QRS Slopes for Potassium and Calcium Monitoring in End-Stage Renal Disease Patients

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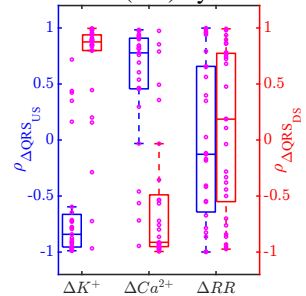[3] Carmen Team, Inria Bordeaux – Sud-Ouest
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Background and aim: Non-invasive estimation of serum potassium, $[K^+]$, and calcium, $[Ca^{2+}]$, are of major importance to prevent ventricular arrhythmias and sudden cardiac death, but current ambulatory estimation methods are limited. In this study, we present a QRS slopes-based analysis to detect and quantify electrolyte abnormalities in end-stage renal disease (ESRD) patients.

Methods: We applied principal component analysis onto 12-lead electrocardiograms (ECGs) of 29 ESRD patients undergoing hemodialysis (HD). Over the first principal component, we analyzed two-minute segments at the end of each HD hour and we computed a mean warped QRS complex (MWQRS) representing an optimal average of QRS complexes in time and amplitude. We calculated the upward (QRS_{US}) and downward (QRS_{DS}) slope of the MWQRS and we quantified the slope change with respect to the end of HD session (ΔQRS_{US} and ΔQRS_{DS}). We assessed the relationship between QRS slope changes and variations in $[K^+]$, $[Ca^{2+}]$ and R-R interval duration (RR) by computing Pearson correlation coefficient ρ.

Results: ΔQRS_{US} and ΔQRS_{DS} significantly increased and decreased, respectively, during HD in association with decreasing $[K^+]$ and increasing $[Ca^{2+}]$. The median ρ of ΔQRS_{US} and ΔQRS_{DS} with $\Delta[K^+]$ were -0.84 and 0.88, respectively. Corresponding ρ values with $\Delta[Ca^{2+}]$ were 0.78 and -0.91. ΔRR presented non-monotonic patterns along HD, with corresponding ρ values for ΔQRS_{US} and ΔQRS_{DS} being -0.13 and 0.19. High interindividual variability in these relationships was

Median (25th/75th %) of ρ between ΔQRS_{US} (blue) and ΔQRS_{DS} (red), and $\Delta[K^+]$, $\Delta[Ca^{2+}]$ and ΔRR.

found. The quantified QRS slope changes in ESRD patients were related to both amplitude and duration changes in the QRS complex during HD.

Conclusions: Changes in QRS slopes are strongly related to variations in $[K^+]$ and $[Ca^{2+}]$ levels during HD in ESRD patients. These results stimulate further studies to monitor ionic concentrations based on ECG depolarization in the search for ion-specific markers.