IN VIVO QUANTIFICATION AND CORRELATION OF INTRACRANIAL ANEURYSM WALL THICKNESS AND WALL SHEAR STRESS

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Introduction: Improving individual rupture prediction of intracranial aneurysms is necessary, since current rupture prediction is poor. *In vivo* assessment of the aneurysm wall (like wall thickness) in combination with other haemodynamic parameters (like wall shear stress), may provide new insights in the development of the aneurysm and may help the physician in deciding whether or not to treat an aneurysm. Detection of a very thin aneurysm wall is challenging, due to limited resolution of most imaging modalities. In a previous study[1] we validated the possibility of using wall intensities for assessment of the aneurysm wall thickness on high field MRI. In this study the relation between wall shear stress and wall thickness was studied.

Methods: 18 patients with intracranial aneurysms were scanned on a 7T MRI scanner (Philips) with a 32 ch receive coil (Nova Medical) after giving written informed consent. The scan protocol included a T1-weighted three-dimensional magnetization prepared inversion recovery turbo-spin-echo (MPIR-TSE) sequence (0.8 mm isotropic resolution, for details see ref.[2]) and high resolution phase contrast angiography (PCA) (0.5 mm isotropic resolution, 6 cardiac phases)[3]. A custom built program (Matlab) was used to semi-automatically determine *in vivo* intensities on MPIR-TSE images of the aneurysm wall, which were normalized to signal of nearby brain tissue. The normalized intensities were used as measure for wall thickness. Unfortunately, parts of the aneurysm wall that were touching the parenchyma could not be analysed. Wall shear stress at peak systole was determined from the PCA as described elswhere[4]. PCA and MPIR-TSE scans were registered using 3D rigid body image registration (MeVisLab). Thereafter, visual and statistical comparisons (Pearson's correlation) between wall thickness and wall shear stress were performed.

Results: A preliminary analysis was performed, including 9 unruptured aneurysms of 7 patients. Other 11 patients showed artefacts in MRI (2), were difficult to register (1), showed too less free portions of the wall (1) or WSS was not yet analysed (7). All analysed aneurysms showed variations in wall thickness. A negative correlation between wall thickness and WSS was found in almost all aneurysms (Table 1). Thinner parts of the aneurysm show higher WSS and thicker parts of the wall correspond with lower WSS (Figs. 1, 2).

Discussion and Conclusion: A novel semi-automated method to determine *in vivo* aneurysm wall thickness was used to study the relation between local wall thickness and WSS. A negative correlation was found between both. The main limitation of the analysing method is that only free portions of the wall can be determined. However, this is the first study presenting a correlation of local wall thickness with WSS from *in vivo* measurements. Future work is needed to include all scanned patients and to perform a rigorous statistical analysis. The correlation may help understanding the pathology in the aneurysm wall, and, eventually, help assessing the risk of rupture.

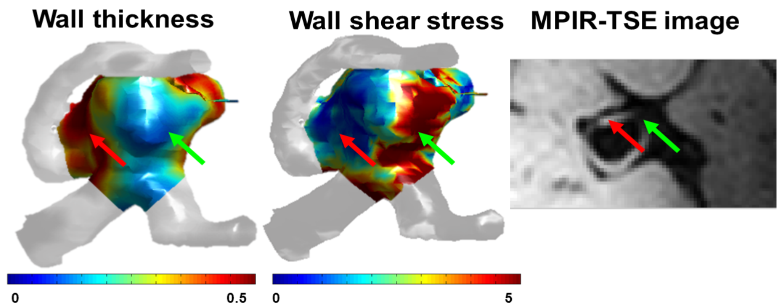

Fig 1: Visual comparison of aneurysm 6. 3D colormap with wall thickness (left), 3D colormap with wall shear stress (middle) and original MPIR-TSE image with wall intensities (right). Parent vessels were manually excluded from analyses (grey). Red arrow: area of low WSS and high wall thickness. Green arrow: area with high WSS and low wall thickness. The arrows are precisely linked to the same geometrical location in the three images.

Table 1: Results of comparison between WSS and wall thickness. Location of the aneurysm, Pearson's correlation coefficient and a visual estimated percentage of the area of the wall that could be analysed (coverage) are given.

Aneurysm	Location	Correlation (ρ)	Coverage
1	M1-M2 left	-0.4	<25%
2	ACOM	-0.3	25%-50%
3	ACOM	0.2	25%-50%
4	MCA right	-0.5	50% - 75%
5	Pericallosal	-0.7	<25%
6	MCA left	-0.7	50% - 75%
7	ICA right	-0.6	25%-50%
8	MCA left	-0.5	50%-75%
9	ACOM	-0.5	<25%

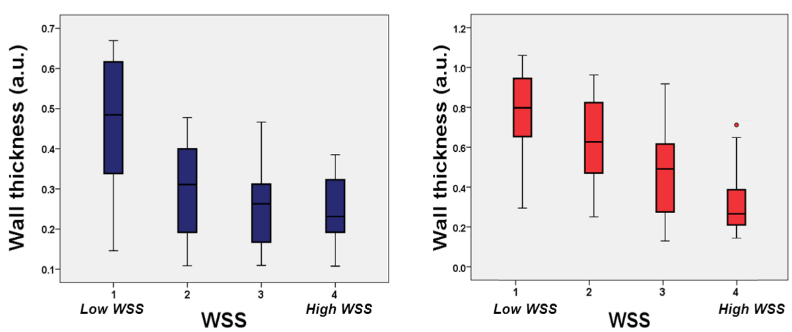

Fig 2: Boxplots of aneurysm 4 and 6 (with highest coverage). Wall shear stress is divided in 4 quartiles with increasing wall shear stress. Boxes represent the median wall thickness and distributions of wall thickness. The circle represent an outlier.

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