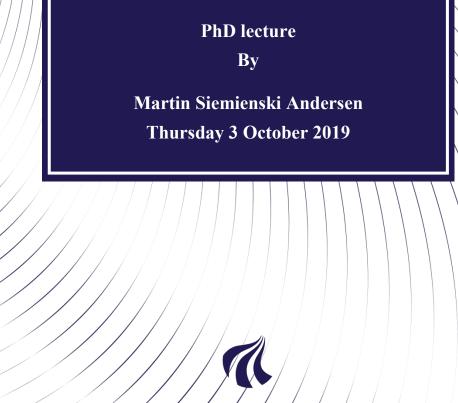
Contraction Sequence of the Left cardiac Ventricle: A Case for High Frame Rate Ultrasound

## by Martin Siemienski Andersen

This dissertation sought to find a methodology for visualization and quantification of the propagation of mechanical waves through the left ventricle (LV). It used the T5 system for image acquisition. The T5 is an experimental phased array ultrasound system capable of up to 2500 fps for some application or 1000 fps for adult cardiac imaging using full field of view while simultaneously showing a live display of the images. Validation image sequences were generated using a high precision translation stage capable of horizontal and vertical motion at 10 µm increments and a tissue mimicking phantom. The second type of images were high frame rate (HFR) in vivo cardiac images with frame rates between 300 fps and 1000 fps. Study A and B presented the Continuous Feature-Tracking (CFT) algorithm, which was capable of accurately describing kinematics. The CFT algorithm was not limited to motion along the axial direction, by analyzing length of line strain in the parasternal shortaxis view. Study C was the first study to show a statistically significant mechanical propagation origin for patients with echocardiographic normal LV function: The mid septal wall segment. These identified waves were consistently moving faster than the electrical excitation velocity through the electrical pathways of the Left Bundle Branch (LBB) and Purkinje network. A new visualization method using strain rate called a Strain Rate Image was developed. The strain rate emphasized changes in the myocardial deformation while presenting them as an image, which made visual interpretation of contraction propagation possible. Study D found statistical significant differences in the duration of the transient wave associated with tissue shortening between patients with echocardiographic normal LV function, LBB block (LBBB), and non-LBBB conduction disorders. Furthermore, a new method using a modified correlation coefficient was developed, which in turn illustrated significantly different measurements when comparing the patient groups. This thesis showed that it was possible to extract propagating mechanical waves from HFR Bmode echocardiographic images. Differences of transient mechanical events between different patient groups were identified. Finally, a proof-of-concept showed how strain should be used in conjunction with HFR echocardiographic images when identifying myocardial deformation.

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DEPARTMENT OF HEALTH SCIENCE AND TECHNOLOGY ALBORG INIVERSITY

This thesis is based on Martin Siemienski Andersen's research work at:

Department of Health Science and Technology Aalborg University, Denmark To fulfill the requirements for the PhD degree, Martin Siemienski Andersen has submitted the thesis: Contraction Sequence of the Left cardiac Ventricle: A Case for High Frame Rate Ultrasound, to the Faculty Council of Medicine at Aalborg University.

The Faculty Council has appointed the following adjudication committee to evaluate the thesis and the associated lecture:

Professor Jan D'hooge Katholieke Universiteit Leuven Belgium

Professor Asbjørn Støylen Norwegian University of Science and Technology Norway

> Chairman: Associate Professor Dan S. Karbing Aalborg University Denmark

Moderator: Associate Professor Claus Graff Aalborg University Denmark

The PhD lecture is public and will take place on:

Thursday 3 October 2019 at 13:00 Aalborg University – Room D2-106 Fredrik Bajers Vej 7 D2 9220 Aalborg East

## **Program for PhD lecture on**

**Thursday 3 October 2019** 

by

## Martin Siemienski Andersen

Contraction Sequence of the Left cardiac Ventricle: A Case for High Frame Rate Ultrasound

Chairman: Associate Professor Dan S. Karbing Moderator: Associate Professor Claus Graff

| 13.00 | Opening by the Moderator   |
|-------|--|
| 13.05 | PhD lecture by Martin Siemienski Andersen  |
| 13.50 | Break  |
| 14.00 | Questions and comments from the Committee<br>Questions and comments from the audience at the<br>Moderator's discretion |
| 16.00 | Conclusion of the session by the Moderator   |

After the session a reception will be arranged