Evaluating Piezoelectric Ballistocardiography for Post-Surgical Heart Rate Monitoring

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Aims: Ballistocardiography (BCG) is a non-invasive measurement technique that measures the ballistic forces generated by the mechanical activity of the heart and circulatory system. BCG has been posited as a potential alternative to ECG for long-term, unobtrusive continuous heart rate monitoring. This study aims to evaluate the feasibility of a custom-made multi-node piezoelectric based BCG sensing mat for measuring heart rate compared to single-lead ECG in a cohort of patients who are recovering from cardiac surgery.

Methods: 14 patients (10 males, mean age 63.47 +/- 9.35) who had undergone either coronary artery bypass surgery (N=8) or different heart valve repair procedures (N=6) were enrolled in this study at the Maastricht University Medical Center. After surgery, patients were transferred to the cardiac ICU to a bed fitted with a custom BCG sensor mat. This novel device consisted of 10 printed PVDF-TrFE piezoelectric sensors on a flexible TPU substrate with a total active area of 90x50 cm^2. BCG and ECG were simultaneously recorded for an average measurement time of 15 hours per patient. BCG heart rate values were extracted over ten second epochs using a multi-node rule-based BCG HR algorithm. Performance was measured using mean absolute error (MAE) to assess the accuracy of the HR values extracted from the BCG signals when compared to the gold standard ECG based heart rates.

Results: Heart rate values derived from the piezoelectric BCG mat resulted in a mean MAE of 1.41 bpm with a mean coverage of 64.45% when compared to ECG.

Conclusion: The findings suggest that piezoelectric based BCG demonstrates potential as a reliable and accurate method for heart rate measurement in patients recovering from cardiac surgery, offering a non-invasive and potentially more patient-friendly alternative to traditional ECG. These results support further investigation and development of this technology for widespread clinical application in remote continuous heart rate monitoring.