Combination of Noninvasive Neurovascular Imaging Modalities in Stroke Patients: Patterns of Use and Impact on Need for Digital Subtraction Angiography

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Background: The diagnostic work-up of acute stroke relies on the use of proper imaging studies. We sought to determine the use of a combination of 2 noninvasive tests, namely magnetic resonance angiography (MRA) and computed tomographic angiography (CTA) in diagnosing vascular lesions and the necessity for a subsequent digital subtraction angiography (DSA) for the definitive diagnosis. *Methods:* Patients admitted to 2 comprehensive stroke centers between January 2008 and July 2010 who had an equivocal initial noninvasive test were reviewed. The proportions of patients who underwent CTA and MRA in combination and those who required additional DSA for definitive diagnosis were determined. The diagnostic yield and impact on management in patients with CTA and MRA combination was compared with patients who underwent CTA and MRA followed by DSA. *Results:* Among a total of 1063 patients (mean age ± SD 63 ± 16), 384 (36%) underwent >1 vascular imaging study. There was no difference in the rates of cardiovascular risk factors and stroke subtype between different combination groups. The agreement between CTA and MRA was high (concordance 81%). Among the 164 patients who underwent both CTA and MRA, a DSA was required for resolution/confirmation in only 27 (16%) patients. Among these 27, DSA findings changed the clinical decision-making in 22 (82%) patients (11 stenotic severities and 11 diagnoses of arteriovenous fistula, aneurysm, or dissection). *Conclusions:* In our experience, a combination of CTA and MRA was frequently used in patients in whom the initial noninvasive imaging was determined insufficient. The combination of findings from CTA and MRA were considered adequate in a large portion of patients resulting in a lower requirement for DSA and higher treatment impact from DSA. **Key Words:** Acute stroke—computed tomographic angiography—digital subtraction angiography—magnetic resonance angiography—neurovascular imaging—treatment modification.

The American Heart Association (AHA) recommends a noncontrast computed tomographic (CT) or magnetic resonance imaging (MRI) scan before intravenous tissue plasminogen activator (tPA) administration in an attempt to exclude intracerebral hemorrhage and extensive ischemic stroke in acute ischemic stroke.[1] The recommendations with regard to vascular studies, however, are not clear, and the setting of specific recommendations for patients with stroke has not been established. The AHA guidelines for secondary prevention recommend that all

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stroke patients should have cranial imaging with CT or MRI to distinguish between ischemic and hemorrhagic strokes, and ischemic stroke patients should have an evaluation sufficient to exclude high-risk modifiable conditions, such as extracranial and/or intracranial arterial disease as the cause of ischemic symptoms.

Generally, noninvasive vascular imaging techniques based on the current practice guidelines incorporate various combinations of either CT angiography (CTA) or magnetic resonance angiography (MRA) with digital subtraction angiography (DSA) for the comprehensive evaluation of acute ischemic stroke. Examples of the necessary determination of severity of lesions can be derived from the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and European Carotid Surgery Trial (ECST), where an increased benefit of surgery was shown for symptomatic patients with a stenosis of >70% (NASCET criteria). Similarly, endarterectomy offers moderate benefit when stenosis ranges from 50% to 70% in asymptomatic patients.[2] DSA, however, remains the criterion standard for the diagnosis of vascular lesions, such as dissection, arteriovenous malformation (AVM) or aneurysm. DSA is a confirmatory tool[1,3,4] that is invasive and requires a certain level of technique and expertise.

The current guidelines do not offer a clear plan for the use of combination of noninvasive tests because of a lack of data. We hypothesized that in patients in whom the initial noninvasive test is not conclusive, the second noninvasive test may provide sufficient information and result in identification of patients in whom the performance of DSA offers a greater diagnostic yield. We sought the management implications of a combination of CTA and MRA studies in acute ischemic stroke patients in order to avoid DSA and to determine the diagnostic yield of DSA performed after 2 noninvasive modalities in the diagnosis and treatment of acute stroke.

Methods

A retrospective study was performed to identify all acute stroke patients admitted to 2 university-affiliated comprehensive stroke centers between January 2008 and July 2010 using prospective databases tracking all acute ischemic and hemorrhagic stroke patients. The databases are updated and maintained on a daily basis by staff personnel within our institutions, and then cross-checked against the acute stroke admission diagnosis reports that are provided by the coding departments of the participating hospitals at the end of each month. These reports are based on *International Classification of Diseases, 9th revision, Clinical Modification* (ICD-9-CM) codes. We collected relevant information for each patient from the individual hospital records. Demographic data and the data on cerebrovascular events (transient ischemic attack or ischemic stroke), location and degree of stenosis, type of interventional procedure, if any, and the initiation of any medical therapy were collected. Moreover, we reviewed the charts to identify presence of premorbid stroke risk factors, such as hypertension, dyslipidemia, diabetes mellitus, cigarette smoking, atrial fibrillation, transient ischemic attack, previous stroke, and coronary artery disease for each patient. Institutional review board approval for the study was obtained from each institution.

Imaging Modalities

The date, time, and findings of each vascular imaging study were determined by medical chart review. The order of the performed imaging modalities was verified to determine if the DSA was performed after the 2 noninvasive tests. Some of the imaging studies were performed during the follow-up of patients, and were not used for initial diagnosis, and these cases were excluded from our analysis. Each imaging modality was reviewed and the findings documented by the staff neuroradiologist were recorded. The proportions of combinations of CTA, MRA, and DSA that were performed for the patients were calculated. The cases in which CTA and MRA discordance needed resolution with DSA or in any case that DSA made a change in management decision-making were identified. Subsequently, it was determined whether the DSA was confirmatory of CTA/MRA findings, changed the treatment plan, or excluded a suspicious condition that was found on CTA or MRA images. The findings of CTA and MRA were compared in those patients who did not have a DSA study to assess the concordance rate.

To further analyze our findings, we had an independent reviewer evaluate the decision making after reviewing the noninvasive studies performed for a randomly selected sample of patients. We asked the independent reviewer to decide whether or not he would recommend a DSA study after the noninvasive studies. The decision was based upon optimal quality imaging reports and whether the patient needs further studies in order to proceed with clinical decision-making.

Statistical Analysis

Statistical analysis was performed using Stata IC software (version 10; StataCorp, College Station, TX). The proportions were compared using Chi-square test, and the means by the Mann–Whitney U test if data distribution was not normal or by the Student t test when it was normally distributed. The Fisher exact test was used for comparing subgroups with small sample sizes. Multiple group comparisons were made by analysis of variance followed by Bonferroni post-hoc correction.

Results

A total of 1063 patients (536 [50%] men) were identified with the diagnosis of stroke, which was confirmed