# Finding the Physiologic Switch to Predict Weaning from Mechanical Ventilation in ARDS

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## Abstract

Weaning from mechanical ventilation is a necessary process towards liberation for ventilatory support for critically ill patients with respiratory failure. However, the timing of its initiation, and its impact on the duration of ventilation are unclear. We hypothesized that non ventilatory parameters in addition to newer perspectives on ventilatory factors may improve prediction for successful weaning. In this study, we took into consideration several ventilatory parameters, standard laboratory blood biomarkers, and demographic parameters.In this study, we established statistical models to predict the outcome of a weaning decision based on a real-time physiological situation of the patient. Then, we found significant parameters in the models and tried to use a clear interpretable algorithm to improve the clinical guidance.

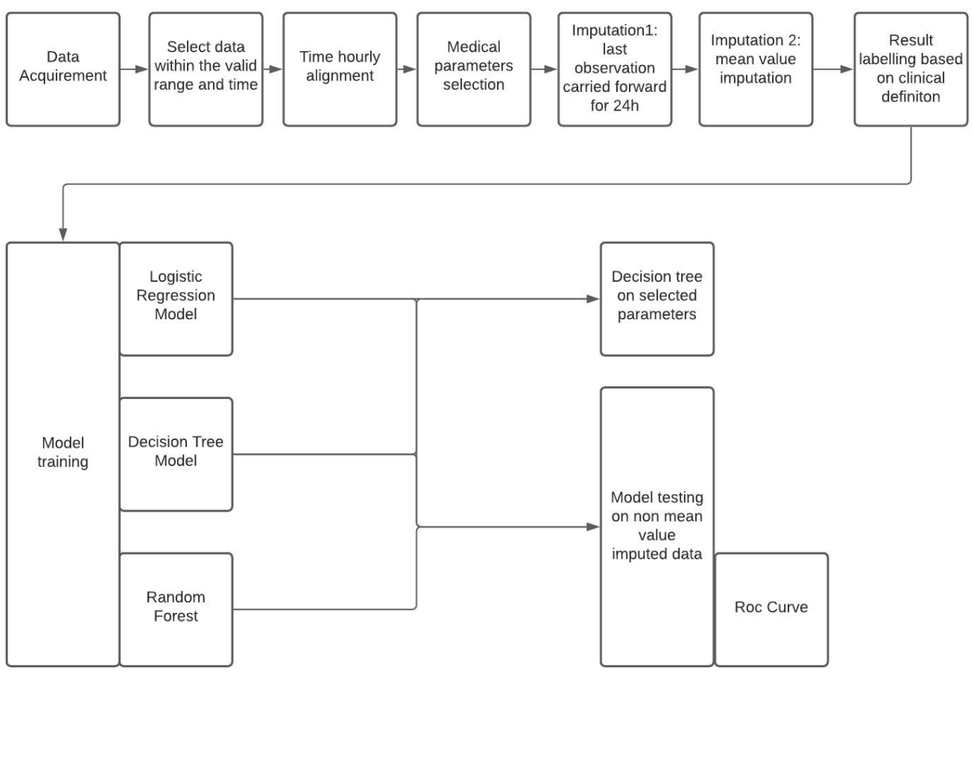
## Introduction

Breathing or ventilation is a critical activity to human to maintain healthy. In general, by the cooperation of multiple muscles and tissues, metabolic wastes such as cardon dioxide gets out and energy support material oxygen gets inside the body.
Acute Respiratory Distress Syndrome (ARDS) is a life-threatening condition where lungs fail to be supplied with enough oxygen. (1) There has been growing demand on curing patients with ARDS especially during Coronavirus disease 2019(COVID-19) pandemic. For patients with ARDS, it is important to provide them with extra oxygen supplies to maintain proper functions of their body systems. There are generally three oxygen support modes of ventilator: controlled mode, spontaneous mode and discharged mode. Controlled mode provides the strongest oxygen support, spontaneous mode supports less and discharged mode supports the least. For patients who come to hospital with severe symptoms, they usually begin with controlled mode of ventilation. However, using controlled mode too long would also damage lungs.(1) What's more, patients are expected to eventually recover their lungs' function and relevant muscle strength during their ventilation and become able to breathe by themselves without the help of ventilators. To conclude, patients cannot stay in the controlled for too long and it is necessary to decide whether it is a proper time to discharge patients from controlled mode of ventilation.

## Methods and Materials

Data were extracted from Cerner system that has been recording patients registered since 2019 at two hospitals in London (November 2019 at Chelsea and Westminster Hospital and since June 2020 at West Middlesex Hospital). This data involves medical information of 926 patients. Patients' medical information was organized by different medical events, e.g., temperature, respiratory rate. In this study, we investigated 32 different medical events including body physical information, medical measurements in blood, ventilatory parameters and doze of relevant drugs which sedate the patients or for the anti-inflammatory purposes
We used an hourly synchronized method to align different medical events. To investigate their statistical relationship, we used imputation methods including last observation carried forward for 24 hours, and mean value imputation. Next, we used three different machine learning models to investigate the relationships

Diagram 1.Workflow of this Study.




## Results

Without the prior knowledge of the quantitative relationship between weaning binary result and variables selected, we decided to use 2 explorative algorithms whose meanings are easier to interpret. At last, we also tried a complex model whose accuracy is usually higher, but it is generally hard to interpret its meaning.

We constructed statistical models that predict well for unsuccessful weaning from mechanical ventilation. The logistic regression model, decision tree model and random forest model achieved negative predictive values of 81.22%, 79.69% and 80.82% respectively. We also found significant parameters which are: ventilatory parameters: **Mean Airway pressure, ventilatory ratio, minute ventilation, Respiratory rate and PF ratio**, blood test parameters: **SpO2, PaCO2** and demographic parameter, **age**

We also noticed that a weaning could still be unsuccessful even though other parameters meet the criteria in protocols (2) These cases can be summarized as follow:
(1) For patients whose 36 Kpa> PF ratio >= 29 Kpa, but Mean Airway Pressure >= 9.4 cmH2O, ventilatory ratio >= 0.75, age < 56, SpO2 >=95%
(2) For patients whose PF ratio >= 36 Kpa, but ventilatory ratio >= 1.4, age < 65, Mean Airway Pressure >= 9.4 cmH2O
(3) For patients whose minute ventilation < 8.3, but if Mean Airway Pressure < 9.4 cmH2O

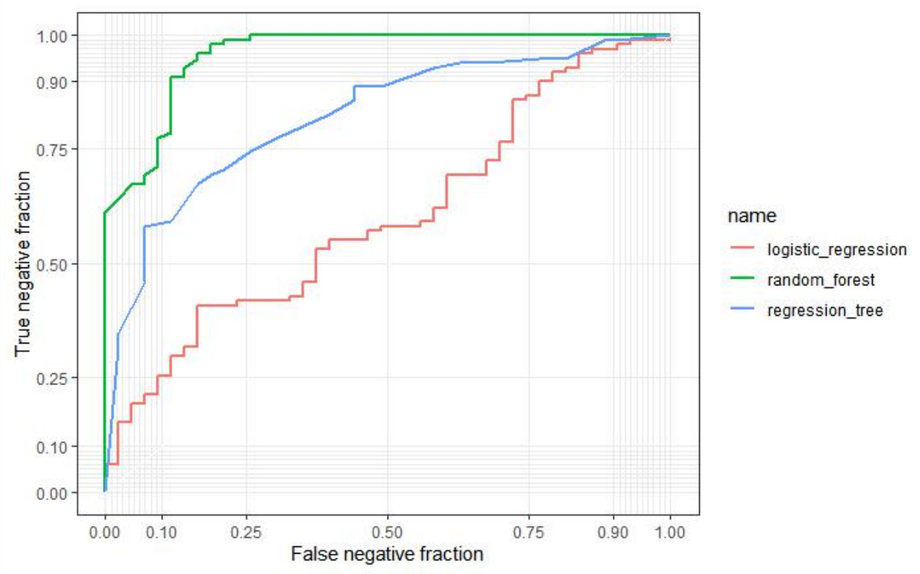



Figure 1 ROC for three machine learning models.

## Discussion

In this study, we synchronized the original medical data and align them on an hourly basis timeline. We used clinical definition to label the ventilatory weaning outcomes and train two simple machine learning model on it. Because of the missing values of the dataset, we used two steps (lastobservation carried forward for 24 hours, mean value imputation) imputations to generate a trainable data set for machine learning algorithms. Models not only performed well in predicting negative results on imputed data but also achieved a satisfying outcome on data without imputation. Among the variables that constitute these models, we found ventilatory parameters: Mean Airway pressure, ventilatory ratio, minute ventilation, Respiratory rate and PF ratio, blood test parameters: SpO2, PaCO2 and demographic parameter age are more significant than the average levels in machine learning models. We believe their biomedical mechanisms and interaction with ARDS recovery worth to further investigate

## Conclusions

In conclusion, we construct three machine learning models that can help to predict unsuccessful mechanical ventilatory weaning therefore hypothesis is tested to be true. We selected parameters from three machine learning models and use them to train a significant decision tree model. This decision tree model indicated some important variables which predict unsuccessful mechanical ventilatory weaning. This study is the first of its kind to my knowledge to identify mean airway pressure, ventilatory ratio, SpO2, PaCO2 and age are relevant variables on weaning strategies

## References

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