Vascular remodeling after AVF creation as angioaccess for hemodialysis: the predictive value of a patient-specific computer model

Introduction
Functioning of hemodialysis arteriovenous fistula (AVF) immediately after surgical creation is mainly hampered by non-maturation, which is characterized by insufficient flow increase and insufficient vessel remodeling. Despite available preoperative diagnostics 20-50% of all newly created AVFs fail\(^1,2\). The initial postoperative flow (pFV) increase is generally accepted to be indicative for proper maturation\(^2\).

Aim of the study
The development of a patient-specific computer model that is able to predict the pFV increase after AVF creation as angioaccess for hemodialysis. Eventually, the model will be used for surgical AVF planning.

Research approach
Vascular hemodynamics is simulated by either one of two different modeling approaches, lumped parameter modeling\(^3\) or 1D-wave propagation modeling\(^4\). For both models the human vascular tree is divided into segments representing local blood and vessel wall properties (fig. 1). All models are adapted to patient-specific conditions and results are compared with clinical measurements.

Patient-specific model input
- CE-MRA\(^5\): Geometry and diameters (fig. 2)
- Ultrasound: Diameters, blood flow and wall distensibility (fig 3)
- PC-MRI: Arterial blood flow and cardiac output
- Tonometry and Penaz method: Radial and finger pressure

Future work
- Test the feasibility of the 1D-model and extend the model with heart and veins
- Incorporate nonlinear pressure-flow relationships for veins and anastomosis
- Introduce visco-elastic behavior of the vessel wall
- Collect patient-specific data for 60 patients
- Perform simulations for 60 patients
- Determine the model’s predictive value

References
1 Allon M, Kidney Int, 62(4): 1109-1124, 2002
3 Westerhof N, J Biomech 2:121-143, 1969
5 Planken RN, PhD thesis, Maastricht, 2006