Cardiovascular magnetic resonance (CMR) for the detection of early aortic atherosclerosis

Background

Patients with chronic disorders are often exposed to inflammatory, metabolic, and hemodynamic risk factors for early atherosclerosis. However, detection of early atherosclerosis is challenging, especially in childhood and adolescence. Since post-mortem studies have shown that atherosclerosis starts in the aorta during childhood, the 'Cardiovascular Disease in Adolescents with Chronic Disease' (CDACD) study recently employed cardiovascular magnetic resonance (CMR) to study preclinical aortic atherosclerosis in adolescents with chronic disease.

Data

The CDACD study enrolled 114 adolescents 12-18 years old with chronic disorders including juvenile idiopathic arthritis, cystic fibrosis, obesity, corrected coarctation of the aorta, and healthy controls. Cardiovascular Magnetic Resonance (CMR) was employed to assess aortic pulse wave velocity (PWV) and aortic wall thickness (AWT), as established aortic measures of preclinical atherosclerosis (Figure 1 and 2).

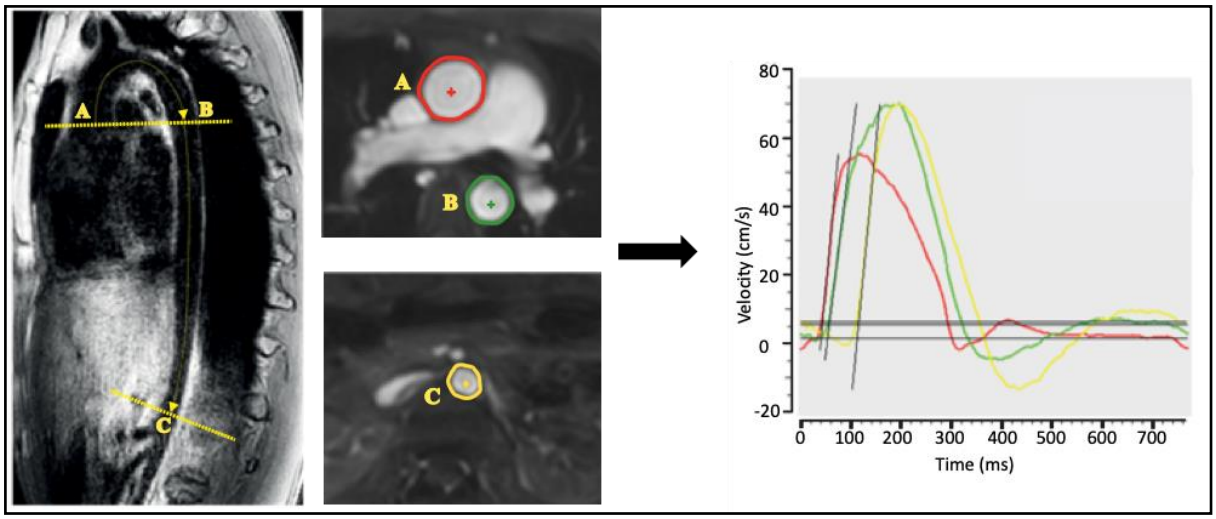

Figure 1. Pulse wave velocity measurement Pulse wave velocity measurement. Red contour (A): ascending aorta, green contour (B): descending aorta, yellow contour (C): abdominal descending aorta. The pulse wave arrival time was measured at A, B, and C and the pulse wave velocity was calculated between A and C (total trajectory).

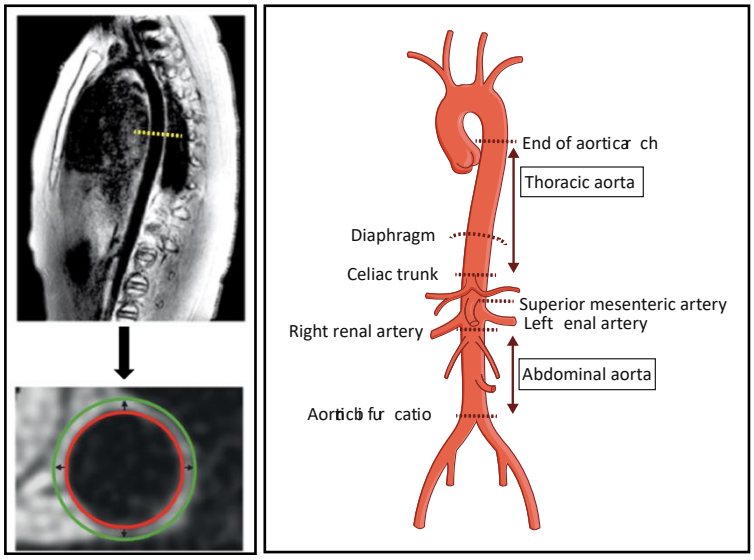

Figure 2. Aortic wall thickness measurement
Green contour: outer contour of aortic wall, red contour: inner contour of aortic wall. The thoracic trajectory spans from the end of the aortic arch until the celiac trunk, the abdominal trajectory spans from below the renal arteries until the aortic bifurcation.

Problem formulation
So far, all aortic measurements were performed manually, which is cumbersome and time-consuming, and prone to user variation. To speed up the measurement procedure and improve its consistency and accuracy, a fully automatic procedure would be preferred, with the possibility to check and correct the outcome of intermediate processing steps and of the final outcome.

Research aims
1. Development of an automated algorithm for the analysis of the aortic PWV and elasticity, in different anatomic segments.
2. Development of a machine learning pipeline to assess the aortic wall thickness (AWT) in different anatomic segments.

Required skills
- Medical image analysis (courses 8DC00, 8DM20)
- Experimental design (for algorithm validation) (course 8DM20)
- Programming in Python
- Machine learning (Keras/Tensorflow and/or Pytorch) (course 8DM50)
- Knowledge of the cardiovascular system (e.g. course 8VM00)
- Independent working
- Good communication (oral and written)

This project fits best to a BME MSc student (60 ECT).

Location
University Medical Center Utrecht (UMCU)
- Department of Pediatric Cardiology
- Image Sciences Institute

Start date & duration
Start date: as soon as possible
Duration: 10 months full-time (60 ECT)

Supervision
Supervision will be performed by:
- Dr. Hugo Kuijf
  UMCU, https://www.umcutrecht.nl/en/research/researchers/kuijf-hugo-hj
- Dr. Henk Schipper
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Literature
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3996237/
https://pubmed.ncbi.nlm.nih.gov/27075677/
https://pubmed.ncbi.nlm.nih.gov/21508002/