

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

**Citation for published version (APA):**

Huberts, W., Bosboom, E. M. H., & Vosse, van de, F. N. (2007). *Vascular remodeling after AVF creation as angioaccess for hemodialysis : the predictive value of a patient-specific computer model*. Poster session presented at Mate Poster Award 2007 : 12th Annual Poster Contest.

**Document status and date:**

Published: 01/01/2007

**Document Version:**

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

**Please check the document version of this publication:**

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

**General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

**Take down policy**

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

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

Huberts W.<sup>1</sup>, Planken R.N.<sup>2</sup>, Bosboom E.H.M.<sup>1</sup>, Tordoir J.H.M.<sup>2</sup>, van de Vosse F.N.<sup>1</sup>

<sup>1</sup>Eindhoven University of Technology, dept of Biomedical Engineering,

<sup>2</sup>University Hospital Maastricht, dept of Surgery

## 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<sup>1,2</sup>. The initial postoperative flow (pFV) increase is generally accepted to be indicative for proper maturation<sup>2</sup>.

## 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<sup>3</sup> or 1D-wave propagation modeling<sup>4</sup>. 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.

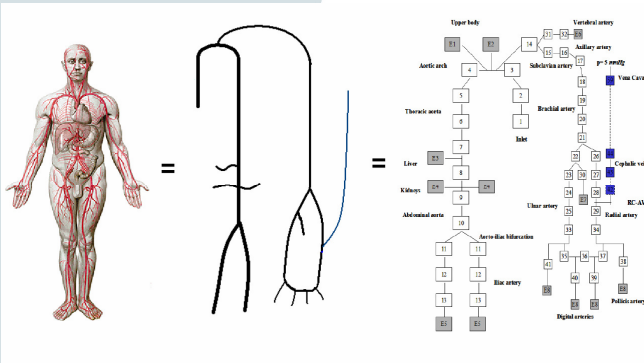


Figure 1: The vascular tree divided in segments.

**Lumped parameter model<sup>3</sup> (0D):** Pressure is represented by electrical potential and flow by electrical current. A resistor and an inductor are used to model the viscous and inertial blood properties. Vessel compliance is modeled with a condensator.

**Wave propagation model<sup>4</sup> (1D):** Flow in a vessel is divided in an inertia dominated core and a friction dominated boundary layer. By assuming equilibrium between inertia and viscous forces at the transition from core to boundary layer, a velocity profile as function of the flow and the pressure gradient is derived that is used to solve the 1D momentum equation.

## Patient-specific model input

- CE-MRA<sup>5</sup>: 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

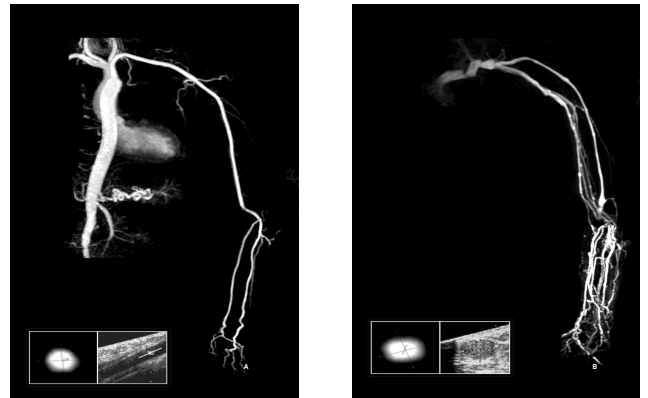


Figure 2: Antero-posterior maximum intensity projections of a CE-MRA image of the left arm arteries (A) and vein<sup>5</sup> (B).

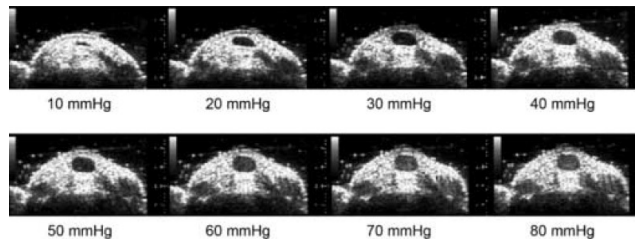


Figure 3: A transversal B-mode image of the cephalic vein for different congestion pressures<sup>5</sup>.

## 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
- 2 Tordoir JHM, Nephrol Dial Transplant 18: 378-383, 2003
- 3 Westerhof N, J Biomech 2:121-143, 1969
- 4 Bessems D, J Fluid Mech 580:145-168, 2007
- 5 Planken RN, PhD thesis, Maastricht, 2006