Neuroimaging Highlight

Dual-Energy CT Differentiation of Iodinated Contrast Staining versus Hemorrhage

Submitted by: Timothy Alves, Ashok Srinivasan

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A 79-year-old female with a history of end-stage renal disease, multiple intracranial aneurysms, and endovascular coil embolization of a large left internal carotid artery terminus aneurysm six years earlier presented with increasing episodic headaches. Because of concern for aneurysmal hemorrhage and/or regrowth a computed tomography (CT) scan was ordered, which showed no acute hemorrhage. Subsequent diagnostic cerebral catheter angiogram showed interval increase and recanalization of the left carotid terminus aneurysm; therefore, a decision for elective repeat endovascular coiling with balloon remodeling was made.

During the uneventful procedure, multiple coils were successfully placed within the aneurysm sac with balloon assistance. However, upon waking from general anesthesia, the patient developed confusion and aphasia. Because the patient had received iodinated contrast material during the endovascular procedure, which could interfere with visualization of acute hemorrhage (resulting from similar attenuation), a dual-energy Gemstone spectral imaging CT head was performed. Although the noncontrast head CT at 140 kVp demonstrated gyriform high attenuation in the left frontal lobe (Figure 1A), the iodine subtraction maps demonstrated no corresponding high attenuation (Figure 1B). Therefore, the high attenuation was believed to indicate iodine staining in ischemic brain, a known phenomenon, rather than true hemorrhage. Follow-up CT performed about 24 hours later showed no hyperattenuation in the left frontal region, confirming the absence of hemorrhage.

The temporary cessation of blood flow during the balloon inflation was considered to be the likely cause of the ischemia. Brain magnetic resonance imaging (not shown) demonstrated multiple small foci of impeded diffusion in the bilateral cerebral and medial cerebellar hemispheres in a watershed distribution possibly related to hypoperfusion; however, no acute blood pressure fluctuations were noted in the anesthetic records and the preoperative cardiac evaluation had been normal. The patient was managed conservatively, returned to neurologic baseline, and was ultimately discharged to home.

Discussion

Dual-energy CT offers more than the ability to distinguish tissues based on attenuation alone; material density analysis allows for detection of voxels that predominantly contain a specific material such as water, iodine, and calcium. By identifying these materials in specific voxels, it is then possible to create images in which the contribution of these materials are minimized, subtracted, or even highlighted. Dual-energy CT uses the three-material decomposition principle to determine the iodine content of each scanned voxel, which can then be subtracted to create a virtual unenhanced image.[1] This method relies on the exaggerated differences in attenuation among brain parenchyma, acute blood products, and iodine at lower peak kilovoltage, because imaging at a peak kilovoltage closer to iodine's K-edge leads to significantly increased attenuation of iodine resulting from a greater contribution from the photoelectric effect.

This emerging technique has proven useful in distinguishing intracranial hemorrhage, which persists on virtual unenhanced images, from iodinated contrast, which does not.[2-4] This can be helpful in guiding appropriate management of neurointerventional patients who have recently received intravenous or intraarterial contrast administration by distinguishing brain parenchymal iodinated contrast straining from hemorrhage.[2-4] Additional scenarios in which dual-energy CT may be useful include differentiating contrast staining versus hemorrhagic conversion in stroke patients, evaluating for acute intracranial hemorrhage in the setting of recent CT myelography (which can be confounded by intrathecal contrast administration), creation of virtual unenhanced images from CT angiography source images to lower radiation dose by eliminating the additional noncontrast scan,[2-5] and minimizing metal artifact in patients with spinal hardware.[6]

Statement of Authorship

TA carried out manuscript design and preparation. AS carried out manuscript design and editing.

From the Department of Radiology, University of Michigan Health System, Ann Arbor, MI 48109
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Correspondence to: Ashok Srinivasan, Division of Neuroradiology, Department of Radiology, UH B2 A209, University of Michigan Health System, 1500 E. Medical Center Drive, Ann Arbor, MI 48109. Email: ashoks@med.umich.edu

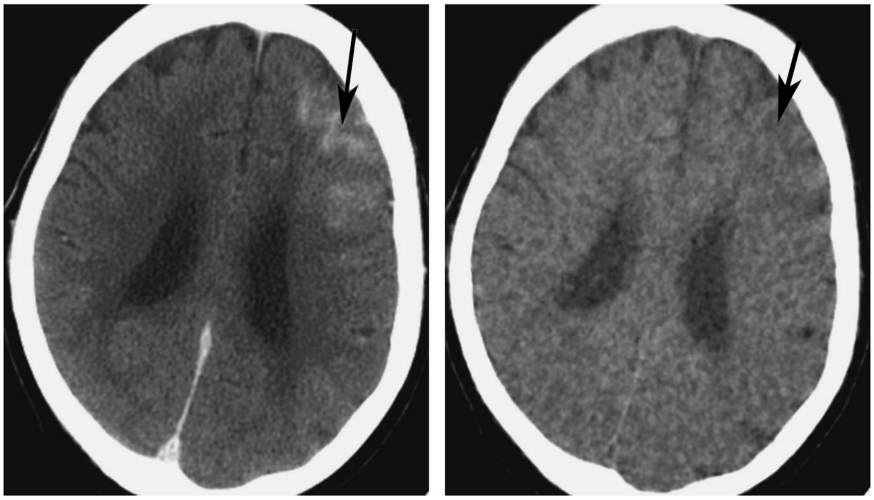

Figure 1: *(A) Nonenhanced head CT (quality check image during the dual-energy CT) obtained shortly after the onset of symptoms demonstrates gyriform high attenuation in the left frontal lobe involving the peripheral cortex/adjacent sulci (arrow), which was concerning for acute hemorrhage. (B) A dual-energy CT derived iodine subtraction map demonstrates lack of any high attenuation in the left frontal lobe in the same locations as (A; arrow), suggesting that the high attenuation was due to iodine staining of ischemic parenchyma and not acute hemorrhage.*

Figure 2: *Repeat nonenhanced CT performed approximately 48 hours after the dual-energy head CT demonstrates complete resolution of the gyriform high attenuation in the left frontal lobe.*

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