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Quantification of Hemodynamic Responses to Diuretic Changes in Patients with Heart Failure using Ballistocardiogram and Electrocardiogram Recordings

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Abstract— **In patients with heart failure, hemodynamic responses to medication changes can potentially be used in clinical decisions and medication delivery tracking.**

I. Introduction

Investigating the hemodynamic responses to medication changes can assist clinical decisions in heart failure (HF) management. In addition, the use of such correlation can further be leveraged in non-invasive home-monitoring systems in order to ensure medication adherence. Increase (decrease) in diuretic dose can be associated with worsening (improving) condition [1]. According to the literature, a decrease in ballistocardiogram (BCG) signal power [1], increase in RJ interval, and decrease in I and J amplitudes [2] are some of the observations made for HF patients with worsening condition.

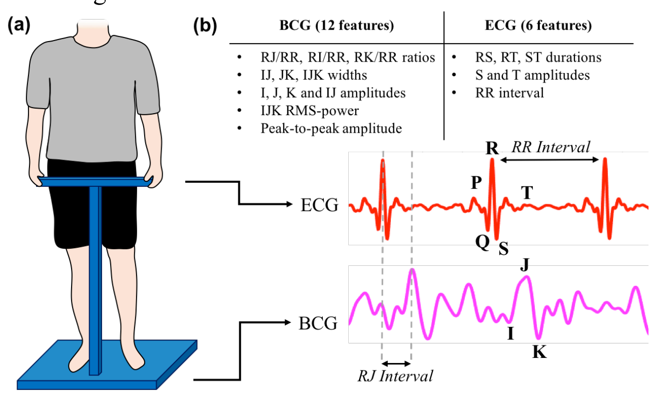

Fig.1: (a) ECG and BCG signals were recorded using a modified-weighing scale. (b) 12 BCG and 6 ECG features were extracted.

II. Methods

BCG and electrocardiogram (ECG) signals of HF patients with reduced ejection fraction (HErEF) were recorded simultaneously with a modified-weighing scale [3] at the day of hospital admission, daily during hospitalization, at discharge, and approximately daily after discharge at home for up to 30 days (Fig.1(a)). For this study, 10 change points from 6 patients were determined with the following criteria: We focused on the days *at home* when only the diuretic dose was changed and all other HF medications (ACE inhibitors, beta-blockers, vasodilators, etc.) were unchanged for at least two days. For the "before" period, the BCG and ECG features were averaged for two days before the change. For the "after" period, the BCG and ECG features were averaged for the day of change and the day after. 18 features were extracted (6 from ECG and 12 from BCG) in total (Fig.1(b)). Low quality recordings resulting from the balance difficulties of HF patients were ignored based on the feature values being outside the possible RI, RJ and RK ranges in literature.

III. Results

The RJ/RR (i.e. pre-ejection period (PEP)/RR), RI/RR and RK/RR ratios increased with increasing diuretics doses (and vice versa) in 90%, 100% and 70% of the readings, respectively. Similarly, the J amplitudes, peak-to-peak amplitudes, IJ amplitudes and IJK RMS power values decreased with increasing diuretics doses (and vice versa) in 90%, 80%, 70% and 70% of the readings, respectively (Fig.2). We could not observe any prominent pattern in the ECG features or in the rest of the BCG features.

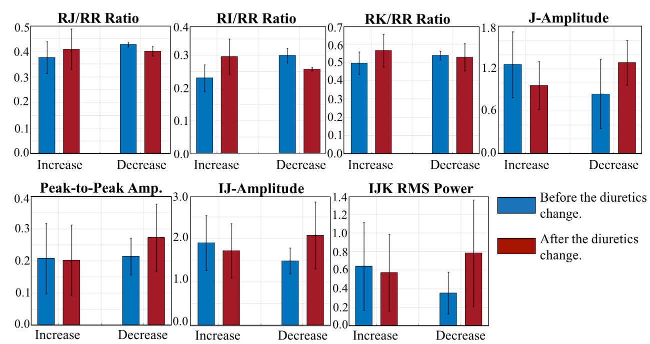

Fig. 2: Feature responses from *all 10 readings* to changing diuretics doses.

IV. Conclusion and Future Work

In this work, we showed that the BCG signals can be used for tracking hemodynamic responses to changes in diuretic doses in patients with HF. This can help remote monitoring and medication titration in patients with HF. In future studies, we will validate our findings with larger datasets.

References

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