The AMPS Insider

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Executive Overview

Uncertainty estimation of deep learning models for atrial fibrillation detection from Holter recordings: A benchmark study • Software-based analysis of T-wave morphology: identifying the electrocardiogram signature of high-risk long QT syndrome • Products News.

Editorial

We continue covering the AMPS tradition of research participation in this TAI issue, as we feature 2 new papers published this past quarter. The first paper is titled: *Uncertainty estimation of deep learning models for atrial fibrillation detection from Holter recordings: A benchmark study*. This is the last publication resulting from our collaboration with the University of Milan and the team of Prof. Roberto Sassi. Dr. Rahman has focused his (recently completed) PhD program working on machine-learning methods to detect atrial tachi-arrhythmias in continuous ECG recordings. This recent work provides useful insights on the quantification of uncertainty estimation and consequent safe integration into clinical practice of atrial fibrillation deep-learning models. AMPS' collaboration with the University of Milan continues with the support of another PhD student, Beatriz Cosculluela, who is currently working on artificial intelligence models aimed to better distinguish atrial fibrillation and atrial flutter in challenging real-world large datasets.

Paper Abstract: With the development of deep learning (DL)-based methods, automated atrial fibrillation (AF) detection from electrocardiograms (ECGs) has recently gained much attention. Although the performance of DL has been encouraging, the susceptibility of DL models to overfitting would benefit from the exploration of uncertainty quantification (UQ) to ensure safe integration into clinical practice. However, there has been limited exploration of UQ methods in the context of DL models for AF detection using Holter ECG recordings, and a comprehensive comparison of various UQ techniques remains absent. This study addressed this gap by introducing a benchmark study wherein 11 distinct UQ methods were rigorously evaluated and compared across three public Holter repositories: IRIDIA-AF, Long-Term AF, and MIT-BIH AF datasets. A residual DL model was used for the UQ methods, which is one of the most common architectures in this domain for its ability to capture complex patterns within ECG data. The findings revealed that batch-ensemble (BE) and packed-ensemble (PE) outperformed other UQ methods concerning both performance, as quantified by sensitivity, specificity and expected calibration error, and computational efficiency. In addition, when we implemented reject inference to discard ECG segments where the model confidence was not sufficiently high, BE and PE still showed to reject the least number of samples, while retaining the highest detection performance.

The second paper is titled: *Software-based analysis of T-wave morphology: identifying the electrocardiogram signature of high-risk long QT syndrome.*

Dr. Pia Porretta is a Lausanne-based cardiologist who recently completed collaborative research with the team of Prof. Extramiana in Paris. This publication is a good example of the usage of T-wave morphology indices available through AMPS solutions implemented as an indicator of high-risk in long QT syndrome patients. Many of the parameters studied by Dr. Porretta are the

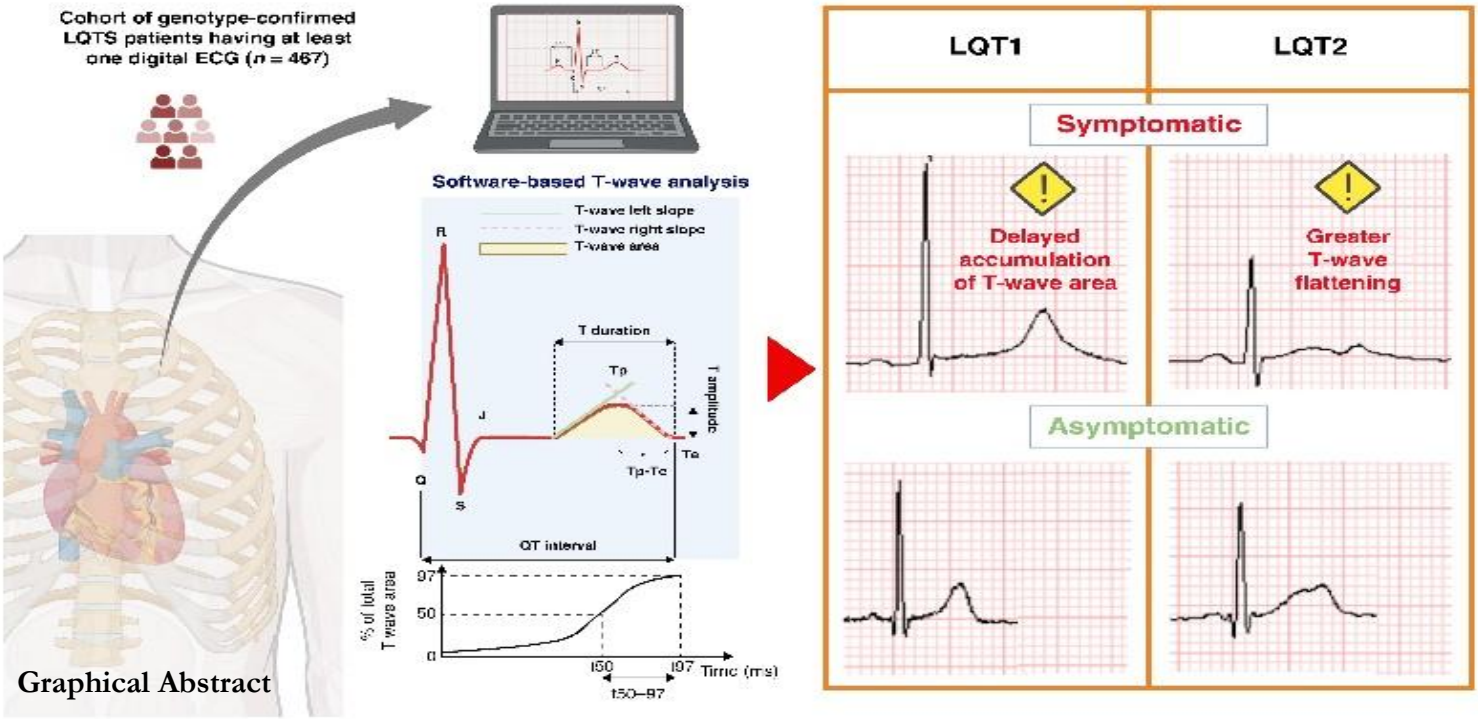
same we typically implement in drug studies to assess the proarrhythmic risk of multi-channel blockers.

Paper Abstract: **Aims -** Despite T-wave morphology abnormalities being well-known distinctive ECG features in patients with long QT syndrome (LQTS), the subjectivity of qualitative 'eyeballing' in T-wave characterization still hampers its integration into diagnostic/prognostic criteria. We herein evaluated whether our quantitative software-based analysis of T-wave morphology (AnTwM) applied to digital ECGs may identify predictors of cardiac events (CEs) in our cohort of LQTS patients.

Methods and results - We enrolled LQT1, LQT2, and LQT3 patients having at least one digital ECG from our cohort of genotype-confirmed LQTS patients. Automated AnTwM analysis, using Glasgow and Bravo algorithms embedded in the CalECG software (AMPS-IIc, USA), provided scalar descriptors of ventricular repolarization. Cox regression analyses identified potential predictors of CEs (i.e. syncope, sudden cardiac death, resuscitated cardiac arrest, or appropriate shock delivered by implantable cardioverter defibrillators). A total of 467 (58% female) patients were followed up for 15 ± 9 years, including 253 (54.2%) LQT1, 182 (39%) LQT2, and 32 (6.8%) LQT3 patients. Corrected QT interval predicted CEs in the whole population (1 ms QTc increase: HR = 1.01, 95% CI: 1.0–1.01, P = 0.03) but not across genotyped subpopulations. Genotype-specific ECG markers associated with a greater risk of CEs were (i) those expressing a delayed accumulation of the mid-late T-wave area (decreased t25 and increased t50) among LQT1 patients and (ii) those expressing T-wave flattening/widening (decreased T-wave ascending/descending slopes) among LQT2 patients.

Conclusion - The software-based AnTwM on digital ECGs represented a reliable tool in clinical practice and identified unique ECG T-wave 'fingerprints' that allowed prediction of CEs in a genotype-specific manner. **Graphical Abstract**

The full articles, as well as other recent journal publications authored or co-authored by our staff can be found on the AMPS website



Graphical Abstract

Products News

- CER-SCor / ACG: continuous development of new features and bug fixes
- CER-S: release version 4.8.1 (bug fixing) and planning for next version 4.9.0
- ECG master: development for the realization of the first version for internal study
- New classifier: work in progress for new beat classifier for Abile/CER-S