Non-invasive Blood Flow Assessment of Aortic Dissection Using 4D Flow MRI and Computational Fluid Dynamics

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Significance of Disease
- Highly lethal disease, with a significant number of patients dying in the hospital:
  - Death rate up to 25%
- In US alone, 10,000 – 17,000 people per year experience aortic dissection.

Background and Current Practice
- Blood pressure lowering medications are given to all patients.
- Patients with type A dissection get surgery, whereas type B dissection patients are simply watched closely (Figure 1).
- Watch and wait approach:
  - There is no way to accurately predict which patients will remain stable, and which will enlarge over time.
  - Opportunity to treat patient early and aggressively is missed!

Aims
- Develop an approach using 4D Flow MRI and computational fluid dynamics (CFD) to assess blood flow in the aorta.
- Identify blood flow patterns that predict future growth of the aorta.

Methods
- 4D Flow is an advanced MRI technique that can assess blood flowing within vessels. (Figure 2)
  - Takes only 10 minutes to perform.
  - MRI doesn’t use radiation.
  - Computer blood flow modeling shows high pressure elevated pressure in the same location as flow jet on 4D Flow MRI.
- Computational fluid dynamics (CFD) uses very powerful computers to predict how blood will flow within a computer model of the aorta. (Figure 3)
  - Good at measuring pressure.
  - Requires a “super computer” and a long time (12-24 hours).

Early Results
- Enlarging aortas show large flow jets in the upper portions of aorta (Figure 4).
- Stable aortas show smaller flow jets (Figure 5).
- Computer blood flow modeling shows high pressure elevated pressure in the same location as flow jet on 4D Flow MRI.

Future Directions
- Identify blood flow patterns that predict aortic enlargement.
- Low-risk patients can be saved from unnecessary procedures and imaging, reducing medical waste.
- High-risk patients can receive early and aggressive treatment to prevent complications.

Funding
- NB, NIH T32 (DT02EIO01632)
- NB, RSNA Research Fellow Grant (RF-1592)
- AF, NIH ROI (#R01HL105297)
- MH, NIH ROI (#R01HL123759)