

Carotid Artery Wall Lipid Quantification by means of 1H-Magnetic Resonance Spectroscopy: Correlation with Carotid Wall Area and Normalized Wall Index.

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Introduction A hallmark of advanced atherosclerosis is the accumulation of lipids in the artery wall. Quantification of artery wall lipid content is of great value for both the assessment of cardiovascular event risk as well as in the evaluation of drug efficacy. 1H magnetic resonance spectroscopy (MRS) has the potential to detect lipid non-invasively. We developed a carotid MRS protocol to non-invasively test the relation between the lipid to water ratio at the location of the carotid artery wall and carotid artery wall dimensions.

Methods 3.0 Tesla MRI and MRS scans were performed in the common carotid arteries of 42 subjects (aged 44 ± 13) using a 5 cm single-element coil. 2D CSI data were collected using a point resolved spectroscopy sequence (PRESS) with the following parameters: TR/TE = 1100/30 ms, 5 mm slice thickness, FOV 8 cm, matrix size 20x20, acquisition time 13 min, 1 acquisition. Saturation bands were placed around the artery. Spectra with and without water suppression were obtained. Four voxels positioned at the centre of the artery (total area 100 mm²) were selected for further analysis (see Figure 1) and were processed using the 3DiCSI package (version 1.9.11, Columbia University). Average spectra were processed and peak fitted using jMRUI 2.2. The water peak was assigned to 4.65 ppm. Methyl and methylene resonances of fatty acid chains were fitted in their characteristic spectral region (0.8 ppm–1.4 ppm). A lipid:water ratio was calculated to permit semiquantitative comparison. 3.0 Tesla MRI axial T1-weighted TSE image stacks were acquired at late diastole. Sequence parameters: slice thickness 3 mm, non-interpolated pixel size 0.25 x 0.25 mm, TE 11 ms and TR according to heart rate, active fat suppression (SPAIR) and a double inversion black blood prepulse. The T1-weighted MR images were utilized to localize the MRS acquisition (see Figure 1). Mean wall area (MWA, mm²) and outer wall area (OWA, mm²) were determined. NWI was defined as the ratio between MWA and the outer wall area. The perivascular area (PVA, mm²) that was included in the MRS voxel was defined as: PVA = 100 - OWA. Serum tryglicerides (TG) and serum total cholesterol (TC) was assessed in all subjects.

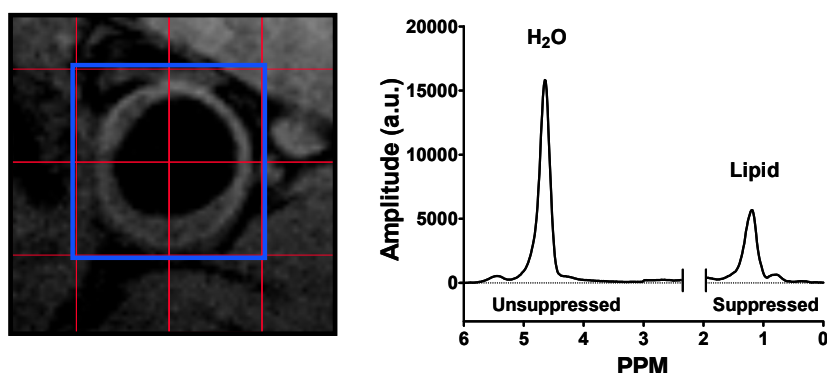


Figure 1: T1-weighted image and 1H-MR spectrum of a volunteer. Four MRS voxels centered over the carotid artery are averaged (blue box). The averaged 10 x 10 x 5 mm MRS voxel includes signal from blood in the lumen, the arterial wall and perivascular tissue. The MRS spectrum is shown on the right.

Results Means and standard deviations were: MWA 16.4 (5.7) mm², NWI 0.33 (0.18), PVA 51.4 (10.3) mm², LA 32.3 (5.5) mm² and lipid:water ratio 0.34 (SD 0.18). The Pearson's correlation coefficient for lipid:water ratio and MWA was 0.34 (p=0.02) and 0.37 (p=0.02) for NWI (Figure 2). PVA and LA did not correlate with the lipid:water ratio (-0.25 p=0.10 and 0.15 p=0.31 respectively). In a multivariate analysis including lipid:water ratio, serum TG, serum TC and MWA, the lipid:water ratio was associated with MWA (p=0.05) independent of serum TG and TC. For the same analysis with NWI this was borderline significant (p=0.052). For PVA and LA this was not significant (p=0.13 and p=0.37 respectively).

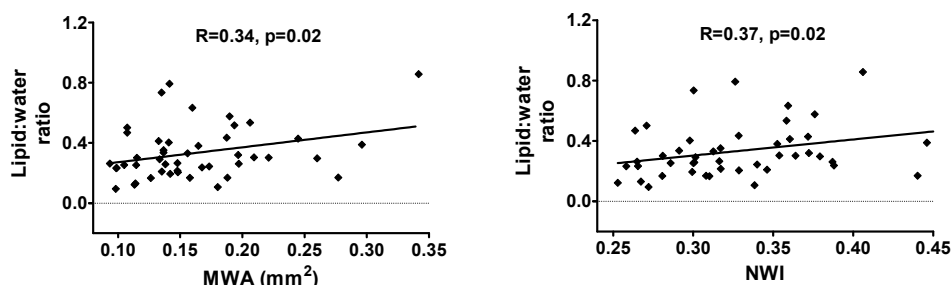


Figure 2: Correlation between the lipid:water ratio and mean wall area (MWA, left) and normalized wall index (NWI, right).

Conclusion The lipid:water ratio quantified by MRS of a voxel that includes the carotid artery wall correlated with the carotid artery wall dimensions, independent of serum lipid levels, while it does not correlate with the lumen area and perivascular area. Further research is needed to resolve whether MRS is a useful tool to assess the efficacy of lipid altering pharmacotherapy in the treatment of advanced atherosclerotic lesions.