A Model Population-Based Approach to Enhance the Detection of Premature Ventricular Contraction of ECGI

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Introduction: Premature ventricular contractions (PVCs) are a type of cardiac arrhythmia characterized by early heartbeats originating from the ventricles. The ability to accurately diagnose and localize PVCs is crucial for effective management but is hindered by the limitations of conventional diagnostic methods such as the 12-lead electrocardiogram. This study explores the use of electrocardiographic imaging (ECGI) and the development of a computer model-based population database to improve the localization and treatment of PVCs. **Methods:** We developed a comprehensive database of 618 simulated PVCs. The simulations were designed to represent a wide range of possible PVC origins, specifically focusing on outflow tract-originated PVCs. From the database, ECGI was calculated using an equivalent single-layer source model and Tikhonov of zero-order regularization to recover the extracellular endocardial and epicardial potential and compute the local activation time (LAT) map. Body surface potentials at the torso surface (BSPM) were calculated using a boundary element method. To address the challenge of accurately locating the origin of PVCs, we developed an estimation algorithm that compares the ECGI LAT map and the BSPM to pinpoint the PVC origin. **Results:** The PVC estimation algorithm was tested using a separate validation set of simulated data not included in the initial database development. The mean geodesic distance error for the earliest activation sites was 33.84 ± 19.23 mm with standard ECGI, but PVC estimation reduced it to 9.28 ± 4.56 mm. Our PVC estimation improved the precision of the standard ECGI to localize PVCs in base, septum, and free wall regions, specifically at the septal and basal regions where standard ECGI was less accurate. In addition, the proposed methodology was tested in a patient's data, reducing the error, measured to the earliest activation site of endocardial mapping, to locate the PVC (15.52 mm) compared to standard ECGI (36.76 mm). **Conclusion:** This study demonstrates the potential of using a population database of simulated PVCs and ECGI to improve the diagnosis and treatment of PVCs. This approach represents a promising avenue for advancing personalized medicine in managing cardiac arrhythmias.