Logistic regression analysis of optimal MR weighting combinations for atherosclerotic plaque assessment

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The diagnosis of a high-risk plaque, containing intra-plaque hemorrhage and/or lipid core, may be important for clinical decision making about patients with advanced atherosclerosis. Multisequence MRI has shown to be promising for plaque assessment. The aim of the present study was to find the optimal MR weighting combinations with the corresponding semi-quantitative cut-off values of relative signal intensities using logistic regression analysis.

Materials and Methods:
Eleven patients (mean age 68 ± 4 years; 7 males) with symptomatic carotid artery disease and a stenosis of more than 70% were investigated with MRI prior (5 ± 4 days) to carotid endarterectomy. Histology served as the standard of reference and was matched with MRI. Nine transversal MRI slices were obtained using the following MR pulse sequences: T1w TFE, TR/TI/TE 10.3/900/4.0 ms, flip angle 15°, NSA 6; PDw TSE, TR/TE 2RR/20 ms, NSA 2; T2w TSE, TR/TE 2RR/50 ms, NSA 2; T1w TSE, TR/TI/TE 570/255/14 ms, NSA 2; Partial T2w TSE, TR/TE 2RR/30 ms, NSA 4. For the T1w TFE sequence, the FOV was 100x100 mm with a matrix size of 256x208, a slice thickness of 3.0 mm and no slice gap. For the other sequences, the FOV was 100x100 mm with a matrix size of 256x256 and a slice thickness of 2.5 mm with a slice gap of 0.5 mm. To be able to generate an MRI standard of relative signal intensities (rSI) compared to surrounding muscle tissue of the various plaque components only operator-defined regions-of-interest (ROIs) with a clear match with histology were included. Optimal cut-off points for the rSI for each component were determined for the five MR weightings by ROC analysis of the rSI. The optimal combinations of the five MR weightings were based on a stepwise logistic regression analysis. An estimation of potential sensitivity and specificity of MR to detect the high-risk plaque was determined.

Results:
Equally divided over eleven patients 99 ROIs (fibrous tissue, 43; lipid core, 8; calcified tissue, 18; hemorrhage, 30) were assessed (Figure 1). The optimal MR weighting combinations and corresponding cut-off values for the various plaque components are listed in Table 1. T1w TFE, T2w TSE are essential to characterize the plaque. Additionally, an arbitrary pair of the sequences partial T2w TSE , PDw TSE, and T1w TSE is needed to identify calcified tissue. The sensitivity and specificity and the 95% confidence intervals for the high-risk plaque were 76% (56-90) and 100% (93-100).

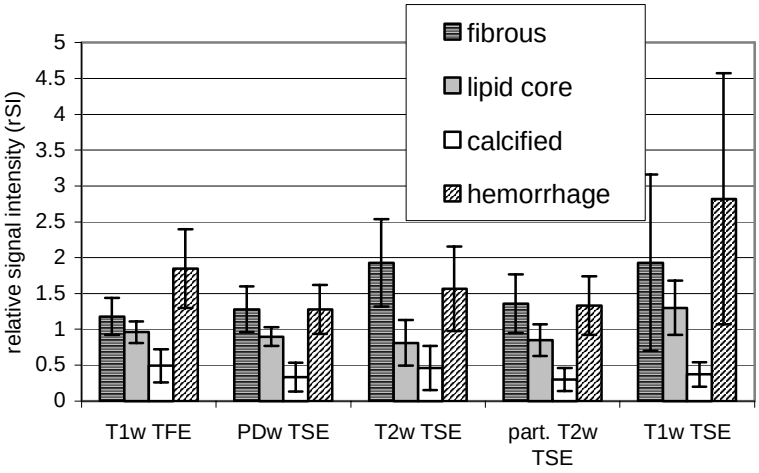

Figure 1. Mean rSI (top of the bars) and standard deviation (vertical lines) of four tissue types and five MR weightings.

Step I. Calcified tissue
an arbitrary pair of partial T2w OR T1w TSE OR PDw TSE (rSI resp. <0.51, <0.64, <0.71), ELSE:
Step II. Lipid core
T2w TSE AND T1w TFE
(rSI resp. <0.92, <1.07), ELSE,
Step III. Hemorrhage
T1w TFE AND "plaque location"
(rSI resp, ≥1.42, location "in main plaque"), ELSE:
Fibrous tissue

Table 1. Optimal MR weighting combinations of four tissue components.

Conclusion:
Multisequence MRI generates a considerable amount of data. Using logistic regression analysis, the optimal MR sequence combinations for plaque assessment could be determined. Potentially, high-risk plaques can semi-quantitatively be detected with high sensitivity and specificity. Larger prospective studies are warranted.