Gadolinium-enhanced MR Angiography in the Evaluation of Carotid Artery Stenosis: Comparison with Digital Subtraction Angiography in 238 Patients

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Purpose: To evaluate the accuracy of contrast-enhanced MR angiography (CE-MRA) with gadobenate dimeglumine in the assessment of carotid artery stenosis on the basis of Digital Subtraction Angiography (DSA) findings.

Materials and Methods: A total of 252 patients (170 male and 78 female; mean age 67.5 years) with suspected carotid artery disease based on Doppler screening (80%) or symptoms of cerebral ischemia were enrolled in the study. Of these, 238 underwent both MR angiography (MRA) on a 1.5 T system and DSA examinations within 2 weeks each other. MR angiograms were acquired using a 2D-TOF (TR/TE/FA: ≤ 30 ms/≤ 7ms/≤ 60°) before and a 3D spoiled gradient-echo sequence (TR/TE/FA: ≤ 7 ms / ≤3ms / ≥30°) after the administration of 0.1 mmol/kg gadobenate dimeglumine (MultiHance, Bracco Diagnostics Inc.) at 2 mL/sec. Both sequences covered a vascular territory from the aortic arch to the carotid siphons. Oblique projection for arch vessels and a minimum of 2 projections for each carotid artery always including a lateral view were obtained at DSA. Image evaluation was performed by four experienced reviewers, three for MRA and one for DSA, blinded to all patient and contrast information. Technical adequacy of vessels visualization, sensitivity, specificity and accuracy as well as inter-reader agreement for detection of clinically significant stenosis (≥ 60%) using DSA as gold standard were calculated for both TOF and CE-MRA and compared using McNemar's and Chi-square tests. Safety was evaluated in terms of monitoring of adverse event, ECG, vital signs and clinical laboratory investigations before and after gadobenate dimeglumine injection.

Results: In general, a greater proportion of the segments were technically adequate with CE-MRA compared to 2D-TOF. The technical failure rate (TFR) was lower (4.1% to 4.9%) across all 3 blinded readers for the carotid arteries in CE-MRA than for 2D-TOF (11.4% to 14.8%). The use of contrast significantly ($p<0.001$) decreased the TFR for all 3 readers. A similar decrease in the TFR from 2D-TOF to CE-MRA was also shown for the on-site evaluation (30.3% versus 6.2%, $p<0.001$). A total of 196 vessels with significant (≥ 60%) stenoses and 108 vessels with occlusions were identified by the DSA reader. The sensitivity for detection of significant disease ranged from 56.6% to 76.3% and from 57.9% to 86.3% for 2D TOF MRA and CE-MRA, respectively. Specificity increased from 81-83% to 89.5-93.6% and accuracy from 78.3-82.2% to 87.8-89.7 for CE-MRA when compared to 2D TOF MRA. All increases in sensitivity, specificity, and accuracy were statistically significant ($p< 0.001$) for all readers, with the exception of sensitivity for Reader 1 and 2. Similar trends with statistically significant increases ($p< 0.001$) in sensitivity, specificity and accuracy were obtained by the on-site investigators who performed quantitative caliper measurements with an overall accuracy value of 87.7% versus DSA. Better inter-observer agreement was noted among the 3 readers for CE-MRA (84.7% agreement) compared to TOF MRA (77.1%) ($p<0.0001$). Thirteen patients (5.2%) experienced an adverse event possibly or probably related to injection of gadobenate dimeglumine, and no significant effects on vital signs, clinical laboratory parameters (hematology, clinical chemistry and urinalysis), or ECG components including PR, QRS and QTc intervals were noted after drug administration.

Conclusion: In the largest study conducted to date, CE-MRA provided better agreement with the results of DSA than 2D TOF MRA. Significant increases in diagnostic performance and test reproducibility were demonstrated in comparison with TOF MRA. Gadobenate dimeglumine is a safe and effective contrast agent for MRA of the carotid arteries at a dose of 0.1 mmol/kg.