4D MRI phase-contrast image to determinate blood flow patterns in aorta

E. Soudah¹, M.R.Cancio², H.Yervilla², F.Carreras³, J.S.Ronda¹, E.Oñate¹

¹International Centre for Numerical Methods in Engineering(CIMNE)
Campus Norte UPC, Barcelona, Spain
²Universidad Central de las Villas – Aula UCLV-CIMNE
Santa Clara, Cuba
³Hospital Sant Pau y Creu Blanca, Barcelona, Spain

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Use Case

- Clinical view:
  - Aorta diseases:
    - Thoracic Aortic Aneurysms (Marfan’s Syndrome)
    - Aorta dissection
  - Valve diseases
    - Aortic Valve Stenosis
    - tricuspid (three leaflets)/bicuspid (two leaflets)

- Mathematical view:
  - Obtain the real blood flow of the aorta directly from the 4D MRI phase-contrast image.
  - 4D combine Phase-Contrast imaging & CFD simulation.
  - Possibility to create a volume mesh from an image segmented.
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- Using 4D MRI image combined with CFD to:
  - Increase objectivity and reproducibility for the assessment of the Aorta.
  - Provide additional information to improve treatment decision.

Outline

- 4D MRI Phase-contrast
- Segmentation & Meshing
- Numerical Results
- Conclusions
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DCM → Slicer → ROI → Filter 1 → Filter N → Filter 1 → Filter N → VTK

Image Manager → NoiseFilter Manager → Segmentation Manager

Numerical solver (CFD) → Pre-Process → VELOCITY → GEOMETRY
Time-resolved phase contrast (PC) MRI with velocity encoding in three directions (flow-sensitive four-dimensional MRI) can be employed to assess three-dimensional blood flow in the entire aortic lumen within a single measurement.

4D phase-contrast image (spatio-temporal)

- n volumetric images defined at n different time steps (in this particular case: 12 time-steps)

Semi-automatic Segmentation method\(^1\)

- Aortic surface pre-segmentation (vesselness enhancement filter)\(^2,4\) and Tresholded\(^3,4\)

\(^1\)Zhao, F., et al., Automated 4D Segmentation of Aortic Magnetic Resonance Images.
\(^4\)Ibañez. Kitware, Inc.
Aorta Velocities
Details Aorta Velocities, for step 4
Details Aorta Velocities, all steps

Aorta Coronal Plane

Aorta Volume
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A multi-method approach towards understanding the pathophysiology of aortic dissections – the complementary role of in-silico, in-vitro and in-vivo information Paula A. Rudenick, Maurizio Bordone, Bart H. Bijnens, Eduardo Soudah, David Garcia-Dorado, and Arturo Evangelista
Aorta dissection

[Diagram showing different views and measurements of the aorta, including pressure and velocity graphs.]
Conclusions

- MRI 4D PC patient-Specific data for Aorta studies.
- More data are available for quantitative studies.
- Combine MRI 4D with CFD Simulations (boundary conditions)
- Improvement quantitative analysis
- Determinate flow patterns and vortex in aorta.

Future Studies

- Velocity sensitive analysis
- Compare 2D & 4D PC Image & CFD
- Compare phantom model & 4D PC image
Thank you

Eduardo Soudah
esoudah@cimne.upc.edu

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