Cardiac fusion imaging of 3D echocardiography and coronary computed tomography angiography

Tim Nordenfur1, Aleksandar Babic2,3,4, Anders Giesecke5, Ivana Bulatovic5, Jonaz Ripsweden5, Eigr Samset2,3,4, Reidar Winter1,5, Matilda Larsson1

1Medical Engineering, School of Technology and Health, KTH Royal Institute of Technology, Stockholm, Sweden. 2GE Vingmed Ultrasound, Oslo, Norway. 3Center for Cardiological Innovation, Oslo, Norway. 4University of Oslo, Oslo, Norway. 5Karolinska Institutet, Stockholm, Sweden.

Background
- Coronary artery disease is the leading cause of death worldwide [1].
- Stenosis in the coronary arteries reduces the myocardial blood supply, inducing ischemia.
- Not all stenoses are functionally significant. Therefore, treatment decision is often based on both stenosis morphology and function.
- Coronary computed tomography angiography (CCTA) and stress 3D echocardiography (3DE) are the most widely used non-invasive morphological and functional modalities.
- Fusion of morphological and functional information to a single multi-modal image improves the treatment decision [2].

Objectives
- Is CCTA/3DE fusion feasible?
- Can CCTA/3DE fusion for patients with suspected coronary artery disease provide incremental diagnostic value?

Data acquisition
- Data were obtained from 20 patients with suspected coronary artery disease.

CCTA: 3D image of the coronary artery tree: morphological information. (Light Speed VCT XT, GE Healthcare)

3DE: 3D+time image of wall motion of the left ventricle (LV): functional information. (Vivid E9, GE Healthcare)

Fusion algorithm

Step 1. Segmentation of LV
- Segmentation of the left ventricle is performed on CCTA and 3DE images.
- CCTA image segmented using a real-time contour tracking library.
- 3DE image segmented using EchoPac 4D Auto-LVQ (GE Healthcare).

Step 2. Alignment of modalities
- LV surfaces are aligned to obtain a common frame of reference.
- Initial alignment based on landmarks: aortic valve, apex and centroid.
- Refined alignment using the iterative closest point algorithm.

Step 3. Image fusion
- Morphological and functional information visualized together:
  - Coronary artery tree and stenosis locations from the CCTA image
  - Left-ventricular wall motion and strain from the 3DE image

Preliminary fusion results
- Automatic CCTA/3DE fusion has been performed on one patient.
- Coronary artery tree from CCTA was visualized with the moving LV and longitudinal strain from 3DE.
- Manual CCTA/3DE fusion has been performed on 20 patients.

Conclusions
- CCTA/3DE image fusion is feasible.
- An automatic CCTA/3DE fusion algorithm has been implemented.
- A validation study is planned using manually fused images.
- A clinical study is planned to assess incremental value for risk stratification in coronary artery disease.

References