Accuracy of Computed Tomographic Angiography Compared to Digital Subtraction Angiography in the Diagnosis of Intracranial Stenosis and its Impact on Clinical Decision-making

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Background: Few studies to date have examined the accuracy of computed tomographic angiography (CTA) compared to digital subtraction angiography (DSA) in diagnosing intracranial stenosis. The purpose of this study was to compare CTA to DSA in diagnosing intracranial stenosis and to explore the impact of the addition of DSA on the management of stroke patients. *Methods:* We retrospectively reviewed all ischemic stroke or patients with transient ischemic attack who underwent CTA and DSA within 30 days of each other at our institution between January 2008 and July 2011. For each study, 2 blinded observers rated the degree of stenosis of 11 intracranial vessels. Disagreements were adjudicated by a third blinded observer. Sensitivity, specificity, negative predictive value, and receiver operating characteristic curves were determined using DSA as the criterion standard. All patient charts were reviewed to determine if the addition of DSA to CTA impacted clinical management. *Results:* Six hundred twenty-seven arterial segments were reviewed. The sensitivity of CTA to diagnose stenosis >50% was 96.6% (95% confidence interval [CI] 88.1-99.6), specificity 99.4% (95% CI 98.1-99.9), and negative predictive value 99.6% (95% CI 98.4-99.9). The intraclass correlation between CTA and DSA measurements was 0.96 (95% CI 0.95-0.97). Five of 57 patients underwent intracranial stenting procedures during the study period. All 5 lesions were correctly characterized as having >70% stenosis on CTA. Of the remaining 52 patients, none had clinical management change based on DSA findings. *Conclusions:* CTA has a high sensitivity and specificity compared to DSA to diagnose intracranial stenosis. The addition of DSA to CTA may not affect clinical management in most patients with suspected stenosis. **Key Words:** Angiography—computed tomographic angiography—diagnostic accuracy—intracranial atherosclerosis.

Intracranial atherosclerotic disease (ICAD) accounts for <10% of ischemic strokes in the United States.[1] However, the prevalence is higher in patients of Hispanic, African American, and Asian ethnicities, making it the most common cause of stroke worldwide.[2] The recurrent rate of stroke in patients with ICAD at 1 year may be as high as 20%.[3] However, with optimal medical management, even patients with severe (>70%) stenosis may have lower rates of recurrence.[4] The accurate diagnosis of ICAD is essential to the initiation of appropriate secondary prevention strategies.

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The criterion standard for diagnosing intracranial atherosclerosis remains digital subtraction angiography (DSA). However, DSA is time consuming and invasive, with a reported risk of neurologic complications of approximately 1%, including a 0.5% chance of permanent neurologic deficit.[5] DSA is also typically restricted to larger centers with expertise in performing these procedures. Noninvasive imaging modalities, such as computed tomographic angiography (CTA), are readily available at most centers and may offer an alternative to DSA in the diagnosis of ICAD. To date, only a handful of studies have reported on the accuracy of CTA compared to DSA in diagnosing ICAD.[6-9] These studies have been limited by small sample sizes and the low prevalence of intracranial atherosclerosis. The aim of this study was to compare the accuracy of CTA with DSA in the diagnosis of ICAD in a university setting with an ethnically diverse patient population.

Methods

Institutional review board approval was obtained before the initiation of this study. We retrospectively identified all patients who underwent both CTA and DSA within 30 days of each other and who were admitted to our institution with a diagnosis of ischemic stroke or transient ischemic attack (TIA) between January 1, 2008 and July 31, 2011. Patients were identified through an electronic search of the radiology imaging archives. Patients were excluded if the final diagnosis included subarachnoid hemorrhage, vasculitis, vasospasm, or dissection. Patients were also excluded if they underwent acute intervention for stroke, such as intra-arterial tissue plasminogen activator infusion, thrombectomy, or stenting before diagnostic imaging with CTA and DSA. We reviewed the paper charts for each patient to determine whether findings on DSA altered clinical management. Changes in clinical management included changes in medications (the addition or discontinuation of medications), surgical or endovascular procedures, or additional diagnostic testing ordered as a result of findings on DSA.

Image Acquisition

CTA was performed as part of our institutional clinical protocol for the evaluation of patients with suspected stroke or TIA. Images were acquired on a GE LightSpeed 16 slice CT scanner (GE Healthcare; Little Chalfont, Buckinghamshire, United Kingdom). Scans were performed according to the manufacturer's recommended protocol. Briefly, each patient received 75 to 100 mL of 370 mg/mL iopamidol (Isovue; Nycomed, Singen, Germany) via an antecubital vein at a rate of 4 mL per second followed by a 50-mL saline bolus. Our image acquisition protocol incorporates a smart preparation technique rather than the recommended delay times of 16 to 20 seconds in order to compensate for patient variability in ejection fraction. Acquisition parameters included a helical scan mode with a 20-cm field of view (FOV), 120 kVp/380 mA voltage/load, 5.63- to 17.5-mm rotation table speed, and a pitch of 1.375:1 for the neck and 0.938:1 for the brain. Scanning was performed in the caudocephalad direction from the aortic arch to vertex encompassing the entire brain. Sagittal, coronal, and axial maximum intensity projection reconstructions were obtained using a 0.625-mm slice thickness with a reconstruction interval of 0.5 to 0.6 mm and a FOV of 20 cm.

DSAs were performed at the request of the treating stroke physician to evaluate for ICAD. A standard transfemoral technique using a 5 French catheter (either Vert, Cordis Endovascular [Miami Lakes, FL], or an angle-tapered Glidecath [Terumo, Somerset, NJ]) was used. Eight to 12 mL of iopamidol was used per vessel. DSA images were obtained at a rate of 2.5 frames per second in standard anteroposterior and lateral projections. Images were acquired on a GE Advantx LCN biplane (GE Healthcare).

Image Analysis

Each study was reviewed by 2 observers with training in the interpretation of CTA and DSA images. Both observers were blinded to clinical status and previous image interpretations. Eleven prespecified vessels were evaluated, including the intracranial internal carotid arteries and the anterior, middle, vertebral, basilar, and posterior cerebral arteries. Vessel segments were excluded if they were judged by either observer to be incompletely visualized either because of technical issues with image acquisition or processing, such as motion artifact, or if the vessel was seen filling only through collaterals or was hypoplastic or absent. Each observer independently rated the degree of stenosis for each vessel at the segment of highest stenosis as judged by visual inspection. The average of the 2 measurements (if within 10%) was used for the final analysis. Any disagreement of >10% was adjudicated by a third observer who was also blinded. In cases of disagreement, the average of the 2 closest measurements were included in the final analysis.

DSA measurements were performed by analyzing the native angiograms at the same level of magnification using the stenosis analysis function on the GE Advantx LCN biplane. The stenotic and reference segments were chosen in accordance with the Warfarin–Aspirin Symptomatic Intracranial Disease (WASID) method.[10] Measurements on CTA were obtained using the ruler function on a GE Radiology RA1000 picture archiving workstation (GE Healthcare). CTA images were viewed on a Barco MDCG3120 3 MegaPixel high-resolution liquid crystal display monitor (BarcoView, Duluth, Georgia). After all images were reviewed, including the source images, the diameters of the stenotic and reference segments were measured on the maximum intensity projection reconstructions orthogonally to the longitudinal