Quantitative tissue characterization of atherosclerotic plaques by Magnetic Resonance: comparison between ex vivo and histological findings

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Introduction

Classification of plaque severity is usually based on the degree of lumen narrowing, i.e. the higher the plaque size, the higher the risk of atherosclerotic plaque. However, there are evidences that mild to moderate stenosis can lead to acute ischemic events independently on plaque size. Furthermore, plaque rupture, that is the critical feature of these moderately but high risk lesions, is frequent in plaques with thinned fibrous cap and/or a rich lipid core rather than in fibrous and calcified plaque with a thickened cap [1].

Therefore, definition of plaque severity based on the identification of constituents can improve to identify high risk atherosclerotic lesions and our understanding on the plaque susceptibility to rupture or to regression and stabilization. Several studies have been done for atherosclerosis characterization with MRI studies both in ex vivo specimens [2,3] and in vivo [4,5]. In particular, it has been shown that [4] Magnetic resonance can distinguish the different plaque constituents, such as fibrosis, calcium, lipids, thrombosis and intraplaque hemorrhage, on the basis of signal intensity in T1, PD and T2 weighted images.

Although a visually, but strongly operator dependent, assessment of tissue characterization can be effectively performed by MR, a more objective and quantitative description of plaque constituents can be done using first and second order statistical parameters. These give information on the kind of plaque constituents and their intraplaque distribution.

The present work explains a method for quantitatively assessing constituents and architecture of carotid and abdominal atherosclerotic plaques, using first and second order linear statistical analysis on Magnetic Resonance Images.

Methods

Intact human carotid and abdominal artery specimens were studied, with a total of 15 studies. After excising, these were fixed and stored in formaline. In order to deal with potential methodologic problems related to the time at which the tissue was excised, sampling were performed only when the interval from death to excision ranged between 10 and 15 hours. MR and histological examination of each specimen was performed within three days after excision.

MR images were acquired with a 1.5 T Sigma LX system (GE Corporation) using a phased-array head coil. Spin Echo T1, PD and T2 weighted sequences were performed in each study with the following parameters: FOV= 10x10, 512x512 images, 4 NEX, T1 sequence: TR = 700msec, TE = 14msec.; PD sequence: TR = 14msec.

Results

Statistical analysis has been applied on three different tissues types: the media area, considered as normal reference tissue, prevalently fibrous plaques and complicated plaques.

Table 1 shows resulting data relevant to first order analysis; in particular, gray level mean values are shown normalized with respect to the mean of a reference ROI selected from a water filled probe acquired together with the specimen.

<table>
<thead>
<tr>
<th>Histo</th>
<th>T1W (mean ± SD)</th>
<th>T2W (mean ± SD)</th>
<th>PDW (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrous plaque</td>
<td>0.83 ± 0.18</td>
<td>0.53 ± 0.11</td>
<td>1.14 ± 0.2</td>
</tr>
<tr>
<td>Complicated plaque</td>
<td>0.37 ± 0.1</td>
<td>0.14 ± 0.09</td>
<td>1.44 ± 0.21</td>
</tr>
<tr>
<td>Media</td>
<td>2.34 ± 0.21</td>
<td>0.14 ± 0.08</td>
<td>0.58 ± 0.09</td>
</tr>
</tbody>
</table>

Table 2: second order statistical analysis results.

In the table 2 resulting PSD area values are shown. Also area values are normalized with respect to a reference ROI PSD area.

Discussion

From the resulting tables it is evident that the first order analysis is able to distinguish atherosclerotic plaque from media tissue, on the basis of plaque constituents, especially on PD and T1 weighted images. On the other hand, classification between simple and complicated plaques is a prerogative of second order analysis. In fact, considering PSD area values on T1, T2 and PD weighted images, it appears that higher PSD in complicated plaque correspond to a more random spatial distribution of their biological components with the respect to media and fibrous plaque.

In conclusion, our present results are relevant to a few data, but such preliminary studies are promising, especially for distinguishing complicated plaque components and their spatial distribution.

References