Application of Synthesized ECG Leads for Real-Time Ischemia Monitoring – From Basic ST-Segment Monitoring to Cardiac Multi-Modality Imaging Analysis

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Introduction: For real-time monitoring synthesized/derived ECG leads from smaller subsets of directly applied leads have been developed: 1) 12-lead derived from 5-wire/6-wire lead-sets for ST-segment monitoring, 2) 12-lead derived three vessel-specific-leads (VSLs) for improved acute ischemia/infraction detection, 3) BSPM derived from 12-lead for discrimination of ischemic vs. non-ischemic ST-segment changes, and 4) Bull's-eye plot of 12-lead derived epicardial potentials using the Computed-Electrocardiographic-Imaging (CEI) method.

Methods: Development databases include: 1) Dalhousie BSPM Superset with 892 patient-records for synthesizing leads, 2) Dalhousie PCI BSPM database with 91 patient-records for locating maximum ST elevation/depression locations for the VSLs method. Validation Datasets include: 1) STAFF-III 12-lead PCI database with 99 patient-records, 2) Glasgow 12-lead AMI database with 116 patient-records. 3) Lund University 12-lead Non-ischemic-ST-Deviation database with 100 patient-records, 4) Subset of 38-patient STAFF-III database with SPECT images. Standard least-square method is used to obtain synthesized leads coefficients. For the CEI method, a universal inverse solution is used to obtain the epicardial potentials from the 12-lead derived BSPM. For performance validation, various standard performance measures are used.

Results: For synthesizing 12-lead, both 5-wire EASI configuration and seven sets of 6-wire dual chest-lead placements all provide acceptable performance. The VSLs method shows better STEMI detection performance than the 12-lead based STEMI criteria. For ischemia detection/localization, 12-lead derived BSPMs correlate well with those constructed from the 120-lead ECG. Finally, the 12-lead derived heart-surface potentials show positive potential area matches the SPECT-indicated hypoperfused territory of the occluded artery.

Conclusions: Advanced synthesized ECGs could be highly useful for ECG-based triage of chest-pain patients. The CEI method, which displays epicardial potentials using compatible formats with other diagnostic imaging modalities, should allow the electrocardiographic information to be incorporated into a cardiac multi-modality-imaging (MMI) decision support system. Whether these methods can be successfully implemented for routine clinical use remain to be validated.