Estimation of potassium levels using QRS slopes in chronic kidney disease patients

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Introduction
Chronic kidney disease (CKD) affects 11-13 % of the world population.
CKD patients commonly present with hyperkalemia (elevated blood potassium concentration), which increases risk for ventricular arrhythmias and sudden cardiac death [1-5].
Blood tests allow to quantify potassium (K⁺) but this is not feasible for ambulatory monitoring.
Electrocardiogram (electrical activity of heart i.e. ECG) estimation of [K⁺] has been proposed to estimate [K⁺] by detection in a timely manner.

Previous attempts have been proposed to estimate [K⁺] by only ECG repolarization (T wave) markers.

In this study, we estimated [K⁺] by quantifying upward (I𝑈𝑈) and downward (Iビジョヌ) slopes of QRS complex (electrical activation of ventricles) during and after hemodialysis (HD) in CKD patients.

Methods and Materials

Study Population and Data Analysis:
- 29 CKD patients from Hospital Clínico Universitario de Zaragoza (HCUZ).
- 48-hour 12-lead ECGs, 1 kHz sampling frequency.
- Acquisition started 5 minutes before the HD treatment onset and lasted for 148 hours.

QRS slopes characterization:
- Location of QRS onset, peak and end
- I𝑈(U) calculated as maximum gradient from QRS onset to QRS peak [8-9]
- Iビジョヌ calculated as minimum gradient from QRS peak to QRS end [8-9]

Potassium estimation:
- Univariable estimators defined as:
  \[ Δ[K⁺] = β₀ + β₁ΔI𝑈(U) + β₂ΔIビジョヌ \]
  - Leave-one-out cross-validation used to evaluate the performance of [ΔK⁺] estimation.
  - Estimation performed individually for each patient.

Results and Discussion
- QRS slope-based markers significantly varied with varying [ΔK⁺] during and after HD, with median Spearman correlation of -0.75 and -0.81 for ΔIビジョヌ and ΔIビジョヌ.
- Good agreement was found between actual and estimated [ΔK⁺], with average error -0.26mM and -0.23mM for ΔIビジョヌ and ΔIビジョヌ.

Conclusions
- QRS slopes vary with potassium in ECGs of CKD patients.
- QRS slope-based estimators allow non-invasive quantification of [K⁺] changes.

Characterization of ECG depolarization, in addition to ECG repolarization, could improve monitoring of hypokalemia and hyperkalemia and prediction of arrhythmic events.

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References

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