Exposure to non-lung protective mechanical ventilation is associated with outcome in critically ill patients with acute brain injury: a machine learning approach

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Introduction

Lung protective mechanical ventilation been associated with reduced mortality in patients with respiratory failure. However the impact of this strategy in neurological patients is unknown[1,2]. We hypothesize that respiratory features, particularly mechanical ventilation settings, pulmonary physiological variables and arterial blood gases are important determinants that contribute to clinical and neurological outcomes in this population.

Objectives/Aims

Our aim is to explore the impact of specific mechanical ventilation variables in patients admitted to the ICU for acute brain injury. Using machine learning models, we will test the hypothesis that use of non-lung protective mechanical ventilation settings would have an adverse influence on clinical outcomes

Methods

A large multicenter clinical ICU database* was searched for patients with traumatic brain injury (TBI) or stroke who were mechanically ventilated (n=839 and 1222 respectively) (Figures 1 and 2). A set of features was crafted based on current recommendations for lung protective ventilation and included time "out-of-range" (OOR) for tidal volume per ideal body weight (>8 ml/kg), plateau pressure (>30 cmH2O), PEEP (<5 cmH2O). Three models were created: (1) A clinical model; and (2) A combined model which includes predefined OOR MV and clinical variables; and (3) A forward selection model integrating the most significant features determining outcome. Outcomes were defined as "Unfavorable" for patients who died or whose discharge motor Glasgow Coma Score (mGCS) was < 5, and "Favorable" for patients who were alive and had a mGCS ≥5 at discharge. Three different machine learning classifiers (generalized linear model, XGBoost, and random forest) were trained using extracted features.

Results

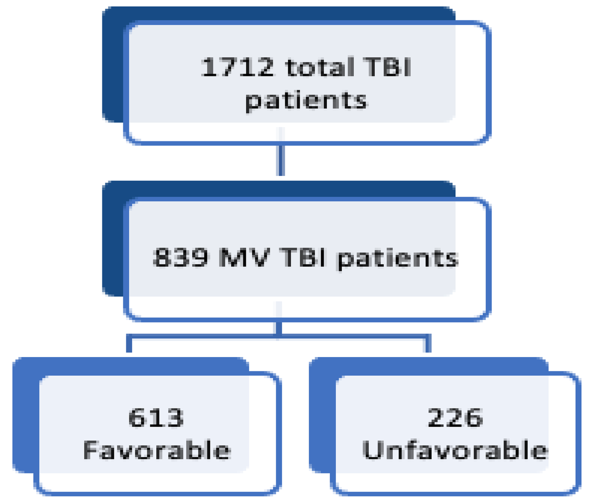

Fig 1. *Classification and criteria for inclusion of TBI patients undergoing MV.*

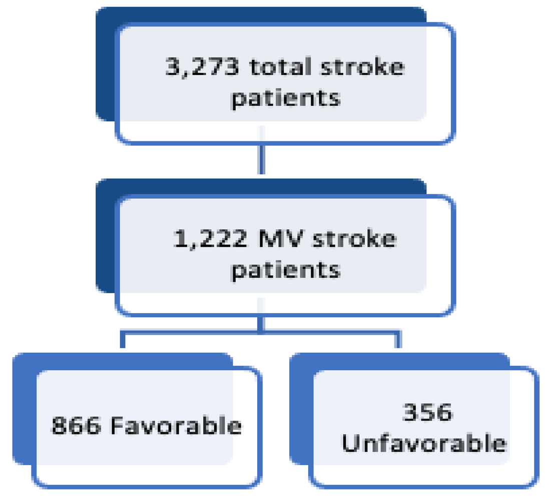

Fig 2. *Classification and criteria for inclusion of stroke patients undergoing MV.*

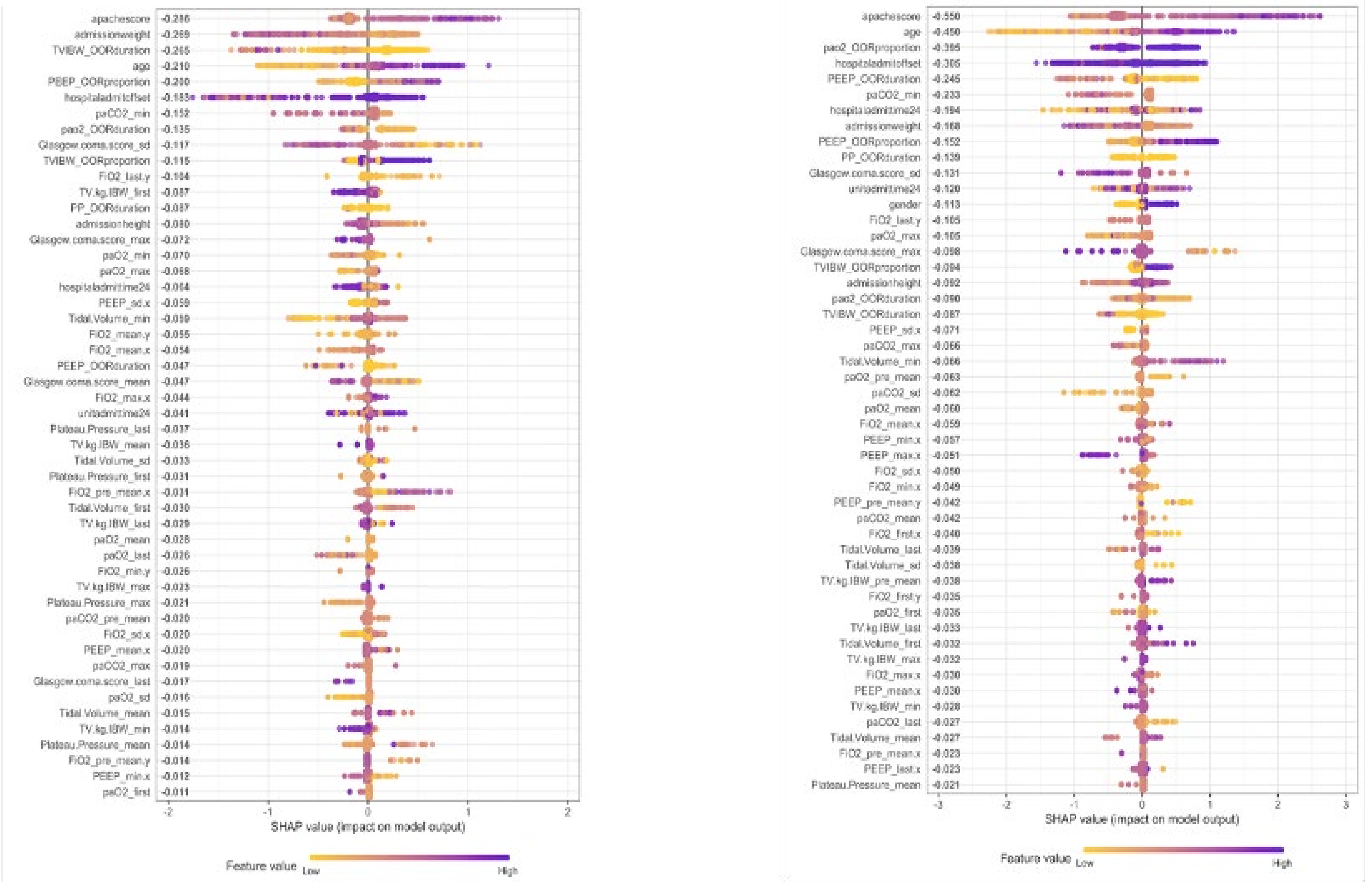

Fig 3. *Ranking of top 50 features for TBI combined model (left) and stroke combined model (right). Negative SHAP value association with favorable outcomes and positive SHAP associated with unfavorable outcomes. A number of OOR MV variables and respiratory physiologic variables contributed to the prediction of outcome. Duration of exposure to OOR tidal volume, PEEP and plateau pressure were identified as top contributors with longer OOR durations predictive of unfavorable outcome.*

Results (cont.)

Model	AUROC	Sensitivity	Specificity
Clinical	0.72 ± 0.13	0.55 ± 0.09	0.75 ± 0.12
Combined	0.81 ± 0.07	0.70 ± 0.17	0.80 ± 0.14
Forward Selection	0.77 ± 0.04	0.65 ± 0.08	0.77 ± 0.02

Table 1. *Summary of mean performance and standard deviation of clinical, combined, and forward selection TBI models from the best performing classifier, the random forest model.*

Model	AUROC	Sensitivity	Specificity
Clinical	0.73 ± 0.10	0.55 ± 0.06	0.75 ± 0.14
Combined	0.79 ± 0.13	0.72 ± 0.33	0.73 ± 0.24
Forward Selection	0.79 ± 0.04	0.64 ± 0.14	0.77 ± 0.05

Table 2. *Summary of mean performance and standard deviation of clinical, combined, and forward selection stroke models from the best performing classifier, the random forest model.*

When compared to the clinical model, the model integrating respiratory with clinical features had higher discrimination, sensitivity and specificity for outcome prediction (Tables 1 and 2). Respiratory predictors, in particular OOR MV variables, were ranked among the leading predictors of outcome in both TBI and stroke populations (Figure 3).

Conclusions

Results indicate that respiratory features are linked to outcome in patients with acute brain injury. Exposure to exposure to non-lung protective MV may impact clinical and neurological outcomes in mechanically ventilated stroke and TBI patients. Ongoing research will include external validation and expansion of the feature space to further investigate the relationship between MV and brain injury outcome.

References

*Data Source: eICU collaborative research database

[1]Piran, P., & Stevens, R. D. (2021). Current Opinion in Critical Care, 27(2), 115–119.

[2] Robba, C., Poole, D., McNett, M., Asehnoune, K., Bösel, J., Bruder, N., … Stevens, R. D. (2020). Intensive Care Medicine, 46(12), 2397–2410.