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Original Contribution

Ultrasound-guided central venous access: which probe is preferred for viewing the subclavian vein using a supraclavicular approach?☆,☆☆

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ABSTRACT

Background: Point-of-care ultrasound guidance using a linear probe is well established as a tool to increase safety when performing a supradiaphragmatic cannulation of the internal jugular central vein. However, little data exist on which probe is best for performing a supradiaphragmatic cannulation of the subclavian vein.
Methods: This was a prospective, observational study at a single-site emergency department, where 5 different physician sonologists evaluate individual practice preference for visualization of the subclavian vein using a supraclavicular approach with 2 different linear probes and 1 endocavitary probe.
Results: Of 155 patients enrolled, there was no clear preference any of the probes ($P = .03$). After pooling linear probe preference, there was a preference for either linear probe over the alternative endocavitary probe (76.8% vs 23.1%, $P < .05$).
Conclusion: We observed a preference for a linear probe over an endocavitary probe. Further investigation is necessary to determine which probe is optimal for this application.

1. Introduction

Central venous catheters are commonly placed in the internal jugular, femoral, or subclavian veins for critically ill patients who require hemodynamic monitoring or administration of centrally acting intravenous medications. In 2006, the American College of Emergency Physicians recognized and endorsed the use of point-of-care ultrasound for safe placement of these catheters to the internal jugular when a supradiaphragmatic cannulation is necessary [1]. More recently, a growing number of adult and pediatric studies have documented the potential use and advantages of point-of-care ultrasound guidance in the cannulation of the subclavian vein (SCV) as well [2–6]. Furthermore, the supraclavicular approach to point-of-care ultrasound-guided SCV cannulation has demonstrated significant advantages with success and safety when compared with the more traditional "blind" infraclavicular approach [7–13].

It is well known that various ultrasound probes can be used to aid with ultrasound-guided SCV cannulation; however, there is no agreed upon consensus as to which probe is best. On the basis of studies for the internal jugular, visualization within the supraclavicular fossa has typically been performed using a high-frequency linear probe in a longitudinal plane of the SCV, which is done to prevent transfixion of the vein and avoid the dreaded complication of an iatrogenic pneumothorax. Although suggested by Mallin et al [14] that the endocavitary probe may be better suited for use for supraclavicular line placement due to the cul-de-sac shape of the supraclavicular space, there remains no studies that have compared the use of different ultrasound probes to visualize the SCV from a supraclavicular approach.

In this pilot study, we sought to identify which probe is preferred by clinicians for the visualization of the SCV using a supraclavicular approach. No attempt was made to determine accuracy or easiness of performing the procedure under ultrasound guidance.

2. Methods

2.1. Study design

This was a single-center, prospective, observational study that compared provider preference of 3 different probes in identifying the SCV using a supraclavicular approach. The study was approved by the site institutional review board.

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2.2. Study setting and population

The study was performed at an urban, level 1 trauma center that supports an Emergency Medicine Residency Program. The emergency department (ED) has an annual census of 57 000 patients. Adult patients presenting to the ED between February 2014 and October 2014 were eligible for participation. Inclusion criteria were age 18 years or more and ability to provide written consent in either English or Spanish. Any patient physically present in the ED was eligible for participation except for those with chest trauma or a history of chest surgery. On the basis of institutional guidelines, prisoners, pregnant patients, and those presenting with psychiatric complaints were also excluded from the study.

2.3. Study protocol

Five physicians of various training levels were asked to visualize the SVC using a supraclavicular approach with 3 different ultrasound probes and then indicate their preferred probe. All 5 physicians were trained in image acquisition by a fellowship trained, expert sonologist. Training sessions consisted of a 30-minute lecture and hands-on training. Undergraduate research student volunteers assisted in patient enrollment and data collection.

After obtaining consent, patients underwent bedside ultrasonography of the SCV by one of the trained physicians. A patient could be scanned by multiple sonologists, as long the sonologists were blinded to the findings and preferences of the prior scanner. A Sonosite Edge ultrasound machine (FUJIFILM SonoSite Inc, Bothell, Washington) with a long footprint linear probe (38 mm, 10-5 MHz), a short footprint linear probe (25 mm, 13-6 MHz), and a microconvex tightly curved footprint endocavitary probe (8-5 MHz) were used for image acquisition. Access to the supraclavicular fossa was obtained by placing patients in the supine position with their heads rotated contralaterally. The SCV was identified by 1 of 2 methods: (1) following the internal jugular vein caudally into the supraclavicular fossa where it meets the SCV or (2) placing the probe into the fossa and angling anteriorly to capture the long-axis view of the SCV (Fig. 1). Either the right or left SCV was scanned at the discretion of the physician performing the scan.

2.4. Outcome measures

The primary end point of this study was sonologist preference by probe type for visualizing the SCV.

2.5. Statistical analysis

Sample size calculations determined that 151 images were required to detect a statistical significance of less than .05 with a power of 80%. We collected data on 174 images to allow for 10% exclusion. Study data were collected and analyzed using Research Electronic Data Capture tools. The data were analyzed used Stata (Version 12.1, StataCorp, College Station, Texas). Categorical variables were analyzed using Pearson χ^2 test.

3. Results

One hundred seventy-four patients were enrolled in the study. Nineteen (10.9%) were excluded due to incomplete data. One hundred fifty-five (90.1%) were included in the final analysis (Fig. 2). The average body mass index (BMI) was 25.9, with 49% being male. Most of the patients (72.9% vs 27.1%, $P < .05$) were obese (BMI, >30.0) (Table 1). Breakdown of assessments done by each sonologist were as follows: 10 by fellowship-trained sonologist (6.5%), 30 by fellow A (19.4%), 23 by fellow B (14.8%), 11 by fellow C (7.1%), and 81 by a Post graduate year-2 resident (52.3%).

There was no individual preference between each of the individual probes (38.7% [n = 60] 25 mm linear, 38.1% [n = 59] 38 mm linear, 23.2% [n = 36] endocavitary; $P = .03$). After pooling linear probes, there was a preference for linear over endocavitary (76.8% [n = 119] either linear vs 23.2% [n = 36] endocavitary; $P < .05$) (Table 2). When comparing all probes, there was no difference in sonologist probe preference based on sex ($P = .81$) or patient BMI ($P = .30$).

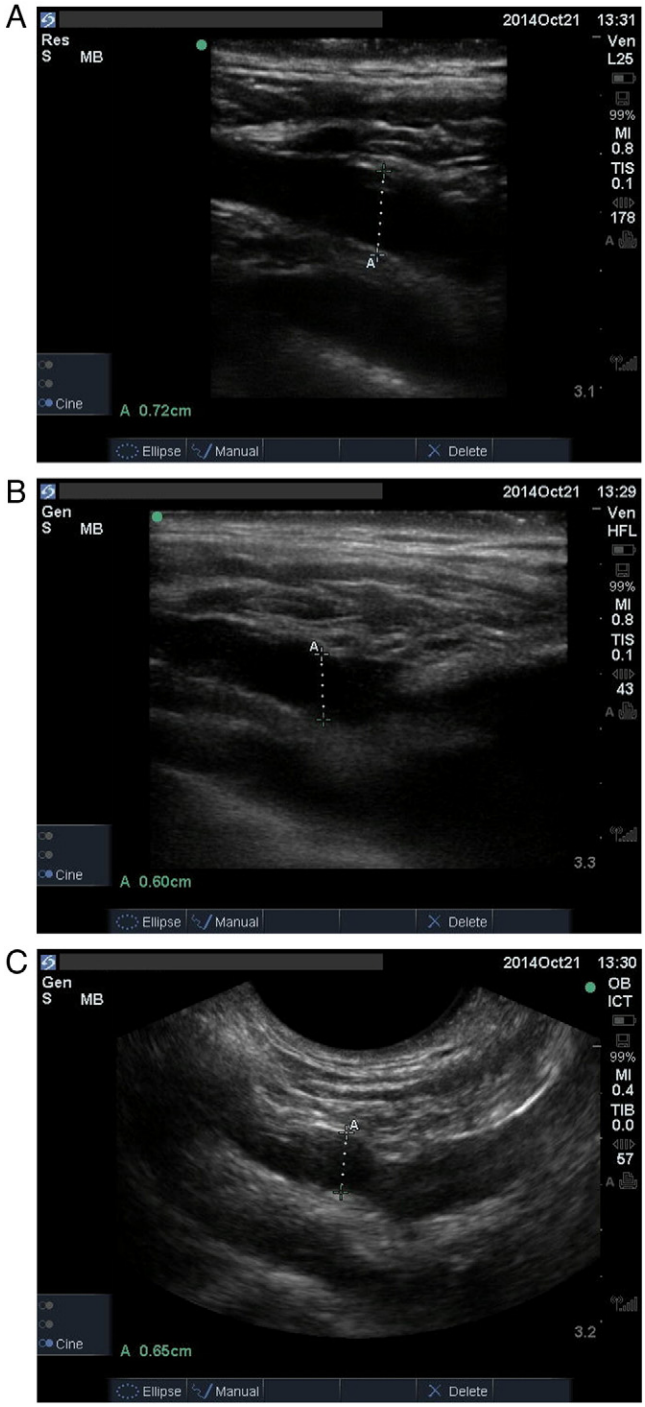

Fig. 1. The SCV from the supraclavicular view, using the L-25 (A), L-38 (B), and endocavitary probes (C).

4. Discussion

In recent years, a growing number of studies have documented the high rates of success and low rates of complications using ultrasound via the supraclavicular approach to assist in subclavian line placement in both pediatric and adult populations [7,8,10–12]. The largest, a retrospective series by Bertini et al [9], reported 100% success rate in the

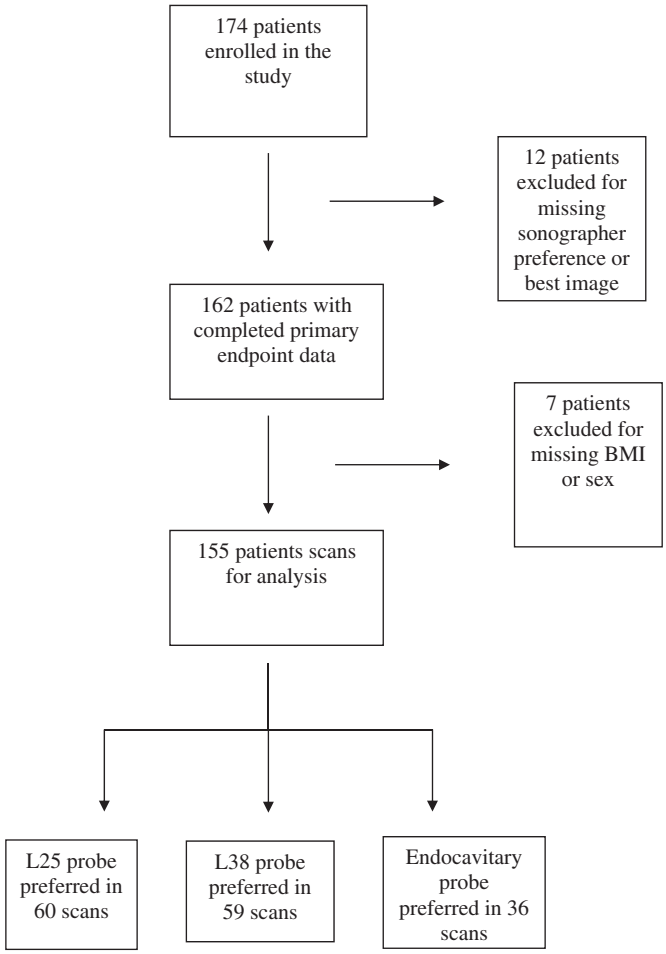

Fig. 2. A total of 174 patients were enrolled and scanned with the 3 probes. Twelve patients were excluded for missing primary end point data and 7 were excluded for missing secondary end point data.

placement of 77 subclavian and 42 brachiocephalic lines without complications. These studies offer encouragement that subclavian venous cannulation can continue to be performed safely and effectively, rather than potentially becoming the "forgotten central line" [15]. However, to date, there are no studies that identify which probe is best suited for this function. Currently, most EDs have ultrasound machines that are equipped with multiple transducers, and classically, linear probes have been used for central line placement.

We suspect much of the reason a linear probe was preferred over the endocavitary probe has to do with the size and shape of the probe. Stabilizing an endocavitary probe head within the supraclavicular fossa is technically challenging, as the sonologist must grip the wand's handle rather than simply holding the probe and anchoring to the patient with a couple of fingers. This situation would be far from ideal in the actual setting of inserting a central line and would vary significantly from ultrasound-guided internal jugular vein and femoral central venous catheters. However, it is important to consider that in a code situation on an obsetrical floor, for example, an ultrasound machine setup is typically only equipped with a large low-frequency curved probe and an endocavitary probe, not a linear one. A physician responding to a peri-arrest situation could use that machine to safely insert a central line (as opposed to blind).

Although not evaluated, pediatric transducers with their very small, tight curved footprints and their higher frequency bandwidths, or "hockey stick"–shaped linear or cardiac curved array probes, may be preferable within the supraclavicular fossa due to their small footprint and high resolution. Better still, we believe, would be an ultrasound transducer that combined the high frequency of a linear array with the curved shape of a curved-array probe. Future studies and advances in probe technology are required to identify the most ideal probe for this application.

Table 1
BMI distribution

BMI category	No. (%)	*P*
Underweight <18.5	4 (2.6)	<.0001
Normal weight 18.5-24.9	38 (24.5)	
Overweight 25.0-29.9	53 (34.2)	
Obese 30.0-39.9	49 (31.6)	
Very obese >40.0	11 (7.1)	
Total	155 (100.0)	

Table 2
Sonographer preference by probe type

Probe	No. (%)	*P*
L25	60 (38.7)	.03
L38	59 (38.1)	
Endocavitary	36 (23.2)	
Total	155 (100.0)	

5. Limitations

There are several limitations to our study. First, only 5 physicians participated in the study, so their preference may not be generalizable to all physicians. Second, all 5 physicians were trained to place ultrasound-guided central venous catheters using linear probes, so they may have already had a natural preference for a linear probe due to previous comfort. Third, patients were enrolled in a convenience sample, which may have created a selection bias. Fourth, we did not require each patient be placed in the same position during assessment, such as uniform Trendelenburg positioning with a neutral head position, which may also have limited the sonologist to best visualize the SCV, though, hopefully, this was mitigated by producing a "real-world" situation that would favor the best performing probe [16,17]. Last, from our observational study, we cannot say whether probe preference translates into improved success or reduced complications because no data were collected on the success of vessel cannulation.

6. Conclusions

Physician sonologists of various training levels had a preference for a linear probe over an endocavitary probe for visualization of the SCV when using a supraclavicular approach.

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