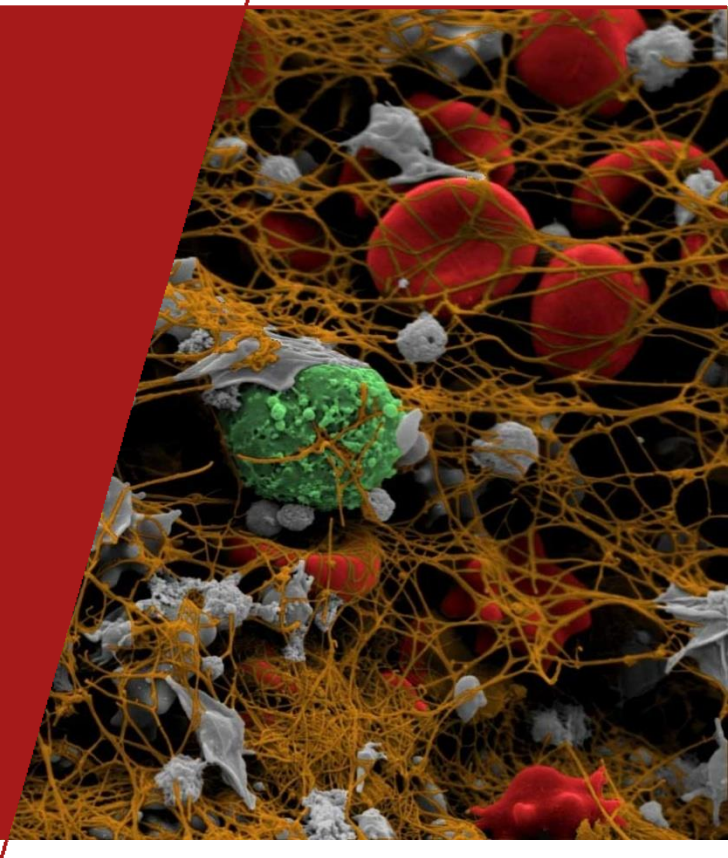
cardiovascular biomechanics

Cardiovascular Biomechanics



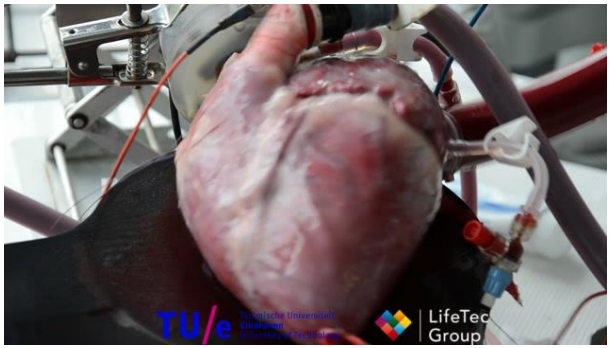
Technische Universiteit Eindhoven University of Technology

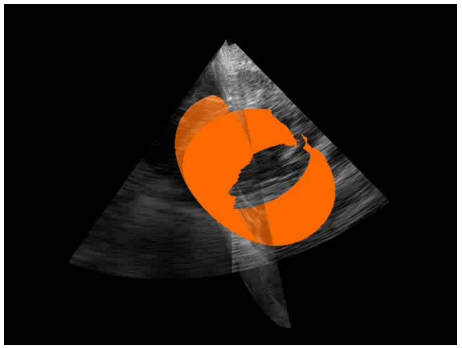
Where innovation starts

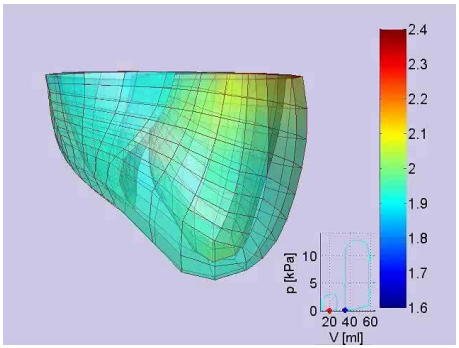
/Biomedical Engineering

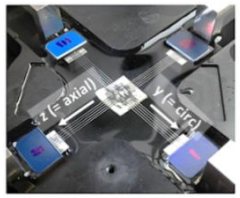
Cardiovascular Biomechanics

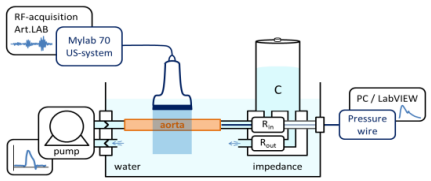
/overview

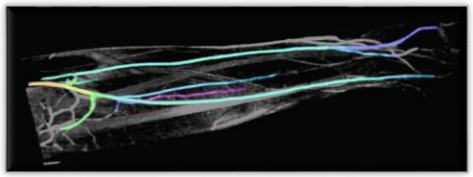


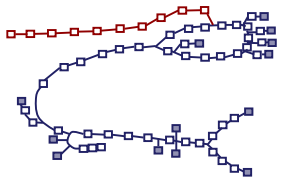












Basic Investigations:

- Biomechanical modeling of physiology, FEM, patient-specific modeling
- Design of experiments and devices, in vitro / ex vivo validation
- Clinical measurements and patient studies
- Model-predicted clinical decision support

Applications:

- Heart failure, coronary stenting, pacing, cardiac support, heart valves
- Coronary disease, peripheral disease, carotid atherosclerosis, aortic aneurysms
- Catheter-based technology and functional ultrasound
- Blood coagulation

Cardiovascular Biomechanics /people


prof.dr.ir. Frans van de Vosse

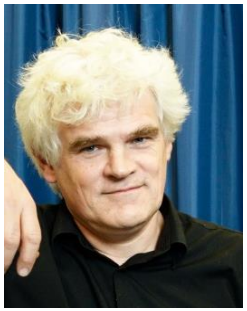

prof.dr. Nico Pijls


prof.dr. Charley Taylor


prof.dr. Marc van Sambeek


dr.ir. Peter Bovendeerd


dr.ir. Richard Lopata


dr.ir. Marcel Rutten


dr. ir. Wouter Huberts


dr.ir. Mascha Maenhout -van Haag


dr.ir. Marielle Bosboom


Alice van Litsenburg

Blood in Motion

Heart at Work

Vessel under Stress

In summary

- Research on cardiovascular physiology and function
- New diagnostic measurements and devices
- Clinical decision support using predictive modelling

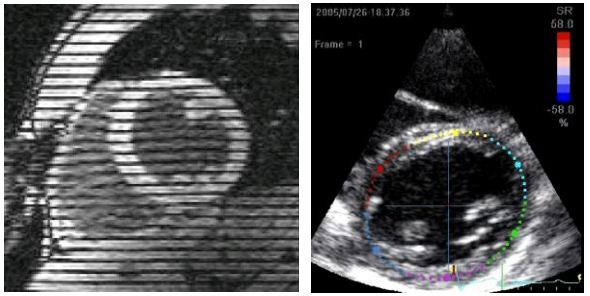
Dr.ir. Peter Bovendeerd

Luca Barbarotta
Emanuele Rondanina

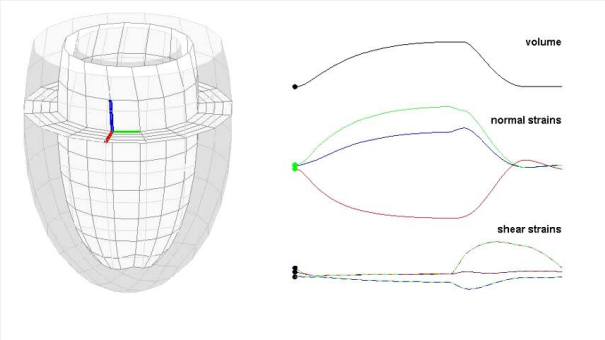
Eric Chen
Tilaï Rosalina

Research: the heart

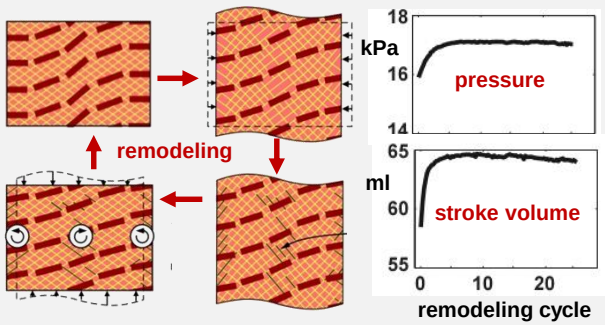
- function from tissue to organ
- growth and remodeling
- focus on mathematical modeling
- to assist in clinical decision making



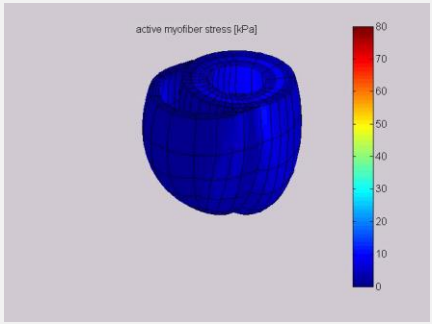
clinical data



pump function and wall mechanics



remodeling of fiber orientation



clinic: cardiac resynchronisation

Examples of Bachelor End Projects

- Nick van Osta: modeling cardiac growth
- Glenn Cremers: area deformation of the mitral annulus
- Koen Franse: tissue orthotropy
- Lex van Houts / Tim van Loon: myocardial contraction in FEniCS finite element package

Dr.ir. Peter Bovendeerd

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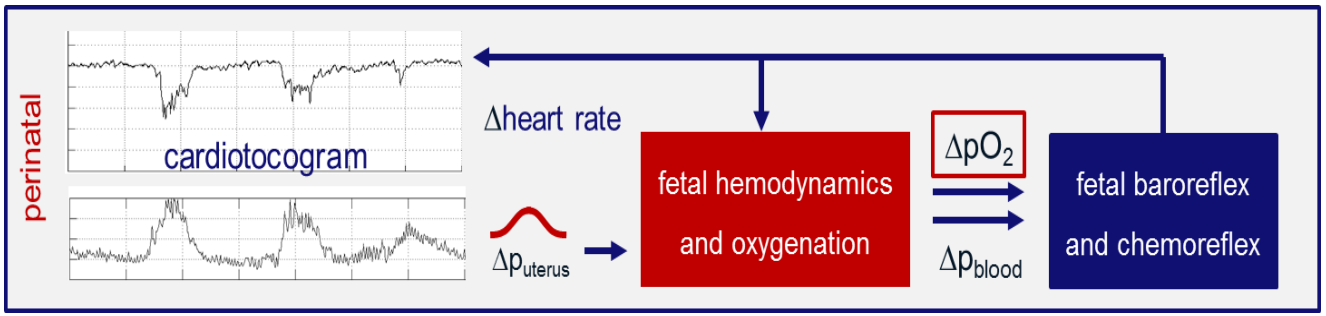
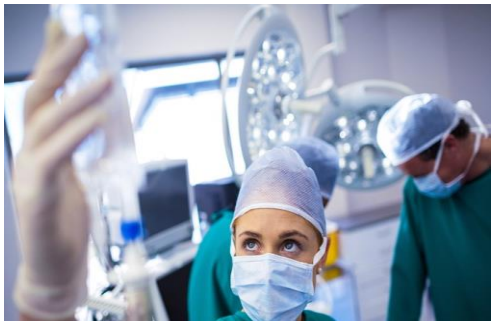
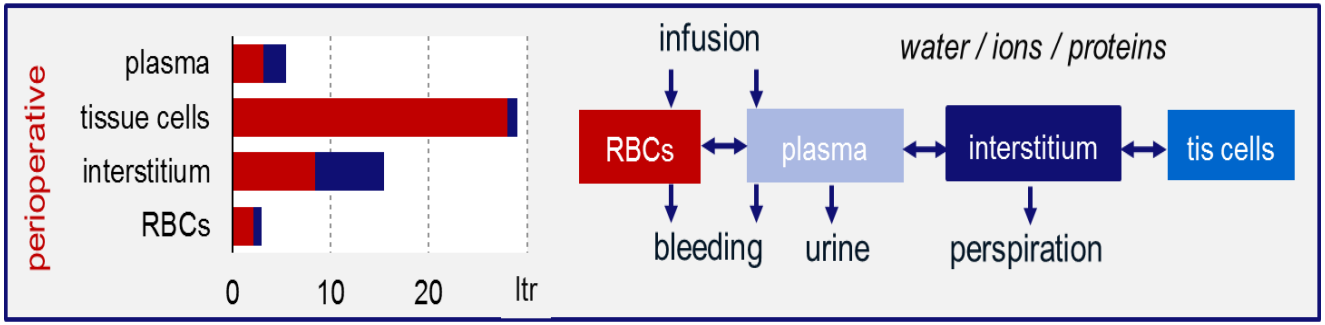
Eric Chen
Tilaï Rosalina

Research: perinatal and perioperative care

- mathematical models of physics and physiology @ system level
- to assist in clinical education and diagnostics







Examples of Bachelor End Projects

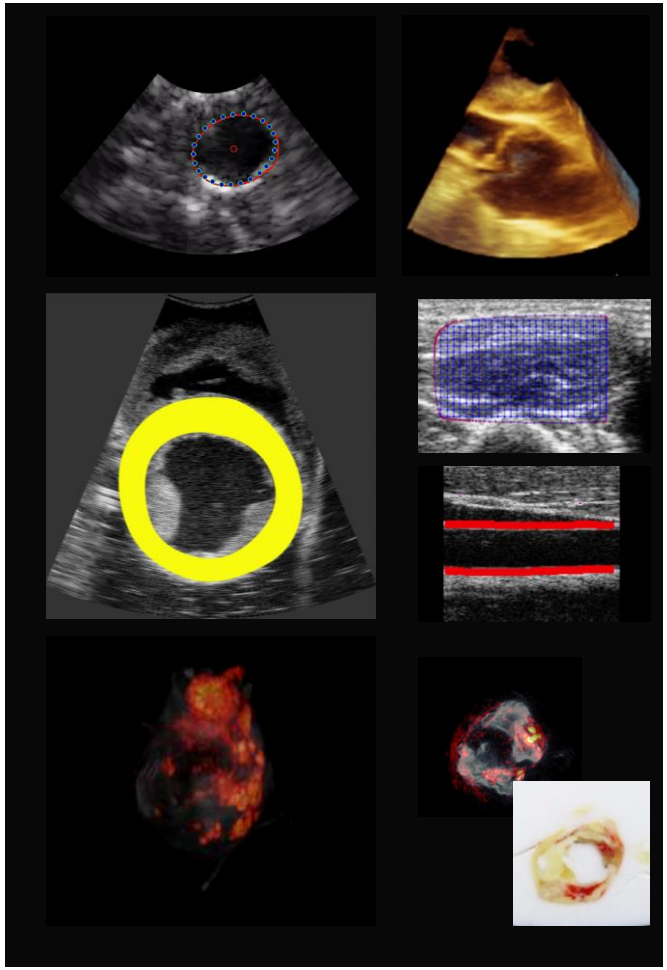
- Tessa van Haaften / Anne van de Meulengraaf / Amy Berendsen: respiratory function
- Hans de Ferante / Lisa Geurten: renal function

Dr.ir. Richard Lopata

Min Wu
Maarten Heres
Niels Petterson
Ümit Arabul
Joerik de Ruijter
Emiel van Disseldorp
Louise Gouteux
Louis Fixen

Research topics: measurements

- **Functional ultrasound imaging**
  - Measure motion, deformation
  - Determine mechanical properties of tissue
  - Measure flow in arteries and tissue perfusion
  - Signal processing / image reconstruction
  - Image analysis: feature detection, segmentation
  - Imaging during exercise
- **Photo-acoustic imaging**
  - Spectral imaging
  - Determine tissue constituents (arteries)
  - Perfusion of skin & muscle



Examples of Bachelor End Projects

- Developing new methods & experimental validation
- Image registration in 3D large area scans
- New methods to measure perfusion
- Photoacoustic signal analysis of tissue samples
- Volunteer studies

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Joerik de Ruijter
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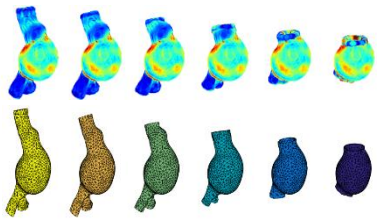
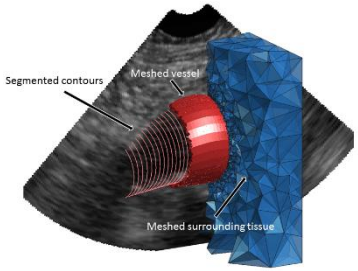
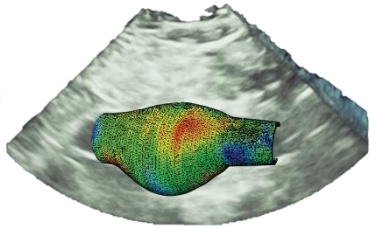
Louis Fixen

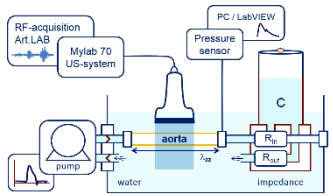
Research topics: models

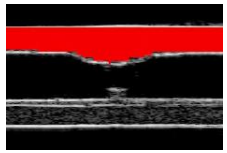
- **Image-based modeling**
  - Patient-specific finite element modeling of AAAs, plaques, peripheral arteries, heart
  - Validation with CT/MR and patient studies
- **Experimental models for validation**
  - Mechanical testing of biological tissue
  - Mock loops to mimic hemodynamics
  - µCT / histology for validation

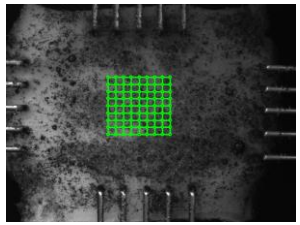










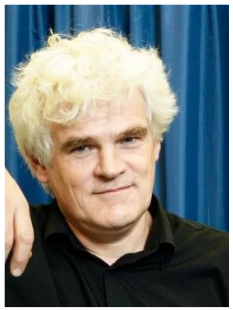


Examples of Bachelor End Projects

- Models of PA and US wave propagation
- Mechanical characterization of arteries
- Development of arterial/flow phantoms
- Simulation models of organs and stents

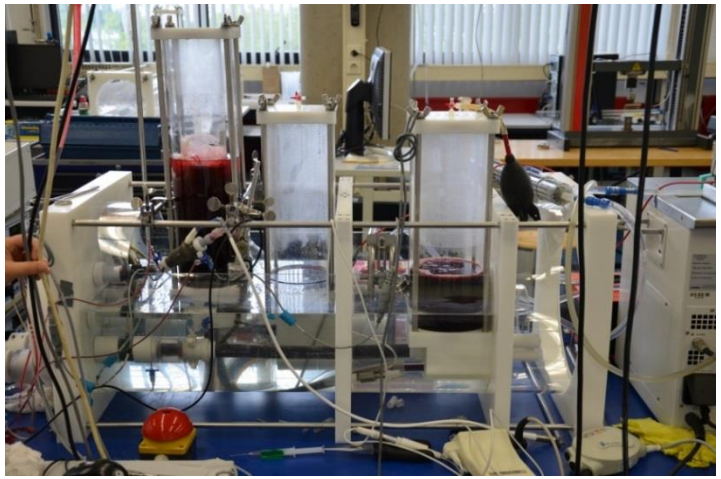
Dr.ir. Marcel Rutten

Stefan Sanders
Jo Zelis
Roel Meiburg
Kim Pennings

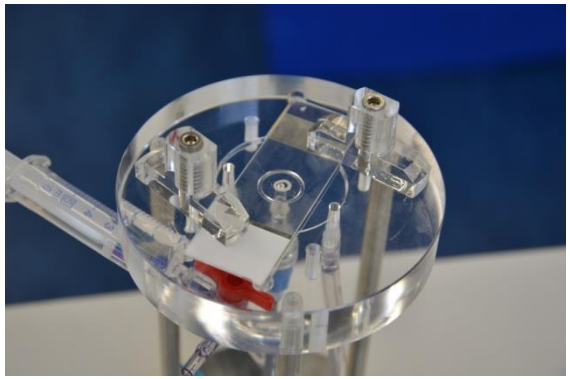


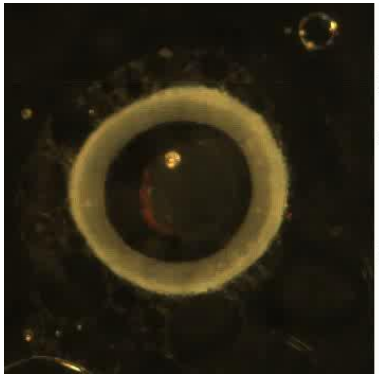
Research topics

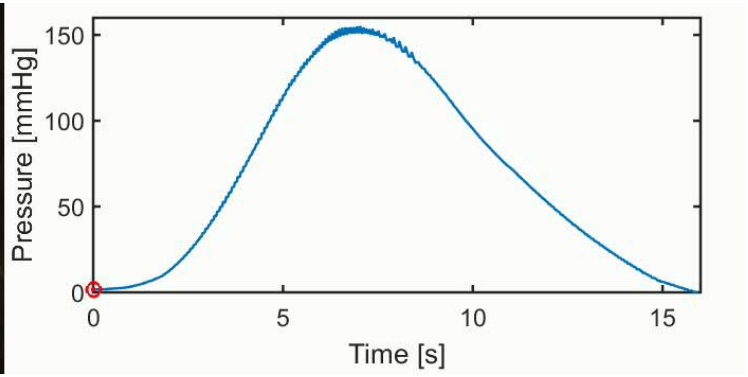
- **Mechanical Circulatory Support (MCS)**
  - Experimental evaluation and optimization of support strategies
  - Long-term patient monitoring
  - Minimal invasive (using MCS itself, and model support)

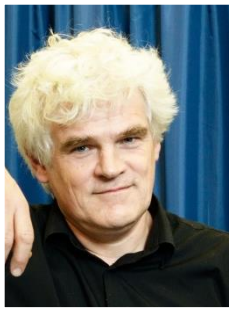


- **Vascular mechanics and diagnostic methods**
  - Modelling of vascular tissue
  - e.g., Video densitometry







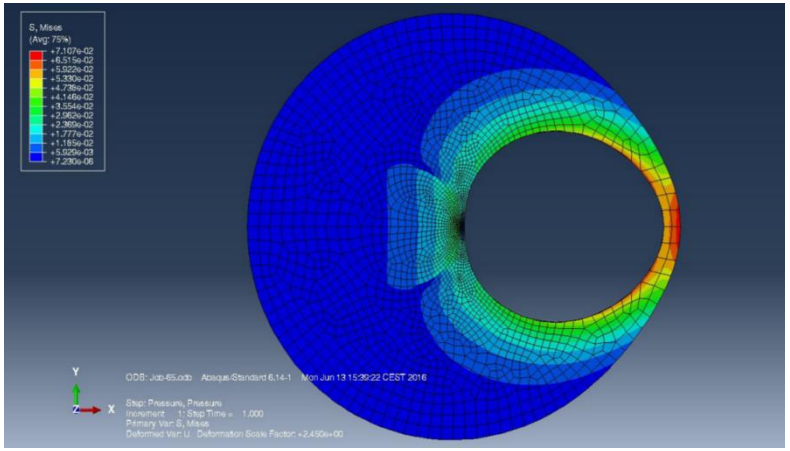


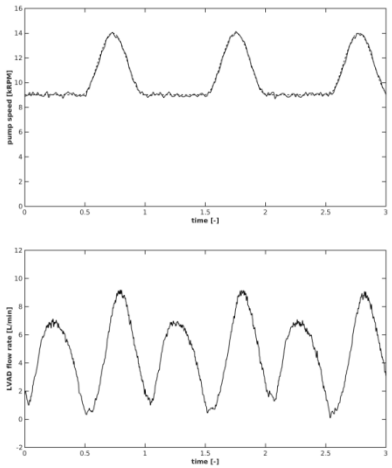
Examples of Bachelor End Projects

- **Vascular mechanics and diagnostic methods**
  - Testing of vascular tissue, diagnosis
  - Computational evaluation of tests
  - This year: Material heterogeneity, experimental detection

- **Mechanical Circulatory Support**
  - Modeling of (parts of) human physiology.
  - This year: determine heart properties with pulsatile pumping

Jeroen Cox, BEP 2016:
Influence of lipid inclusion in cap stress





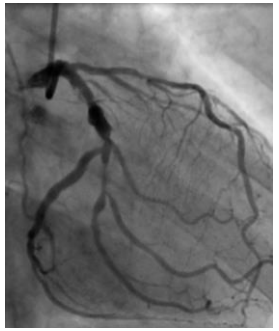
Melissa Niemantsverdriet, BEP 2016:
Pulsatile pumping

Ellen de Boer, BEP 2016:
Video densitometry of aortic regurgitation

Dr.ir. Mariëlle Bosboom

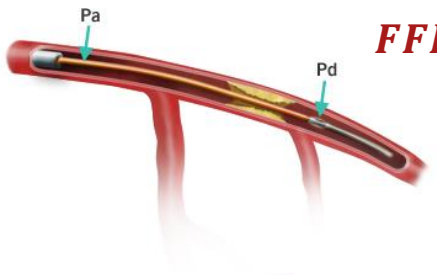
Luc Bakker
Daniëlle Keulards
Kujtim Gashi
Luuk Otterspoor

Research: computed FFR



- Coronary artery disease
- Stenosis: severe obstruction → ischemia
- Decision support: fractional flow reserve (FFR)
- Measured versus computed

Examples of Bachelor End Projects

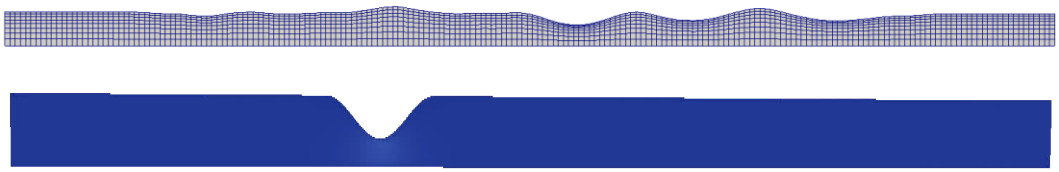


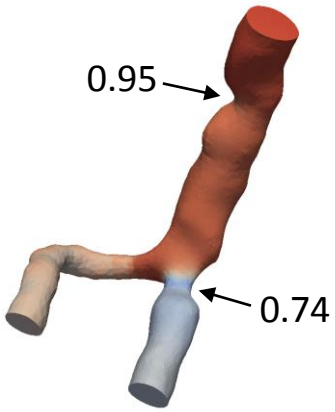
$$FFR = \frac{P_d}{P_a}$$

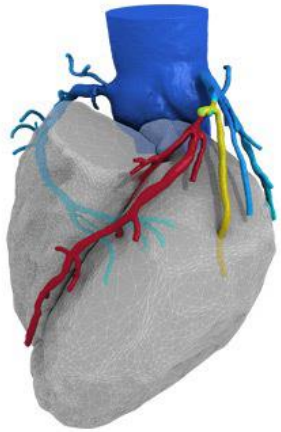
- Ariënne Baijense / Catherine Taelman:
  Comparison computations and clinical measurements

How complex should CFD model be?

- Elmer Middendorp / Bing Lin: Fluid Structure Interaction
- Larissa Jansen / Maite van der Knaap: 2D versus 3D







Dr.ir. Wouter Huberts

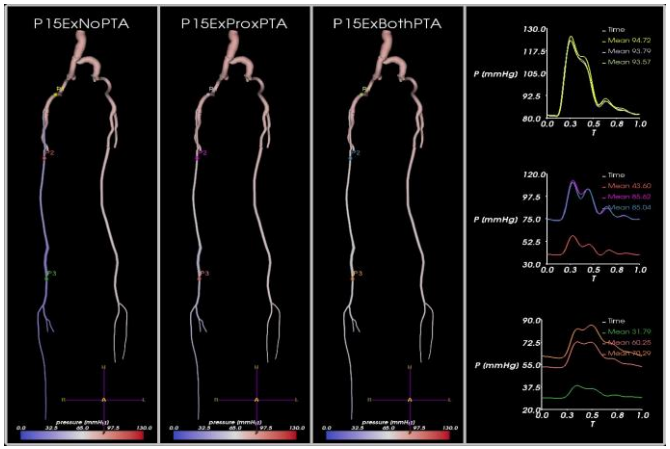
Sjeng Quicken
Niek Zonnebeld

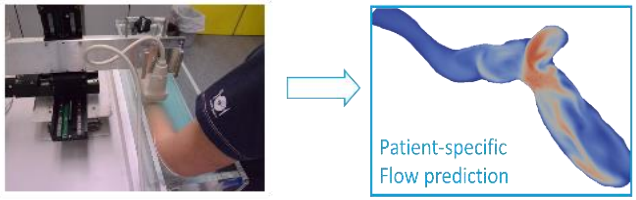
Stefan Heinen
Raoul Stevens

Research: model-predicted clinical decision support

- **Approach**
  - Personalized mathematical modeling
  - Uncertainty quantification & sensitivity analysis
  - Develop measurement protocols for personalization

- **Application areas**:
  - Peripheral arterial disease
  - Vascular access surgery
  - Neurovascular modeling (cerebral autoregulation)
  - Aortic dissection
  - Intensive care

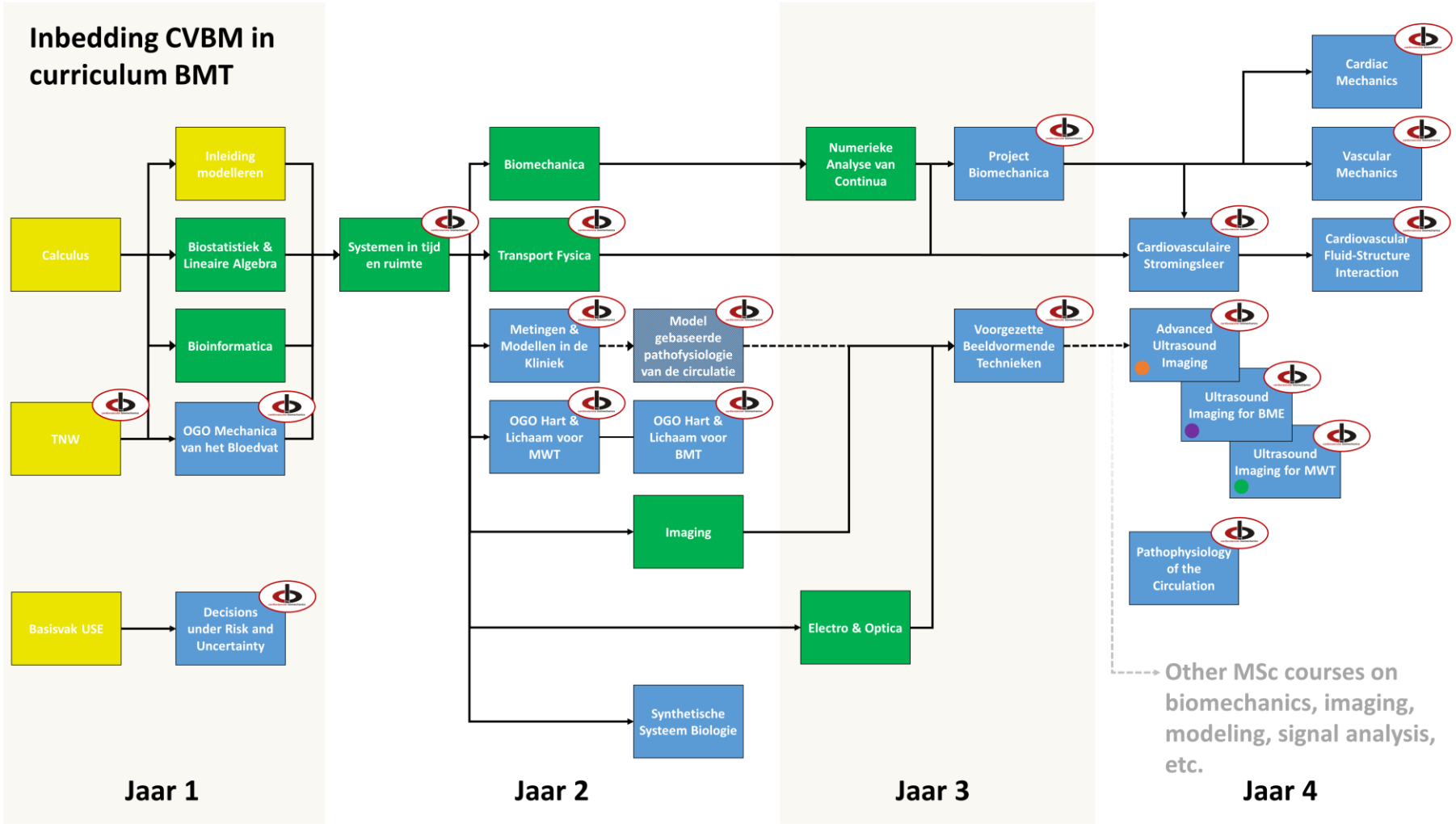


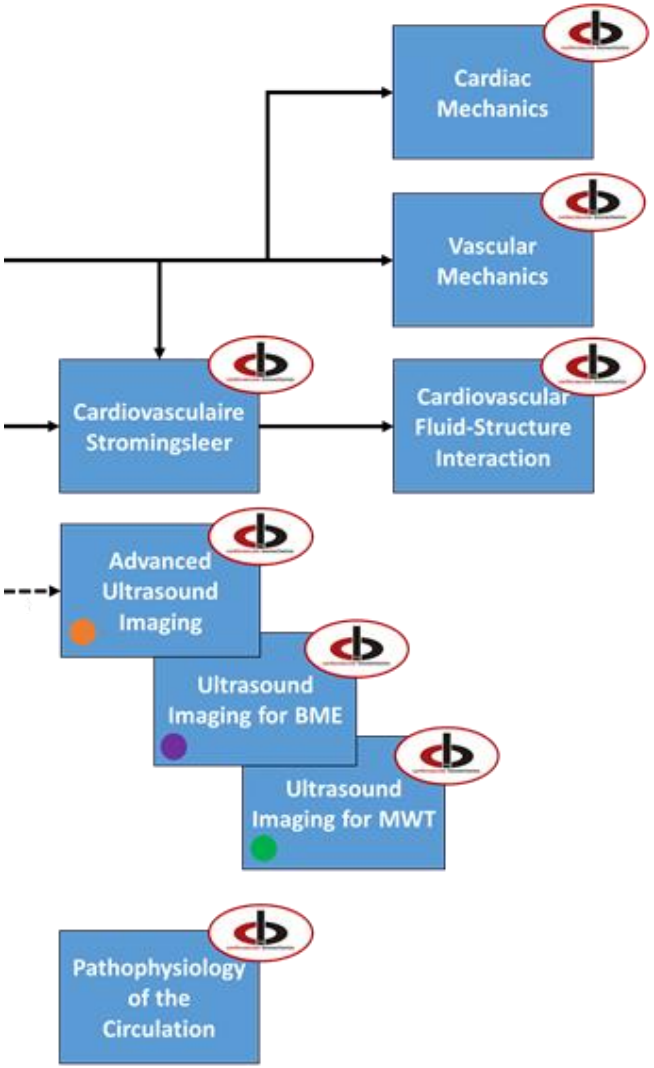


Examples of Bachelor End Projects

- Sarah van Meel: analysis of pulse oximeter measurements
- Angelique Wallaard: modeling extracorporeal life support
- Stanley Wirjadi: lumped modeling of an aortic dissection
- Paula Bartelds: modeling cardiac changes after vascular access
- Sjors van Veldhoven: US measurements for vascular access

Cardiovascular Biomechanics





Master Courses

- Cardiovascular Fluid Mechanics
- Cardiac Mechanics
- Vascular Mechanics
- Cardiovascular Fluid Structure Interaction

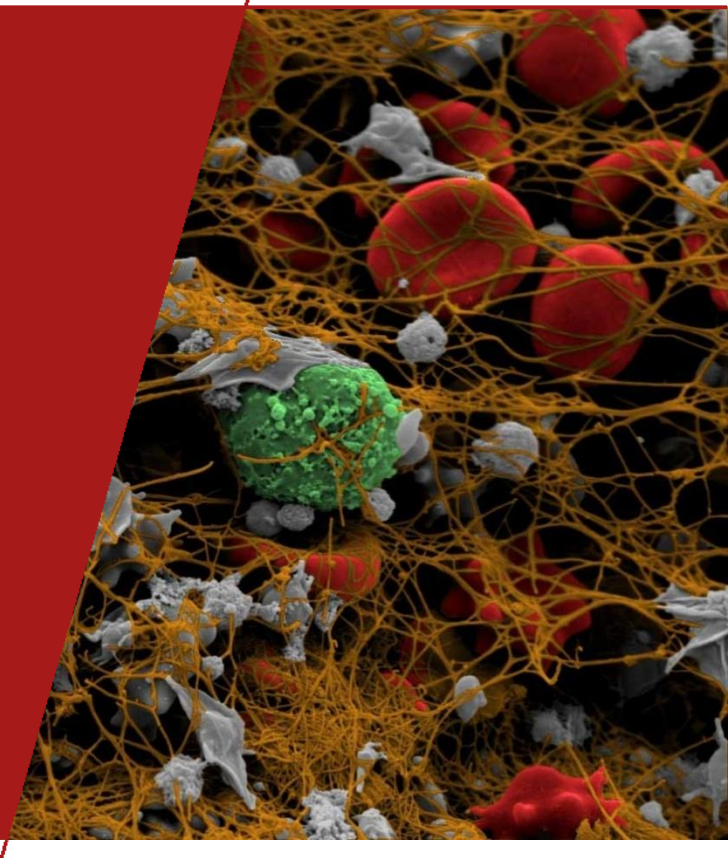
- Advanced Ultrasound Imaging
- Ultrasound Imaging for BME
- Ultrasound Imaging for MWT

- Pathophysiology of the Circulation
- Clinical Modules for ME

cardiovascular biomechanics

Cardiovascular Biomechanics

- modeling of physiology, FEM, patient-specific modeling
- experiments in-vitro / ex-vivo / in-vivo
- design of experiments and devices
- clinical measurements and patient studies



TU/e Technische Universiteit Eindhoven University of Technology

/Biomedical Engineering

Where innovation starts