Dual-Energy CTA to Diagnose Subarachnoid Hemorrhage: Ready for Prime Time?

In the article published in this issue of the *American Journal of Neuroradiology*, "Evaluation of Virtual Noncontrast Images Obtained from Dual-Energy CTA for Diagnosing Subarachnoid Hemorrhage,"[1] the authors studied 84 patients, including 55 with subarachnoid hemorrhages (SAHs), by using standard (true) noncontrast head CT (TNC), dual-energy CT (DECT) angiography, and a virtual noncontrast CT (VNC) derived from the DECT angiography. The goal was to compare the ability of VNC to detect SAH by using TNC as the criterion standard (100% presumed sensitivity). Comparisons were made at the "individual level" (ie, based on the CT as a whole for a given patient) and on the "lesion level" on the basis of 27 different subarachnoid-designated regions on the CT scan. Image noise between the 2 modalities was also compared as was radiation dosage. The authors found no statistical difference in SAH detection between VNC and TNC, with VNC having very high sensitivity and specificity. There were, however, 3 patients with subarachnoid hemorrhages on TNC that were missed on VNC, and there were 86 "lesion level" misses. Image noise was higher for VNC, and radiation dosage was higher for TNC. The authors concluded that VNC is an effective technique to detect SAH with less radiation.

This publication is important in that it focuses attention on the radiation dosage as part of diagnostic neuroradiologic imaging. It is important for clinicians to be aware of the radiation dosages of tests we order or at the least to be aware of the comparative doses of tests that might yield similar sensitivities and specificities. DECT angiography has been used for other disease entities outside the central nervous system, and only very few publications have touched on its use within the central nervous system, including 1 article on unruptured aneurysms[2] and another on a heterogeneous collection of intracranial bleeds.[3] The effort here to use DECT as the initial evaluation tool to diagnose SAH is creative and unique. Radiation is potentially detrimental, particularly for younger patients. The carcinogenic effect of even 1 CT scan has been documented and is the subject of considerable research attention.[4] With the average age of 55 years for SAH from aneurysmal rupture in this country, radiation exposure is very relevant. Any effort at reducing the dose is welcome.

Nevertheless, one must very carefully perform a risk/benefit analysis for any dose reduction in terms of potential compromise in missed diagnoses and the ultimate harm to patients of such misses. This is the crux of interpreting the use of VNC as opposed to TNC as the initial test of choice in the work-up of suspected SAH. An estimated 80%–85% of atraumatic SAH is caused by a ruptured cerebral aneurysm. However, not all are.[5,6] The morbidity and mortality of aneurysmal SAH are still quite high despite advances in neurocritical care and endovascular and microsurgical aneurysm repair techniques. The missed diagnosis of even 1 aneurysmal rupture could lead to rerupture, with a significant possibility of neurologic devastation or death and might outweigh any potential benefit from radiation spared.

Thus, the missed diagnoses of 3 patients with SAH by using VNC in this study bear some discussion. First, the clinical importance lies in the ability of VNC to detect SAH at the "individual" and not the "lesion" level. We are in the business of treating patients, not CT scans. The authors used 2 statistical techniques to demonstrate the utility of VNC in assessing SAH: 1) the McNemar test with a κ statistic, which measures agreement or reliability; and 2) sensitivity and specificity with their associated positive predictive and negative predictive values, which measure validity. If we accept noncontrast CT as the criterion standard for evaluating SAH, then we only need to report sensitivity and specificity to make this point.

The finding of 94.5% sensitivity at the "individual" level is quite high. However, is it adequate for detection of SAH when the consequence for a missed diagnosis is potentially dire and the risks of the additional radiation possibly quite acceptable in this setting? Confidence intervals would have been helpful here to emphasize the point that this statistic is associated with sampling variation and that the true value of sensitivity can conceivably be lower. Of course, one could debate whether a noncontrast CT scan, which itself has a certain sensitivity and specificity for detecting SAH, is, in fact, the criterion standard for diagnosing SAH. Is MR imaging better? How about a spinal tap? The question is, of course, controversial. The McNemar test showed an "almost perfect" agreement between the 2 tests, documenting that much of the time, the 2 tests agree. However again, much of the time may not be good enough if missing a cerebral aneurysm rupture is one of these times. A significant time lag between the ictus and the 3 missed SAHs on CT attests to the notion that the sensitivity of CT for SAH drops with time and that a low threshold for timely CT when SAH is suspected is justified. Using VNC to detect SAH with reduced radiation bears future investigation.

Part of the methodology of this study is a clinical algorithm whereby DECT angiography is obtained as a first technique to work-up a potential SAH, looking for both cerebral aneurysms and SAH. This approach is somewhat contrary to that used by many for the evaluation of suspected aneurysmal SAH.[5,7] Typically, the effort is to diagnose SAH first and only secondarily to determine the etiology. Therefore, if the CT finding is negative, for example, typically a spinal tap is performed to try to determine whether there has been a hemorrhage.[8] Obtaining a CTA first puts the cart before the horse in that incidental vascular lesions may be encountered. Alternatively, often either no imaging or MR imaging, which avoids radiation altogether, would suffice. The utility of finding incidental vascular lesions is ambiguous, and such findings may open Pandora's box because the management of such lesions is very controversial. The management of SAH is less controversial; therefore, an effort to establish this diagnosis, neutralizing a vascular cause by using endovascular or surgical means to prevent rebleeding, should be paramount. Therefore, in deciding whether the reduction in radiation risk associated with the use of DECT angiography is worthwhile, one must also weigh in the following: 1) the risk associated with a possible missed SAH diagnosis; 2) the risk associated with increased radiation accompanying a potentially lower imaging threshold for performing CTA in the evaluation of potential SAH (assuming that clinicians view the DECT angiography as affording 2 diagnostic tests for the radiation cost of 1); 3) the risk associated with uncovering incidental vascular lesions; and 4) nephrotoxic and allergic risks associated with DECT angiography. This risk/benefit analysis is beyond the scope of this study and this "Commentary" but would be a welcome addition to future work on this topic.

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