Detection of plaque vascularity using delayed contrast enhanced MRI: Correlation with contrast enhanced ultrasound

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Introduction: Neo-vessels within carotid artery plaques provide a pathway for the introduction of red blood cells and other circulating inflammatory cells into the core of the plaque. Non-invasive detection of these neo-vessels could identify plaques at risk of further expansion or rupture. Contrast enhanced ultrasound is highly sensitive [1,2] in detecting neo-vessels, with the ability to detect individual microbubbles, and thus, individual neo-vessel channels. In comparison to magnetic resonance imaging, ultrasound is limited in detecting other features of a plaque, such as intraplaque hemorrhage, that make it at high risk of causing cerebral vascular events. The purpose of this study was to correlate the ability of MRI to detect plaque vascularity with the findings of contrast enhanced ultrasound.

Materials and Methods: 14 patients (11 men and 3 women) with significant carotid stenosis posted for elective endarterectomy underwent contrast enhanced ultrasound and MRI examination. An iU22 system with a L9-3 dedicated linear carotid probe (Philips Medical Systems, Netherlands) was used to acquire ultrasound images. Definity (Bristol Myers Squibb, Canada), a lipid-encapsulated perfluoropropane was used as the ultrasound contrast agent and low mechanical index and interval delay scanning methods were adopted to detect entry of microbubbles into the plaque [3]. The images were downloaded into dedicated software for generating time-intensity graphs and maximum temporal intensity projection images (QLab, Philips Medical Systems, Netherlands). A plaque was classified as neovascular negative if the signal intensity within a region of interest drawn over the plaque was zero in the maximal temporal intensity projection over the entire ultrasound procedure (30 minutes). Immediately after the ultrasound procedure, patients were moved to a 1.5T GE HDx MRI where high resolution MR images were acquired of the carotid arteries using a dedicated carotid coil array (ScanMed, USA). An axial 3D T1-weighted MR image volume was acquired at the carotid bifurcation with the following scan parameters: TR/TE/θ (6.0/2.7/15) with 0.7mm isotropic voxels, taking 59 seconds to acquire a single phase. A low *b* value diffusion pre pulse was used to eliminate signal from the luminal blood. 6 individual phases were repeated, and each phase was reconstructed, non-rigidly registered, and then volume averaged. For the subsequent scan, 0.1ml/kg body weight of GdDTPA was injected (Gadovist, Berlex, USA), and an identical 3D volume acquisition was repeated 3-5 minutes post injection. This post contrast volume was non-rigidly registered to the pre-contrast volume. Contrast uptake was quantified by drawing an ROI around the carotid artery immediately proximal to the bifurcation and plotting mean signal intensity over the 6 phases. Positive contrast enhancement was defined as signal intensity within the ROI that was seen to be increasing after the first post contrast image.

Results: Of the 14 patients seen, 12 patients were defined by ultrasound as neovascular positive (Figure 1A) and 2 patients were neovascular negative (Figure 1B). This finding correlated very well with MR-detected intraplaque hemorrhage with all 12 of these patients presenting with some signal hyperintensity in the carotid artery. Furthermore, MR plaque enhancement (Figure 1C and E) was also seen in all twelve of these patients. However, one patient showed delayed enhancement on MR, which was declared negative on contrast enhanced ultrasound and was diagnosed as a plaque ulceration. Figure 1D and F shows a patient in which no MR contrast agent distribution was seen.

Discussion: While image acquisition times for the post contrast MRI are not on the time scales to allow permeability or perfusion quantification [4], the delayed enhancement uptake patterns correlate very well with neovascular positive areas as detected on contrast enhanced ultrasound. Additionally, other than image registration, no post processing was required to generate these enhancement patterns, yielding a clinically viable method of detecting neovascularity.

Conclusion: In this small study, MRI detected plaque neovascularity in all patients diagnosed as neovascular positive on contrast ultrasound. Thus delayed contrast enhanced MR technique appears to be a simple, clinically useful tool in detecting plaque neovascularity.

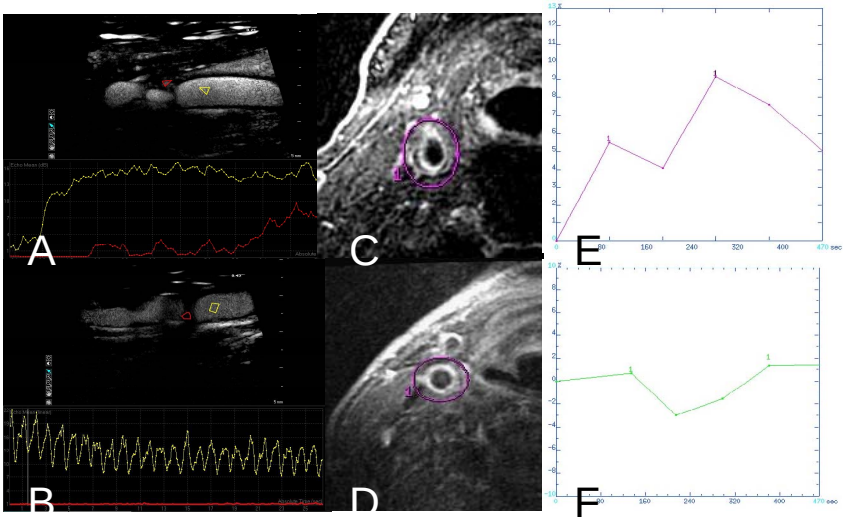

Figure 1: Tile A shows the maximal temporal projection of a pulse inversion ultrasound image showing the time signal intensity course of luminal blood (yellow ROI) and intraplaque vascularity (red ROI). In tile B, a patient in which the intraplaque vascularity is not detected and stays at zero the entire length of the ultrasound procedure. Tile C shows the corresponding MR for the patient shown in tile A. The contrast uptake curve over the multiple phases is shown in tile E. Conversely, a MR non enhancing (tiles D and F) plaque corresponds well with the ultrasound non-enhancing plaque seen in tile B.

References:

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