Abstract: 543

Automated detection of mitral annular plane systolic excursion in transoesophageal echocardiography based on deep learning

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Introduction:

Major surgery and interventions may impact cardiac function. Perioperative monitoring is currently based on vital signs and clinical observations. However, this does not offer a complete monitoring of left ventricular function throughout the intervention. We hypothesize that functional monitoring of the heart can be performed automatically based on transoesophageal echocardiography (TOE) images. One parameter that has been shown to correlate well with ejection fraction is mitral annular plane systolic excursion (MAPSE). To aid functional monitoring of the left ventricle perioperatively, we propose a technique for detecting MAPSE in TOE images of the left ventricle.

Purpose:

The purpose of this study is to automatically track the movement of the mitral annular plane in TOE sequences of the left ventricle and detect MAPSE via a deep learning approach.

Method:

Recordings from 131 consecutive complete TOE exams from the Echocardiography Unit were anonymized and used for training. Recordings from 23 consecutive TOE exams, also anonymized, were used as test set. All recordings were manually annotated with the location of the landmarks indicated in both 4-chamber (4C) and 2-chamber (2C) views. All recordings were made using state-of-the-art clinical scanners. The captures include 3 to 5 heart cycles of standard 4C and 2C views.

An approach based on a fully convolutional neural network was implemented and trained in a supervised manner to predict the location of two landmarks on the mitral annular plane in B-mode TOE images from 4C and 2C views. The model was also trained to account for noise by recognizing when detecting the landmarks is not feasible due to poor image quality. We have implemented all necessary post processing calculations to automatically estimate MAPSE based only on raw TOE B-mode sequences.

Results:

Preliminary results on the test data show that the landmark detector is able to track the vertical movement of landmarks on the mitral annular plane with a mean error of 0.88 mm and a standard deviation of 0.27 mm (Fig. 1: Upper left and lower left: tracked mitral attachment points on a sample case presented upper right. Lower right: all measured Y-axis excursion values versus the reference). The classifier for detecting ultrasound frames where landmark detection is not feasible has a sensitivity of 0.82 and a specificity of 0.91.

Conclusion:
The landmark detector is showing promising results in tracking of the mitral annular plane excursion. This can provide a fast calculation of MAPSE and eliminate intraobserver variability. This may be included in a more extensive cardiac monitoring for any type of surgery without the need of manual input from echocardiographers. Further research is ongoing and a comparison with clinical MAPSE values is underway.