Improvement in Automated STEMI Detection by Modeling and Classification of the ST Segment

Reza Firoozabadi*, Richard Gregg, Saeed Babaeizadeh
Advanced Algorithm Research Center, Philips Healthcare, Cambridge, MA, USA

Background: Accurate analysis of the ST segment is critical in diagnosis of the ST segment elevation myocardial infarction (STEMI). Negligible to high levels of artifact from different sources may be present throughout the ST segment and could either mimic a nonexistent ST elevation (false STEMI), or modify the ST level and negatively impact the precise diagnosis of the underlying disease. Filtering and averaging the beats in an ECG interval reduces the artifact level on the ST segment, but does not eliminate it entirely.

Methods: We studied two approaches for improving the ST segment analysis, compared to simply using the raw average ST segment waveform: a short-duration smoothing window and an ST segment curve-fitting model. The smoothing approach used quadratic polynomial least-squares approximation of the average ST segment in a time window of up to 20 milliseconds. The curve-fitting method modelled the ST segment by a section of a parabola using a quadratic polynomial equation. A modified version of Philips DXL$^{(TM)}$ algorithm was used to analyze the 12-lead 10-second recordings for various cardiac conditions including STEMI. Our test database contained 146,349 recordings from a single medical center with 2,524 recordings labeled acute MI (prevalence of 1.7%) by experts.

Results: We compared the STEMI detection performance for the raw average, smoothed, and curve-fitted ST segments (Table 1). A 20-fold decrease in the number of false positives (FP) is observed after smoothing or curve-fitting. The curve-fitting method shows 121 fewer FPs than smoothing, but slightly more false negatives. The higher performance of the curve-fitting approach is the result of its monotonic ST segment model, despite the short-duration smoothing which may follow the trend of slow-varying or high amplitude artifact.

Conclusion: Curve-fitting or smoothing the ST segment reduces the number of false STEMI detections significantly compared to the analysis of the raw average waveform.

Table 1. STEMI detection performance for raw average, smoothed, and curve-fitted ST segments (total=146,349 ; positives=2,524 (prevalence of 1.7%)).

	FP	FN
Raw Average Waveform	27,645	1,071
Smoothed (Quadratic Polynomial Least-Squares)	1,368	1,745
Curve-Fitted (Modeled by Parabola)	1,247	1,775