Semiautomated Quantitation of Carotid Artery Stenosis in Gadolinium-Bolus Magnetic Resonance Angiography

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Magnetic resonance angiography (MRA) has become the standard method for evaluation of carotid occlusive disease. Fast imaging methods combined with bolus intravenous injection of gadolinium contrast have improved the quality of these images. Nevertheless, the gold standard for evaluation was based on projection arterial angiography. The properties of these images are rather different. Whereas most previous evaluations of MRA have used visual assessment of images, we evaluate an algorithm in which a computer algorithm plays the primary role in defining arterial lumen margins, hence, disease. The accuracy of this semiautomated algorithm is shown to compare favorably with gold-standard arteriography in a series of 50 patients.

KEY WORDS: magnetic resonance angiography, carotid atherosclerosis, North American Symptomatic Carotid Endarterectomy Trial, quantitation

MAGNETIC RESONANCE ANGIOGRAPHY (MRA) has become a popular method for noninvasively diagnosing vascular disease. The addition of bolus injection of gadolinium, although invasive, appears to significantly improve the quality of MRA images for some anatomies. However, the majority of MRA images are reviewed by creating maximum intensity projection (MIP) images that appear like intra-arterial angiography (IAA), ignoring the ability to compute values, because of the digital nature of the acquisition device. In this study, we compared a semiautomated algorithm (SAQ) for measuring carotid stenosis versus observer ratings of the IAA and MRA source data in a cohort of 50 patients.

METHODS

Patient Recruitment

After informed consent and Institutional Review Board approval, 50 patients undergoing IAA for suspected carotid occlusive disease were recruited to have bolus gadolinium MRA studies of their necks performed within 3 days of the IAA. Three neuroradiologists reviewed the conventional angiograms and MRA source images and assigned a percent stenosis using North American Symptomatic Carotid Endarterectomy Trial (NASCET) methods. The values for the left carotid arteries on IAA then were provided to one of us who used an internally developed application to determine a method of operation that provided good agreement with IAA values. The method then was applied to all vessels in a blinded fashion. Measurements were repeated 3 times for one of us to provide intraobserver variability estimates and one time by 2 other observers. Of the 100 vessels, 15 were totally occluded by conventional angiography.

Gadolinium Bolus MRA Technique

The details of the gadolinium bolus technique have been described elsewhere and has been quite robust and successful in clinical practice. Briefly, a phase-contrast MRA of the entire neck is obtained to provide location information to position the gadolinium bolus sequence. Then a “timing sequence” is run at the level of the carotid bifurcation to

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Fig. 1. Upon selecting the study, a coronal MIP is displayed. The user draws an ROI on it, which includes the vessel segment of interest.

Fig. 2. This ROI defines a volume of interest (VOI), which is displayed as a MIP. The user may view this VOI at any angle and interactively refine the VOI. Refining the VOI improves the appearance and does not affect the measurement.