

An innovative Medical Decision Support tool for neurological outcome prediction from post-resuscitation Electrocardiograms (MILESTONE)

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Background: The prediction of poor neurological outcome after Out-of-Hospital Cardiac Arrest (OHCA) represents a major challenge in post-resuscitation care. This is currently based on a complex multiparametric prognostication approach and the existing decision support tools are characterized by unsatisfactory performance.

Purpose: The aim of the present study is to develop a machine learning (ML) tool for clinical decision support in the prediction of neurological outcome in patients who have experienced an OHCA. We present an innovative Medical Decision Support tool for neurological outcome prediction from post-resuscitation Electrocardiograms (MILESTONE), which can be used in a post-resuscitation setting.

Methods: MILESTONE uses an ECG image as an input from which it extracts features by computer vision techniques. Those features, used to feed the ML model for the prediction of the neurological outcome, were retrieved from a dataset of 1341 ECGs collected from a Utstein-style OHCA registry: 431 post-ROSC ECGs of patients with poor neurological outcome (defined according to the Cerebral Performance Category > 2) at discharge (class 1); 568 post-ROSC ECGs of patients with good neurological outcome (CPC_≤2) and 342 ECGs of healthy subjects (class 0). Image features were extracted by several computer vision algorithms derived from the scale-invariant feature transform (SIFT) method. The extracted features, patient's age and gender were used to train an XGBoost classifier. Nested cross-validation was applied to optimize the model's parameters and to test its generalization capability. Class weightage technique was introduced to make our classifier more prone to detect positive cases. Model's performance was evaluated by the balanced accuracy, the Area Under the Curve of the Receiver Operating Characteristic curve (AUC-ROC), and the F1-score in both the validation and the test sets.

Results: Our model achieved an AUC-ROC and F1-score of 88.5±4.1% and 78.2±7.3% respectively in the hold-out set (Figure). MILESTONE reached a balanced accuracy of over 80% as a proof of the robustness of the results and the high discrimination capability for both classes, although it has an intended bias towards the identification of patients with worse outcomes. In terms of explainability, MILESTONE has the potential to correlate machine-readable ECG features with more well-known macro features used in clinical practice such as QT intervals, peak shapes, etc.

Conclusions: We present the first use of computer vision-based ECG features able to predict poor neurological outcome in patients resuscitated from OHCA. Poor neurological outcome represents a major challenge in post-resuscitation care and this innovative and flexible tool showed an extremely promising performance. Moreover, this tool can be re-trained either for different pathologies or on any time length of ECG recording thus continuously improving its performance.

