Localization of the subendocardial injury from 12-lead ECG with moving equivalent dipole of the ST segment

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Injury currents (INJ) in subendocardial ischemia (SI), presenting as NSTE-ACS, produce ST-segment depressions and T-wave inversions on the 12-lead ECG. However, these changes do not reliably indicate the ischemic region. This study investigates whether modeling cardiac electrical activity using moving equivalent dipole (MED) behavior during the ST segment and T wave can improve localization of the affected area.

To estimate MED characteristics strength, orientation, and location from 12-lead ECG data, we solved the inverse problem using a boundary element method (BEM) with an adaptable torso model. Dipole positions were optimized throughout the cardiac cycle, yielding model-predicted potentials with a relative normalized mean square (RNMS) error of approximately 3.5%. MEDs during ischemia were projected onto a 3D ventricular model to identify affected segments based on a 12-segment left ventricular subdivision.

Ischemic ECG recordings were obtained from 103 patients within the STAFF III database who underwent the elective coronary artery occlusion (RCA, LCX, and LDA). In 42 of them, the concomitant baselines before and after the occlusion also exhibited ECG signs of subendocardial injury (SI). In those patients, we compared the MED-related data during the occlusion ischemia (OI) and SI.

In all 42 patients, the OI MED pattern differed from that of SI. In OI, the ST segment MEDs were correctly allocated to the appropriate ischemic segments (Starc, CINC 2023). In contrast, in SI, the ST-segment MEDs were oriented mainly towards the ventricular basal segments. In two cases of RCA occlusion with a similar SI and OI pattern, though more pronounced in the OI pattern, the ST MED returned to its original location after restitution. Hence, none of the initial SI patterns were resolved due to vasodilatation. The behavior of MEDs during the heart's repolarization can be explained by unipolar electrograms (Potse et al., AJP 2009).