Modeling coronary hemodynamics in health and disease

Citation for published version (APA):
Horst, van der, A., Boogaard, F. L., Veer, van 't, M., Rutten, M. C. M., & Vosse, van de, F. N. (2011). *Modeling coronary hemodynamics in health and disease*. Poster session presented at Mate Poster Award 2011 : 16th Annual Poster Contest.

Document status and date:
Published: 01/01/2011

Document Version:
Accepted manuscript including changes made at the peer-review stage

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

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

openaccess@tue.nl

providing details and we will investigate your claim.

Download date: 05. Oct. 2023

Technische Universiteit
Eindhoven
University of Technology

Modeling coronary hemodynamics in health and disease

Arjen van der Horst, Frits Boogaard, Marcel van 't Veer,
Marcel Rutten, Frans van de Vosse

cardiovascular **biomechanics**

Introduction

Background Miniaturized sensors on guide wires are now able to directly assess epicardial coronary artery disease.
Problem To quantify microvascular disease from epicardial hemodynamics, a model of the vessels and cardiac muscle is required.
Aim To couple a 1D wave propagation model to a structural based heart contraction model, able to describe coronary hemodynamics in health and disease.

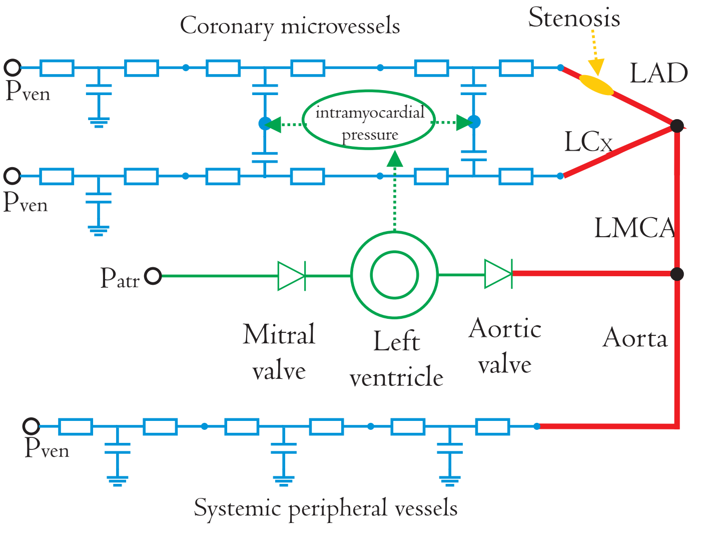

Fig. 1 *Schematic representation of the model. The different colors represent the different parts.*

Methods

The model consists of the following parts (Fig. 1):

1. A one-fiber heart contraction model [1] for the left ventricle and the two valves.
2. A 1D wave propagation model [2] with a velocity profile that depends on the Womersley parameter (Fig. 2, left).
3. Windkessel elements to model the coronary microvessels and peripheral circulation.
4. A stenosis element [2] that takes the viscous and unsteadiness contribution into account (Fig 2, right).

The model is tested for a normal and two pathological situations, i.e. a stenosis in the LAD and hypertrophic cardiomyopathy (HCM).

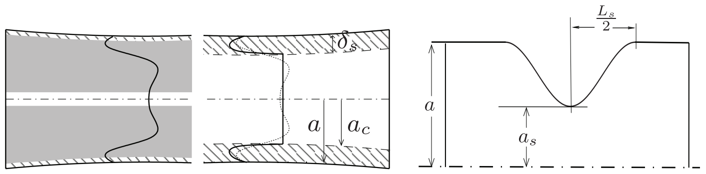

Fig. 2 *The approximate velocity profile (left) and the shape of the axisymmetric stenosis element (right).*

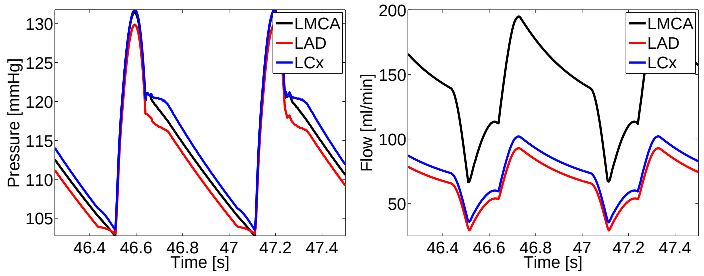

Fig. 3 *Pressure and flow relations in the left coronary arteries obtained with the model.*

Results

Stable and physiologic solutions were obtained in both normal (Fig. 3) and pathological situations (Fig. 4). The general shape of the simulated pressure signal distal to a severe stenosis was similar to measurements form the clinic (Fig. 4(a,b)). In the HCM-heart simulation the characteristic exacerbated retrograde flow in systole was also captured by the model (Fig. 4(c-f)).

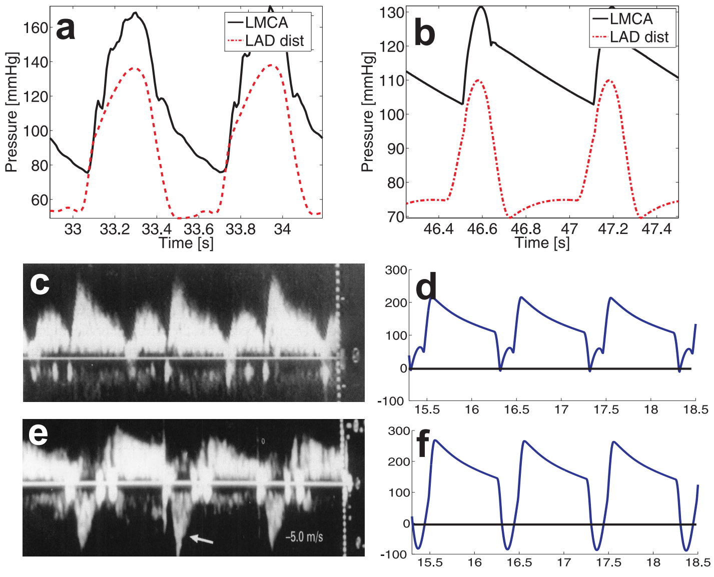

Fig. 4 *Coronary pressures gradients measured distal and proximal to a stenosis measured in the clinic (a) and simulated (b). Coronary flow in a normal (c,d) and HCM (e,f) heart, measured in a human [3] (c,e) and simulated (d,f).*

Conclusion

A relatively simple structural-based heart contraction model has been successfully coupled to a 1D wave propagation model. The 1D continuous representation of the epicardial vessels enables the evaluation of hemodynamic indices measured during hyperaemia in the catheterization laboratory, e.g. FFR, HSR, IHDVPS, and h-MRv.

/Department of Biomedical Engineering

References

1 Bovendeerd P.H.M, *et al.* (2006), *Ann. Biomed. Eng.*, **34**, 1833-1845.
2 Bessems, D., (2007), PhD thesis. Eindhoven University of Technology.
3 Crowley, J.J., *et al.* (1997), *Heart*, **77**, 558-563.