CARDIAC ARRHYTHMIAS

MATHEMATICAL MODELING AND UTILITY OF THE DERIVED 22-LEAD ELECTROCARDIOGRAM

ACC Poster Contributions
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Background: The cardiac electrical field is dipolar and is measured by the electrocardiogram (ECG) which may be described by a 3 lead-vector space. There are 22 leads used in clinical practice including the standard 12-lead ECG, right heart leads V3R-V6R, posterior leads V7-V9, and the vectorcardiographic (VCG) leads X, Y, Z. It would be advantageous to derive these 22 ECG leads from just 3 measured leads using a universal patient coefficient matrix (UPCM) that can be computed using simplex optimization (SOP). The objective is to derive the ECG (dECG) from 3 measured leads using a SOP-computed UPCM and calculate the quantitative and qualitative correlations with the measured ECG (mECG).

Methods: A total of 371 mECGs of varying morphology for both men and women age 18 and older were acquired including 371 standard 12-lead ECGs, 353 VCGs, 75 right heart ECGs, and 34 posterior ECGs. The ECG morphologies included normals, acute MIs, LVH, bundle branch blocks, paced beats, PVCs, and non-specific STT types. Each ECG was interpreted by 2 physicians who were blinded reference standards. The SOP technique was used to derive a UPCM from an additional training set of 20 ECGs. Leads I, aVF, and V2 from the mECGs were chosen as the 3 lead-vector basis orthogonal lead set from which the dECGs were synthesized. The derived vs. measured test case ECGs were compared using Pearson and Kappa statistics.

Results: The dECGs showed high correlation with mECGs overall by Pearson correlations (0.84-0.88). No clinically significant differences were noted in 98.1% of the dECGs. ECG rate, rhythm, segment, and axis interpretations showed 100% correlation. Acute MI differentiation showed 100% correlation. Kappa analysis of the mECG vs. dECG showed high overall correlations (0.73-1.00).

Conclusions: The 22-lead ECG can be derived from just 3 measured leads using the SOP technique. The comparison of the mECGs and dECGs shows high quantitative and qualitative correlations. Using this technology a 22-lead derived ECG can be displayed instantaneously in real-time to enhance patient observation capabilities and will allow for a convenient and cost effective acquisition and analysis of the ECG in telemetry and critical care areas of health care.