

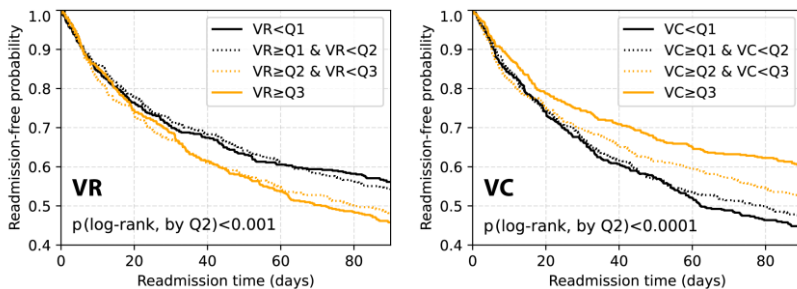
Lazy Electrocardiographic Markers for Readmission Risk Stratification in Discharged Heart Failure Patients

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Early readmission after intensive care discharge remains frequent in heart failure (HF) patients. We investigated whether pre-discharge ECG recordings contain prognostic information reflecting residual abnormalities in ventricular depolarization.

We analyzed ECG recordings (10 seconds, 500 Hz, lead I) from 2,092 HF patients in the MIMIC-IV ECG database. Two markers were extracted from the signal without QRS segmentation using frequency-specific amplitude envelopes computed via FFT filtering and the Hilbert transformation. The first marker (VR) quantified the relative distribution of low and mid-frequency components and was designed to reflect depolarization dynamics. The second marker (VC) quantified the correlation between closely spaced amplitude envelopes, capturing the instability of QRS morphology. Effects were evaluated using Kaplan–Meier analysis and Cox proportional hazards models adjusted for age, sex, atrial fibrillation, and pacemaker presence.



Readmission-free probability stratified by proposed feature quartiles.

Both markers were associated with readmission risk, with VC showing stronger separation in the Kaplan–Meier analysis (log-rank $\chi^2 = 18.8$, $p < 10^{-6}$) and remaining independently associated with outcome in multivariable Cox models ($p < 0.005$), whereas VR exhibited a weaker effect. The markers were only moderately correlated ($r = 0.31$). Extensive surrogate and robustness analyses confirmed that the observed associations were not attributable to spectral, numerical, or acquisition-related artifacts. Pre-discharge ECG recordings contain complementary prognostic information, and the analysis of proposed physiologically motivated depolarization markers may support post-ICU risk stratification in HF patients.