Virtual intervention using a wave propagation model of blood flow in patient specific arterial trees

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David Bessems[1], Kees Visser[2], Marcel Rutten[1], Frans van de Vosse[1]

[1] Eindhoven University of Technology, Department of Biomedical Engineering

[2]Philips Medical Systems, Best

Introduction

Numerical models of the arterial tree may be used to obtain clinically relevant information for pre-operative decision making in cardiovascular surgery. Here, a 1D wave propagation model by [1] is used to evaluate a possible intervention alternative of a patient specific arterial tree with a stenosed femoral artery.

Methods

Images of the patients arterial tree are obtained using contrast-enhanced MRI techniques. An automatic vessel-tree tracking method is used to obtain the vessels centreline and local lumen radius (figure 1). From this, a spectral element mesh is built as shown on the right.

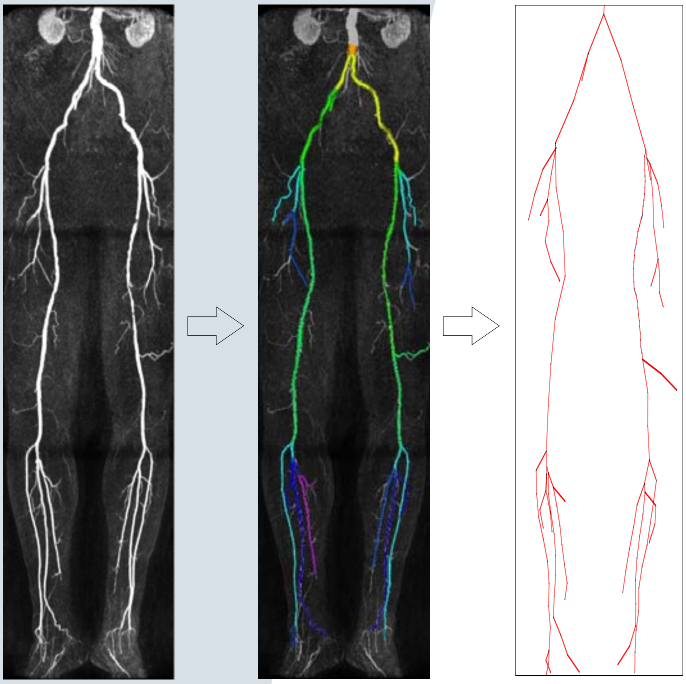

Figure 1: MR image of the lower part of the body (left), tracking of the vessel lumen using vessel tree tracking (middle) and transformation to a 1D spectral element mesh.

Below the renal arteries a physiological flow pulse is prescribed and the truncated ends are endowed with 3 element Windkessel models. The wave propagation model by [1] is used to compute the pressure, flow and wall shear stress throughout the geometry.

Numerical Results

As a result of the stenosed artery, the pressure proximal to this stenosis is elevated with respect to the pressure in the healthy leg, whereas the flow in the diseased leg has decreased. In the stenosed region a pressure drop occurs as a result of the increased local velocity.

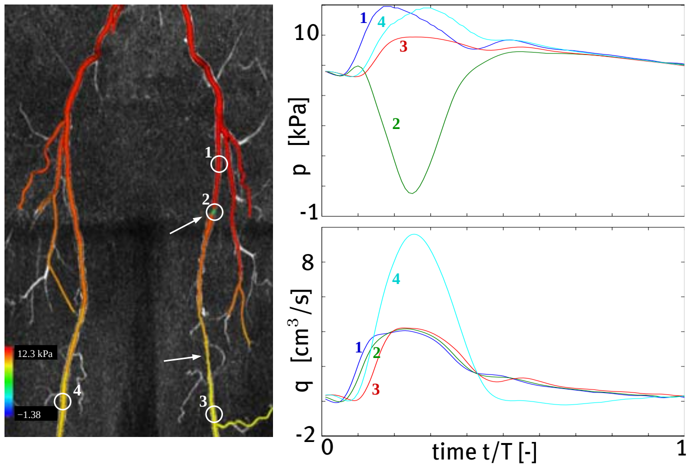

Figure 2: Computed pressure (p) and flow (q) of part of the geometry. The arrows indicate stenosed regions and the circles show the monitored positions.

A bypass is introduced around the proximal stenosis and the distal narrowing is treated by virtual angioplasty. Figure 3 shows the improved pressure and flow after this intervention.

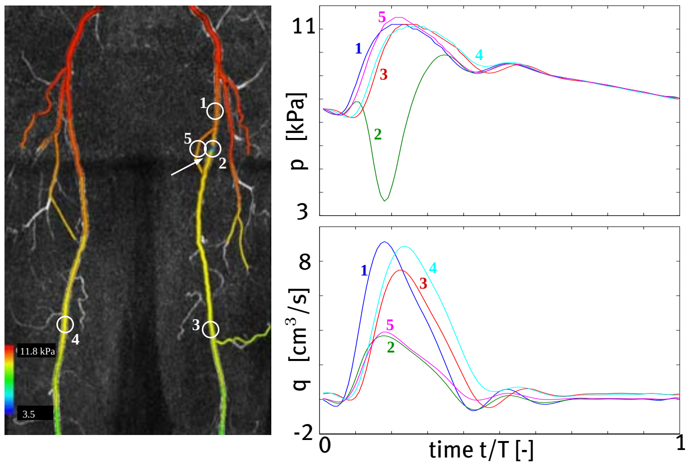

Figure 3: Computed pressure (p) and flow (q) of part of the geometry after virtual intervention. The arrows indicate stenosed regions and the circles show the monitored positions.

Discussion

- ☐ The model by [1] is validated for wave propagation in straight vessels but discontinuities such as bifurcations and stenoses need further attention.
- ☐ Values for the local arterial wall thickness and Young's modulus are taken constant but should also be obtained from patient data.

References

1. Bessems, D. (2006). A wave propagation model of blood flow in large vessels based on boundary layer theory. *submitted.*

PO Box 513, 5600 MB Eindhoven, the Netherlands