Ask CaJEM

In this issue we present our opening installment of "*Ask CaJEM*", a format for you to find concise responses to clinical questions that are not easily answered in standard textbooks. Please submit your questions to the Editor at rrodriguez@hghed.com

When looking at a non-contrast head CT, what actually appears white in an acute hemorrhagic stroke?

John Stein, MD
Department of Emergency Medicine
UCSF Medical Center
San Francisco, California

Computed tomography (CT) of the head has become an invaluable tool in emergency diagnosis of intracranial hemorrhage. In this potentially disabling and/or life-threatening condition, early and accurate diagnosis is crucial and likely will change patient outcome. For this reason, it is important to have a good understanding of the variable appearance of blood and an evolving hematoma on head CT.

The Hounsfield scale is a range of Hounsfield units (Hu)—numerical indications of a tissue's ability to attenuate an x-ray beam. In other words, Hus are a measure of the density of a structure on CT[1]. The units are established on a relative scale with the attenuation of water as the reference point. Water is always 0 Hu, bone is +1000Hu and air is -1000Hu (see fig 1). The attenuation ments of various elements of whole blood have been studied and well-documented [2]. There is a linear relationship between the attenuation of blood and hemoglobin and hematocrit levels[2, 3]. Additionally, it has been established that plasma, iron and calcium minimally contribute to the attenuation of blood and clot and that hemoglobin is predominantly responsible[3].

Typically what is displayed on head CT in the setting of acute hemorrhagic stroke is white-appearing, hyperdense hematoma. The density value is between 60-80Hus and is primarily due to fibrin meshwork formation, the protein component of hemoglobin and increase in hematocrit from clot retraction. The density will increase to 80-100Hu as the clot continues to retract and serum is absorbed over the first week[4]. The exception to this is subarachnoid hemorrhage. CT is most sensitive in the first 12 hours and depends on volume of blood and hematocrit. Density of the hematoma decreases rapidly after the first 24 hours. This is thought to be caused by dilution by cerebrospinal fluid and rapid clearing of subarachnoid hematoma[5].

Reasons an *acute* hematoma may appear isodense on CT include coagulopathy and anemia[6]. Recall that the attenuation is linearly related to hemoglobin and hematocrit levels. At hemoglobin levels less than 10gm/dL the Hu are within the range of gray matter and may make detection on CT very difficult[3].

Additionally, the hematoma may appear heterogeneous on CT for three reasons. First, acute hemorrhage (of less than one hour duration) will appear heterogeneous, demonstrating mixed

ties of blood and forming clot ranging from 40-60 Hus. The earlier the CT, the more fresh blood, the more isodense the lesion appears. Second, active rebleeding or ongoing hemorrhage may appear heterogeneous on CT with isodense, fresh blood amidst hyperdense formed clot[7]. This is most commonly seen in epidural hematomas seen in the hyperacute phase with active arterial bleeding. Third, occasionally with a large hematoma there may be a fluid-fluid level representing sedimented cellular element and supernatant. Termed the "hematocrit effect", this is seen in active, large volume hemorrhage and in patients with coagulopathies[4].

Occasionally, a patient may present some time after the initial hemorrhagic event. When a CT is warranted based on clinical suspicion of a subdural hematoma (SDH), it is important to understand the changes in appearance that occur. At one to three weeks, the subacute phase is established; the clot begins to liquefy and protein is degraded and absorbed. During this phase there will be an isodense period making CT diagnosis at this time very difficult[9]. Most SDHs will resolve completely but rarely chronic SDHs will develop. This occurs more commonly in the elderly and takes two weeks to months to develop depending on the initial size of the hematoma. On CT this appears as a low attenuation collection which may have septated areas with fluid levels if rebleeding occurred [9].

When evaluating a head CT for hemorrhagic events, it is important to keep in mind the various stages of evolution of hematomas and the various factors which will alter its appearance, especially measuredensiage of the blood. Be wary of a "negative" CT when clinical suspicion is high, particularly in the setting of anemia, coagulopathy.

Krista Huerta, MD
Senior resident-Emergency medicine
Alameda County Medical Center
Oakland, California

1. Seeram E: Physical principles of computed tomography: *Computed tomography.* Philadelphia, WB Saunders Company, 2001, pp66-7.
2. New PFJ, Aronow S: Attenuation measurements of whole blood and blood fractions in computed tomography. Radiology 121:635-40, 1976.
3. Norman D, Price D, Boyd D et al: Quantitative aspects of computed tomography of the blood and cerebrospinal fluid. Radiology 123:335-8, 1977.
4. Parizel PM, Makkat S, Van Miert E et al: Intracranial hemorrhage: principles of CT and MRI interpretation. Eur Radiol 11:1770-1783, 2001.
5. Edlow JA, Caplan LR: Avoiding pitfalls in the diagnosis of subarachnoid hemorrhage. NEJM 342:29-36, 2000.
6. Kaufman HH, Singer JM, Sadhu VK et al: Isodense acute subdural hematoma. J of Comp Asst Tom 4:557-9, 1980.
7. Greenberg J, Cohen WA, Cooper PR: The "hyperacute" extraxial intracranial hematoma: computed tomographic findings and clinical significance. Neurosurg 17:48-56, 1985.
8. Peterson OF and Espersen JO: How to distinguish between bleeding and coagulated extradural hematomas on the plain CT scanning. Neurorad 26:285-92, 1984.
9. Fischbein NJ, Dillon WP, Barkovich AJ: Trauma: *Teaching atlas of brain imaging.* New York, Thieme Medical Publishers, 2000, pp 425-31.