Abstract Title: A RANDOM FOREST CLASSIFIER FOR PREDICTING CEREBRAL VASOSPASM FOLLOWING SUBARACHNOID HEMORRHAGE

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Background: Cerebral vasospasm (CV) is a life-threatening phenomenon in patients with subarachnoid hemorrhage (SAH), and is of critical importance since it contributes to delayed cerebral ischemia (DCI) and concomitant morbidity and mortality in this population[1]. It is standard clinical practice to admit patients post-SAH to an intensive care unit (ICU) for 14-21 days following SAH for close monitoring and potential intervention for clinically significant CV. Since current monitoring capabilities cannot determine which patients with SAH ultimately develop CV, considerable hospital resources are consumed supporting and observing many patients with SAH who never develop CV[2].In this context, our group was motivated to explore the feasibility of using machine learning to predict CV in patients following SAH using routinely measured clinical values, with the end goal of guiding clinicians to monitor patients with a level of vigilance commensurate to their actual risk for complication. Herein, we train and validate a random forest classifier for the prediction of CV warranting angiographic intervention using several clinical measures from the electronic medical record (EMR).

Methods: Using the Perioperative Data Warehouse[3], we extracted EMR data from ICU patients who were admitted for SAH at our institution between 2013 and 2021. Time-series of blood pressure (BP), laboratory sera (sodium, albumin, hemoglobin, glucose, creatinine, potassium, and chloride), and intracranial pressure (ICP) were extracted for the entire hospital admission for qualifying patients. CV was defined as angiographic vasospasm warranting intra-arterial verapamil infusion. All datapoints proceeding verapamil administration, unavailable datapoints, and datapoints within time-series with fewer than 100 datapoints at the time-of-prediction were excluded. Each time-series was condensed to a 21-dimensional feature vector by extracting measurements at various percentiles. A random forest classifier was subsequently trained to predict CV based on the described distributions and its predictive power was validated using a five-fold cross validation within the study cohort at 240, 720, 1440, 2160, 2880, and 3600, 4320 minutes prior to verapamil administration. Receiver operator characteristic (ROC) curves and the associated areas under each curve (AUC) were computed to assess predictive power.

Results: A total of 1,534 SAH patients (average age 51.3 years, 45% female) were identified; 1,027 contained complete datasets and were included. Sample sizes at times-of-prediction ranged from 82 to 72 patients based on the count of patients with at least 100 datapoints available. Sample sizes and AUCs for each predictive model at each time interval prior to verapamil injection are shown in Table 1.

Time before Verapamil Injection	Mean AUC			Sample size: verapmil / no verapamil
	BP	ICP	Lab Sera	
240 mins	0.67	0.81	0.71	82/1027
720 mins	0.67	0.83	0.72	81/1027
1440 mins	0.6	0.82	0.71	80/1027
2160 mins	0.63	0.83	0.69	79/1027
2880 mins	0.63	0.8	0.72	77/1027
3600 mins	0.6	0.8	0.72	75/1027
4320 mins	0.62	0.79	0.74	72/1027

Table 1. AUCs and sample sizes for each predictive model.

Conclusion: Our findings indicate that a random forest classifier trained on ICP following SAH is a strong predictor of cerebral vasospasm necessitating verapamil injection up to three days prior to injection (average AUC=0.81). Furthermore, the same classifier trained on BP and laboratory sera achieved less predictive power than when trained on ICP. This report details, to our knowledge, the first machine learning-based approach to strongly predict severe cerebral vasospasm requiring verapamil administration based on routine clinical measurements in the literature.

References
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