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AAA growth predicted with wall stress

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Introduction

The risk of rupture of Abdominal Aortic Aneurysm (AAA) is nowadays estimated by the maximum AAA diameter and the diameter growth over time. We have shown previously that AAA wall stress, as computed with patient-specific finite element models, is strongly related to the AAA diameter [1]. Intraluminal thrombus (ILT) is found in most AAAs and may influence the computed wall stress.

Objective

The objective is to evaluate the effect of ILT on the wall stress and to determine if wall stress can be used to predict whether AAAs are stable or progressively growing.

Methods

Finite element models are created of the AAAs of 30 patients and wall stresses are computed with and without ILT. The BI-method is used in the simulations to correct for the initial stress that is present in the AAA during imaging [2]. As single wall stress parameter, the 99-percentile wall stress is used [1].
All patients are divided in 2 groups, based on diameter growth rates and the AAA characteristics are compared. Wall stresses as computed with and without ILT are compared for the stable and progressive AAAs.

Results

Due to the ILT, the stress on the inner surface of the wall is strongly reduced. Only at the location where the ILT is thickest the effect is visual on the outer surface (see arrows).

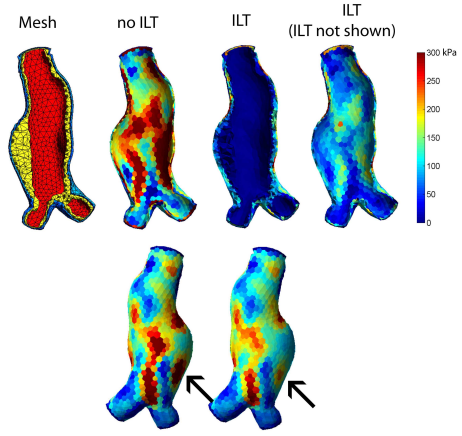

Fig. 1 *Typical AAA wall stress distribution. Anterior (top) and posterior (bottom) cross-sectional views of the mesh and the wall stress with and without ILT.*

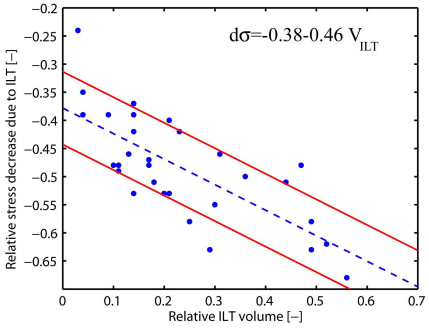

Fig. 2 *Reduction in wall stress as function of relative ILT volume.*

Table. 1 *AAA characteristics of stable AAAs (<3mm growth per year, n=17) and progressive AAAs (n=11).*

AAAs	Stable	Progressive	p-value
diameter(mm)	50±3	51±4	.26
AAA vol(ml)*	119±29	160±37	<.01
rel ILT vol(%)*	16±10	35±15	<.01
99-p stress(kPa)			
no ILT*	441±70	517±78	.01
ILT	240±54	223±59	.44

* Significantly different

Both the AAA volume and relative ILT volume are significantly higher for the group progressive AAAs, but the maximum diameter is equal in both groups. The stress as computed without ILT is also significantly higher, but when the ILT is included, no difference in both groups can be found.

Conclusion

- ILT reduces AAA wall stress, the effect is linearly related to the relative ILT volume.
- Progressive AAA growth is not related with the diameter but with the AAA volume and relative ILT volume.
- Higher wall stress is related to AAA growth but only when ILT is not included in the simulations.

References:

[1] Speelman L. , Bosboom E. M. H. , Schurink G. W. H. , et al.: *Patient-Specific AAA Wall Stress Analysis: 99-percentile versus peak stress* (Eur. J. Vasc. Endovasc. Surg., 2008)

[2] de Putter S. , Wolters B. J. , Rutten M. C. , et al.: *Patient-specific initial wall stress in abdominal aortic aneurysms with a backward incremental method* (J. Biomech., 2007)