LOCAL PARAMETERS THAT INFLUENCE THE LOCAL GROWTH OF ABDOMINAL AORTIC ANEURYSMS

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Aims

A structurally compromised wall causes fast aneurysm growth and vice versa, which in turn increases risk of rupture. Similarly, an intraluminal thrombus (ILT) weakens the aortic wall and influences the growth rate. High wall stress accelerates the metabolism in the aortic aneurysm wall, which can also increase the growth rate and the rupture risk. In order to further explore these factors, this study investigated the influence of the local diameter, the ILT layer thickness and wall stress on the growth rate.

Method

The infrarenal aorta of asymptomatic patients (n=90) was retrospectively reconstructed from at least two Computer Tomography-Angiography (CT-A) scans (median follow-up of one year) and biomechanically analysed with the Finite Element Method (FEM) [1]. Each individual abdominal aortic aneurysm FEM model was automatically sliced orthogonally to the lumen centreline, and represented by 100 cross-sections with corresponding diameter, ILT thickness and wall stress [2], see Figure 1. The data were grouped according to these parameters and significance among the groups was calculated.

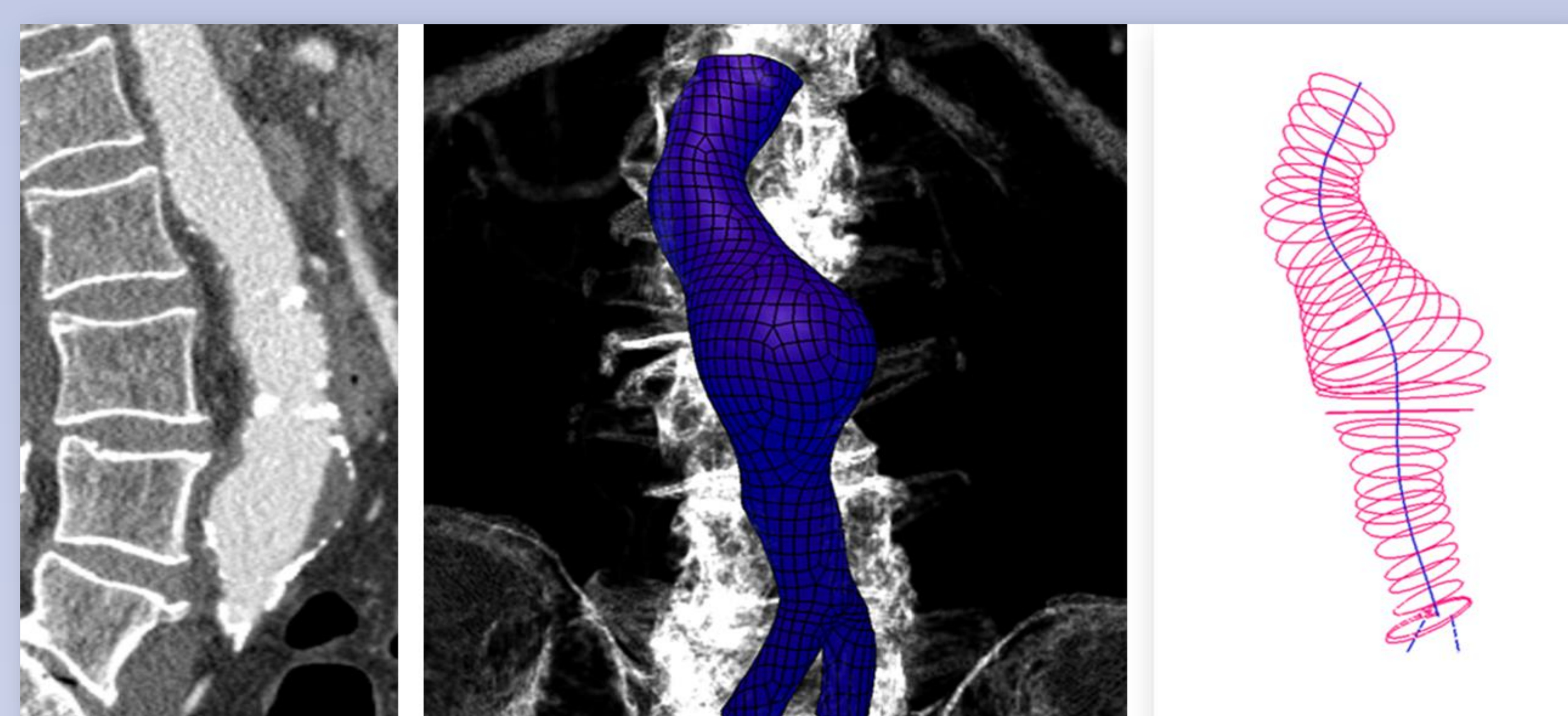

Figure 1: Derivation of the surrogate model to monitor the diameter expansion of an individual aneurysm. (Left) CT-A scan; (middle) Three-dimensional reconstruction; (right) cross-section based surrogate model that represents the wall geometry.

Results

Diameter growth was continuously distributed all over the aneurysmal sac reaching median absolute and relative peaks of 3.06 mm/year and 7.3%/year, respectively. The local growth rate was dependent on the local baseline diameter (Figure 2(a)), the local ILT thickness (Figure 2(b)) and, for wall segments not covered by ILT, also on the local wall stress level (Figure 3(left and middle)). For wall segments that were covered by a thick ILT layer, wall stress did not affect the growth rate, see Figure 3(right). The effect of the local diameter was much larger (1.02 mm/y versus 1.75 mm/y; $p < 0.001$) when absolute growth (mm/year) instead of relative growth (%/year) was analysed. Finally, a thin ILT layer reduced aneurysm growth, whereas a thick layer accelerated it (Figure 2(b)); more results are reported elsewhere [3].

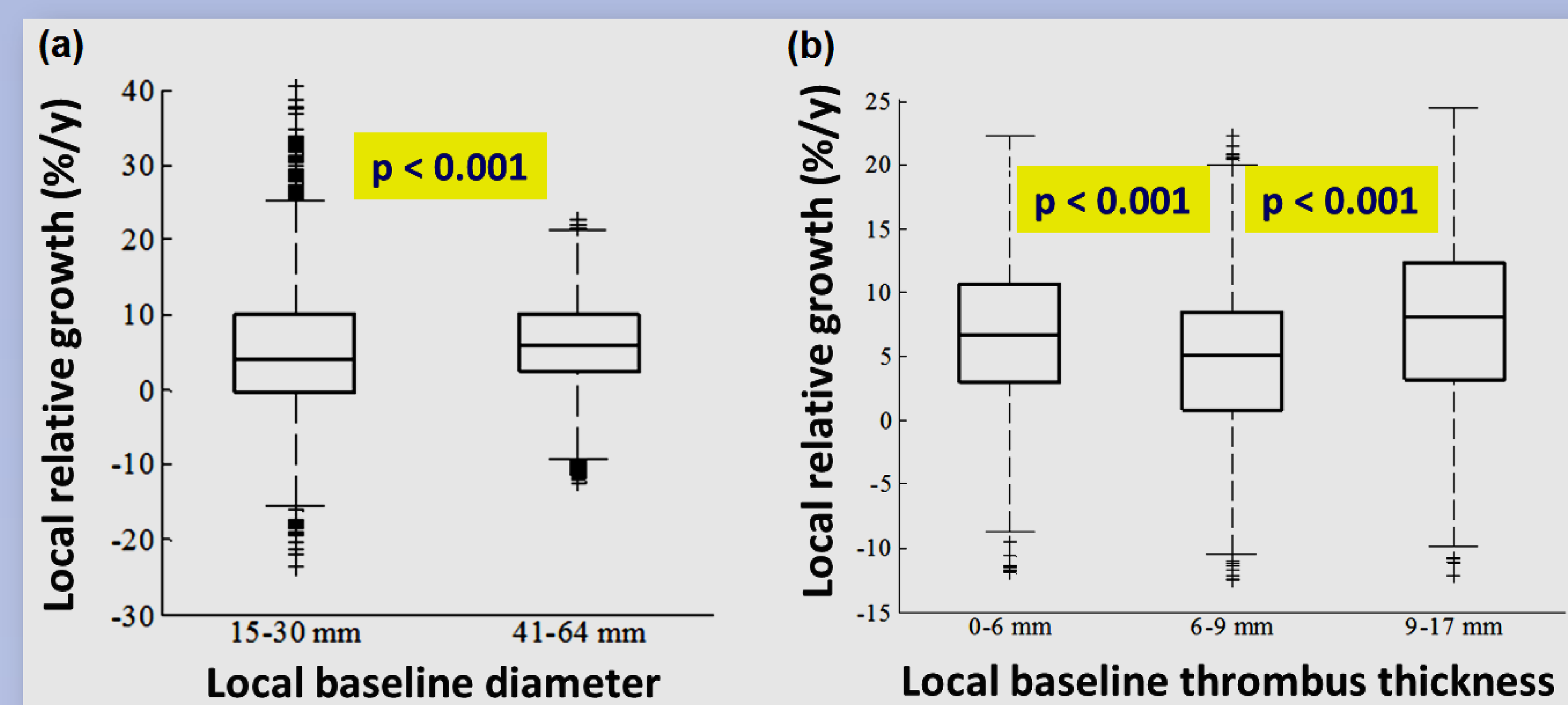

Figure 2: Effect of local baseline diameter (a) and local intra-luminal thrombus (ILT) layer thickness (b) on the local relative aortic cross-sections. Gender, smoking status and statin consumption were similar in the tested groups.

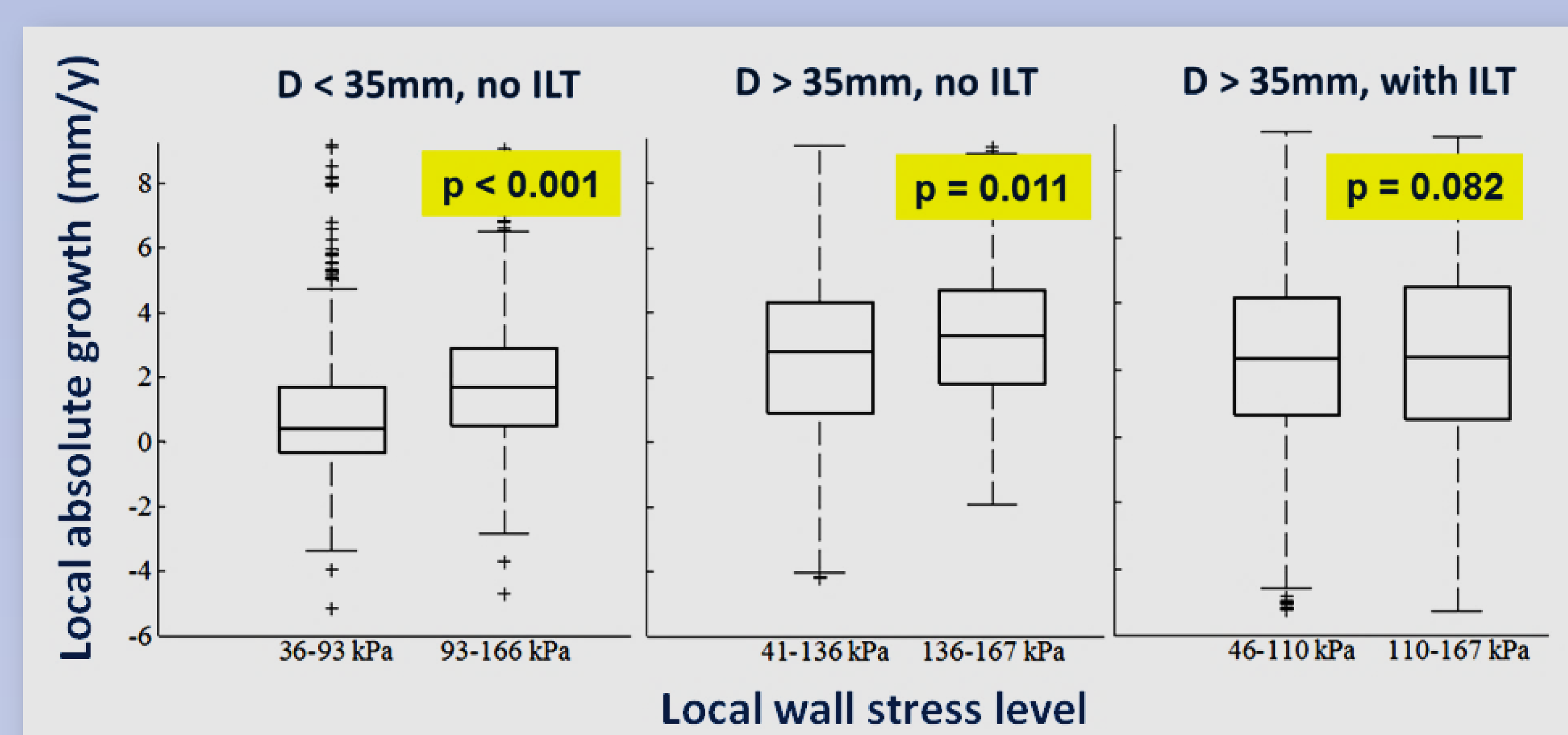

Figure 3: Effect of wall stress on the local absolute growth for non-aneurysmal cross-sections free of ILT (left), aneurysmal cross-sections free of ILT (middle) and aneurysmal cross-sections covered by ILT (right). Gender, smoking status and statin consumption were similar in the tested groups.

Conclusions

Diameter is not only a strong global predictor but also a local predictor of growth. However, the effect of local baseline diameter on relative growth is small (Figure 2(a)) and baseline volume might be a better predictor of aneurysm growth [4]. In addition, and independent of the diameter, the ILT thickness and wall stress (for the ILT-free wall) also influence local growth rate. This seems in agreement with the documented correlation of wall stress with FDG uptake [5] and wall histopathology [6]. The high stress-sensitivity of non-dilated aortic walls suggests that wall stress peaks could initiate AAA formation. In contrast local diameter and ILT thickness determine aneurysm growth for dilated and ILT-covered aortic wall cross-sections.

References

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