Towards model-based rupture risk assessment of abdominal aortic aneurysms

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Introduction

Knowledge of the wall stress distribution can help to predict the rupture risk of abdominal aortic aneurysms (AAA's) [1]. Although AAA wall stress results from combined action between the blood and the wall, previously published models for patient-specific wall stress assessment did not include fluid-dynamic effects.

Objective

To facilitate the incorporation of blood/wall interaction in AAA wall stress assessment, a method for generating patient-specific hexahedral finite element meshes of the AAA lumen and wall is presented. The applicability of the method is illustrated by a simulation of blood/wall interaction in a characteristic AAA.

Mesh Generation

From a CT image, the lumen centrelines and boundary surface are determined by semi-automated centreline tracking [2] and segmentation using a 3D Active Object [3] (Fig. 1).

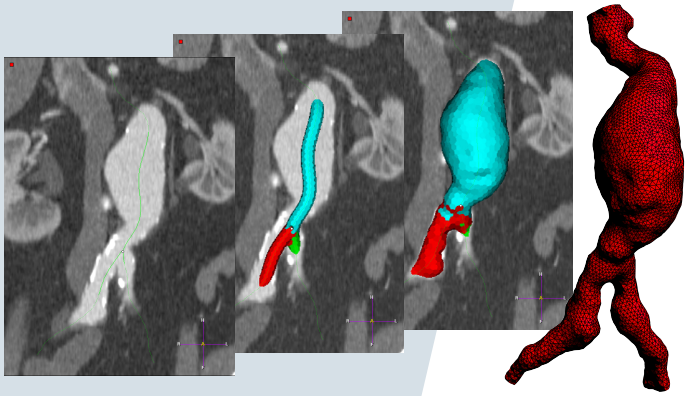

Figure 1 *Lumen segmentation and segmented boundary surface.*

A centreline-based initial lumen mesh is incrementally transformed to fit the segmented boundary surface. A wall mesh of uniform thickness is generated around the lumen (Fig. 2).

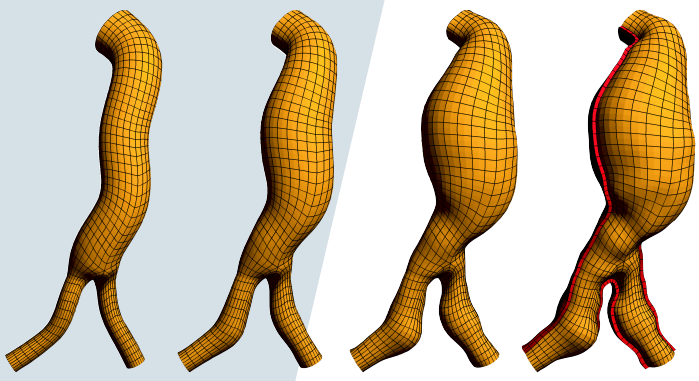

Figure 2 *Lumen mesh transformation (orange) and wall mesh (red).*

Blood/wall interaction

Blood/wall interaction in the AAA is simulated using a decoupled approach yielding the wall stress (Fig. 3), blood velocity distribution (Fig. 4) and wall shear stress (Fig. 5).

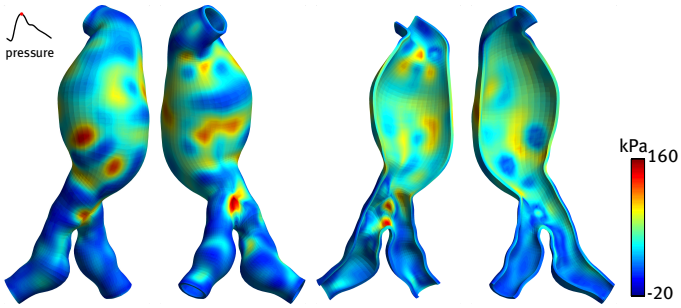

Figure 3 *Maximal principal stress in the AAA wall.*

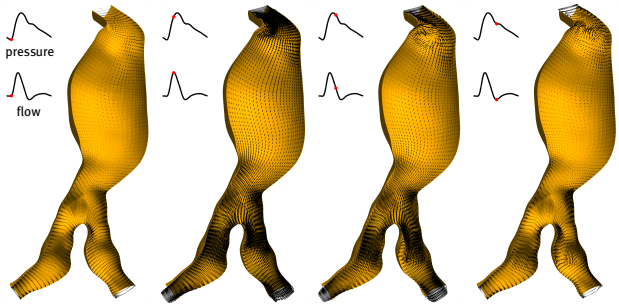

Figure 4 *Blood velocity distribution in the AAA lumen.*

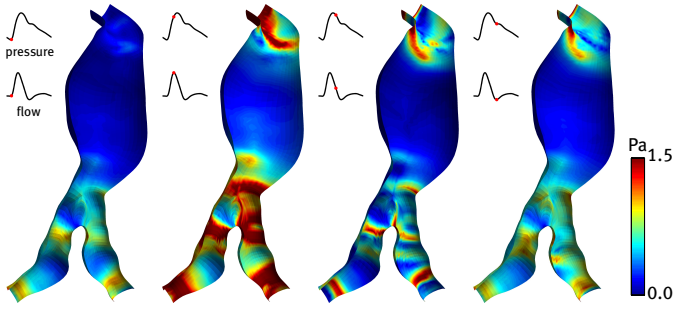

Figure 5 *Shear stress on the AAA lumen/wall interface.*

Discussion

The method yields a flexible approach to generating patient-specific hexahedral meshes of the AAA lumen and wall. This approach facilitates studies of the effect of blood/wall interaction on AAA rupture risk.

Acknowledgement

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References

[1] Fillinger MF et al. J Vasc Surg 2003;37(4):724–732.
[2] Wink O et al. Magnet Reson Med 2002;47:1169–1175.
[3] Gerard O et al. IEEE Trans Med Imaging 2002;21(9):1059–1068.

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