QUANTIFICATION OF MORPHOLOGIC AND MICROVASCULAR VESSEL WALL CHARACTERISTICS OF ABDOMINAL AORTIC ANEURYSMS WITH MRI

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Introduction

The pathogenesis of abdominal aortic aneurysm (AAA) and the factors leading to rupture of AAA remain incompletely understood. It is known that AAA rupture risk is strongly correlated with absolute anteroposterior (AP) diameter but at present there are no good markers that predict AAA growth rate and rupture risk in individual patients[1]. The current threshold for surgery is a AAA diameter >5.0-5.5 cm, as rupture risk outweighs the risks associated with surgery. However, many patients that exceed the surgical threshold remain asymptomatic, and, conversely, some patients with smaller AAA progress to rupture[2]. Abundant histological data now link AAA vessel wall characteristics such as wall thickness and adventitial vasa vasorum with AAA progression and rupture risk[3,4]. Here we set out to image AAA vasa vasorum by (dynamic) contrast-enhanced MRI of the AAA vessel wall and pharmacokinetic analysis of the enhancement dynamics. The purpose of this work was to develop a quantitative analysis tool and demonstrate its applicability to investigate these characteristics over time in relation to AAA growth.

Material and methods

Seven patients with AAA (mean D_{max}±SD: 51±8.4 mm; mean age ± SD: 71±7.1 years) were included for this study. Adventitial vasa vasorum was imaged using a dynamic contrast-enhanced sequence with a temporal resolution of approximately 20 s (TR/TE, 12/1.5 ms; flip α, 35°; slice thickness, 6 mm; FOV, 400 mm; matrix, 256 x 256). All included patients had a circular intraluminal thrombus with a thickness of >2 mm. K^{trans} served as a measure to characterize the adventitial vasa vasorum and was calculated by fitting of the enhancement time-series on a pixel-by-pixel basis. In addition, patients underwent contrast-enhanced MR imaging with the following parameters: TR/TE, 15/1.5 ms; flip α, 15°; slice thickness, 1.5 mm; FOV, 400 mm; matrix size, 268 x 384. The amount of slices imaged was dependent on the craniocaudal extent of the aneurysm. Contrast (Gadovist, Bayer Schering Pharma AG, Berlin, Germany) was given during the acquisition of the dynamic contrast-enhanced images (10 mL injected at 0.5 mL/s). The inner and outer boundaries of the vessel wall and the vessel lumen contour were identified using a custom image analysis package (VesselMass, Leiden University Medical Center and Medis Medical Imaging Systems, Leiden, The Netherlands). Wall thickness was calculated on the slice showing the maximal anterior-posterior diameter (fig 1b). Associations between wall thickness, K^{trans} and maximal diameter were computed by the Pearson correlation coefficient (r) and were visualized by scatter plots.

Results

In all patients the AAA vessel wall and lumen could be segmented properly. Mean wall thickness, excluding luminal thrombus, was 1.9 ± 0.2 mm. K^{trans} was 0.027 ± 0.005 min^{-1}. There was a strong correlation between mean wall thickness and maximum diameter (r=0.94) as well as between K^{trans} and wall thickness (r=0.62). Furthermore, K^{trans} values exhibited strong heterogeneity over the AAA wall (note the non-uniformity of the red-colored pixels over the vessel wall fig. 1c)

Conclusions

We present a method to quantitatively analyze AAA wall components, including adventitial vasa vasorum characteristics based on (dynamic) contrast-enhanced MRI and demonstrate its clinical applicability. Aneurysm wall thickness and amount of adventitial vasa vasorum were strongly correlated with maximal AAA diameter. Future follow-up studies are needed to elucidate whether AAA vessel wall characteristics can be used as a rupture risk stratification tool.

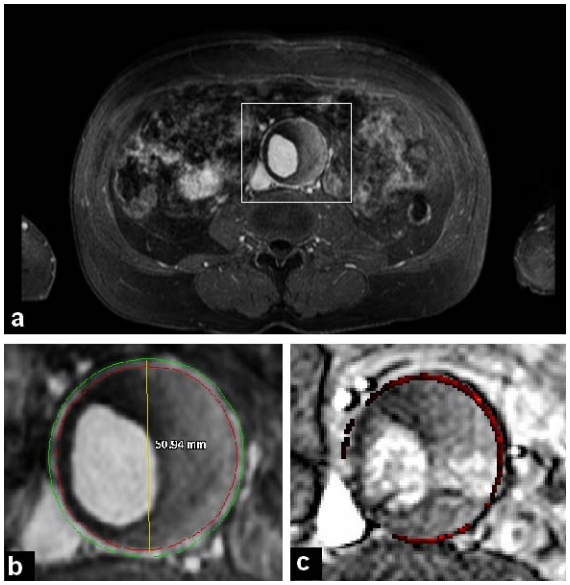

Figure 1. Contrast enhanced fat-saturated T1-weighted images showing AAA with an anterior-posterior diameter of 51 mm (a). Boundaries of automatically determined outer and inner vessel wall contour are marked with green and red ROIs, respectively (b). Corresponding dynamic contrast-enhanced image shows a heterogeneous distribution of K^{trans} values throughout the vessel wall (c).

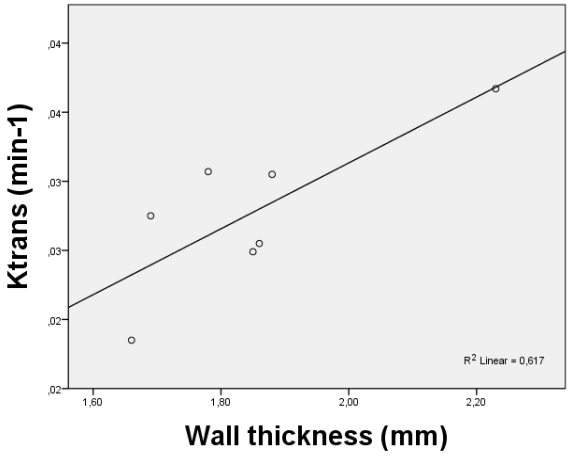

Figure 2 Correlation between wall thickness and K^{trans}.

References

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