and fatigue being independently associated with self-perceived medical errors.[30]

In a study with EM residents, sleep deprivation was found to significantly impact resident lives both personally and professionally with many social activities and meaningful personal pleasures being deferred or postponed during residency.[31]Additionally, residents in that study reported that sleep loss and fatigue had a major impact on their ability to perform their work. While baseline characteristics have not been established and cross-specialty studies have not been done, one study of IM residents found that 23% had an abnormal ESS score.[32]

Coping Tools: Resilience and Mindfulness

EPs are subjected to high-stress situations on a regular basis. Stress is not burnout but a natural response defined as a state of mental or emotional strain or tension resulting from adverse or very demanding circumstances. Reaction to stressors is highly individualized, and numerous emotional and physical disorders have been linked to stress. Understanding the response to stress can provide insight into specific behavioral modifications that can be used to cope with stress in more positive ways.

There are numerous types of coping mechanisms, some positive and associated with increased mindfulness and resilience, and some negative, which worsen symptoms of burnout. Resilience, too, is a unique and central component of well-being, identified as "the ability of an individual to respond to stress in a healthy, adaptive way such that personal goals are achieved at minimal psychological and physical cost."[33] It is increasingly recognized as a strategy that may reduce physician stress, particularly burnout, anxiety, and depression. In one study conducting semi-structured interviews with a variety of physicians, self-awareness, self-monitoring, and mindfulness-based, stress-reduction techniques were determined to be as effective as techniques to reduce the negative feelings of emotional distress and consequent rumination while enhancing a physician's capacity for empathy.[34] This notion of self-awareness and self-care is thought to be teachable and can be enhanced, as demonstrated by one pilot study involving family medicine residents.[35]

Connor Davidson Resilience Scale

The Connor Davidson Resilience Scale (CD-RISC) was developed for clinical practice for patients with mental health concerns, particularly post-traumatic stress disorder and anxiety, as a measure of stress and adaptability. The initial paper also states three potential uses: to explore the biologic aspects of resilience; to use in clinical practice in an effort to recognize resilient characteristics and evaluate responses to interventions; and as a screening tool for high-risk, high-stress activities or occupations.[36] The initial intent was to use the scale with patients suffering from mental illness. The CD-RISC targets five factors: personal competence; trust/tolerance/strengthening effects of stress; acceptance of change and secure relationships; control; and spiritual influences. The tool has been shown to have convergent and discriminant validity and to be reliable in multiple nationalities and populations.[37,38]

While it is one of the most widely used instruments for resilience, the CD-RISC may have some limitations, specifically a "ceiling effect." In other words, the scale's lack of items to detect higher levels of resilience characteristics as variables and of its capacity to measure higher levels of resilience limits its usefulness in analyzing certain professions known for higher levels of resilience, and thus may be deficient.[39]

Perceived Stress Scale

The Perceived Stress Scale (PSS) measures the degree to which situations in one's life are viewed as stressful. This tool was designed with the intent of creating a psychometrically sound global measure of perceived stress that could provide information on the relationship between stress and pathology.[40] The PSS has been widely used across the globe and most frequently with university students and those attempting to stop smoking. There are multiple studies on resident physicians who have used the PSS as an assessment of their well-being. In several of these studies, perceived overall stress was strongly related to work hours and was found to affect physicians more than other healthcare professionals (e.g., nurses).[41] Resident physicians who screen positive for burnout also have higher perceived levels of stress, a pattern similarly shown in faculty physicians.[42,43] Resident physicians have also been noted to have higher perceived levels of stress than matched controls in the general population.[43] In several studies with nurses and faculty physicians, implementation of a resiliency program has shown improvement in scores on the PSS.[44-46]

The PSS is a highly reliable and valid measure of stress in adults across multiple ethnicities. It provides individuals insight into their typical stress-response state. This awareness, in turn, may potentially increase mindfulness and be used to target relaxation behaviors to relieve stress. A potential limitation of the PSS is that the initial intent of the tool was to link stress to pathologic behavior, particularly tobacco abuse. However, many studies in the medical literature have used the PSS to assess patients pre- and post-intervention for multiple disease processes. If one considers burnout symptoms pathological insofar as they have been linked to issues such as substance abuse, medical error, and poor patient satisfaction, then this limitation is of debatable significance.

Coping Inventory to Stressful Situations

The Coping Inventory to Stressful Situations (CISS) measures three types of coping styles when one encounters a stressful or challenging situation: emotion-oriented; task-oriented; and avoidance-oriented coping. It also measures distraction and social diversion. The tool is aimed at determining an individual's preferred coping style to provide a better understanding of the relationship between that individual's coping style and his or her personality. The results can be used to help intervention planning for individuals in stressful situations. There is also a modified 21-item tool for specific social situations or interpersonal conflicts (CISS: Situation- Specific Coping Measure [CISS:SSCM]).

The CISS and CISS:SSCM are reliable measures of coping styles, demonstrating internal consistency, test-retest reliability, and item-remainder correlation. The CISS scales also have demonstrated construct validity as assessed by factor analysis in adults, undergraduates, and adolescents.[47] Data from the study of medical students and physicians in practice have shown that task-oriented coping plays a role in reducing burnout symptoms, while emotion-oriented and avoidance-oriented coping may do the opposite. Therefore, the CISS may be a valuable tool in identifying individuals who may require additional training in specific coping strategies to improve their resilience and/or reduce their risk of burnout.[48]

In a study of 616 emergency department (ED) personnel, increased levels of burnout were associated with emotion-oriented coping while decreased levels were observed in those with task-oriented coping.[49] This was also demonstrated in a study of 50 IM physicians.[50] The CISS has also been used to study medical students, demonstrating a correlation of task-oriented coping with higher levels of emotional intelligence.[51] Emotional intelligence – the ability to perceive, process, and regulate emotions effectively – is thought to be a strong predictor of resident well-being.[52] Two other studies of medical students found that avoidance-oriented coping was associated with increased measure of fatigue and depressive symptoms.[53,54]

The Ways of Coping Checklist, the Ways of Coping (Revised), the Ways of Coping Scale

The Ways of Coping Scales (WCCL, CAPS, WAYS) identify two distinct, general types of coping: problem-focused and emotion-focused. Problem-focused coping is aimed at problem solving or doing something to alter the source of stress. Emotion-focused coping is aimed at reducing or managing the emotional distress that is associated with or cued by the situation. While most stressors will elicit both types of coping, problem-focused coping tends to predominate when the individual feels as if

something constructive can be done, leading to engagement of the problem, and emotion-focused coping predominates when the individual believes the stressor is something that must be endured, leading to problem avoidance and disengagement.[55,56] The Ways of Coping measures are not designed to assess coping traits and/or style. Each administration of the tool is aimed at understanding the coping processes an individual engages in a particular stressful encounter rather than attempting to define their coping style or traits.

The CAPS measure has potential benefit in prospectively identifying individuals with more emotion-focused coping strategies who may be at risk of burnout. Its main limitation is that this tool is situation-specific and does not reflect the complexity of the situations in medical practice nor encompass the entirety of an individual coping skillset. Its strength lies in making an individual aware of how he or she copes with different, specific, stressful situations and providing language around coping responses that may be more mindful, healthful, and productive for them, their team, and their patients.

Coping Orientation to Problems Experienced

The Coping Orientation to Problems Experienced (COPE) Inventory and, more recently, the Brief COPE were designed to assess the different ways in which people respond to stress. This tool looks at many dimensions of coping, including both functional and dysfunctional responses. These dimensions include the following: active coping; planning; suppression of competing activities; restraint coping; seeking social support for instrumental reasons; seeking social support for emotional reasons; focusing on and venting emotions; behavioral disengagement; positive reinterpretation and growth; denial, acceptance; and turning to religion.[59,60]

The COPE Inventory was validated in a population of almost 1,000 undergraduate students in its final iteration. The authors state there is no such thing as an "overall" score on this measure and do not recommend a particular way of generating a dominant coping style for a given person. Instead, they advocate looking at each scale separately to see how it relates to the other variables. Thus, this tool may help with insight into coping response and personal reflection.

The Brief COPE has been used in studies involving IM and EM residents. In the study with IM residents, those residents who employed the strategies of acceptance, active coping, and positive reframing had lower emotional exhaustion and depersonalization, suggesting that residents who place a high priority on healthful relationships, engage in spiritual activities, and practice humility may have important coping mechanisms that mitigate burnout.[56,58,59] Residents who employed denial, disengagement, self-blame, and humor were found to have higher emotional exhaustion and depersonalization. Disengagement and venting were found to be negatively correlated with personal accomplishment.

These tools are relatively short, free, and easy to use. They provide individuals with insight into their typical coping responses, thereby increasing mindfulness. Although used in physician populations, they have not been validated specifically in physician populations.

Mood and Personality Tools

Personality typing is a psychological concept popularized in the 1940s. Conceptually, it is founded on the notion that individuals favor certain psychological preferences and that personality traits affect how they perceive and interact with their environments. The ED is a unique medical environment where there is great emphasis on leadership, communication, and teamwork. The application of personality and mood assessment instruments may provide useful information about individual ED providers and create a more dynamic, efficient, and sound working environment.

Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) is the most widely used of the personality assessment tools. This introspective, self-assessment tool separates people into four dichotomies that each focus on a particular aspect of information processing: extraversion/introversion; sensing/intuition; thinking/feeling; and judging/perceiving. In the medical community, the MBTI has been studied in medical students, dental students, and resident and attending physician populations, primarily among surgeons and anesthesiologists. Many researchers have applied the MBTI to assess for personality patterns among different specialties and identify personalities at increased risk for burnout.[61-64] While the MBTI is the oldest and most well-studied in the physician population, it has yet to be shown how MBTI results can be implemented to benefit individual practitioners and the work environment.

Profile of Mood States

The Profile of Mood States (POMS) is a self-report, psychological rating scale that assesses multiple dimensions of mood over a distinct period of time. Such mood states include the following: anger-hostility, confusion-bewilderment, depression-dejection, fatigue-inertia, tension-anxiety, vigor-activity, and friendliness. The dynamic nature of the assessment may allow for real-time evaluation for risks of burnout and second- victim syndrome following an unforeseen or unfavorable outcome.

While the tool has been used in several physician populations,[65-71] it is not well validated in the medical field.[72-76] The enthusiasm of IM interns was found to give way to sustained depression, anger, and fatigue at the end of internship.[67] A study of early-career physicians showed that acute sleep deprivation secondary to long call hours negatively affected mood.[65] In one study of IM residents, mood disturbances were identified as common, and the decline in

empathic concern was specifically found to persist throughout training unlike other mood disturbances that were no longer present by the end of residency.[67]

Thomas-Kilmann Conflict Mode Instrument

The Thomas-Kilmann Conflict Mode Instrument (TKI) is a self-assessment tool that identifies individual conflict-handling styles, which are categorized into five "modes:" competing, collaborating, compromising, avoiding, and accommodating. Conflict is inevitable in any team-based field due to personality and work-style differences. EPs manage the expectations and reactions of patients in crisis. Patient-centered care requires collaboration between the clinicians, patients, family, and other providers, which may lead to another source of conflict.

The TKI has been validated in the medical population including nurses, residents, board-certified physicians, hospital administrators, and program directors, although not specifically among emergency clinicians.[77-80] In studies of resident physicians, there is a tendency for higher levels of accountability and successful execution of administrative tasks in individuals with collaborating or competing conflict modes.[78,79] Identifying individual conflict-management styles, the TKI can help provide insight to EPs regarding their strengths and potential weakness in dealing with conflict, which may ultimately help them become better leaders in the department and better team players.

LIMITATIONS

There are an overwhelming number of assessment tools available in the literature that can be used to measure the different components of physician well-being. While our literature search was methodical and broad, we acknowledge that we may have missed some key assessment tools. At times, a single author determined the inclusion eligibility of the tools identified in our literature search strategy. However, consensus between at least two reviewers was required for an instrument to be included in this paper.

Assessment tools must be suitable for and validated in the population of interest. A majority of the tools we found have been used in a physician population but have never been validated in this population. Many of the tools have been designed for and validated in special populations; however, their applicability, reliability, and validity in a physician population is not clearly demonstrated in the medical literature. In the absence of independent validation, the results of these tools should be interpreted with caution.

Physician well-being is multifactorial, and it is difficult to purely divide these components by topic or sub-category as they have a complex interplay with one another. We have reviewed the tools based on the well-being topics that were most commonly found in the medical literature and that were of highest potential value. Very few tools exist that were either designed for use in a physician population or have been validated in physicians. We have highlighted the tools from each topic that are most relevant for use in assessing an EP population.

CONCLUSION

Physician well-being is a complicated topic, and there is no standardized approach for assessing it. We provide a framework of the assessment tools that can be used to evaluate the positive states of physician well-being. The assessment tools reviewed vary in the topic assessed, cost, length, and applicability to a physician population. This manuscript is intended to provide the reader with several available options for evaluating different components of physician well-being. It is at the discretion of the reader to determine which tool would be most appropriate for the outcome he or she is trying to measure. There is great opportunity for the development of new tools and validation of those that are already in use.

There is clearly much to be done in the development of resources to mitigate burnout, foster resilience, and improve well-being. When undertaking an assessment of physician well-being, it is of critical importance to understand what you want to assess and to ensure you have selected the best tool to assess it. We hope this manuscript gives emergency physicians a starting point to evaluate their own well-being and the well-being of their peers, trainees, and students.

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Emergency Medicine Physician Assistant (EMPA) Postgraduate Training Programs: Program Characteristics and Training Curricula

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Dear Editor:

The Society of Emergency Medicine Physician Assistants (SEMPA) read with great interest the article titled "Emergency Medicine Physician Assistant (EMPA) Postgraduate Training Programs: Program Characteristics and Curricula" by Kraus et al.[1] We appreciate the authors conducting research describing EMPA postgraduate training program characteristics and agree that more research is needed in this field. As the largest national organization representing EMPAs, we would like to expand on a few points regarding these programs and overall EMPA practice.

Kraus at al. write that based on their research, there is an opportunity for the development of a standardized curriculum for postgraduate training programs. SEMPA also recognized this opportunity and our Postgraduate Education Committee, which is comprised of EMPA postgraduate program directors from across the country, in 2015 developed and released EMPA postgraduate training program standards.[2] The standards are designed to serve as a guideline for new and existing programs in an effort to standardize EMPA postgraduate education.

The authors also mention that emergency physicians (EPs) have certification and re-certification exams, lifelong learning through maintenance of certification activities and that EMPAs do not have continuing education requirements. Like EPs, EMPAs have certification and re-certification requirements. We are required to pass the Physician Assistant National Certifying Examination (PANCE) offered by the National Commission on Certification of Physician Assistants (NCCPA). To maintain certification, physician assistants (PAs) are required to earn 100 credits of continuing medical education (CME) every two years and pass a re-certification exam every 10 years.[3] SEMPA also recommends that EMPAs complete at least 50% of their CME in emergency medicine (EM).[4]

In the paper, there is a statement about how there is the lack of a specialty-specific certifying examination. Since 2011, the NCCPA has offered specialty certification in the form of an Emergency Medicine Certificate of Added Qualifications (CAQ), which requires specific CME hours, patient care experience, procedural experience, and passing an emergency medicine specialty exam.[5]

The authors state that there is voluntary accreditation through the Accreditation Review Commission on Education for the Physician Assistant (ARC-PA). Unfortunately, there is currently no accreditation process for PA postgraduate training programs. Previously, ARC-PA did accredit postgraduate training programs. However, in 2014 ARC-PA placed the accreditation process in abeyance.[6] There has been discussion that ARC-PA may resume postgraduate training program accreditation in 2019, though nothing has been confirmed.

During their study, Kraus et al. identified 29 EMPA postgraduate training programs. Since their data collection period from October 2016 to February 2017, more programs have started and about 40 programs are currently in existence.[7-9] The growth of these programs highlights the needs of the workforce along with PAs seeking more specialized training.

Finally, SEMPA would like to recognize that completing a postgraduate training program is one but not the only pathway for PAs entering EM. While Kraus et al. write that there are no EM-specific standards or competencies for EMPAs, SEMPA has previously addressed this by recommending that PAs without EM experience seek appropriate experience and education, document their learning and procedures, consider the CAQ when eligible, obtain basic certifications (ACLS, PALS, ATLS, etc.) and participate in the specialty through membership in SEMPA.[4]

Whether EMPAs complete a postgraduate program or receive on-the-job training/experience, they are valuable members of the emergency care workforce committed to partnering with EPs.

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Rapid Discharge After Interfacility Transfer for Mild Traumatic Intracranial Hemorrhage: Frequency and Associated Factors

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Introduction: Traumatic intracranial hemorrhage (TIH), brain injury with radiographic hemorrhage, is a common emergency department (ED) presentation, and encompasses a wide range of clinical syndromes. Patients with moderate and severe neurotrauma (Glasgow Coma Scale [GCS] < 13) with intracranial hemorrhage require care at a trauma center with neurosurgical capabilities. However, many patients with mild traumatic intracranial hemorrhage (mTIH), defined as radiographic bleeding and GCS ≥ 13, do not require operative intervention or intensive care unit monitoring, but are still routinely transferred to tertiary care centers. We hypothesized that a significant proportion of patients are managed non-operatively and are discharged within 24 hours of admission.

Methods: This was a retrospective, observational study of consecutive patients age ≥ 16 years, GCS ≥ 13 who were transferred to an urban, medical school-affiliated, 100,000 annual visit ED over a seven-year period with blunt isolated mTIH. The primary outcome was discharge within 24 hours of admission. We measured rates of neurosurgical intervention, computed tomography hemorrhage progression, and neurologic deterioration as well as other demographic and clinical variables.

Results: There were 1079 transferred patients with isolated mTIH. Of these, 92.4% were treated non-operatively and 35.8% were discharged within 24 hours of presentation to the tertiary ED. Patient characteristics associated with rapid discharge after transfer include a GCS of 15 (odds ratio [OR] 2.9, 95% confidence interval [CI], 1.9 – 4.4), subdural hematoma ≤ 6mm (OR 3.1, 95% CI, 2.2 – 4.5) or the presence of an isolated subarachnoid hemorrhage (OR 1.7, 95% CI, 1.3 – 2.4). Of patients with length of stay < 24 hours, 79.8% were discharged directly from the ED or ED observation unit.

Conclusion: Patients transferred to tertiary care centers are frequently discharged after brief observation without intervention. Risk can be predicted by clinical and radiographic data. Further prospective research is required to determine a safe cohort of patients who could be managed at community sites. [West J Emerg Med. 2019;20(2)307–315.]

INTRODUCTION

Traumatic intracranial hemorrhage (TIH) is common and encompasses a wide variety of clinical syndromes. There were an estimated 2.5 million emergency department (ED) visits for traumatic brain injury (TBI) in 2010, with the rate of TBI visits having increased eight-fold more than the rate of total ED visits during that time.[1] Patients with TIH have TBI with an associated radiographic finding, usually on computed tomography (CT) imaging. Multiple different types of lesions, including subdural hematoma (SDH), traumatic subarachnoid hemorrhage (SAH),

cerebral contusions and epidural hematomas, make up the broader group of TIH. Importantly, each of these disease subtypes has a unique clinical trajectory, which depends on both the type of lesion and the severity of injury at presentation.[2,3]

In organized trauma systems, patients are routinely transferred to tertiary care centers. Trauma systems reduce mortality for patients with severe injuries[4] by providing these critically ill patients rapid access to specialized physicians and care environments.[5] In the hub-and-spoke model of trauma care, emergency medical services protocols aid in the primary triage of injured patients to a local hospital (spoke) vs direct transportation to a Level I trauma center (hub). Emergency physicians or trauma surgeons at spoke sites must determine which patients have severe injuries or require specialized consultation that warrants transfer to the hub. This transfer decision is not as rigorously defined as those for the prehospital providers. Advanced Trauma Life Support provides some guidance, but lack of routine protocols means that much is done based on physician gestalt and historic clinical practice.

While validated guidelines exist to aid the decision to image patients with head trauma,[6] the subsequent disposition of patients who are diagnosed with TIH is not as clear. There is ample evidence to support the transport of individuals with severe and moderate TBI (Glasgow Coma Scale Score [GCS] <12)[7,8] to a trauma center for evaluation by a neurosurgeon and management in an intensive care unit (ICU).[9] Clinicians extrapolate this transfer practice and also routinely transfer patients with mild traumatic intracranial hemorrhage (mTIH), defined as having intracranial hemorrhage (IH) with a GCS of 13-15, though there is growing evidence that some patients with mTIH may be able to be managed in lower resource settings.[2,10-12] However, a relative lack of resources, including advanced monitoring capabilities or neurosurgical backup, as well as clinical experience, may make community providers understandably hesitant to defer transfer and monitor these patients at the presenting facility.

Rapid discharge after transfer (RDAT) is a relatively common phenomenon.[13-15] In one study over a two-year period at a Level I trauma center, 24% of patients transferred after injury were discharged within 24 hours of admission; orthopedic injuries and head trauma were the top two organ systems in patients found to be quickly discharged.[16] There has been no prior investigation evaluating RDAT solely in patients with mTIH. Given the frequency with which these patients are transferred and their heterogeneous clinical prognosis, this is likely a population in which a better understanding of risk could be used to streamline care processes.

This study attempted to quantify the frequency of RDAT in a retrospective cohort of patients. We hypothesized that a substantial percentage of patients transferred to the tertiary facility would be non-operatively managed and discharged within 24 hours of their transfer. Our secondary objective was to identify clinical and radiographic factors associated with RDAT. Additionally, we explored the association of these factors with other clinical endpoints, including death, neurosurgical intervention and evidence of worsening on CT imaging.

Population Health Research Capsule

What do we already know about this issue?
Most patients with traumatic intracranial hemorrhage (TIH) and Glasgow Coma Scale Score ≥ 13 transferred for neurosurgical consultation do not require operative intervention or intensive care unit admission.

What was the research question?
What percentage of patients with mild traumatic intracranial hemorrhage (mTIH) are discharged within 24 hours post neurosurgical evaluation/observation?

What was the major finding of the study?
Of 1079 transferred patients with isolated mTIH, 35.8% were discharged within 24 hours of emergency department presentation.

How does this improve population health?
Streamlining mTIH care by improving use of community hospital resources can concurrently unburden trauma centers, decrease costs, and reduce family inconvenience.

METHODS

Study Design, Setting and Participants

This was a retrospective, observational study performed at a single urban, academic Level I trauma center with an annual ED volume of over 100,000 visits. Patients age ≥16 with blunt head trauma were identified by running a query of a proprietary electronic health record (EHR) using the *International Statistical Classification of Diseases and Related Health Problems* (9th ed.) codes for TIH (852.00-853.10, 851.00-851.90, 800.00-801.9, 803.00-804.9) from January 1, 2009, through December 31, 2015. We excluded patients who had a GCS ≤ 12. Individuals with trauma to other organ systems (defined as requiring a consultation with a service other than neurosurgery) were then excluded to create a subgroup of individuals with isolated cranial trauma. We reported data as recommended by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[17]

Data Collection

We created a data entry form and stored the data in Microsoft Access (Microsoft Corporation, Redmond, Washington). After the initial database query of the EHR was conducted and we excluded ineligible patients (defined above), chart data were abstracted from physician notes, radiology reports, laboratory data, and discharge summaries into a standardized data collection instrument. Four trained emergency physician reviewers who were not blinded to the study hypothesis abstracted clinical data. Abstractor output was reviewed after the first 100 charts, and again at intervals throughout the review process. Reviewers met periodically to review the abstraction process; ambiguous charts were reviewed at that time. A senior investigator monitored the progress of the abstractors. Conflicting abstraction was resolved by consensus of the primary investigators after in-depth chart review. For patients discharged from the ED or the ED observation unit (EDOU), records were reviewed for any subsequent TIH-related admissions. No data were missing for any of the key clinical variables. We gave priority to real-time data over summary data. A subset of data for the clinical outcome variables was abstracted by a second, board-certified emergency physician, and inter-rater reliability was assessed using kappa statistics calculated for key variables.

Data collected included age, gender, insurance status, transferring hospital, disposition from the ED, hospital length of stay (LOS), admitting service, anti-platelet use (aspirin and other anti-platelet agents), daily anticoagulant (warfarin, novel oral anticoagulant [NOAC]) use, mechanism of injury, pre-transfer GCS, GCS at the time of initial neurosurgical evaluation, initial cranial CT results, follow-up CT results, neurosurgical exam at admission (mental status, cranial nerve exam, strength exam, sensation exam), neurosurgery recommendations (surgery including burr hole drainage, intracranial pressure monitoring, pharmacotherapy, platelet administration, anticoagulation reversal, routine repeat head CT), neurological deterioration (worsening of reported symptoms, seizures, change in neurologic examination including lethargy, somnolence, agitation, delirium, new focal deficit, seizures, worsening headache, nausea or vomiting), and neurosurgical procedures performed. Clinical historical and physical exam variables were gathered from the initial emergency medicine and neurosurgery notes.

We abstracted clinical course and information reflecting overall trauma burden (other organ systems) from hospital discharge summaries. Follow-up information after discharge was collected from visit notes from the hospitals and medical practices in the healthcare system. Cranial CT results were abstracted from the finalized attending radiologist reports. The number, location and size of hematoma(s) were noted, along with the presence of midline shift. We counted confluent hematomas as a single lesion (e.g., a frontoparietal SDH). As is routine at the study hospital, patients transferred from an outside hospital had their scans uploaded and interpreted by in-house radiologists and these interpretations were coded as the first CT finding. Radiographic data were abstracted separately using a different data form in order to blind the abstractor to the rest of the patient's clinical information and outcomes.

Per protocol at the study hospital, all patients with TIH received a neurosurgical consultation. Patients routinely underwent repeat neuroimaging at six hours and subsequently as indicated by the treating team. Initial disposition of these patients was governed by an institutional head trauma guideline, which considers patient and scheduling factors. This first separates out patients with isolated mild head injury who are stable for monitoring in an EDOU; patients could also be placed in observation at the discretion of the emergency physician or neurosurgical attending physician. Subsequently, patients with multisystem traumatic injuries were admitted to the trauma surgery service while those with isolated non-operative head trauma (patients outside of EDOU criteria for SDH < 10mm, GCS 15) were admitted on a rotating basis to the neurosurgery, trauma surgery or neurology services. The hospital's institutional review board approved this study.

Analysis

We performed an initial univariate analysis looking at the association between individual factors and discharge in less than 24 hours using chi-square tests. Multivariate logistic regression analysis used variables that were significant in the univariate analysis at $p \leq 0.2$. We then removed variables in a forward stepwise fashion using Statistical Package for the Social Sciences version 21 (IBM Corporation, Armonk, New York).

RESULTS

The patient selection process is summarized in Figure 1. There were 1079 patients enrolled with isolated mTIH who were transferred for neurosurgical evaluation and further treatment. Table 1 compares clinical characteristics of patients whose LOS was equal to or greater than 24 hours with the RDAT patients. Table 2 summarizes the CT findings, clinical outcomes and dispositions of these two groups. Inter-rater reliability was excellent for the clinical outcome variables. We routinely did repeat CTs to document intracranial hemorrhage (ICH) stability, and patients in the < 24-hour LOS group had a mean of 2.1 CTs (range 2-5) performed during their admission while patients who had a LOS > 24 hours had a mean number of 2.7 CTs (range 2 – 14). Patients undergoing neurosurgical intervention account for the wider range as we measured all brain imaging during the admission period including post-operative imaging. LOS in our cohort is described in Figure 2. The median LOS for this cohort was 47 hours. LOS was not significantly different when compared for each year of the seven-year study period (p=0.42). Patients with prolonged LOS represent a cohort of more complex medical conditions and debilitation that was the major contribution to their fall

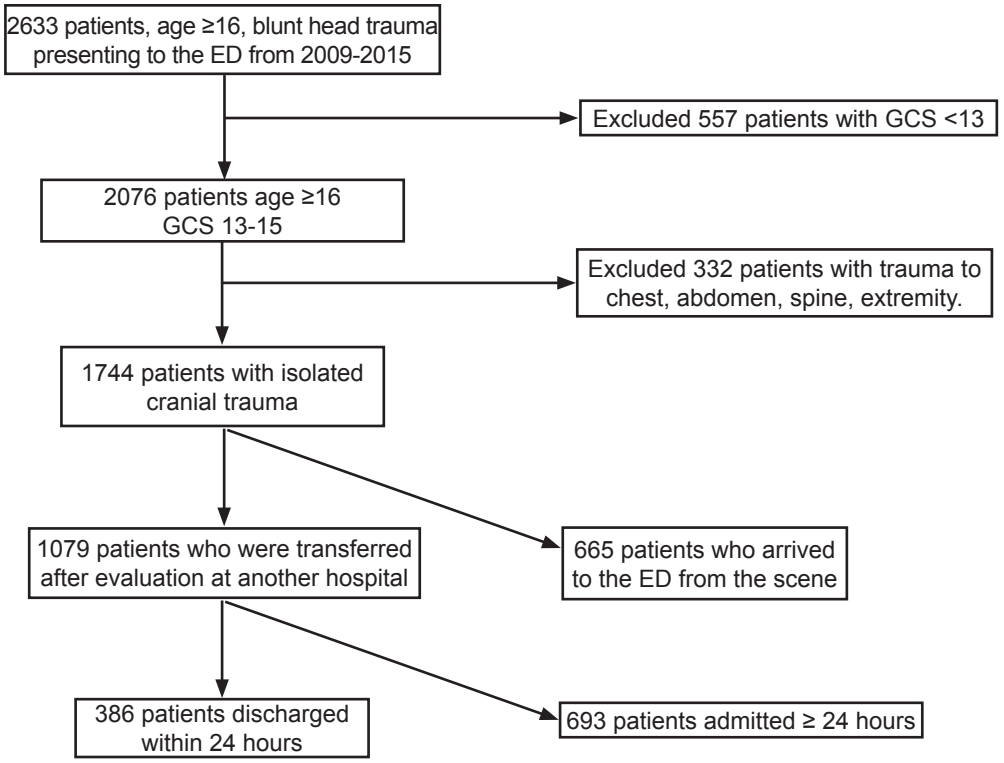

Figure 1. Flow chart summary of patients enrolled into the study. *ED,* emergency department; *GCS,* Glasgow Coma Scale Score.

and subsequent ICH. Evaluation and treatment of their underlying medical issue (eg.., syncope, infection, cancer) and obtaining a safe discharge plan (rehabilitation bed or skilled nursing facility) were shared themes in these patients. Kappa values were 1.0 for need for neurosurgical intervention, 0.88 for radiologic worsening and 0.86 for the neurologic deterioration variable. Because LOS was an administrative variable, kappa values were not calculated.

The primary objective was to quantify the rate of RDAT in patients transferred with mTIH: 386 patients (35.8%) were discharged within 24 hours after transfer. Multivariate logistic regression identified three variables associated with a RDAT: GCS of 15, isolated traumatic SAH, and a SDH whose thickness was 6mm or less (Table 3). Most RDAT patients were either discharged directly from the ED or from the EDOU. Ten patients in the RDAT group received fresh-frozen plasma for vitamin K antagonist reversal. As anticipated, none of the patients discharged within 24 hours required ICU admission, intubation or a neurosurgical intervention. Additionally, 50.6% of mTIH patients were discharged within 48 hours. There were no patients who suffered a neurologic deterioration during transfer from the first to the second hospital.

Two transferred patients died within 24 hours of transfer. The first was a 92-year old-female with critical aortic stenosis and congestive heart failure (CHF) who had multiple falls and was found to have a 3-millimeter SDH and small amount of SAH. She developed respiratory distress, had a "do not resuscitate/intubate" code status and was admitted for comfort care/CHF; she passed away with respiratory failure. The second patient was a 93-year-old male with lung cancer, pulmonary fibrosis and a pacemaker who fell and struck his head. He had subarachnoid blood on his CT. He had pacer malfunction with complete heart block, and given his "do not resuscitate" status and a discussion with his family he was made comfortable, admitted, and then passed away.

Follow-up information was available in 85.3% (with 83% of follow-up occurring greater than 30 days after the index visit) of all patients and 76% of patients discharged from the ED or EDOU (with 87% of follow-up occurring greater than 30 days after the index visit). There were no noted deaths within 30 days. Eight patients returned to the ED with a complication related to their intracranial hemorrhage, and five patients were admitted. Three patients had delayed, planned neurosurgical procedures after discharge. These cases are further detailed in the Appendix.

DISCUSSION

mTIH is a relatively common diagnosis and, while there is ample evidence showing that mTIH is primarily treated non-

Table 1. Patients discharged within 24 hours after interfacility transfer when compared to patients with longer length of stay clinical variables.

	Discharged within 24 hours N=386	LOS ≥ 24 hours N=693	Comparison		
	%	%	OR	95 CI	P value
Demographic/history					
Age≥60	54.1	72.6	2.2	1.7-2.9	< 0.0001
Male sex	55.2	56.1	1.0	0.8-1.3	0.7
Aspirin use	17.1	28.7	1.9	0.1-2.7	< 0.0001
Warfarin use	4.2	12.4	3.3	1.9-5.7	< 0.0001
Other Anti-platelet	2.6	4.8	1.9	0.9-3.9	0.08
NOAC	0.3	0.1	0.6	.03-8.9	1.0*
HTN	40.2	48.1	1.4	1.1-1.8	0.01
Intoxicant	17.6	14.1	0.8	0.5-1.1	0.13
Insurance					
Private	52.3	35.4	0.5	0.4-.6	< 0.0001
Medicare	36.8	53.9	2.0	1.6-2.6	< 0.0001
Medicaid	6.5	6.6	1.03	0.6-1.7	0.9
Self-pay	4.4	4.0	0.9	0.5-1.7	0.7
Mechanism					
Fall	72.3	83.1	1.9	1.4-2.5	< 0.0001
MVC	7.3	4.3	0.6	0.3-.9	0.04
Assault	13.2	6.2	0.4	0.3-.7	< 0.0001
Pedestrian struck	0.8	1.4	1.9	0.5-6.8	0.39*
Bicyclist struck	4.2	1.6	0.4	0.2-.8	0.009
Motorcycle collision	1.6	1.6	1.0	0.4-2.8	1.0
GCS					
15	91.5	77.5	0.32	0.2-.5	< 0.0001
14	7.5	16.2	2.4	1.5-3.6	< 0.0001
13	1.1	6.4	6.5	2.3-18	< 0.0001
Clinical outcomes					
Neurologic event	1.0	8.9	9.4	3.4-26	< 0.0001
Repeat CT worse	2.9	10.1	3.8	2-7.3	< 0.0001
Neurosurgical intervention	0	11.8	n/a	n/a	< 0.0001[f]
Death	0.5	2.9	5.7	1.3-24.5	< 0.0001

LOS, length of stay; *OR,* odds ratio; *CI,* confidence interval; *NOAC,* non-vitamin K antagonist oral anticoagulants; *HTN,* hypertension; *MVC,* motor vehicle collision; *GCS,* Glasgow Coma Scale Score; *CT,* computed tomography.
*P value in some cases is significant for discharge within 24 hours, and in other cases for >24 hours.
[f]Fisher exact test.

operatively,[2,3,11] the remainder of management of these patients, including which subgroups need repeat imaging, ICU monitoring and transfer to tertiary trauma centers, remains unclear. Given the lack of clear, evidence-based guidelines, management of patients with mTIH may present an interesting opportunity to optimize resources. This study takes the first step toward creating a framework for transferring head-injured patients by examining the outcomes of patients transferred to a single Level I trauma center, along with factors associated with RDAT.

RDAT was common after transfer of patients with mTIH, occurring in greater than one-third of transferred patients. While this is the first study to evaluate the transfer of patients with mTIH, other studies examining the utility of trauma transfer have shown similar rates of expedited discharge, ranging from 6% to 39%.[14,15,18] These data reflect the fact that mTIH patients behave similarly to other mildly injured trauma patients, and that TIH alone without change in mental status does not pose an increased risk compared to other trauma patients. Additionally,

Table 2. Patients discharged within 24 hours after interfacility transfer when compared to patients with longer length of stay: radiologic findings and disposition variables.

	Discharged within 24 hours N=386	LOS ≥ 24 hours N=693	Comparison		
	%	%	OR	95% CI	P value
CT lesions (all)					
Any SAH	45.6	48.2	1.1	0.9-1.4	0.4
Any SDH	52.6	66.2	1.8	1.4-2.3	< 0.0001
Any EDH	2.9	3.9	1.4	0.7-2.8	0.4
Any contusion	22.0	28.0	1.4	1.0-1.8	0.03
Any skull fracture	14.3	15.3	1.1	0.8-1.5	0.6
CT lesions isolated					
Isolated SAH	25.9	17.0	0.6	0.4-0.8	< 0.0001
Isolated SDH	34.5	36.2	1.1	0.8-1.4	0.5
Isolated EDH	0.5	0	1.0[f]		1.0[f]
Isolated contusion	9.1	7.7	0.8	0.5-1.3	0.5
Isolated skull fracture	4.2	2.2	0.06	0.2-1	0.06
Depressed skull fracture	0.5	0.6	1.1	0.2-6	1.0[f]
SDH ≥ 6mm	12.7	26.0	2.4	1.7-3.4	< 0.0001
SDH ≥ 10 mm	5.2	19.0	4.3	2.6-7	< 0.0001
Any SDH midline shift	5.4	16.7	3.5	2.2-5.7	
Disposition					
ICU admission	0	19.1	<0.0001	2.8-5.0	< 0.0001
Floor admission	19.2	60.6	3.7	0.3-0.5	< 0.0001
EDOU	38.1	18.9	0.4	0.01-0.04	< 0.0001
Treated/released	41.7	1.4	0.02		< 0.0001
AMA/LWCT	1.0	0	0.02[f]		0.02
Admitting services					
Trauma	6.0	20.4	4.0	2.5-6.4.0	< 0.0001
Neurosurgery	3.4	24.9	9.5	5.3-17.0	< 0.0001
Neurology	7.8	22.8	3.5	2.5-5.3	< 0.0001
Medicine	1.6	11.1	7.9	3.4-18.3	< 0.0001
Pediatrics	0.5	0.4	0.8	0.1-5.0	1.0[f]
Emergency/EDOU	38.1	18.9	0.4	0.3-0.5	< 0.0001
Emergency/discharged	41.7	1.4	0.02	0.01-0.04	< 0.0001
AMA/LWCT	1.0	0	0.02[f]		0.02[f]

LOS, length of stay; *OR,* odds ratio; *CI,* confidence interval; *CT,* computed tomography; *SAH,* subarachnoid hemorrhage; *SDH,* subdural hematoma; *EDH,* epidural hemorrhage; *ICU,* intensive care unit; *EDOU,* emergency department observation unit; *AMA,* against medical advice; *LWCT,* left without completing treatment.
P value in some cases is significant for discharge within 24 hours, and in other cases for >24 hours.
[f] Fisher's exact test.

the high rate of rapid discharge, coupled with the fact that only 1% of patients returned with delayed or missed injuries, indicates that a carefully identified cohort of these patients might be able to be managed in a community setting.

Patients with traumatic SAH (tSAH) are at particularly low risk. It has been suggested that tSAH is a benign entity that can be treated as a concussion.[19] The same conclusion was reached in another series of 120 tSAH patients admitted to an EDOU.[2] This subject has also been the focus of a recent meta-analysis of over 15,000 tSAH patients.[20] Since tSAH are not expansile surgical lesions, it is expected that patients with isolated tSAH would have decreased need for intervention when compared to SDH, which can exert pressure and cause the brain to shift.

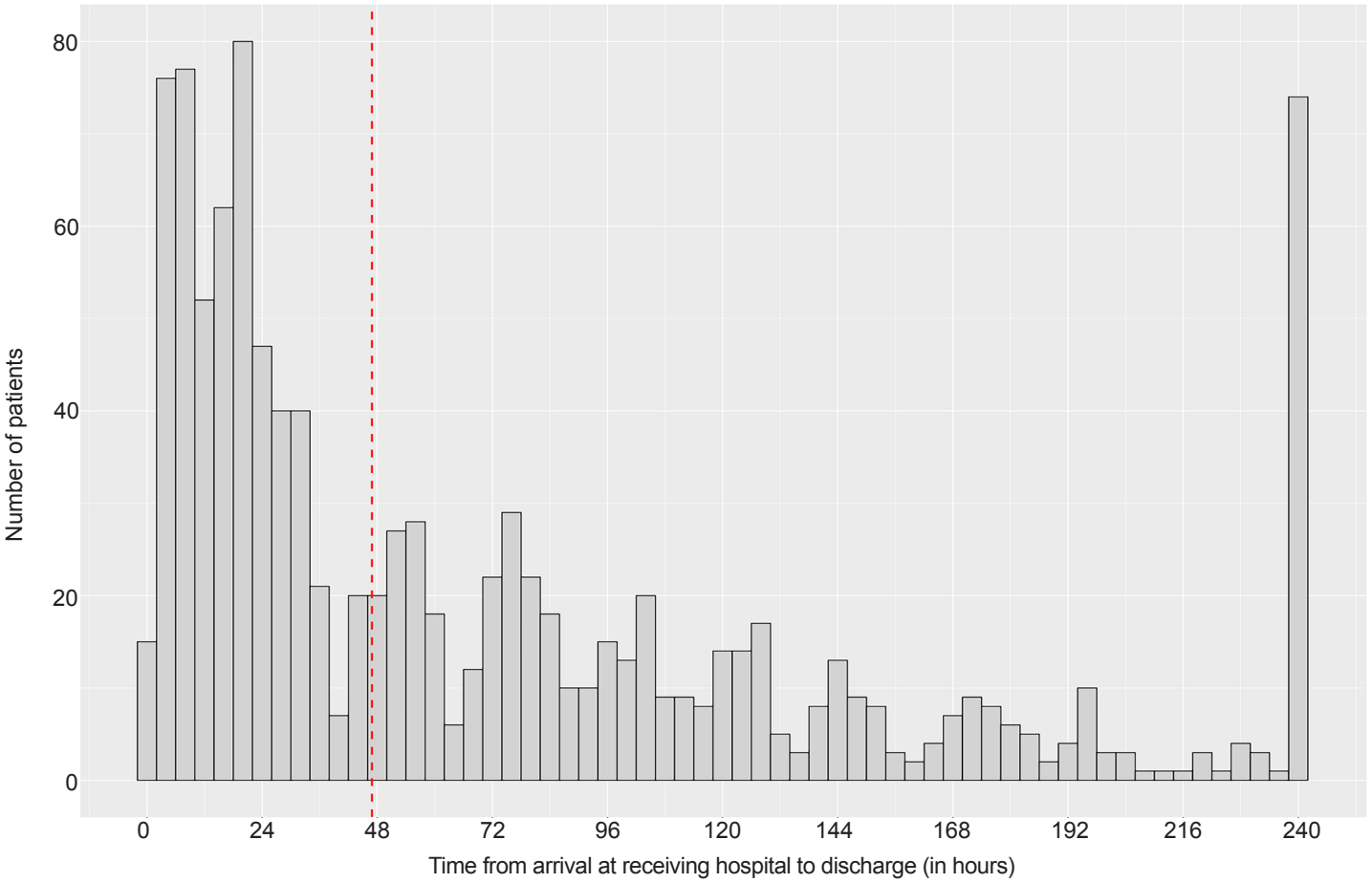

Figure 2. Distribution of hospital length of stay for transferred patients with traumatic intracranial hemorrhage and GCS ≥ 13.
GCS, Glasgow Coma Scale Score.
Dashed line indicates the median length of stay.

It is surprising that coagulopathies were not prominently represented as a high-risk variable in this report. Many patients who were on warfarin had attempted reversal with vitamin K and fresh frozen plasma (FFP) prior to transfer. Additional FFP was used in the ED if the international normalized ratio had not decreased to less than 1.4. During this study period, it was also a standard neurosurgical recommendation to transfuse dose of platelets for any patient on anti-platelet drugs including aspirin. These interventions may explain why there were not more negative outcomes in coagulopathic patients. It may be that CT stability after complete reversal doesn't impart any more risk than in a patient who never had abnormal bleeding parameters. Our study had few patients on NOACs, so conclusion and comments on the effects of these drugs are beyond the scope of this paper.

This idea of delayed transfer of patients with mTIH is not a new one and came out of necessity given distances between some hospitals and the closest regional trauma center. Levy reports on a non-transfer protocol for patients with GCS 13-15 and with available consultation and CT image review with a neurosurgeon at a nearby Level I trauma center.[21] An Israeli study of three trauma centers without neurosurgical backup demonstrated that teleconsultation and clear, imaging-specific transfer protocols could drastically reduce transfer frequency.[22] Finally, Rhee and colleagues demonstrated the safety an mTIH protocol that included a six-hour observation period without neurosurgical consult or routine, repeat head CT.[23]

There are several barriers to overcome before patients with mTIH can be cared for at a hospital without neurosurgical capabilities. Researchers must gather prospective evidence examining the propensity of different lesion types to cause neurologic deterioration and the ability of non-neurosurgical providers to manage these lesions.[24-26] If a decision is made to trial a non-transfer protocol it makes greater sense to do so in an urban area, where transport times to a neurosurgeon are low. There would need to be a decision made regarding which service/provider (EDOU, hospitalist, neurologist, acute care surgeon) would care for these patients. A protocol[27] should be in place to allow a rapid accept/transfer mechanism to a Level I trauma center to ensure timely intervention or ICU level of care. Telemedicine may be used to provide experienced backup.

Table 3. Multivariate logistic regression: variables associated with length of stay < 24 hours.

Variable	OR	95% CI
GCS 15	2.9	1.9 - 4.4
SDH 6mm or smaller	3.1	2.2 - 4.5
Isolated SAH	1.7	1.3 - 2.4

OR, odds ratio; *CI,* confidence interval; *GCS,* Glasgow Coma Scale Score; *SDH,* subdural hematoma; *SAH,* subarachnoid hemorrhage.

Finally, patients will need follow-up to monitor resolution of ICH and neurologic complaints. Neurosurgical consultation and follow-up is recommended in cases of persistent ICH or neurologic symptoms and in patients who need to be restarted on anticoagulation or antiplatelet therapy.

LIMITATIONS

The most important limitation of this investigation was that it was performed at a single institution with substantial neurosurgical expertise and ED providers who are accustomed to evaluating and monitoring brain-injured patients. Additionally, all patients were evaluated by neurosurgeons during their ED stay. While given the paucity of interventions performed, it is unlikely that these evaluations changed outcomes and it is difficult to apply these findings toward transfer practice at community hospitals, limiting the generalizability of the results. Additionally, transfer rates for mTIH may be different nationally than within the single trauma system studied here. Unfortunately, national estimates of trauma transfer rates are not available, and the highly region-dependent nature of trauma care would limit even national estimates. However, this investigation still highlights an area for potential improvement, and the risk factors identified here are broadly applicable.

As this was a retrospective study, there were some intrinsic data validity issues, but the study design attempted to minimize these. The variables included in the study were either administrative or not subject to significant interpretation as indicated by kappa levels of our primary clinical-outcome variables. Due to resource constraints, CTs could not be re-read by a radiologist blinded to the clinical status of the patient. Instead, the final CT interpretations approved by the attending radiologist were used. Some patients who were discharged from the ED may have been initially intended to have been placed in the EDOU or admitted but were instead directly discharged from the ED after a period of observation due to bed availability. There was no way to retrospectively determine this intent from the EHR/administrative record. Additionally, the criteria for when to perform a neurosurgical intervention are not well defined in patients who are neurologically intact, an issue that no doubt influenced our neurosurgical intervention variable. All of these issues highlight the importance of future prospective examinations of patients with mTIH, so that these factors can be appropriately accounted for in the study design.

Because it was not possible to gather data from the sending facility, the first available examination was the initial evaluation at the tertiary care site. Therefore, there is some possibility that patients' clinical status may have changed substantially during the period of transfer, leading to the exclusion of some patients who deteriorated on transfer. While this could not be directly addressed in this analysis, the fact that patients who presented directly from the scene had similar clinical outcomes to the transferred group suggests that this phenomenon probably did not have a significant effect. Again, this suggests the importance of a future, multicenter prospective study.

Finally, even though our follow-up approached 80%, the development of a complication after head trauma can be a rare event and it is possible that patients lost to follow-up suffered a neurologic event and either died or were taken to a hospital outside of our network.

CONCLUSION

Our investigation showed that rapid discharge after transfer was a common phenomenon, occurring in greater than one-third of patients with mTIH who were transferred to a tertiary care center. Further prospective, systems-based research should attempt to determine a low-risk subgroup of these patients and create systems that allow them to be cared for in the community.

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Diagnosis and Management of Oncologic Emergencies

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Oncologic emergencies may be seen in any emergency department and will become more frequent as our population ages and more patients receive chemotherapy. Life-saving interventions are available for certain oncologic emergencies if the diagnosis is made in a timely fashion. In this article we will cover neutropenic fever, tumor lysis syndrome, hypercalcemia of malignancy, and hyperviscosity syndrome. After reading this article the reader should be much more confident in the diagnosis, evaluation, and management of these oncologic emergencies. [West J Emerg Med. 2019;20(2)316–322.]

INTRODUCTION

Oncologic emergencies are common in emergency medicine (EM). However, they may not often present to emergency departments (ED) that do not serve a robust oncology population. Furthermore, some oncologic emergencies can be subtle in presentation and may be overlooked, contributing to increased morbidity and mortality. We have selected four of the most important oncologic emergencies to review. We will highlight pearls and pitfalls for the emergency physician (EP) so that the recognition, evaluation, and management of these conditions will result in better patient outcomes.

NEUTROPENIC FEVER

Neutropenic fever (NF) is one of the most well-known oncologic emergencies. Up to 80% of patients receiving chemotherapy for hematologic malignancies will develop NF at least once during the course of therapy.[1-3] Patients with solid tumors are reported to develop NF at a rate of 10-50% during the course of chemotherapy.[1-3] The likelihood of fever increases with the duration and the severity of neutropenia as well as the rate of decline of the absolute neutrophil count (ANC).[4] The ANC nadir is often 7-10 days after the conclusion of chemotherapy.[5] NF is defined as a single oral or axillary temperature of ≥ 38.3°Celsius (C) (101°Fahrenheit [F]) or a temperature ≥ 38.0°C (100.4°F) sustained over 60 minutes in a patient with an ANC < 500/μL (microliter).[5] Neutropenia can be characterized as mild, moderate, severe, or profound (Table 1).[5, 6]

Table 1. Degree of neutropenia.

Mild neutropenia	ANC 1000-1500
Moderate neutropenia	ANC 500-999
Severe neutropenia	ANC 100-499
Profound neutropenia	ANC < 100

ANC, absolute neutrophil count.

While EPs should be most concerned with bacterial etiologies of NF, it is actually uncommon for a definite etiology to be determined for an episode of NF.[7,8] Only 20-35% of episodes of NF are due to a clinically documented infection (i.e., source identified by culture, antigens, or other testing modalities).[2-4, 7-8] This should be expected since NF may be due to the underlying malignancy itself (e.g., leukemia), mucositis, toxicity of the chemotherapeutic agents, or a host of other etiologies.[2, 3] If a bacterial source is the culprit, it is most likely to be endogenous flora from the gut (e.g., *Escherichia coli*, *Enterobacter*), skin (e.g., *Staphylococcus*, *Streptococcus*), or respiratory tract (e.g., *Streptococcus*).[2-4, 7-8] The past few decades have seen a change in the bacterial epidemiology associated with NF. Gram-positive bacterial infections (e.g., *Staphylococcus*, *Streptococcus)* have become at least as likely as gram-negative infections (e.g., *Escherichia coli, Pseudomonas)* due to a rising incidence of indwelling catheters and a higher

community burden of *Staphylococcus*.[2-4, 7-9] Additionally, the incidence of *Clostridium difficile (C. diff)* and resistant gram-negative pathogens is increasing.[10] A fungal etiology is unlikely if it is the patient's first episode of NF; however, this risk increases if the patient is taking empiric antibiotics, receiving total parenteral nutrition, or has concurrent mucositis.[11]

Once a patient is identified as having NF, it is incumbent upon the EP to proceed systematically in terms of diagnostic evaluation, antibiotic administration, and disposition. Standard initial testing should include a complete blood count (CBC) with manual differential, complete metabolic panel (CMP), two sets of blood cultures (including one from an indwelling line if applicable), urinalysis and culture, and chest radiograph (CXR) (two views preferred).[5] If the patient has diarrhea, consider adding stool cultures and *C. diff* testing. Keep in mind that in the winter influenza testing should be regarded as standard for NF evaluation. It is important to keep in mind that the neutropenic patient will not be able to mount a robust inflammatory response, and thus the sensitivity of a CXR will decrease.[12-14]

Broad-spectrum antibiotics should be administered within 60 minutes once NF is identified and appropriate cultures have been obtained.[5,15-16] The choice of empiric antibiotic (e.g., cefepime, meropenem) will vary based on the institution according to the local antibiogram. Refer to Table 2 for common empiric regimens for NF.[17-22]

Empiric coverage for gram-positive organisms (e.g., vancomycin) is indicated in patients who are hypotensive, have a skin and soft tissue source, are currently taking a fluoroquinolone or trimethoprim/sulfamethoxazole, or who have an indwelling line.[5] While NF is most certainly a medical emergency requiring timely source assessment and delivery of broad-spectrum antibiotics, it is no longer standard to admit all NF patients to the hospital.[23-26] In fact, recent literature suggests that EPs are not familiar with the most recent NF guidelines both in terms of antibiotic deployment (i.e., when vancomycin is recommended) and disposition.[23-24] Much as in other diseases seen in EM, a continuum exists in NF such that some patients will be at much higher risk of developing sepsis and its related morbidity and mortality.

Any decision on disposition of the NF patient should be made in conjunction with the patient's oncologist or the on-call oncologist. Even if the patient is clearly in need of admission, early oncology input is essential as they may well have pertinent clinical information that is not available in the electronic medical record regarding prior episodes of NF for that patient, current chemotherapy regimen and side effects, and potential for more unusual pathogens (e.g., fungal, viral, parasitic).[26] While all NF patients were commonly admitted in the past, disposition of patients with NF is no longer straightforward as not all patients may require admission to the inpatient setting.[26] In addition to the cost and resource utilization (i.e., occupied inpatient bed) associated with an inpatient stay, there is risk to the patient with neutropenia in being admitted to the hospital with subsequent exposure to nosocomial pathogens.[27] Any NF patient with sepsis requires admission to the hospital as do those patients with significant co-morbid illness (e.g., congestive heart failure, chronic obstructive pulmonary disease) or an unstable social situation precluding reliable follow up.[24-26] Select patients (i.e., not septic, no major co-morbid illness, stable social situation) may be suitable for outpatient management of NF. Most experts recommend using the Multinational Association for Supportive Care in Cancer score (MASCC) for assisting with disposition decisions (Table 3).[28]

Table 2. Common empiric antibiotic selections for neutropenic fever.

Cefepime	Meropenem	Piperacillin-tazobactam	Ceftazidime
2 grams IV Q8	1 gram IV Q8	4.5 grams IV Q6-8	2 grams IV Q8

IV, intravenous; *Q8*, every 8 hours; *Q6-8*, every 6-8 hours.

Table 3. Multinational Association for Supportive Care in Cancer (MASCC) scoring tool.

Characteristic	Weight (points)
Burden of febrile neutropenia with no or mild symptoms	5
No hypotension (systolic blood pressure > 90 mmHg)	5
No chronic obstructive pulmonary disease	4
Solid tumor or hematological malignancy with no previous fungal infection	4
No dehydration requiring parenteral fluids	3
Burden of febrile neutropenia with moderate symptoms	3
Outpatient status	3
Age > 60 years	2

mmHg, millimeters of mercury.

It is important to note that a higher MASCC score is associated with better outcomes. Scores ≥ 21 are considered "low risk" and these patients may be suitable for outpatient management.[28] In the past few years, a new scoring system referred to as CISNE (Clinical Index of Stable Febrile Neutropenia – see Table 4)[29] has been developed, and early literature comparing MASCC and CISNE has been promising in terms of equivalence.[30-31] However, it is important to note that the clinical practice guidelines were developed before CISNE was validated, and use of this tool should be considered with consultation from the patient's oncologist.

Table 4. Clinical index of stable febrile neutropenia (CISNE).

Characteristic	Score (points in parentheses)
Eastern cooperative oncology group performance status	< 2(0) or ≥ 2 (+2)
Stress-induced hyperglycemia (blood glucose ≥ 121 mg/dl)	No (0) or Yes (+2)
COPD	No (0) or Yes (+1)
Cardiovascular disease history (valvular disease, cardiomyopathy, cor pulmonale)	No (0) or Yes (+1)
NCI mucositis grade ≥ 2	No (0) or Yes (+1)
Monocytes	≥ 200 μL (0) or < 200 μL (+1)

mg/dl, milligrams per deciliter; *COPD*, chronic obstructive pulmonary disease; *NCI*, National Cancer Institute; *μL*, microliters. Used in adult outpatients with solid tumor, fever, and ANC ð 500.

TUMOR LYSIS SYNDROME

Tumor lysis syndrome (TLS) is a rare but potentially deadly metabolic crisis with an estimated mortality of 29-79%.[32-35] With early and aggressive intervention, the mortality rate in TLS can be impacted significantly. TLS is the most frequently encountered metabolic complication of hematologic malignancy by an EP.[32-37] Tumor lysis syndrome occurs due to the liberation of intracellular components into the circulation.[32] It rises in incidence with malignancies that have rapid cell turnover (e.g., hematologic malignancies).[33] While TLS most commonly occurs subsequent to chemotherapy, it may occur spontaneously in patients with hematologic malignancies (especially acute leukemias).[34,35] Patients with solid tumors rarely develop TLS after chemotherapy.[34] Those with baseline renal dysfunction, elderly patients with comorbidities, and patients taking multiple medications are at greater risk of developing TLS.[32-35] Presenting symptoms can include fatigue, signs of dehydration, seizures, cardiac dysrhythmia, nausea and vomiting.[36-37]

The predominant intracellular contents released systemically include potassium, phosphate, and uric acid. Consequently, laboratory values may reflect hyperkalemia, hyperphosphatemia, hypocalcemia, and hyperuricemia.[36] Initial testing should include CBC with differential, CMP, lactate dehydrogenase, uric acid, phosphate, total and ionized calcium levels, and urinalysis. An electrocardiogram (ECG) should also be obtained given the potential for electrolyte derangements.[32-39] Hyperkalemia poses the most immediate threat to the patient and is secondary to massive cellular breakdown, which overwhelms the kidneys. Hyperkalemia may be worsened by patient use of potassium-sparing medication, metabolic acidosis or prior renal insufficiency or failure. Phosphorous is present in malignant cells fourfold compared to normal cells; therefore, lysis of malignant cells releases large quantities of phosphate into the circulation, which ultimately binds with calcium to form calcium phosphate crystals.[39] The crystals deposit into soft tissue and can contribute to complications such as urinary obstruction, iritis, and skin lesions.[36-38] Hypocalcemia secondary to phosphate binding may cause symptoms of anorexia, vomiting, seizures or cardiac arrest.[41] The Cairo-Bishop criteria are preferred to diagnose TLS (Table 5). The diagnosis of TLS can be made before the development of acute kidney injury (AKI) and this is the best time for intervention.[36-40] Patients with TLS who develop AKI have a higher rate of mortality.[41]

Table 5. Cairo-Bishop criteria for clinical and laboratory tumor lysis syndrome.

Two or more of the following criteria either three days prior to or seven days after chemotherapy:
• Uric acid: ≥ 8mg/dL or 25% increase from baseline
• Potassium: ≥ 6 mEq/L or 25% increase from baseline
• Phosphorous: ≥ 6.5 mg/dL for children or ≥ 4.5mg/dL for adults or 25% of increase from baseline
• Calcium: ≤ 7mg/dL or 25% decrease from baseline
Clinical tumor lysis syndrome
Laboratory tumor lysis syndrome plus one or more of the following:
• Creatinine > 1.5 times the upper limit of age-adjusted reference range
• Cardiac dysrhythmia or sudden death
• Seizure

mg/dl, milligrams per deciliter; mEq/L, milliequivalents per liter.

Once TLS is identified, initial interventions consist of aggressive intravenous fluid (IVF) administration and correction of electrolyte abnormalities.[39-43] Isotonic fluid resuscitation is recommended with a goal of at least 2000-3000 L/m^2/day (liters per meters squared per day) for adults and children. (Use goal of 200 milliters per kilogram [kg] per day for children less than 10 kg)[39-43] Hyperkalemia secondary to TLS should be a treatment priority and should proceed similarly as with other hyperkalemic patients.[39-43] Ultimately, dialysis may be required for severe or refractory cases of TLS to treat renal failure as well as severely elevated uric acid, potassium or phosphate levels.[39-42] Phosphate binders such as aluminum hydroxide (300-600 mg [milligram] oral dose) may be used to treat excess phosphorus in stable patients who have a phosphate level ≥ 6.0 mg per deciliter (dl).[40] Symptomatic hypocalcemia (e.g., seizures, tetany or cardiac dysrhythmias) should be treated with calcium gluconate one gram intravenously.[40-41] This dose may be repeated as required for symptom management. It is important to emphasize that

asymptomatic hypocalcemia should not be treated as the additional calcium may cause calcium phosphate precipitation and acute obstructive uropathy.[39-41]

Additionally, hyperuricemia should be addressed to prevent uric acid nephropathy as it may lead to decreased filtration rate and crystal obstruction.[44] Allopurinol is effective in the prevention of uric acid production; however, it does not decrease uric acid already present, and so is less effective in treating TLS.[44-45] Rasburicase, a recombinant urate oxidase, has shown good promise when used for hyperuricemia.[44-47] Humans lack urate oxidase, which metabolizes uric acid to the more soluble allantoin, which can then be renally excreted.[44-45] Studies have shown rasburicase is more effective in lowering serum uric acid levels in patients with TLS compared to allopurinol, is well tolerated by patients, and does not require adjustment for changes in creatinine.[45-46] The recommended dose is 0.2 mg/kg by IV therapy. Of note, rasburicase is contraindicated in patients with history of glucose-6-phosphate dehydrogenase deficiency.[47] Management of TLS requires coordination with the patient's oncologist and frequent laboratory testing and intensive nursing care, which is often why these patients necessitate an intensive care unit (ICU) admission.[32]

HYPERCALCEMIA OF MALIGNANCY

Hypercalcemia is seen in 10-30% of patients with malignancy and is most commonly associated with breast cancer, lung cancer, non-Hodgkin's lymphoma and multiple myeloma, although it may be seen with any malignancy.[48-55] Twenty percent of malignancy-related hypercalcemia is secondary to bony metastases, and it should be noted that the incidence of hypercalcemia increases with advanced disease and portends a poor prognosis.[50] Multiple pathways lead to hypercalcemia of malignancy; however 80% can be attributed to parathyroid-related protein (PTHrP) activity.[51] PTHrP increases bone resorption via osteoclast activity and enhances calcium resorption in the renal tubule. [51] Importantly, an EP should consider malignancy in any patient (without a known diagnosis of malignancy) presenting with hypercalcemia of unclear etiology.[48-50] In these patients, the likelihood of an underlying malignancy rises in direct correlation to the degree of hypercalcemia.[48] Importantly, symptoms are related to the rate of rise of serum calcium and are not solely based on the absolute value.[51]

The symptoms of hypercalcemia are vague and often reflect symptoms associated with significant volume depletion due to the osmotic diuresis associated with hypercalcemia.[51] The most common symptoms are anorexia, nausea, vomiting and constipation, but may include malaise, polyuria, polydipsia, lethargy, confusion, and even coma.[48-52] Laboratory analysis should include both a total calcium and ionized calcium level when possible. If ionized calcium values are unavailable, a corrected calcium value can be calculated as follows: Corrected calcium level = measured calcium level + (0.8 x [4.0 - serum albumin level {g/dl}]) The EP should also send a full CMP, CBC, a magnesium level, and phosphate level. Parathyroid and PTHrP testing are useful for the oncologist, but are not indicated in the emergent setting.[52-55] An ECG may show prolonged PR, widened QRS, shortened QT, and ventricular dysrhythmias.[52-55] Immediate treatment for calcium levels below 12 mg/dl can be deferred. Patients with moderate hypercalcemia with levels of 12-14 mg/dl should be treated based on clinical judgment and symptom control as these levels may have been reached either acutely or subacutely and may even be well tolerated. Nonetheless, any patient with a serum value >14mg/dl is generally symptomatic and should receive an intervention to lower the level. [52,55] Cardiac arrest may occur with levels >15 mg/dl. [49]

Initial emergent management of hypercalcemia involves aggressive IVF administration with an initial bolus of 1000-2000 ml of isotonic fluid followed by an infusion rate of 200-300 ml/hr (milliliters per hour) to achieve urine output of 100-150 ml/hr. [49, 52-55] Loop diuretics will decrease serum calcium levels, and studies have shown high doses are required to be effective; therefore, use should only be considered in the euvolemic patient or those with concurrent volume overload. [49, 52-55] Bisphosphonates lower calcium levels by inhibiting osteoclasts and stabilize the bone matrix by binding to calcium phosphate. These medications are renally excreted, and the dose will need to be adjusted based on renal function.[49] Complications may include self-limited infusion-related fever or AKI.[49] Calcitonin decreases bone resorption and enhances urinary excretion of calcium and may be employed via intramuscular or IV route.[52-54] The effects are rapid though transient with poor efficacy; therefore, utilization should be considered in adjunct with bisphosphonates when rapid reduction of serum calcium is required.[49]

Glucocorticoids are most effective in patients with Hodgkin's or non-Hodgkin's lymphoma or any malignancy that overproduces calcitriol.[52-53] Glucocorticoids inhibit conversion of 25-hydroxyvitamin D to calcitriol, decreasing gut absorption and renal reabsorption of calcium. These medications have slow onset of action and dosing is uncertain, though a recommended dose is IV hydrocortisone 200-300 mg/day.[52-54] Hemodialysis is reserved for those patients with oliguric renal failure.[52-54] Most patients who have mild symptoms, or are asymptomatic with a serum calcium < 14 mg/dl, are good candidates for outpatient management after discussion with their oncologist. [49, 54] Patients in the moderate or severe range of hypercalcemia should be considered for monitored or ICU admission depending on presentation, labs and clinical judgment. Finally, given the significant mortality associated with this presentation, it is important to establish goals of care with the patient and his or her oncologist.

HYPERVISCOSITY SYNDROME

Hyperviscosity syndrome (HVS) is a rare but potentially catastrophic consequence of increased serum viscosity due to excess serum proteins.[56-59] Hyperviscosity syndrome is the consequence of a significant excess in serum proteins (e.g., Waldenström's macroglobulinemia [WM] or multiple myeloma) or cellular components (e.g., white blood cells in acute leukemias).[60] Patients with WM are at highest risk for HVS with 40-90% of HVS cases occurring from WM.[61] HVS can also be seen in diseases such as multiple myeloma (second most common cause of HVS), leukemia, and polycythemia.[59] Hyperviscosity syndrome results in relative hypoperfusion, and resultant clinical manifestations represent end-organ dysfunction that may mimic other disease pathology. For example, patients with HVS may complain of visual changes (mistaken for cerebral vascular accident), dyspnea (mistaken for pulmonary embolus or congestive heart failure), or altered mental status (mistaken for sepsis). The classic triad of HVS is mucosal or skin bleeding, visual changes, and focal neurologic deficits; although it is not clear what percentage of patients present with this classic triad.[56-60] The EP should consider this diagnosis in any patient found to have a markedly elevated white blood cell count (i.e., >100 x 10^4) or hemoglobin (i.e., approaching 20 g/dl) associated with symptoms of hypoperfusion.[61-63] Lab values that will offer the most information include the CMP (total protein and albumin level), CBC (hemoglobin, white blood cell count) with peripheral smear, and coagulation testing (coagulopathy is common in HVS).[63-66] Blood transfusion can significantly worsen HVS and should be avoided if possible. The mainstays of therapy are decreasing serum viscosity through IV fluid resuscitation, plasmapheresis, or leukopheresis.[63-67] Phlebotomy (e.g., polycythemia) or even urgent chemotherapy (e.g., acute leukemia) may also be indicated.[63-67] Evidence for these interventions suggests they do not alter the course of the disease but rather help with symptom alleviation. All patients with HVS will require admission to the hospital and warrant strong consideration for ICU admission.

CONCLUSION

Oncologic emergencies are becoming increasingly common presentations in the ED both in the community and academic settings. Emergency providers must appreciate the complexity of NF and understand that early, broad-spectrum antibiotics are key to reducing mortality even if the patient does not ultimately get admitted. Tumor lysis syndrome is a subtle but lethal metabolic derangement seen most often in hematologic malignancies that requires aggressive fluid resuscitation and electrolyte management. Hypercalcemia of malignancy heralds a poor prognosis and goals of care should be addressed while providing IV volume resuscitation to counter the osmotic diuresis caused by the hypercalcemia. Finally, hyperviscosity syndrome is especially dangerous as it mimics more common presentations but should be in the differential for any patient with WM, multiple myeloma, severe leukocytosis (i.e., >100 x 10^4), or a hemoglobin > 20 g/dl. All of these oncologic emergencies require early involvement of oncology for management.

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The Crashing Obese Patient

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Emergency physicians (EP) frequently resuscitate and manage critically ill patients. Resuscitation of the crashing obese patient presents a unique challenge for even the most skilled physician. Changes in anatomy, metabolic demand, cardiopulmonary reserve, ventilation, circulation, and pharmacokinetics require special consideration. This article focuses on critical components in the resuscitation of the crashing obese patient in the emergency department, namely intubation, mechanical ventilation, circulatory resuscitation, and pharmacotherapy. To minimize morbidity and mortality, it is imperative that the EP be familiar with the pearls and pitfalls discussed within this article. [West J Emerg Med. 2019;20(2)323–330.]

INTRODUCTION

Obesity has become one of the nation's leading public health crises.[1] In fact, more than one-third of the adult population of the United States (U.S.) is now considered obese.[2] Obesity is typically defined as a body mass index (BMI) greater than 30 kilograms per square meter (kg/m^2). People with a BMI greater than 40 kg/m^2 are classified as morbidly obese.[3] As BMI increases, so does the incidence of significant comorbid conditions such as diabetes, obstructive sleep apnea, hypertension, and dyslipidemia. In addition, obesity induces a number of anatomic and physiologic changes that affect resuscitation and emergency department (ED) management.

The emergency physician (EP) is frequently called upon to resuscitate and manage critically ill patients. The obese patient whose condition is unstable, rapidly changing, and requires emergent resuscitation, the so-called "crashing" obese patient, presents a unique challenge for even the most skilled EP. Changes in anatomy, metabolic demand, cardiopulmonary reserve, ventilation, circulation, and pharmacokinetics require special consideration. This article focuses on critical components in the resuscitation of the crashing obese ED patient, namely rapid sequence intubation, mechanical ventilation, circulatory resuscitation, and pharmacotherapy. To minimize morbidity and mortality, it is imperative that the EP be familiar with the pearls and pitfalls discussed in this article.

ALTERATIONS IN RESPIRATORY PHYSIOLOGY

The respiratory system of the obese patient undergoes several anatomic and physiologic alterations that affect emergent airway management and initiation of mechanical ventilation. Anatomically, obese patients have an increased neck circumference due to excess cervical adipose tissue. Increased neck circumference is strongly associated with the upper airway collapse observed in obstructive sleep apnea.[4] Additionally, increased soft tissue deposition in the relatively closed space of the oropharyngeal cavity leads to pharyngeal airway narrowing.[5] As observed in sleep, loss of neuronal compensation in the setting of sedation with or without paralytic can lead to upper airway collapse. Increased neck circumference as well as dorsocervical fat deposition can limit neck extension. While it remains unclear if obesity is an independent risk factor for a difficult airway, obesity and its associated conditions are considered in several commonly used scoring systems to assess for potentially difficult intubations, including the Wilson scoring system, LEMON (Look-Evaluate-Mallampati-Obstruction-Neck mobility), and the HEAVEN (Hypoxemia, Extremes of size, Anatomic challenges, Vomit/blood/fluid, Exsanguination/anemia, Neck mobility issues) criteria.[6-8] Rapid access to a surgical airway can be limited when landmarks are obscured in a short, obese neck. Some recommend initial sharp dissection followed by palpation within the incision to facilitate landmark

identification.[9] Overall, obesity and its associated anatomic changes should alert the EP to the possibility of a difficult airway and prompt appropriate planning and back-up.

Physiologically, obese patients have markedly decreased lung volumes. In fact, for each unit increase in BMI, functional residual capacity (FRC), expiratory reserve volume, vital capacity, total lung capacity, and residual capacity decrease 0.5% to 5%.[10] Of these changes in lung volumes, the reduction in FRC is perhaps the most important, as further decreases lead to the closure of small airways and an increase in airway resistance.[1] Reduction in FRC is an important contributor to the marked limitation in safe apnea time in the obese. Increased airway resistance results in under-ventilated areas of lung, atelectasis, and intrapulmonary shunting.[1] Decreased lung volumes also reduce lung compliance in the obese patient. In addition to decreased lung volumes, decreased lung compliance, increased airway resistance, and intrapulmonary shunting, obese patients also develop ventilation-perfusion (V/Q) mismatch due to the fact that their upper lung zones are aerated preferentially, whereas lower lung zones are perfused preferentially.[1] Finally, chest wall compliance is reduced due to the increase in adipose tissue in the thoracic cage. All of these alterations in respiratory physiology can be worsened when the obese patient is placed in the supine position.

As a result of these physiologic changes, it is not surprising that oxygen consumption and the work of breathing (WOB) are significantly increased in the obese patient.[11] Oxygen consumption is approximately 1.5 times higher in the obese patient than in the non-obese patient.[11] Due to the increase in oxygen consumption and WOB, obese patients produce more carbon dioxide than non-obese patients.[12] To compensate, the obese patient adopts a rapid, shallow breathing pattern. In fact, normal spontaneous respiratory rates in the morbidly obese patient range from 15-21 breaths per minute compared with 10-12 breaths per minute in non-obese patients.[13,14]

Overall, these anatomic and physiologic alterations in respiratory physiology lead to a marked decrease in pulmonary reserve.[1] Decreased pulmonary reserve predisposes the patient to the rapid onset of hypoxemia during rapid sequence intubation (RSI), which can result in peri-intubation cardiac arrest.

INTUBATION

In critically ill obese patients, intubation is a high-risk procedure that can be fraught with peril. As discussed in the preceding section, obese patients have very little cardiopulmonary reserve and can desaturate rapidly to critical oxygen levels during intubation. Numerous studies have highlighted obesity as a risk factor for difficult intubation.[15-18] De Jong and colleagues reported an increased incidence of difficult intubation in obese patients.[19] They found that an elevated Mallampati score, limited mouth opening, reduced cervical mobility, the presence of obstructive sleep apnea, and severe hypoxemia were associated with difficult intubation.[13,19] Additional factors that have been shown to predict difficult intubation in obese patients include a short neck, a thick neck, diabetes mellitus, and abnormal upper teeth.[1,20,21] Given the challenges of airway management in the obese patient, it is crucial for the EP to optimize intubation conditions to reduce the risk of poor outcome.

Preoxygenation

Critically ill patients undergoing RSI should be preoxygenated adequately prior to intubation in order to prolong the time to reach critical oxygen saturation thresholds during apnea. The primary goal of preoxygenation is to create an oxygen reservoir by replacing nitrogen within the FRC with oxygen.[1] Common methods of preoxygenation include the use of a face-mask (FM) with 100% fractional inspired oxygen concentration (FiO_2), bag-mask ventilation (BMV), noninvasive positive pressure ventilation (NIV), and high-flow nasal cannula (HFNC) devices. Often, the traditional methods of preoxygenation using a FM or BMV are insufficient in the critically ill obese patient.[13] But NIV can be beneficial and is the preoxygenation method preferred by many.[13] The application of continuous positive airway pressure (CPAP) at 10 centimeter (cm) H_2O has been shown to reduce atelectasis, improve oxygenation, and increase apnea time without hypoxemia in the obese patient undergoing surgery.[13,22,23] Bilevel positive airway pressure (BPAP) can also be used to preoxygenate obese patients, although it is less well studied than CPAP.[1] Compared with the use of a FM with 100% FiO_2, BPAP improves oxygen saturation readings prior to intubation.[1,24] When clinically feasible, CPAP or BPAP should be maintained for at least five minutes during the preoxygenation period.[25] HFNC devices can be considered for the obese patient; however, the minimal positive pressure delivered by HFNC devices can be expected to have little impact on FRC, and evidence supporting their benefit in preoxygenation prior to RSI is limited.[13]

Patient Positioning

Proper positioning is critical for success in both preoxygenation and intubation of the obese patient. Given the alterations in respiratory physiology, obese patients should be placed in either a semirecumbent (head of the bed elevated to 25 degrees) or a sitting position during preoxygenation.[1,13] The upright or semirecumbent position may decrease air trapping, decrease atelectasis, and improve oxygen saturation prior to intubation.[13,26] Similar to the optimal position for preoxygenation, obese patients should be placed in a head up or ramped position to optimize the laryngoscopic view for intubation (Figure).[1,27-29] To ensure proper position, the EP should align the patient's sternal notch with his or her external auditory meatus.[1,28,29]

A. Sniffing position

B. Ramped position

C. Semi-recumbent

Figure. Patient positioning for intubation

Medication Dosing

Improper dosing of RSI medications can cause significant patient discomfort and may increase the incidence of complications during intubation. Several recent studies demonstrated that obese patients often receive inappropriate doses of sedative and paralytic medications during RSI.[30-32] Bhat and colleagues demonstrated that obese patients were more likely to be underdosed with both etomidate and succinylcholine during RSI.[32] It is therefore important for the EP to be knowledgeable about the proper dosing of medications commonly used during RSI (Table). Medications dosed on *total* body weight include etomidate and succinylcholine, whereas propofol and the nondepolarizing neuromuscular blocking medications (e.g., rocuronium) are dosed on *ideal* body weight.[1,21] Ketamine is dosed on lean body mass.[1,21]

Laryngoscopy

It is wise for the EP to consider each intubation of an obese patient as a difficult intubation. As such, adequate preparation is of paramount importance. In addition to the equipment needed for direct laryngoscopy, advanced airway equipment (e.g., supraglottic airway, video laryngoscope, gum elastic bougie, surgical airway equipment) should be placed at the bedside. Video laryngoscopy may be preferred over direct laryngoscopy in the obese patient.[1,33,34] For patients who require BMV during intubation attempts, recall that obesity is a risk factor for difficult BMV.[13,35] The use of an oral or nasal airway, a two-handed jaw thrust, or a two-person technique can improve the efficacy of BMV.[1,21]

Table. Weight-based medication dosing.[1,16]

Total body weight	Ideal body weight	Lean body mass
Etomidate	Propofol	Ketamine
Succinylcholine	Rocuronium	
Fentanyl	Vecuronium	
Midazolam		

MECHANICAL VENTILATION

Initiation of mechanical ventilation in the intubated obese ED patient can be challenging. Improper ventilator settings can lead rapidly to respiratory or hemodynamic deterioration and increased morbidity and mortality. Similar to the mechanical ventilation of non-obese patients, important ventilator settings for the obese patient include ventilator mode, respiratory rate, positive end-expiratory pressure (PEEP), and, in volume-controlled modes, tidal volume.

The two most common modes of mechanical ventilation used in the obese patient are volume-controlled ventilation (VCV) and pressure-controlled ventilation (PCV).[36] To date, the superiority of one mode over the other has not been demonstrated in the literature.[13] Notwithstanding, some clinicians prefer PCV, as the decelerating waveform may improve distribution of airflow to the alveoli.[13]

The benefits of a low-tidal-volume (6-8 milliliters per kilogram [ml/kg]) ventilation strategy in patients with acute respiratory distress syndrome (ARDS) have been well established.[37,38] In recent years, the use of low-tidal-volume ventilation has also been recommended for patients without ARDS.[39-41] Importantly, the tidal volume must be calculated using *ideal* body weight rather than total body weight. This is especially important for the intubated obese patient, for whom the use of total body weight to determine the tidal volume can lead to injurious lung volumes, barotrauma, and ventilator-induced lung injury.

As previously discussed, obese patients produce excessive amounts of carbon dioxide due to increased metabolic demand, increased oxygen consumption, and increased WOB.[11-14] As a result, they adopt a rapid, shallow breathing pattern and have a normal respiratory rate that ranges from 15-21 breaths per minute.[13,14] When setting

the ventilator, it is important to account for this altered physiology and initially set a higher respiratory rate than for the non-obese patient.[13]

Obese patients demonstrate improved respiratory mechanics and alveolar recruitment when provided with PEEP.[1,13,42] PEEP reverses airflow limitations and helps to prevent alveolar derecruitment caused by the decrease in FRC.[1,13] Importantly, the optimal level of PEEP in ventilated obese patients remains uncertain.[13] They might benefit from a higher initial PEEP setting (i.e., 10 cm H_2O) in contrast to non-obese patients, who are commonly started on lower levels of PEEP (i.e., 5 cm H_2O).[13,43,44] The initial PEEP setting in the individual obese patient should also take into account the anticipated hemodynamic effects when PEEP exceeds extant intrathoracic pressure, including decreases in venous return, right ventricular output, and pulmonary perfusion. Expiratory flow limitation observed in the obese can result in an auto-PEEP phenomenon. In that event, extrinsic PEEP should be set at two-thirds intrinsic PEEP.[13]

Finally, the ventilated obese patient should be placed in a reverse Trendelenburg or sitting position.[1] Similar to optimal patient positioning for preoxygenation and RSI, the reverse Trendelenburg or sitting position reduces intrathoracic pressure, reduces atelectasis, improves V/Q mismatch, decreases the incidence of hypoxemia, and may improve the laryngoscopic view.[27,28]

ALTERATIONS IN CIRCULATORY PHYSIOLOGY

Similar to the respiratory system, the physiology of the circulatory system is altered in obese people. Alterations in circulatory physiology were first reported in 1964 by Alexander, who described the linear relationship between a patient's weight and total blood volume.[45] Greater total blood volume increases stroke volume, which ultimately leads to an increase in preload and myocardial wall tension. Ferraro and colleagues demonstrated that these physiologic changes cause an eccentric left ventricular hypertrophy, impaired ventricular relaxation, and diastolic dysfunction.[46] Diastolic dysfunction eventually leads to systolic dysfunction, pulmonary hypertension, and right ventricular hypertrophy. Together, these physiologic changes have been termed the "obesity cardiomyopathy syndrome."[47]

For the majority of ED patients, initial assessment of the circulatory system begins with a noninvasive blood pressure measurement. Importantly, standard blood pressure cuffs are often too narrow and too short for the obese patient. In many cases, this leads to an overestimation of blood pressure.[48,49] If the obese patient appears moribund, demonstrates signs of poor perfusion (i.e., cool and mottled skin), or is critically injured, the EP should consider early placement of an invasive arterial line to accurately determine the mean arterial blood pressure.[50]

Intravenous (IV) fluid administration is one of the most common interventions in critically ill ED patients. Unfortunately, obesity has been shown to be an independent risk factor for difficult IV access.[51-53] The causes of difficult IV access in the obese patient are likely multifactorial and include increased adipose tissue, increased tissue edema, and smaller vein caliber. Alternatives to peripheral IV access include the intraosseous route and central venous access. Importantly, these alternatives also have limitations and complications in the obese patient. Kehrl and colleagues demonstrated that a standard 25 millimeter (mm)-intraosseous needle might not be long enough for patients with a BMI greater than 43 kg/m^2.[54] In these severely obese patients, the EP should consider using an extended 45-mm intraosseous needle.[54] However, in a study of out-of-hospital cardiac arrest, Kawano and colleagues demonstrated worse patient outcomes in those who had intraosseous vascular access compared with those who had IV access.[55]

Ultrasound guidance is rapidly becoming an essential tool in scenarios involving difficult IV access.[56] The use of longer catheters reduces the rate of IV dislodgement,[56] and ultrasound guidance during cannulation has a higher successful rate than the standard blind approach.[57] Additionally, Au et al. demonstrated that the use of ultrasound guidance for IV access reduced the need for central venous access.[58]

Placement of a central venous line in an obese patient can be problematic. Risks associated with central venous access in the obese patient include inability to place the line, the need to use extended-length needles to assist with cannulation, and higher infection rates.[59-61] Although many physicians use a landmark approach to central venous access, this method is not reliable in obese patients.[62,63] Furthermore, traditional depths of insertion are often too shallow in the obese patient.[61,64] Although EPs are trained in ultrasound-guided cannulation of the central veins, up to 40% of EDs in the U.S. do not have bedside ultrasound available.[65] Whenever possible, the EP should use ultrasound to guide central venous cannulation of the femoral, internal jugular, and subclavian veins.[65]

For patients in cardiac arrest, the delivery of high-quality cardiopulmonary resuscitation (CPR) is crucial to achieve return of spontaneous circulation. Critical components of high-quality CPR are compressions delivered at the proper rate and depth and allowing full recoil of the chest between compressions.[66] Current international guidelines for the resuscitation of adult patients in cardiac arrest recommend placement of the hands on the lower half of the sternum during CPR.[66-68] Given the increased adipose tissue of the chest wall and a more cephalad displacement of the diaphragm in obese patients, this hand location might not be the optimal position for CPR in obesity. Lee and colleagues found that the optimal hand position for CPR in obese patients might be slightly more cephalad than in non-obese patients.[67]

PHARMACOTHERAPY

As highlighted in the preceding intubation section, medication dosing in the obese patient is challenging. Importantly, almost all dosing recommendations have been developed for non-obese patients and are then extrapolated to the obese population. This extrapolation can lead to dosing errors and result in medication toxicity or treatment failure. Proper medication dosing is determined by many factors. Perhaps the most important one is the lipophilicity of the medication. In general, when a medication is highly lipophilic, it rapidly distributes to the peripheral tissues and should be dosed based on total body weight. In contrast, when a medication is hydrophilic, the volume of distribution is lower, so the dose should be based on ideal or adjusted body weight. An additional factor that affects medication dosing is renal function. If a medication is cleared by the kidney, it should be dosed on actual creatinine clearance rather than calculated creatinine clearance.[69] In the obese patient, the EP should pay special attention to cardiovascular, sedative, antimicrobial, and anticoagulant medications.

Cardiovascular Medications

Beta (β)-adrenergic receptor blockers, calcium channel blockers, digoxin, lidocaine, and procainamide are commonly administered cardiovascular medications in the ED. β-Adrenergic receptor blockers, digoxin, and procainamide are relatively hydrophilic medications and should be dosed on ideal body weight, whereas calcium channel blockers are more lipophilic and should be dosed based on total body weight. Vasoactive medications (e.g., norepinephrine, epinephrine, dobutamine) do not require dosing adjustments in the obese patient.

Sedative Medications

Sedative medications are used frequently in the ED for post-intubation sedation, procedural sedation, severe agitation, and induction for intubation. Sedatives are generally highly lipophilic medications that can have prolonged half-lives in the obese patient. To prevent accidental oversedation, the initial dose of a sedative should be based on ideal body weight, with subsequent doses based on the patient's response and anticipated duration of treatment. The EP should use extra caution with benzodiazepines in the obese patient. When given via continuous infusion, benzodiazepines (along with the analgesic fentanyl) can have an extremely long duration of action.[70]

Antimicrobial Medications

Given the emphasis on early recognition of sepsis and early administration of broad-spectrum antimicrobial agents, it is imperative to dose them correctly in the obese patient. Fuller and colleagues demonstrated an eightfold increase in the likelihood of underdosing of vancomycin for every 10-kg increase in body weight.[71] For vancomycin, total body weight should be used to determine the proper initial loading dose.[72] For penicillins, cephalosporins, and carbepenems, the EP should use the higher end of dosing recommendations. In contrast to these agents, the dose of aminoglycosides should be calculated based on ideal body weight. If the patient has a total body weight that is more than 130% of his or her ideal body weight, then adjusted body weight should be used to calculate the aminoglycoside dose.[73]

Anticoagulant Medications

Obese patients and those with metabolic syndrome are at increased risk for venous thromboembolic events (VTE).[74-77] Anticoagulant medications used to treat thromboembolism are considered high-risk medications; therefore, proper dosing, especially in the obese patient, is imperative.[78] Low-molecular-weight heparin (LMWH) is commonly used to treat VTE and is dosed at 1 mg/kg/day. Some LMWH formulations have maximum dosing recommendations, which may lead to subtherapeutic levels in the obese patient.[79] If the obese patient's total body weight exceeds 190 kg, anti-Xa levels should be monitored to ensure appropriate levels of anticoagulation.[80] Unfractionated heparin could be used if LMWH is not available, but LMWH has been shown to be at least equivalent in head-to-head comparisons, with less frequent dosing and less total volume infused.[81,82X] To date, no large, randomized controlled trials have evaluated the use of newer, direct oral anticoagulants in the obese patient. If these medications are being considered for treatment of VTE in an obese ED patient, the EP should consider consulting with a pharmacist for dosing recommendations.

CONCLUSION

Resuscitation of the crashing obese ED patient presents numerous challenges for the EP. Even prior to the development of critical illness, obese patients have alterations in respiratory physiology, circulatory physiology, and pharmacokinetics that significantly affect their ED evaluation and resuscitation. These alterations greatly affect the EP's approach to rapid sequence intubation; initiation and management of mechanical ventilation; circulatory assessment; vascular access; CPR; and the dosing of critical, high-risk medications. It is our hope that, through the application of the pearls and pitfalls discussed in this article, the EP can minimize morbidity and mortality in this very sick patient population.

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Evaluation and Management of Septic Arthritis and its Mimics in the Emergency Department

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Septic arthritis is a dangerous medical condition associated with significant morbidity and mortality. However, the differential diagnosis can be broad with conditions that mimic this disease and require different evaluation and treatment. This narrative review presents the emergency medicine evaluation and management, as well as important medical conditions that may mimic this disease. Septic arthritis commonly presents with monoarticular joint pain with erythema, warmth, swelling, and pain on palpation and movement. Fever is present in many patients, though most are low grade. Blood testing and imaging may assist with the diagnosis, but the gold standard is joint aspiration. Management includes intravenous antibiotics and orthopedic surgery consult for operative management vs. serial aspirations. Clinicians should consider mimics, such as abscess, avascular necrosis, cellulitis, crystal-induced arthropathies, Lyme disease, malignancy, osteomyelitis, reactive arthritis, rheumatoid arthritis, and transient synovitis. While monoarticular arthritis can be due to septic arthritis, other medical and surgical conditions present similarly and require different management. It is essential for the emergency clinician to be aware how to diagnose and treat these mimics. [West J Emerg Med. 2019;20(2)331-341.]

INTRODUCTION

Monoarticular arthritis is a common presentation to the emergency department (ED) and major cause of disability in the United States. Monoarticular arthritis has a wide range of potential etiologies, ranging from benign to life-threatening. One of the most concerning causes in a patient with monoarticular arthritis is septic arthritis. The prevalence of septic arthritis among ED patients with monoarticular arthritis varies significantly between studies; however, an incidence of 4-60 cases per 100,000 population per year is suggested in the literature.[1-6] Based on the literature, higher rates of septic arthritis are present in immunocompromised patients and those with prosthetic joints, where disease incidence increases to 70 cases per 100,000 patients annually.[7-13] Septic arthritis possesses a bimodal incidence, with peaks in both childhood and adults over the age of 55 years.[4-9]

Septic arthritis consists of a bacterial infection of the joint space that is associated with rapid joint destruction within days if not adequately treated. Mortality rates can be significant, ranging from 3-25%.[3,5-7] Despite the severity of illness, septic arthritis may be subtle, with many patients lacking the classic signs, symptoms, or laboratory findings.[8-10] There are also a large number of conditions that may mimic septic arthritis, further confounding the diagnosis.

METHODS

We searched PubMed and Google Scholar for articles using the keywords "septic arthritis," "monoarthritis," "synovial fluid," "diagnosis," "treatment," and "emergency." Restricting the literature search to studies published in English, we found an initial 258 articles. We reviewed all relevant articles and decided by consensus which studies to include for the narrative review, focusing on articles investigating ED patients, studies evaluating synovial fluid results, and studies investigating septic arthritis diagnosis or management. A total of 133 articles were selected for inclusion in this review. We did not conduct

a systematic review or meta-analysis, but rather a narrative review evaluating the emergency medicine investigation and management of septic arthritis and its mimics.

DISCUSSION

Septic arthritis typically affects one joint but may be polyarticular in up to 20% of cases (most commonly in immunocompromised patients).[10,14,15] The most frequently affected joint is the knee, followed by the hip, shoulder, and elbow.[8-11] Septic arthritis results from bacteremia in 70% of cases due to the absence of a protective basement membrane within the joint lining.[8-11,15-29] This provides easy passage of bacteria into the synovial fluid. Other causes include direct inoculation from trauma or a medical procedure and contiguous spread from osteomyelitis, an abscess, cellulitis, or septic bursitis.[8-11,15-18]

Organisms

The majority of cases are due to Gram-positive organisms (e.g., *Staphylococcus aureus*), with approximately 15% being due to Gram-negative organisms (Table 1).[15-25] The incidence of methicillin-resistant *S. aureus* (MRSA)-related septic arthritis is increasing.[20] *Neisseria gonorrhoeae* is another common cause in younger adults; these patients can present with migratory polyarthritis, pustular rash, urethritis, and tenosynovitis.[8-11,15,17] Polymicrobial infections (e.g., *Pantoea agglomerans* and *Nocardia asteroides*) typically occur after penetrating trauma, such as bite wounds, or with organic foreign material.[6-10,18-25] Small breaks in the skin and mucous membranes provide entry points for Gram-positive bacteria, while Gram-negative infections result from injection drug use, gastrointestinal sources, or urinary tract mucosal injury.[8-11,15-28] Once bacteria are present within the normally sterile synovial fluid, the body sends immune cells to the site of infection.[8-11,15,26,27] The combination of bacteria within the joint capsule, the host inflammatory response, and tissue ischemia can result in significant joint damage.[10,26,27]

History and Examination

Obtaining an accurate history and assessment of risk factors can provide important clues to the diagnosis. A careful evaluation for risk factors can significantly change

Table 1. Common organisms causing septic arthritis.[6-11,15-26]

Bacteria (frequency)	Clinical characteristics
Staphylococci (56%)	
Methicillin-sensitive *Staphylococcus aureus* (42%)	All: skin breakdown, cellulitis over the site (46% of cases), prosthetic joint, recent operation on joint, damaged joint All: high mortality (7-18%) and joint function loss (27-46%)
Methicillin-resistant *Staphylococcus aureus* (10-50%)	
Coagulase-negative staphylococci (3%)	
Streptococci (16%)	
Streptococcus viridans (1%)	All: splenic dysfunction, post splenectomy, diabetes, cirrhosis All: associated with high frequency of bacteremia (66%) and polyarticular disease (32%) All: high mortality (19%), but good functional outcomes in those that survive
Streptococcus pneumoniae (1%)	
Unspecified/other streptococci (14%)	
Gram-negative rods (15%)	
Pseudomonas aeruginosa (6%)	All: Immunocompromised status, gastrointestinal disorder or infection, injection drug use, elderly Enteric Gram-negative rods: Urinary tract infection found in 50% of patients All: 5% mortality
Escherichia coli (3%)	
Proteus species (1%)	
Klebsiella species (1%)	
Others (4%)	
Other (12%)	
Polymicrobial (5%)	All: immunocompromised status, travel or residence in an endemic area, gastrointestinal disorder or infection Neisseria: increases with high-risk sexual activity; 75% occur in women, 72% are polyarticular, 32% have urinary symptoms, recovered from joint fluid in < 50% of cases Tuberculosis: indolent course with gradually progressive joint pain and swelling, symptoms often occur for > 1 year before the diagnosis; only 50% of patients have chest radiograph with active tuberculosis Brucella: more common in immigrants to the United States, typically occurs in regions with unvaccinated livestock and unpasteurized dairy; 54% have sacroiliac joint involvement
Anaerobes (0.6%)	
Mycobacterium tuberculosis (1.8%)	
Neisseria gonorrhoeae (1.2%)	
Brucella (1-11%)	
Miscellaneous (4%)	

a provider's pretest probability of septic arthritis.[8,9] Table 2 provides sensitivity, specificity, positive likelihood ratio (+LR), and negative likelihood ratio (-LR) for various history and examination findings.[8] Of note, this table combines values from several meta-analyses.[8,9] Several of the findings were not available for pooling of data due to heterogeneity and unreliable methodology of included studies. The most common risk factor is preexisting joint disease or damage; however, this is present in less than half of patients with septic arthritis.[6-8,10] Other risk factors are typically related to the route of the infection, including hematogenous (e.g., injection drug use), direct inoculation (e.g., trauma or recent procedure), or contiguous spread (e.g., abscess).[8-10,18]

While each risk factor in isolation has only a modest impact on the likelihood of septic arthritis, the overall risk rises as the number of risk factors increases.[8-10] Many patients with septic arthritis possess several risk factors.[6-11,15,16] For example, patients with rheumatoid arthritis are at an increased risk for septic arthritis due to joint damage, poor skin condition, and immunosuppression.[26,29] Rheumatoid arthritis complicated by septic arthritis is associated with poor outcomes including high morbidity and mortality.[10,29,30] Interestingly, one study found that approximately 22% of all patients with culture-proven septic arthritis had no associated risk factors or underlying joint disease.[30] This can be partly explained due to septic arthritis from *N. gonorrhoeae* in young patients with otherwise normal joints, though most cases of septic arthritis were due to *S. aureus*.[30]

Patients traditionally present with a constellation of signs and symptoms including joint pain, tenderness to palpation, swelling, erythema, warmth, and painful or limited range of motion.[8,9,17] The most common symptom is joint pain, which is found in 85% of patients.[8,9] Joint swelling occurs in 78% of cases,[8,9] while joint tenderness has been suggested to be 100% sensitive.[6,7,15,17] Fever $\geq$ 39°C occurs in up to 58% of patients, and the absence of fever should not be relied upon

Table 2. History and examination findings in septic arthritis.*[8,9]

Finding	Sensitivity	Specificity	-LR (95% CI)	+LR (95% CI)
History				
Age > 80 years	18.9	94.6	0.86 (0.70-0.96)	3.5 (1.7-6.4)
Rheumatoid arthritis	67.6	72.5	0.45 (0.27-0.67)	2.5 (1.9-2.9)
Diabetes	10.8	96.0	0.93 (0.79–1.0)	2.7 (1.1–6.2)
Joint surgery (< 3 months)	24.0	96.5	0.78 (0.63–0.90)	6.9 (3.7–11.6)
Hip or knee prosthesis	35.1	88.6	0.73 (0.55–0.88)	3.1 (1.9–4.5)
Skin infection, no prosthesis	32.4	88.4	0.76 (0.58–0.91)	2.8 (1.7–4.2)
Skin infection and prosthesis	24.3	98.4	0.77 (0.62–0.88)	15.0 (8.0–26.0)
HIV	75.0	38.8	0.64 (0.23–1.37)	1.2 (0.76–1.5)
Joint pain	85.0	-	-	-
New joint swelling	77.0	-	-	-
Rigors	16.0-21.0	-	-	-
Fever, subjective	44.0-97.0	-	-	-
Diaphoresis	31.0	-	-	-
Physical examination				
Limited motion	92.0	-	-	-
Pain with motion	100	-	-	-
Pain with axial loading	36.0	-	-	-
Tender to palpation	68.0-100	-	-	-
Swelling	45.0-92.0	-	-	-
Joint effusion	92.0	-	-	-
Erythema	13.0-64.0	-	-	-
Increased heat on palpation	18.0-92.0	-	-	-
Fever > 37.5°C	34.0-90.0	-	-	-

-LR, negative likelihood ratio; *+LR,* positive likelihood ratio; *CI,* confidence interval; *HIV,* human immunodeficiency virus.
*Remaining numbers represented by hyphens could not be calculated due to heterogeneity and unreliable methodology.[8,9]

to exclude the diagnosis; however, up to 90% of patients have been shown to have a low-grade fever (≥ 37.5°C).[8,9] Joint pain that is sudden in onset is more suggestive of intrinsic joint pathology, such as septic arthritis.[8-10,17,18] A joint with painful and limited active and passive range of motion is suggestive of intra-articular infection.[8,9]

Laboratory Testing

Serum blood tests are inadequate to rule out septic arthritis. Synovial fluid is the gold standard test for making the diagnosis of septic arthritis. While a complete blood cell count, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) are often obtained, the results of these tests will not sufficiently lower the post-test probability to influence the decision to obtain synovial fluid.[8-110,17,18] The serum white blood cell (WBC) count may be elevated above 10 x 10^9/liters (L), but the sensitivity ranges from 42-90% with +LR of only 1.4 (95% confidence interval [CI] [1.1-1.8]).[8,9,31-36] The sensitivity of ESR differs based upon the specific cut-off value that is selected, with a sensitivity of 66% for 15 mm/hr to > than 90% for 30 mm/hr.[7-10,30,35-37] One meta-analysis suggests a +LR of 1.3 (95% CI [1.1-1.8]) for ESR > 30 mm/hr.[9] CRP > 10 mg/L also has a sensitivity approaching 90%; however, a level of 100 mg/L has a poor +LR of 1.6 (95% CI [1.1-2.5]).[8,9,35] While procalcitonin demonstrates promise, at this time it requires further study before routine use.[8,10,17,18,38,39] Blood cultures should be obtained in patients with septic arthritis, as they can help identify the source if the synovial fluid culture is negative. Blood cultures will be positive in over one-third of all patients, and 14% of patients with negative synovial fluid cultures will have positive blood cultures.[6,10,15,17,18]

Imaging

Radiographs are typically obtained of the affected joint and may demonstrate soft tissue swelling or a joint effusion.[10,40,41] Later stages of septic arthritis may reveal chronic bony changes and calcium deposits.[10] Advanced imaging, including computed tomography and magnetic resonance imaging, possesses greater sensitivity and specificity than plain radiographs, though it is of low utility for the acute diagnosis.[10,40-42] Ultrasound may provide assistance in determining the presence of intra-articular effusion and locating the site of optimal aspiration.[10,26,43,44]

Synovial Fluid

Synovial fluid is the gold standard for excluding septic arthritis in patients with high clinical suspicion. Results of the aspiration also assist with determining the etiology of joint effusion (Table 3). However, some of these findings may overlap between categories.[8,17,18,45] The numbers from this table have been obtained from several meta-analyses and are provided here in one location.

A synovial white blood cell count (sWBC) ≥ 50 x 10^9/L is concerning for septic arthritis (Table 3).[8,9,17,18] Moreover, the likelihood of septic arthritis increases as the sWBC rises, with levels ≥ 100 x 10^9/L demonstrating an aggregate +LR of 13.2 (95% CI [3.6-51.1]).[8-10] While the sWBC values can affect the likelihood of septic arthritis, it is important to consider that the patient's immune status may affect these findings, resulting in low sWBC counts in patients with significant immunocompromised status.[8,9,45] A sWBC ≥ 50 x 10^9/L (or 50,000 cells/mm^3) may also be found in several other inflammatory conditions (e.g., gout, pseudogout).[8-10,17,18,32] Additionally, nearly half of patients with culture-proven septic arthritis may have sWBC counts ≤ 28,000 cells/mm^3, even in cases due to *S. aureus,* with *N. gonorrhoeae* accounting for 5% of all cases.[8-10,17,18,32] Synovial polymorphonuclear cells (sPMN) can also be significantly elevated in cases of septic arthritis.[8,9,15] Unfortunately, this test does not significantly alter probability of septic arthritis, with a +LR of 2.7 (95% CI [2.1-3.5]) when the sPMN is > 90% and a -LR of 0.34 when the sPMN is < 90%.[8,9]

Other diagnostic assessments include synovial Gram stain, culture, protein, lactate dehydrogenase (LDH), glucose, and lactate.[8-10,15,17,18] Synovial culture is the single most important test and should be ordered on all patients from whom synovial fluid is collected. Synovial fluid will demonstrate growth in approximately 80% of all cases of nongonococcal septic arthritis.[8-10] The remaining 20% of negative cultures may demonstrate no growth for a variety of reasons including small number of bacteria present within the joint space, obtaining a sample after initiation of antibiotics, mistaken diagnosis of septic arthritis, poor sampling technique, or poor plating technique.[8-10,17,18,45] To decrease the likelihood of false negative synovial cultures, larger amounts of synovial fluid should be collected and placed in blood culture bottles. Synovial Gram stain sensitivity ranges from 29-65% in cases of Gram-positive septic arthritis; however, this decreases to 40-50% in Gram-negative cases and 25% in gonococcal cases.[15-18,45-53]

Synovial protein and glucose do not significantly change the likelihood of septic arthritis.[8,9] One study found that a synovial lactic dehydrogenase less than 250 U/L may exclude the diagnosis of septic arthritis, but further studies are needed.[8,53] The presence of crystals does not rule out septic arthritis.[8,10,17,18,45,54] Synovial lactate has been suggested to have the best diagnostic accuracy of all synovial fluid markers in septic arthritis. Levels above 10 mmol/L demonstrate a +LR > 20.[8,51,55-57] Of note, it is important that the laboratory be able to differentiate D-lactate, produced by bacteria, from L-lactate, produced by humans.[8,57] Therefore, this may not be feasible at all institutions.

Management

Rapid diagnosis and treatment reduce the risk of significant morbidity and mortality.[10,17,18,58,59] Risk factors associated with increased risk of joint destruction include age > 65 years, diabetes, and beta-hemolytic streptococci infection, while risk factors for mortality include age > 65 years, confusion at time of initial presentation,

Table 3. Categories of synovial fluid findings in monoarticular arthritis.

Synovial fluid measure	Normal fluid	Noninflammatory	Hemorrhagic	Inflammatory	Septic
Color	Clear	Yellow	Red	Yellow	Yellow/green
Clarity	Transparent	Transparent	Bloody	Translucent-opaque	Opaque
Viscosity	High	High	Variable	Low	Variable
White blood cells	< 2 x 10^9/L	< 2 x 10^9/L	< 2 x 10^9/L	2-100 x 10^9/L	10-100 x 10^9/L
Percentage of PMNs	< 25%	< 25%	50-75%	> 50%	> 75-80%
Culture result	Negative	Negative	Negative	Negative	Usually positive

Synovial result	+LR (95% CI)	-LR (95% CI)
sWBC > 100 x 109/L	13.2 (3.6-51.1)	0.83 (0.80-0.89)
sWBC > 50 x 109/L	4.7 (2.5-8.5)	0.52 (0.38-0.72)
sWBC 25-50 x 109/L	3.2 (2.3-4.4)	0.35 (0.23-0.50)
sPMN > 90%	2.7 (2.1-3.5)	0.51 (0.39-0.65)
sLactate > 10 mmol/L	> 20*	0.14-0.45*

PMNs, polymorphonuclear neutrophil; *sWBC,* synovial white blood cell count; *sPMN,* synovial polymorphonuclear cell count; *sLactate,* synovial lactate; *CI,* confidence interval; *+LR,* positive likelihood ratio; *-LR,* negative likelihood ratio; *L,* liter.
*Unable to pool results to obtain accurate 95% confidence intervals.

and polyarticular involvement.[30,59-61] Components of management include early recognition and treatment, with 1) joint aspiration, 2) antibiotics, and 3) orthopedic surgery consultation for possible operative management.[10,17,18,58,59]

Due to the potential for rapid joint destruction, broad-spectrum antibiotics are often needed.[17,18,58,59] In patients with strong concern for septic arthritis or in those who are critically ill, both Gram-negative and MRSA coverage is recommended with a combination of cefepime or an antipseudomonal beta-lactam agent and vancomycin, respectively.[17,18,58,59] If the patient is allergic to vancomycin, daptomycin, clindamycin, or linezolid may be utilized instead.[17,18,58,59] Once the specific organism is determined, antibiotic therapy should be narrowed. There is currently no role for intra-articular antibiotics or intra-articular corticosteroids for these patients in the ED setting.[10,58]

While many patients may be managed with antibiotics alone, it is important to involve orthopedic surgery, as some patients may require arthroscopy, serial arthrocentesis, or arthrotomy in addition to the antibiotics.[10,17,18,58,59] Arthrocentesis removes bacteria and toxins, decompresses the joint space, and improves blood flow, which may improve recovery.[10,17,18,58,59] Arthrocentesis is typically repeated on a daily basis until cultures are negative and effusions resolve.[10,17,18,58,59] In cases that fail to respond to serial arthrocentesis, soft tissue infections that extend outside of the joint or involvement of the hip joint, surgical drainage is often indicated.[1,58,59] Septic arthritis involving the shoulder may be managed with surgical or radiologically-guided techniques.[10,58-60] Some joints, such as the sternoclavicular joint, do not respond well to antibiotics alone.[58-64] In these cases, cardiothoracic surgical consultation is recommended.[58-64]

Joint Aspiration

Most joint aspirations are within the purview of the emergency physician.[10,58,59] While it is traditionally recommended to avoid aspirating through a site with overlying cellulitis, one recent review suggested there was no harm from aspirating through cellulitis, with the only direct definitive contraindication an underlying abscess.[65] Additionally, anticoagulation is a relative contraindication, but should be weighed against the much higher risk associated with missing a case of septic arthritis.[66] Prosthetic joints should be discussed with orthopedic surgery prior to aspiration.[67] If unable to obtain fluid on the initial aspiration, several techniques may be used to increase the likelihood of success. Using a larger gauge needle and a smaller syringe can improve the ability to obtain fluid by generating a greater pressure difference.[68] Additionally, compression of the contralateral side of the joint with gentle rotation of the needle while aspirating will be of benefit.[68] Finally, ultrasound should be considered for arthrocentesis, as it locates the area with maximal fluid, while avoiding vascular structures and tendons.

Special Considerations

Gout

Gout can predispose patients to septic arthritis due to chronic joint damage.[8,10,54,69] Patients with a first instance of an erythematous, swollen, painful joint and those with atypical presentations of their usual gout should undergo joint aspiration. Joint fluid in gout traditionally demonstrates uric acid, or calcium pyrophosphate crystals in pseudogout; however, it is important to note that these crystals do not exclude concomitant septic arthritis, as the pathologies may coexist in up to 5% of cases.[54,69] Patients with gout and septic

arthritis often demonstrate sWBC counts > 50 x 10^9/L;[54,70] however, up to 10% of patients may demonstrate sWBC < 6 x 10^9/L.[70] Patients with concern for possible septic arthritis should undergo joint aspiration, antibiotics, orthopedic consultation, and admission.[17,18,69,70]

Human Immunodeficiency Virus (HIV)

Patients with human immunodeficiency virus and acquired immunodeficiency syndrome are predisposed to a variety of orthopedic conditions, including infections and vascular infarctions due to a chronic immunocompromised and inflammatory state.[8,10,71-73] In this population, septic arthritis is most commonly associated with MRSA, though tuberculosis and fungal species have also been identified.[71-73] Patients may not be able to produce a normal immune response to septic arthritis, resulting in lower sWBC levels.[71-73] Patients with either new or chronic joint pain with effusion should undergo aspiration given the high risk of opportunistic infections.

Table 4. Musculoskeletal Infection Society definition of periprosthetic joint infection.[67,76]

Two positive periprosthetic cultures with phenotypically-identified organisms
Or
A sinus tract communicating with the joint
Or
Three of the following minor criteria:
Elevated CRP and ESR
Elevated sWBC or positive leukocyte esterase strip
Elevated synovial neutrophil percentage
Positive histologic analysis of periprosthetic tissue
A single positive culture result

CRP, C-reactive protein; *ESR,* erythrocyte sedimentation rate; *sWBC,* synovial white blood cell count.

Prosthetic Joint

Prosthetic joint infection (PJI) occurs most commonly within the first two years after surgery, with a rate of 1-2% for hip and knee arthroplasties and 1% with shoulder arthroplasty.[67,74-77] Unlike native joints, prosthetic joints do not contain cartilage and are not at risk of cartilage destruction.[67,77] Acute infections (i.e., < six weeks from operation) should receive urgent antibiotics to preserve the prosthesis, while more chronic infections (i.e., > six weeks from operation) may be treated with less urgency.[67] Chronic infection is more common than acute postoperative and acute hematogenous infection in these patients.[78,79] Risk factors for PJI include longer procedural time, postoperative wound drainage, obesity, malnutrition, diabetes, anticoagulants, tobacco use, heavy alcohol use, poor hygiene, prior surgery at the same site, and bacterial colonization.[79-84] *S. aureus* is the most common organism, followed by *S. epidermidis* and *Pseudomonas* due to the production of a protective bacterial biofilm.[84-86]

Signs and symptoms depend upon the patient's immune response and whether the infection is acute or chronic.[67] Acute infections typically present with a new effusion, erythema, and warmth combined with general symptoms of fever and malaise, while chronic infections may present with more subtle signs of pain over time without significant external evidence of infection.[67,76,87] Findings may also include an open wound, sinus tract, or abscess.[67,76,88,89] If there is concern for a PJI, the physician should obtain serum laboratory testing (i.e., WBC, ESR, CRP) and perform a joint fluid aspiration in consultation with the patient's orthopedic surgeon.[67,88-90] Cultures from a draining wound are not recommended due to risk of skin flora contamination.[67,76] Diagnostic criteria are shown in Table 4.[67,76]

Importantly, the specific thresholds for septic arthritis differ compared to native joints. For acute PJI, thresholds of sWBC 10 x 10^9/L and sPMN > 90% are recommended.[90-92] For chronic PJI, sWBC 3 x 10^9/L and sPMN > 80% are recommended.[74,75,88,89] One publication recommended joint aspiration for a CRP > 100 mg/L for acute infection.[67] Revision surgery and antibiotics are usually required. However, compared with native joint infections, these are typically not needed emergently.[67,76] If patients present with fever and an acute onset of symptoms, blood cultures should be obtained and antibiotics administered in the ED.[67,76] Otherwise, antibiotics may be withheld until the case is discussed with the orthopedic surgeon.[67,76]

Hemophilia

Hemarthrosis is a common presentation among patients with hemophilia A and B.[93-97] This is a hallmark of more severe hemophilia and is associated with chronic disability and reduced quality of life.[93-96] Hemarthrosis can result in chronic joint damage and increases the risk of septic arthritis at a rate of 15-40 times that of the general population.[93-96] Patients with hemophilia who have joint pain, swelling, or erythema should be asked about prior hemarthroses, factor levels, prophylactic medications, and recent factor administration. In most patients, joint aspiration should be avoided in the setting of hemarthrosis.[97,98] However, if the patient presents with severe pain, fever, joint erythema, or swelling in the absence of trauma and septic arthritis is suspected, aspiration of synovial fluid is important.[93-96] Aspiration of hemarthrosis may improve pain and rehabilitation in patients with rapid intra-articular accumulation of blood, although this is controversial.[97,98] Before conducting aspiration of suspected hemarthrosis,

emergency physicians should discuss the aspiration with hematology and orthopedics, specifically addressing possible factor replacement prior to joint aspiration.[97,98]

Mimics

A significant number of conditions may mimic the presentation of septic arthritis, creating difficulty in diagnosis. Knowledge of these conditions and their presentation, diagnosis, and management may improve patient outcomes. Table 5 demonstrates these conditions, and Appendix 1 lists these mimics with evaluation and management recommendations.

CONCLUSION

Septic arthritis is a potentially deadly condition that unfortunately does not always present classically. The red, hot, swollen joint mandates consideration of septic arthritis. No physical examination finding can rule out the condition, and serum blood tests should not be used to exclude septic arthritis. Diagnostic aspiration is required, with the sample sent for synovial WBC, Gram stain, culture, and lactate. Synovial lactate and culture are the best laboratory tests, as some patients can present with normal synovial WBC and Gram stain. Management requires orthopedic surgery consultation and antibiotics. There are a significant number of mimics of septic arthritis, including abscess, cellulitis, gout, rheumatoid arthritis, osteomyelitis, malignancy, Lyme disease, and avascular necrosis. A focused history and examination, along with dedicated diagnostic evaluation, can assist in differentiating these conditions.

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Table 5. Septic arthritis mimics.

Abscess
Avascular necrosis
Cellulitis
Crystal-induced arthropathy
Lyme disease
Malignancy
Osteomyelitis
Reactive arthritis
Rheumatoid arthritis
Transient synovitis

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Delayed Recognition of Acute Stroke by Emergency Department Staff Following Failure to Activate Stroke by Emergency Medical Services

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Introduction: Early recognition and pre-notification by emergency medical services (EMS) improves the timeliness of emergency department (ED) stroke care; however, little is known regarding the effects on care should EMS providers fail to pre-notify. We sought to determine if potential stroke patients transported by EMS, but for whom EMS did not provide pre-notification, suffer delays in ED door-to-stroke-team activation (DTA) as compared to the other available cohort of patients for whom the ED is not pre-notified–those arriving by private vehicle.

Methods: We queried our prospective stroke registry to identify consecutive stroke team activation patients over 12 months and retrospectively reviewed the electronic health record for each patient to validate registry data and abstract other clinical and operational data. We compared patients arriving by private vehicle to those arriving by EMS without pre-notification, and we employed a multivariable, penalized regression model to assess the probability of meeting the national DTA goal of ≤15 minutes, controlling for a variety of clinical factors.

Results: Our inclusion criteria were met by 200 patients. Overall performance of the regression model was excellent (area under the curve 0.929). Arrival via EMS without pre-notification, compared to arrival by private vehicle, was associated with an adjusted risk ratio of 0.55 (95% confidence interval, 0.27-0.96) for achieving DTA ≤ 15 minutes.

Conclusion: Our single-center data demonstrate that potential stroke patients arriving via EMS without pre-notification are less likely to meet the national DTA goal than patients arriving via other means. These data suggest a negative, unintended consequence of otherwise highly successful EMS efforts to improve stroke care, the root of which may be ED staff over-reliance on EMS for stroke recognition. [West J Emerg Med. 2019;20(2)342-350.]

INTRODUCTION

Background and Importance

Optimizing the management of acute ischemic stroke is a priority for emergency departments (ED).[1-7] Intervention for stroke patients is time sensitive, with guidelines recommending administration of intravenous (IV) recombinant tissue plasminogen activator (rt-PA) within 4.5 hours of symptom onset and initiation of endovascular procedures "as early as

possible," when indicated.[8,9] Due to time sensitivity of treatment of acute stroke, emergency medical services (EMS) agencies and providers have been foci of educational efforts to drive earlier recognition. Prehospital scales have been developed to help providers identify these patients.[10,11] These tools have been validated and demonstrate moderate sensitivity and high specificity.[12-16] Additionally, EMS pre-notification to receiving hospitals for incoming stroke patients is considered a best practice.[4,13]

Multiple studies have demonstrated that pre-notification for acute stroke has improved timeliness of care including time to imaging,[1,3,4,7,12,13] time to stroke team evaluation,[4] and time to thrombolytic administration.[1,3,7] Pre-notification also is associated with an increased rate of IV rt-PA administration overall.[4, 7] While multiple investigations have shown EMS efforts in the areas of early identification and pre-notification to be successful in improving timeliness of acute stroke management, to date no research has been reported regarding potential unintended adverse consequences of these care process improvements. More specifically, we are unaware of any reports of the downstream consequences should EMS providers fail to identify an acute stroke patient and pre-notify.

Population Health Research Capsule

What do we already know about this issue?
Stroke patients for whom emergency medical services (EMS) provides prenotification to the receiving hospital experience improved timeliness of care including time to imaging and stroke activation.

What was the research question?
Do stroke patients arriving by EMS without prenotification experience the same timeliness of care as those presenting in a similarly undifferentiated state to triage?

What was the major finding of the study?
Stroke patients arriving by EMS without prenotification experience poorer timeliness of care than those who arrive to triage.

How does this improve population health?
This finding suggests the need for improved Emergency Department provider awareness of EMS patients with potential stroke as well as the need for increased awareness for EMS providers as well.

Goals of This Investigation

We postulated that EMS recognition and notification of acute stroke may be so effective that failure to pre-notify by EMS may influence timeliness of recognition of stroke symptoms by ED staff after ED arrival. We theorized that among patients for whom EMS did not recognize stroke symptoms, arrival by EMS may be associated with delays in subsequent stroke team activation by ED staff, compared to patients for whom only ED staff were responsible for recognizing stroke (i.e., those who arrived via private vehicle).

METHODS

Study Design and Setting

This was a cohort study in which we employed a previously developed methodology to retrospectively query the prospective stroke registry of our urban, regional referral stroke center hospital to identify all consecutive patients who presented to the adult ED and met criteria for stroke team activation between June 15, 2014, and June 15, 2015.[17] During the study period, there were 67,795 adult ED visits and approximately 27,000 adult inpatient admissions. The center is a primary teaching site for multiple residencies, including emergency medicine (EM) and neurology, and there is a stroke team available in-house 24 hours per day, seven days a week. The ED is staffed by board-certified/board-eligible attending emergency physicians, who supervise EM and off-service rotating residents. Nursing staff are dedicated to the ED and do not float to other units, and many have achieved advanced specialty certifications. All American Heart Association/American Stroke Association *Get With The Guidelines* recommendations have been implemented,[18] and ED nursing and physician staff undergo periodic acute stroke continuing education. We use a traditional nurse triage model.

Given our geographic location and tertiary care status, the catchment area for potential stroke patients is large. Approximately 25 unique EMS agencies bring patients to our facility each year, almost all advanced life support services. EMS providers provide pre-arrival notification via radio for all inbound patients and give in-person handoff directly to ED nursing staff. EMS providers are encouraged to independently activate the stroke team from the field for patients who have a positive prehospital stroke screen. For patients without prehospital activation, ED nurses receiving in-person handoff are empowered to activate stroke resources independently, prior to physician involvement. For potential stroke patients not recognized by either EMS or ED nurses, stroke resources may be activated by a physician.

EMS providers undergo stroke recognition education as part of their biannual continuing education. In Massachusetts, EMS providers operate under standardized prehospital statewide treatment protocols, and stroke assessment is performed under the guidance of these protocols using, at the time this data

were gathered, the Massachusetts Stroke Scale (MASS) or "or equivalent nationally recognized stroke scale."[19] The MASS is an analogue of the Cincinnati Prehospital Stroke Scale.[11,16]

Our investigation was approved by the University of Massachusetts Medical School Institutional Review Board.

Selection of Participants

By protocol, the stroke team was activated when any patient presented to the ED with symptoms or findings consistent with an acute stroke within 12 hours of symptom onset. Our multidisciplinary stroke committee previously established the 12-hour window, accounting for three key considerations: prioritizing sensitivity over specificity for the mobilization of the stroke team and resources, availability of resources enabling possible treatment beyond 4.5 hours of symptoms in select cases, and institutional research protocols. The committee felt that the potential patient benefit to be gained from this expanded window outweighed the potential inefficiencies it may have caused. Because the key criteria for stroke team activation were symptoms or findings consistent with stroke at the time of activation, some patients within the registry may have had an ultimate diagnosis other than stroke, such as transient ischemic attack.

The institution maintains a prospective registry of all patients for whom the stroke team is activated, which includes patient demographics and time stamps for care events, including ED arrival, stroke team activation, computed tomography completion, and thrombolytic administration time. A stroke nurse coordinator maintains the registry and verifies its accuracy based upon established institutional guidelines. Numerous automated and manual processes exist to ensure 100% registry capture of all patients for whom stroke resources are activated.

Methods and Measurements

Research assistants (RA), blinded to the study aims, were trained in data abstraction from the electronic health record (EHR). One study author independently abstracted at least the first 10 encounters reviewed by each RA to test for rater reliability, and there were no discrepancies. A formal analysis of inter-rater reliability was not performed. The RAs retrospectively reviewed the EHR (ED PulseCheck, Optum Clinical Solutions, Inc., Eden Prairie, Minnesota; Soarian, Cerner Corporation, North Kansas City, Missouri; and OnBase, Hyland Software, Inc., Westlake, Ohio) for each patient in the registry to validate the registry data and abstract the following fields (determined a priori) using standardized abstraction forms: mode of arrival (EMS vs non-EMS); prehospital stroke activation (yes or no); initial vital signs (heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, and pulse oxygen saturation); supplemental oxygen use and delivery method (none, nasal cannula, face mask, bag-mask ventilation, or intubated); Glasgow Coma Scale score (GCS); level of orientation (person, place, and time–range of 0-3); National Institutes of Health Stroke Scale (NIHSS) score; initial blood glucose value; elapsed time since the patient was last known to be at his or her baseline neurologic condition; previous history of stroke or transient ischemic attack; previous history of diabetes mellitus; and previous history of hypertension.

In order to identify cases in which staff inadvertently omitted documentation of prehospital activation, in the case of patients for whom there was not specific documentation regarding prehospital activation, we also compared the stroke team activation timestamp and the ED arrival timestamp. If the activation time occurred prior to the patient's arrival, we considered prehospital activation to have occurred. Abstractors also reviewed the EHR to determine whether the ED team documented treatment of another emergent, life-threatening condition that may have delayed stroke recognition or care, such as airway/breathing intervention required, hypertension, hypotension, hypoglycemia, emergent electrolyte abnormality, or more than one of the above conditions. Rare missing values in the registry were obtained from the EHR by the abstractor.

A second investigator independently searched the EHR for missing values after the initial abstraction and also independently validated all abstracted data for a subset of cases primarily abstracted by each RA. Missing values not available in either the registry or the EHR (vital signs, n=1; glucose, n=4; and GCS, n=75) were replaced with the corresponding median value for the remaining data set, except for GCS, which was replaced with the value 15, after verifying that the remaining registry fields and NIHSS supported such as value. One entry in the registry was an exact duplicate, so the affected patient was analyzed only once. For 12 patients, there were conflicting entries between the EHR and the stroke registry as to the mode of arrival. Two senior investigators, not involved in initial abstraction (Martin Reznek and Sean Michael), reviewed each of these cases independently and blindly and had agreement upon the mode of arrival for 10 of the 12 patients (Cohen's kappa=0.81). The two patients for whom consensus was not reached were excluded from analysis. We have previously validated and employed a similar abstraction and data verification methodology for another registry-based study.[17]

Outcomes

Based on the electronic timestamps for ED arrival and stroke team activation, we calculated the door-to-activation (DTA) time for each patient in the stroke registry. We chose DTA to isolate any subsequent variation in stroke care processes from the process we wished to study–that of time to stroke recognition and the effect of EMS pre-notification. All subsequent stroke care processes are dependent on timely recognition of stroke syndromes and activation of stroke resources, the most appropriate measure of which is DTA. National guidelines stipulate a goal of stroke team

activation within 15 minutes of patient arrival. We selected this dichotomous variable of DTA ≤ 15 minutes as our primary outcome given its prevalence in the literature as a key step in ED stoke care.[20] Additionally, we felt it had face validity in that timely activation of resources is a prerequisite to operationalizing rapid acute stroke care, often requiring orchestration among a large and diverse team. DTA also has an inherent threshold effect on all other targets for timely stroke care in the guidelines. Achieving door-to-imaging time within 25 minutes or door-to-needle time within 60 minutes, for example, is heavily influenced by DTA (and may be impossible if DTA exceeds 25 minutes or 60 minutes, respectively).

Secondary clinical outcomes were admission to a neurology service, final ED diagnosis of stroke or intracranial hemorrhage, and administration of IV thrombolytics or neurointerventional procedure, which were recorded directly in the registry and verified in the EHR.

Analysis

Our routine quality monitoring data suggested that approximately 72% of patients achieved DTA ≤ 15 minutes, so we estimated that the sample size required to demonstrate a two-sided difference in proportions of 10 percentage points with 80% power was 179, which was achievable using one year of registry data. We filtered the dataset to include all patients who either did not arrive via EMS or who arrived via EMS but did not have stroke team activation initiated from the prehospital setting or immediately upon arrival. Patients transferred from other facilities for stroke care were excluded, as their symptoms were, presumably, already recognized. We excluded patients with documentation of another emergent, life-threatening condition that may have delayed stroke team activation and occurred prior to activation or initial neuroimaging. Patients for whom the documented duration of symptoms was shorter than the DTA time (one possible explanation being that symptoms may have begun while already in the ED) were reviewed for potential exclusion by full-text review of the EHR documentation by a senior investigator, but no cases of documented symptom onset while in the ED were identified in the included population.

Our primary predictor of interest was mode of arrival (EMS without prehospital activation vs arrival not by EMS). We chose our comparison groups because they represent a population presenting to the ED without prior knowledge that a stroke is suspected, which allows for assessment of the time to recognition of stroke symptoms. In contrast, comparing EMS arrivals with prehospital activation to either other category risks an unbalanced comparison. We identified 17 additional candidate predictors by investigator consensus, which are listed in Tables 1a and 1b, based upon their plausibility as confounders and/or inclusion in prior studies. Preliminary analysis did not reveal a significant contribution of any temporal effects including arrival hour of day, day of week, or month/year, so we did not include any. We used a calculated mean arterial pressure (MAP) in lieu of including both systolic and diastolic values to reduce dimensionality.

Specifics of our statistical data analysis are available in web Appendix A. They are omitted from the main body of this article in the interest of brevity.

RESULTS

Characteristics of Study Subjects

There were 490 consecutive stroke activation patients in the registry during the study period. Of these, 383 arrived via EMS, with 277 (72.3%) presenting with EMS stroke pre-notification. Of the 213 patients who arrived either by EMS without pre-notification or arrived by other means, 11 were documented to have delays in stroke care due to a more emergent management consideration (airway/breathing intervention, n=8; hypertension, n=2; hypotension, n=1) and were excluded. NIHSS was captured on 100% of patients. Clinical outcomes of included and excluded patients are shown in the study flow diagram (Figure). Tables 1A and 1B report the baseline characteristics of included patients. The secondary clinical outcomes are similar between modes of arrival (Table 2).

Of the 200 included patients, 83 (41.5%) achieved DTA ≤ 15 minutes, and DTA ranged from < 1 minute to 3 hours 37 minutes (median 20 minutes, interquartile range [IQR] 25 minutes). Among patients who arrived via EMS without prehospital activation, 32.1% achieved DTA ≤ 15 minutes (median 22, IQR 25 minutes), compared to 52.1% among patients who did not arrive via EMS (median 14, IQR 21 minutes).

Main Results

Overall performance of the multivariable regression model was excellent, with area under the curve 0.929. Parameter estimates for all terms are listed in Appendix A. Arrival via EMS without prehospital stroke activation, compared to arrival not via EMS, was associated with an adjusted odds ratio of 0.37 (95% confidence interval [CI], 0.15-0.92 for achieving DTA ≤ 15 minutes in the multivariable model (p=0.03). This is equivalent to a risk ratio of 0.55 (95% CI, 0.27-0.96).

DISCUSSION

Our investigation found that potential stroke patients arriving without EMS pre-notification were only 55% as likely to meet the national 15-minute goal for DTA time as those arriving via means other than EMS. This striking finding is important and likely reflects an unintended, negative consequence of the ongoing emphasis on prehospital recognition of stroke and activation of in-hospital resources by EMS. While it is well known that pre-notification hastens ED stroke care processes, this is the first study to show that failure to pre-notify actually results in erosion of timeliness of care.

Even when controlling for demographics, patient factors (such as vital signs and history), stroke severity (including NIHSS and duration of symptoms), and propensity to arrive via

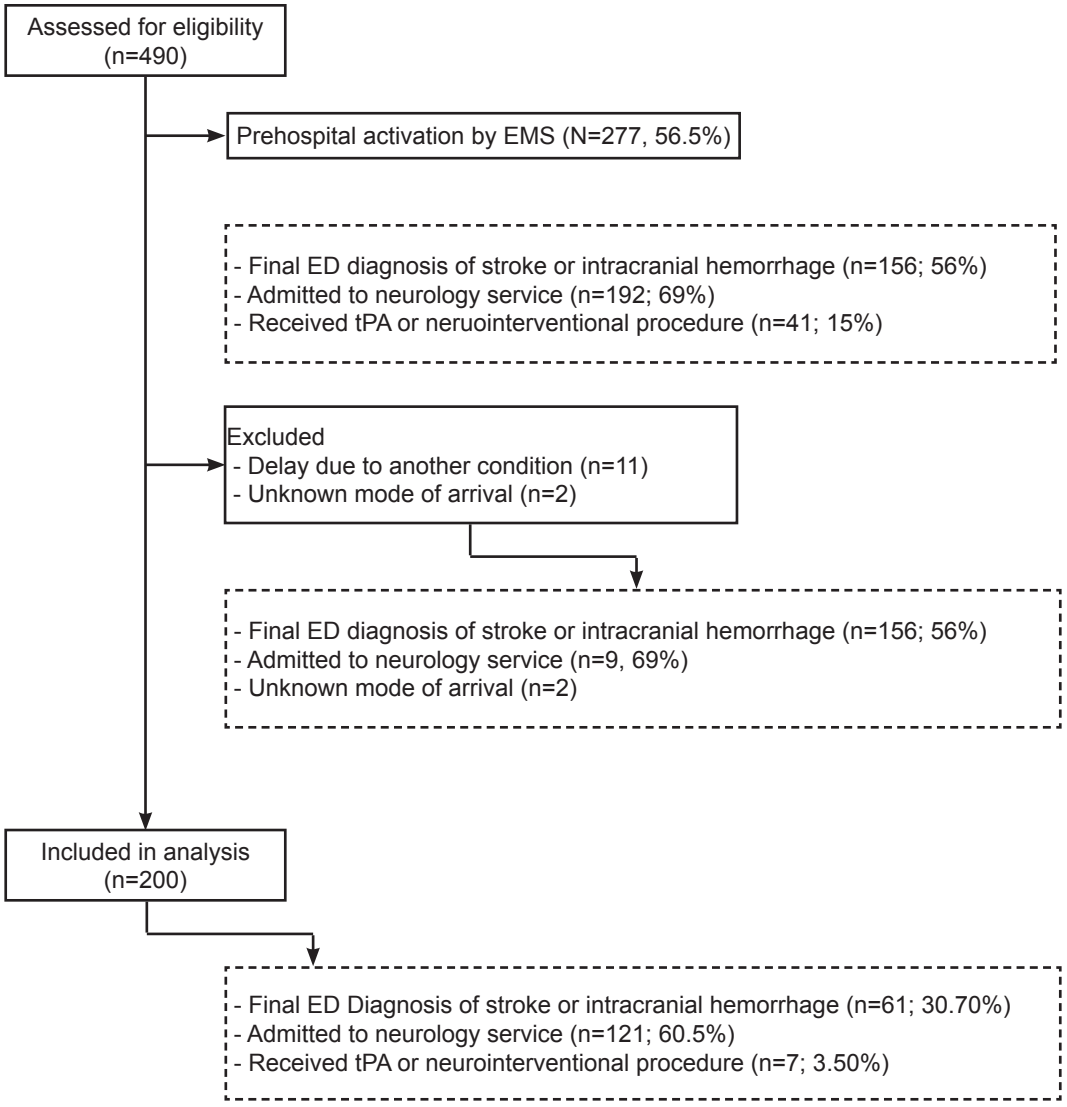

Figure. Study flow diagram.
EMS, emergency medical services; *ED,* emergency department; *tPA,* tissue plasminogen activator.

EMS, stroke patients arriving via the "front door" enjoyed more timely recognition and resource activation by ED staff than those arriving via the ambulance entrance if EMS had not already recognized the stroke symptoms in the field. Our investigation was not designed to investigate causality; however, we believe the underlying mechanism is likely to be multifactorial, including triage process, ED operations (such as bed allocation), nursing assessments, or physician evaluations. Most importantly, however, we postulate that our observed results also may have been due to the success of EMS early identification and pre-notification efforts in our region, potentially creating a false sense of security and causing ED staff to become over-reliant on EMS decision making. Like our region, pre-notification success has occurred in many regions across the United States, leading us to believe that our findings may be relevant and significant for ED stroke care processes nationwide.

During the study period of our investigation, 106 patients arrived by EMS without pre-notification, while 277 (72%) did enjoy pre-notification by EMS, prompting reflection of why over a quarter of patients did not experience pre-notification by EMS. In Massachusetts, EMS providers operate under the Massachusetts Statewide Treatment Protocols, which contain and mandate the use of the MASS, or an "equivalent nationally recognized stroke scale."[19] This scale is analogous to the Cincinnati Prehospital Stroke Scale and therefore likely exhibits similar performance characteristics. With the Cincinnati scale, providers can be expected to demonstrate a sensitivity of approximately 60%,[11,16] predicting a "miss rate"

Table 1A. Discrete predictor variables and study subject characteristics.

Discrete predictor	All patients n (%)	Patients arriving via EMS without prehospital activation % (n=106)	Patients arriving not via EMS % (n=94)	Patients with DTA ≤ 15 minutes % (n=83)	Patients with final ED diagnosis of stroke or ICH % (n=61)
Mode of arrival (EMS)*	106 (53.0)	100	0	41.0	50.8
Sex (female)	111 (55.5)	59.4	51.1	44.6	49.2
GCS score (<14)*	21 (10.5)	19.8	0	12.0	13.1
History of diabetes mellitus	60 (30.0)	34.9	24.5	25.3	31.1
History of hypertension	129 (64.5)	68.9	59.6	62.7	70.5
History of stroke/TIA	66 (33.0)	34.0	31.9	26.5	31.1
Orientation level (<3)*	49 (24.5)	37.9	9.6	28.9	27.9
Supplemental oxygen (intubated, high-flow, or non-rebreather mask versus nasal cannula or none)*	8 (4.0)	7.5	0	4.8	4.9

EMS, emergency medical services; *DTA,* door-to-activation; *ED,* emergency department; *GCS,* Glasgow Coma Scale Score; *TIA,* transient ischemic attack; *ICH,* intracranial hemorrhage.
*P-value<0.05 for univariate difference between patients arriving via EMS without prehospital activation and patients arriving not via EMS.

Table 1B. Continuous predictor variables and study subject characteristics.

Continuous predictor	Range for all subjects	Median (IQR) for all subjects	Median (IQR) among patients arriving via EMS without prehospital activation	Median (IQR) among patients arriving not via EMS	Median (IQR) among patients with DTA ≤ 15 minutes	Median (IQR) among patients with final ED diagnosis of stroke or ICH
Age (years)*	26-98	65 (53,76)	70 (56,82)	60 (52,70)	63 (53,76)	70 (58,78)
Blood glucose (mg/dl)	62-393	113 (98,137)	116 (101,140)	111 (97,130)	113 (99,137)	112 (98,161)
Blood pressure-systolic (mmHg)	97-232	148 (131,165)	146 (125,165)	149 (134,165)	159 (137.178)	154 (141,168)
Blood pressure-diastolic (mmHg)*	31-140	84 (73,93)	79 (68,88)	87 (78,100)	86 (71,104)	87 (75,100)
Heart rate (min-1)	37-149	79 (70,89)	80 (70,89)	79 (70,88)	83 (70,92)	79 (69,89)
NIHSS (1-42 points)*	0-25	2 (1.5)	4 (1,8)	1 (0,3)	3 (1,5)	3 (1,8)
Oxygen saturation (%)	81-100	98 (96,99)	98 (96,99)	98 (96,98)	98 (96,98)	98 (97,99)
Respiratory rate (min-1)	9-35	18 (16,20)	18 (16,20)	18 (16,20)	18 (16,20)	18 (16,20)
Time since patient last known to be at baseline neurologic condition (hours)	0.5->12	2.5 (1.0,5.7)	2.0 (1.0,5.1)	3.0 (1.0,6.0)	2.25 (1.0,6.0)	3.0 (1.0,6.0)

IQR, Interquartile range; *EMS,* emergency medical services; *DTA,* door-to-activation; *ED,* emergency department; *ICH,* intracranial hemorrhage; *mg/dl,* milligrams per deciliter; *mmHg,* millimeters of mercury; *NIHSS,* National Institutes of Health Stroke Scale.
*p-value<0.05 for univariate difference between patients arriving via EMS without prehospital activation and patients arriving not via EMS.

Table 2. Secondary clinical outcomes by mode of arrival.

Secondary outcome	Arrival via EMS without prehospital activation (n=106)	Arrival not via EMS (n=94)	P value for difference
Final ED diagnosis of stroke or ICH n (%)	30 (28)	31 (33)	0.45
Admitted to neurology service n (%)	65 (61)	56 (60)	0.88
Received tPA or neurointerventional procedure n (%)	5 (4.7)	2 (2.1)	0.45

EMS, emergency medical services; *ED,* emergency department; *ICH,* intracranial hemorrhage; *tPA,* tissue plasminogen activator.

of approximately 40%. Our investigation, while not designed specifically to investigate sensitivity and specificity, found a miss rate less than 40%, in fact just slightly more than 25%. If our experience in central Massachusetts is that the screening tool is more sensitive than previously reported for the Cincinnati scale, it is possible that our proposed unintended consequence of over-reliance on EMS pre-notification may be more pronounced than in areas of the country if, and where, the sensitivity remains 40%.

The initial validation study of the Cincinnati scale listed presenting complaints of the 13 patients missed by the scale and eventually diagnosed with stroke.[16] Among those 13 patients, seven presented with some symptom of disequilibrium such as ataxia or vertigo, and 10 were diagnosed with posterior circulation infarcts.[16] The Cincinnati Prehospital Stroke Scale does not directly assess cerebellar function, and this may contribute to its failure to identify these patients.

Because chief complaints in our center were recorded as unstructured free-text, and total NIHSS scores do not differentiate between posterior circulation symptoms and other stroke patterns, our data provide little ability to objectively determine whether delays in recognition in our study stemmed from the same limitations. We did, however, visualize terms and phrases entered as the free-text chief complaint in our EHR among patients without pre-notification and DTA > 15 minutes using a word cloud (Appendix B). This post hoc analysis revealed a high frequency of words such as dizziness, vomiting, altered mental status, and vertigo. While this certainly cannot be used to make any firm conclusions, the similarities of our experience to the original Cincinnati investigation, in this regard, indicate that there may be potential to improve prehospital case identification with additional education for prehospital providers or even modification of the EMS stroke screening tools to better identify posterior circulation strokes. Our post hoc review, coupled with the original Cincinnati validation findings, indicate that further research may be prudent to assess the potential association between posterior circulation events and missed pre-notification.

In addition to improving prehospital identification and notification as a potential counter-measure to the primary findings of this investigation, ED provider-focused intervention may also be prudent. As EMS providers have become increasingly aware and astute at identifying strokes and providing pre-notification, it is possible that ED staff have become too reliant upon EMS identification of the patients. Additional education for ED nursing and provider staff regarding the findings of this investigation and the potential limitations of the screening tool in use by EMS may help boost index of suspicion as cases come through the door by ambulance. Further education and empowerment of triage staff may also reduce DTA times in this subpopulation.

LIMITATIONS

The primary limitation of our investigation was the single-center design, which naturally prompts consideration of the generalizability of our results. It may be the case that our EMS and ED triage processes related to acute stroke were unique to our center and region. However, as the regional stroke center, significant efforts had been made to follow nationally accepted guidelines and recommendations in standardizing our EMS and ED stroke care, so we believe that our processes were likely to be similar to other regions and centers. As in any single-center investigation, we also could not rule out other unmeasured, locally-unique factors beyond our stroke specific processes having influenced our results. While our investigation was not multicenter, we feel that the findings remain important in that they are novel and reveal an opportunity for improvement that likely exists at centers outside of ours.

Our study intentionally did not focus on clinical endpoints, instead favoring process metrics known to affect the timeliness of stroke care. The study was not powered to evaluate door-to-thrombolytic time, given the rare nature of this outcome. Thus, it is possible that patients who experienced DTA delays fared no worse than those who met the goals; however, we feel that our primary process endpoint of DTA remains important and relevant given the accepted national emphasis on timely stroke recognition. Our results also do not precisely identify which subprocesses made the largest contributions to delays (EMS processes or care after ED arrival). Our EHR did not differentiate between arrival via basic life support (BLS) vs advanced life support (ALS). While the majority of 911-originated calls in our system arrive ALS, and both ALS and BLS providers uniformly used the MASS, it is impossible to assess for differences in prehospital stroke recognition between ALS vs BLS EMS providers.

Ambulatory patients and those arriving via EMS were initially triaged in different areas in our ED. While the triage systems were identical, there were potential differences in workflows at each of the triage areas, and it would be difficult to account for some of these factors systematically. For example, the triage nurse at our ambulance entrance had the additional responsibility of bed assignment of all incoming ED patients. While this nurse was responsible for relatively fewer patients requiring triage, it remains possible that the additional job demands may have eroded the effectiveness of stroke identification by the ambulance-entrance triage nurse. Additionally, ED patients arriving to our institution via EMS vs private vehicle, while fewer in number, were of higher acuity in general. This may have created an unmeasured demand-capacity disparity between the triage areas. However, it remains unclear in which direction this potential unmeasured effect would have biased the results, if at all. While our ED employs "pull to full" practices, and triage nurses prioritize patients using standardized scoring methods at both triage locations,[29] during times of high ED census, ambulance patients may have had de facto priority in bed placement to facilitate EMS provider return to service. While not unique to our ED, this practice also may have created an unmeasured effect in which stroke patients not identified by the triage nurse may have had disparities in the time until their next opportunity to be evaluated by another provider, based on

their arrival mode. The directionality of such an effect, however, would likely strengthen our findings, as patients arriving not via EMS would be more likely to have experienced delays.

Prehospital activation documentation was unstructured in our EHR. While it was commonly documented by providers and nurses, this left the potential that it was inadvertently omitted. We employed a secondary capture mechanism of comparing the stroke team activation time and the patient's ED arrival time to determine whether activation had occurred for patients if prehospital activation was not specifically documented. As with any surrogate marker, there was potential that some patients may have been misclassified to either the prehospital activation or no prehospital activation group. However, we believe this to be unlikely given our objective secondary capture method. Finally, a limitation of any observational study is the possibility that unmeasured variables may play a role in confounding (i.e., influencing the probability of arrival via EMS) and/or may directly affect the outcome of interest. Our use of a prospectively-collected stroke registry with robust data-cleaning and validation somewhat mitigated this risk, as the design of the registry by multiple stakeholders and the influence of national data collection standards for accreditation were more likely to have identified important variables than the authors alone. However, our methods could not have entirely accounted for the possibility that important predictors may have gone unidentified.

Our final model's strong area under the curve suggested against there being a large number of unmeasured predictors, but it was difficult to identify unmeasured confounders in the propensity score creation. The associated tradeoff of potential model overfitting due to the inclusion of many variables and interaction terms was also mitigated by our use of penalized regression and model validation techniques. Our final model had intuitive appeal and face validity based on theory, which also suggested against overfitting.

CONCLUSION

In summary, our single-center data demonstrate that potential stroke patients arriving via EMS without prehospital notification (and presumably without EMS recognition of their stroke symptoms) are less likely to meet door-to-activation goals than patients arriving via other means. These results suggest the existence of a deleterious, unintended consequence of otherwise highly successful programs to improve prehospital identification and notification. The root of this unintended consequence may lie in over-reliance on EMS pre-notification and a resultant decreased index of suspicion for stroke among ED staff for patients not identified as such by EMS. Future efforts may be directed toward both increasing the sensitivity of prehospital stroke screening tools and developing improved processes for secondary screening on arrival for this cohort of patients.

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Why Residents Quit: National Rates of and Reasons for Attrition Among Emergency Medicine Physicians in Training

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Introduction: Recruiting and retaining residents who will complete their emergency medicine (EM) training is vital, not only because residency positions are a limited and costly resource, but also to prevent the significant disruptions, increased workload, and low morale that may arise when a resident prematurely leaves a program. We investigated national rates of EM resident attrition and examined the reasons and factors associated with their attrition.

Methods: In this retrospective, observational study we used national data from the American Medical Association National Graduate Medical Education Census for all residents who entered Accreditation Council for Graduate Medical Education-accredited EM programs between academic years 2006-2007 and 2015-2016. Our main outcome was the annual national rate of EM resident attrition. Secondary outcomes included the main reason for attrition as well as resident factors associated with attrition.

Results: Compared to the other 10 largest specialties, EM had the lowest rate of attrition (0.8%, 95% confidence interval [CI] [0.7-0.9]), or approximately 51.6 (95% CI [44.7-58.5]) residents per year. In the attrition population, 44.2% of the residents were women, a significantly higher proportion when compared to the proportion of female EM residents overall (38.8%, p=0.011). A greater proportion of Hispanic/Latino (1.8%) residents also left their programs when compared to their White (0.9%) counterparts (p<0.001). In examining reasons for attrition as reported by the program director, female residents were significantly more likely than male residents to leave due to "health/family reasons" (21.5% vs 9.6%, p=0.019).

Conclusion: While the overall rate of attrition among EM residents is low, women and some under-represented minorities in medicine had a higher than expected rate of attrition. Future studies that qualitatively investigate the factors contributing to greater attrition among female and some ethnic minority residents are necessary to inform efforts promoting inclusion and diversity within the specialty. [West J Emerg Med. 2019;20(2)351-356.]

INTRODUCTION

Methods of resident selection for graduate medical training have been widely studied, with prior work examining factors used by programs to select residents as well as exploring predictors of resident success during training.[1,2] One driver for the numerous analyses of the residency selection process is that training programs invest a significant amount of effort and resources to recruit and develop successful residents.[3,4] The premature loss of a resident during training for any reason is disruptive and can create significant difficulties for programs in terms of patient care responsibilities, increased burdens on other providers, and program morale.[5] For emergency medicine (EM), the competition for coveted residency positions has become increasingly intense.[6]

To ensure that this limited resource is allocated justly and effectively, it is incumbent upon programs to enroll those applicants who are likely to successfully complete residency training. Although other specialties have studied the factors surrounding attrition, EM has not investigated how often attrition occurs among its trainees and for what reasons.[7-9] This study's primary objective was to examine national rates of resident attrition in Accreditation Council for Graduate Medical Education (ACGME)-accredited EM programs between 2006 and 2016. Secondary objectives included investigating the reasons for attrition as well as the resident characteristics associated with attrition.

METHODS

Study Design and Setting

This was a retrospective observational study using de-identified complete national data from the annual American Medical Association (AMA) National Graduate Medical Education (GME) Census.

Study Population

The study population included all categorical residents without prior United States graduate medical education training who entered ACGME-accredited EM programs between academic years 2006-2007 and 2015-2016. The attrition group consisted of any resident at any level who left his or her program during a specific year.

Measurements

We calculated the attrition rate for any year using aggregated national data as the percentage of all residents who left their programs. To ensure anonymity the de-identified dataset included resident characteristics that were limited to gender, race/ethnicity, and medical school type (i.e., allopathic, osteopathic, and international). Per the census database, a primary status and reason for each resident departure was reported by the program director (PD). Attrition statuses included the following: 1) dismissal; 2) transfer to another EM program; 3) transfer to a non-EM program; 4) transfer unknown; and 5) withdrawn. Transfer "unknown" means whether it was unknown by the PD at the time of the report to the AMA National GME Census to what specialty the trainee transferred. Reasons for attrition included the following: 1) change in career plans; 2) health/family reasons; 3) military obligations; and 4) other/unknown.

There are two main ways to view resident attrition: There is attrition from the training program the resident initially enrolled in, and there is attrition from the specialty altogether. For several reasons, we chose the most inclusive definition by counting all attrition statuses, including attrition from one EM program to go to another EM program as well as attrition from the specialty altogether. First, we wanted to be consistent with prior work in other specialties so as to be able to compare our results.[10] Second, attrition from a program or a specialty results in the same negative consequences of morale, workload, and scheduling for the program and its remaining residents. Third, residents who leave one EM program to go to another EM program may highlight the unique systemic challenges he or she faced in that particular program, rather than challenges due to a poor specialty choice, which one presumes would result in attrition to another specialty. Since we were unable to parse out specific details of why each resident left his or her program based on the attrition status and reason reported by PDs, we aimed to provide the most inclusive definition of attrition to gain the most complete picture.

Outcomes

Our primary outcome was the annual national rate of EM resident attrition. Secondary outcomes included the main status and reason for attrition as well as resident characteristics associated with attrition.

Data Analysis

We analyzed data using SPSS for Windows v24.0 statistical software (SPSS, Inc., Chicago, Illinois). To assess for the presence of differences in attrition as well as the status and reason for attrition based upon resident characteristics (i.e., gender, race/ethnicity, medical school type), we employed chi-square analyses followed by the Marascuilo procedure where appropriate for the data.[11] To ensure differences in attrition by gender were not due to potentially changing numbers of women choosing to specialize in EM over time, we evaluated changes in the proportion of female residents using simple linear regression, with the proportion of female residents serving as the outcome variable and calendar year serving as the predictor. Comparisons of independent proportions were made using the *z*-test. Data are presented as counts, proportions, and 95% confidence intervals (CI) around proportions. All *p*-values were two-tailed; we accepted $p<0.05$ as statistically significant. This study was reviewed and determined to be exempt by the Maine Medical Center Institutional Review Board.

RESULTS

There were a total of 51,882 unique EM residents in the AMA National GME Census database during this 10-year period. The annual number of active EM residents enrolled in an ACGME-accredited program ranged from a low of 4,389 in 2006-2007 to 5,865 in 2015-2016. When comparing overall rates of attrition between EM and the other top 10 largest specialties, EM had the lowest rate of attrition (0.8%, 95% CI [0.7-0.9]), or approximately 51.6 (95% CI [44.7-58.5]) residents per year (Table 1). The majority of EM residents graduated from allopathic medical schools (82.4%, 95% CI [81.4-83.4]), followed by those from osteopathic (11.2%, 95% CI [10.5-11.9]) and international (6.4%, 95% CI [6.0-6.8]) medical schools. There were no significant differences in attrition by type of medical school graduate (χ^2=7.150, df=2, p=0.028).

From 2006 to 2016, women comprised 38.8% (95% CI [37.9-39.7]) of EM residents, with no significant changes in gender composition noted during the study period (F=0.607, p=0.436). In the attrition population, 44.3% (95% CI [40.0-48.4]) of the residents were women, a significantly higher proportion when compared to the proportion of female EM residents overall (z=-2.544, p=0.011).

When examining attrition status, almost half of the residents who left their programs "withdrew" (47.0%, 95% CI [42.8-51.4]) (Table 2). There were no differences in attrition status by gender except for those who were "dismissed," with a significantly greater proportion of men receiving this status than women (16.0% vs 8.3%; χ^2=9.852, df=4, p=0.043). When examining the primary listed reason for attrition, the majority reported a "change in career plans" (57.4%, 95% CI [50.9-63.3]) (Table 3). A significantly greater proportion of women than men reported "health/family" reasons for attrition (21.5% vs 9.6%; χ^2=9.923, df=3, p=0.019). All other queried reasons for attrition were similar between women and men.

Race/ethnicity responses to the AMA National GME Census were reported alone or in combination with any other race/ethnicity response. "Alone" indicated those who selected only one race/ethnicity response, whereas "in combination" indicated those who selected more than one race/ethnicity response. An individual could therefore be represented in more than one race/ethnicity category if that individual reported more than one race/ethnicity response. As such, there were 52,490 subjects in this analysis with 1.2% of the subjects reporting more than one racial/ethnic category. Whites comprised the largest group of EM residents (71.3%), followed by Asians (13.0%), Hispanics/Latinos (6.3%), Blacks/African Americans (5.0%), other (3.3%), American Indians/Alaskan Natives (0.8%), Native Hawaiians/other Pacific Islanders (0.2%), and unknown (0.1%). When comparing attrition across race/ethnicity categories, White (0.9%) residents experienced significantly less attrition than their Hispanic/Latino (1.8%) counterparts (χ^2=32.243, df=7, p<0.001) (Table 4). In addition, the proportion of Hispanic/Latino residents who were "dismissed" from their programs (39.3%), was significantly greater than Asian (10.5%) and White (7.5%) residents experiencing dismissal (χ^2=67.516, df=24, p<0.001) (Table 5).

Table 1. Mean annual resident attrition rates by medical specialty.

Specialty	Overall % (95% CI)
Anesthesiology	1.2 (1.0-1.4)
Emergency medicine	0.8 (0.7-0.9)
Family medicine	1.8 (1.5-2.1)
Internal medicine	0.9 (0.8-1.0)
Neurology	1.5 (1.2-1.8)
OBGYN	1.5 (1.2-1.8)
Pathology	1.9 (1.6-2.2)
Pediatrics	1.0 (0.8-1.2)
Psychiatry	6.0 (5.7-6.3)
Radiology	0.9 (0.8-1.0)
Surgery-general	2.7 (2.4-3.0)

CI, confidence interval; *OBGYN*, obstetrics and gynecology.

Table 2. Attrition status by EM resident gender.

Attrition status	Number of residents	Number male [%, (95% CI)	Number female [%, (95% CI)]
Dismissed	65	46 [16.0%* (12.2-20.7)]	19 [8.3%* (5.4-12.6)]
Transfer in EM	77	44 [15.3% (11.6-20.0)]	33 [14.5% (10.9-19.6)]
Transfer out of EM	63	29 [10.1% (7.12-14.1)]	34 [14.9% (10.9-20.1)]
Transfer unknown	68	33 [11.5% (8.31-15.7)]	35 [15.4% (11.3-20.6)]
Withdrawn	242	135 [47.0% (41.3-52.8)]	107 [46.9% (40.6-53.4)]
Total	515	287	228

EM, emergency medicine; *CI,* confidence interval; *df,* degrees of freedom.
*χ^2=9.852; df=4; p=0.043.

Table 3. Attrition reason by EM resident gender.

Attrition reason	Number of residents	Number male [%, (95% CI)]	Number female [%, (95% CI)]
Change in career plans	139	81 [60.0% (51.6-67.9)]	58 [54.2% (44.8-63.3)]
Health/family reasons	36	13 [9.6%* (5.7-15.8)]	23 [21.5%* (14.8-30.2)]
Military obligations	2	0	2 [(1.9% (0.5-6.6)]
Other/unknown	65	41 [30.4% (23.2-38.9)]	24 [22.4% (15.6-31.2)]
Total	242	135	107

EM, emergency medicine; *CI,* confidence interval; *df,* degrees of freedom.
*χ^2=9.923; df=3; p=0.017.

DISCUSSION

The rate of attrition for EM residents is low, and it is the lowest when compared to the other 10 largest specialties. This is consistent with results from prior work also demonstrating the relatively low rate of EM resident attrition (1.5%) compared to other specialties.[10] Our investigation did not address whether this finding is due to a positive training environment, appropriate career selection, shorter training programs, or the resiliency of EM trainees, although all are possible contributing factors. While the low attrition rate experienced by EM programs is commendable, the premature loss of a resident during training can still be disruptive and damaging to morale for both the resident and the program. Furthermore, observations on the resident characteristics associated with attrition may inform current efforts to promote inclusion and diversity within the specialty.[12,13]

During the study period, we found that female EM residents were significantly more likely to leave residency than their male colleagues. Female EM residents were also less likely to be dismissed from their programs and significantly more likely to report health or family causes as the reason for their attrition during training than male residents. These findings suggest male and female EM residents may experience different demands in and outside of residency training. For example, prior work demonstrated that while depressive symptoms increased during intern year for both men and women, this increase was significantly greater for women, who cited work-family conflicts as a contributing factor.[14] This discrepancy remains consistent among practicing emergency physicians, for whom factors associated with career satisfaction include schedule flexibility and sufficient time with family.[15,16] In addition, a majority of female physicians reported deferring important life decisions (e.g., getting married, having children) in order to pursue their medical careers.[17]

While it was not clear from our data if childcare had any role in the greater likelihood of female EM residents prematurely leaving their programs, with most medical residents being of child-bearing age, it is possible that the challenges of having and raising children during training play a role in this gender discrepancy. Female residents may also be more likely to be caretakers of elderly parents or other ill family members than their male peers.[18] Current American Board of Emergency Medicine policy on resident leave for any reason recommends up to six weeks of sanctioned time away per year without the requirement of extending residency training.[19] However, the ABEM policy also stipulates that "if a

Table 4. EM resident race/ethnicity compositions in the overall and attrition populations.

Race/ethnicity	Total count	Total attrition count	% Overall population (95% CI)	% Attrition population (95% CI)	Attrition rate (95% CI)
White	37413	329	71.3 (67.5-75.1)	63.4 (54.1-72.6)	0.88% (0.75-1.01)
Asian	6849	76	13.0 (11.9-14.2)	14.6 (10.8-18.5)	1.11% (0.82-1.40)
Hispanic/Latino	3302	60	6.3 (5.6-7.0)	11.5 (6.0-17.1)	1.82% (0.94-2.71)
Black/African American	2613	32	5.0 (4.6-5.3)	6.2 (3.9-8.5)	1.22% (0.77-1.68)
American Indian/ Alaska Native	414	5	0.8 (0.7-0.9)	1.0 (0.1-1.8)	1.21% (0.15-2.27)
Native Hawaiian/ Pacific Islander	114	0	0.2 (0.2-0.3)	0	0
Other	1717	17	3.3 (2.9-3.7)	3.3 (1.5-5.1)	0.99% (0.45-1.53)
Unknown	68	0	0.1 (0-0.2)	0	0
Total	52490	519			

EM, emergency medicine; *CI,* confidence interval; *df,* degrees of freedom.

Table 5. Attrition status by EM resident race/ethnicity.

Attrition status	Number White [%, (95% CI)]	Number Asian [%, (95% CI)]	Number Hispanic/Latino [%, (95% CI)]	Number Black/African American [%, (95% CI)]
Dismissed	22 [7.4%* (5.0-11.0)]	8 [10.5%* (5.4-19.4)]	22 [39.3%* (27.6-52.4)]	3 [9.4%* (3.2-24.2)]
Transfer in EM	43 [14.6% (11.0-19.1)]	14 [18.4% (11.3-28.6)]	11 [19.6% (11.3-31.8)]	3 [9.4% (3.2-24.2)]
Transfer out of EM	42 [14.2% (10.7-18.7)]	12 [15.8% (9.3-25.6)]	2 [3.6% (0.98-12.1)]	5 [15.6% (6.9-31.8)]
Transfer unknown	43 [14.6% (11.0-19.1)]	13 [17.1% (10.3-27.1)]	3 [5.4% (1.8-14.6)]	3 [9.4% (3.2-24.2)]
Withdrawn	145 [49.2% (43.5-54.8)]	29 [38.2% (28.1-49.4)]	18 [32.1% (21.4-45.2)]	18 [56.2% (39.3-71.8)]
Total	295	76	56	32

EM, emergency medicine; *CI,* confidence interval; *df,* degrees of freedom.
*χ^2=67.516; df=24; p<0.001.
American Indian/Alaska Native, Native Hawaiian/Pacific Islander, Other, and Unknown were not included due to their small sample sizes.

residency program already has a policy in effect for leave time that is less than six weeks, the program may operate according to its own policy."

While a full discussion of the history and controversies surrounding paid parental and family leave in the United States is beyond the scope of this paper,[20] its relevance cannot be overstated in light of the increasing numbers of women who are entering medicine[21] and the growing numbers of physicians from younger generational cohorts (e.g., millennials) who may place greater value on work-life balance than physicians from prior generations.[22] Although our study could not discern the specific circumstances behind a resident's choice to leave training due to "health or family reasons," we suspect standardizing parental, family, and medical leave policies and providing affordable access and support for child and elder care may be steps to help address this gender discrepancy in attrition. Residency programs may also take creative steps to accommodate residents who need to take leave (e.g., scheduling more demanding rotations earlier in pregnancy or allowing residents to design reading or research electives that comply with Residency Review Committee-EM requirements) to minimize the time needed away from training.

There were limited racial differences in EM resident attrition. Although Asian, Hispanic/Latino, and Black/African American residents comprised greater proportions of the attrition population than the overall population, in pairwise comparisons between groups, only Hispanic/Latino residents were significantly more likely to leave and be dismissed from training than their White counterparts. It should be noted that the EM resident attrition rate in all racial/ethnic groups remained low, with each group experiencing a rate less than 2%. Nonetheless, the higher attrition rate experienced by a traditionally under-represented minority group in medicine raises questions about the unique challenges faced by physicians-in-training who are part of this under-represented group. Previous reports have noted that ethnic minority trainees perceive barriers to success in academic medicine that are based on their race.[23-25] These barriers may also be present in the training environment of EM programs and could partially account for this difference in attrition.

LIMITATIONS

There are important limitations to these results. First, this study was an investigation of broad trends and we were unable to ascribe specific causes or individual reasons contributing to a resident's choice to leave a training program. Second, the census data relied on the report of PDs, who may have a different perspective on the reasons for attrition as compared to that of the resident. Stigma may also have caused PDs to decrease the number of residents ascribed to dismissal or withdrawal as opposed to other attrition statuses. Third, the categories of attrition statuses and reasons queried by the census were rather broad and may not encompass realities that cross multiple selections. Fourth, we were unable to obtain more granular data on resident race and ethnicity, so those who responded with two categories, for example, were double counted in analyses using race/ethnicity. However, this group of residents accounted for only 1.2% of the study population and likely had limited effects on our results. Finally, the question of what interventions could prevent resident attrition is also left unanswered, and provides fertile ground for future research.

CONCLUSION

National rates of EM resident attrition are the lowest among similarly-sized specialties. Among EM residents who do leave their programs, women were more likely than men to leave. Women were also more likely to cite health or family reasons as the primary reason for their attrition. In addition, Hispanic/Latino residents were more likely to leave than their White counterparts. Future studies that qualitatively investigate the factors that contribute to more female and ethnic minority residents to prematurely leave their training are necessary. This work should also examine what interventions programs can take to mitigate attrition among all residents.

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Use of Emergency Department Pharmacists in Emergency Medicine Resident Milestone Assessment

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Introduction: The use of competency-based milestones for emergency medicine (EM) was mandated by the Accreditation Council for Graduate Medical Education in 2013. However, clinical competency committees (CCC) may lack diverse, objective data to assess these new competencies. To remedy the lack of objective data when assessing the pharmacotherapy sub-competency (PC5) we introduced a unique approach that actively involves departmental clinical pharmacists in determining the milestone level achieved by the resident.

Methods: Our pharmacists assess the pharmacotherapy knowledge of the residents through multiple methods: direct observation of orders, communication with the residents while performing patient care within the emergency department (ED), and real-time chart review. This observation occurs informally on a daily basis in the ED and is incorporated into the routine work of the pharmacist. The pharmacists use the PC5 sub-competency as their standard evaluation tool in this setting to keep all assessments consistent.

Results: Since our residency program introduced pharmacist assessment of resident pharmacotherapy knowledge, the CCC has conducted seven biannual meetings. Of the 120 separate PC5 sub-competency assessments made during those meetings there was 100% agreement between the pharmacist's assessment and the CCC's final assessment of the trainee. A survey of the CCC members concluded that the pharmacists' assessments were useful and aided in accurate resident evaluation.

Conclusion: The use of ED pharmacists in assessing the pharmacotherapy sub-competency provides important information used in resident assessment of the PC5 milestone. [West J Emerg Med. 2019;20(2)357–362.]

INTRODUCTION

The use of competency-based milestones for emergency medicine (EM) began in July 2013 as mandated by the Accreditation Council for Graduate Medical Education (ACGME).[1] An ACGME milestone is an observable behavior of the EM resident that fits within five levels of proficiency. These are graded on a scale from one to five. A level 1 proficiency is expected of a medical school graduate, while a level 5 is the expected achievement only after years of practice in the specialty. A level 4 rating is expected of a graduating EM resident according to standards set by the American Board of Emergency Medicine.[3] Since their introduction many residency programs have anecdotally noted difficulty in implementing some of these milestones as an assessment tool. As stated by Carter: "Milestones are complex, multifaceted, and sometimes fairly dense descriptions of a level of attainment on the road to competence… Milestones often are meant to be assessed by using multiple modalities."[2]

Within the 23 EM milestones, pharmacotherapy (PC5) is a subset of the "patient care" competency. In assessing PC5 proficiency the observer ideally should document how the EM resident "[s]elects and prescribes appropriate pharmaceutical agents based upon relevant considerations such as mechanism of action, intended effect, financial considerations, possible adverse effects, patient preferences, allergies, potential drug-food and drug-drug interactions, institutional policies, and clinical guidelines; and effectively combines agents and monitors and intervenes in the advent of adverse effects in the emergency department" (ED).[4] The suggested assessment methods for this sub-competency according to the ACGME include the following: Standardized Direct Observation Tool (SDOT), portfolio, simulation, oral boards, global ratings, and medical knowledge examinations.[3] One difficulty in using these multiple modalities is the lack of objective, multi-source data available to the clinical competency committees (CCC) when assessing trainees. To increase the amount of objective data obtained for the pharmacotherapy sub-competency, our institution took a unique approach by actively involving pharmacists. We used assessments from ED-based pharmacists to provide 180° evaluations that can be an objective component of the level-assessment achieved by residents in the PC5 sub-competency.

METHODS

Originally, the CCC for our ACGME-accredited residency program was comprised of five emergency physicians, the residency program director (PD), and the associate PD. At the start of our residency program, the two ED pharmacists jointly submitted their PC5 evaluations for each resident to the CCC. The departmental pharmacist assesses residents' pharmacotherapy knowledge by direct observation of their verbal and electronic medical record orders, communication with them while performing patient care within the ED, and chart review of active ED patients. These observations occur on a daily basis and are incorporated into the pharmacists' routine work without any significant, additional burden on them.

The pharmacists created an Excel spreadsheet to document their observations. The documentation was based on clinical scenarios that matched the specific medication knowledge evaluated for the resident's postgraduate year (PGY). Then, the pharmacists met to synthesize their comments and jointly assign a numeric value for each resident's milestone assessment. The pharmacists used the PC5 sub-competency as their standard assessment tool to keep all assessments consistent. To provide more assessment opportunities, the pharmacists also observed resident performance during yearly mock oral boards via real-time video. Mock oral boards included two single-case encounters and one triple-case encounter. Encounters were the same for all levels of residents, and the number of pharmacotherapy choices for an encounter varied significantly depending on the type and underlying diagnoses.

Since PC5 includes evaluating patient allergies, every case had at least one pharmacotherapy evaluation point. One pharmacist reviewed each case and documented the pharmacotherapy decision-making. Results were then discussed between the ED pharmacists to determine the overall score for the performance. Observation of the same case repeatedly with different residents likely increased pharmacist evaluation reliability. During these sessions, the pharmacists only assessed the medication management sections of the cases. A separate tool was created for use during the mock oral boards (Table 1). The pharmacists use the results of this tool to help incorporate their final resident evaluation on PC5.

The pharmacists also assessed the residents' specific medication knowledge. Based on consensus between the residency leadership and the pharmacists, medication knowledge was separated into basic, intermediate and advanced skill levels, which were applied to each resident based on his/her level of training. Our current assessment plan is as follows:

- PGY-1 – analgesia, antiemetics, and antihypertensives
- PGY 2 – anti-infectives, pediatric medication dosing, procedural sedation medications
- PGY 3 – cardiorespiratory arrest medications, vasopressors, anti-coagulant reversal agents.

PGY-3 assessments include more advanced medications. For example, we placed cardiorespiratory arrest medications in this category because the more senior residents serve in the team leader role and lead in the resuscitation of the critically ill patient.

Our EM residency program is based at an urban, academic center with annual ED volume of 55,000 patients at our main hospital. The program started in 2014 as a three-year program with eight residents per class, with an increase to 10 per class in 2018. This quality improvement project was submitted to the institutional review board (IRB) and was exempt from formal IRB approval requirements.

Our ED is staffed by two full-time pharmacists who completed Doctor of Pharmacy degrees (PharmD) at United States universities, followed by two years of residency training in pharmacy practice and EM. Both were board-certified pharmacotherapy specialists in 2012. They were qualified as preceptors by the American Society of Health-System Pharmacists residency accreditation standards with experience evaluating pharmacy students and residents against educational standards, and are active members of the pharmacy department's Residency Advisory Committee. Program-specific evaluation education was provided at two points in the process. The first occurred when the pharmacists were asked to submit evaluations to the CCC and the PD explained to them how the PC5 sub-competency was evaluated. The second occurred when the pharmacists were asked to join the CCC. At that point the PD provided additional information on the evaluation of non-pharmacotherapy milestones and reviewed all of the other

Table 1. The pharmacist assessment tool of pharmacotherapy for use in mock oral boards.

	3 - Exemplary	2 - Competent	1 - Needs improvement
Pharmacotherapy selection	Identifies appropriate medication by name	Selects an effective medication in the correct class but does not select the optimum therapy	Unable to determine appropriate medication class
	Selected medication is effective for patient presentation	Selected medication is effective for patient presentation	Selected medication is not effective for patient presentation
	Selected medication considers all contradictions and warnings	Selected medication considers contraindications and major warnings	Selected medication is contraindicated or has major warnings not addressed during case
Dosing/route/ frequency	Provides a complete pharmacotherapy recommendation including appropriate dose, route, and frequency	Provides a dose and route but does not verbalize frequency	Does not verbalize a dose or gives an incorrect dose, route, or frequency
		Refers to hospital policy or protocols to determine dose/route/frequency (e.g., "consult pharmacy")	
Follow-up and monitoring	Has a strategy to proactively assess patient response to therapy	Does not have a proactive plan for monitoring response therapy	Does not assess patient's response to therapy
	Able to identify common monitoring parameters	Able to identify common monitoring parameters	Not able to identify common monitoring parameters

requirements for EM residency graduation.

The pharmacists are present in the ED 10 hours a day/seven days a week, including most holidays, from noon to 10 pm. Their workspace is centrally located in the physician and nursing area in the center of the ED. This location makes them accessible to staff and enables them to assess our residents in real time. The residents work eight- to 12-hour shifts; therefore, the shift variability between the pharmacists and residents enables them to encounter two separate shifts of EM residents. Typically, three EM residents are working in the ED at one time: one PGY-1, one PGY-2, and one PGY-3 per shift. Based on historical data, the PGY-1 sees 1.2 patients per hour on average, with the PGY-2 and PGY-3 seeing approximately 1.5 patients per hour each. Given the pharmacist's 10-hour shift, this translates to the pharmacist seeing approximately 4.2 resident patients per EM resident per hour for the three residents. This does not include the patients of residents rotating from off service, physician assistants, nurse practitioners, medical students, and attending-only patients for whom the pharmacists also provide care and review charts. Therefore, on any given day the approximate 42 patients seen per shift by the pharmacists to evaluate the EM residents does not add to their normal workflow.

The pharmacist assists at the bedside with critically ill patients, procedural sedations, and overdoses, and performs chart review on other patients. Due to the close proximity of pharmacist and physician workstations, the pharmacist is able to continually evaluate clinical performance throughout his/her shift while the EM residents care for patients of all acuities. The pharmacist conducts chart review of the residents' medication orders, observes their bedside care, and listens to them as they present their plans to the attendings. For patients not receiving any medication therapy, the pharmacist review of the EM resident is minimal; nevertheless, the pharmacist's observations could add to other areas of resident evaluation (e.g., professional values and communication skills).

As stated above, the daily observation of residents does not add to our ED pharmacists' workload. Their only additional duties are to attend the mock oral board sessions and prepare an assessment report for the CCC. The CCC meets informally monthly in order to address resident education concerns early. The CCC performs formal resident assessments biannually. During the biannual CCC meeting, a report is generated by the pharmacists for each resident being assessed. Using the historical data of average patients per hour and pharmacist shift length, the average EM resident had approximately 50 patient encounters reviewed, which made up the semi-annual report prepared by the ED pharmacists.

The pharmacists presented this report to the CCC, which was used with other evaluations to assess the PC5 sub-competency. Additionally, the pharmacists provided a written narrative that included observed patient and nursing interactions. These comments were available for incorporation into other competency evaluations such as professional values (PROF1), patient-centered communications (ICS1), and team management (ICS2). An anonymous survey of the CCC members was conducted using www.surveymonkey.com (SurveyMonkey Inc., San Mateo, CA) to elicit their feedback on the effectiveness of the pharmacists' assessment (Figure 1).

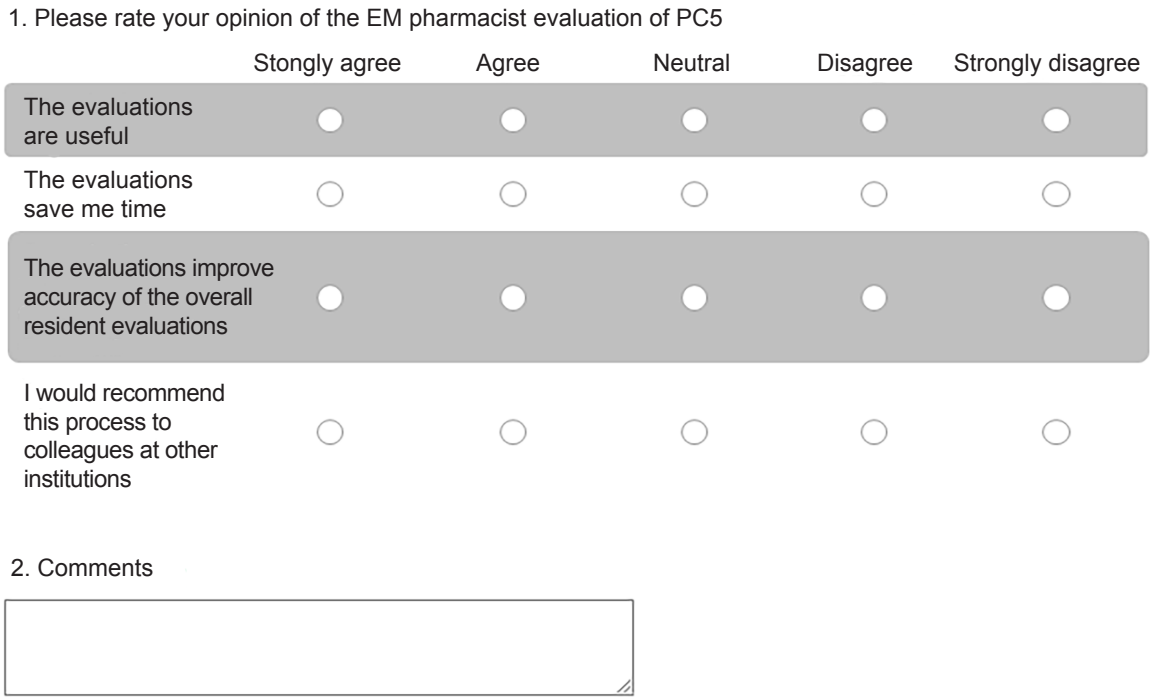

Figure 1. An anonymous survey instrument used to gather opinions of clinical competency committee members about the evaluation of emergency medicine residents by clinical pharmacists.
EM, emergency medicine.

RESULTS

Since introduction of pharmacist assessment of resident pharmacotherapy knowledge, seven biannual CCC meetings have occurred with 120 separate resident assessments made by the ED pharmacists and the CCC with regard to the PC5 sub-competency (Table 1). The range of PC5 scores improved over time for all classes evaluated (Figure 2). In all 120 assessments, there was 100% agreement between the pharmacist sub-competency recommendation and the CCC final assessment of the trainee over the 3.5-year period (Figure 3).

All CCC members responded to the survey except for the PD, who was ineligible due to input in the development of the survey instrument. All respondents agreed or strongly agreed that pharmacist evaluations were useful, saved time, and improved the accuracy of the overall resident evaluations (Table 2). Most respondents agreed or strongly agreed that they would recommend this process to other institutions.

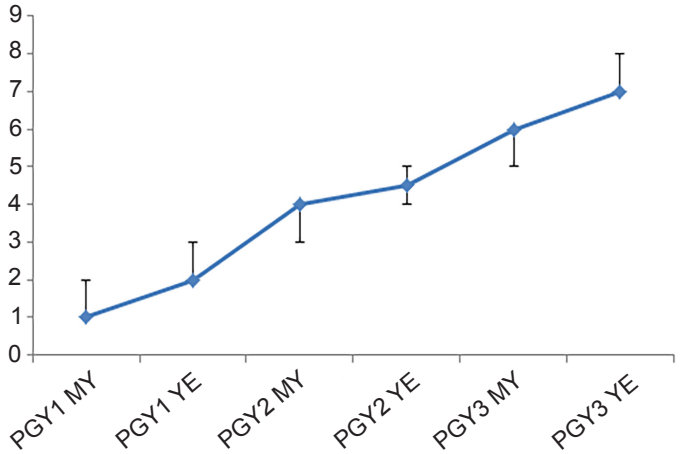

Figure 2. The median pharmacotherapy milestone scores assigned to residents by clinical pharmacists during each training year, at the mid-year (MY) and year-end (YE) evaluations. Interquartile range is represented by the bars.
PGY, postgraduate year; *PC5*, pharmacotherapy sub-competency.

DISCUSSION

Using ACGME milestones is a step toward reliable assessment of a resident's competence; however, these assessments can be problematic, particularly with regard to consistency and agreement of assessment level.[5,6] The pharmacists who evaluate our residents' pharmacotherapy competency have four years of doctoral training in pharmacology and therapeutics (In contrast, only one to two blocks of pharmacology are included in most medical school curriculums prior to clinical rotations). Additionally, pharmacy residencies often include preceptor development, including techniques for completing evaluations and providing feedback

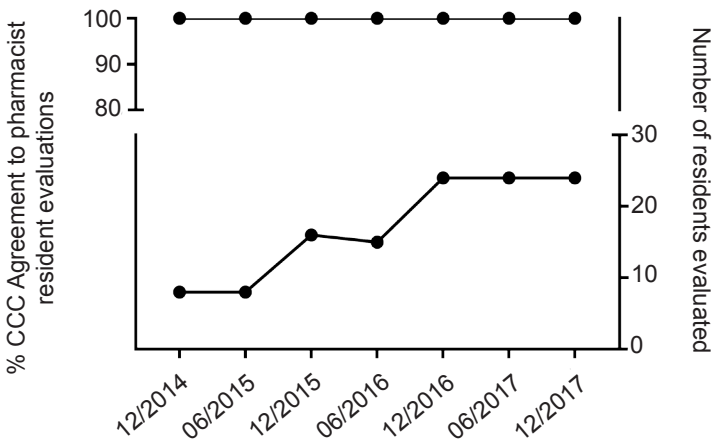

Figure 3. Members of the clinical competency committee agreed with the clinical pharmacists' evaluation (top) of residents' mastery of the pharmacotherapy sub-competency milestone, even as the number of residents increased (bottom).
CCC, clinical competency committee.

both during initial residency training and as ongoing education for accredited preceptors. The use of ED pharmacists to assist in the assessment process of resident milestones, especially with the pharmacotherapy sub-competency, allows for resident learning opportunities from a non-physician clinical perspective, and also provides important input into the assessment of PC5. Given the complexities of this milestone, resident assessment in the real-world setting during actual patient care likely adds to the accuracy of the evaluation.

In our experience, the assessments were timely and well received, leading to the CCC's 100% acceptance of the PC5 sub-competency assessments submitted by the pharmacists. They provide a different perspective beyond that offered by physician assessment and medical knowledge testing. Given their education and post-doctoral training leading to EM specialization and their board certification in pharmacotherapy, as well as their years of clinical experience working in the ED, we believe that pharmacists play a vital role in our multidisciplinary approach to evaluating resident milestones and that their input leads to better trained emergency physicians.

In August 2017, the American College of Medical Toxicology (ACMT) released a position statement in full support of having clinical pharmacists in the ED 24 hours a day.[7] The ACMT statement came concurred with that of the 2015 American College of Emergency Physicians statement in support of clinical pharmacy services in the ED.[8] Both statements referenced not only the safety aspects of having pharmacists in the ED – by reducing medication errors, tailoring patients' therapy based on concurrent disease states, medications, allergies, and presenting symptoms, and positively impacting time-critical diagnoses therapies – but also a financial benefit for cost avoidance and improved reimbursement rates.[7,8]

Notwithstanding the usual barriers to evaluation, which include difficulty evaluating residents who have been on off-service rotations for a majority of the evaluation period and evaluating pharmacotherapy knowledge for uncommon scenarios, the pharmacist's daily observation of the EM resident adds another layer of assessment that might not otherwise be available. ED pharmacists are a valuable asset within the department on many levels, and the addition of their resident-assessment capability only further highlights the academic and clinical value for full-time ED-based pharmacists. Their evaluation scores were accepted 100% of the time by the CCC, and their input was considered valuable and clinically accurate. As a result, the pharmacists' assessments and comments on the PC5 sub-competency were consistently included in the CCC's official milestone update. The perceived added value of non-physician provider input for other milestones was decided upon by the committee, and the ED pharmacists were officially included as formal members of the CCC. This use of a pharmacist as a resident assessor could be expanded across other specialties that use department-specific pharmacists, such as the intensive care unit setting, pediatrics, and internal medicine.

LIMITATIONS

Our CCC members were not blinded to the pharmacist evaluators. They and the pharmacists know and work with each other on a regular basis. This could have influenced the survey results, perhaps by inflating the positive impressions of the pharmacists. In addition, the evaluative tool for assessing residents during the oral boards was not specifically validated for PC5. Lastly, the medication choices to assess the residents'

Table 2. Rating of the clinical pharmacists' assessment by the clinical competency committee.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Evaluations are useful	71.4 %	28.6%	0%	0%	0%
Evaluations save me time	85.7%	14.3%	0%	0%	0%
The evaluations improve accuracy of the overall resident evaluations	71.4%	28.6%	0%	0%	0%
I would recommend this process to colleagues at other institutions	71.4%	14.3%	14.3%	0%	0%

knowledge base were chosen by group consensus of the residency leadership and the pharmacists without validation specifically to the PC5. The pharmacists at our institution have significant training and experience in both EM and preceptorship, making them ideally suited to evaluate PC5 and participate in the CCC. Incorporating pharmacists without this level of training and experience could produce different results.

CONCLUSION

Integrating ED-based clinical pharmacists into the assessment process of EM residents adds a valuable area of focus that may otherwise be difficult to obtain.

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Individualized Interactive Instruction: A Guide to Best Practices from the Council of Emergency Medicine Residency Directors

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Over the last several years, there has been increasing interest in transitioning a portion of residency education from traditional, lecture-based format to more learner-centered asynchronous opportunities. These asynchronous learning activities were renamed in 2012 by the Accreditation Council for Graduate Medical Education (ACGME) as individualized interactive instruction (III). The effectiveness and applicability of III in residency education has been proven by multiple studies, and its routine use has been made officially acceptable as per the ACGME. This article provides a review of the current literature on the implementation and utilization of III in emergency medicine residency education. It provides examples of currently implemented and studied III curricula, identifies those III learning modalities that can be considered best practice, and provides suggestions for program directors to consider when choosing how to incorporate III into their residency teaching. [West J Emerg Med. 2019;20(2)363–368.]

BACKGROUND

One of the most recent trends in medical education is the transition from traditional didactics (i.e., lecture-based classroom teaching) to online learning modules, collectively referred to as asynchronous learning. Over the last several years, asynchronous learning has been shown to be a successful learning style for many learners. For example, Liu and colleagues performed a meta-analysis of what the authors termed "blended learning" (i.e., the combination of traditional teaching methods with asynchronous learning) throughout all health professional learners. Their review found that blended learning consistently performed better than no intervention and that it did not perform inferiorly to traditional "non-blended" learning.[1] A host of additional data exists, demonstrating that learners prefer smaller learning environments[2] and that these methods can address the challenge of teaching physician self-assessment and fostering the practice of lifelong learning.[3]

It is known that there is a broad range of the use of asynchronous learning across the field of medicine. Looking specifically at resident training, a survey of internal medicine program directors (PD) revealed that out of the 214 responding programs, 71.5% used asynchronous learning sometimes, somewhat often, or very often.[4] Examples of asynchronous learning curricula can be found in nearly every medical area and specialty, from a pediatrics gastroenterology subspecialty rotation,[5] microsurgery competencies in plastic surgery,[6] and radiology residents receiving more real-time feedback on radiographic reads,[7] to journal club for general surgery.[8] There are examples for the training of fellows[9] and faculty.[10] There are even examples of all learners, laypeople and medical professionals, participating in a basic life support class[11] and for interprofessional learners from all levels of training and fields participating in teamwork training.[12]

The early 2000s to 2010s saw a unique challenge to residency programs specifically as Free Open Access Meducation (FOAM) resources increased exponentially.[13] Anecdotal evidence at that time suggested that residents were using these resources for their own asynchronous education, with or without residency

program oversight. Programs faced the decision to either begin vetting and incorporating these resources into their curricula or to maintain a more traditional didactic approach. Questions were raised whether time spent in asynchronous learning could even be counted as part of Accreditation Council for Graduate Medical Education (ACGME) required didactic time.

In 2008, the Council of Emergency Medicine Residency Directors (CORD) in conjunction with a task force from the Residency Review Committee for Emergency Medicine (RRC-EM) set out to critically evaluate the ACGME EM Program Requirements specifically pertaining to educational conferences. One of the suggestions from that task force was for residency programs to actively consider incorporating asynchronous learning as an educational tool.[3] Not long after the task force's recommendations, the RRC-EM published criteria allowing up to 20% of conference didactic time to be spent in asynchronous learning, which was renamed individualized interactive instruction (III).[14] A subsequent publication from the same group further defined specific requirements of a valid III program (see section on "Cautions of Implementation").[15]

Since then, there has been increasing research into how and which aspects of EM residency teaching can be transitioned to III.[16] Some programs have applauded it as the way of the future,[17-18] while others have advised caution in implementation.[19-20] Multiple ideas have been published on how to incorporate III such as flipped classroom,[21] journal article discussion boards,[22] or a series of varied online learning tasks.[23] Comprehensive databases have emerged offering vetted sources, centralized information, and access to experts.[24]

Surveys have shown extensive utilization of III among residents,[25] as well as significant incorporation into EM training programs.[26-27] A survey by Waxman and colleagues in 2014 showed that 63% of programs were incorporating III into residency training; however, they noted there were significant variations in the structure of the curricula. Of the 37% that were not using III, 71% had concerns related to the understanding and implementation of III within the ACGME/RRC-EM criteria.[26] The purpose of this article is to provide a review of the current literature on III and best practices recommendations for programs to consider as they refine their already-existing III curricula or implement a curriculum for the first time.

APPRAISAL OF THE LITERATURE

This article is the second in a series of best practice reviews from the CORD Best Practices Subcommittee. The first three authors performed a search of PubMed for articles published from inception to March 31, 2018, using the same keywords "asynchronous learning" and "individualized interactive instruction." Bibliographies of all relevant articles were reviewed for additional studies. The search authors screened articles to evaluate for any that addressed the specific topics of implementation and utilization of III curricula within the field of EM.

The search yielded a total of 664 articles, of which 19 were deemed to be directly relevant to EM and for inclusion in this review. When supporting data were not available, recommendations were made based upon the authors' combined experience and consensus opinion. Prior to submission, the manuscript was reviewed by the entire CORD Best Practices Subcommittee. It was additionally posted to the CORD website for two weeks for general feedback and review from the entire CORD community.

CURRENT USES OF III IN EMERGENCY MEDICINE

In 2015, the CORD III Task Force performed an updated survey of PDs of ACGME-accredited EM residency programs on their current use of III (unpublished data). Of the 77 unique programs that responded (approximately 46% response rate), 74% reported incorporating III into their programs. More four-year format programs used III than three-year programs (91% compared to 67%). Programs implementing III were divided among those who offered either four or five hours of synchronized didactics weekly, or some variation thereof. Of those who reported not using III, the most cited rationale was an unclear definition of what constituted III. Other programs were concerned about compliance or the resources required for implementation. Offerings for III credit were quite diverse. Many programs offered online learning modules, FOAM resources, and board review sessions for III credit. Some used simulation, journal club, and attendance at national or regional meetings. This survey shows that although there is a high rate of utilization of III among programs, there still remains a wide variation in qualifying activities.

While there is a significant amount of literature on the importance and acceptance of III as a learning tool, no standard or consensus method of implementation currently exists in EM. In addition, there is a dearth of information (only the single survey as described above) in the published literature as to how individual EM residency programs specifically implement III. And there is significant variation among programs based on qualitative preliminary surveys. Some research even suggests that III may not be an adequate replacement for all of the didactics in a traditional curriculum, specifically for novice learners, concerns namely being their ability to identify specific knowledge gaps and their need to have adequate expert oversight to ensure true knowledge acquisition and retention.[20] Several publications in recent years highlight examples of how EM residency programs nationwide have and are using III; some selected examples are discussed below.

Wray and colleagues implemented an III curriculum in 2013 and measured the effect on in-training exam (ITE) scores. Faculty and chief residents created four modules per month, each designed to be completed in less than one hour. Educational content included journal articles, audio and video lectures, podcasts, links to FOAM resources, and modules

linked to quizzes. Residents were required to complete these modules, and their progress was monitored in addition to ITE scores. The group found that despite the decrease in traditional conference hours, time now allotted to III, there was no negative impact on resident ITE scores.[28]

Pensa and colleagues created a digital course for residents in 2014 and surveyed residents to assess satisfaction. The program educational material was curated by faculty from various FOAM/digital resources, and participation was optional. The modules included an assignment page with the content; a discussion page, which was a mandatory component of the module and allowed for learners to post queries and for faculty members to answer questions; and a multiple-choice quiz page for assessment. Thirty-three of 48 residents participated in the survey in the first year and appeared overall to find the course useful, although there were significant variations in time spent participating in the course both among residents as well as faculty. The biggest barrier to participation identified by residents was lack of time.[29]

Kornegay and colleagues developed an III curriculum implemented during the 2011-2012 academic year. Faculty members identified gaps in the pre-existing synchronous curriculum and topics better suited for independent learning and then developed a web-based platform consisting of curated content and an evaluation component, namely a reflective writing assignment or quiz. Of responding residents, about 80% were satisfied, very satisfied, or extremely satisfied with the new modality. The group also analyzed conference attendance and ITE scores and found that postgraduate year (PGY)-1 resident attendance rate significantly improved from the prior year (85% vs 62% mean), although other curricular changes in the program (e.g., small group-based learning, interactive case-based conferences, and changes in off-service rotations) may have also enhanced participation. There was no statistically significant difference in mean ITE scores pre- and post-intervention. Faculty reported a time commitment of about four to eight hours per month, which was comparable to the time spent to prepare one hour of instruction for weekly conference pre-intervention.[30]

Kothari and colleagues designed an III curriculum based on Academic Life in Emergency Medicine (ALiEM)'s popular Approved Instructional Resources (AIR) series. The AIR series curates FOAM content from the top 50 open-access EM and critical-care blog and podcast sites, provides associated core teaching points and multiple-choice questions for residents, and tracks resident participation to provide residency PDs with resident progress.[24] Kothari and colleagues then implemented a second component to their III curriculum, which consisted of two high-impact journal articles selected by faculty on a monthly basis. The group found that introduction of the III did not negatively affect residency educational conference; attendance across all PGY levels was comparable to the year before.[31]

Other innovative strategies and formats to implement III in EM have been centered upon discrete, focused topic areas within the larger EM curriculum, such as pediatrics,[32-33] palliative and end-of-life care,[34] and disaster medicine.[35] Commonalities exist among these examples, namely facilitators' deliberate choosing of either a specific asynchronous learning program or a specific topic to be taught using asynchronous learning depending on their program's needs.

BEST PRACTICE RECOMMENDATIONS:

1. III should be used cautiously with the novice learner.
2. When deciding to develop or implement an III curriculum, first identify gaps in the current curriculum or those topics that may be best transitioned to an III format. This is likely to vary between programs.
3. A combination of available III (e.g., online blogs, podcasts, and journal articles) seems to attract a greater number of residents to participate, likely as this variety addresses a broader span of individual learning preferences.
4. Transition to III does not seem to negatively affect resident ITE scores or weekly conference attendance rates.

CAUTIONS OF IMPLEMENTATION

The ACGME policy statement on the use of III within EM residency education is very strict as to the criteria that must be met for an activity to be considered III. Given that up to 20% (one out of every five hours) of previously considered core curriculum time can now be spent as III, there may be a natural inclination among programs to begin to cut back on planned, traditional educational activities. This is a fallacy, and there are several ways that implementation of III can go wrong (Table).[15] Below are listed some common pitfalls encountered when implementing III.

Table. ACGME criteria for III.[15]

1. The program director must monitor resident participation.
2. There must be an evaluation component.
3. There must be faculty oversight.
4. The activity must be monitored for effectiveness.

ACGME, Accreditation Council for Graduate Medical Education; *III*, individualized interactive instruction.

Independent Reading and Use of Question Banks

The ACGME places particular emphasis on any potential III being a planned activity that is tailored for the individual's level of learning. Resident-directed reading is not considered

a planned activity. Additionally, independent use of a question bank is not directed to the individual's particular needs, even if the astute resident is choosing specific topics to review. Faculty may choose a specific reading or set of questions to include as a part of III, but these by themselves do not qualify.

Resident Attestations of Completion

An attestation of completion of an III activity is not considered to be adequate enough to prove resident participation. There must be a separate, tangible source of evaluation. Tracking quiz completion/participation after an online module or required reading would provide ample proof of activity completion, just as a sign-in sheet before a simulation does the same.

Audio, Video, or Podcasts

These learning methods are considered to be passive learning, and use of them alone does not qualify as III. However, they can be combined with other learning modalities, such as a particular question set from an online question bank, to include an active component.

Monitoring for Effectiveness

At the time of implementation of the chosen curricula, PDs must have a plan for how they will go about tracking the effectiveness of the III program. This can take many different forms: use of periodic review quizzes; objective clinical performance; test scores on the ITE, etc. However, this type of evaluation must be planned over several generations of residents to account for individual class variation and ensure the III program itself is not causing knowledge gaps. Regular check-ins with residents to ensure their continued perspective of the curricula as beneficial are also recommended.

BEST PRACTICE RECOMMENDATIONS:

1. Before designing or implementing an III curriculum, carefully review the ACGME criteria to ensure compliance.
2. Resident-driven use of question banks does not meet III criteria.
3. An attestation of completion does not meet III criteria for participation.
4. Use of passive learning methods alone (e.g., podcasts) does not meet III criteria.
5. Regular curriculum assessment is essential to ensure adequate instructional merit and continued benefit to resident learning.

OPTIONS FOR III ACTIVITIES

Several best practices have emerged from surveying EM PDs who have implemented III, both with respect to high quality, effective educational programming and compliance with RRC-EM regulations.[27]

Simulation

Simulation activities easily satisfy the requirements of III. They can provide an individual resident the opportunity for self-directed work on a particular area of improvement with direct faculty supervision and immediate feedback. These work best when a resident identifies a particular case, topic, or procedure on which he or she would like to focus.

Online Resources

A wealth of freely accessible material is available for III learning via podcasts, blogs, and online modules. PDs need to creatively consider how they will allow for the use of such material for III while maintain compliance with RRC regulations. Additionally, faculty must take care to appropriately vet all resources to ensure credibility and academic rigor.[36-37] Perhaps the most widely adopted single resource is the ALIEM-AIR Series,[24] which (as of its 2016 publication) has been implemented in 65 programs. This group rigorously selects the highest quality online resources, as judged by EM faculty, provides a quiz for an evaluative component, and allows for online discussion. Individual PDs are able to monitor both the modules as well as their residents' participation. Other best practices include discussion sessions with a faculty lead about a particular podcast or blog post.

National/Regional Conferences

Attendance at specialty society meetings offers many learning opportunities. To rise to the level of III and meet the criteria set forth by the ACGME, programs have instituted a number of policies for such activities. Monitoring participation and faculty oversight are key areas of concern, and can be addressed by checking in with faculty who are also attending or presenting at a particular session. Some programs require discussion or written assignments following the session or conference.

Question Banks

Many question banks are available online and in print for residents' use in preparing for standardized tests. While answering questions alone does not meet criteria for III (see "Cautions of Implementation" above), reviewing specific questions missed or themes with a faculty member would be acceptable.

Other Opportunities

Multiple other activities are in use in EM programs for III including journal clubs, research and teaching activities, oral boards practice, and many others.

BEST PRACTICE RECOMMENDATIONS:

1. When designing an III curriculum, many options for learning activities are available to be included: simulation, online resources, national/regional

conferences, question banks with faculty oversight, etc.
2. When choosing online sources, take care to ensure credibility and academic rigor, scoring methods exist and can be used to assess these factors.

LIMITATIONS

While all attempts have been made to create an inclusive review of the current use of III in EM residency education, limitations must be acknowledged. In the identification of pertinent articles for inclusion, although multiple search terms were used and bibliographies cross-referenced, it is possible that some articles may not have been identified by the current review. We chose articles based on their primary relevance to the field of EM; thus, our analysis was not intended to be an expansive review of the history of the use of III or its current use in other medical fields or specialties. In the absence of data, every effort was made to make conservative recommendations based on the authors' experience and expertise as educators in the field of EM and, although a potentially limiting factor, these opinions were available for review by the entire CORD Best Practices Subcommittee prior to publication.

The primary limitation to this data analysis was the relative paucity of data available on the direct implementation or utilization of full III curricula within EM residency programs. Multiple sources have supplied information pertaining to the use of specific, topic-based curricula, but few show analysis of a more extensive use of III as might pertain to what can be considered a core curriculum.

CONCLUSION

This article provides a review of the literature currently available on the implementation and use of III in emergency medicine residency education. It can be said conclusively that III has been proven to be an accepted part of modern residency education. Preliminary data suggest that III may very well augment resident learning without negatively affecting standardized testing scores or resident participation in other traditional didactics. Care must be given to choose the appropriate learning level of the resident and ensure ACGME compliance with curricular activities. However, despite multiple sources of curricula options, there remains a paucity of information regarding the effectiveness of specific III as it pertains to resident knowledge acquisition and retention. More research is needed to further refine what we determine to be gold standard III modalities. Until then, it is the authors' intention that readers will be more aware of the ACGME guidelines and the III options that exist in order to avoid the potential pitfalls of implementation at their home institutions.

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Creating Consensus: Revisiting the Emergency Medicine Resident Scholarly Activity Requirement

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Introduction: In the context of the upcoming single accreditation system for graduate medical education resulting from an agreement between the Accreditation Council for Graduate Medical Education (ACGME), American Osteopathic Association and American Association of Colleges of Osteopathic Medicine, we saw the opportunity for charting a new course for emergency medicine (EM) scholarly activity (SA). Our goal was to engage relevant stakeholders to produce a consensus document.

Methods: Consensus building focused on the goals, definition, and endpoints of SA. Representatives from stakeholder organizations were asked to help develop a survey regarding the SA requirement. The survey was then distributed to those with vested interests. We used the preliminary data to find areas of concordance and discordance and presented them at a consensus-building session. Outcomes were then re-ranked.

Results: By consensus, the primary role(s) of SA should be the following: 1) instruct residents in the process of scientific inquiry; 2) expose them to the mechanics of research; 3) teach them lifelong skills, including search strategies and critical appraisal; and 4) teach them how to formulate a question, search for the answer, and evaluate its strength. To meet these goals, the activity should have the general elements of hypothesis generation, data collection and analytical thinking, and interpretation of results. We also determined consensus on the endpoints, and acceptable documentation of the outcome.

Conclusion: This consensus document may serve as a best-practices guideline for EM residency programs by delineating the goals, definitions, and endpoints for EM residents' SA. However, each residency program must evaluate its available scholarly activity resources and individually implement requirements by balancing the ACGME Review Committee for Emergency Medicine requirements with their own circumstances. [West J Emerg Med. 2019;20(2)369–375.]

INTRODUCTION

Background

In 1999 the Research Directors' Interest Group (RDIG) of the Society of Academic Emergency Medicine (SAEM) developed a consensus statement on the emergency medicine (EM) scholarly project requirement for residents.[1] Program requirements for both American Osteopathic Association (AOA)/American College of Osteopathic Emergency Physicians (ACOEP) and the Accreditation Council for Graduate Medical Education (ACGME) EM residencies identify scholarly activity (SA) as a core requirement of training (Figure 1).[2,3] Additionally, residents in osteopathic programs have a requirement to produce a research project of publishable quality and submit it for review and approval to the ACOEP six months prior to residency graduation.

Importance

The initial intent of the SA requirement in the evolution of EM was in part to counter critics who argued that EM did not have robust, specialty-specific literature or the necessary academic productivity to be a distinct specialty.[4] Therefore, the SA requirement was pressed into service to identify that scope of practice and create that body of evidence. Nearly 40 years after the formal recognition of EM, the need for SA remains, although there is no single approach to it among residencies.[5] The single accreditation system (SAS) for graduate medical education scheduled to be in place in July 2020, is an unprecedented opportunity for creating a consensus understanding and implementation of a revised SA requirement.

Population Health Research Capsule

What do we already know about this issue?
There has been no single approach among residencies for the emergency medicine resident scholarly activity (EM SA) requirement.

What was the research question?
We set out to produce a consensus document on best practices, processes and outcomes for the EM SA.

What was the major finding of the study?
The EM SA should instruct residents in scientific inquiry, expose them to the mechanics of research, and teach them how to formulate a question, search for the answer and evaluate its strength.

How does this improve population health?
Consensus on the endpoints and documentation of the outcome of the EM SA may serve as a best-practices guideline for EM residency programs.

AOA/ACOEP Program Requirements
Basic Standards for Residency Training in Emergency Medicine[2]
"The resident shall complete a research project during the course of the emergency medicine training program that will be sent to the ACOEP in the following manner. The resident shall submit an outline for the project by the end of the osteopathic graduate medical education (OGME)-2 training year, implementation and data collection methods and provide an interim report by the end of the OGME-3 year, and a final product suitable for publication six months prior to the completion of the OGME-4 year of residency. A permanent copy shall be retained in the resident's file at the institution. All research projects shall be approved by the program director."

Accreditation Council for Graduate Medical Education (ACGME) Program Requirements for Graduate Medical Education in Emergency Medicine:[3]
"Section IV: Residents' Scholarly Activities
IV.B.1. The curriculum must advance residents' knowledge of the basic principles of research, including how research is conducted, evaluated, explained to patients, and applied to patient care. (Core)
IV.B.2. Residents should participate in scholarly activity. (Core)
IV.B.3. The sponsoring institution and program should allocate adequate educational resources to facilitate resident involvement in scholarly activities.

Figure 1. American Osteopathic Association (AOA) and Accreditation Council for Graduate Medical Education (ACGME) emergency medicine resident scholarly activity requirement.

Goals

We set out to produce a revised consensus document on best practices, processes, and outcomes for EM SA by engaging relevant stakeholders in a consensus workshop convened by the RDIG and the Evidence- based Healthcare Implementation (EBHI) interest groups of SAEM.

METHODS

Study Design

The 2017 RDIG and EBHI workshop used similar consensus methodology with a reiterative process of collecting and consolidating ideas from a group of relevant stakeholders in a four-step, consensus-building process (nominal group technique) that was previously used in an *Academic Emergency Medicine* (*AEM*) consensus meeting.[6] And as with the prior RDIG consensus (1999), this methodology included convening at the annual SAEM meeting.[1] The institutional review board at the lead author's institution deferred review to the SAEM board, which reviewed and approved the project. In the months leading up

to the consensus meeting, RDIG/EBHI members reviewed prior work on this topic.[1,5,7] Based on this research, (flow diagram, Figure 2) a survey was drafted by representatives of interest group membership.

The draft survey included demographic questions about respondents and ranking-scale responses to queries about the goals, definition, and endpoints for the SA as well as the role of the research director in the process. This was largely based on the questions used in the original RDIG survey.[1] To establish face and content validity, we piloted the survey among approximately 20 expert EM faculty (from diverse geographical regions) involved in resident education and familiar with SA curriculum development and delivery. The key stakeholders were from the following groups: Association of Academic Chairs in EM, Residency Review Committee/ACGME, program directors (PD), and Emergency Medicine Residents' Association (EMRA). We revised the survey based on feedback from the pilot survey. Revisions were made based on the ACGME focus on quality improvement (QI) on Clinical Learning Environment Reviews visits, and information about knowledge translation/QI were added. After this, and to involve additional expert judgment to support the content validity and to demonstrate that the content would be understood, the survey and project goals were reviewed and approved by the SAEM board without further changes.

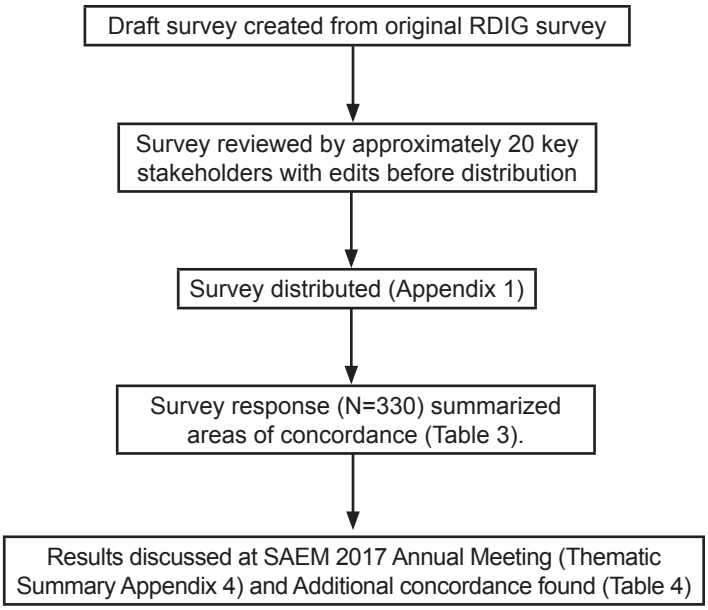

Figure 2. Flowchart of the process in developing consensus on scholarly activity requirements.
RDIG, Research Directors' Interest Group; *SAEM*, Society of Academic Emergency Medicine.

Selection of Participants

We then distributed the survey (Appendix 1) via email to multiple groups with stakeholder interest, including several SAEM interest groups, committees of the American College of Emergency Physicians (ACEP), American Academy of Emergency Medicine (AAEM), and ACOEP, EMRA and AAEM's resident association (AAEM/RSA), and to PDs and associate/assistant PDs and other EM educators via the Council of Emergency Medicine Residency Directors (CORD) listserv. Instructions to recipient groups were to forward the survey link liberally to any groups or individuals that might have a vested interest in this topic. Participants may have received multiple surveys based on overlapping memberships.

Intervention, Measurement and Outcomes

The second step of the process included analyzing the results from the returned surveys. Responses were on a four-point Likert scale (from 1=disagree 1, 2=somewhat disagree, 3=somewhat agree to 4=agree). Consensus was defined *a priori* as a ranking of 3.33 or higher. These results were used to find areas of concordance and discordance among the group and were presented at a combined RDIG/EBHI two-hour, consensus-building session at the SAEM annual meeting in May 2017. Stakeholder representatives, who had access to the data in advance, were given the opportunity to briefly present their viewpoints. A few of these presenters were delegates provided by their organizations (ACOEP, EMRA), while others were selected to present due to their availability. A robust group discussion followed.

The third step was re-ranking the outcomes using an anonymous electronic polling system at the interest group meeting. For those who could not access the electronic polling system, a paper form of the poll was available (also submitted anonymously unless respondents elected to identify themselves). Following the group meeting, the results in an abbreviated form were also presented and discussed as a part of a didactic about SA best practices at the SAEM scientific assembly. The fourth step, conducted after the conference, was the summary by the workgroup and included qualitative summarization of the discussion.

Analyses

Results for demographic variables were reported in simple frequencies and percentages. We reported Likert-ranked results in mean scores.

RESULTS

First Iteration

A convenience sample of 330 stakeholders responded to the distributed survey (Appendix 1). Those who agreed to be identified for their participation are listed in Appendix 2. Of the 330 respondents, 54% were affiliated with an EM

post-graduate year (PGY) 1-3 program, 44% with a PGY 1-4 program, and 2% other (e.g., family practice (FP)/EM program). The most common age range selected was 31-40 years old; 60% of respondents were male. Organizational representation of participants and their positions can be found in Tables 1 and 2, respectively. Based on our definition of consensus, the primary role of SA, the definition of SA, the minimal endpoints consistent with the definition of the SA, the role of the research director and other respondent findings can be found in Table 3.

The primary focus of the conversation at the combined interest group meeting of the EBHI and the RDIG at SAEM 2017 included describing the elements of minimum standards for a scholarly project, since consensus had not been reached for these elements in the first iteration of the process. In this second iteration, the verbiage "minimal endpoint" was interchanged with "outcome" for SA to meet with the group's desire to see that the successful completion of the SA requirement should result in the resident submitting to the residency program a measurable product. This product is the outcome of the SA. Therefore, the engagement and discussion at the meeting set out to further clarify what constitutes best-practice, measurable outcomes for the SA.

Second Iteration

Over 50 participants gathered at the annual SAEM meeting to discuss the resident scholarly project and the data from the survey. Those who agreed to be identified for their participation are listed in Appendix 3. The positions of stakeholder representatives are summarized in Appendix 4. Following these stakeholder position presentations, there was a discussion on content themes as summarized in Appendix 5. After the discussion another iteration of consensus building occurred, facilitated by electronic polling. The group additionally agreed on best-practice, measurable outcomes of the SA. (Table 4)

A summary of the best-practice consensus on the SA has been formatted in a PD handout format (Appendix 6). After the consensus manuscript was prepared, it was reviewed and approved by the board of each of the three major entities in our specialty – SAEM, ACEP, and the ACOEP.

Table 1. Demographics of organizations represented. (Respondents could check all categories that applied to them.)

Answer choices	Respondents N=321	
SAEM Research Directors' Interest Group	11.53%	37
SAEM Evidence-based Healthcare Implementation Interest Group	8.41%	27
SAEM Research Committee	10.59%	34
ACEP Research Committee	7.48%	24
ACEP	79.75%	256
SAEM	34.27%	110
AAEM	32.40%	104
ACOEP	26.17%	84
CORD	37.69%	121
EMRA	37.38%	120
AACEM	1.87%	6
ACGME/RRC	4.98%	16
Other (please specify)	7.79%	25

SAEM, Society of Academic Emergency Medicine; *ACEP*, American College of Emergency Physicians, *AAEM*, American Academy of Emergency Medicine; *ACOEP*, American College of Osteopathic Emergency Physicians; *CORD*, Council of Emergency Medicine Residency Directors; *EMRA*, Emergency Medicine Residents' Association; *AACEM*, Association of Academic Chairs of Emergency Medicine; *ACGME*, Accreditation Council for Graduate Medical Education; *RRC*, Residency Review Committee.

Table 2. Demographics—positions held (respondents could check all that applied to them).

Answer choices	Responses	
Faculty of EM residency program	35.09%	113
Program director (or assistant PD)	28.26%	91
Research director (or assistant)	15.22%	49
Fellowship director (or assistant)	3.11%	10
Resident/fellow	34.78%	112
Department chair (or vice)	6.52%	21
ACGME/RRC member	1.24%	4
EM physician	21.12%	68
Program coordinator	0.31%	1
Other (please specify)	5.59%	18
Total respondents: 322		

EM, emergency medicine; *ACGME*, Accreditation Council for Graduate Medical Education; *RRC*, Residency Review Committee; *PD*, program director.

DISCUSSION

While conceptually some attitudes toward SA have remained the same as in the 1999 RDIG consensus statement on this topic, others have evolved with time. The primary goal for the SA, which is to instruct residents in the process of scientific inquiry, remains a priority. However, four of the previous goals[1] no longer had the highest ranking of importance (to teach problem-solving skills; to learn the art of medical writing; to expose the resident to research for consideration of an academic career; and to help focus the resident on an area of interest or expertise). Therefore, these four goals have been removed from our current consensus proceedings. In contrast, in respect to the definition of the scholarly project, *all* of the elements of the SA activity identified in the 1999 consensus remained prioritized,[1] along with one additional element – being able to critically appraise the literature.

Table 3. First iteration.

Category	Ranking
Primary role of the scholarly activity	
Instruct the resident in the process of scientific inquiry	3.48
Expose the resident to the mechanics of research	3.51
Teach the resident lifelong skills including search strategies and critical appraisal	3.38
Teach the resident how to formulate a question, search for the answer, and evaluate the strength of the answer	3.41
Definition of the scholarly activity	
Should include the general elements of hypothesis generation	3.53
Information gathering or data collection	3.61
Evidence of data analysis or analytical thinking	3.47
Interpretation of results or statement of conclusion	3.6
Being able to critically appraise medical literature	3.52
Role of the research director	
Help set the guidelines for the scholarly activity	3.51
Check timeline for project completion	3.37
Help create a departmental environment for research	3.74
Help provide tools and resources for research	3.8
Act as a motivator for scholarly activity among residents	3.67
Instruct the resident in critical appraisal skills	3.63
Endpoints consistent with the definition of the scholarly project	
A public health project	3.62
A quality improvement exercise	3.47
A systematic review	3.54
A paper of publishable quality	3.81
A published, original research paper	3.92
Developing an evidence-based practice guideline	3.47
A book chapter	3.45
Other	
The activity can be spread over three or more years	3.39
Responsibility of the project primarily rests with the resident	3.66
Responsibility of the project is supported by a combination of the resident, the program and research directors.	3.37

With regard to the submitted SA outcomes, several proposals did not meet the bar for best practice as determined by this consensus group. Items such as "writing a case report," "developing a curriculum," "being a listed member on a consensus policy statement," "writing and presenting a lecture," "publishing original research prior to residency," "participating in or creating an online blog or podcast" all had merit to some participants but did not rank high enough to be considered universally accepted as endpoints. This does not mean that a PD cannot accept any or all of these as acceptable endpoints for either a particular resident or at a particular program. It simply means that these proposals did not rank with the highest concordance of best practice within this group of stakeholders.

Traditional methods to demonstrate SA, such as authorship on peer-reviewed original research publications, will always be one of a number of ways to evaluate scholarly productivity. However, it is also critical to address how to evaluate contributions via non-traditional formats and work products, such as blogs, contributions to FOAMed websites, tweets, etc, which have become the new traditional.[8] Our findings with regard to the definition of SA may be perceived as more narrow than the more expanded definitions of scholarship and perspectives and discussions on this topic that have shown up in the literature more recently.[9-11] Specifically, these vary from Boyer's expanded definition of scholarship, which asserts that scholarship should have four separate yet overlapping meanings: the scholarship of discovery; the scholarship of integration; the scholarship of application; and the scholarship of teaching.[9]

Table 4. Outcome of the scholarly activity requirement for residents in emergency medicine.

Category	Ranking
Outcome of the scholarly activity	
Written documentation of the project archived by the residency	3.73
A developed and implemented protocol (research or quality improvement)	3.80
A research paper that includes a hypothesis, collected and analyzed data (or showed analytical thinking), and a conclusion (or interpretation of results)	3.93
A research abstract submission	3.55
An oral research presentation	3.61

It will be incumbent upon stakeholders in the future to address how to measure and recognize these new SA and academic accomplishments and how to create an academic currency from them that can be recognized institutionally (e.g., by university tenure and promotion committees) and externally (e.g., by funding agencies). Innovative metrics are already evolving. For example, altmetrics[12] helps researchers track and demonstrate the reach and influence of their work beyond traditional citations in peer-reviewed publications. These and other new metrics will impact the ways by which the strength of scholarly effort is measured. Furthermore, while traditionally the research director has had the role of supervising these activities, as non research-based scholarship becomes more prevalent, programs will be needed to determine the most qualified individual(s) to teach and evaluate these efforts.

The work product or output of the SA should imbue lifelong learning skills to the participating resident, with the goal to expand the evidence-based practice of EM and advance the care of patients in the emergency department. EM residents should be in a position to accelerate both knowledge translation and knowledge application. Faculty in EM residency programs should demonstrate academic development that promotes career progression and recognizes competence as mentors and educators preparing residents for academic, administrative, and clinical careers. Departments of EM should benefit from these activities by institutional and extramural recognition. Finally, this residency-training requirement may contribute to the inspiration for a subset of residents to pursue a career in academic EM, thus augmenting this portion of the EM workforce.

SA requirements during residency training should be aimed at equipping residents with skills that take them beyond being mere consumers and implementers of evidence-based medicine to being physicians who can implement the skills learned from SA to continue to develop new knowledge and further the specialty. Additionally, the SA should contribute to faculty and departmental development in a synergistic fashion. Knowledge translation from the time of establishing evidence to the time of adoption into practice traditionally has been delayed by years. At this juncture, the ACGME is in the process of revising the Common Program Requirements. Optimally those changes will both continue to require rigorous scholarship and support the resources (faculty and institutional) to enable the consensus model we have drafted. [13] Additionally, with the SAS on the horizon, there is the opportunity to reshape and redefine the scholarly requirement to better serve patients, trainees, physicians, and the specialty of EM.

LIMITATIONS

The consensus process has several limitations that were discussed by Summers et al.[1] and need to be considered when interpreting the results. There is the potential for bias if the representatives of the respective stakeholder organizations expressed their personal opinions rather than the perspective of the organization. However, this was minimized by formally requesting organizations to send representatives. Additionally, it is possible that the individuals who participated in the process do not represent the range of opinions of their organizations on SA. Furthermore, in contrast to experts who usually participate in a nominal group-technique consensus building, a percentage of the consensus participants (residents) were novice learners. Our rationale for the inclusion of residents is that they were clearly vested stakeholders who have expertise in many of the non-research SA areas. It is notable that while they may not be in a position to adequately evaluate how the SA applies to the attending-level, independent practice of EM, we did not collect information to identify how knowledgeable they were in non research-based scholarship.

The total number of survey recipients is not known nor was there available to us a response rate overall for the different stakeholder groups. We have no way of knowing whether those on a listserve actually received the survey. This uncertainty combined with the fact that respondents frequently were members of multiple stakeholder groups made it impossible to dissect these results by group. Furthermore, we were unable to show how many total residency programs were represented and what fraction of all residencies (ACGME and AOA) were represented. Despite these limitations, we feel confident in reporting the initial survey responses because many of the experts identified their perspectives by name, and the ratings of those reported as consensus were consistent. The elements of the survey response

that lacked agreement were reviewed and underwent a re-vote in the second iteration of the process. As a consensus project, the response rate and sampling were not as rigorous as one might find in a research study.

CONCLUSION

Having been approved by the boards of SAEM, ACEP, and ACOEP, this consensus document may serve as a best-practice guideline for residency programs by delineating the goals, definition and endpoints for EM resident scholarly activity. In applying this guiding document, residency programs should evaluate the resources they have available and implement their individual site requirements by balancing the Review Committee in Emergency Medicine requirements with their own circumstances. Future discussion to determine how non-traditional work products can best be evaluated and incorporated into this activity requirement should be encouraged.

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On behalf of the SAEM Research Directors' Interest Group and the Evidence Based Healthcare Implementation Interest Group and Approved by the SAEM, ACEP, and ACOEP boards.

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Response to "Creating Consensus: Revisiting the Emergency Medicine Scholarly Activity Requirement"

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Dear WestJEM Editorial Board:

As representatives of the Emergency Medicine Residents' Association (EMRA), the Council of Residency Directors in Emergency Medicine (CORD), the American College of Osteopathic Emergency Physicians - Residents and Student Organization (ACOEP-RSO), and the American Academy of Emergency Medicine - Residents and Students Association (AAEM-RSA) we write in response to "Creating Consensus: Revisiting the Emergency Medicine Scholarly Activity Requirement."[1] This paper presents the outcomes of efforts by the Society of Academic Emergency Medicine's Research Directors Interest Group to understand emergency physicians' attitudes and opinions on resident scholarly activity. We applaud the authors for their work on this challenging topic, and the editors for bringing it forward for discussion. However, we have some reservations about applications of its conclusions.

In emergency medicine (EM), our Accreditation Council on Graduate Medical Education (ACGME) Review Committee has granted wide latitude to programs when defining scholarly activity.[2] A previous survey of EM programs found that a majority of program directors cited curriculum development, review articles, and lectures as ways in which residents adequately fulfill the scholarly activity mandate.[3] Such activities were considered scholarly activity by the ACGME in the past,[2] and maintained with the recent update to the Common Program Requirements, which were revised to mirror Boyer's Model of Scholarship including "discovery, integration, application, and teaching."[4,5] The ACGME includes activities such as "grants," "creation of curricula," "electronic educational materials," and "contribution to professional committees...or editorial boards"[4] when defining faculty scholarly activity. These broad parameters encompass the spectrum of scholarship that exists in academic departments and embraces evolution, growth, and innovation in education. Kane et al. seeks to modify these requirement by suggesting that scholarly activity solely focus on the instruction of residents in scientific inquiry, and exposure to the mechanics of research. This change would narrow the definition of scholarly activity beyond what is currently accepted by the ACGME, and such an interpretation would preclude the use of national leadership and curriculum design for fulfillment of the scholarly activity requirement. While we appreciate the authors' perspective, their scope of scholarly activity is of a more traditional research model and not of scholarship, which includes academic development and contributions. This would fall short of providing diverse opportunities to residents for how they use scholarly activity to grow their careers and our specialty.

Kane et al. made significant effort to have numerous opinions included in their consensus definition for scholarly activity. However, despite these efforts, CORD was absent from their in-person meeting. While CORD's members responded to the survey, no subgroup analysis was performed, so viewpoints of the subset of emergency physicians who have the most direct contact with residents and their scholarly activity are not specifically outlined in this paper. This is a significant limitation to the consensus that these authors seek.

We also feel that the methodology used to interpret the survey fails to describe consensus. The cut point chosen to define consensus of 3.33 on a 4-point Likert scale makes it possible

for 100% of respondents to "somewhat agree" with a statement and for this to not represent consensus. It also suggests that people who "somewhat agreed" with an option were actually voting against consensus on that item. The *American Journal of Public Health* recommends that, when building consensus, "if agreement of at least two thirds of participants can be reached... consensus is established."[6] This recommendation is more closely represented by a cut point of 2.66, which could have allowed case reports, curriculum design, or blog posts to count toward a consensus definition. Thus, the items included in their definition of consensus (and more importantly, those left out) cannot be meaningfully interpreted.

EMRA, CORD, ACOEP-RSO, and AAEM-RSA support a broad definition of scholarly activity that extends beyond the points proposed by Kane et al. We encourage the reader to consider the breadth of activity that contributes to the scholarly advancement our speciality when deciding what to require for trainees. There is real value in work which contributes to the discovery, integration, application, and teaching of emergency medicine, and we hope that the ACGME EM-RC will continue its practice of broadly defining scholarly activity, and not limit the future of this vibrant speciality.

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Response to Letter to the Editor

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Dear *West*JEM Editorial Board:

We thank Pasichow et al. for taking the time to both read and comment on the consensus work reported in Kane et al.[1] Foremost, our work was not intended to remove from individual program directors the ability to locally define scholarly activity. Program directors are already guided by a list of minimum expectations that the Review Committee for Emergency Medicine (EM) has labeled as "examples of acceptable resident scholarly activity."[2] Some programs will strive to achieve more than the minimum and prepare their residents for a higher level of scholarship and research. Pasichow et al.'s well-presented comments on the nature of scholarship are discussed in greater detail in an article published in the *West*JEMby Ander and Love.[3] The article provides information on how to apply Boyer's model, and provides both standards and a model to determine if a project meets a "test of scholarship."

Our stated goal was to identify best practices for the scholarly requirement from as broad a perspective as possible. The original work dates back 20 years, and represents the specific views of research directors at that time.[4] Medicine in general and EM in particular have evolved since then. Current Accreditation Council for Graduate Medical Education (ACGME) requirements include emerging emphasis on quality improvement.[5] In response, our work has added quality improvement to a list of best practices for the scholarly requirement. Pressures from demographics and delivery of care continue to change the practice of EM.[6] When combined with emerging technologies, our collective professional view of scholarship will also need to evolve. To address the influence of continued change in EM, there may be value in regularly revisiting the scholarly activity requirement on a more frequent basis. Both the upcoming changes to the ACGME Common Program requirements and their application by our Review Committee may impact when it is best to next revisit the scholarly requirement.[7]

In the end, stimulating dialogue such as that provided by this letter to the editor is the greatest opportunity for the application of our work. Hopefully, some of the resultant discussion will occur at the level of individual residency programs within the ACGME-required "Self Study" process.[8] As each program sets its individual "program aims" and performs "strategic assessment" to "take the program to the next level," our work and discussion such as this will hopefully be of value.

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Opportunities for Research in Mental Health Emergencies: Executive Summary and Methodology

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Introduction: Despite the ever-increasing numbers of mental health patients presenting to United States emergency departments, there are large gaps in knowledge about acute care of the behavioral health patient. To address this important problem, the Coalition on Psychiatric Emergencies convened a research consensus conference in December 2016 consisting of clinical researchers, clinicians from emergency medicine, psychiatry and psychology, and representatives from governmental agencies and patient advocacy groups.

Methods: Participants used a standardized methodology to select and rank research questions in the order of importance to both researchers and patients.

Results: Three working groups (geriatrics, substance use disorders, and psychosis) reached consensus on 26 questions within their respective domains. These questions are summarized in this document.

Conclusion: The research consensus conference is the first of its kind to include non-clinicians in helping identify knowledge gaps in behavioral emergencies. It is hoped that these questions will prove useful to prioritize future research within the specialty. [West J Emerg Med. 2019;20(2)380–385.]

INTRODUCTION

Emergency departments (ED) across the country are increasingly a point of care for patients with acute mental and behavioral health needs. From 1992-2001, approximately 53 million visits to United States (U.S.) EDs were due primarily to mental health concerns.[1] Patients often present during an acute mental health crisis, with suicidal ideation, homicidal ideation, agitation, substance abuse or withdrawal, acute psychosis, or following a suicide attempt.[2-5] The assessment of patients with behavioral health needs is challenging in part because of the varied nature of the presentations, the frequent coexistence of medical and psychiatric disorders, and the difficulty in obtaining a reliable history and exam from patients who may be uncooperative, intoxicated, have major neurocognitive disorders, or be delirious. Furthermore, assessment and treatment in the ED can be challenging due to insufficient space, time, staff, and resources. To help provide leadership and improvements in emergency mental health care in U.S. EDs, the Coalition on Psychiatric Emergencies (CPE) was founded to promote education, policies, and research that will ultimately improve the quality of behavioral healthcare for patients.

Since the 1994 Macy report, promotion of research within emergency medicine (EM) has had a number of successes, including the successful establishment of the Emergency Medicine Foundation.[6-8] Promotion of research and training in behavioral emergencies, however, has not garnered the same level of attention. Training in behavioral emergencies was almost non-existent outside of psychiatry before the 19th century,[9] and the subspecialty of emergency psychiatry was not established until 1988. Prior to that time, individuals with mental illness, when they were treated by physicians at all, were treated by general practitioners with little formal training. The development of specialties in medicine led to the establishment of board certification and mandated lifelong learning, which in other areas of medicine has been associated with improved outcomes for patients.[10]

Given that EDs now provide the majority of care for patients who are admitted,[11] the ED has naturally served a similar function for behavioral health patients as well.[12] Given the open access and availability of EDs nationwide, they are also frequently the only source of care for mental health patients who may have poor healthcare literacy, inadequate access to care, or insufficient insurance.[13-14] Thus, contemporary EDs are uniquely positioned to address acute behavioral emergencies.[3] Unfortunately, despite the importance of EDs in caring for mental health patients, there are currently many gaps in our understanding of optimal ED care for behavioral emergencies. Although the U.S. leads the world in EM research, only a small proportion of this research is dedicated to psychiatric emergencies.[15-16] Thus, there remains great need for further prioritization, collaboration, and investment in this area.

To address this need, the CPE convened a research consensus conference with experts from both psychiatry and EM. Unlike previous consensus conferences in this area, which included only clinicians and/or research scientists,[1, 17] the current conference instead convened a diverse set of organizations representing clinician stakeholders, clinical researchers, psychology, governmental agencies and patients' advocacy organizations so as to ensure that resulting priorities reflected both patient priorities and scientific need.[2, 3, 12, 18-23]

Objectives

The objectives of the conference were to highlight and prioritize areas of greatest research need within selected domains of emergency psychiatry while taking the patient perspective into account, and then to summarize these recommendations into consensus documents.

METHODS

The Coalition on Psychiatric Emergencies

CPE includes over a dozen professional organizations, patient advocacy groups, and systems of care,[24] all with an interest in behavioral emergencies. The steering committee at the time of the conference consisted of representatives from the following organizations: the American College of Emergency Physicians (ACEP), the American Association for Emergency Psychiatry, the Depression and Bipolar Support Alliance, the National Alliance on Mental Illness, and the Emergency Nurses Association. The steering committee was responsible for identification of priority domains, planning the conference, inviting participants and stakeholders, and determining the methodology.

Conference Methodology

This structured expert consensus conference was held December 7, 2016. The overarching question of the conference was to investigate whether early treatment might positively affect outcomes for patients with mental health crises,[25] similar to other critical conditions of the conference.[25] By consensus, the CPE steering committee identified four priority domains on which to focus: geriatric behavioral health emergencies; suicidality and acute depression; substance use disorders (SUD); and acute psychosis. As in previous conferences of these types, the four domains were chosen a priori based on their importance to providers currently caring for patients with behavioral emergencies.[17]

The 35 participants in the conference were sorted into working groups by self-identified interest and expertise. While participants each worked in a single group, they were able to provide feedback and comments on the priorities identified by other working groups both during the conference and after. Each workgroup appointed a moderator who conducted the consensus building during the conference (see below), and a group leader who identified relevant articles prior to meeting in person. Each participant was provided with these articles and was free to contribute any additional articles desired.

Consensus building on research questions within each domain was accomplished by use of the nominal group technique in person.[26-27] The nominal group technique is a four-step process in which participants are invited to identify ideas and raise exploratory questions, record these ideas, discuss them freely, iteratively focus and revise them, and then vote on relative importance. Participants work independently but in the presence of one another. This method was chosen as it has the advantage of preventing any particular expert from dominating the conversation or influencing the voting.

Specific research ideas, questions, and question variants were voted on in person using the dot method. Questions that received more votes were deemed to be more important, and thus were ranked more highly within each domain. As research on behavioral emergency questions are of importance to industry, representatives

of pharmaceutical companies were permitted to attend. However, those representatives were not allowed to vote on the final wording or rank order importance of any question.

At the end of the conference day, all groups presented their research questions to all stakeholders. Stakeholders from other priority domains were permitted to ask questions or make clarifying points, but were not permitted to vote on any research question. After the conference, each group was allowed to form additional consensus on the final form of each question in any manner desired, typically by email. However, stakeholders from other priority domains were not permitted further opportunities to revise or edit these questions.

Identification of Relevant Stakeholders

Identification of relevant stakeholders (i.e., conference participants) was accomplished primarily by a web search for publications in each particular domain. The search strategy was not conducted with formalized keywords, but identified stakeholders were expected to have either one or more publications in the relevant domain or have given lectures in this area at a national conference. As this method of identification would be expected to weight the participant list most heavily towards researchers, clinicians with relevant interest and expertise were also identified by member organizations on the CPE steering committee. Individuals representing patient advocacy groups and governmental agencies, also nominated by member organizations on the CPE steering committee, were included in order to create a robust and diverse set of expert opinions. The inclusion of non-clinicians and non-clinical researchers was an important difference between this conference and previous conferences of this type.[1, 17] Expert participants were asked to self-declare conflicts of interest using the standard ACEP conflict-of-interest form for committees.

RESULTS

A total of 35 stakeholders (57% female, average age 47), including 13 non-clinicians, with an average of 17 years in their relevant fields participated in the consensus conference. The research priorities identified by each working group are listed more fully in the accompanying articles. However, the following themes emerged from the conference and had consensus from both the participants in each group and non-group stakeholders. With regard to geriatrics, more research is needed on identification, screening, and management of older adults at risk for worse outcomes because of behavioral emergencies.[28] This includes, but is not limited to, appropriate SUD screening for older adults specifically as an important component of the medical screening exam.

With regard to substance use, more research is needed on screening and intervention for substance use in the ED.[29] Indeed, in the period of time that has elapsed since this conference the director of the National Institute of Drug Abuse has made public comments likening the failure of EDs to provide treatment options to patients with SUD as potential "malpractice."[30] In the psychosis workgroup, better methods for screening, measurement, and evaluation of psychosis are needed. More patient involvement is needed to determine the most relevant patient outcomes for emergency treatment of psychosis.[31]

Despite initial agreement on some important questions by the suicide workgroup during the conference, this working group was unable to agree on the final format of research questions after the conference. Consequently, although the expert participants recognize the importance of suicide-related research to both patients and families, no key research questions are available from this group.

DISCUSSION

Summaries of the most important recommendations from the working groups are outlined below.

- Tables 1 – 3: Research questions regarding older adults with behavioral changes.
- Table 4: Research questions regarding individuals with SUD and behavioral emergencies.
- Tables 5 – 6: Research questions regarding individuals with acute psychosis.

CONCLUSION

More research is needed in the area of acute mental and behavioral health disorders in order to care for patients in the acute care setting more effectively. This research consensus conference, organized by the multi-disciplinary Coalition on Psychiatric Emergencies, was the first of its kind to build consensus from a group with diverse expertise and experience to prioritize research goals in four domains within mental health and behavioral emergencies. Continued consensus building among diverse stakeholders in this field should be an ongoing priority, as research in these domains has implications for both practicing medical personnel and the individuals in their care.

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Table 1. Key research questions to guide efforts for improved care of older adults with behavioral changes through screening and identification.

Question 1	What are the barriers to screening for alcohol or substance use in older adults?
Question 2	Using age as a stratification method, what are the medical and radiographic components of an appropriate medical screen for patients with psychiatric symptoms with an emphasis on sensitivity, specificity, and accuracy; do routine screening labs, including urine, affect management and disposition in older adults with psychiatric symptoms?
Question 3	How often does noncompliance with prescribed medications contribute to emergency department presentations with agitation or behavioral changes?

Table 2. Key research questions to guide efforts for improved care of older adults with behavioral changes through improved management strategies.

Question 4	What is the most effective pharmacologic agent to manage acute agitation in the acute care setting?
Question 5	Does earlier treatment with psychotropic medications decrease length of stay in the emergency department (ED) for elderly agitated patients and does choice of treatment matter?
Question 6	How often are older adults restrained physically or chemically in the ED; does the rate of restraint use vary with underlying psychiatric disorders, and what are the harms or benefits of their use?
Question 7	What are barriers to initiating pharmacologic treatment for acute psychiatric illness in the ED among older adults?
Question 8	Does the initiation of home-based services for patients discharged from the ED with dementia help reduce the rate of ED return visits?
Question 9	What are the necessary components of an effective decision-support tool to determine whether it is safe to start or stop psychiatric medications, and does the use of such a tool improve outcomes?

Table 3. Key research questions to guide efforts for improved care of older adults with behavioral changes through improved identification and management of delirium.

Question 10	What are the barriers to diagnosis of delirium in the emergency department (ED), and how can they be overcome?
Question 11	Is ED length of stay an independent risk factor for the development of delirium?
Question 12	Does ED length of stay contribute to worse morbidity and mortality or adverse medical events in older adults with delirium?
Question 13	What are the most effective non-pharmacologic interventions in the ED to manage or prevent delirium?
Question 14	Does having an ED pharmacist involved in patient care help reduce rates of delirium in the ED?

Table 4. Key research questions to guide emergency department-based interventions for substance use disorders.

Question 1	What are the most effective, efficient and appropriate ways to screen for SUD in the ED?
Question 2	What are the most effective ED-based interventions for SUDs?
Question 3	What is the role for initiation and management of SUD treatment and detoxification in the ED?
Question 4	What is the role of sociocultural and generational factors in acceptability, accessibility, and benefit of ED-based initiatives?
Question 5	What are the best practices for the evaluation and management of the acutely intoxicated patient?
Question 6	What role can peer mentors, or patient navigators, play in improving patient outcomes?

ED, emergency department; *SUD*, substance use disorder.

Table 5. Key research questions to guide efforts for individuals with psychosis through screening and identification.

Question 1	Can a research-based triage tool be developed to assess psychosis in emergency department patients?
Question 2	What outcomes are meaningful for patients/families when assessing the effectiveness of psychosis interventions?

Table 6. Key research questions to guide efforts for effective interventions and management of the patient with acute psychosis.

Question 3	What is the recommended treatment for psychosis in the emergency setting?
Question 4	What affects emergency provider decision-making in treatment choice for psychosis?
Question 5	What system outcomes can be affected by early treatment of psychosis in emergency settings - both within the emergency care setting and thereafter?
Question 6	Are there appropriate care locations for psychotic patient presentations instead of the emergency department?

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Emergency Medicine Research Priorities for Early Intervention for Substance Use Disorders

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Introduction: Patients with substance use disorders (SUDs) frequently seek emergency care, and the emergency department (ED) may be their only point of contact with the healthcare system. While the ED visit has been increasingly recognized as providing opportunity for interventions around substance use, many questions remain.

Methods: In December 2016 the Coalition on Psychiatric Emergencies (CPE) convened the first Research Consensus Conference on Acute Mental Illness, which consisted of clinical researchers, clinicians from emergency medicine, emergency psychiatry, emergency psychology, representatives from governmental agencies and patient advocacy groups. Background literature review was conducted prior to the meeting, and questions were iteratively focused, revised, voted on and ranked by perceived importance using nominal group method.

Results: The main goal of the SUD workgroup was to identify research priorities and develop a research agenda to improve the early identification of and management of emergency department (ED) patients with SUDs with the goal of improving outcomes. This article is the product of a breakout session on "Special Populations: Substance Use Disorder." The workgroup identified with high consensus six research priorities for their importance related to the care of ED patients with SUDs in these overall domains: screening; ED interventions; the role of peer navigators; initiation of SUD management in the ED; specific patient populations that may impact the effectiveness of interventions including sociogenerational and cultural factors; and the management of the acutely intoxicated patient.

Conclusion: Emergency providers are increasingly recognizing the important role of the ED in reducing adverse outcomes associated with untreated SUDs. Additional research is required to close identified knowledge gaps and improve care of ED patients with SUD. [West J Emerg Med. 2019;20(2)386–392.]

INTRODUCTION

In 2016, the National Survey on Drug Use and Health (NSDUH) demonstrated that only 2.3 million of the 20.5 million individuals with an identified need for treatment of a substance use disorder (SUD), had received care within the prior year.[1] Nonetheless, patients with SUD frequently seek emergency care, making up half of the more than 4.9 million emergency department (ED) visits for drug-related complaints.[2]

Patients with unmet treatment needs are more likely to be hospitalized than those receiving treatment for a SUD, and substance use is associated with higher rates of unintentional injuries, motor vehicle collisions, interpersonal violence, human immunodeficiency virus infection, and intentional or accidental overdose.[3-6] Increasingly, the ED visit has been identified as a unique opportunity for intervention and linkage to treatment for patients who are at risk for or who currently have SUDs, whether for tobacco, opioid or alcohol use.[7-10]

The ED may be the only point of contact with the healthcare system for some patients with SUDs. An ED visit for an acute injury, illness or overdose may provide a window of opportunity where patients are more receptive to education about and referral to treatment for SUD.[11] Over the past decade, significant strides have been made in the field of ED-based identification, interventions and referrals for the treatment of SUD, but many questions remain. The goal of the SUD workgroup of the Coalition on Psychiatric Emergencies Research Consensus Conference on Acute Mental Illness was to identify research priorities and develop a research agenda to improve the early identification of and management of ED patients with SUDs with the goal of improving outcomes.

METHODS

Please see the Executive Summary (Appendix) for full methods. Participants from a variety of disciplines – emergency medicine (EM), emergency psychiatry, emergency psychology, clinical research, governmental agencies, and patient advocacy groups – were invited to participate in a research consensus session held prior to a joint emergency-psychiatry conference (the 7th Annual National Update on Behavioral Emergencies). Background literature reviews were performed prior to the in-person meeting. A total of 38 articles were circulated to the SUD group in advance. The working group initially identified three key areas: identification and diagnosis/screening; ED-based interventions; and linkages to the continuum of care. During the conference, the group spent time discussing research gaps related to addiction in the ED and identified 36 research topics. After spending time generating the initial 36 questions, the group re-reviewed them and held additional discussions to add clarity and intent; it then condensed the list to 24 questions.

A nominal group technique was employed to develop group consensus on the highest priority research gaps. Each member was given five points with which to vote for the questions they felt were most important. The questions were then ranked by the number of votes. The group identified six key research questions to guide ED-based interventions for SUD. Following the nominal technique, additional input was solicited from participants, questions were iteratively focused and revised, voted on, and then ranked by importance. Following the in-person session, the workgroup developed additional consensus by meeting electronically to further refine the final form of each question.

The working group focused on SUD was made up of seven people: one EM clinician researcher, one EM clinician, and two clinician psychiatrists; a non-physician student; a participant from a medical association, and an observer from industry. The average age of the participants was about 42 years old; four were females and three were males.

RESULTS

During the consensus conference, research questions and topics were sequentially proposed by individual members of the workgroup, and were transcribed into a large working board visible to all group members in real time. Workgroup members proposed research topics individually and in a sequential fashion, for a total of 36 research topics. Topics were discussed, grouped, voted on, and prioritized using the nominal group technique.

DISCUSSION

The workgroup identified six questions as the highest priority areas for early identification of SUDs in the ED. (Additional questions and discussion, organized by topic, are also included in Table 1 and Table 2.)

Screening

Based on a robust literature search, the United States Preventive Services Task Force (USPSTF) and the American College of Emergency Physicians (ACEP) recommend screening and brief intervention for alcohol use disorders in primary care and ED settings.[11-13] The role of universal screening for illicit drug use, either in the primary care or ED setting, is less clear. Although evidence is lacking, increased rates of illicit drug use among ED patients, recent increases in opioid-associated mortality, and recent ED-based studies showing improved outcomes after ED intervention, provide a basis for the role of ED screening for SUDs.[8,12,14-16]

While ED-based research studies focused on SUDs have used screening to identify potential study subjects, little is known about either the impact or the most effective implementation of ED-wide screening procedures in the day-to-day functioning of an ED. Multiple studies have adapted, developed and piloted a variety of screening tools for SUDs using tablet- and kiosk-based platforms, but consensus on the most effective implementation of ED-based screening algorithms outside of a research study has not been reached.[2,7,17,18] Several EDs have implemented Screening, Brief Intervention and Referral Treatment (SBIRT) programs including use of health promotion advocates such as in Project Alcohol and Substance Abuse Services, Education, and Referral to Treatment (ASSERT), or training ED residents and faculty as part of Substance Abuse and Mental Health Services Administration's (SAMSHA) SBIRT training grants as best practice.[19]

Table 1. Key research questions to guide emergency department-based interventions for substance use disorders.

Question 1	What are the most effective, efficient and appropriate ways to screen for SUD in the ED?
Question 2	What are the most effective ED-based interventions for SUD?
Question 3	What is the role for initiation and management of SUD treatment and detoxification in the ED?
Question 4	What is the role of sociocultural and generational factors in acceptability, accessibility, and benefit of ED-based initiatives?
Question 5	What are the best practices for the evaluation and management of the acutely intoxicated patient?
Question 6	What role can peer mentors, or patient navigators, play in improving patient outcomes?

SUD, substance use disorder; *ED*, emergency department.

Table 2. Key research questions to guide efforts for improved care of individuals with substance use disorders.

Topic area 1: What are the most effective, efficient and appropriate ways to screen for SUD in the ED?
What is the best approach for sensitively and effectively screening for drug and alcohol use in the ED?
How effective are current screening tools in different populations and do results vary with patient characteristics/identity: generational (i.e., millennial vs geriatric), gender, religious, cultural factors?
What is the most cost-effective way to implement high-quality ED-based screening for SUD ?
What is the role for SUD screening in ED triage? For universal screening?
Topic area 2: What are the most effective ED-based interventions for SUD?
Which ED-based interventions can reduce cost, reduce mortality and increase treatment adherence?
Do harm reduction initiatives (i.e., overdose prevention education, naloxone distribution) improve outcomes?
To which types of treatment/services should ED patients with SUD be referred?
Topic area 3: What is the role for initiation and management of SUD treatment and detoxification in the ED?
Who is appropriate for ED-initiated outpatient treatment of alcohol withdrawal?
Is there a need for development of a validated ED-based protocol for initiating outpatient treatment of alcohol withdrawal?
Is there a need for development of a validated ED-based protocol for initiating buprenorphine for the treatment of OUD, including who is most likely to benefit and when?
Topic area 4: What is the role of sociocultural and generational factors in acceptability, accessibility, and benefit if ED-based initiatives?
Topic area 5: What are the best practices for the evaluation and management of the acutely intoxicated patient?
Do better evaluation, diagnosis and treatment of agitation of patients with acute intoxication of traditional drugs of abuse as well as newly emerging novel psychoactive substances (NPS) currently exist?
Are there clinical guidelines for management of acute stimulant intoxication?
What is the appropriate role of drug/toxicology screens in the ED?
Is there evidence based-criteria for medical workup prior to psychiatric evaluation?
Topic area 6: What role can peer mentors, or patient navigators, play in improving patient outcomes?
What role can peer mentors, or patient navigators, play in improving patient outcomes?

SUD, substance use disorder; *ED*, emergency department; *NPS*, novel psychoactive substances; *OUD*, opioid use disorder.

Although several of these programs are of long standing and have linked thousands of ED patients to SUD care, the most effective and efficient way to screen in diverse ED settings remains unclear.[12] Importantly, the logistics of who administers the screen and how it is performed (e.g., triage nurse; tablet-based or self-administered; emergency provider) will influence the overall acceptability of the process to the patient, the sensitivity to detect SUDs, the integration of the process into the ED workflow, and the overall sustainability. The most efficient and effective approach to screening for SUDs will likely vary based on patient population, geography, ED volume, community resources, ED staffing and academic vs community hospital settings, and may vary across cultural and generational patients within ED populations. Increasingly, the ED has been recognized as an important venue to identify and engage patients with SUDs.[13]

Intervention

Although significant strides have been made in improving outcomes for ED patients with risky alcohol use, uncertainly surrounding the most effective interventions to reduce illicit drug use persist. A fairly robust literature exists supporting the implementation of SBIRT for alcohol use disorders in primary care settings[11,20] although mixed results have been seen in the ED.[7,21,22] Brief interventions incorporate principles of motivational interviewing, an evidence-based counseling technique that uses empathy, positive framing, reflective listening, and gentle education to enhance motivation to reduce risky behaviors.[10,23] Brief interventions for patients with at-risk or hazardous drinking usually focus on reducing use, while the focus for patients with dependence is on enhancing motivation to accept a referral to formal treatment.[13-15] Some ED-based studies have shown success in reducing alcohol consumption, episodes of binge drinking and episodes of driving after drinking in harmful and hazardous alcohol drinkers, although other studies have been less encouraging, with no persistent effect at one year.[7,22,24,25]

ED-based brief interventions for drug use have been less promising. The Screening, Motivational Assessment, Referral, and Treatment in Emergency Departments (SMART-ED) Clinical Trials Network Study across six academic EDs did not detect differences in drug use at any point in time.[16] Additionally, a single, large, randomized control trial (RCT) found that a brief motivational intervention for patients with alcohol or drug use disorders did not improve attendance at post-ED intervention over a case management intervention.[16,18,19] However, there were several methodological issues with these studies, and it is likely that one intervention may not be effective for all types of drugs at all levels of severity.

More recently, ED-based interventions specific to patients with opioid use disorders (OUD) have shown more promise. One pilot RCT of ED patients with non-medical opioid use found a significant reduction in overdose-risk behaviors and a reduction in non-medical opioid use at six months after an ED-based motivational interview intervention compared to usual care.[9] In one single ED-based RCT, patients with opioid dependence who received a brief intervention and ED-initiation of buprenorphine were significantly more likely to be engaged in treatment for OUD at 30 days (78% vs 37%) and had fewer days of opioid use than the standard referral to treatment group.[20] This study, augmented by the persistent rapid rise of opioid-associated fatalities, has prompted a number of EDs across the country to develop programs initiating treatment with buprenorphine for OUD in the ED, although many questions remain about how to optimize implementation, patient selection, models of linkage and induction/dosing algorithms to maximize safe and effective linkage to treatment.[21,22] Studies are needed to optimize these and other strategies to enhance the success of ED-initiated buprenorphine, and to better characterize patient and provider facilitators and barriers to the implementation of this intervention.

In the general population in the Western world, approximately 10% of women and 20% of men will have an alcohol use disorder (AUD).[23] About 50% of individuals with AUD are expected to have withdrawal symptoms with reduction or cessation of alcohol use, and 3-5% will have severe complications of withdrawal including seizures or delirium.[23] That said, ED clinicians routinely care for those with the highest risk of complicated withdrawal. General consensus and non-ED based literature suggest patients with mild to moderate AUD may be appropriate for outpatient management with or without oral benzodiazepines.[29,30] However, there is a paucity of prospective, ED-based studies to provide guidance for the ED population.

Patients at high risk for severe withdrawal and therefore generally inappropriate for outpatient management, include those with a history of alcohol withdrawal seizure or delirium, psychiatric or medical co-morbidities, or patients who receive multiple doses of benzodiazepines without significant reduction in Clinical Institute Withdrawal Assessment scale.[24] Clinical decisions regarding the disposition of patients at risk for or with symptoms of alcohol withdrawal are challenging given the dearth of prospective, evidence-based ED studies to guide the risk-benefit analysis of discharging the patient who is at risk for moderate to severe alcohol withdrawal. Moreover, although multiple outpatient regimens for the treatment of alcohol withdrawal symptoms have been described, no clear evidence exists for the most appropriate medication type and dosing schedule.[23,25,26]

Patient Population Factors

Little is known about the role of sociocultural and generational factors in the acceptability, accessibility, and benefit of ED-based initiatives to reduce harmful substance use and provide linkage to treatment for SUD. Many novel interventions rely on relatively new mobile health and other technology, including smartphone, text messaging and videoconferencing-based interventions, or wearable biosensors, which many be more appealing to younger patients, but create an additional barriers for identifying or intervening in substance use for populations with less intrinsic exposure to technology because of cultural factors or age.[27-29] Although intervention developers may be specifically targeting younger patients, cultural and generational factors should be considered in the development and implementation of ED-based initiatives given the pervasive distribution of SUDs across all demographics.[1-3]

Initial Substance Use Disorder Management

Intoxicated patients present unique challenges to the emergency physician. They can be agitated and disruptive.[30] Patients present with alcohol intoxication alone or in combination with other drugs, but an increasing number of

visits are due to stimulants, novel psychoactive substances (NPS) and designer drugs.[31] Literature on management of alcohol intoxication exists but is built on consensus and our limited knowledge of treating agitation in general. Little research has been done on the best management for stimulants and newer substances and the current literature consists mainly of descriptive small series, case reports, or surveys of clinicians' experiences.[3]

Of the more than 4.5 million ED visits in 2009 for drug-related causes,[34] 32% involved alcohol use alone or in combination with other drugs. Nearly 94,000 visits were for stimulants and over 400,000 were for cocaine, while fewer were for phencyclidine, gamma hydroxybutyrate, and ecstasy.[35] While it is not clear how many of these visits were for substance-related intoxication as opposed to withdrawal, drug seeking or other reasons, it is clear that the intoxicated patient presents unique challenges to the ED treatment team. Furthermore, the burden of caring for patients with acute, alcohol-related visits more than doubled between 2001 and 2011 reflecting an increased number of visits, longer length of stay, and more intensive use of diagnostic services.[36]

When a patient presents with suspected drug intoxication and is sleepy or sedated, management is straightforward and supportive until the substance clears and the patient awakens. When a patient is agitated, disruptive, and not cooperative, management is more difficult. Management of agitation in general is not well studied,[37] and it is not surprising that our understanding of the best approach to managing the patient who is agitated because of intoxication is limited and based more on retrospective reviews, anecdotal information, and expert consensus.[38,39] Experts recommend identification of drugs/alcohol as cause of agitation as a first step, followed by verbal de-escalation and medications as necessary, but the research to back this approach is lacking.[40-41]

Another issue to consider when treating intoxicated patients in the emergency setting is the value of laboratory testing such as drug screens and blood alcohol levels. Available toxicology screens often miss substances, and patient history may be more helpful than expensive diagnostic tests except in situations where patients are obtunded or otherwise unable to provide a history.[42-43] As clinical intoxication frequently does not align with blood alcohol levels, questions frequently arise in determining patient ability to make medical decisions, including the ability to refuse medical care or, depending on the ED setting, when patients are appropriate for psychiatric evaluation.[44-46] No clear evidence-based consensus currently exists on the best practices for medical workup prior to psychiatric evaluation.

Substance use is a well-known risk factor for suicide, and a large percentage of individuals who die by suicide are intoxicated at the time of their deaths.[47] One challenge is how to best assess risk of suicide in the patient who presents to the ED with suicidal statements when intoxicated but later recants when sober saying they either "just said those things" because they were intoxicated or denying any memory of making suicidal statements or having suicidal thoughts. Persistent knowledge gaps exist around best practices for this ED population.

Peer Mentors

Peer mentors, people with the lived experience of recovery from addiction and mental illness, are becoming increasingly common in the healthcare landscape.[48] Peer mentors have been identified as a potential bridge to treatment for ED patients after non-fatal opioid overdose, although the impact of this approach on outcomes is unclear.[49] Early indicators suggested that using peer mentors and peer-led programs can be a helpful diversion for people with addiction and mental health emergencies.[50-51] Larger studies have shown limited benefit from peer interventions, often due to inconsistent program fidelity and heterogeneous approaches.[52] Emerging efforts to create fidelity models are promising.[53] However, interventions need to be evidenced based and administered by individuals adhering to critical actions with routine fidelity checks and supervision. Additional research to explore the impact of a potentially important and effective way to support and engage people with addiction emergencies, including after opioid overdose, who require linkage to early recovery resources are needed.

LIMITATIONS

There are several limitations to this study. First, this was not a structured review of literature but rather the outcome of an expert consensus group meeting that was held in 2016. By the time of this paper's publication, it is possible that studies may have been conducted that answer or speak to some of the highlighted questions raised. Second, the group focus was narrowed to the early identification and management of patients presenting to the ED with SUDs, drugs and alcohol. Although we recognize the impact on tobacco use disorder and other medical and psychiatric comorbidities, given our limited time, we limited the scope of our work to the care and management of SUDs in the acute care settings and thus we did not specifically discuss tobacco or include focus on the management of other comorbidities. As with many in-person consensus conferences, participation is limited to those who were able to travel and attend in person; had all of the original invitees or others with valuable experience been able to attend, the findings may have been different. Nonetheless, we have highlighted a number of priority areas in which additional research is clearly needed and that can guide ongoing research as we work to improve outcomes of ED patients with SUDs.

CONCLUSION

Emergency providers are increasingly recognizing the important public health role that EDs can play to reduce adverse outcomes associate with undiagnosed and untreated

substance use disorder. Much like the ED is the "front door" for hospital admission, it is also a portal to the community to identify patients with SUDs and to deliver interventions to improve outcomes.

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A Research Agenda for the Assessment and Management of Acute Behavioral Changes in Elderly Emergency Department Patients

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Introduction: Agitation, mental illness, and delirium are common reasons for older adults to seek care in the emergency department (ED). There are significant knowledge gaps in understanding how to best screen older adults for these conditions and how to manage them. In addition, in areas where research has been performed, implementation has been slow. A working group convened to develop a set of high-priority research questions that would advance the understanding of optimal management of older adults with acute behavioral changes in the ED. This manuscript is the product of a breakout session on "Special Populations: Agitation in the Elderly" from the 2016 Coalition on Psychiatric Emergencies' first Research Consensus Conference on Acute Mental Illness.

Methods: Participants were identified with expertise in emergency medicine (EM), geriatric EM, and psychiatry. Background literature reviews were performed prior to the in-person meeting in four key areas: delirium; dementia; substance abuse or withdrawal; and mental illness in older adults. Input was solicited from all participants during the meeting, and questions were iteratively focused and revised, voted on, and ranked by importance.

Results: Fourteen questions were identified by the group with high consensus for their importance related to the care of older adults with agitation in the ED. The questions were grouped into three topic areas: screening and identification; management strategies; and the approach to delirium.

Conclusion: It is important for emergency physicians to recognize the spectrum of underlying causes of behavioral changes, have the tools to screen older adults for those causes, and employ methods to treat the underlying causes and ameliorate their symptoms. Answers to the identified research questions have great potential to improve the care of older adults presenting with behavioral changes. [West J Emerg Med.2019;20(2)393-402.]

INTRODUCTION

Older adults, age 65 and over, account for approximately 15% of visits to emergency departments (ED) in the United States (U.S.).[1] However, with the aging population, this is expected to increase to 25% by the year 2030.[2] For many conditions, older adults are more likely to be misdiagnosed, have delayed diagnoses, and to have complications from their medical management.[3] After an ED visit they are more

likely to have functional decline, medical complications, or a revisit, re-hospitalization, or death.[4] This is in part because of physiologic changes that occur with aging, underlying frailty or other geriatric syndromes, more medical co-morbidities, atypical presentations of symptoms, reduced physiologic reserve, and greater risk of medication complications or interactions. As a result, they are the population most at risk for decompensation if not identified and managed early.

Behavioral changes in older adults can arise from a range of different underlying causes, including delirium from an acute medical problem, dementia, alcohol or substance use or withdrawal, and mental illness. There are several barriers to the identification of causes of behavioral changes in older adults. One is that underlying dementia can make it difficult to obtain an adequate history. In addition, in the absence of collateral information, it may be impossible to determine whether there has been a change from their baseline. Delirium can also cause behavioral changes, but symptoms may wax and wane, and may present as hyper-active, hypo-active, or mixed. Despite the existence of ED-validated, rapid screening tools, emergency physicians find recognizing delirium in the majority of their patients challenging.[5] It has also been shown that alcohol and substance use or withdrawal in older adults is under-recognized by physicians, which could lead to a delay in diagnosis.[6] Finally, hearing and vision impairments in older adults can make it difficult for physicians to obtain an accurate history and physical exam. All of these challenges can impede the rapid identification of the causes of behavioral changes in older adults.

There are also challenges when it comes to management of older adults with behavioral changes. Dosages of psychoactive medications used in younger adults are more likely to result in side effects or sedation when used in older adults.[7] Older adults are also more likely to suffer medication interactions, since on average they take more daily prescribed medications. Pharmacological and non-pharmacological interventions that improve outcomes of agitation or delirium in the ED have not been well studied.

Given the underlying medical complexity and frailty of older adults, the causes of their behavioral changes are both likely to be misdiagnosed, while they are potentially the most likely to benefit from early intervention. For these reasons, the research questions identified here have the potential to impact a significant number of vulnerable older adults in the ED.

METHODS

Participants from a variety of disciplines – emergency medicine (EM), emergency psychiatry, emergency psychology, clinical research, governmental agencies, and patient advocacy groups – were invited to participate in a research consensus session held prior to a joint emergency-psychiatry conference (the 7th Annual National Update on Behavioral Emergencies). Background literature reviews were performed prior to the in-person meeting. Literature reviews were conducted via journal review, academic databases, and web-based searches. Searches fell within the scope of the priority domain, geriatric behavioral emergencies, as identified by the Coalition on Psychiatric Emergencies (CPE) steering committee. The workgroup leaders identified articles of importance within four key areas: delirium; dementia; psychiatric illness; and substance abuse in the elderly. Key articles in these areas were circulated electronically to the group to review in advance of the in-person meeting. A nominal group technique was employed to develop group consensus on the highest priority research gaps. Following the nominal technique, input was solicited from all participants during the meeting, questions were iteratively focused and revised, voted on, and then ranked by importance. See Executive Summary and Methodology for full methods [Appendix].

RESULTS

Key research questions identified by the multi-disciplinary working group were sorted into three categories: screening and identification; management strategies; and the approach to delirium. The working group was composed of eight individuals. There were two clinician emergency physicians (EP), one emergency clinician-researcher, two psychiatrists, and a non-physician student. The group also included two observers, one from industry and the other from an EM professional association. The average age of the participants was around 40 years old.

The group discussed the 37 articles that were reviewed in advance of the consensus conference. The working group identified 25 initial research questions to address gaps in the current literature. Using the nominal group technique the group then ranked the questions to identify the ones of most importance. Specific research ideas, questions and question variants were voted on using the dot method. Each participant was provided with 20 dots with which to vote. The questions that received four or more dots were considered more important. Those with three or less were considered less important. After voting, the group identified 14 questions that were considered of high importance for advancing the understanding of optimal management of older adults with acute behavioral changes in the ED. The questions were then discussed further, iteratively focused and revised. Following the in-person meeting, the workgroup developed additional consensus and worked electronically to further refine the final form of each question. Below we provide background information and a more detailed explanation for each question.

DISCUSSION

The most important questions as identified by the workgroup are outlined below.

Topic Area 1: Screening and Identification (Table 1)

Question 1: What are the barriers to screening for alcohol or substance abuse in older adults?

The ED represents an important point of contact during which alcohol use disorders (AUD) or substance use disorders (SUD) or high-risk use can be identified in patients who are asymptomatic or in those who present with behavioral changes from acute intoxication or withdrawal. AUDs and SUDs are prevalent yet under-recognized problems among older adults. The prevalence of AUDs among older adults is higher among patients within a healthcare setting compared with the overall prevalence in the community, with estimates of 14% for patients in ED, 18% for medical inpatients, and 23-44% for psychiatric inpatients.[8] Many older ED patients with AUD may not be easily identified in the ED.[9]

The reasons for under-recognition of alcohol and substance use among older adults are likely multi-factorial. Elderly people may be less likely to disclose a history of excessive alcohol intake, and the problem is compounded by the fact that healthcare workers have a lower degree of suspicion when assessing older people.[10-11] In addition, older adults may be unaware that their alcohol consumption is excessive or abusive until secondary events occur, and at that point may not attribute their problems to alcohol consumption.[12]

Another challenge to screening and identification of high-risk older adults occurs because many screening tools were developed and validated primarily in younger adults and may miss older adults. The Alcohol Use Disorder Test (AUDIT) and CAGE questionnaires have worse sensitivity and specificity among older adults using the traditional cutoffs, and do not perform well for the identification of high risk or heavy use.[13,14] However, other screening tools have been developed specifically for older adults, such as the Short Michigan Alcoholism Screening Instrument-Geriatric Version, or the AUDIT score using a lower cutoff score.[15]

Table 1. Key research questions to guide efforts for improved care of older adults with behavioral changes through screening and identification.

Question 1	What are the barriers to screening for alcohol or substance abuse in older adults?
Question 2	Using age as a stratification method, what are the medical and radiographic components of an appropriate medical screen for patients with psychiatric symptoms with an emphasis on sensitivity, specificity, and accuracy; do routine screening labs, including urine, affect management and disposition in older adults with psychiatric symptoms?
Question 3	How often does noncompliance with prescribed medications contribute to emergency department presentations with agitation or behavioral changes?

Once older adults with high-risk drinking are identified, they are less frequently referred for treatment. In one study, medical staff identified only 3% of benzodiazepine abusers, 38% of smokers, and 33% of drinkers. Of those identified, only 67%, 21%, and 58% patients, respectively, were referred for additional services.[16] Among inpatients, older adults with alcohol use disorders are less often recognized and even when they are identified, they are referred for treatment at about half the rate of younger adults.[10] This suggests that referral services are underutilized in this population, and medical staff may be biased against referring older patients.

Even though the American College of Emergency Physicians (ACEP) recommends routine screening and intervention in the ED for alcohol misuse,[17] this practice has not been widely adopted in EDs for individuals of any age.[18] Further research is needed on the best screening tools to identify AUDs and SUDs among older adults in the ED to discern the barriers to screening using existing tools or direct questioning of patients about alcohol intake, and to determine the most effective interventions after identification of high-risk patients.

Question 2: Using age as a stratification method, what are the medical and radiographic components of an appropriate medical screen for patients with psychiatric symptoms with an emphasis on sensitivity, specificity, and accuracy; do routine screening labs affect management and disposition in older adults with psychiatric symptoms?

Medical screening, commonly referred to as "medical clearance," is a critical part of the ED evaluation of patients with mental health disorders, agitation, or behavioral changes.[19] Specifically, medical screening is often required before a patient can be admitted or referred for admission to a psychiatric service or facility. Several studies primarily in younger patients have examined the medical screening of mental health patients.[20-21] These studies have generally found that routine laboratory examinations are of low yield, prompting a recent ACEP task force to conclude that routine laboratory testing should not be ordered unless prompted by medical history, previous psychiatric diagnoses, or physician examination. However, this recommendation was given only a level C rating.[22] In one retrospective study, authors subjectively determined whether abnormalities identified after admission would have changed management or disposition. In this report, the frequency of lab abnormalities was higher in patients over 40 years of age and almost universal in patients over 60 years of age. However, none of the abnormalities required transfer of a patient to a medical unit.[23]

Although general agreement exists that older psychiatric patients are at higher risk of medical disease, the exact age cutoff that would prompt routine screening is unknown. In addition, the optimal minimal screening studies required for these older patients are also not clear. There can sometimes be disagreement between EPs and psychiatrists as to what

medical workup is required, such as whether imaging, routine toxicology, thyroid function tests, or liver function testing are necessary in all older patients. The more extensive workup may help identify medical pathology that is contributing to the psychiatric disorder. However, routine, extensive testing can also contribute to cost and length of stay (LOS).

While severe lab abnormalities identified on screening tests, such as severe hyponatremia, might warrant redirection from a psychiatric service to a medical service, it is not clear how often patients determined to have an acute psychiatric illness by the EP have significant incidental lab abnormalities on their screening tests. Further work is needed to make more concrete recommendations about medical screening tests needed in older adults presenting with psychiatric symptoms in the absence of other medical symptoms or complaints that would suggest a concurrent illness requiring medical management.

Question 3: How often does noncompliance with prescribed medications contribute to ED presentations with agitation or behavioral changes?

Older adults are prescribed more medications on average than younger adults. Particularly for psychiatric medications, accidental or intentional non-compliance on the part of the patient can result in acute behavioral or psychiatric symptoms. Among schizophrenic patients, non-compliance is thought to account for approximately 40% of return visits within two years of discharge and over $2 billion in readmission costs for this population alone.[24] The scope of the problem in terms of how many visits for delirium, mental health, or acute agitation could have been prevented by improved medication compliance is not well defined. This is important to determine for several reasons. If non-compliance does account for a large percentage, then this would add evidence for the importance of a good medication history for older adults with behavioral changes. In addition, it could lend strength to interventions such as improved outpatient medication management strategies, proactive involvement of ED pharmacists, more thorough patient education about the risks of medication non-compliance, or systems to monitor medication use.

Topic Area 2: Management Strategies (Table 2)

Question 4: What is the most effective pharmacologic agent to manage acute agitation in the acute care setting?

The symptoms of patients with delirium, behavioral changes, or acute mental health crises can sometimes not be managed solely through redirection or de-escalation. At times, psychotropic medications such as anti-psychotics or benzodiazepines are needed to maintain patient or staff safety or to treat the symptoms of agitation. The most effective medications for either treatment or prevention of delirium among older ED patients have not been well studied. Studies in the inpatient and post-surgical settings have not found a benefit from anti-psychotics for prophylaxis or treatment of delirium.[25,26] Based on scant evidence, one recent expert consensus panel recommended that the underlying cause of the behavioral changes be treated first, and that medications be used as a second line, with low doses of second-generation antipsychotics being preferred in older patients only if necessary.[27,28] In ED-based research, droperidol has been found to be safe and effective,[29] but carries an FDA black-box warning about use in patients >65 years of age and is not available in many EDs. Intramuscular (IM) ziprasidone has also been studied among older adults with dementia.[30] Of note, these medications are not without risks, and all antipsychotics are listed as potentially dangerous medications by the American Geriatrics Society Beers Criteria.[31]

Table 2. Key research questions to guide efforts for improved care of older adults with behavioral changes through improved management strategies.

Question 4	What is the most effective pharmacologic agent to manage acute agitation in the acute care setting?
Question 5	Does earlier treatment with psychotropic medications decrease length of stay in the ED for elderly agitated patients and does choice of treatment matter?
Question 6	How often are older adults restrained physically or chemically in the ED, does the rate of restraint use vary with underlying psychiatric disorders, and what are the harms or benefits of their use?
Question 7	What are barriers to initiating pharmacologic treatment for acute psychiatric illness in the ED among older adults?
Question 8	Does the initiation of home-based services for patients discharged from the ED with dementia help reduce the rate of ED return visits?
Question 9	What are the necessary components of an effective decision-support tool to determine whether it is safe to start or stop psychiatric medications, and does the use of such a tool improve outcomes?

ED, emergency department.

Medications used to manage agitation may worsen other conditions, such as delirium, or cause gait instability. Efficacy must be weighed against side effects such as sedation, extra-pyramidal symptoms, and QT prolongation. The optimal dose and choice of medication for older patients will vary depending on the underlying etiology of their agitation and coexisting medical problems. The optimal medications, and their impact in terms of LOS and symptom severity and duration have not been well established.

Question 5: Does earlier treatment with psychotropic medications decrease length of stay in the ED for elderly agitated patients and does choice of treatment matter?

Decreasing LOS is also important to decrease ED crowding and potential adverse events.[32] Some authors have noted that

psychotropic medication administration may increase LOS for psychiatric patients compared to patients who do not receive medication.[33,34] A retrospective study found that use of physical or chemical restraint in patients over 65 years of age was associated with longer LOS by over 12 hours.[35] Patients requiring repeat doses of IM antipsychotics had a significantly longer LOS in the ED compared with non-repeat users of IM antipsychotics. However, patients who were initially administered oral, second-generation antipsychotics did not have longer stays in the ED even if a repeat dose was given.[36] Given the association of many psychotropic medications with delirium and their sedating side effects it is plausible that medication choice in the ED may affect disposition or even cause a delay in discharge or admission.[37] However, this has not been conclusively demonstrated in a prospective study.

Question 6: How often are older adults restrained physically or chemically in the ED; does the rate of restraint use vary with underlying known psychiatric disorders, and what are the potential harms or benefits of their use?

Approximately 10-30% of elderly patients in the ED have acute delirium,[38] and it is often under-recognized and difficult to manage.[39] There is also evidence that patients with psychiatric illness such as bipolar disorder,[40] dementia, or depression are at greater risk for delirium.[41] The use of physical or chemical restraints in the treatment of delirium has been studied in other settings such as skilled nursing facilities[42] and intensive care units,[43] and restraint prevention programs have been suggested.[44] Several studies have shown that most patients will be cooperative with an oral dosing regimen despite the belief that they may be too agitated or uncooperative.[45] An injected medication is likely to be experienced as assault rather than therapy or relief.[46]

Little work has been done to describe restraint use among older adults in the ED. The factors that predispose to restraint use, such as underlying psychiatric illness, or nature of the behavioral changes, physical strength, and other potential factors have not been defined. In addition, there are many potential risks and benefits of restraints in older adults, including potential harm to the patient with restraints, and potential patient or staff harm without restraints. Research into the outcomes of restraint use in this population would help better define the risks and benefits in order to aid providers in deciding on whether to use restraints, and which form to use.

Question 7: What are barriers to ordering pharmacologic treatment for acute psychiatric illness in the ED among older adults?

The use of any medication is more complicated among older adults due to their higher risk of adverse medication side effects or interactions with other medications. However, medications can also improve their symptom management and can generally be safely used among older adults. For example, the use of risperidone, ziprasidone, and olanzapine for treating acute agitation allows patients to follow oral maintenance treatment once the acute symptoms are ameliorated.[47] In addition, many patients take benzodiazepines or anti-psychotics on a regular basis, and failure to give them their regular, scheduled dose could lead to the emergence of symptoms of their underlying disorder or withdrawal symptoms.

There are a number of potential barriers to treating older adults with psychiatric illness in the ED, including patient factors (unwillingness to take oral medications, difficulty providing a history, severe altered mental status or agitation) and provider factors (lack of knowledge of appropriate medications, concern about side effects, or failure to obtain a detailed medication history). As a result, there may be missed opportunities for better symptom control, which could lead to worse outcomes. The treatment of agitation and aggression needs to be further refined.[48]

Question 8: Does the initiation of home-based services for patients discharged from the ED with dementia help reduce the rate of ED return visits?

With an estimated 3.8 million Americans with dementia,[49] proper treatment in the ED and on discharge from the ED is essential. Patients with dementia frequently present to the ED when they cannot be safely managed in their home environment, when they have been aggressive, have had medication complications, or have had frequent wandering and falls.[50] Home health visits or other home-based services such as physical or occupational therapy, home physician visits, meal delivery services, or medication delivery services could potentially help prevent ED visits. Home-based care programs have been found to improve independence and quality of life for patients and caregivers.[51] Patients with dementia who have presented to the ED at least once may represent a high-risk cohort who are more likely to require additional ED-based care in the future.[52] It is possible that intervening with this group could reduce future visits by improving medication compliance, health quality, and allowing medical problems to be managed at home. EDs have traditionally not been well equipped to arrange home healthcare services. However, initiating the orders for home-based services from the ED could potentially reduce ED recidivism among high utilizers.

Question 9: What are the necessary components of an effective decision-support tool to determine whether it is safe to start or stop psychiatric medications, and does the use of such a tool improve outcomes?

The initiation or discontinuation of psychiatric medications is a complex decision, requiring knowledge of appropriate indications for use of medications; which patients can safely take them given their history, comorbidities, and other medications; starting doses; which medications can be safely stopped; and

which need to be tapered. It is estimated that 60%-83% of patients are taking antipsychotics for non-U.S. Food and Drug Administration-approved conditions, with an estimated cost of $6.0 billion in 2008.[53,54] Electronic prescribing devices with decision support systems significantly reduce error rates.[55] However, such systems are costly and not widely implemented. Moreover, the use of electronic health records for decision support at the clinical level is not widely reported.

Given the complexity of the decision to start, stop, or alter the dose of psychiatric medication, physicians may benefit from decision support tools. Tools could search for interactions with other medications or provide guidance regarding indications, appropriate geriatric dosing, or the appropriate start and stop tapering time- frames. Decision support tools for this specific indication have not been well studied or widely implemented. Studies would need to show their impact and effect on clinical outcomes in order to provide support for their widespread use.

Topic Area 3: The ED Approach to Delirium (Table 3)

Question 10: What are the barriers to diagnosis of delirium in the ED, and how can they be overcome?

Delirium is common among older adults in the ED and is associated with many adverse outcomes.[56] Unfortunately, while common, it is also widely under-recognized. Some studies have reported it is missed approximately 57-83% of the time.[5] Well-validated screening tools such as the Brief Confusion Assessment Method,[5] and the Richmond Agitation Sedation Scale[57] exist and have been studied specifically in older ED patients. Despite the existence of good screening tools, recognition of delirium remains low. This may be in part due to the heterogeneity of delirium, which can variably involve hypoactive, hyperactive, or mixed states, with waxing and waning severity. It may also be due to a lack of awareness of the importance of delirium in older adults, and lack of training in the available screening tools to identify delirium in these patients.

There are a mixture of patient factors (mixed presentation, hearing impairment, cognitive deficits, prior cerebrovascular accidents), provider factors (lack of awareness, lack of time), and systems factors (perceived lack of interventions if delirium is identified) that could contribute to the low rates of diagnosis. To increase the rates of recognition and eventually the early intervention for delirium, it must first be detected by the provider, nurse, or other member of the healthcare team. Identifying the reasons for low recognition is the first step toward improving identification and outcomes for patients with delirium in the ED.

Question 11: Is ED length of stay an independent risk factor for the development of delirium?

The ED, for many reasons, is a potentially deliriogenic environment; so longer LOS could lead to the development or worsening of delirium. ED boarding and crowding are a growing and multifactorial problem nationwide that can lead to prolonged ED LOS.[58] Prior studies have shown a higher risk for delirium with ED LOS over 10 hours.[59] Delirium predicts longer inpatient LOS[60] and is an independent risk factor for six-month mortality.[61] The association between ED LOS and the development of delirium has not been widely studied enough to generalize the findings. In addition, it is important to understand what factors about a prolonged ED LOS contribute to the onset of delirium in order to develop effective strategies or policies to intervene and prevent it.

Question 12: Does ED length of stay contribute to worse morbidity and mortality or adverse medical events in older adults with delirium?

It is known that longer ED LOS are associated with longer inpatient stays.[62] In addition, delirium in older ED patients is an independent predictor of longer hospital LOS[60] and six-month mortality.[61] It is possible that longer ED LOS could cause higher rates of morbidity and mortality for delirious older patients. Older adults may have longer stays due to the need for more extensive testing, more complex disposition decisions, and the need to obtain collateral information. In addition, due to boarding and crowding, longer ED stays for all patients are becoming more common. It is therefore important to determine whether the longer stays are associated with higher rates of morbidity, mortality, or adverse events for patients with delirium.

Question 13: What are the most effective non-pharmacologic interventions in the ED to manage or prevent delirium?

Delirium occurs in about 20% of hospitalized older adults and 70-87% of older adults in the intensive care unit, and costs over $7 billion annually.[63] Preventing delirium is the most effective strategy for reducing its complications, morbidity, mortality, and cost. Many multimodal, or multidisciplinary,

Table 3. Key research questions to guide efforts for improved care of older adults with behavioral changes through improved identification and management of delirium.

Question 10	What are the barriers to diagnosis of delirium in the ED, and how can they be overcome?
Question 11	Is ED length of stay an independent risk factor for the development of delirium?
Question 12	Does ED length of stay contribute to worse morbidity and mortality or adverse medical events in older adults with delirium?
Question 13	What are the most effective non-pharmacologic interventions in the ED to manage or prevent delirium?
Question 14	Does having an ED pharmacist involved in patient care help reduce rates of delirium in the ED?

ED, emergency department.

non-pharmacologic interventions have been studied for delirium in the inpatient and post-operative settings. These may include early mobilization, fluid/electrolyte balance and hydration, frequent redirection, provision of activities, pain control, natural light during daylight hours, regulation of sleep/wake cycles, minimization of interruptions during sleep, proactive provision of hearing- and vision-aid devices, and minimization of psychoactive medications, among others.[64,65]

Protocols for reducing delirium among older ED patients have been suggested in nursing[66] and EM literature.[67] However, there have not been sufficient studies in the ED to determine and quantify what measures may reduce the rates of development of delirium among high-risk patients, improve the symptom severity of delirium, reduce the length of delirium, or reduce hospital LOS. Potential interventions would need to be feasible within the ED setting, cost effective, and easy to implement. Given the high cost as well as the long-term cognitive changes and increased mortality associated with delirium, this represents an extremely important question for the field of EM.

Question 14: Does having an ED pharmacist involved in patient care help reduce rates of delirium in the ED?

Many medications and combinations of medications commonly used in the ED can worsen or contribute to delirium in older adults. Delirium could be worsened by inappropriate medication selection or the use of doses that are too high for older adults. The involvement of ED pharmacists in patient care have been shown to help with accurate medication use and dosage, as well as improve time to appropriate treatment for time-sensitive conditions such as sepsis[68,69] and stroke.[70,71] Having an ED pharmacist review home medications for older patients in the ED with altered mental status or behavioral changes could help identify causes of delirium. In addition, an ED pharmacist review of medications and doses administered within the ED could help reduce overmedication, which can cause or prolong delirium, or dangerous medication combinations in delirious patients.

LIMITATIONS

There are several limitations to this study. First, this was not an empirical review of literature, but rather an expert consensus group, which was held in 2016. While individuals with expertise in the care of older adults in the acute care setting were integral to the discussion, there were no internal medicine-trained geriatricians in the consensus group. By the time this paper is published, it is possible studies will have been conducted that answer or speak to some of the highlighted questions raised.

Second, the group focus was narrowed to four key areas: delirium; dementia; substance use or withdrawal; and mental illness in older adults. It did not focus on the less common reasons that older adults present to the ED with acute brain dysfunction or altered mental status such as neurologic diagnosis, including stroke or intracranial hemorrhage. The group felt it was of greater impact to focus on the more common medical and psychiatric reasons older adults present to the ED with confusion or agitation.

CONCLUSION

Older adults represent a growing proportion of the population and account for a disproportionately high number of ED visits. There are numerous, multifactorial challenges that can make the screening, assessment, and management of behavioral changes more difficult compared with younger adults. Consensus building and discussion among a diverse set of stakeholders should be a priority for future research. In addition, there are significant knowledge and implementation gaps. The topics discussed here represent critical research questions to move the field forward and help emergency physicians provide better care to older adults presenting with agitation or behavioral changes.

To address these knowledge and implementation gaps, further research is needed in the key areas identified here. Successfully addressing these challenges will require research involving interprofessional teams as well as a public health perspective. Many of the solutions are beyond the scope of an individual clinician's capabilities. The solutions will require systems-based or hospital-based changes and integration with other teams, such as social work, nursing, pharmacy, and outpatient or home-based care. Because of the integrated nature of high quality care of geriatric patients, the research will also need to involve interprofessional teams to be successful.

The prioritization of research questions in the area of geriatric behavioral health emergencies will help guide future research to solutions that have the potential to improve the care of older adults presenting to EDs with behavioral changes.

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A Research Agenda for Assessment and Management of Psychosis in Emergency Department Patients

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Introduction: Emergency departments (ED) manage a wide variety of critical medical presentations. Traumatic, neurologic, and cardiac crises are among the most prevalent types of emergencies treated in an ED setting. The high volume of presentations has led to collaborative partnerships in research and process development between experts in emergency medicine (EM) and other disciplines. While psychosis is a medical emergency frequently treated in the ED, there remains a paucity of evidence-based literature highlighting best practices for management of psychotic presentations in the ED. In the absence of collaborative research, development of best practice guidelines cannot begin. A working group convened to develop a set of high-priority research questions to address the knowledge gaps in the care of psychotic patients in the ED. This article is the product of a subgroup considering "Special Populations: Psychotic Spectrum Disorders," from the 2016 Coalition on Psychiatric Emergencies first Research Consensus Conference on Acute Mental Illness.

Methods: Participants were identified with expertise in psychosis from EM, emergency psychiatry, emergency psychology, clinical research, governmental agencies, and patient advocacy groups. Background literature reviews were performed prior to the in-person meeting. A nominal group technique was employed to develop group consensus on the highest priority research gaps. Following the nominal group technique, input was solicited from all participants during the meeting, questions were iteratively focused and revised, voted on, and then ranked by importance.

Results: The group developed 28 separate questions. After clarification and voting, the group identified six high-priority research areas. These questions signify the perceived gaps in psychosis research in emergency settings. Questions were further grouped into two topic areas: screening and identification; and intervention and management strategies.

Conclusion: While psychosis has become a more common presentation in the ED, standardized screening, intervention, and outcome measurement for psychosis has not moved beyond attention to agitation management. As improved outpatient-intervention protocols are developed for treatment of psychosis, it is imperative that parallel protocols are developed for delivery in the ED setting. [West J Emerg Med.2019;20(2)403-408.]

INTRODUCTION

Psychosis is an important clinical problem, not only for patients but for families and healthcare workers as well. Patients with mental disorders represent an increasing fraction of total presentations to emergency departments (ED) over time. In 2014, mental disorders were the 10th leading cause of United States ED visits for males aged 15-65 years, and mental disorders were the primary ED diagnosis in slightly over five million ED visits.[1] Thus, development of better management approaches to assess and treat psychosis has become critical. With other high volume/high risk medical emergencies – traumatic injuries, cerebrovascular accidents, cardiac arrhythmias – emergency medicine (EM) has been able to partner with other medical specialties to jointly research and develop best practice care. However, translation of best practice care of psychosis specific to an emergency setting has yet to occur.

Mounting evidence suggests early intervention predicts improved outcomes in younger, first-episode psychotic patients. Yet to our knowledge, no evidence-based interventions linking first-episode psychotic ED patients into specialized treatment have been tested. This deficit highlights the collaborative treatment chasm between mental health and ED specialty fields. Appropriate recognition, categorization and management of psychosis should be a key element of comprehensive emergency care; achieving these goals can be done through improved mental health and emergency care collaboration. The goal of this research consensus workgroup was to explore and enumerate the current knowledge gaps for the care of psychosis specifically in an emergency setting.

METHODS

Participants from a variety of disciplines – EM, emergency psychiatry, emergency psychology, clinical research, governmental agencies, and patient advocacy groups – were invited to participate in a research consensus session held prior to a joint emergency-psychiatry conference (the 7th Annual National Update on Behavioral Emergencies). Background literature reviews were performed prior to the in-person meeting. Literature reviews were conducted via journal review, academic databases and web-based searches. Searches fell within the scope of the priority domain identified by the Coalition on Psychiatric Emergencies (CPE) steering committee: acute psychosis. The workgroup leaders identified articles of importance and circulated them electronically to the group for review in advance of the in-person meeting. A nominal group technique[2] was employed to develop group consensus on the highest priority research gaps. Following the nominal group technique, input was solicited from all participants during the meeting, questions were iteratively focused and revised, voted on, and then ranked by importance. Following the in-person meeting, the workgroup developed additional consensus and worked electronically to further refine the final form of each question. Please see the Executive Summary for the full methods (Appendix).

RESULTS

The group consisted of three emergency psychiatrists, an emergency psychologist, an emergency physician, clinical researcher and participant from a professional medical association. The average age of the participants was approximately 40 years old and included five females and two males. The group developed 28 separate questions. After clarification and voting, the group identified six high-priority research areas. Questions were further grouped into two topic areas: screening and identification; and intervention and management strategies. The questions organized by topic, are included in Table 1 and 2.

Table 1. Key research questions to guide efforts for individuals with psychosis through screening and identification.

Question 1	Can a research-based triage tool be developed to assess psychosis in ED patients?
Question 2	What outcomes are meaningful for patients/ families when assessing the effectiveness of psychosis interventions?

ED, emergency department.

Table 2. Key research questions to guide efforts for effective intervention and management of the patient with acute psychosis.

Question 3	What is the recommended treatment for psychosis in the emergency setting?
Question 4	What affects emergency provider decision-making in treatment choice for psychosis?
Question 5	What system outcomes can be affected by early treatment of psychosis in emergency settings - both within the emergency care setting and thereafter?
Question 6	Are there appropriate care locations for psychotic patient presentations instead of the ED?

ED, emergency department.

DISCUSSION

This discussion highlights current knowledge gaps and rationale as to why improved patient care processes cannot be implemented until this research is conducted.

Question 1: Can a research-based triage tool be developed to assess psychosis in ED patients?

Psychosis is a symptom rather than a definitive diagnosis, and it is a continuous rather than a categorical phenomenon. At one extreme, patients can be quietly delusional and at risk of self-harm and at the other extreme, paranoid with poor reality testing posing an extreme and immediate risk to ED staff and

other patients. While rating scales for psychosis such as the Brief Psychiatric Rating Scale have been employed for over 50 years and assess several domains of psychosis, they have not been incorporated into ED care.[3] The ED-based scales that have been developed and normed tend to focus primarily on agitation as the primary outcome and not on the variety of psychosis symptoms.

Tools assessing positive and negative domains of psychosis have not been standardized as valid or reliable within an ED setting.[4] This deficit has led to a misunderstanding of the true incidence and prevalence of psychosis presentations in EDs. Without better, clearer definitions, ED and mental health providers will continue to have a chasm in care. Articulation of a more refined definition of psychosis that is measurable, relevant to ED care, understandable to ED providers, and captures the most salient symptoms of psychosis should be a high priority on any research agenda to ensure that both mental health and emergency providers are sharing a common language. Creation of such tools can then guide goal-directed treatment strategies within the ED.

An additional difficulty with psychosis presentations to an ED is the heterogeneous etiologies that can produce episodes of psychoses. Psychotic presentations are not all related to underlying mental illness (e.g., postictal states, metabolic derangements, substance intoxication/withdrawal, etc.). Because of this, there is a need to employ organized evaluations of psychosis. Using standardized algorithms would improve correct etiology identification and lead to proper treatment choices. For example, up to half of patients presenting to psychiatric EDs have concurrent substance use disorder. Schanzer et al. found ED clinicians inaccurately ascribed first presentations of psychosis to primary psychiatric disorders instead of substance misuse in one quarter of patients evaluated.[5] This type of inaccurate diagnosing creates missed opportunities for chemical dependency interventions and leads to referral of patients to the wrong levels of care. Standardized ED medical evaluation algorithms for psychosis have been published in academic literature and adopted in several states, which help ED staff detect primary psychotic disorders from medical mimics.[6-11] Without universal adaptation of medical evaluation protocols for psychotic presentations, there is a continued risk of misidentifying mental health etiology from medical etiology, leading to inappropriate or missed interventions.

Question 2: What outcomes are meaningful for patients/families when assessing the effectiveness of psychosis interventions?

At present, literature regarding emergent psychosis intervention has predominantly focused on management of agitation.[12-15] First- or second-generation antipsychotic medication interventions have measured outcomes such as achieving calm behavior[16] or decreasing need for additional medications.[15,17] These measures neglect the vast spectrum of distressing, patient-level experiences of psychosis such as delusional thought content, sensory hallucinations, and negative affective states. While agitation can be a symptom of psychosis, agitation is not a pathognomonic symptom for psychosis; thus, efficacy of psychosis interventions must be broadened. While it is possible there is a direct link between treatment of agitation and alleviation of patient symptoms, further research in this field is needed. Because the bulk of literature has focused on management of agitation, it is not well known what the most important outcomes are for psychosis intervention in the ED according to patients and families. The effects of emergency intervention care choices relative to patient/family satisfaction, patient quality of life, patient course of illness, future patient/family crisis help seeking, etc., is also largely unknown. Additional patient- and family-centered studies in this area are necessary.

Question 3: What is the recommended treatment for psychosis in the emergency setting?

There is mounting evidence that early and aggressive intervention for first-episode psychosis (FEP) related to schizophrenia makes a significant impact on longer term outcomes.[18] Since many patients with FEP present initially to the ED rather than to mental health treatment settings, opportunities to link patients into care are dependent upon the knowledge base of the ED providers. As compared to other medical disorders treated in the emergency setting, there is a significant deficit in best practice interventions for first, or subsequent, episodes of psychosis. At least one randomized, controlled trial demonstrated the superiority of outpatient, multimodal treatment strategies for FEP as compared to treatment as usual,[19] but how similar interventions can be developed for an emergency setting is unclear. More specifically, while recommendations for psychosis treatment are available in psychiatric literature, no studies have yet standardized the education and engagement of these non-ED best practice recommendations such as medication management, family psychoeducation, social skills training, and supported employment/education programs, into emergency care protocols.[19,20] Therefore, it is not known if rapid linkage to specialized outpatient treatment can improve outcomes.

It could be argued that the lack of standardized algorithms for new onset psychosis care as compared to interventions for other newly diagnosed disease states, such as diabetes, represents both a healthcare disparity in how mental illness is managed and a chasm in collaborative care between emergency and mental health researchers. As programs for earlier identification and intervention (i.e., prodromal presentations) are implemented nationally and internationally, it is not well defined as to how emergency providers will receive education and training to identify individuals at risk and provide recommended care.[21] In addition to management of FEP, it is unclear what best practice emergency guidelines are for psychosis decompensation along the life course of the illness. It is not known if psychotic presentations in the first three years of an illness should be

targeted and treated differently than in later years.

Aside from medication strategies, little research has been conducted investigating non-pharmacologic interventions for psychosis in the ED. Psychotic patients in the ED have a wide variety of behavioral presentations, often with subtle but important variations. For example, agitated patients may self-present seeking appropriate and effective medication for their condition, or they may be brought in involuntarily because of resistance to treatment, hostility, paranoia, and physical aggression. Often the literature on psychotic agitation does not distinguish between these two presentations and focuses on selecting an appropriate medication and route of medication for agitation. However, the importance of engagement, collaboration and, specifically, the art of engaging the individual around medication is key.[22]

Psychiatric emergency service (PES) practitioners note a significant reduction in outcomes such as decreased use of restraint and seclusion, as well as increased safety to both staff and patient, when the attempt to form a therapeutic alliance is prioritized.[23] PES refers to specialized psychiatric crisis response centers and are not housed within EDs, generally managed by psychiatrically trained staff. ED providers may not receive the same training on building therapeutic alliances with patients as compared to mental health practitioners. It is unclear if providing increased education to ED providers on enhancing patient alliance could lead to improved ED patient engagement, as these types of outcome studies have not been conducted.

Question 4: What affects emergency provider decision-making in treatment choice for psychosis?

In a recent longitudinal review, Bessaha's group highlighted the lack of standardized clinical protocols when they examined disposition decisions for psychotic illness presentations.[24] There were significant differences in hospitalization rates dependent upon non-clinical factors such as race, gender, and geographic location, although why these differences exist is unknown. How patients present to emergency settings, what resources are available to them, the level of emergency provider training in behavioral health assessment, and familiarity with psychopharmacology principles all may ultimately contribute to the disposition decision-making of the emergency provider. It is not understood how the interplay between patient severity level and non-patient factors combines to determine treatment decisions. It is unclear if these decisions are efficacious in illness management.

Question 5: What system outcomes can be affected by early treatment of psychosis in emergency settings – both within emergency care settings and thereafter?

While earlier questions focused on patient-centered outcomes, it is not known if evidenced-based care can positively affect system-level outcomes such as ED throughput. Nationally, there is recognition that patients with mental health complaints have longer ED lengths of stay (LOS) than those presenting without mental health complaints.[25] More specifically, patients who present in mental health crisis and who have a diagnosis of psychosis have longer ED LOS than patients without mental health complaints.[16,26] At present, knowledge gaps exist in how often a patient receives an intradepartmental intervention, how early into an emergency presentation patients receive treatment, and whether earlier intradepartmental interventions can make a difference in disposition choices. These metrics are not monitored in the same way EDs deliver interventions such as early goal-directed treatment of sepsis, time to cardiac catheterization, or door to needle time for cerebrovascular accidents. Creating evidenced-based guidelines and metrics for acute mental illness should mimic acute medical disorder protocols. Because we do not have a standard, goal-directed psychosis treatment algorithm, it is unclear if early treatment can affect ED throughput, subsequent inpatient psychiatric LOS, or safety outcomes (i.e., use of restraints/seclusion or patient/family/provider injury).

Question 6: Are there appropriate care locations for psychotic patient presentations instead of the ED?

With increasing alternative models of care – specifically PES – it is not fully known how these settings can contribute to better patient or system outcomes. Mental health systems of care do not have standardized formulas on which to base decisions about developing new facilities, and PES are not all developed and accessed in the same way. How PES care enhances psychosis management differently than general ED care as it relates to patient- and system-level outcomes is unknown. For example, in comparing PES services with general EDs, which site provides more consistent psychosis interventions, which site is better able to serve first-onset psychosis vs safety net concerns such as medication refills; which site works better with non-mental health professionals (such as emergency medical services, or police)? Additional research is needed to compare and contrast psychosis outcomes between these differing models of care.

LIMITATIONS

There are several limitations to this study. First, this was not an empirical literature review, but rather an expert group of research clinicians and others who engaged in a nominal group technique to come to a consensus on setting future research priorities for the management of psychosis in the ED based on the knowledge of the current gaps in existing literature. Due to the lack of existing literature on psychosis management in the ED, the two articles sent for review prior to the conference focused on early interventions for psychosis in the community setting.[19,21] By the time this paper is published, it is possible studies may have been conducted that focus on the gaps in knowledge outlined through this research consensus conference. An additional limitation includes use of the nominal group technique, as it is different from large literature reviews/meta-analytic studies, which highlight what is known. This meeting

and subsequent discussion focused on gaps in literature in order to set a future research agenda focused on psychosis management in the ED. Discussing what does not exist vs what is known could be perceived as a limitation. Our hope is that in highlighting what is missing from current literature, we can help shape research agendas moving forward.

Another limitation was in the psychosis workgroup selection. While the group engaged a variety of practitioners from emergency settings, it was limited to emergency specialists. One could argue that the inclusion of important stakeholders, such as inpatient psychiatric clinicians, could have provided additional perspectives on what areas are of highest priority to explore. Lastly, the group focus was narrowed to primary psychosis and did not include psychotic presentations due to substance intoxication/withdrawal or medical etiologies. We excluded substance-related psychosis presentations because we knew that a different group at this conference, which focused on substance-related presentations, was performing an identical critical review. Identification of psychotic presentations due to underlying medical problems has been extensively discussed in the literature in the context of the ongoing medical clearance work. The group felt it was of greater impact to focus on primary psychotic illness management, which has not had the same type of attention and focus in the research literature.

CONCLUSION

EDs are increasingly expected to provide interventions for acute psychosis, both for first episodes of psychosis or during exacerbations of chronic illness, yet there are no current, evidence-based protocols for treatment of psychosis care. Addressing the identified research questions would serve as first steps in developing standardized algorithms for psychosis care and improving treatment in the ED setting.

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Best Practices for Evaluation and Treatment of Agitated Children and Adolescents (BETA) in the Emergency Department: Consensus Statement of the American Association for Emergency Psychiatry

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Introduction: Agitation in children and adolescents in the emergency department (ED) can be dangerous and distressing for patients, family and staff. We present consensus guidelines for management of agitation among pediatric patients in the ED, including non-pharmacologic methods and the use of immediate and as-needed medications.

Methods: Using the Delphi method of consensus, a workgroup comprised of 17 experts in emergency child and adolescent psychiatry and psychopharmacology from the the American Association for Emergency Psychiatry and the American Academy of Child and Adolescent Psychiatry Emergency Child Psychiatry Committee sought to create consensus guidelines for the management of acute agitation in children and adolescents in the ED.

Results: Consensus found that there should be a multimodal approach to managing agitation in the ED, and that etiology of agitation should drive choice of treatment. We describe general and specific recommendations for medication use.

Conclusion: These guidelines describing child and adolescent psychiatry expert consensus for the management of agitation in the ED may be of use to pediatricians and emergency physicians who are without immediate access to psychiatry consultation. [West J Emerg Med. 2019;20(2)409–418.]

INTRODUCTION

Background

Agitation and aggression in children and adolescents in the emergency department (ED) can be dangerous and distressing for patients, families and staff.[1] Agitation and aggression can disrupt care, cause injury, or necessitate use of physical restraint. Of youth presenting to the ED for psychiatric care, 6-10% require restraint.[2-3] At least 30 children in the United States (U.S.) have died in restraint-related incidents, which has led to regulations limiting the use

of restraint to emergencies where least restrictive options have been exhausted.[4-5] There is little guidance or standardization toward use of less restrictive options, especially medications, to manage agitation and avoid restraint.

There are no randomized controlled trials, expert consensus guidelines, or comparative studies of medication efficacy or safety in the ED setting. A survey of emergency physicians (EP) regarding pro re nata (as needed) (hereafter referred to as STAT/PRN) medications commonly used for agitation, and review papers providing recommendations for medication use, all emphasize use of first- and second-generation neuroleptics, benzodiazepines, and mood stabilizers.[2,6-9] These are largely inspired by consensus guidelines for treatment of agitated adults or pediatric outpatients with chronic aggression.[10-12] Symptoms and triggers that underlie agitation in the ED may be different from those that underlie chronic aggression among outpatients.[13]

A small number of studies have examined the use of STAT/PRN medications for acute agitation in psychiatrically hospitalized youth. There is only one randomized, placebo-controlled study of STAT/PRN medication for acute agitation, which found no difference between diphenhydramine vs placebo.[14] Intramuscular (IM) administration (of either diphenhydramine or placebo) was significantly more effective than by mouth (PO) administration. A retrospective study of STAT/PRN medications in 49 psychiatrically hospitalized youth reported antihistamines were used most commonly, followed by neuroleptics and sedative-hypnotics.[15] Only 32% of all PRNs were clearly effective on chart review. Benzodiazepines and neuroleptics were equally efficacious, and IM administration was significantly more effective than PO administration across medication classes.

A retrospective study of STAT/PRN medications among psychiatrically hospitalized youth found that olanzapine was more likely than lorazepam or chlorpromazine to produce a "settling effect" within 30 minutes or less; all were generally well tolerated, although the authors noted that a small number of youth experienced paradoxical agitation with lorazepam.[16] Two case-controlled, retrospective, chart-review studies have assessed the relative efficacy of IM ziprasidone, compared to other IM neuroleptics, in psychiatrically hospitalized adolescents. The first compared IM ziprasidone to IM olanzapine; there was no significant difference in efficacy, although ziprasidone subjects received significantly more emergency medications.[17] A second compared the combination of IM haloperidol with IM lorazepam and IM ziprasidone. There was no significant difference found in restraint duration, use of STAT/PRN medications, or vital sign changes.[18]

Population Health Research Capsule

What do we already know about this issue?
Pediatric agitation in the emergency department (ED) is both prevalent and challenging with no existing standard, despite the need for careful multidisciplinary evaluation and management.

What was the research question?
Can an evidence-based, consensus guideline be developed for the management of pediatric agitation in the ED?

What was the major finding of the study?
Evidence-based, expert consensus guidelines for management were developed including etiology-driven treatment strategies.

How does this improve population health?
Standardizing pediatric agitation management in the ED supports consistent and evidence-based care for patients and staff at risk for injury and negative outcomes.

Importance

These studies have limited generalizability to STAT/PRN use of these medications for acute agitation or aggression in ED settings. Without evidence-based or expert consensus guidelines to direct decision-making, physicians in the ED setting typically use medications with which they are most comfortable, although these may not be the most effective or safest choice with significant variance in practice.[2,6]

Goals of Investigation

We aim to present consensus guidelines for management of agitation among pediatric patients in the ED, including use of STAT (for immediate administration) or STAT/PRN medications, in follow up to the Consensus Statement of the American Association for Emergency Psychiatry (AAEP) Project BETA Psychopharmacology Workgroup guidelines for agitation in adults.[10]

METHODS

Study Design and Setting

Given the dearth of child psychiatrists in the U.S., this workgroup focused on the consensus of a group of experts in this subspecialty. The workgroup was assembled from experts in emergency child and adolescent psychiatry and psychopharmacology from the AAEP, the American Academy of Child and Adolescent Psychiatry (AACAP) Emergency Child Psychiatry Committee, and peer recommendation. Sixteen experts participated, all board certified in child and

adolescent psychiatry with some additionally board certified in pediatrics. The experts represented 14 hospitals in eight states.

Interventions

The non-voting project chair (RG) facilitated discussion, information gathering, and consensus building. Consensus was obtained using consensus development methodology, specifically the Delphi method, which was developed to obtain reliable opinion consensus and avoid bias.[19-20] Per the Delphi method, opinions were elicited from the experts through a series of emailed questionnaires and structured solicitation of feedback. There were six rounds of questionnaires and feedback in total, starting with determining the structure of the guidelines (by age/weight, medication class, severity or etiology of agitation), and then narrowing progressively to choose the assessment strategies, etiologic categories, medications, doses, and cautions noted below. In the first of these rounds of questionnaires, experts assessed the standardized review of the existing literature on management of agitation summarized above, as well as published and unpublished guidelines and protocols used by EDs across the country (solicited through AAEP, AACAP, and outreach to several EDs and experts in the field). All opinions were anonymized and aggregated by the project chair to avoid direct confrontation between experts and prevent bias. This manuscript also underwent two rounds of workgroup feedback.

RESULTS

The following summarizes the consensus recommendations for the evaluation and pharmacological management of agitation among pediatric patients in the ED.

Multimodal Approach

There is consensus that management of agitation in the ED should be individualized, multidisciplinary, and collaborative. Medication should serve as one part of a comprehensive strategy to address the behavior. Clinicians should attempt to understand the etiologic factors leading to agitation, use non-pharmacologic de-escalation strategies, and choose medication based on the patient's specific needs and history. For example, consider a child with autism who is brought to the ED for aggression triggered by anxiety, who then becomes agitated and attempts to flee the ED due to hunger and sensitivity to fluorescent lights. Effective treatment requires addressing his anxiety (considering non-pharmacologic and pharmacologic interventions), hunger, and sensory needs. In many cases, addressing etiologic factors proactively and non-pharmacologically can obviate or completely eliminate the need for pharmacologic management.

Etiology Drives Choice of Treatment

There is consensus that, whenever possible, the etiology of agitation should be ascertained and all treatments targeted to the root causes of the agitation. Diagnostic assessment occurs in parallel with symptomatic management. Collateral information, response to non-pharmacologic interventions, mental status and change in symptoms over time inform this ongoing assessment. While standardized scales are often used in adult settings, there are few broadly used, evidence-based tools for pediatric agitation; thus, thoughtful clinical assessment is imperative. Cross-disciplinary collaboration and communication is also key to identifying potential causes of agitation. The bedside nurse is uniquely suited to notice changes in the patient's mental status or behavior, implement non-pharmacologic strategies early, and quickly engage crisis services. Family members provide a crucial premorbid developmental and behavioral baseline of their child and may help elucidate the cause of agitation.

The assessment of etiology starts with asking why the child has become agitated now and here, considering antecedents such as environmental or interpersonal triggers, as well as internal stressors such as pain or acute psychiatric symptoms. Psychiatric history, medication review, including any potential for toxic ingestion (intentional or accidental), allergies, past medical history, developmental history and a focused social and family history, including trauma history, should also be obtained.[21]

Medical evaluation of agitated patients is critical, although completing a full physical examination and any indicated laboratory/imaging studies may be challenging during acute agitation. If the etiology of agitation is unknown or mixed, there is consensus that the clinician should use best clinical judgment and provide symptomatic management based on available diagnostic and clinical information. The clinician should continuously reevaluate the differential diagnosis, observing response to intervention closely, and adjust diagnostic assessment and management accordingly.

Differential Diagnosis

Agitation is a symptom, like pain, with many potential etiologies and often multiple factors contributing in the moment. The potential etiologies for acute agitation among youth in the ED includes physical disease (such as pain, delirium, intoxication and catatonia), anxiety, developmental and cognitive disabilities, behavioral disorders, trauma, mania, psychosis, sensory or physical limitations, and difficulty communicating needs. Even if a child has a known history of psychiatric or developmental disorders, comorbid physical disease, anxiety or other acute triggers should still be ruled out and a broad differential maintained. Non-pharmacologic approaches used for de-escalation should be employed early with a preventative, proactive approach.

Non-pharmacologic Management

There is consensus that non-pharmacologic approaches should be used to prevent and de-escalate agitation before pharmacologic measures are considered. A multidisciplinary approach allows primary and secondary prevention strategies.

Primary prevention includes changes to the ED environment to make youth more comfortable, clear communication to reduce anxiety, and effective assessment and treatment of pain and other acute physical symptoms. Secondary prevention includes modifications for youth identified to be at baseline elevated risk for agitation or for youth beginning to show signs of agitation. Family members may identify calming strategies that have been effective in the past, which may contribute to crisis and behavioral planning. An agitated child should be moved away from other patients to a calming, safe area without access to sharps and dangerous objects.[21]

Even if a youth in the ED is becoming highly agitated, simple non-pharmacologic de-escalation strategies can be effective and should always be attempted before, with, and after pharmacotherapy. Communicating in a neutral yet empathic tone, communicating at the patient's eye level, and using clear, concrete and simple language (or visual communication tools for youth with developmental disabilities) are helpful. Reunification with (or separation from) family members, food, drink, distraction, preferred comfort items from home, or sensory coping kits can ease tension. Firm limits on unacceptable behaviors and specific praise for adherence to requests and de-escalation mold behavior while also modeling for families how to parent in the face of disruptive behaviors. Reflective statements and validation help youth who struggle with articulating complex emotions feel understood, while clarifying triggers for agitation and promoting problem-solving.

Rationale for Medication Use

The goal of pharmacotherapy is twofold: 1) target the underlying cause of distress; and 2) calm the patient sufficiently for rapid assessment and treatment.

While medication for agitation is often considered when non-pharmacologic interventions have "failed," pharmacologic and non-pharmacologic strategies should be used in concert with non-pharmacologic de-escalation efforts continuing during and after medication administration. When medication is used, it should be calming but not excessively sedating, as a youth who is asleep cannot be evaluated, participate in care, or leave the ED. Medication should be chosen for its calming effect but also to address the underlying etiology of the youth's distress, so no one medication will be appropriate for all patients or all types of agitation.

General Recommendations Regarding Medication Use (Table 1, Table 2)

A current medication list and medication history (including prior STAT/PRN medication use) helps to avoid drug interactions and adverse drug events (ADEs) and inform medication choice and dosing. Often a half dose or extra dose of a home medication can ameliorate escalating agitation. There is neither firm evidence nor consensus to support the use of one medication or even class of medication for all patients. Risks of ADEs should be weighed against potential benefit, while considering patient age, weight, medical comorbidity, and development when choosing a medication. There is consensus that PO administration should be tried whenever possible before the IM route. If intravenous access is already in place and safely accessible, this is preferred to IM administration. Neuroleptics should be used judiciously, only when truly indicated, and with appropriate monitoring, given potential adverse effects, particularly extrapyramidal adverse effects. Response to any intervention should be observed and documented closely.

Diphenhydramine, benzodiazepines, and alpha-2 agonists are generally calming and can also provide symptom-focused treatment. Diphenhydramine, with a more benign ADE profile and greater familiarity among families and medical providers, should be considered for younger children, youth with mild to moderate anxiety, youth with severe anxiety not secondary to delirium, intoxication, or withdrawal, and youth with mild agitation and no clear psychiatric or significant physical health history. Diphenhydramine and benzodiazepines should be avoided in delirium or in children where there is history of, or concern for, paradoxical disinhibition. Alpha-2 agonists can also provide symptomatic management of anxiety, hyperactivity, and hyperarousal, although these medications require blood pressure monitoring.[22]

Neuroleptics can be considered for most causes of severe agitation. Total daily dose should be monitored closely. Olanzapine can potentially be more sedating than haloperidol or risperidone and has less risk for cardiac adverse events or extrapyramidal symptoms. Given the risk of respiratory suppression if given concomitantly with benzodiazepines, olanzapine and benzodiazepines should not be administered parenterally within one hour of each other.[23] Despite the studies noted above of PRN ziprasidone for agitation in psychiatric inpatients, there is consensus that ziprasidone is not recommended due to its activating potential, QT prolongation risk, and need for concomitant food intake when administered PO.

There is consensus that if an initial dose of medication was ineffective, a second dose of the same medication is preferable to adding multiple different medications (unless limited by ADE), as children can be vulnerable to drug-interaction adverse effects. An exception to this was combining haloperidol and lorazepam, which was generally considered preferable to a second dose of a neuroleptic in non-delirious patients. The etiology of agitation should be reassessed continuously, especially after two doses of a particular medication, and youth who have received multiple doses should be monitored continuously. Total daily dose or not to exceed instructions should be written and cumulative doses monitored, lest akathisia, delirium, and iatrogenic syndromes such as neuroleptic malignant syndrome be misperceived as worsening agitation.

There is consensus that ketamine and barbiturates are

Table 1. Considerations when selecting a psychotropic for acute agitation management.

Medication factors
Formulas available
Onset and duration of action
Presence or absence of active metabolites
Interactions with other medications the patient has received in the ED or takes at home
Metabolism and exrcetion
Potential side effects or other drug effects that may be advantageous
Patient factors
Etiology or etiologies of agitation
Routes of administration available (PO, IV, IM, NGT)
GI function
Nutritional status and physical size
Hepatic function
Renal function
Other co-morbid physical health concerns
Desired response or effect on patient
Previous experience with psychotropics
Response to non-pharmacologic de-escalation strategies
Patient preference
Family expectation and family preference
System factors
Training and experience with non-pharmacologic approaches to agitation management and with use of different medications for agitation
Comfort of other work providers with use, monitorind and management of a given medication
Availability of monitoring practices within the care setting and hospital system

ED, emergency department; *PO*, by mouth; *IV*, intravenous; *GI*, gastrointestinal; *IM*; intramuscular; *NGT*, nasogastric tube.

not recommended for treatment of agitation and that opioid analgesics should not be used for agitation unless for pain control.

Specific Guidelines for Medication Use (Figure)

Below are the consensus medication regimens for the five most common etiologies of agitation: delirium; substance intoxication/withdrawal; developmental disability-related; psychiatric diagnosis; and unknown ctiology. Youth may present with agitation of mixed etiology, for example an adolescent with bipolar disorder who presents intoxicated, or a child with autism spectrum disorder who is delirious secondary to medical illness. In such complex cases, the ED clinician should use his or her best judgment in assessing the relative contribution of each etiologic factor to the presentation and strongly consider consulting child and adolescent psychiatry or other pediatric subspecialists for assistance.

Agitation Due to Delirium

Delirium is a complex clinical syndrome in which underlying physical disease, pharmacologic factors or both cause acute onset of mental status change with fluctuating course, involving symptoms of inattention, altered level of awareness and other cognitive deficits.[24] Management of delirium requires identification and treatment of underlying etiologies. The initial approach should include reduction or discontinuation of medications that may be causing or exacerbating delirium. Pain should be treated while avoiding over-sedation and limiting exposure to opioid analgesia, which can worsen delirium. Medications may be needed to address underlying etiologies potentiating delirium, support sleep, and ameliorate physical symptoms such as pain or nausea. Medication for agitation can be necessary for safety, as well as avoiding medications that may worsen confusion or behavior in the setting of delirium, namely anticholinergics, benzodiazepines, and opioid analgesics.

Neuroleptics are the most commonly used pharmacologic intervention for delirium. Second-generation neuroleptics such as risperidone, olanzapine, and quetiapine have eclipsed haloperidol as the first-line agents.[25-27] Choice of neuroleptic should account for the patient's particular needs including route of administration, time to effect, potential side effects, illness factors, patient past experience with neuroleptics, and the specific symptoms of delirium

Table 2. Medication reference.

Medication	Dose	Peak effect	Max daily dose	Notes/monitoring
Diphenhydramine (antihistaminic)	PO/IM: 12.5-50mg 1 mg/kg/dose	PO: 2 hours	Child: 50-100 mg Adolescent: 100-200 mg	Avoid in delirium. Can be combined with haloperidol or chlorpromazine if concerns for EPS. Can cause disinhibition or delirium in younger or DD youth.
Lorazepam (benzodiazepine)	PO/IM/IV/NGT: 0.5 mg-2 mg 0.05 mg-0.1 mg/kg/dose	IV: 10 minutes PO/IM: 1-2 hours	Child: 4 mg Adolescent: 6-8 mg Depending on weight/proir medication exposure	Can cause disinhibition or delirium in younger or DD youth. Can be given with haloperidol, chlorpromazine or risperidone. Do not give with olanzapine (especially IM due to risk of respiratory suppression.
Clonidine (alpha2 agonist)	PO: 0.05 mg-0.1 mg	PO: 30-60 minutes	27-40.5 kg: 0.2 mg/day 40.5-45 kg: 0.3 mg/day >45 kg: 0.4mg/day	Monitor for hypotension and bradycardia. Avaoid giving with BZD or atypicals due to hypotension risk.
Chlorpromazine (antipsychotic)	PO/IM: 12.5-60 mg (IM should be half PO dose) 0.55 mg/kg/dose	PO: 30-60 minutes IM: 15 minutes	Child <5 years: 40mg/day Child >5 years: 75mg/day	Monitor hypotension. Monitor for QT prolongation.
Haloperidol (antipsychotic)	PO/IM: 0.5 mg-5 mg (IM should be half a dose of PO) 0.55 mg/kg/dose	PO: 2 hours IM: 20 minutes	15-40 kg: 6mg >40 kg: 15 mg Depending on prior antipsychotic exposure	Monitor hypotension. Consider EKG or cardiac monitoring for QT prolongation, especially for IV administration. Note EPS risk with MDD > 3mg/day, with IV dosing having very high EPS risk. Consider AIMS testing.
Olanzapine (antipsychotic)	PO/ODT or IM: 2.5-10 mg (IM should be half or 1/4 dose of PO)	PO: 5 hours (range 1-8 hours) IM: 15-45 minutes	10-20 mg Depending on antipsychotic exposure	Do not give with or within 1 hour of any BZD given risk for respiratory suppresion
Risperidone (antipsychotic)	PO/ODT: 0.25-1mg 0.005-0.01mg/kg/dose	PO: 1 hour	Child: 1-2 mg Adolescent: 2-3 mg Depending on antipsychotic exposure	Can cause akathisia (restlessness/agitaion) in higher doses.
Quetiapine (antipsychotic)	PO: 25-50 mg 1-1.5 mg/kg/dose (or divided)	PO: 30 minutes-2 hours	>10 years: 600 mg Depending on prior antipsychotic exposure	More sedating at lower doses Monitor hypotension.

PO, by mouth; *IM*, intramuscular; *IV*, intravenous; *NGT*, nasogastric tube; *mg*, milligram; *EPS*, extrapyramidal symptoms; *DD*, developmental disability; mg/kg, milligrams per kilogram; *BZD*, benzodiazepines; *EKG*, electrocardiogram; *AIMS*, Abnormal Involuntary Movement Scale; *MDD*, major depressive disorder; *ODT*, orally dissolving tablet.

Figure. Clinical decision flow chart.
PO, by mouth; *IM*, intramuscular; *IV*, intravenous; *NGT*, nasogastric tube; *EtOH*, ethanol; *Utox*, urine toxicology; *PCP*, phencyclidine; *EPS*, extrapyramidal symptoms; *ASD*, autism spectrum disorder; *DD*, developmental disability; *BZD*, benzodiazepines; *ODT*, orally dissolving tablet; *PTSD*, post-traumatic stress disorder; *ADHD*, attention deficit hyperactivity disorder; *ODD*, oppositional defiant disorder; *CD*, conduct disorder; *pt*, patient.
*For these etiologies, in absence of consensus, medication options are listed alphabetically; ☢ Do not give olanzapine and benzodiazepines within one hour of each other.

being targeted. Clonidine may be used if there is reason to avoid neuroleptics. Melatonin may be helpful for sleep regulation if this is contributing to agitation.

Agitation Due to Substance Intoxication or Withdrawal

In cases of known or suspected substance intoxication or withdrawal, medication choice should be dictated by clinical presentation and the suspected substances. If urine toxicology is indicated, and the results are negative, newer synthetic drugs, such as synthetic cannabinoids and cathinones, should be suspected. Gas chromatography and mass spectrometry, where available, can also help to identify an ingestion. If the substance ingested is unknown, there is consensus that lorazepam should be used, and potentially combined with haloperidol if the patient is severely agitated or hallucinating.

Agitation in a Patient with Developmental Delay or Autism Spectrum Disorder

Youth with autism or developmental disabilities can be particularly vulnerable to ADEs from many of the medications commonly used to treat acute agitation, including benzodiazepines. Therefore, behavioral strategies are especially important in this population. Youth with autism or developmental disabilities often become agitated in the context of unrecognized physical or sensory discomfort, including headache, dental pain, gastrointestinal distress/constipation, and overstimulation. A detailed history from parents or guardians and close observation/examination can often elucidate potential triggers and inform treatment. A care plan with a list of specific triggers and calming strategies helps coordinate care across shifts in the ED setting. Asking parents or guardians about the child's prior medication responses, either positive or negative, can also inform choice of PRN medication. An extra dose of the child's regular standing medication may be preferable given risk of ADEs. IM administration should be avoided unless absolutely necessary for safety.

Agitation in the Context of Acute Psychiatric Illness

Agitation can occur in youth with a range of psychiatric illnesses, both acute and chronic. Missing home medications, at times due to waiting in the ED, is a frequent cause of agitation, so administering those home medications or administering an extra half or full dose can be effective. Youth with chronic psychiatric illness may alternatively become agitated for reasons that have nothing to do with their illness (e.g., a teen with a history of bipolar mania who is delirious, intoxicated, or in severe pain). Clinicians should also recall that mania and psychosis are rare in preadolescents; thus, a child presenting with agitation with disorganized thinking/behavior, hallucinations or delusions is more likely to be delirious, catatonic, or having difficulty communicating his or her experiences due to autism, intellectual disability, or psychological trauma.

Agitation of Unknown Etiology

While every effort should be made to identify the etiology of agitation, there will be patients for whom this is not possible, and the clinician should use his or her best judgment. For mild agitation, de-escalation strategies should be used while triggers for agitation are assessed. For moderate agitation, lorazepam, diphenhydramine or olanzapine can be used (though olanzapine and lorazepam should not be co-administered). For severe agitation, lorazepam can be combined with haloperidol, or chlorpromazine, or olanzapine can be used as single agents.

DISCUSSION

While there was consensus as to general principals of medication use for agitation and some specific agents and strategies as described above, there was not consensus to support the use of one medication or even class of medication for all patients. This reflects both the absence of a strong evidence base, heterogeneity of the patient population, multifactorial nature of agitation, and practice differences between hospitals, regions, training programs, and individuals.

The specific ED setting will also have significant influence on choice of medication for agitation, and even on when medications are indicated. In the situation of an unlocked medical ED containing numerous pieces of equipment with which a child could (purposefully or accidentally) harm himself or herself or others, it may be faster to medicate an agitated child than in a psychiatric ED with specialized staff and an environment designed for safety. Psychiatric EDs, however, rarely have child life support that can be crucial in preventing agitation among young or developmentally-delayed children in a pediatrics ED. Medical or pediatric EDs can administer IV medications compared to psychiatric EDs, which typically use IM medications if PO is not possible. Medical EDs may be more comfortable with potential ADEs such as QT prolongation or respiratory suppression if they have rapid or routine access to telemetry or airway support, but may balk at using unfamiliar psychiatric medications like chlorpromazine. Psychiatric EDs often lack immediate access to pediatric or emergency medicine support, which may complicate assessment and management of delirium or catatonia secondary to physical illness. Hospital formulary, tradition, and milieu preferences will also influence medication choice.

While these consensus guidelines are written largely with psychiatrists and child psychiatrists in mind, they are informed by expert consensus from providers with training in pediatrics and consultation psychiatry. We anticipate these guidelines may also be of use to pediatricians and EPs working in ED settings without immediate access to psychiatry consultation. When available, psychiatric consultants can help elucidate the etiology of agitation. Psychiatric consultation can also assist with the choice of medication and ongoing non-pharmacologic de-escalation strategies. Especially if a first dose of medication

for an agitated child was not effective, psychiatry should be consulted to reevaluate the differential diagnosis and the pharmacologic and non-pharmacologic treatment plan. Psychiatry consultation should also be obtained for patients with more complex psychiatric pathology and those who are on complex regimens already, patients with a history of paradoxical reaction to medication, and patients with agitation of mixed etiology. Involvement of other mental health providers, including psychologists and social work, can be helpful in the diagnostic assessment as well as implementation of non-pharmacologic management strategies.

LIMITATIONS

This report describes the results of expert consensus guidelines for psychopharmacologic management of agitation among pediatric patients in the ED. These guidelines are based on a systematic review of the literature, a review of existing guidelines and hospital protocols, and utilization of an accepted and evidence-based, consensus generation process designed to reduce bias. However, these guidelines are still predominantly based on expert opinion. They have not been tested for efficacy either in isolation or in comparison to existing guidelines or hospital protocols.

CONCLUSION

In summary, while agitation in the ED occurs frequently and with high costs to patients and clinical programs, there is vastly insufficient research into the understanding, prevention, assessment or treatment of agitation in this context. Further research is needed in many areas of pediatric emergency psychiatry, and especially into the comparative efficacy of different medications for agitation in different types of patients, and into the efficacy of these medications compared to placebo or to non-pharmacologic de-escalation strategies.[28-29] ED nursing and staff, pediatricians, emergency physicians, and adult psychiatrists need training in rapid diagnosis and stabilization of agitated youth, as well as support for non-pharmacologic de-escalation and crisis management. Computerized/electronic medical record-based assessment and risk stratification tools may be useful, as may be clinical pathways directed at providing support and ancillary services (child life, psychiatric, or social work consult) to at-risk youth before agitation occurs.

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Controlled Substance Use Among Psychiatric Patients in a Rural North Carolina Emergency Department

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Introduction: Emergency department (ED) visits for mental health and substance use disorders have been on the rise, with substance use disorders frequently coexisting with mental health disorders. This study evaluated substances commonly used/abused by patients presenting to the ED of a rural, regional medical center with subsequent admission for mental health treatment in Robeson County, North Carolina.

Methods: This retrospective, single-center study was approved by the Southeastern Health Institutional Review Board. We reviewed medical records of psychiatric patients presenting to the ED with ultimate admission to the inpatient psychiatric unit between January 1, 2016, and June 30, 2016. Frequencies of controlled substances testing positive on urine drug and alcohol screenings in admitted patients were obtained and analyzed. We also made ethnic and gender comparisons.

Results: A total of 477 patients met inclusion criteria. The percentage of patients testing positive were as follows: tetrahydrocannabinol (THC) (40%); cocaine (28.7%); alcohol (15.1%); benzodiazepines (13%); opiates (9.6%); amphetamines (2.9%); barbiturates (2.3%); and methadone (0.8%). A relatively higher proportion of patients tested positive for THC than any other substance ($p \leq .0002$). We found statistically significant differences for gender ($p = .0004$) and ethnicity ($p < .0001$) compositions regarding substance use/abuse.

Conclusion: The majority of admitted psychiatric patients in this study tested positive for at least one controlled substance. The two substances that most often returned positive on the urine drug screen test in our sample were THC (marijuana) and cocaine. These findings may provide insight into concomitant substance abuse and psychiatric disorders, which could instigate public policy development of preventative health initiatives that explore the relationship between controlled substance use/abuse and mental health disorders in rural counties like Robeson County. [West J Emerg Med. 2019;20(2)419-425.]

INTRODUCTION

As the gatekeeper of the healthcare system, the emergency department (ED) serves as the safety net for most Americans, especially the uninsured, low socioeconomic status, and medically underserved populations. The ED is a primary entry point to the healthcare system for many patients who are unable to access care in outpatient centers.[1] Patients with mental health and substance addiction issues

are a particularly vulnerable population that has greater dependence on the ED for its primary healthcare needs. Prior research has shown that ED visits for mental health and substance use disorders are increasing,[1] and that substance use disorders frequently coexist with mental health disorders.[2] Mental health patients with substance use disorders use EDs at a higher rate than those without. Indeed, the combination of mental health issues and substance abuse contributes to the complexity of care and management of such patients.[2] In light of this, emergency physicians and psychiatrists may need to acquire more knowledge about the issue to understand better the nuances involved in the care of this unique population.

Literature on psychiatric patients with substance use/abuse issues in underserved, rural areas such as Robeson County in North Carolina is sparse. Robeson County has some of the worst health outcomes out of all counties in the state, and its life expectancy is the lowest.[3] It ranked 100 out of 100 counties in "Health Factors," and 95 out of 100 counties in "Health Outcomes" in 2015.[4] Furthermore, the Robeson County Department of Public Health designated substance misuse/abuse as one of its two top priority areas of focus during the same year.[4] Substance use/abuse is a major contributor to morbidity and mortality in Robeson County as well as throughout the state in general. Coupled with the national trend of disproportionately increasing rates of mental health visits to EDs,[5] we sought to better understand the relationship between mental health patients and their use/abuse of controlled substances. In this study, we explored the rate of controlled substance use/abuse among psychiatric patients who presented to the ED in a rural North Carolina regional medical center. We hypothesized that controlled substance use, as proxied by a positive urine drug screen (UDS) test, was highly prevalent (≥50%) and that ethnicity as well as gender differentials existed in the types and pattern of use of these substances among the psychiatric patients presenting to the ED.

Population Health Research Capsule

What do we already know about this issue?
As mental health and substance use disorders frequently coexist, emergency department (ED) visits for these associated disorders are on the rise.

What was the research question?
How high is the rate of controlled substance use among psychiatric patients in a rural ED?

What was the major finding of the study?
Over 60% of the patients admitted to inpatient psychiatry tested positive for at least one controlled substance.

How does this improve population health?
Understanding concomitant substance use and psychiatric disorders could spur early interventions to improve care for this vulnerable population.

METHODS

Study Population

We conducted this study at the Southeastern Regional Medical Center (SRMC) (ED), the flagship hospital for Southeastern Health in Lumberton, North Carolina. Lumberton is the county seat for Robeson County, and SRMC serves as the region's sole comprehensive hospital. The ED is one of the busiest in the state with over 65,000 annual visits. The hospital maintains an acute inpatient psychiatric unit with 26 beds, and psychiatric professionals provide consultation for ED patients. The populations served by Southeastern Health reflect challenging characteristics that are common to many other rural communities. The hospital's catchment area is estimated to be 950 square miles with a population of approximately 133,000.[6] Patient demographics include a racially diverse, minority-majority population with a large Native American subpopulation. The median household income is $30,608. With a per capita income of $15,559, 30.6% of its economically disadvantaged residents live in poverty.[6]

Design, Exclusion, and Inclusion Criteria

This study was approved by the Southeastern Health Institutional Review Board prior to the initiation of data collection. We performed a retrospective review of medical records for patients who presented to the ED at Southeastern Health and were ultimately admitted to the inpatient psychiatric unit. We included patient encounters between January 1, 2016, and June 30, 2016. We reviewed a total of 613 encounters of which 477 met the inclusion criteria. Inclusion criteria consisted of patients 18 years or older who presented to the SRMC ED and were subsequently admitted to the inpatient psychiatric unit. In addition, we included patients if they were admitted to the psychiatry department directly from the ED or admitted to a medical floor and subsequently transferred to the inpatient psychiatric unit after medical stabilization.

Inclusion criteria also required that the patient had undergone the hospital's standard medical clearance labs: compete blood count, basic or comprehensive metabolic

panel, alcohol level (EtOH), thyroid stimulating hormone level, UDS and pregnancy test (for females age 18-50). Exclusion criteria were as follows: pregnant patients, patients who had missing/incomplete data, and patients who were admitted to the psychiatric department from an outside facility. We also excluded patients who underwent psychiatric evaluation in the ED and were not admitted to the inpatient psychiatric department. The ED protocol regarding patients with primary substance abuse disorders is to refer them to a local substance abuse treatment center. They are not admitted to the psychiatry service of the hospital and thus were not included in this study.

Data Collection, Protection of Human Subjects, and Variables of Interest

All psychiatric patients who present to the ED at SRMC undergo a standard medical screening process, which includes a UDS. Data were collected, de-identified, and entered into a Microsoft Excel spreadsheet. We stored the data on a secure flash drive and analyzed them on a password-protected computer. The following data points were collected on each patient from the medical records: age, sex, race (self-reported on registration), and the presence or absence of tetrahydrocannabinol (THC), opioids, phencyclidine, methaqualone, methadone, cocaine, benzodiazepine, barbiturates, amphetamine, and alcohol. While serum alcohol levels were measured in the ED, on data collection we recorded alcohol level as a dichotomous qualitative variable (+/-) instead of a quantitative variable for ease of data collection and analysis.

Presence of all other substances was determined by the hospital's standard UDS. The hospital laboratory uses the Beckman Coulter® AU 5822 Clinical Chemistry System (Beckman Coulter, Inc., Atlanta, Georgia) for all UDS. The UDS instrument used at this institution does not have the capability to detect multiple opioids – both synthetic and semisynthetic. In fact, synthetic opioids such as tramadol and fentanyl are not detected by this screen. Neither are fentanyl analogs (e.g., carfentanyl) detected. The semisynthetic opioids oxycodone and buprenorphine are not detected by the screen. However, some other semisynthetic opioids, such as hydrocodone, hydromorphone, and oxymorphone, are detected.

Statistical Analysis

We generated descriptive statistics such as frequencies/percentages for the categorical variables of interest. Means, standard deviations, and ranges were computed for the continuous variables. We performed a chi-squared test of goodness-of-fit (non-parametric test of equality of proportions across categories) in a follow-up analysis involving the most common drugs used by gender and ethnicity. Unless otherwise stated, all inferential tests were statistically significant whenever $p \leq .05$. For the analyses, we used the statistical package for the social sciences (SPSS) version 24 (IBM, Chicago, Illinois) together with MedCalc Statistical Software version 16.4.3 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2016).

RESULTS

Demographics

A total of 477 patients met inclusion criteria. The mean age was 37 years (±13.9 standard deviations) with values ranging from 18-97 years. There was a significant gender difference in the entire sample with more males than females (57% vs. 43%) (p=.004) testing positive on UDS for controlled substances. For race/ethnicity, patients who self-reported as Native American and Caucasian each made up 34.2% of the population, and 28.7% self-identified as African American, 0.2% as Hawaiian, and 2.7% as other (Table 1). This ethnicity distribution of the sample population is consistent with the ethnic/racial composition of the community. According to 2016 United Sates (U.S.) Census Bureau data, the estimated population of Robeson County was 31.3% Caucasian, 41% Native American, 24.2% African American, and 0.2% Hawaiian.[3] Controlling for the Hawaiian and "other" categories of ethnicity/race, we found that in terms of controlled substance use reflected through testing positive on a UDS, there was no statistically significant difference in the percentages of the distribution of the major ethnicities, namely Native American (34.2%), African American (28.7%), and Caucasian (34.2%), represented in the sample (p=.232).

Substance Use

The number of substances present in a psychiatric inpatient ranged from none to six, and the mean (average) number of substances that tested positive on UDS was 1.13 (±1.06 standard deviations). Furthermore, 166 (34.8%) of

Table 1. Patient demographics (N=477).

Characteristics	N	%	P
Gender/sex			.004
Female	207	43.6	
Male	270	56.6	
Race/ethnicity			< .0001
American Indian	163	34.2	
African American	137	28.7	
Caucasian	163	34.2	
Hawaiian	1	0.2	
Other	13	2.7	

the 477 patients did not have a positive UDS. Conversely, 311 (65.2%) patients had at least one substance recorded on their UDS. Regarding specific substances used, THC was the most common substance for which 191 (40%) patients tested positive. Cocaine was the second most common substance, with 137 (28.7%) patients testing positive. The third and fourth were alcohol and benzodiazepines, with 72 (15.1%) and 62 (13.0%) patients, respectively, testing positive (Table 2). A positive test result for opioids was recorded on 46 (9.6%) patients, while amphetamines and barbiturates were recorded on another 14 (2.9%) and 11 (2.3%), respectively. Methadone tested positive in four (0.8%) patients' drug screens. These results are reported in Table 2 with THC as the reference.

Table 2. Substance use profile — distribution by the type of substance abused by patient (N = 477).

Substance	N*	%*	P**	95% CI (LL%, UL%)
THC (marijuana)	191	40.0	reference	reference
Opioids	46	9.6	< .0001	(25.17, 35.43)
Phencyclidine	0	0	n/a	n/a
Methaqualone	0	0	n/a	n/a
Methadone	4	0.8	< .0001	(34.71, 43.69)
Cocaine	137	28.7	.0002	(5.28, 17.21)
Benzodiazepine	62	13.0	< .0001	(21.6, 32.2)
Barbiturate	11	2.3	< .0001	(33.05, 42.27)
Amphetamine	14	2.9	< .0001	(32.39, 41.71)
Alcohol	72	15.1	< .0001	(19.36, 30.24)

CI, confidence interval; *THC*, tetrahydrocannabinol; *n/a*, not applicable; *LL*, lower limit; *UL*, upper limit
*These Ns total more than 477 because of multiple choices of substance types. The percentages were based on the 477 original total.
**P values were based on the difference of proportion of substances used with THC as reference.
na = not applicable.

All other substances for which patients tested positive were statistically significant among relatively smaller proportions of patients compared with THC. For example, the proportional positive test result of 40% for THC among the patients compared with that of opioids (9.6%) was significantly higher (p<.0001), with a 95% confidence interval of the difference between the proportions being (25.17 to 35.43).

Based on a subgroup analysis, patients testing positive for THC were more likely to be Native American (p<.0001) males (p=.001) than the other ethnic groups and gender, respectively. African-American and Caucasian males were equally as likely to test positive for THC. Similarly, patients testing positive for cocaine, the second common substance for which most patients often tested positive, were more likely to be Native American (p<.0001) male (p=.002). This trend of the results was again true for alcohol—that is, a Native American (p<.0001), except in this case, regardless of gender, was more likely to test positive than people of other ethnicities. Lastly, for the fourth most commonly used substance, benzodiazepine, those patients testing positive were more likely to be Caucasian (p<.0001) females (p=.042) than any of the other ethnicities in the study.

DISCUSSION

The purpose of this study was to determine if controlled substance use (proxied by positive test result on UDS) was high among psychiatric patients who presented to the ED of a rural medical center. In addition, we aimed to examine which controlled substances were most commonly or often used (again, as gauged by a positive test result on a UDS) by this patient population. Furthermore, we sought to investigate whether ethnicity or gender differentials existed for the types and pattern of controlled substances for which positive tests resulted. Consistent with our primary hypothesis, we found that the majority of psychiatric patients, 65.2%, had at least one controlled substance in their system through testing positive on a UDS. This reflects a major public health challenge. Successful treatment of these patients likely requires attention to controlled substance use and abuse, in addition to their primary psychiatric conditions.

As indicated in the results, gender and ethnicity were significant factors relating to substance use by psychiatric patients in the study. The findings involving ethnicity are significant from a clinician's standpoint because while Native Americans were proportionally represented as African-Americans and Caucasians in the sampled population, they tended to test positive for three of the four most common drugs observed at much higher rates than the other two groups. Such information is clinically useful as it could provide a means that alert the physician to look for warning signs during physician-patient interactions.

Findings from this study show that THC was the most common controlled substance for which patients in the study sample tested positive at a relatively higher proportion than others. The rate of THC use in the sampled population was much higher than rates reported in the general U.S. population. While it has been reported that 9.52% of U.S. adults had used THC in the prior year,[7] 40% of patients in this study population tested positive. Some states have enacted legislation allowing THC for recreational use; however, it remains illegal in North Carolina for both medical and recreational uses. Because it is illegal, the relatively high rates of THC use may place patients at risk of legal and myriad other problems such as employment

and social benefit barriers. Moreover, the long-term mental health effects of THC remain unclear in the extant literature. These highlight the importance of a holistic approach to mental health treatment, including substance abuse education, treatment, and management.

Cocaine was the second most frequently used substance reported with 28.7% of patients testing positive. This rate is dramatically higher than the rate of cocaine use/abuse by the general U.S. population. Studies have shown that 0.6% of U.S. adults reported using cocaine within the prior 30 days.[8] One potential reason for the high levels of cocaine use in the study population is its geographic location. Robeson County is located halfway between New York and Miami on Interstate 95. Rural North Carolina locations often serve as temporary cocaine storage sites for criminal groups as they move the product from one region to another.[9] Robeson County's rural nature and proximity to a major highway makes it an ideal site for cocaine storage and distribution.

The U.S. Department of Justice, has estimated that 75-80% of the cocaine in North Carolina is distributed as crack cocaine.[9] Due to the economic disparity of our population, this is presumed to be the primary form used by our patients. The estimated price of powdered cocaine is $100 per gram, while crack cocaine is sold for approximately $10-25 per rock.[9] As cocaine use induces changes in neurotransmitters such as dopamine and glutamate, its use complicates mental health treatment. Studies show that chronic cocaine use leads to impairment in cognition and stress management, and can lead to increases in anxiety, irritability, paranoia and psychosis.[8] These highlight the necessity of a multi-faceted approach to mental health care in the study population.

Alcohol was present in the serum of 15.1% of patients studied. However, no data were available for overall alcohol use/abuse rates in the county. Alcohol acts as a central nervous system depressant and is commonly used by patients with psychiatric conditions. Alcohol intoxication and withdrawal affect numerous neurotransmitters including gamma-aminobutyric acid, dopamine, N-methyl-d-aspartate, adrenocorticotropic hormone, and endorphins.[10] Patients who use alcohol are at risk for myriad psychiatric problems including depression, anxiety, hallucinations, impaired judgment, and impaired cognition.[10] In addition, the concurrent use of alcohol with prescription medications can lead to numerous adverse effects. Screening for alcohol use and abuse is essential in the treatment of patients with psychiatric complaints, as alcohol treatment and mental health treatment are codependent entities. The success of one depends on the other.

Benzodiazepines were present in 13% of patients studied. One of the limitations of this study is that we were unable to determine when benzodiazepines were ingested and for what purpose. Benzodiazepines serve as a therapy for certain psychiatric conditions such as anxiety and panic disorders. They are also frequently administered to acutely agitated patients in the ED. Administration of benzodiazepines in the ED occasionally occurs prior to the collection of the patient's urine specimen for the UDS. When this occurs, the patient's urine will test positive for ED-administered benzodiazepines. Conversely, abuse of benzodiazepines is not uncommon. Benzodiazepines may be abused to potentiate the effects of other drugs and are sometimes misused to mitigate withdrawal symptoms from other substances.[11]As stated, we were unable to determine the exact role that benzodiazepine use plays in the patient population, but screening for benzodiazepine use and abuse should be included in all comprehensive psychiatric treatment regimens.

Most surprisingly, opioids were found to be the fifth most common controlled substance found in the patient population. Opioids were present in 9.6% of patients, and methadone was present in an additional 0.8% of patients. This finding is lower than expected, given the nation's current opioid epidemic. In 2016, the same year in which the data for this study was collected, the Centers for Disease Control and Prevention reported that 42,249 Americans died from opioid overdoses.[12] Similarly, North Carolina reported 1,956 opioid overdose deaths in 2016.[12] As evidenced by the number of opioid-related deaths, the opioid crisis exists throughout the entire state of North Carolina.

In Robeson County, 1.476 opioid prescriptions were written per resident in 2016, and the statewide average was 1.06—almost 47% above the state average.[13] Additionally, there were 113.3 opioid pills per resident prescribed in the county in 2016. This is higher than the statewide average of 78.3 pills per person.[13]Although opioid abuse remains a national and local health crisis, only a small percentage of the study patients tested positive for opioids in their UDS. Furthermore, it is uncertain whether the opioids detected in these patients represented therapeutic use, misuse or illegal use. It is also worth noting that the majority of ED patients with primary substance abuse disorders are referred to substance abuse treatment centers and are not admitted to the psychiatric service unless they have a primary psychiatric condition.

In North Carolina and throughout the U.S., we must caution against over-interpretation of the relatively low prevalence rate of opioid use in our study population. Indeed, the drug-screening kit used in this study does not detect the presence of the semi-synthetic opioid oxycodone or synthetic opioids tramadol, buprenorphine, fentanyl, and fentanyl analogs (e.g., carfentanyl). A growing body of evidence suggests that fentanyl and synthetic opioids account for a substantial proportion of opioid use and abuse. In 2016, 47% of all opioid-related deaths in the U.S. were attributed to use/abuse of synthetic opioids other than methadone.[15]

Numerous fentanyl products are available by prescription, and fentanyl and other novel synthetic opioids

are sold illegally on the streets. Often, synthetic opioids may be erroneously marketed on the streets to unsuspecting users as heroin or other narcotics.[16] Synthetic opioids may be found in powdered or pill form, and may be smoked, injected, snorted, or ingested by the user.[17] These synthetic opioids are not detected by the commonly available, commercial UDS kits such as the one used used in this study. Hence, the prevalence of their use in the study population is not empirically well known. Consequently, we would suspect that the rate of opioid use could be significantly higher than the 9.6% observed among the population studied.

LIMITATIONS

No causation or correlation can be adduced from this study, but it could provide useful insights that serve as a foundation for future studies for a rural, healthcare-needy, underserved, and vulnerable population. There are several limitations to this study, the first of which relates to interpretation of UDS in general. Each drug tested is detectable in the urine for different periods of time. Given this, it is very difficult to accurately obtain and compare the true prevalence of one drug to another.[14] Moreover, certain commonly abused opioids, including fentanyl and tramadol, are not reliably detected with the test machine used at this facility. Synthetic amphetamines and benzodiazepines are also not detected. Therefore, the use of these drugs may be more prevalent in the population than reported here.

This study was conducted at a single medical center in a rural area where the demographics may not be fully representative of all counties in North Carolina. Also, because patients with acute psychosis may require some of the medications measured for agitation they may not, in a real sense, be abusing those substances. When administered prior to urine collection, this could lead to a positive drug screen. As mentioned previously, there were also several patients who must have been prescribed benzodiazepines and/or opioids pain medications on an outpatient basis. These patients who were more likely to test positive on presentation to the ED might have been included in this study despite not necessarily qualifying as substance-abusing subjects. Indeed, we were unable to obtain accurate data on those cases from the medical records to determine the number of patients who might have been legally prescribed medications that would have led to a positive controlled-substance screen result. The electronic medical records reviewed indicated that many patient encounters had missing or incomplete home medication lists. Furthermore, for patients who were administered benzodiazepines screening in the ED, the timing of the urine collection was not consistently documented. Patients who received benzodiazepines prior to collection of their urine would likely have a positive UDS result for benzodiazepines.

The short duration of the time span or the relatively short period reviewed for the study may have limited the observance of greater prevalence of drug use/abuse in the subpopulation of patients studied. Hence, prevalence may be underestimated. Despite these limitations, our results provide baseline information that could trigger conversations among healthcare stakeholders to devise ways to intervene to improve the health of this unique population nationwide.

CONCLUSION

This study highlights that mental health and substance use disorders frequently coexist. In the rural area studied, over 60% of patients admitted to inpatient psychiatry tested positive for one or more controlled substances. While our findings may not necessarily reflect accurate drug usage rates due to the increasing use of synthetic opioids, which are not easily detectable with many UDS kits, these results may provide insight into concomitant substance abuse and psychiatric disorders in rural areas. Ideally, this study will spur local, state, and federal agencies to look more closely at the relationship between substance use and mental health disorders and guide them in developing preventative health initiatives and allocating requisite resources to help mitigate substance abuse, especially in these underserved areas of need. Ultimately, our study suggests the need for multiregional, longitudinal studies to examine the substance abuse rates as well as patterns in psychiatric populations in various regions and differing socioeconomic strata. Most importantly, future studies should be able to differentiate legal uses from cases of actual substance abuse.

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This Article Corrects: "Just Missing the Mark: Discharging High-risk Atrial Fibrillation/Flutter without Thromboprophylaxis"

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Just Missing the Mark: Discharging High-risk Atrial Fibrillation/Flutter without Thromboprophylaxis
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Erratum in
West J Emerg Med. 2019 March;20(2):426. All references to the name Smith (i.e., Smith et al. and Smith and colleagues) should be revised to Vinson. The duration of referenced study in paragraph 4 is incorrect. The duration of the study should read 16 months rather than 14 months.

Source: Vinson DR, Warton EM, Mark DG, Ballard DW, Reed ME, Chettipally UK, Singh N, Bouvet SZ, Kea B, Ramos PC, Glaser DS, Go AS, for the TAFFY investigators of the CREST Network. Thromboprophylaxis for patients with high-risk atrial fibrillation and flutter discharged from the Emergency Department. *West J Emerg Med*. 2018;19(2):346-360.

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This Article Corrects: "Behind the Curtain: The Nurse's Voice in Assessment of Residents in the Emergency Department"

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Behind the Curtain: The Nurse's Voice in Assessment of Residents in the Emergency Department
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Erratum in
West J Emerg Med. 2019 March;20(2):427. First author's last name was misspelled in the original publication [Ashley Palvic]. Author's name has been corrected to read Ashley Pavlic.

Abstract

Introduction: Feedback provides valuable input for improving physician performance. Conventionally, feedback is obtained from attending physicians; however, residents work in close contact with other members of the care team, especially nurses. Nurses may have more opportunity to directly observe trainees. In addition, they may value different behaviors and provide unique feedback. The objective of this study was to examine the nurse's perspective of resident performance in the emergency department.

Methods: This was a retrospective, mixed-methods study of nursing assessments of residents using a five-point scale from 1 (unsatisfactory) to 5 (outstanding) and providing comments. Analysis included descriptive statistics of the quantitative assessments and content analysis of the nursing comments by a group of attendings, residents, and nurses.

Results: Nurses assessed residents as above expectation or outstanding, especially for the categories of "How would you rate this resident's attitude?" (65%) and "Is this resident a team player?" (64%). Content analysis of the comments yielded nine themes including being kind, communication with nurses, being a team player, work ethic and efficiency, and respect for other team members. Of the comments made, 50% provided positive feedback, and the majority of comments (80%) were determined to be actionable.

Conclusion: Our data indicate that nurses provide feedback on residents' kindness, efficiency and communication. These two aspects of interacting in the healthcare setting may not be highlighted in conventional, attending provider feedback, yet they are clearly noted by the nurse's voice. [West J Emerg Med. 2019;20(1)23–28.]

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9th Annual National Update on Behavioral Emergencies Conference (NUBE) in Las Vegas, Nevada (December 12-14, 2018)

The American Association for Emergency Psychiatry held the 9th Annual National Update on Behavioral Emergencies on December 12-14, 2018 in Las Vegas. We had a robust set of abstract presentations that the *Western Journal of Emergency Medicine* was gracious enough to publish in this issue. Please join us next year for the 10th Annual National Update on Behavioral Emergencies in Scottsdale, Arizona December 11-13, 2019. A call for speakers and abstracts will be out shortly on our website: https://www.emergencypsychiatry.org/

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1 Management of Pediatric Agitation and Aggression: Lessons Learned from the National Consensus Pediatric BETA Guidelines

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Introduction: Agitation in pediatric acute care settings is common and disruptive. We begin with a case example of an agitated patient on a pediatric medical unit. Using data from a survey of 38 North American children's hospitals we will outline the prevalence, screening methods, clinical guidelines, and physician training in the management of agitation. We will describe hospital practice in the comprehensive evaluation and management of pediatric agitation and aggression at one institution, followed by a summary of the literature on medications for agitation. We conclude with the National Consensus Pediatric BETA Guidelines for the management of pediatric agitation and aggression in emergent settings.

Methods: A case presentation will be followed by data from a national survey of pediatric hospitalists and consultation/ liaison psychiatrists. A clinical pathway for management of agitation will be described. Using a *Medline and PsycINFO* search from 01/01/1996-01/01/2017, we will summarize the literature on psychopharmacological management of agitation in pediatric patients. Using the Delphi method for consensus guideline development, a team of emergency department-based child and adolescent psychiatrists from across the United States created the Consensus Guidelines.

Results: Results of the survey of 38 North American academic children's hospitals revealed 85.5% of the respondents encountered agitation in pediatric patients at least once a month. Most viewed agitation in pediatric patients as highly important, yet 55.1% do not screen for risk factors of agitation, 65.3% reported no clinical guidelines for agitation, and 57.1% indicated no physician training in pediatric agitation. A multidisciplinary clinical pathway for agitation in pediatric patients will be outlined. Evidence for the following medication classes will be described: antihistamines, benzodiazepines, typical antipsychotics, atypical antipsychotics, mood stabilizers, anti-depressants, and stimulants. The Consensus Guidelines outline standardized recommendations for medications.

Conclusion: Agitation in pediatrics patients is a concern continent-wide, but there is little training or standardization of care. Clinical pathways exist and can ensure identification and early management. Data about psychopharmacological management of agitation exists and updated Consensus Guidelines provide standardized guidelines for the management of agitation.

2 Evidence-based Care for Suspected Pediatric Somatic Symptom and Related Disorders in Emergent Settings

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Introduction: Somatic symptom and related disorders (SSRDs) are a group of diagnoses characterized by the presentation of one or more physical symptoms that are either inconsistent with physical disease based on a thorough medical evaluation or vastly disproportionate to findings on a thorough medical evaluation, and result in significant impairment. These symptoms are often significantly influenced by psychological factors including acute or chronic distress, as well as visceral hypersensitivity and habituation of maladaptive responses to somatic sensations. These conditions are common in pediatric medicine, accounting for up to 50% of primary care visits for abdominal pain, headache, and fatigue. There is a lack of a coordinated approach to SSRD care, often resulting in excessive and unnecessary healthcare utilization, miscommunications, missed opportunities to intervene, and considerable frustration from patients, families and providers.

Methods: There is limited information in the literature for how to provide SSRD care in practice and no current consensus guidelines for SSRD care in youth. At our institution, we convened a multidisciplinary group of providers, used LEAN methodology to assess problematic areas, including areas of inefficiency or disruption in work flow, gathered data from primary care providers statewide to inform understanding, and developed an evidence-based, institutional clinical practice guideline for management of SSRD care within the emergency department (ED) and inpatient setting. In addition, we have integrated education on SSRDs into our pediatric and psychiatric trainee curriculum.

Results: We will present the consensus-building process and multidisciplinary group formation used at our institution to develop standardized tools, resources, a clinical protocol and a clinical practice guideline. This includes a review of our value stream map as part of incorporating LEAN methodology in our process. We will review current evidence in SSRD practice, including data gathered from a statewide survey on practice. We will share our clinical protocol that outlines a detailed approach to suspect and confirm diagnoses of SSRD starting in the ED setting, as well as principles and contents from an interdisciplinary, hospital-wide clinical practice guideline with several associated clinical resources for practical application of the practice guideline and protocol.

Conclusion: Our institutional and statewide data align closely with existing evidence that indicates SSRDs are common, that providers, both medical and psychiatric, have little training or education on these conditions, that these conditions often present in emergent settings, and that patients and families often seek an overly physical conceptualization to their symptoms that is devoid of mental health involvement, which often leads to unnecessary and significant healthcare utilization. Initial results from our institutional approach, resulting in consensus-based practice guidelines, protocol and resources, suggest a model that can be used in ED and inpatient settings to address the needs of this pediatric population.

3 Pediatric Patients with Behavioral Emergencies: Who's Coming in and What Happens While They're Here?

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Introduction: Children and adolescents evaluated in the emergency department (ED) represent a vulnerable population, especially when presenting for psychiatric symptoms. For these patients the ED environment may be stressful and lacking in needed resources. Data describing children seen within the ED are currently limited; this study aims to describe the pediatric patient population treated for mental health concerns within one ED, which may promote better-tailored treatment and support resources in the future.

Methods: The study describes 339 visits generated over two months in 2017 at LAC+USC Medical Center. We reviewed charts to determine each child's stated age and gender, as well as whether the patient belonged to one or more vulnerable subpopulations. The factors of interest included involvement with the social services and legal systems, history of psychological trauma, diagnoses of post-traumatic stress disorder (PTSD) or autism spectrum disorder (ASD), and whether the patient required a "behavioral code" during his or her visit.

Results: The study determined that 76.1% of the charts included at least one risk factor assessed during our review. Males were more likely than females to present by the age of 11, while the opposite was true for patients age 12-17. We also determined that 38% of patients had been involved with child protective services, or a regional center (system for individuals with developmental disabilities), or the juvenile justice system, and that 5.6% were involved with multiple systems. Two hundred twenty-five patients had experienced psychological trauma, with 30 patients carrying an official diagnosis of PTSD. Of behavior codes called, 23% were for ASD patients, with these patients being far more likely to display dangerous behaviors in the ED compared with neurotypical children.

Conclusion: This study demonstrates that a majority of children evaluated in our ED for psychiatric concerns also belonged to at least one vulnerable subpopulation. Especially striking was that behavioral codes were far more likely to be called for ASD patients than neurotypical patients, implying that EDs that work with this population may benefit from extra training in preventing and managing agitated behavior in children with ASD.

4 Creating Elasticity and Improving Handoffs Increases Throughput on an Emergency Psychiatry Service

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Introduction: As the population of New Orleans continues to increase, psychiatric services at its main safety-net hospital, the relatively new University Medical Center New Orleans (UMCNO), have had to increase with it. At UMCNO, psychiatric patients in the emergency department (ED) are ideally managed in the behavioral health emergency room (BHER) until either admission, transfer, or discharge. The BHER holds 26 beds, but staffing limitations prevent all 26 from being open continuously. Historically, there are fewer discharges from inpatient psychiatric units citywide on weekends, which then causes overflow of the BHER into the main ED and slows throughput throughout the hospital. Because of this, elasticity in the system and effective reassessments by the emergency psychiatry consult service are key to minimizing lengths of stay and saturation events.

Methods: In April 2018, efforts were undertaken to create more elasticity in the BHER as well as more effective handoffs to easily identify what is needed for each patient to ensure a safe discharge. Changes included the following: actively anticipating the need to expand to 26 beds starting Sunday evening; creating a mindset of "continuously seeking an inpatient bed" during peak times; and using the electronic health record (EHR) for handoffs between providers. Lengths of stay (LOS) for patients in the BHER as well as hours on psychiatric saturation were tracked monthly before and after the changes were made, as were the

total number of emergency psychiatry consults, discharge rates, and transfer rates.

Results: The number of consults per day has been increasing by about 13.8% a month over the last few years and is now around 16-17 a day. The service discharges about 45% of the patients consulted to us; and of those requiring admission, about 35% are transferred to other psychiatric unit, with the rest being admitted to UMCNO's 60-bed inpatient psychiatric unit. Looking at the seven months before and after the changes were made, the average LOS has decreased from 15.98 hours to 13.78 hours (a 17% decrease), and the number of hours on saturation decreased from 42.3 hours a month to 19.2 hours (a 55% decrease).

Discussion: While our goal of zero hours on saturation was not met, the data show that by planning for the increase in volume during the weekend with more staff starting Sunday evening to open all 26 beds, we were able to lower saturation hours, which helps throughput in the main ED and throughout the hospital. Furthermore, by increasing the hours of clerks on weekends (who are responsible for transferring patients when our inpatient unit is full), we were able to transfer more patients throughout the weekend than previously. And finally, by integrating our handoff within our EHR, we were able to quickly identify those patients who could potentially be discharged safely and what was needed to ensure that safe discharge. Combined, these efforts lowered the average of LOS in the BHER.

5 Potentially Avoidable Transfers of Veterans with Mental Health Conditions in the Veterans Health Administration

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Objective: Over 40% of the 2.4 million emergency department (ED) visits to Veterans Health Administration (VHA) hospitals are from veterans who live in rural areas, a population at increased risk of interfacility transfer. Veterans may undergo interfacility transfer to obtain emergent or urgent access to specialized health services, particularly mental health care. However, such transfers raise questions regarding appropriate use of resources, travel burdens for patients and families, and logistical challenges for ED staff and providers that may delay timely care. We sought to describe ED-based, interfacility transfer rates within the VHA and to estimate the proportion of potentially avoidable transfers (PAT) of patients with mental health conditions relative to other diseases.

Methods: This observational cohort included all patients who were transferred from a VHA ED to another VHA hospital between 2012 and 2014. We extracted data from Clinical Data Warehouse administrative data. PAT was defined as discharge from the receiving ED without a procedure, or hospital length of stay at the receiving hospital ≤ 1 day without having a procedure performed. We conducted facility-level and diagnosis-level analysis to identify conditions for which an alternative to transfer, such as telehealth access to specialty care, could be developed and implemented in low-volume or rural EDs.

Results: Of 6,131,734 ED visits during the three-year study period, 18,875 (0.3%) were transferred from one VHA ED to another VHA facility. Rural residents were transferred three times as often as urban residents (0.6% vs. 0.2%, $p<0.001$), and 23.6% of all VHA-to-VHA transfers met the PAT definition. Mental health conditions were the most common reason for interfacility transfer (34% of all interfacility transfers), followed by heart disease (12%). Of transfers that met PAT criteria, 11% were for mental health diagnoses whereas 21% were for heart disease. Geographic analysis suggested that overall PAT proportion ranged across regions from 8-53% with mental health PATs between 2-42%.

Conclusion: VHA interfacility transfer is commonly performed for mental health diagnoses, and there is substantial regional variation in potentially avoidable transfers in a national sample of transfers. A significant proportion of these transfers may be potentially avoidable. Future work should focus on improving capabilities to provide specialty evaluation locally for these conditions, possibly using telehealth solutions. Additional work should also focus on measuring the timeliness of these transfers.

6 Reducing Emergency Department Length of Stay and Wait Times for Psychiatric Patients

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Introduction: In the past 20 years there has been a significant decline in the number of inpatient psychiatric beds in the United States, while the number of patients seeking psychiatric treatment in the emergency department (ED) has increased over the same time period. Given the increase in demand for psychiatric services and decrease in availability of inpatient treatment the ED is becoming the de facto place of treatment for the majority of psychiatric crises. Psychiatric patients experience longer lengths of stay (LOS) when compared to non-psychiatric patients,

especially when transfer to another facility is required. Therefore, improvements in the efficiency of evaluation, treatment and disposition of psychiatric patients benefit both patients and the EDs that care for them.

Methods: To improve throughput and reduce wait times in the ED at our Level I trauma center located in the Upstate region of South Carolina, we implemented several improvements. We then tracked pre- and post-intervention metrics, including LOS and the time from ED consultation order to the completion of psychiatric consultant documentation. The intervention consisted of several protocols with various checkpoints for required documentation necessary for progression through overall mental health evaluation and treatment. In addition, structured psychiatrist and social worker evaluation-note templates were standardized to improve documentation accuracy, consistency, efficiency and overall patient safety. A separate tracking system is monitored by a dedicated psychiatric advanced practice provider to ensure compliance on note completion and order set utilization. The time from ED consult order to completion of psychiatric consultant documentation and mean LOS (in hours +/-standard deviation [SD]) were measured for six months before (10/2016 to 03/2017) and eight months after (4/2017 to 11/2017) institution of these protocols. We then compared pre- and post-intervention measures using Student's t-test ($p<0.05$).

Results: The number of ED patients seen by a psychiatrist were 3,331 and 4,482 in the pre- and post-intervention time frames, respectively. Overall mean LOS significantly decreased from 38.2 (SD+57.5) to 24.9 (SD+37.6) hours after institution of these new protocols. In addition, mean LOS for patients discharged to home or to a psychiatric facility also significantly decreased from 36.9 (SD+53.7) to 21.8 (SD+30.7) and 42.8 (SD+66.5) to 31.8 (SD+49.1) hours, respectively. Time from consult order to completion of ED psychiatrist documentation significantly decreased from 11.3 (SD+9.8) to 6.2 (SD+6.9) hours. All four comparisons were significantly different with p-values ≤ 0.01.

Conclusion: The implementation of these protocols showed a rapid, sustained improvement in overall efficiency of evaluation and disposition of psychiatric patients in our ED. The decrease in time to evaluation for patients discharged home, as well as a decreased time to transfer to inpatient level of care for those requiring hospitalization made for greater throughput and decreased demand on ED resources. Of note, this improvement in efficiency was observed despite an increase in the volume of psychiatric patients seen by the ED over the course of the study. Our institution continues to track outcomes and has implemented further changes including hiring several dedicated ED psychiatrists, with a goal of providing 24/7 availability of in-house psychiatrists embedded in the ED in an effort to further decrease LOS and improve patient care.

Given the shortage of psychiatrists and declining numbers of psychiatric hospital beds, until an alternative solution for this difficulty of access to psychiatric services is implemented the demand for psychiatric services in the ED will remain high. While more study is needed to determine the generalizability of our findings, we believe that implementation of similar interventions would likely benefit other EDs struggling with delays in psychiatric evaluation and disposition.

7 Placebo/Active Controlled, Safety, Pharmaco-Kinetic/Dynamic Study of INP105 (POD® olanzapine) in Healthy Adults

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Introduction: A 2008 survey of emergency department staff (ED) found that 65% had witnessed physical attacks, 32% reported at least one verbal threat per day, and 18% had been assaulted at least once with a weapon. While many of the attacks were due to acute agitation, only 6% of the surveyed EDs had a protocol for medication selection and 40% provided training for staff. During acute agitation episodes – up to seven million/year in U.S. hospitals and EDs – olanzapine (OLZ) intramuscular (IM) is favoured due to a shorter Tmax over oral tablets or oral disintegrating tablets (ODT); however, IM administration requires cooperation, is invasive and can be painful. Uncooperative patients require restraint for the administration of OLZ IM that may be viewed as an assault, thereby reducing trust in medical personnel and increasing the likelihood of staff injuries. When possible, non-injectable forms are preferred during agitation; however, currently approved oral products have slower onset of effect, often requiring labour-intensive observation of the medicated patient until resolved.

INP105 is a drug-device combination product consisting of a powder form of OLZ delivered by a precision olfactory delivery (POD®) device to the vascular-rich, upper nasal space for rapid control of agitation in a cooperative or uncooperative patient (with a potentially caregiver administered dose). For this study a near-final formulation of OLZ was administered by the research embodiment of the POD (I231) device. For subsequent studies, INP105 will use the final commercial formulation adjustments and the commercial POD device. INP105 should provide faster onset of relief compared to oral therapy and be a more accessible dosage form compared to IM therapy without a needle. INP105 may also be suitable for early use by the patient who has insight into his or her condition and can recognize early symptoms of agitation before escalating, uncontrolled agitation leads to violence and injury to the patient, the caregiver and/or healthcare workers. The objectives of this

SNAP 101 study were the following: 1) Establish safety and tolerability of three single, ascending doses of INP105; 2) compare pharmacokinetic (PK) data for OLZ)from three INP105 doses with OLZ IM (5 and 10 milligrams [mg]) and orally disintegrating tablets (OLZ-ODT) 10 mg; 3) establish and compare pharmacodynamic (PD) effects of INP105 to OLZ IM and OLZ-ODT; and 4) explore PK/PD and dose-response relationships for INP105.

Methods: SNAP 101 was a randomized, double-blind, placebo- and active comparator-controlled, ascending-dose, 2-way, 2 period, incomplete block, crossover Phase 1 trial to compare the safety, tolerability, PK and PD of three doses of INP105 (5 mg, 10 mg and 20 mg) with two doses of OLZ IM (5 mg and 10 mg) and one dose of OLZ-ODT (10 mg).

Period 1 was open label; Period 2 was double-blind with at least 14 days between dosing in the two periods. Dose escalation was staggered across cohorts to allow a monitoring committee to assess safety and tolerability of INP105 between doses.

Following all dosings in both periods, PD assessments were made by frequent and regular vital signs recordings as well as visual analogue scale for subjective assessment of sedation, the Agitation/Calmness Evaluation Scale, an objective assessment by the investigator, and the timed Digit Symbol Substitution Test. Blood was drawn at frequent timepoints over the 120 hours post dosing for PK evaluation.

All subjects were observed as inpatients for at least 72 hours post-dosing of reference therapy and IP. Follow-up occurred four, five and 14 days after dosing for each study period. The first two subjects receiving 10 mg OLZ IM had clinically significant hypotensive events following administration, and thus the study design was immediately changed with the remaining 36 subjects (12 per cohort) being randomized to OLZ 5 mg IM or OLZ ODT 10 mg. After each block of 12 subjects completed period 1 dosing, five days of observation and nine days of washout, they returned for period 2 dosing when they received INP105 (n=9) or placebo. After a further five days of observations and nine days of washout, a safety monitoring committee (SMC) reviewed the safety data before allowing dose to be escalated to the next level, ie, SMC 1 approved proceeding from INP105 5 mg to INP105 10 mg; but at SMC 2, the decision was made to reduce the dose for cohort 3 from INP105 20 mg (four capsules) to 15 mg (three capsules) due to the frequent but not substantial drops in blood pressure noted after cohort 2, period 2 dosing.

Conclusion: This SNAP 101 study (completed in 2018 with results expected in December), which administered OLZ to the vascular-rich, upper nasal space with the novel POD® device, should guide further clinical development for a needle-free, easy self- or caregiver-administered, rapidly effective OLZ treatment to abort episodes of acute agitation in low-intensity community or ED settings. Safety signals (blood pressure drops) suggestive of appreciable pharmacodynamic effects of OLZ were noted with OLZ IM 5 mg and with cohort 2 and 3, period 2 dosings (INP105 at 10 and 15 mg doses or placebo) at the SMCs. Their formal analysis, along with other PD measures and PK data, is anticipated.

8 Development of a Precision Olfactory Delivery (POD®)-Olanzapine Drug-Device Product for Agitation

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Introduction: Agitation is a cluster of behaviors observed in multiple psychiatric diseases, which can increase the likelihood of violent behavior. Atypical antipsychotics, including oral and intramuscular (IM) olanzapine (OLZ), have been approved for chronic and acute agitation treatment, respectively, for schizophrenia and bipolar I disorder in the U.S. for over 20 years. During acute agitation episodes, IM OLZ is preferred over oral treatments due to a shorter Tmax. However, IM OLZ is invasive, predominantly administered in a hospital setting, and may require restraint if the patient is uncooperative, potentially reducing trust between patient and medical personnel and increasing the likelihood of injuries. When possible, non-injectable routes of administration are preferred during agitation events; however, slower-onset oral products often require labor-intensive observation of the medicated patient until adequate symptom resolution.

Impel NeuroPharma is developing INP105, a drug-device combination product consisting of a novel OLZ powder formulation for upper nasal cavity administration using precision olfactory delivery (POD®) technology. This rescue therapy is designed to provide non-invasive, rapid relief of acute agitation comparable to IM injection, without excessively sedating the patient, in a reasonably safe and tolerable manner. POD technology is designed to deliver drug to the upper nasal mucosa with minimal effort or coordination for self or caregiver administration.

Methods: OLZ formulations were designed and manufactured to optimize powder characteristics and device compatibility. Formulations were characterized by analytical methods to assess chemical and physical state as well as device compatibility. Lead formulations were evaluated in rat and non-human primate (NHP) pharmacokinetic (PK) studies, where dose was administered by species-specific POD devices, and plasma samples for PK analysis were analyzed by liquid chromatography mass spectrometry. Formulation selection for further evaluation was based on analytical and PK properties, and a single formulation was identified for inclusion in the INP105-101 proof-of-concept, clinical study.

Results: Approximately 30 formulations designed for nasal delivery by POD technology were manufactured and then assessed using analytical chemistry techniques and device-compatibility testing. Twenty of the formulations were evaluated in rat and NHP PK models. Short-term stability tests and device compatibility testing were used to further narrow down formulations for additional PK studies. The lead formulation was tested to five months of stability with >99% assay, <1% total impurities, and positive device compatibility over the storage period. All formulations tested in NHP PK studies resulted in a Tmax of less than 53 minutes and a Cmax greater than 26 nanograms per milliliter (ng/mL). The lead formulation, selected for clinical development in the INP105-101 study, exhibited a Tmax of 17 minutes, similar to that reported for IM OLZ, and a Cmax of 71 ng/mL, approximately threefold higher than the reported Cmax in patients receiving 10 milligrams (mg) IM OLZ.

Conclusion: Impel NeuroPharma is developing a drug-device combination product that will administer powder OLZ to the vascular-rich, upper nasal space with a novel precision olfactory delivery (POD®) device. It is needle-free, easily administered by self or caregiver, and a potentially rapidly effective OLZ treatment to abort episodes of acute agitation in the low-intensity community clinic or emergency department setting. This series of preclinical development studies has led to the identification of a lead formulation to be tested in the INP105-101 proof-of-concept clinical study for further development.

9 Heroin Abstinence: A Case Report of Kratom in the Emergency Department and Beyond

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Introduction: Kratom, an herb that was traditionally used by Southeast Asians to boost energy, is increasingly being used in the United States. According to the American Kratom Association, an estimated two to three million chronic pain sufferers resort to kratom as a "safe," natural alternative to prescription opioids. Some of the reported beneficial effects include analgesic effects, muscle relaxation, and anti-inflammatory properties. In the drug addiction world however, kratom is being propagated as a legal alternative to getting high that is undetectable on routine drug screen. Kratom, or mitragynine, is a major psychoactive alkaloid. Several studies have found that kratom has stimulant effects in small doses but sedative effects in large doses, binding to mu and kappa receptors (Yusoff et al. 2014). Kratom causes cravings and an array of opioid-like withdrawal symptoms when users attempt to decrease usage. Withdrawal symptoms include restlessness, severe bone pain, muscle aches, tearing or runny nose, gastrointestinal (GI) symptoms, blurred vision, depression, irritability, and changes in mood. This case report documents one patient who used kratom as an alternative to heroin use. We also describe its subsequent addictive potential and the successful management of his withdrawal symptoms with an opioid detoxification protocol.

Case Presentation: Our patient was an adult Caucasian male with a past psychiatric history of depression and severe opioid use disorder identified by appropriate history- taking. The patient recounted that he had been using kratom for the prior two and a half years as a "legal alternative" to heroin, motivated by his partner. At the time of encounter, he reported "strong cravings" and withdrawal symptoms when he attempted to abstain from kratom. Urine drug screen was negative. A quick Clinical Opioid Withdrawal Scale (COWS) evaluation was noted to be 30, and inpatient detoxification was deemed appropriate. He admitted to using initially four capsules per day, which increased up to 30 capsules a day over the 30-month time period. He reported having spent a lot of money to feed his habit and noted weight loss and decreased appetite. He reported, "I felt high," and maintained that he had abstained from illicit heroine use. The patient admitted that he had not known kratom had addictive properties and reported that the withdrawal symptoms were more protracted – as long as two months post his last use when compared to that of heroin after being "hard stopped" during a brief incarceration. We used a COWS assessment and scoring to determine management of his withdrawal symptoms at initial presentation and over a short period of time. We measured vital signs, hepatic function, and management of withdrawal symptoms daily two hours after the delivery of daily buprenorphine and naloxone (using tapering protocol) for five days. We also administered clonidine at a dose of 0.1 milligrams (mg) by mouth every six hours (PO q6h), baclofen 10 mg PO for muscle spasms, chlorproamazine/ diphenhydramine 50mg as needed (PRN) for agitation, and ibuprofen 600mg PO q6h PRN for generalized joint pain. We monitored his symptomology by patient evaluation, daily vital signs, and a physician-guided questionnaire.

Results: Electrolytes, renal function and liver studies were found to be within normal limits; however, his heart rate was elevated at 100 beats per minute on day of admission. Blood pressure was 122/75 millimeters of mercury and temperature was 97.5° Fahrenheit with a body mass index of 21.5. Urine toxicology was negative for all drugs of abuse including methadone and opiates. The patient's pupils were constricted and there was profuse diaphoresis visible over his forehead. He also reported joint pain throughout his body, and he was unable to sit still. His eyes were tearing, he had uncontrollable yawning, and complained of "skin crawl." The patient denied having any GI symptoms such as diarrhea or nausea, and he also denied having tremors. No tremors were observed, although muscle twitching of his forearm and biceps was noted. His COWS score was noted to be 30 on day one, and considered moderately severe. HIS COWS score

reduced to five by day four. Of note, the COWs scale increased to 10 by day seven on 0mg of buprenorphine and naloxone.

Conclusion: Kratom possesses properties that can be successfully used as an alternative to heroin use. Nonetheless, there is a potential for abuse, which results in severe opioid- like withdrawal symptoms when the user attempts abstinence. Patients require increasing amounts of kratom as they develop tolerance. Kratom withdrawal symptoms can be successfully managed with opioid detox protocol or buprenorphine/naloxone protocol over a period of five days, although symptoms noticeably last longer. Pharmaceutical companies should explore safe, physician-guided administration of kratom to reduce heroin use and add to our repertoire of methadone or buprenorphine in managing opioid use disorders.

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10 A Case Report and Postulated Systematic Approach to the Evaluation of Emotionalism Post Stroke in a Crisis Unit

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Introduction: Emotionalism post stroke, when inadequately addressed, can cause distress to patients including embarrassment, confusion, possible caregiver complaints, and an overall decrease in health-related quality of life (Badhan, et al, 2014). Also known as pathological laughing and crying (PLC), emotionalism post stroke refers to the involuntary and neurologic pseudo-bulbar affect (PBA). It often leads to uncontrolled and exaggerated expressions of inappropriate, emotionally charged outbursts such as laughing and/or crying (Parvizi, et al, 2001). This "emotional lability" is usually seen in patients with neurological disorders, in particular stroke, and was first described in the literature in 1872. While the exact mechanism can be debated, studies suggest a lesion in the upper brainstem leading to involuntary triggering of the facio-respiratory patterns associated with laughter and crying that involve the motor cortices (Parvizi, et al. 2001) or the cerebellum (Sak, Wilson, 1924). However, with recent studies reporting the prevalence of depression as high as 29% post stroke (Ayerbe, et al, 2013), identifying differences between post-stroke depression and PBA in the emergency setting is crucial for appropriate treatment and disposition. A critical component of patient history with regard to PLC is the lack of inciting stimulus in reports of numerous episodes of pathological crying. This study aims to outline a systematic approach to evaluate and manage patients with PLC in the emergency department (ED).

Case Presentation: The patient was a 74-year-old Caucasian male with no formal PPH and PMH of T2D, HLD, HTN, who was brought by his wife to the ED with complaints of excessive crying and a reported verbalization of suicidal ideation. Upon interview, patient stated that he had been having "crying spells" in excess of emotional stimulus for the prior three months, increasing in severity. He denied neuro-vegetative symptoms of depression. Patient also denied recent stressors. He admitted to a transient ischemic attack five months prior to his presentation. He stated there were no neurological deficits at the time of encounter except for a noted decreased sense of taste. The patient admitted to having suicidal ideations (SI) but without intent, plan, or means. He determined that he had intermittent SI in the context of observing, "Doesn't everyone think about that sometimes?" He did not report details of his SI as he determined they were passive and vague thoughts of what it would be like to be dead. He denied past or recent suicide attempts or self-injurious behavior. The patient reported he had met with his primary care physician who advised him to go to the ED for further evaluation. The patient and his wife, also in her 70s, reported they thought the ED could prescribe medications and were not seeking hospitalization. His wife stated that the patient had been "crying at the drop of a hat." She noted that this was not usual for him and denied any recent stressors, or past episodes. She further stated, "I was at my wit's end and I feel like something is wrong with him." Patient stated the breaking point was his inability to attend an important engagement due to a dis-inhibited "crying spell" that lasted > 10 minutes. He and his wife reported frustration. The patient also reported, "I can't take it. Please help me." Patient affect was depressed, with intermittent "episodes of crying." We placed him on hold and re-evaluate status.

Method: Patient consent for this study was obtained. A literature search was performed in PubMed and JAMA Psychiatry for articles published on pathological laughing and crying since 1900, using multiple combinations of the search terms, which included the following: post stroke crying syndrome, emotionalism post stroke, involuntary emotional expression, and post stroke neurological disorders. The development of evidence approach and drafting of systemic approach.

Results: On observation, the patient had depressed affect and intermittent episodes of crying without provocation. He repeatedly denied being depressed and denied neuro-vegetative symptoms of depression despite his affect. Psychological review of systems was negative. Vital signs, complete blood count, and electrolytes were within normal limits. Collateral information was obtained and old chart review revealed mild to moderate small-vessel ischemic changes, including a semi-ovale infarct five months prior to presentation. His wife stated she wanted help for his presumed depression. Clinical pathway for the evaluation of emotionalism post stroke in the crisis unit

includes performing the following: patient intake and triaging —> medical clearance and laboratory work —> patient history, and collateral information —> If patient psychiatrically stable by negative psychological review of systems, consider past medical history for risk factors significant for stroke —> consider ancillary tests to rule out differential diagnoses —> Patient education and reassurance —> Discharge with follow up as a key to diagnosis. Criteria for discharge can include lack of PPH, patient denial of neuro-vegetative depressive symptoms, access to immediate follow-up, social support, lack of social concerns, collateral comfortable with discharge plan and understanding of next steps regarding treatment and follow-up. Citalopram prescribed to patient resulted in decrease in incidence of crying spells. Studies show Citalopram, paroxetine, and sertraline provide >90% efficacy and reduction in depressive affect and pathological crying in patients (Schiffer et al, 2005).

Conclusion: Post-stroke, neuro-psychiatric pathological crying syndrome is a disorder that results from lesions affecting the pseudo-bulbar aspects of the brain and can go unrecognized. Due diligence on the part of the physician can allow for appropriate disposition, and time and cost-effective steps for proper management of the patient presenting with PLC in the ED. Definitive treatment includes outpatient management with a selective serotonin re-uptake inhibition, in particular Citalopram, paroxetine, and sertraline.

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