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Development of Machine Learning Prediction Models for Self-Extubation after Delirium Using Emergency Department Data

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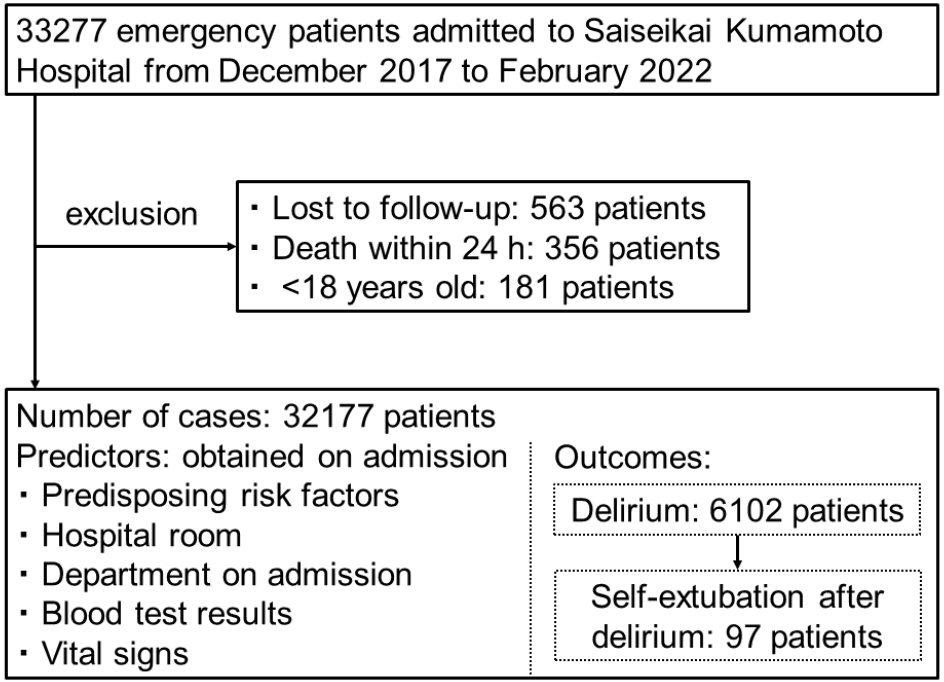
Background

- Delirium is common in hospitalized patients, with a prevalence of 8%–17% in emergency department patients.
- Delirium causes incidents such as self-extubations, so it is critical to predict the occurrence of delirium and take preventive measures before it occurs.
- There is a tool for predicting self-extubation incidents, but it is not specific to delirium.

Objective

- The goal of our research is to create a model that predicts the onset of delirium in the early stages of hospitalization, where delirium is more likely to occur, as well as a machine learning prediction model that predicts the occurrence of self-extubation after delirium occurs.

Flow chart for selection of study patients



Clinical Outcomes

- Incident delirium was defined as a positive confusion assessment method (CAM) after hospitalization.

  ➞6102/32177 patients

- Cases of delirium-related self-extubation among those who developed delirium and were reported in the incident report were defined as self-extubation after delirium.

  ➞ 97/32177 patients

Predictors

- Predictive models were developed using data available at the emergency department at the time of admission.

- A total of 45 predictors, including blood test values and vital signs, were used in addition to basic information such as age and gender.

Algorithm

- The XGBoost algorithm, a type of decision tree ensemble learning, was used to develop the prediction models.

- This algorithm was chosen due to its high prediction accuracy and compatibility with the later described interpretive technique.

Predictive Performance Evaluation

- The discriminating ability of each model was assessed by the area under the receiver operating characteristic curve (AUROC) as well as sensitivity and specificity.
- The calibration performance was assessed by calibration slope.
- A stratified five-fold cross-validation was performed as internal validation, and the mean and standard deviation of each metric were calculated.

Handling of Imbalanced Data

- In this study, the frequency of occurrence of the outcomes is low and extremely unbalanced.

  ➞ Self-extubation after delirium: 97/32177 patients

- We used "cost-sensitive learning", which adjusts the loss function of the XGBoost algorithm to minimize the loss function by attaching weights to minority classes to make them more strongly identified.

Machine Learning Interpretability Method

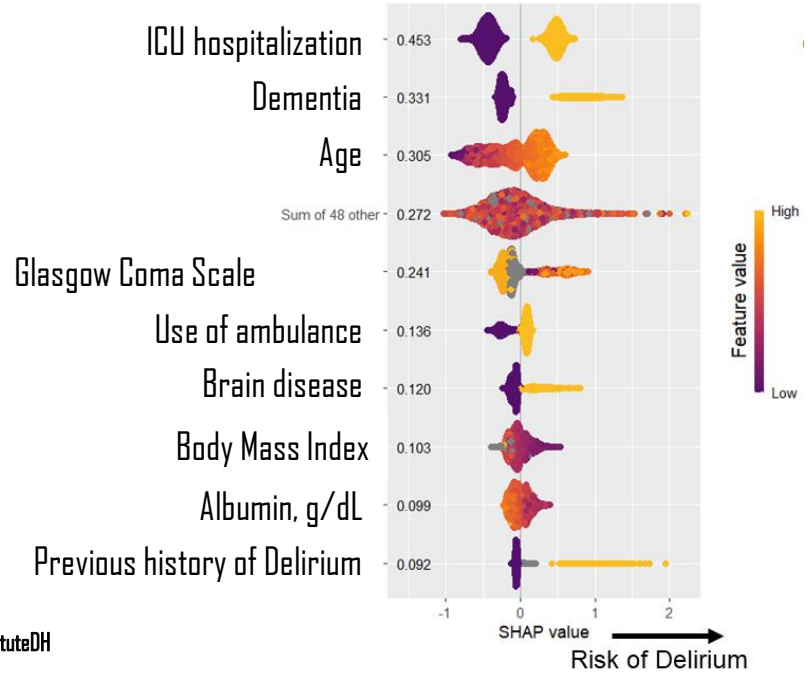
- To visualize the relationship between predictors and outcomes, we used Shapley additive explanation (SHAP), a model-agnostic machine learning method.
- SHAP is a method for visualizing predictors' contributions by using Shapley values, which are guaranteed to be distributed fairly in cooperative game theory.

Prediction accuracy of each model after stratified 5-fold cross-validation

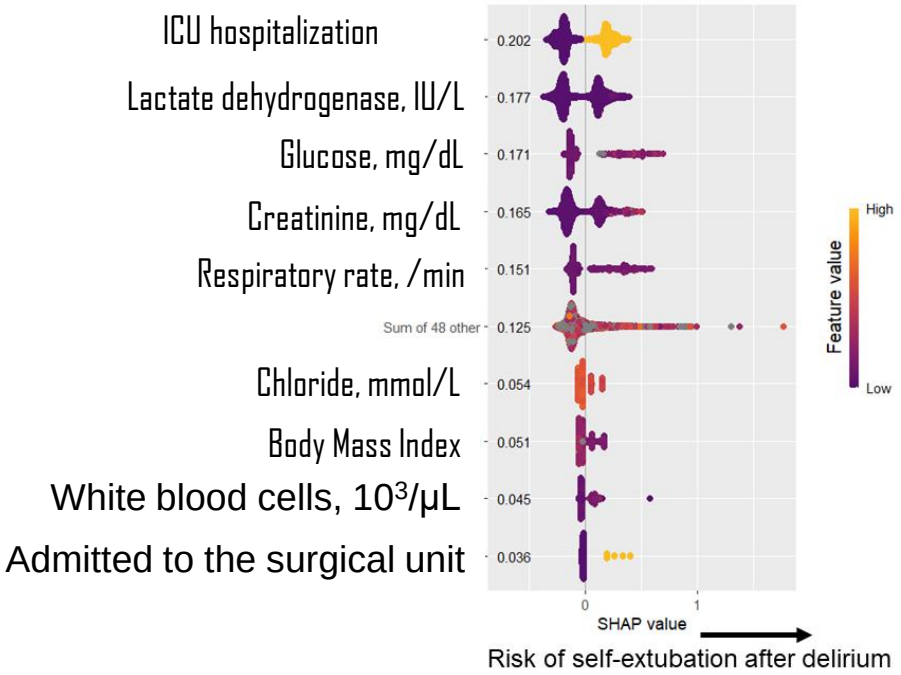
Prediction models	AUROC	Sensitivity	Specificity	Calibration slope
Delirium	0.818 ± 0.006	0.828 ± 0.030	0.672 ± 0.035	1.067 ± 0.044
Self-extubation after delirium	0.782 ± 0.050	0.872 ±0.046	0.631 ± 0.125	1.309± 0.270

Importance of Predictors_Top10

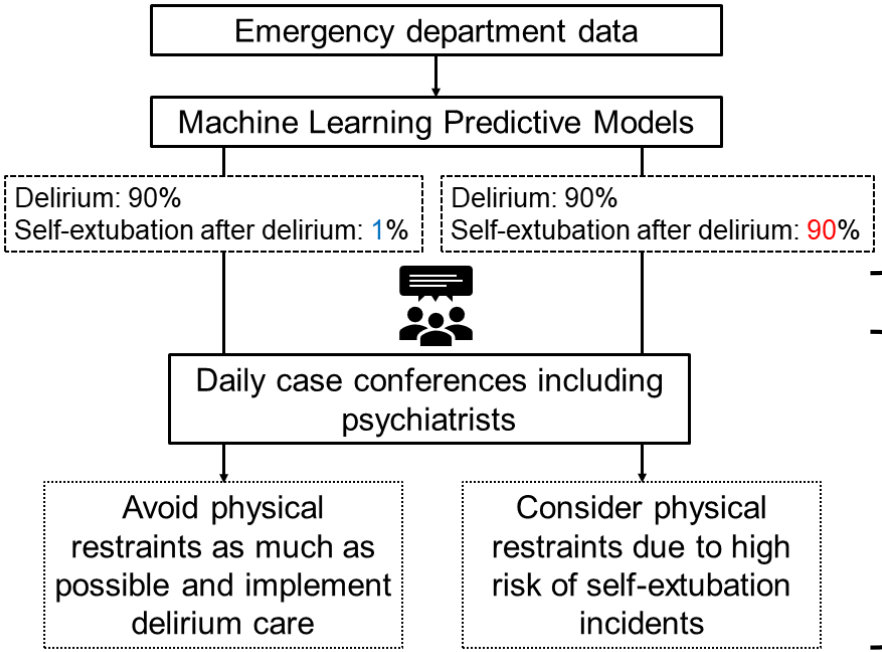
Delirium



Self-extubation after delirium



Conceptual diagram of decision support using machine learning predictive models



The key is to be able to predict early on when the patient arrives at the hospital.

By comparing the results of the two predictive models, a decision can be made as to whether or not to perform "physical restraint".

Conclusion

- We demonstrated that it is possible to create a delirium prediction model as well as a machine learning model to predict self-extubation following delirium.

- The application of these techniques to medical decisions like physical restraints would increase the value of medical care.