2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Deep Learning-Based Early Prediction of Intraoperative Hypotension

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***Abstract*— This work focuses on predicting near-term onset of hypotension prior to onset using convolutional neural networks. Based solely on the arterial blood pressure curve, our initial attempt can predict an onset with 60% sensitivity and 80% specificity 5-15 minutes before onset.**

Clinical relevance **Hypotension is common during large surgery. By identifying and treating hypotensive episodes early, preferably even before onset, hypotension and its associate post-surgery complications are reduced. Even a prediction with 80% sensitivity/specificity is valuable for the anesthesiologist.**

I. INTRODUCTION

Intraoperative low blood pressure (hypotension) is common during large surgery and has been associated with adverse outcomes, mainly renal- and myocardial injury and even death [1]. By identifying and treating hypotensive periods early, preferably even before onset, the amount of hypotension and thus the risk of damage to the heart muscle and kidney are reduced.

Data-driven healthcare, in the form of continuous monitoring in the perioperative period with both invasive and non-invasive sensors, advanced signal processing, and machine learning, has proven to be able to predict hypotension [2]. However current prediction models use binary classification based on a fixed goal of mean arterial pressure (MAP) over 65 mmHg. In our project, we develop a new and promising prediction approach classification based on a deep learning artificial intelligence (AI) technique called convolutional neural networks (CNN) to predict hypotension prior to onset with a personalized MAP goal set by the anesthesiologist.

II. METHODS

A hypotensive event is defined as a period of at least one minute where the MAP $<$ 65 mmHg or the threshold determined by the anesthesiologist. In a cohort of total 138 high risk surgical adult patients at the Karolinska University Hospital Sweden, we applied the CNN from Ismail Fawaz et al. [3] to high resolution arterial blood pressure curve data to create a binary classification model for early prediction of hypotension during surgery. The model was trained on 100 patients and validated on 38 patients.

III. RESULTS

There were a total of 1034 hypotensive periods and 1802 periods free of hypotension. The CNN-based model was able to predict hypotension at 5, 10 and 15 minutes before onset of hypotension with 60% sensitivity and 80% specificity with an area under the curve (AUC) around 0.8. At a 60% specificity, the sensitivity is 76-85%. Fig. 1 shows the three receiver operating characteristic curves (ROC).

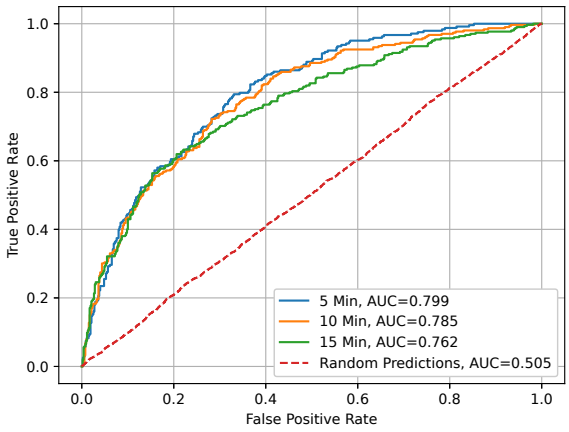

Fig. 1. ROC of the CNN-based prediction of hypotension within x minutes

IV. DISCUSSION & CONCLUSIONS

Deep learning with CNN can be used to predict intraoperative hypotension using only the high-resolution arterial blood pressure curve data. Although our current results are not as good as the results of Hatib et al. [2], we believe our future results will improve with more data and better methods. In the future, we will hopefully be able to predict not only the onset of hypotension, but also the duration of the hypotensive period and/or the area under threshold (duration multiplied with the average amount of hypotension).

ACKNOWLEDGMENT

The authors would like to thank Antoine Honoré and Lina Abdel-Halim for the assistance in obtaining the patient data.

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