Anaesth Crit Care Pain Med 41 (2022) 101015

Contents lists available at ScienceDirect

Anaesthesia Critical Care & Pain Medicine

journal homepage: www.elsevier.com

Original Article

Computational signatures for post-cardiac arrest trajectory prediction: Importance of early physiological time series

Han B. Kim [a,c,g,1], Hieu T. Nguyen [a,g,1], Qingchu Jin [a,1], Sharmila Tamby [b], Tatiana Gelaf Romer [a], Eric Sung [a], Ran Liu [a], Joseph L. Greenstein [a], Jose I. Suarez [c,d,e], Christian Storm [f], Raimond L. Winslow [a], Robert D. Stevens [c,d,e,g,*]

[a] Department of Biomedical Engineering, Whiting School of Engineering, Johns Hopkins University, Baltimore, MD, USA
[b] Department of Computer Science, Whiting School of Engineering, Johns Hopkins University, Baltimore, MD, USA
[c] Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
[d] Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, USA
[e] Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA
[f] Department of Nephrology and Intensive Care Medicine, Charité-Universitätsmedizin, Berlin, Germany
[g] Laboratory of Computational Intensive Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

ARTICLE INFO

Article history:
Available online

Keywords:
Cardiac arrest
Prognostication
Machine learning
Physiological time series
Precision medicine

ABSTRACT

Background: There is an unmet need for timely and reliable prediction of post-cardiac arrest (CA) clinical trajectories. We hypothesized that physiological time series (PTS) data recorded on the first day of intensive care would contribute significantly to discrimination of outcomes at discharge.

Patients and methods: Adult patients in the multicenter eICU database who were mechanically ventilated after resuscitation from out-of-hospital CA were included. Outcomes of interest were survival, neurological status based on Glasgow motor subscore (mGCS) and surrogate functional status based on discharge location (DL), at hospital discharge. Three machine learning predictive models were trained, one with features from the electronic health records (EHR), the second using features derived from PTS collected in the first 24 h after ICU admission (PTS_{24}), and the third combining PTS_{24} and EHR. Model performances were compared, and the best performing model was externally validated in the MIMIC-III dataset.

Results: Data from 2216 admissions were included in the analysis. Discrimination of prediction models combining EHR and PTS_{24} features was higher than models using either EHR or PTS_{24} for prediction of survival (AUROC 0.83, 0.82 and 0.79 respectively), neurological outcome (0.87, 0.86 and 0.79 respectively), and DL (0.80, 0.78 and 0.76 respectively). External validation in MIMIC-III (n = 86) produced similar model performance. Feature analysis suggested prognostic significance of previously unknown EHR and PTS_{24} variables.

Conclusion: These results indicate that physiological data recorded in the early phase after CA resuscitation contain signatures that are linked to post-CA outcome. Additionally, they attest to the effectiveness of ML for post-CA predictive modeling.

1. Introduction

Cardiac arrest (CA) is an abrupt cessation of myocardial function that affects more than half a million people in the United States annually. Patients resuscitated from cardiac arrest can experience a wide range of outcome trajectories, from complete recovery to death or severe neurologic disability [1]. A challenge in post-CA care is to accurately predict outcome, especially in the early phase when patients are treated in the intensive care unit (ICU). Physical examination findings and neurophysiological tests lack prognostic accuracy, especially when assessed less than 72 h after CA [2]. The recommended paradigm of multi-modality prognostication can be difficult to implement, and the predictive performance of its different elements, while studied individually, are unknown in aggregate [3]. Timely and accurate characterization of post-CA

* Corresponding author at: Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA.
E-mail address: rstevens@jhmi.edu (R. D. Stevens).
[1] Contributed equally

https://doi.org/10.1016/j.accpm.2021.101015