

What is the in vivo axial strain of a porcine coronary artery?

Citation for published version (APA):

Broek, van den, C. N., Tuijl, van, S., Rutten, M. C. M., & Vosse, van de, F. N. (2008). What is the in vivo axial strain of a porcine coronary artery? In *Proceedings of the 16th European Society of Biomechanics Conference (ESB 2008) 6-9 July 2004, Lucerne, Switzerland* (pp. on-cd). European Society of Biomechanics (ESB).

Document status and date:

Published: 01/01/2008

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.

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WHAT IS THE IN VIVO AXIAL STRAIN OF A PORCINE CORONARY ARTERY?

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Introduction

Knowledge of mechanical properties of living arteries is important to understand vascular function during health and disease. An effective way to study the behavior of living tissue is organ culture. In arterial culture the artery should be loaded at in vivo levels to maintain the artery's viability. The in vivo axial strain of coronary arteries, however, is unknown. Therefore, the aim of this study is to determine the physiological axial strain of the porcine left anterior descending coronary artery (LAD). Based on Weizsäcker (1983) and Schulze-Bauer (2003) it was hypothesized that: *The in vivo axial strain of an artery is the strain at which the axial force (F_{ax}) is relatively insensitive to changes in pressure (P).* This “physiological” strain (fig.1, right, red line) was determined in an organ culture model. To test the hypothesis an isolated beating heart experiment, in which a porcine heart is loaded physiologically, was performed. Due to the pumping of the heart, a cyclic axial strain is induced to the coronaries.

Material and methods

The **culture model experiment** protocol:

- A segment of a porcine LAD was excised.
- The length was measured of (fig. 1):
 - The segment still fixed to the heart (l_{heart})
 - The segment at its ex vivo length (l_{ev})
- The segment was loaded with a pulsatile pressure in the culture model
- The segment length was increased until the F_{ax} change during a P cycle was minimized (l_{phys})

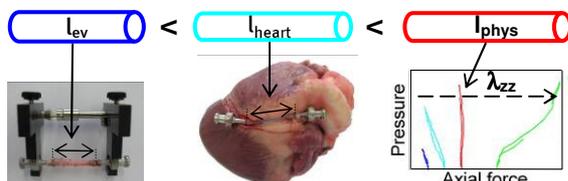


Figure 1: Definition of different segment lengths.

Isolated porcine heart experiment

The in vivo axial strain was measured on an isolated beating porcine heart model (PhysioHeart, HemoLab). Markers were positioned in parallel to the LAD. By high speed camera recording of the markers during a heart beat, the ex vivo strain amplitude was measured. At the end of the marked segment was dissected to determine l_{heart} and l_{ev} .

Results

- There was a small spread in the determined axial strains, i.e. λ_{heart} and λ_{phys} , in the culture model experiment (n=12, fig.2a).
- The following axial strains have been determined in the isolated beating heart experiment (preliminary results \rightarrow n=1, fig. 2b):
 - $\lambda_{heart} = 1.2$
 - $\lambda_{phys,min} = 1.3$
 - $\lambda_{phys,max} = 1.38$
- The “physiological” stretch derived from the culture model experiment equals the maximum stretch of an artery during a heart beat.

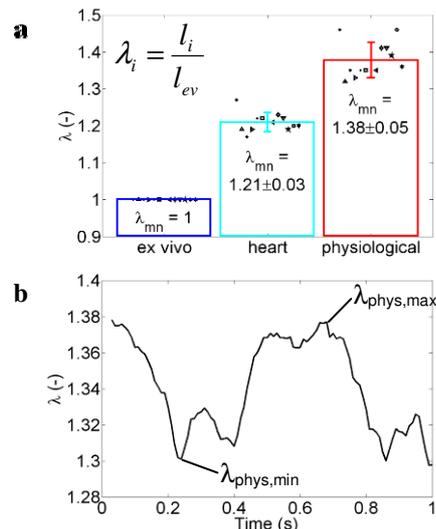


Figure 2a) Axial stretches derived from the culture model experiment; b) Stretch of segment during a heartbeat in the isolated porcine heart experiment.

Conclusion

The average “physiological” stretch of the porcine LAD is found to be 1.38, which is equal to the maximum stretch during a heartbeat in the isolated heart experiment. More isolated heart experiments need to be conducted to be conclusive on whether the in vivo axial strain is indeed the strain at which the axial force is relatively insensitive to changes in pressure.

References

- Weizsäcker *et al*, J. Biomech., 16:703-715, 1983
 Schulze-Bauer *et al*, J. Biomech. Eng., 125:395-406, 2003