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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

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 \textit{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.
- \textit{In-vitro} experiments
  - Validation of the computational model
  - Development of image-guided implantation procedures.

Future work
- Optimize stent-graft design
- Model the stent-grafts in finite element simulations
- Test stent-graft prototypes in \textit{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: