

Sensitivity analysis of a venous valve model

Citation for published version (APA):

Keijsers, J. M. T., Leguy, C. A. D., Huberts, W., Narracott, A. J., Rittweger, J., & van de Vosse, F. N. (2015). *Sensitivity analysis of a venous valve model*. Poster session presented at Mate Poster Award 2015 : 20st Annual Poster Contest, Eindhoven, Netherlands.

Document status and date:

Published: 17/12/2015

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

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.

Sensitivity analysis of a venous valve model

J.M.T. Keijsers^{1,2}, C.A.D. Leguy¹, W. Huberts³, A.J. Narracott⁴, J. Rittweger¹ and F.N. van de Vosse²



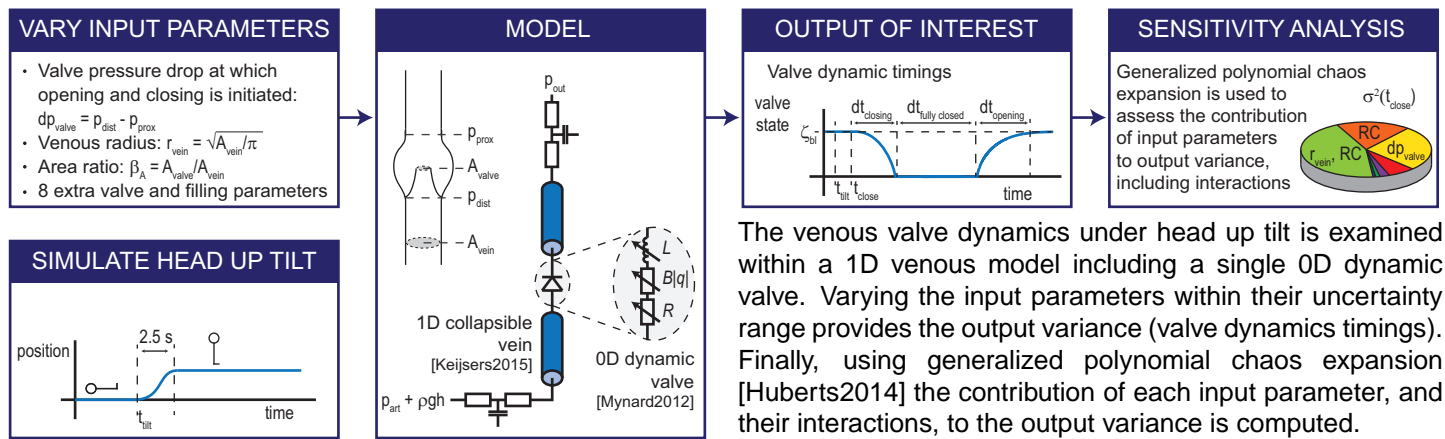
INTRODUCTION

Patients suffering from chronic venous disease show symptoms as varicose (dilated) veins, edema, and even venous ulcers in the legs. An important cause is the increased venous pressure during exercise due to leaking venous valves sometimes combined with obstructed venous

outflow. Venous refilling time is amongst others a diagnostic parameter to determine the severity of the disease.

AIM: Examine the dynamics of a healthy venous valve under head up tilt with a lumped venous valve model using a sensitivity analysis to assess the most important parameters.

METHODS

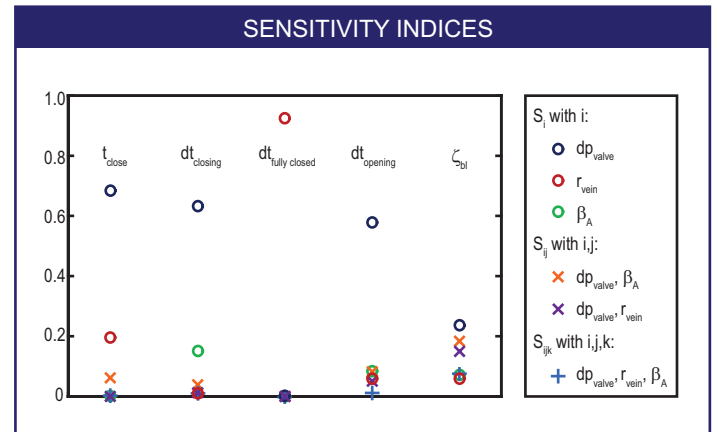


The venous valve dynamics under head up tilt is examined within a 1D venous model including a single 0D dynamic valve. Varying the input parameters within their uncertainty range provides the output variance (valve dynamics timings). Finally, using generalized polynomial chaos expansion [Huberts2014] the contribution of each input parameter, and their interactions, to the output variance is computed.

RESULTS

The sensitivity indices show how the output variance is attributed to each individual input parameter (S_i) and their second (S_{ij}) and third order (S_{ijk}) interactions.

- For the time at which the valve starts to close t_{close} , the time needed for the valve to close $dt_{closing}$ and to open $dt_{opening}$, the valve pressure drop dp_{valve} (o) is the main parameter determining the variance.
- The variance in the time the valve remains closed $dt_{fully\ closed}$ is almost solely determined by the venous radius r_{vein} (o).
- The baseline valve state ζ_{bl} is mainly determined by the valve pressure drop dp_{valve} (o) and its interaction with the venous radius r_{vein} (x) and the area ratio β_A (x).



DISCUSSION & CONCLUSION

This study suggests that the most important input parameters for the valve dynamics under head up tilt are the valve pressure drop (related to valve dynamics) and the venous radius (related to venous filling). In the future, a better estimate of venous filling can be obtained by measuring venous radius using ultrasound and more insight into the valve dynamics can be obtained from 3D simulations.

References

W. Huberts, W. Donders, T. Delhaas, and F. van de Vosse. Applicability of the polynomial chaos expansion method for personalization of a cardiovascular pulse wave propagation model. *Int J Numer Method Biomed Eng*, 30(12):1679–1704, 2014.

J. M. T. Keijsers, C. A. D. Leguy, W. Huberts, A. J. Narracott, J. Rittweger, and F. N. van de Vosse. A 1d pulse wave propagation model of the hemodynamics of calf muscle pump function. *Int J Numer Method Biomed Eng*, 31(7):e02714, 2015.

J. P. Mynard, M. R. Davidson, D. J. Penny, and J. J. Smolich. A simple, versatile valve model for use in lumped parameter and one-dimensional cardiovascular models. *Int J Numer Method Biomed Eng*, 28(6-7):626–641, 2012.