A computational model for surgical planning of vascular access

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CONTROVERSES ET ACTUALITÉS EN CHIRURGIE VASCULAIRE
CONTROVERSIES & UPDATES IN VASCULAR SURGERY

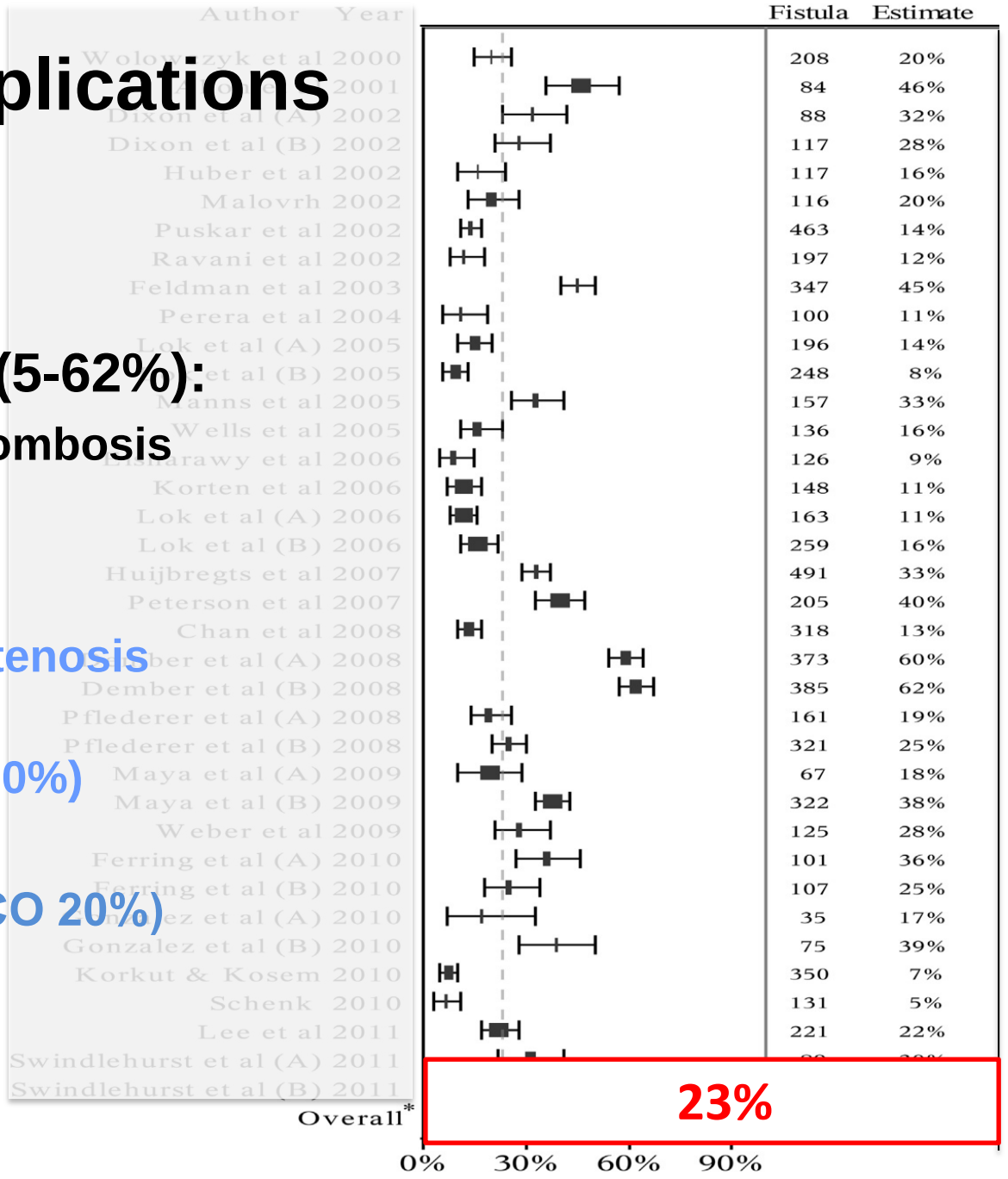
Faculty Disclosure

Jan H.M. Tordoir

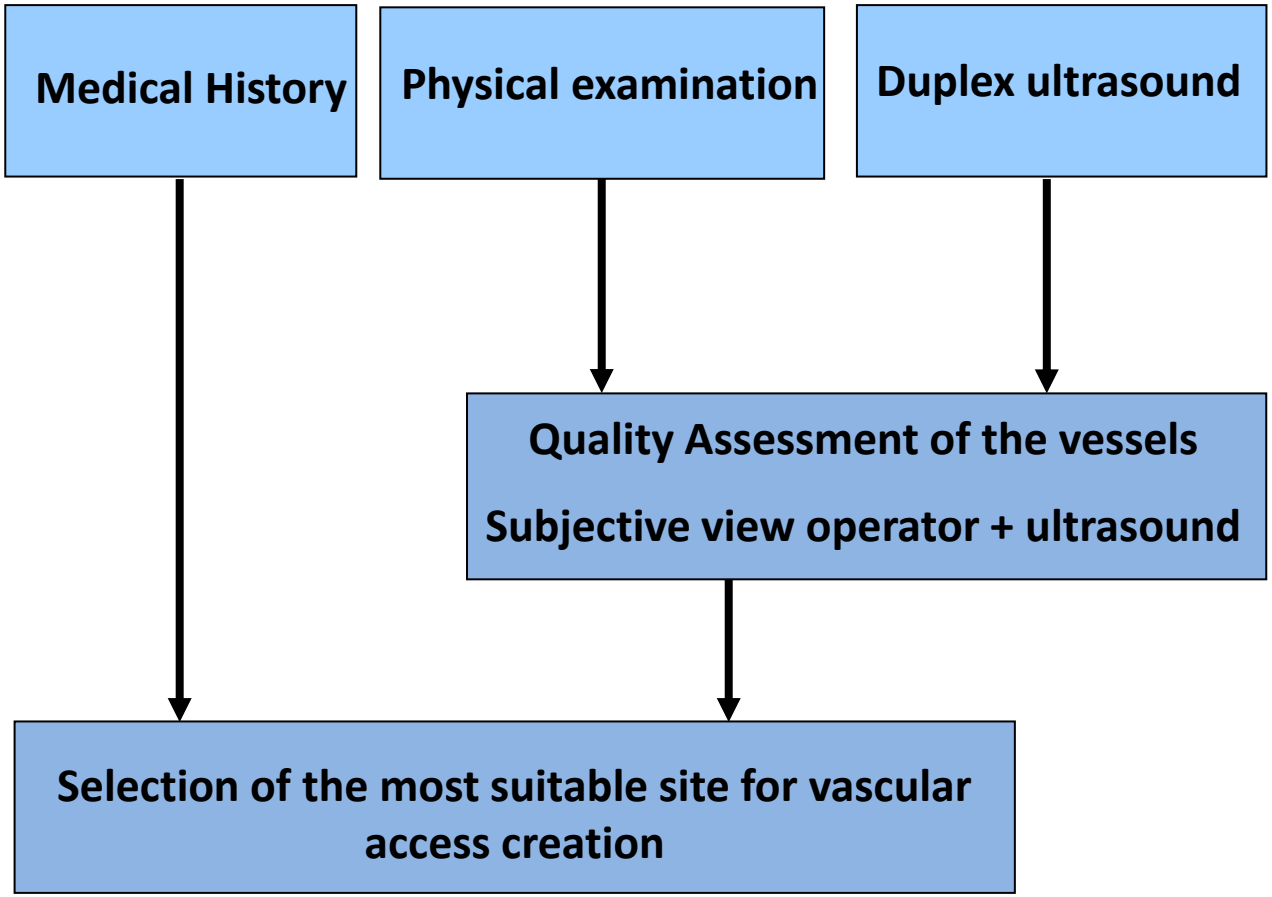
I have **no financial relationships** to disclose.

AVF Complications

- **Short term failure(5-62%):**
  - **Postoperative thrombosis**
  - **Non-maturation**
- **Long term failure:**
  - **Development of stenosis (patency)**
  - **Steal syndrome (20%)**
  - **High access flow**
  - **Cardiac failure (↑CO 20%)**



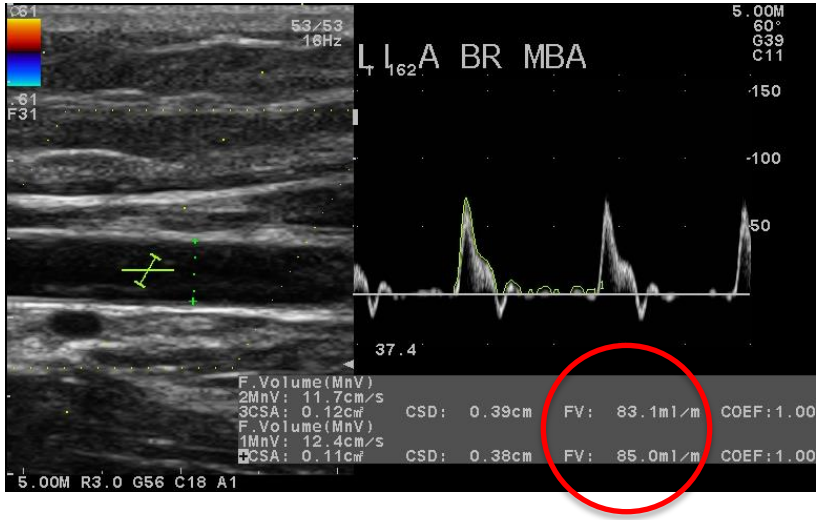
Current practice preoperative workup

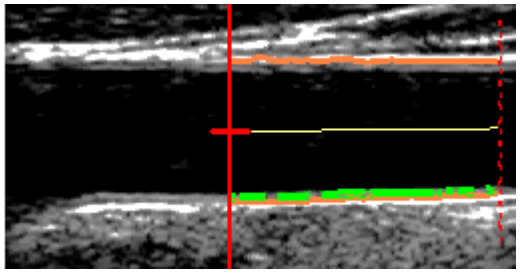


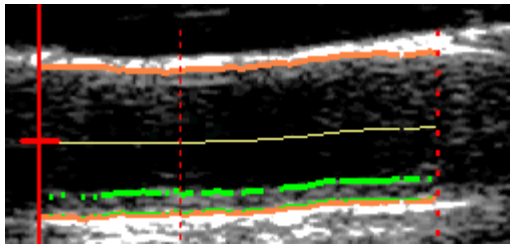
Input parameters modeling tool

Advanced Ultrasonography

- ❑ Arterial & venous anatomy
- ❑ Arterial & venous diameters
- ❑ Arterial & venous distensibility
- ❑ Arterial flow







Computer simulation for access planning

Lumped parameter modelling

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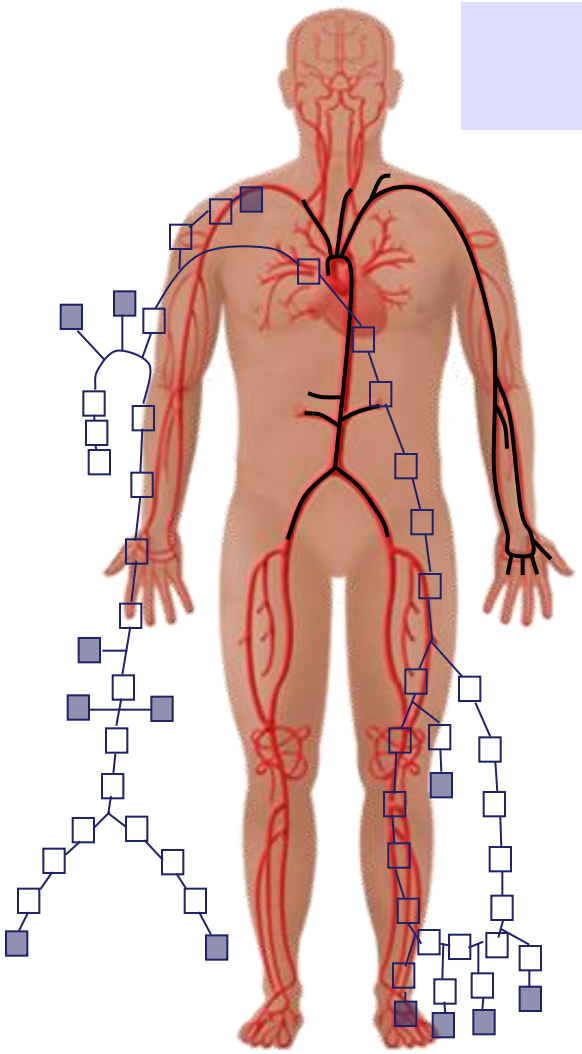
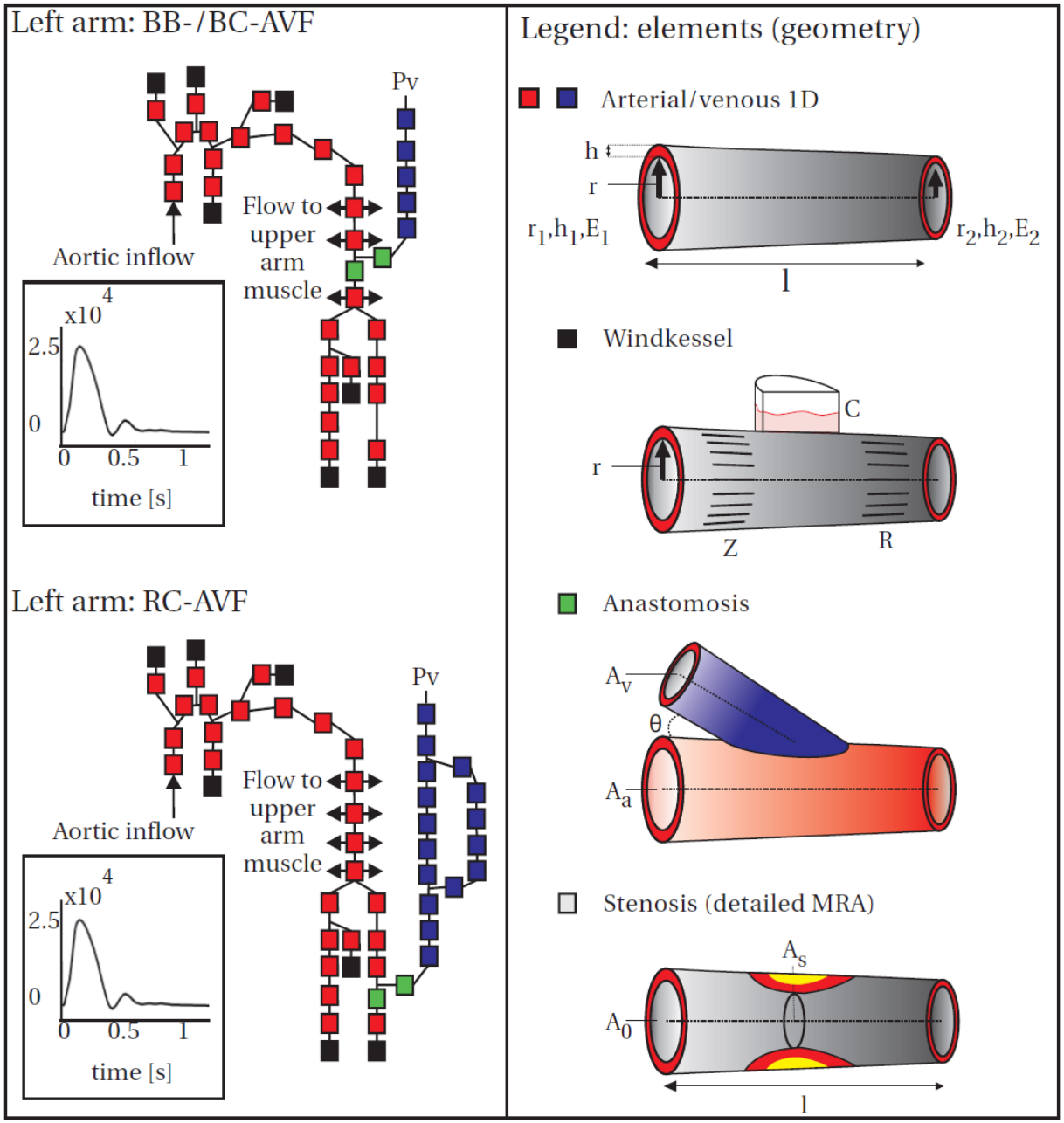
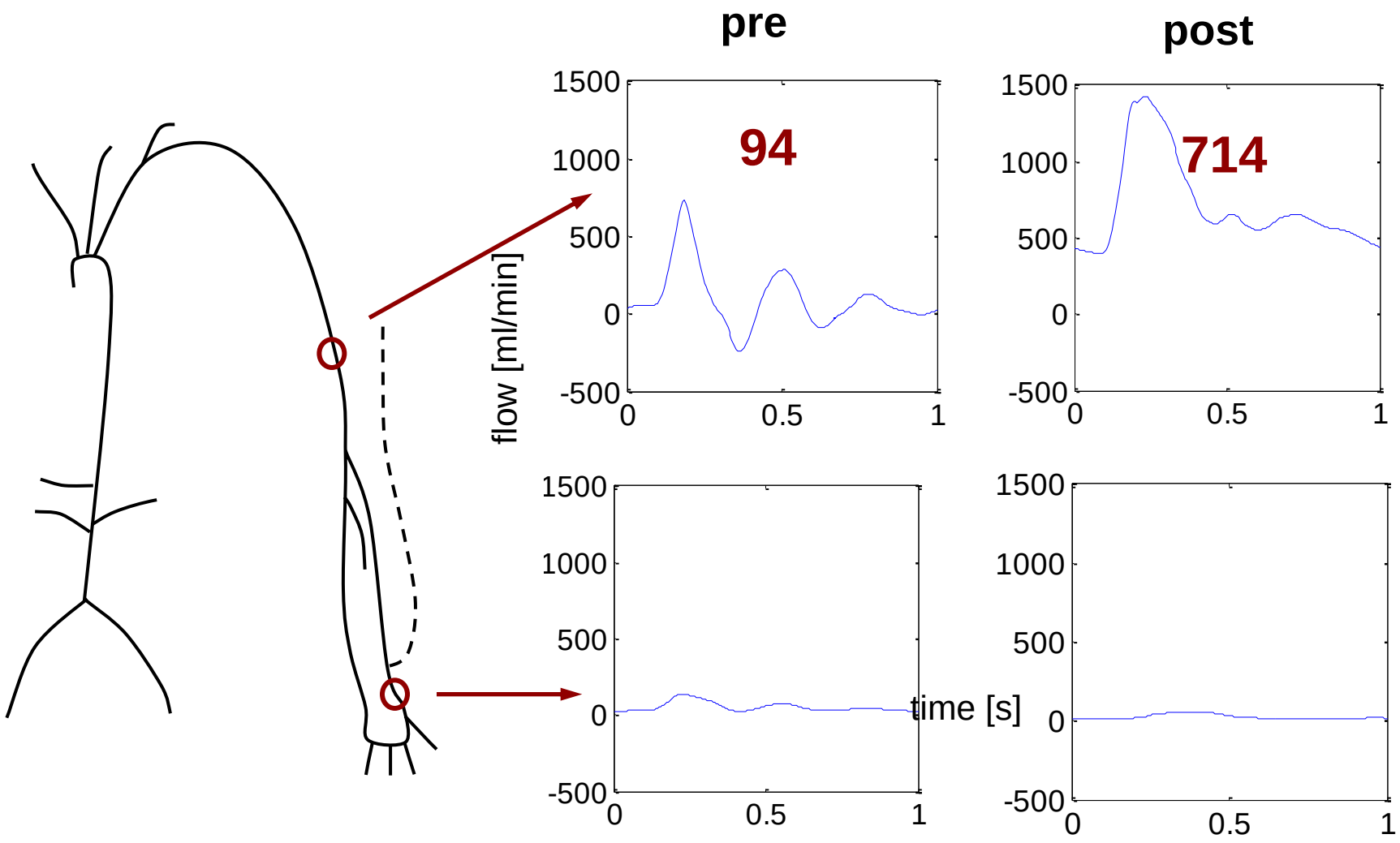


Computer simulation for access planning

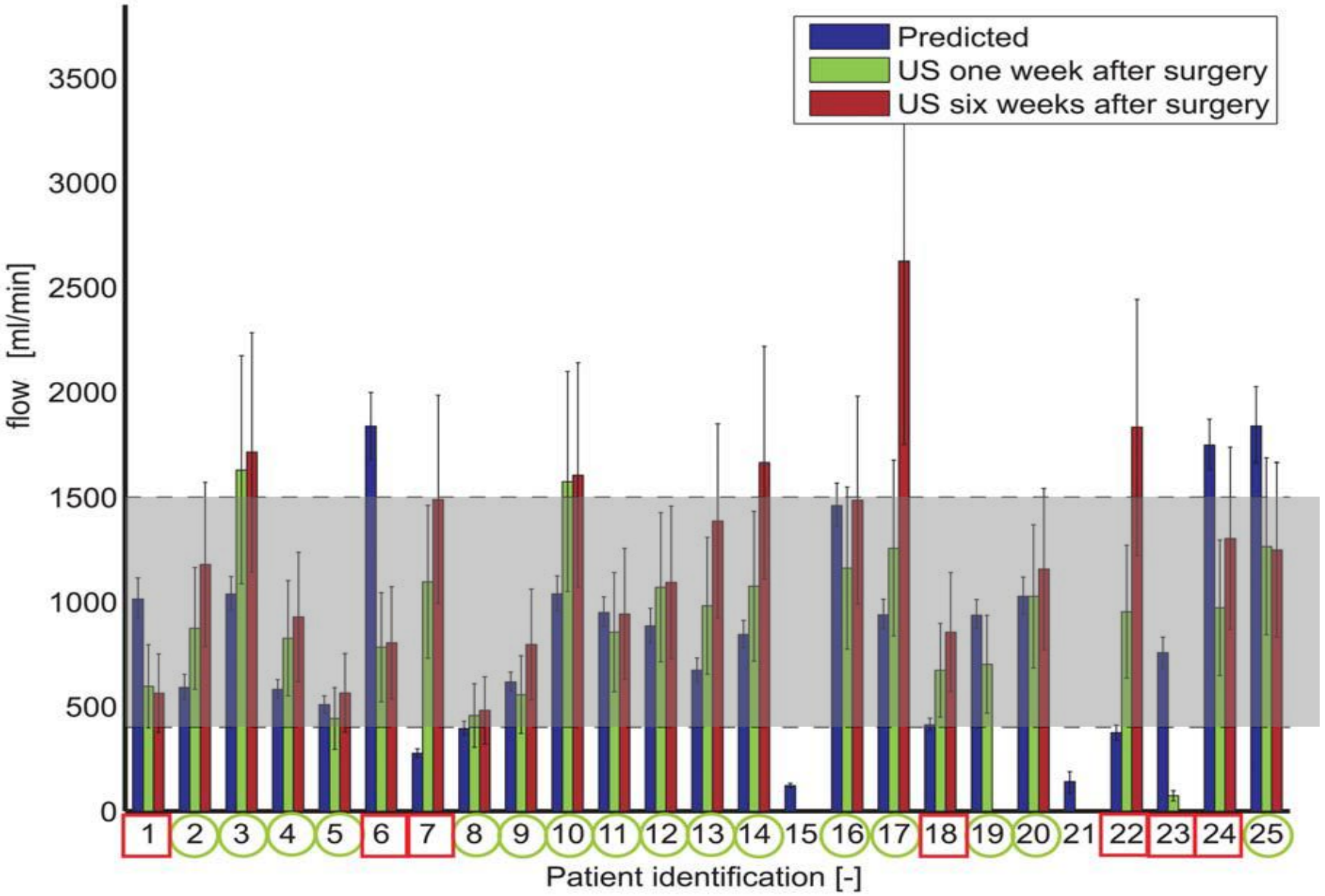
1 D Lumped parameter model with pulse wave propagation



Computer simulation for access planning
1 D pulse wave propagation model



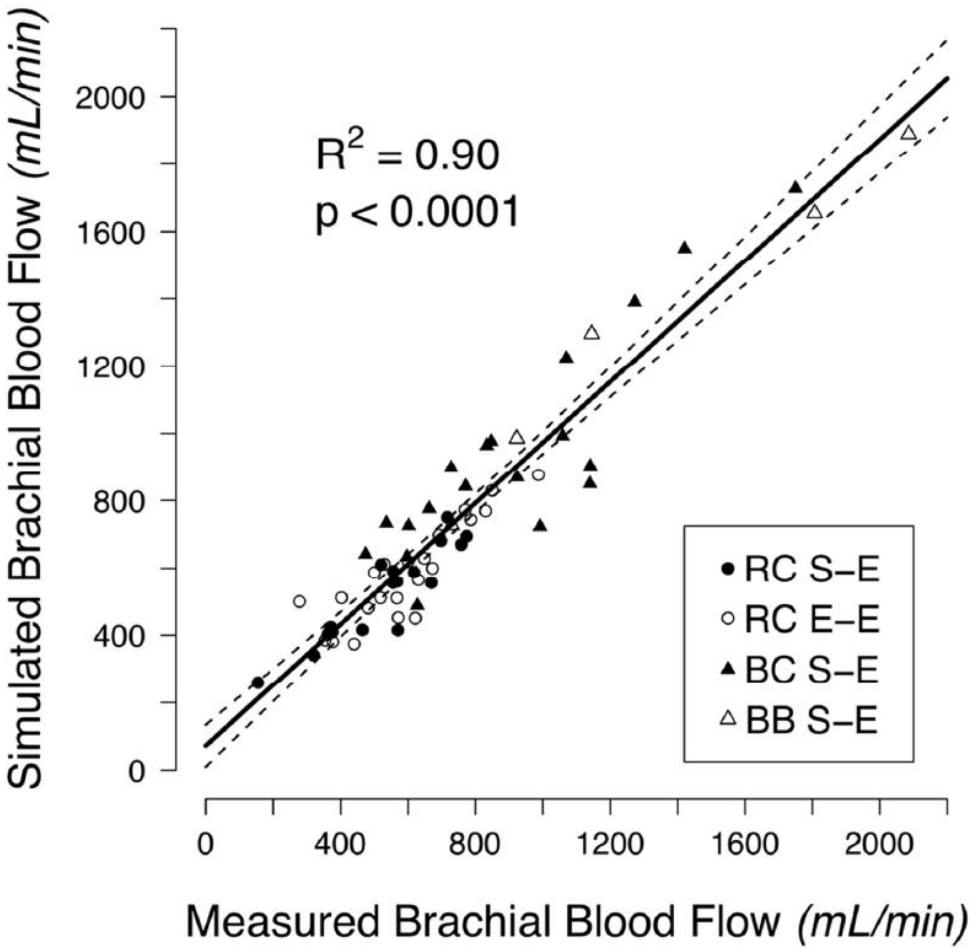
Computer simulation for access planning



Simulated and measured postoperative flows for the created AVF

Computer simulation for access planning

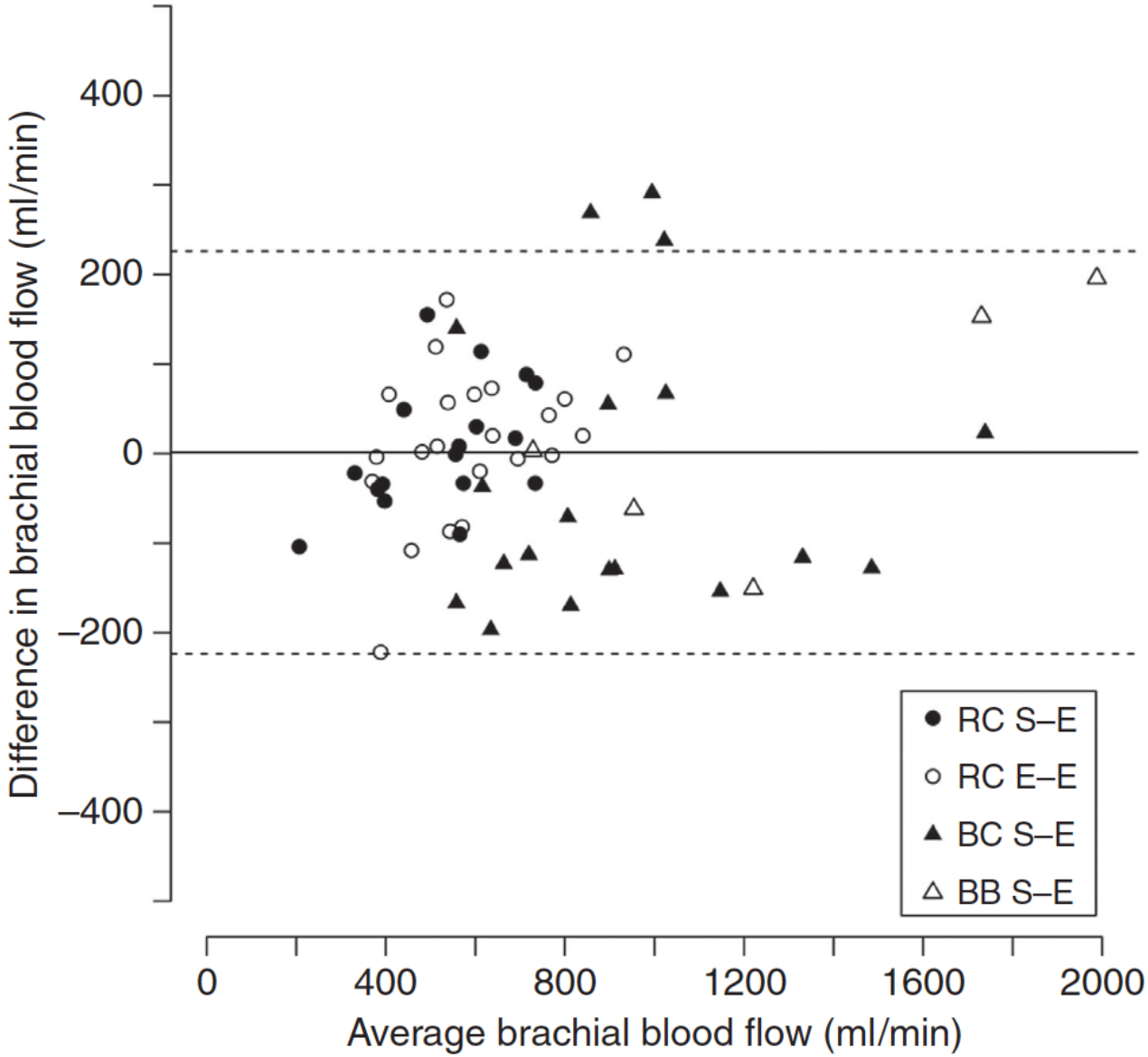
N=90



Correlation between measured and predicted brachial artery blood flow volume at 40 days after AVF surgery

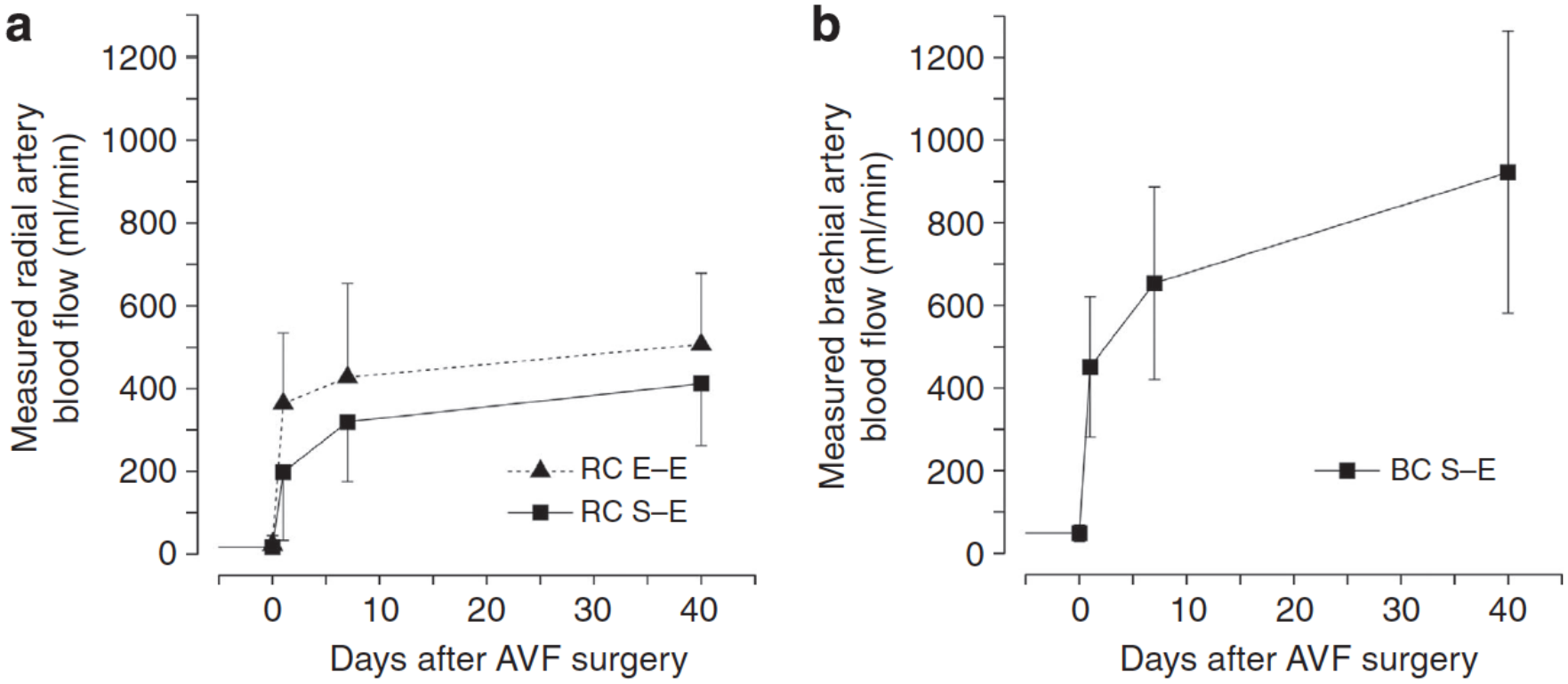
Empty circle: radiocephalic (RC) end to end (E-E); full circle: RC side to end (S-E); full triangle: brachiocephalic (BC) S-E; empty triangle: brachiobasilic (BB) S-E.)

Computer simulation for access planning



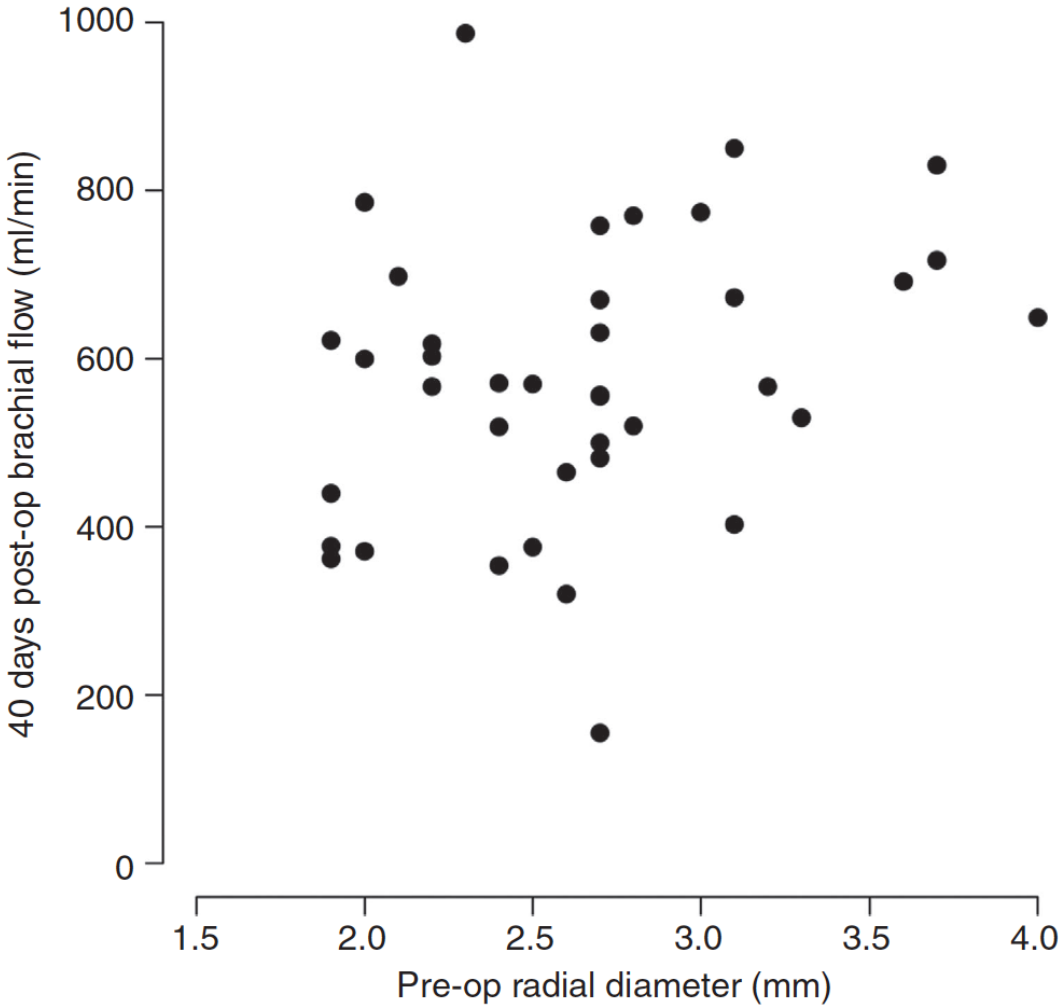
Alt-Blandman plot for variation in simulated and ultrasound measured bloodflow

Computational Simulation to Predict Maturation



Bloodflow volume adaptation following vascular access surgery.
a= radiocephalic (RC) end to end (E-E) and side to end (S-E)
b = brachiocephalic (BC) S-E).

Computational Simulation to Predict Maturation



Correlation between preoperative (Pre-op) radial artery diameter and measured brachial artery blood flow volume at 40 days after surgery (post-op) in 39 patients with distal AVF

Preoperative assessment: computational simulation

Summary

- Patient-specific assessment & surgical planning
- Multi-scale computational modelling framework
- Dedicated preoperative vessel imaging
- Input of high quality duplex scanning parameters
- Improvement of Short-term maturation?

Preoperative assessment: computational simulation

Future directions

- Multicenter randomised clinical study comparing conventional *vs* computer simulation work up for AVF creation in incident patients
- 8 sites in the Netherlands (4 university and 4 general hospitals)
- Expected number of patient inclusions: 364 (in 3 years)
- Primary outcome parameters: early failure rate and time to first cannulation
- Secondary outcome parameters: primary patency between both groups