A COMPUTATIONAL METHOD FOR QUANTITATIVE ASSESSMENT OF THE MOVEMENT OF THE THORACIC AORTA

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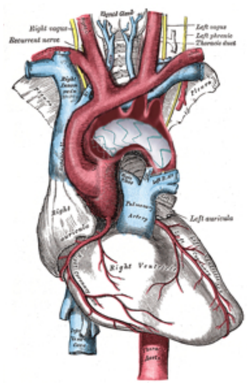
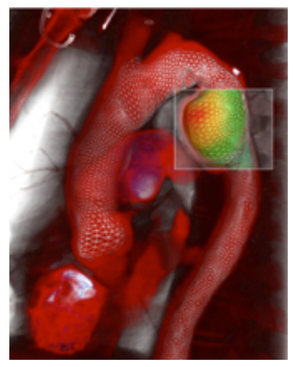
ABSTRACT

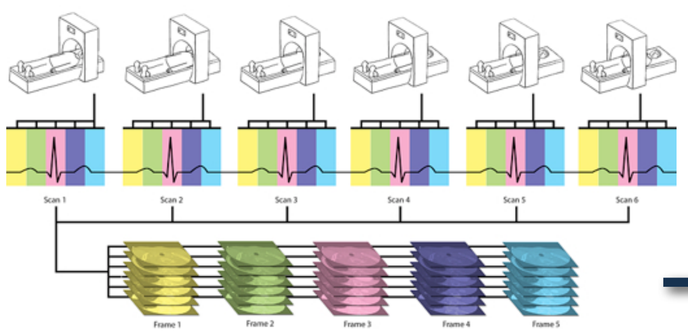
The causal relationship between strain on the vessel wall and the development of vascular pathologies is a common hypothesis in vascular medicine. However, the study of these effects is mostly limited to static vessel models. Limited by the intricate fluid-structure interactions, state-of-the art hemodynamic methods work under the assumption that motion of the vessel wall not due to blood flow can be neglected. While this simplification allows for trustworthy measurements of forces in vessels further from the heart, it does not hold for the thoracic aorta, which is strongly influenced by the motion of the myocardium. Pathologies arising in this part of the vascular system are amongst the most hazardous and difficult to treat. Nonetheless, their pathogenesis, ramifications and the precise effects of the various treatment options available are only poorly understood.



The purpose of this study is the development and application of methods capable of describing the motion of the thoracic aorta from ECG-gated CT sequences during the cardiac cycle. The obtained measurements are used for deepening the understanding of patterns of movement in the thoracic aorta as well as for the evaluation of the effects of interventions such as stent-grafting. Results of the proposed method on 4 examplary cases are presented. In all of these, a pathology in the aortic arch has been treated by supra-aortic rerouting followed by stent-graft placement. ECG-gated CT sequences are aquired after rerouting and after stent-graft placement. The movement during one sequence is computed using an automatic registration method that results in a dense deformation field. An automatic segmentation procedure is used to extract the region of interest - the wall of the aorta. Comparing these pre- and post-interventional models allows for new insights into the detailed effects of the performed interventions.



METHOD

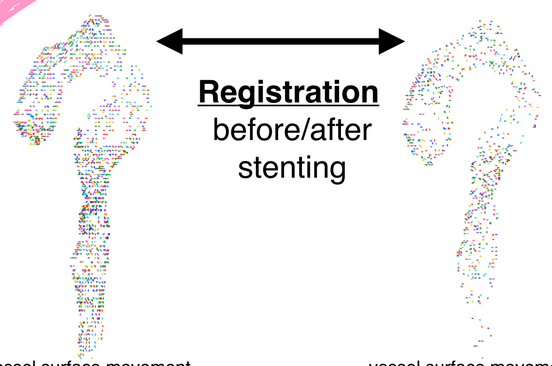


raw ECG-gated CTA sequence

Tracking
during one heart beat

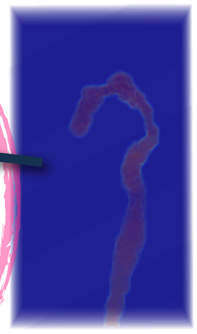
dense deformation field

Registration
before/after stenting



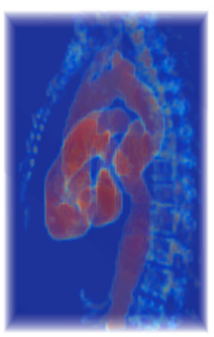
vessel surface movement (*before* stenting)

vessel surface movement (*after* stenting)

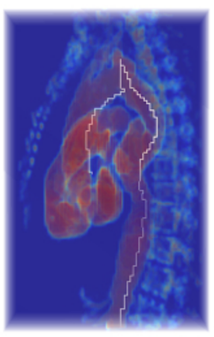


Segmentation
vessel wall of the aorta

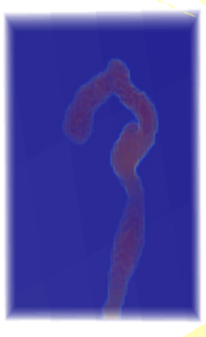
vesselness



intensity model

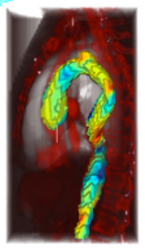


minimal cost path

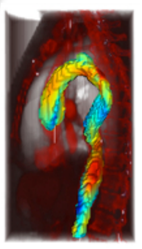


level set segmentation

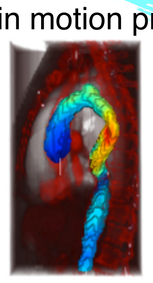
Analysis
difference in motion properties



change in ... bending



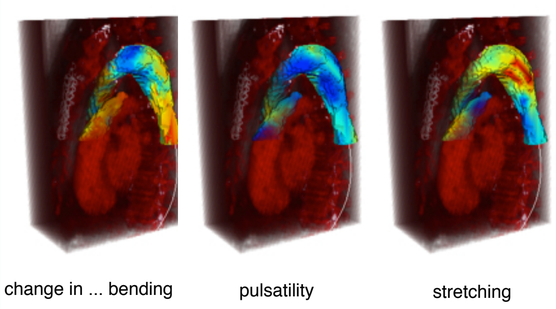
pulsatility



stretching

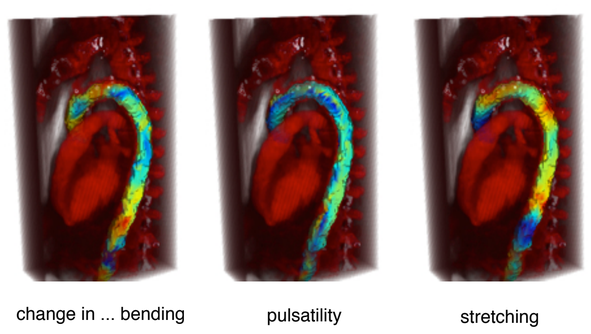
RESULTS

CASE A



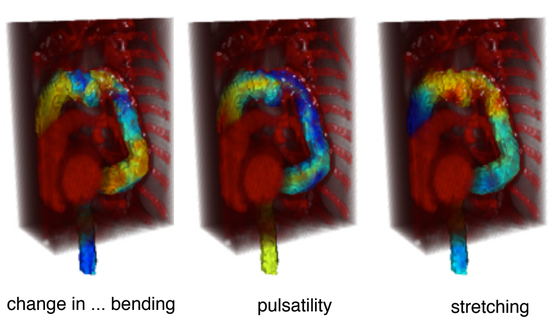
change in ... bending | pulsatility | stretching

CASE B



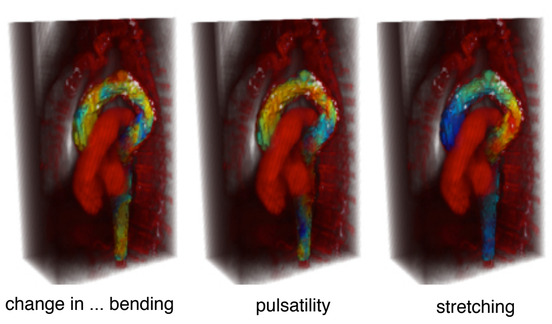
change in ... bending | pulsatility | stretching

CASE C



change in ... bending | pulsatility | stretching

CASE D



change in ... bending | pulsatility | stretching

REFERENCES & FUTURE DIRECTIONS

Segmentation and Deformation Analysis of the Aorta in Gated CTA sequences in a MDL Framework
E. Schwartz, G. Langs, J. Holfeld, R. Gottardi, C. Loewe, P. Peloschek, M. Czerny
Medical Image Understanding and Analysis 2009.

Evaluating deformation patterns of the thoracic aorta in gated CTA sequences
E. Schwartz, R. Gottardi, J. Holfeld, C. Loewe, M. Czerny, G. Langs
International Symposium on Biomedical Imaging 2010

- increase resolution in order to detect smaller deformation patterns
- analyze & compare different segments of the aorta / stent using
  - multi-resolution &
  - manifold methods
- learn movement patterns for outcome prediction