ECMO PAL V-V: DEEP NEURAL NETWORK FOR VENOVENOUS ECMO PROGNOSTICATION

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Background

Venovenous extracorporeal membrane oxygenation (V-V ECMO) is a lifesaving therapy for critical lung failure. ECMO is a highly complex and expensive procedure and is fraught with complications and potential adverse events. Patient selection and prognostication is essential to ensure good treatment outcomes and effective allocation of hospital resources. Previously, V-V ECMO prognostication scores have been developed, including RESP, PRESERVE, and PREDICT-VV [1]–[3]. Previously published scores have been based on traditional statistical methods, which may not accurately model the complex variable interactions present during ECMO therapy [4]. Artificial intelligence (AI) can model complex non-linear interactions between multiple patient variables and has been used successfully over a range of medical prognostication applications. The aim of this research was to investigate an AI model for V-V ECMO outcomes prediction based on a large international dataset.

Methods

The Extracorporeal Life Support Organization (ELSO) registry was used for training and initial validation of the model. 15,602 adult V-V ECMO patients from 590 ECMO centres were used for model training and testing. Initially, 116 pre-ECMO variables were analyzed. *Random Forest permutation importance* was used to identify variables with modest prognostic power (> 0.001). Deep neural networks were explored using hyperparameter optimization via *Tree-Structured Parzen estimation*. Initial internal validation was performed using five-fold cross-validation. Metrics of interest were sensitivity, positive predictive power (precision), and area under the receiver operating characteristic (AUC). The variable of interest was survival to hospital discharge.

Results

A deep neural network (ECMO Predictive Algorithm - ECMO PAL V-V) was developed. Five-fold validation demonstrated a sensitivity and precision to hospital survival of 80 ± 1 % and 70 ± 1%, respectively. AUC was found to be 0.73 ± 0.01. The five most predictive variables were age, COVID status, lactate, how long the patient was intubated prior to ECMO, and pH (Table 1).

Variable Name	Predictive Power	Survival Influence
Age	0.05	Negative
COVID	0.04	Negative
Lactate	0.02	Negative
Time Intubate	0.02	Negative
pH	0.02	Positive

Table 1: Top predictive variables for V-V ECMO survival outcome. The influence on survival to hospital discharge with variable increases is either positive (improves survival) or negative (reduces survival).

Conclusion

This research aimed to investigate an AI tool for VV-ECMO outcomes prediction. Our tool (ECMO PAL) demonstrated good sensitivity and precision in predicting hospital survival over internal five-fold validation. Interestingly, the model reliably predicted ECMO survival but had more difficulty predicting mortality. This finding contrasts our previously developed AI venoarterial ECMO prediction model [4]. ECMO PAL development is ongoing, with further optimizations and external validation underway. ECMO PAL V-V will eventually be incorporated into our existing ECMO PAL framework and hosted as a free online web app (ecmo-pal.icu).

References

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