Endovascular treatment of AAAs using geometry-matched stent-grafts

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Introduction

An abdominal aortic aneurysm (AAA, Figure 1a) is a local dilation in the infrarenal aorta. To prevent an AAA to rupture, which is fatal in 80-90% of the cases[1], a prosthesis is placed in the AAA.

An alternative for the conventional open surgical repair is the less invasive endovascular repair, in which a stent-graft is inserted in the AAA via the femoral arteries (Figure 1b). This repair procedure has major perioperative advantages, such as reduced blood loss and faster recovery[2], but major complications, like migration and endoleaks, are often seen in endovascular repair.

Hypothesis

In this study, it is hypothesized that migration and endoleaks can be prevented using a geometry-matched stent-graft (Figure 1c).

Objectives

- ❑ Develop methods for manufacturing and implanting geometry-matched stent-grafts
- ❑ Evaluate the geometry-matched stent-grafting principle

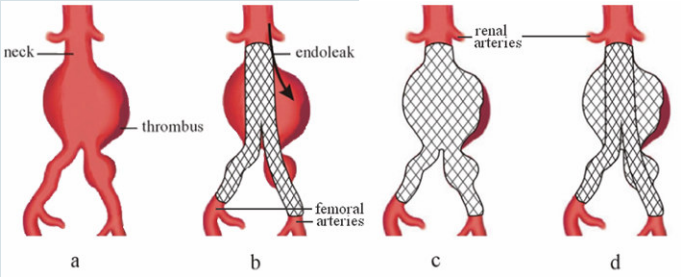

Figure 1 a) AAA b) Conventional stent-graft c) Geometry-matched stent-graft d) Hybrid stent-graft

Methods

Manufacturing

Using Rapid Prototyping, a patient-specific mould is made to create different designs of Nitinol stents. The stents are embedded in a graft to prevent corrosion. A poly-urethane graft can be created on-demand with the desired geometry.

There are two conflicting requirements in the design:

- Sufficient radial stiffness to keep the lumen open
- Possibility of inserting the stent-graft in a delivery system (diameter ‹ 7mm)

Implantation

For an optimal positioning of the stent-graft, a 3D high-resolution reconstruction of the AAA during the intervention is necessary. For this, a combination of 3D rotational angiography (3DRA, Figure 2) and intravascular ultrasound (IVUS, Figure 3) will be used.

Evaluation

The geometry-matched stent-grafts will be compared with the conventional stent-grafts using finite element simulations and *in-vitro* experiments.

Thrombus formation likely will occur in geometry-matched stent-grafts due to reversed flow. A hybrid stent-graft (Figure 1d) can be the solution to this problem.

- ❑ Finite element simulations
  - Prediction of short-term results (pressure, stress, flow)
  - Optimization of the stent-graft design.
- ❑ *In-vitro* experiments
  - Validation of the computational model
  - Development of image-guided implantation procedures.

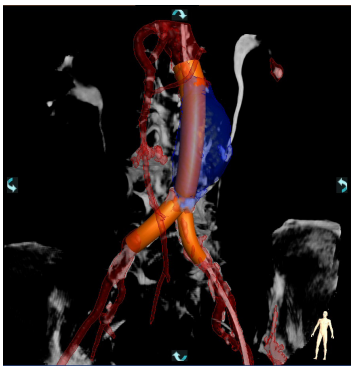

Figure 2 3DRA of AAA stent-graft (Philips Medical Systems)

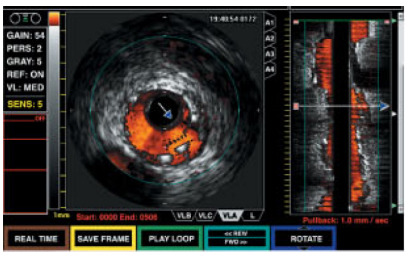

Figure 3 IVUS image of the aorta (Volcano, IVG3–system)

Future work

- ❑ Optimize stent-graft design
- ❑ Model the stent-grafts in finite element simulations
- ❑ Test stent-graft prototypes in *in-vitro* set-up
- ❑ Develop tools for 3D reconstruction from 3DRA and IVUS
- ❑ Registration of 3DRA/IVUS with pre-operative CT
- ❑ Optimize implantation procedures

References:

[1] *Van der Vliet et al., Lancet. 1997 Mar 22;349(9055):863-6.*
[2] *Prinssen et al., N Engl J Med. 2004 Oct 14;351(16):1607-18.*