CineECG for visualization of changes in ventricular electrical activity during ischemia

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Background: CineECG is a newly developed method which provides an anatomical visualization of ventricular de- and repolarization in a non-invasive manner. It combines the electrical information from the 12-lead electrocardiogram (ECG) with a 3D heart model. The location and direction of the average ventricular de- and repolarization over time is projected on the model. Until now, it has not been used for visualization of ventricular electrical activity during myocardial ischemia.

Purpose: We aimed to visualize changes in ventricular de- and repolarization during acute ischemia with CineECG and relate these to changes in the ECG.

Methods: CineECG was used to provide the location and direction of the average ventricular de- and repolarization over time, using a standardized 3D heart/torso model. Continuous ECG’s during percutaneous transluminal coronary angioplasty with prolonged balloon inflation from the STAFF III database were used as study sample. ECG’s at baseline and at every 10 seconds during the first 150 seconds of balloon inflation were analyzed with CineECG. For the terminal QRS-complex, ST-segment and terminal T-wave, the direction of the CineECG was determined. The changes in CineECG direction relative to the direction at baseline were quantified by calculating the Δangle between the CineECG direction at baseline and the direction after every 10 seconds of inflation. Additionally, the root mean square amplitude (rmsA) of the ST-segment of all ECG leads was computed for every ECG.

Results: 94 patients from the STAFF III database were included, 10 patients were excluded due to too much signal noise of the ECG. Within 10 seconds after start inflation, the median Δangle for the terminal QRS-complex, ST-segment and terminal T-wave were 21.8° [11.4 – 34.2], 20.6° [8.0 – 43.9] and 23.5° [11.8 – 48.0], respectively. The median Δangle for the terminal QRS-complex reached its maximum after 130 seconds (41.0° [23.0 – 70.8]). The median Δangle of the ST-segment gradually increased to 26.1° [13.1 – 56.0] after 140 seconds of inflation. The Δangle of the terminal T-wave was greatest 30 seconds after start inflation (26.3° [12.6 – 49.2]), and changed only slightly during inflation. The rmsA of the ST-segment was 0.04 mV [0.03 – 0.08] during the first 10 seconds of inflation, and gradually increased until 0.08 mV [0.05 – 0.15] mV at 150 seconds.

Conclusions: CineECG proves to be very sensitive in detection of early changes in the ECG during prolonged balloon inflation, even before great changes occur in ST-amplitude. Therefore, CineECG might support the early detection of acute ischemia, even before clear ECG changes are visible.
Figure 1. Example of the changes in the CineECG during balloon inflation of the left anterior descending artery. The Δangle was determined for the terminal QRS-complex, the ST-segment and the terminal T-wave. RAO = right anterior oblique, LAO = left anterior oblique, RMS = root mean square.