Detection and Segmentation of Anastomoses in Epicardial Ultrasound Images for Quality Assessment of Coronary Artery Bypass Graft Surgery

by

Alex Skovsbo Jørgensen

Up to 9% of coronary artery bypass graft surgery (CABG) anastomoses contain stenoses >50% post-surgery. This can cause post-operative morbidity and mortality for the patients. Intraoperative anastomosis quality assessment can be used to detect anastomotic errors to enable anastomosis revision during the primary surgery. Epicardial ultrasound (EUS) can be used to locate errors and quantify the stenotic rates within anastomoses to determine the anastomotic quality. Currently, the anastomotic quality is evaluated manually from EUS images as no objective methods are available. This can be time consuming and surgeons have to be trained in interpreting EUS images or use peer reviews by a radiologist.

The aim of this thesis was to develop medical image analysis methods to enable automatic quantification of stenotic rates from in vivo EUS sequences of CABG anastomoses made on healthy porcine vessels. For this purpose methods were developed to automatically detect and extract the vessel lumen area of anastomotic structures within in vivo EUS sequences. The anastomosis detection was used to locate anastomotic structures within EUS images to remove human interaction in analysis of EUS sequences. To extract the vessel lumen area of anastomotic structures from in vivo EUS sequences approaches for vessel lumen segmentation, inter-frame vessel motion correction, and segmentation quality control were developed.

An area under the curve of 0.966 (95% CI: 0.951-0.984) and 0.989 (95% CI: 0.985-0.993, p < 0.001) of a precision-recall and receiver operator characteristic curve respectively, was obtained in detecting vessel regions extracted within EUS images in the anastomosis detection algorithm. The vessel lumen area of anastomotic structures was extracted with a mean Dice coefficient of 0.85 (+/- 0.13) and a mean absolute area difference of 20.62% (+/- 25.85) when compared to manual segmentations.

The developed methods were able to automatically detect and track anastomotic structures within EUS sequences without user interaction. The proposed methods have the potential to extract the vessel lumen area from EUS sequences to quantify the stenotic rates of CABG anastomoses.
To fulfil the requirements for the Ph.D. degree, Alex Skovsbo Jørgensen has submitted his thesis: Detection and Segmentation of Anastomoses in Epicardial Ultrasound Images for Quality Assessment of Coronary Artery Bypass Graft Surgery, 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 Wiro Niessen
Erasmus MC Rotterdam
The Netherlands

Professor Rasmus Larsen
DTU Compute
Denmark

Chairman:
Professor Johannes J. Struijk
Medical Informatics Group, Aalborg University
Denmark

Moderator:
Associate professor Claus Graff
Medical Informatics Group, Aalborg University
Denmark

The Ph.D. lecture is public and will take place on:
Friday 13 March 2015 at 13:00
Aalborg University – Fredrik Bajers Vej 7 C2-209
9220 Aalborg East

Program for Ph.D. lecture

Friday 13 March 2015

Detection and Segmentation of Anastomoses in Epicardial Ultrasound Images for Quality Assessment of Coronary Artery Bypass Graft Surgery

Chairman: Professor Johannes J. Struijk
Moderator: Associate Professor Claus Graff

13.00 Opening by the Moderator

13.05 Ph.D. lecture by Alex Skovsbo Jørgensen

13.50 Break

14.00 Questions and comments from the Committee

Questions and comments from the audience at the Moderator’s discretion

16.00 Conclusion of the session by the Moderator

After the session a reception will be arranged in C1-215 (MI meeting room)