# Incidence of AHA Type 4/5 Atherosclerotic Plaque and Outcome in Patients with Suspected Acute TIA/Stroke: A Prospective, Observational MRI Study Using Novel 3D Turbo Spin Echo, Continuously Variable Flip Angle, Double Inversion Recovery Technique

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**Introduction:** Atherosclerosis is a systemic disease with uncommon grave thromboembolic consequences, including stroke and acute coronary syndrome, which are leading causes of morbidity and mortality. A recently developed pathophysiological model, the American Heart Association model of atherosclerotic lesion progression and regression, identifies the types 4 and 5 plaque as critical presymptomatic lesion states. MRI is a promising vascular imaging technique that may allow insight into the actual occurrence and importance of such lesions. Our recently developed 3D MRI technique has temporal efficiency and spatial resolution characteristics which enable prospective study of such disease in clinical patient populations. The purpose of this work was to observe the incidence of type 4/5 atherosclerotic plaques in a prospective, clinically stroke-suspected population, and, to relate this observation to angiographic stenosis and immediate patient outcomes.

**Methods and Materials:** High-resolution T1- and T2-weighted black-blood 3D turbo spin echo (TSE) pulse sequences were developed on site and optimized for use with the clinical-stroke-protocol receiver-coil array in order to keep the imaging set-up unchanged. These sequences are slab-selective versions (A) of a single-slab 3D-TSE technique that uses very short (500 μs), non-spatially-selective refocusing radio-frequency pulses to achieve an inter-echo spacing as small as 3 ms for typical pulse-sequence parameters (B). Compared to conventional TSE pulse sequences, which usually have an echo spacing of more than 10 ms, the shorter echo spacing, and, hence, higher sampling efficiency, for the 3D-TSE technique permits single-slab imaging of relatively large volumes within a reasonable acquisition time, thus avoiding image artifacts associated with 3D multi-slab methods.

All studies were performed on a Sonata scanner (Siemens Medical Solutions, Malvern, PA, USA) utilizing a three-coil combination that included birdcage-head, butterfly-neck and cervical-spine receiver coils. Our standard clinical stroke protocol examination was amended to include high-resolution, black-blood imaging of the carotid bifurcations by using the 3D-TSE pulse sequences introduced above. Blood signal suppression ("black blood") was achieved by using a standard non-spatially selective, spatially-selective double-inversion-recovery preparation. Pulse sequence parameters for the T1-weighted 3D-TSE acquisition included: TR/TE, 800/24 ms; ETL, 27; NEX, 2; matrix, 243 x 448; and for the T2-weighted acquisition included: TR/TE, 2000/132 ms; ETL, 51; NEX, 2; matrix, 255 x 448. In addition, the T2-weighted acquisition used continuously-variable flip angles for the refocusing radio-frequency pulses to permit longer echo-train duration without introducing strong T2 weighting (C). Both acquisitions used: field-of-view, 12.6 x 22.0 cm; true in-plane resolution, 0.5 x 0.5 mm; z axis coverage, 66 mm; slice thickness, 3.0 mm reconstructed at 1.5-mm intervals.

Consecutive patients referred with symptoms of acute stroke or transient ischemic attack were imaged from December 22, 2004, through July 22, 2005. 3D TSE images and CE MRA data were used to grade plaques based on the MRI modified AHA classification (6 possible classifications) by two independent, blinded reviewers. Imaging, demographic and discharge diagnosis data were collected by chart review.

**Results:** Of all 73 completed studies, 56/73 (76%) were identified as having suitable image quality, graded and utilized to test interobserver agreement. 23/73 (24%) studies were excluded due to poor image quality (habitus, motion). Quadratic Kappa agreement among all grades was good, 0.66. Specific Kappa agreement for the type 4/5 category was fair, 0.29 (95%CI 0.03-0.56). Consensus scoring identified 24 type 4/5 plaques in 336 graded segments (3 segments per side in 56 patients). Overall, 20/56 (36%) patients demonstrated a type 4/5 plaque in any location, 4/20 having bilateral type 4/5 plaques. 1/20 (5%) with type 4/5 plaque had an ipsilateral acute or hyperacute stroke of cryptogenic or large vessel cause of a total of 13/56 patient events observed. 3 patients demonstrated severe MRA stenosis (70-99%) and 2 of these correlated with the presence of a type 4/5 plaque, both without stroke.

**Discussion:** As expected, our high risk study population demonstrated a high incidence of type 4/5 plaque (36%). Interestingly, severe stenosis, the only clinically accepted marker of critical disease showed a limited, positive correlation with this type plaque (66%). It was expected that few acute events would be observed in those with underlying type 4/5 plaques (5%). Our initial experience in the grading system resulted in limited interobserver agreement. Hopefully, more reader experience and improved image SNR through utilization of dedicated surface receiver coils will lead to improved agreement.

**Conclusion:** MRI AHA type 4/5 carotid plaque is common in patients with high cerebral athero-thromboembolic risk and is not often associated with an acute event. Patients having such lesions may warrant aggressive preemptive treatments in order to best improve aggregate patient outcomes.

**Acknowledgements:** This work was supported by NIH grant NIH R01 NS35142.

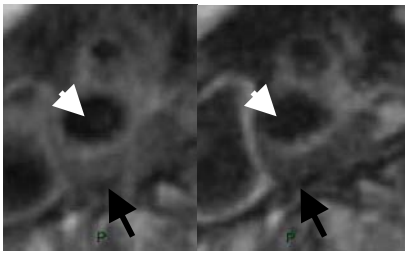

Figure 1:
T1- and T2- weighted images of the carotid bifurcation indicate an AHA type 4 atherosclerotic plaque by the black arrows. Note the low signal lipidic core beneath a high signal, intact, fibrous cap. The internal carotid artery vascular lumen is indicated by white arrows.

**References:**

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