Assessment of flow - displacement and wall-shear-stress by 4D aortic MRA

Dr. med. Jonathan Nadjiri
Institute of diagnostic and interventional Radiology
Director of the Institute: Univ.-Prof. Dr. Ernst J. Rummeny
Technical University of Munich

Research Group of Cardiovascular Imaging
Dr. med. Jonathan Nadjiri, Dr. med. Alexandra Sträter, PD Dr. med. Daniela Pfeiffer, Dr. med. Michael Rasper
No disclosures
Agenda:

✓ Introduction of 4D Flow:

✓ Prognostic value of systolic Flow Displacement

✓ Applications of 4D Flow

Features

4D Flow - Useful or just pretty images?

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Why do we need 4D Flow:

- Current examinations in CT or MRI are mainly static
  - dynamic processes and compliance of the vessel wall are assessed
- Prognostic parameters like diameters are rather unreliable
  - Aortic rupture in patients with aortic dilation can occur in patients where diameters are well below operative treatment indication

We would like to know our high risk patients
What is 4D Flow:

- 3D Phase Contrast Sequence (Spoiled GRE) with time resolution.
- Allows for:
  - Assessment of blood flow in 3 dimensions over time
  - Pressure maps
  - Wall shear stress
  - Complex flow analysis
  - Does not require i.v. contrast
- Requires:
  - Dedicated software and extensive post-processing
  - Long scan time (not necessarily)

4D-Flow MRI: Technique and Applications

4D-MR-Flussmessung: Technik und Anwendungen

Authors
Alexandra Sträter¹, Armin Huber², Jan Rudolph¹, Maria Berndt³, Michael Rasper¹, Ernst J. Rummeny³, Jonathan Nadjiri¹
Histopathology of increased Wall Shear Stress

Valve-Related Hemodynamics Mediate Human Bicuspid Aortopathy

Journal of the American College of Cardiology Aug 2015, 66 (8) 892-900; DOI: 10.1016/j.jacc.2015.06.1310
Prognostic value: Systolic Flow Displacement

**Prognostic value:**

*FlowDisplacement* = \( \frac{r}{AoDiameter} \)

**Flow Displacement**

**Graph A:** Diameter at First Study versus Aortic Growth Rate
- \( r = 0.45 \)

**Graph B:** Systolic Flow Displacement versus Aortic Growth Rate
- \( r = 0.71 \) *
Prognostic value: Systolic Flow Displacement
Prognostic value: Systolic Flow Displacement

Aortic flow patterns and wall shear stress maps by 4D-flow cardiovascular magnetic resonance in the assessment of aortic dilatation in bicuspid aortic valve disease

José Fernando Rodríguez-Palomares, Lydia Dux-Santoy, Andrea Guala, Raquel Kale, Giuliana Maldonado, Gisela Teixidó-Turá, Laura Galian, Marina Huquet, Filipa Valente, Laura Gutiérrez, Teresa González-Alujas, Kevin M. Johnson, Oliver Wieben, David García-Dorado, and Arturo Evangelista.
Perioperative change of Wall Shear Stress

Perioperative evaluation of regional aortic wall shear stress patterns in patients undergoing aortic valve and/or proximal thoracic aortic replacement

Emilie Bollache, PhD, Paul W. M. Fedak, MD, PhD, Pim van Ooij, PhD, Ozair Rahman, MD, S. Chris Malaisrie, MD, Patrick M. McCarthy, MD, James C. Carr, MD, Alex Powell, MS, Jeremy D. Collins, MD, Michael Markl, PhD, and Alex J. Barker, PhD.

Perioperative evaluation of regional aortic wall shear stress patterns in patients undergoing aortic valve and/or proximal thoracic aortic replacement.
Bollache E, Fedak PWM, van Ooij P, Rahman O, Malaisrie SC, McCarthy PM, Carr JC, Powell A, Collins JD, Markl M, Barker AJ.
Future aspects:

- Accelerated sequences → 4 D Aortic flow measurement in 2 min

k-t accelerated aortic 4D flow MRI in under two minutes: Feasibility and impact of resolution, k-space sampling patterns, and respiratory navigator gating on hemodynamic measurements

Emilie Bollache, Alex J Barker, Ryan Scott Dolan, James C Carr, Pim van Ooij, Rouzbeh Ahmadian, Alex Powell, Jeremy D Collins, Julia Geiger, Michael Markl

- More prognostic studies needed:
  - AAA and long term follow-up examinations in patients without treatment.
  - Translation of methods to other sides of the aorta
Summary:

- 4D Flow? Pretty images but with high potential as a future biomarker for interventions/operations
- 4D Flow better detects the prognostic parameter “Flow Displacement”
- 4D Flow depicts areas of altered histopathology
- 4D flow detects postoperative changes of the flow patterns
Thank you very much for your attention!