

T-Wave Alternans Evolution During Hemodialysis Treatment and Correlation with $[K^+]$ and $[Ca^{2+}]$ Concentrations

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Aim: End-stage renal disease (ESRD) patients requiring hemodialysis (HD) treatment experience rapid blood electrolyte fluctuations that can trigger ventricular repolarization instability, increasing arrhythmia vulnerability and cardiovascular risk. T-wave alternans (TWA) may serve as a non-invasive marker of such instability. In this work, we assessed the correlation between TWA amplitude and variations in serum potassium $[K^+]$ and calcium $[Ca^{2+}]$ concentration levels in ESRD patients during an HD session.

Methods: A total of 29 48-hour Holter ECGs from ESRD patients (12 leads, sampling frequency 1000 Hz), including a complete HD session together with a set of synchronous hourly-collected blood samples (before, 3 during the HD and at the end of the session), were analyzed. The index of median alternans (IMA), quantifying the average absolute TWA amplitude, was measured in consecutive 1-hour intervals using a fully automated method based on periodic component analysis (π CA) and the Laplacian likelihood method. Intra-patient Pearson's correlation coefficient (r) between IMA and both $[K^+]$ and $[Ca^{2+}]$ ionic concentrations along the HD session was assessed.

Results: Analysis of the temporal evolution of IMA during the HD demonstrated a direct correlation with $[K^+]$ variations, and yielded a result of (median [Q1,Q3]) $r = 0.79$ [0.32,0.91] (Fig. 1a). Moreover, variations in $[Ca^{2+}]$ level showed an inverse association with IMA with $r = -0.59$ [-0.82,-0.08] (Fig. 1b).

Conclusion: TWA amplitude, measured by IMA, is responsive to the rapid intradialytic fluctuations of serum $[K^+]$ and $[Ca^{2+}]$. Since these electrolyte shifts directly drive repolarization instability, IMA emerges as a promising non-invasive biomarker for real-time monitoring of arrhythmic risk in ESRD patients.

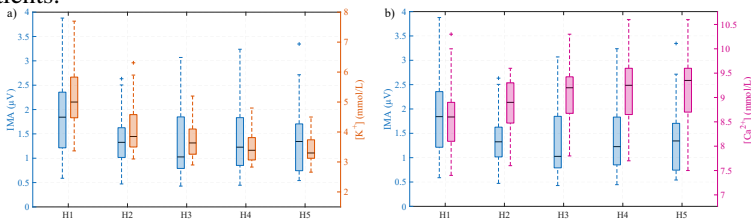


Figure 1: Hourly distributions of IMA (blue) and (a) $[K^+]$ (orange) and (b) $[Ca^{2+}]$ (pink) concentrations across patients along the 5-hour HD session.