Fresh frozen plasma transfusion is a potential predictor of mortality in patients undergoing extracorporeal membrane oxygenation

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Research Article

Keywords: Extracorporeal Membrane Oxygenation, transfusion requirement, fresh frozen plasma, mortality, risk factors, activated partial thromboplastin time, uric acid, platelet counts

Posted Date: February 23rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1317550/v1

Abstract

Background The patients of extracorporeal membrane oxygenation (ECMO) supported were usually developed bleeding complications and required substantial transfusions, but the risks and predictors of transfusion requirements during ECMO support remain uncertain. This study aims to interpret the risk factors of ECMO patients' in-hospital mortality and investigate the predictors of blood transfusion in ECMO patients.

Methods 113 ECMO patients' clinical parameters were collected in the cohorts. The logistic regression and least absolute shrinkage and selection operator (LASSO) binomial regression analysis were employed to identify the risk factors of ECMO patients' in-hospital mortality. Machine learning approaches were performed to confirm the variable importance. The backward stepwise multiple linear regression analyses were used to examine the predictive values of candidate importance variables.

Results Eleven variables including age, coronary heart disease (CHD), multiple organ failure, bleeding complications, anemia, fresh frozen plasma (FFP) transfusion, platelet (PLT) transfusion, direct bilirubin (DBIL), lactate dehydrogenase (LDH), activated partial thromboplastin time (APTT), and ECMO duration were identified could as independent predictors for patients' mortality. Age, FFP transfusion and ECMO duration were the top three important indexes among eleven variables in the selection of feature importance, and with the risk contribution values were 1.03 (95% CI, 1.01-1.06; p = 0.014), 1.07 (95% CI, 1.01-1.14; p = 0.026) and 1.05 (95% CI, 1.00-1.09; p = 0.043), respectively. FFP transfusion over 2.5 mL/kg/d, age over 48 years old more likely dead in ECMO patients. Furthermore, APTT (R=0. 32, p<0.001), PLT counts (R=-0.40, p<0.001) and uric acid (UA) (R=0.39, p<0.001) were associated with the FFP transfusion, which could as an independent factor for predicting FFP transfusion, with the estimate values were 0.06 (95% CI, 0.02-0.11; p = 0.009), -0.03 (95% CI, -0.05–0.01; p = 0.007) and 0.01 (95% CI, 0.00-0.02; p = 0.003), respectively.

Conclusion FFP transfusion was markedly associated with in-hospital mortality among patients receiving ECMO, and APTT, PLT counts and UA were the influence factors for FFP transfusion. It is suggesting that better monitoring of the above three indicators may reduce utilization of FFP, thus improving ECMO patients' outcomes.

Introduction

Extracorporeal membrane oxygenation (ECMO) is a form of life support used as an advanced medical therapy for patients with severe cardiac or pulmonary failure. Since Hill *et al* (1) first successfully treated adults with respiratory distress syndrome using ECMO in 1972, ECMO use has progressed remarkably in recent years. According to the data from the Extracorporeal Life Support Organization, there have been 492 ECMO centers with 16605 cases internationally in 2021(2), coupled with remarkable growth in the number of hospitals offering ECMO, especially for adult patients(3).

ECMO is known to be associated with high transfusion requirements due to common complications including hemorrhage and impaired coagulation related to platelet (PLT) dysfunction and consumptive coagulopathy(4, 5). ECMO patients with lower hemoglobin (Hb) require more daily red blood cells (RBC) and

fresh frozen plasma (FFP)(6). Antiplatelet agents, larger Hb decline and longer ECMO duration increase daily PLT requirements (6). However, ECMO patients have a greater transfusion burden, which mortality is greater in the case of extreme transfusion requirements(7). The requiring of a high volume of RBC was reported to increase the risk of morbidity and mortality in ECMO patients (8–13). In contrast, little is known about whether transfusions of FFP are associated with mortality and morbidity among patients receiving ECMO.

The underlying disease before ECMO implantation or complications after ECMO implantation has been reported to aggravate bleeding complications and was associated with total transfusion requirements(6, 14). Patients with sepsis were associated with total transfusion requirements. Hypertension increases daily FFP requirements(6). Patients supported with ECMO developed Acquired Von Willebrand syndrome (AVWS) required transfusions of blood, FFP and/or platelet concentrates(14). Hence, making early identification of these factors and providing appropriate treatment may reduce the incidence of life-threatening bleeding and mortality in ECMO patients.

The objective of this study was to investigate the presence of factors that would help to predict the clinical outcome and assess the risk factors of blood transfusion in ECMO patients.

Materials And Methods

2.1 Patient and data collection

Clinical and laboratory data were collected from 174 patients who received ECMO support between January 2014 and June 2020 at West China Hospital of Sichuan University in this retrospective cohort study.

The clinical information included age, sex, body mass index (BMI), ECMO duration (d), ECMO model, hospital stay(d), coronary heart disease, severe pneumonia, valvular heart disease, high blood pressure, diabetes, multiple organ failure, bleeding complications, venous thrombosis, electrolyte disturbance, respiratory failure, hypoproteinemia, renal insufficiency and anemia.

The laboratory index included red blood cells (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cells (WBC), lymphocyte (Lymph), monocyte (Mono), platelets (PLT), prothrombin time (PT), international normalized ratio (INR), activated partial thromboplastin time (APTT), fibrinogen (FIB), thrombin time (TT), total protein (TP), albumin (ALB), total bilirubin (TBIL), direct bilirubin (DBIL), aspartate transaminase (AST), alanine transaminase(ALT), lactate dehydrogenase (LDH), UREA, creatinine (CREA), uric acid (UA) and glucose (GLU) were collected during ECMO time. Moreover, the utilization of RBC, FFP, PLT, and cryoprecipitate (CRYO) transfusion were recorded at the same time.

The study was approved by the Regional Ethics Committee of West China Hospital of Sichuan University, and conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all individual participants before data collection.

2.2 Statistical Analysis

The patient's characteristics were described as number (%) for categorical variables and median (interquartile range [IQR]) or mean ± standard deviation (SD) for continuous variables, respectively. Categorical variables were compared using the Chi-square test or Fisher's exact test when appropriate. Continuous variables following normal distribution were compared by using t-test between two groups, while the Mann-Whitney test or Kruskal-Wallis test were performed for variables that did not follow a normal distribution. Multiple tests were adjusted by using the Bonferroni method.

The least absolute shrinkage and selection operator (LASSO) binomial regression was applied to identify the most nonredundant and robust variables associated with mortality based on the parameter lambda (λ). The optimal value of λ was defined by tenfold cross-validation with minimum partial likelihood deviance in the data cohort. The clinical and laboratory indicators from all patients were significant in the LASSO regression was used to build and evaluate the variable importance in different machine learning models. The backward stepwise multiple linear regression analyses were used to examine the influence of candidate importance variables. Linear correlations were tested using Pearson's or Spearman's rank method. All statistical analyses were performed using R software (version 4.0.5) and a p-value (two-sided) of < 0.05 was statistically significant.

Results

Patient characteristics

Clinical features, collected from 174 patients before and during ECMO treatment were analyzed to identify potential biomarkers for the outcome. Among these 174 patients, 61were excluded (12 were < 18 years old, 12 received ECMO < 1 day, 23 without baseline height or weight data, 14 with insufficient clinical information). In the end, 113 patients were included in the final analysis.

The patient's characteristics are shown in Table 1 and Supplementary Table S1. Among these patients, we found that a total of 36 patients (31.9%) died during the hospital stay. The patients' characteristics include age, hospital stay, multiple organ failure, and bleeding complications were significant differences in the surviving group from the dead group (all $p < 0.05$). However, there were no significant differences between the two groups in other variables.

Table 1
Population characteristics

	ALL	dead	alive	p-value
	N = 113	N = 36	N = 77	
age	46 [32;55]	51 [41;60]	44 [30;54]	**0.025**
sex				0.073
man	73 (64.6%)	28 (77.8%)	45 (58.4%)	
feman	40 (35.4%)	8 (22.2%)	32 (41.6%)	
BMI	23.1 [21.3;26.0]	23.4 [21.8;26.2]	23.0 [20.8;25.6]	0.430
ECMO duration (d)	7.00 [4.00;13.0]	9.50 [3.00;17.0]	7.00 [4.00;12.0]	0.387
ECMO model				0.876
V-A	53 (46.9%)	16 (44.4%)	37 (48.1%)	
V-V	60 (53.1%)	20 (55.6%)	40 (51.9%)	
hospital stay(d)	23.0 [13.0;39.0]	16.0 [6.75;25.2]	28.0 [16.0;42.0]	**0.003**
Coronary heart disease				0.072
no	103 (91.2%)	30 (83.3%)	73 (94.8%)	
yes	10 (8.85%)	6 (16.7%)	4 (5.19%)	
Multiple organ failure				**0.049**
no	84 (74.3%)	22 (61.1%)	62 (80.5%)	
yes	29 (25.7%)	14 (38.9%)	15 (19.5%)	
Bleeding complications				**0.006**
no	75 (66.4%)	17 (47.2%)	58 (75.3%)	
yes	38 (33.6%)	19 (52.8%)	19 (24.7%)	

Values are median (interquartile range) or n (%). Abbreviations BMI: Body mass index (kg/m²) ; ECMO : extracorporeal membrane oxygenation ; VV:veno-venous; VA:veno-arterial.

Laboratory parameters

The laboratory parameters are shown in Table 2 and Supplementary Table S2. Comparison of biological parameters of patients receiving ECMO treatment between the two groups, we found that the TBIL, DBIL, and PT in the dead group was much higher than in the surviving group (all $p < 0.05$). However, the PLT counts were significantly decreased in the dead group when compared to the survival group ($p = 0.003$). However, there was no remarked difference between the two groups in RBC, HB, WBC, APTT, FIB, TT, and so on.

Table 2
Laboratory parameters during ECMO treatment.

	ALL	dead	alive	p-value
	N = 113	N = 36	N = 77	
Red blood cell 10^{12}/L	3.08 [2.89;3.48]	3.09 [2.89;3.48]	3.08 [2.89;3.46]	0.841
Hemoglobin g/L	92.3 [85.9;101]	91.2 [85.8;102]	92.4 [85.9;101]	0.808
White blood cell 10^9/L	12.9 (5.17)	13.1 (6.00)	12.8 (4.78)	0.824
Platelet counts 10^9/L	86.8 [65.5;126]	74.6 [53.8;96.3]	91.6 [69.7;128]	**0.003**
Total bilirubin umol/L	31.1 [20.3;66.8]	50.2 [27.0;97.3]	25.9 [17.7;55.2]	**0.006**
Direct bilirubin umol/L	18.7 [10.1;52.6]	26.5 [14.8;68.7]	16.4 [8.80;39.9]	**0.012**
Prothrombin time (s)	15.8 [14.0;19.0]	16.6 [14.9;19.9]	15.5 [13.6;18.5]	**0.043**
INR	1.42 [1.25;1.72]	1.46 [1.33;1.81]	1.41 [1.18;1.70]	0.075
APTT (s)	54.5 [46.3;65.8]	57.0 [49.2;74.4]	54.2 [45.2;64.8]	0.079
Fibrinogen g/L	2.51 [1.92;3.78]	2.47 [1.92;3.80]	2.51 [1.94;3.77]	0.988
Thrombin time (s)	30.2 [20.5;53.6]	28.7 [21.9;45.4]	33.4 [20.5;54.0]	0.460
INR: International normalized ratio; APTT: Activated partial thromboplastin time				

Blood product utilization

Blood product utilization of patients receiving ECMO treatment was shown in Table 3. The median FFP (mL/kg/d) transfusion was higher in the dead patients (4.44; IQR = 1.67–8.41) when compared to survival patients (2.15; IQR = 0.75–4.62) (p = 0.012). However, no significant statistical difference was found in the utilization of other blood products including RBC, PLT, and cryoprecipitate between the two groups. The proportion of FFP and PLT transfusion in the dead group was higher than in the survival group. Furthermore, compared with cryoprecipitate and PLT transfusion, the proportion of FFP and RBC transfusion is the highest in all ECMO patients (Fig. 1).

Table 3
Blood product utilization during ECMO

	[ALL]	dead	alive	p.value
	N = 113	N = 36	N = 77	
RBC utilization (mL/kg/d)	4.08 [1.78;6.81]	4.24 [2.03;9.83]	3.85 [1.78;6.24]	0.363
FFP utilization (mL/kg/d)	3.01 [1.06;5.55]	4.44 [1.67;8.41]	2.15 [0.75;4.62]	**0.012**
PLT utilization(U)	1.00 [0.00;3.00]	2.00 [0.00;6.25]	1.00 [0.00;3.00]	0.074
Cryoprecipitate(U)	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.648
Abbreviations RBC = red blood cell, FFP = fresh frozen plasma, PLT = platelet.				

Independent predictors for mortality

Although there are differences in the part of clinical indicators between the survival group and the death group of ECMO patients, it is still unknown which indicators were associated with the risk of death. Here, we analyzed all clinical indicators including patient characteristics, laboratory parameters, and blood transfusion index by univariate logistic regression analysis and found that 13 clinical indicators were significantly correlated with patients' death (supplementary Table S3). Next, we further evaluated these 13 clinical variables by selecting features with coefficients in the LASSO binomial regression model (Fig. 2) and finally identified 11 variables including age, CHD, multiple organ failure, bleeding complications, anemia, FFP transfusion, PLT transfusion, DBIL, LDH, APTT, and ECMO duration could as an independent predictor for patients' death in this model.

Feature importance confirmation

Because 11 certain variables were confirmed significantly correlated with the patients' death, we chose to focus on the variable importance interpretation of these 11 indicators by different Machine Learning algorithms such as Random Forest and XGBoost. We found 6 confirmed importance variables including ECMO duration time, PLT transfusion, age, FFP transfusion, CHD, and bleeding complications in the Random Forest model (Fig. 3). Furthermore, we found that the most important variables in the XGBoost model are consistent with the Random Forest model, with ECMO duration, age, and FFP transfusion being ranked in the top three (Fig. 4).

Shapley values explanation the prediction of mortality

From Random Forest and XGBoost model, we found that ECMO duration time, age, and FFP transfusion contribute more to the model than other variables. However, we do not know how each variable affects the probability of mortality. To overcome this issue, we further employed the Shapley values, one technique from game theory, to provide consistent interpretations on both local and global levels. We also found that ECMO duration, age, and FFP transfusion are the most important for patient mortality (Fig. 5A). Moreover, the positive or negative relationship between each variable and patient mortality prediction in Shapley values.

High leves of age, FFP and ECMO_duration in the mode were assignated positive Shapley values are more likely to predict patients' mortality (Fig. 5B).

In addition, to investigate the interaction between the explanatory variables and the patient's corresponding outcome, we performed the non-linear interaction analysis of age, FFP and ECMO_duration. From the interaction between the FFP value and its patients corresponding Shapley value, we found the proportion of patients' mortality was increasd when FFP over 2.5, and these patients were assigned positive Shapley values (Fig. 6A). we also found the same result that patients are more likely to died when older than 48 years (Fig. 6B). However, we found ECMO duration time over 15 days or lower than 1.5 days more likely dead in ECMO patients (Supplementary Fig. S1).

Next, we divide age, FFP, and ECMO duration time into different categories to understand the interaction between the distribution of characteristics and patient outcome. The results indicated that the patients who spent more time on ECMO treatment and with older ages, and the overdose of FFP transfusion more likely died in the duration of ECMO treatment (Fig. 7).

Determinants of FFP transfusion

Based on the results described in the previous sections, we found FFP transfusion was an important variable on ECMO treatment-related death. So, we further investigate which variables affect the FFP transfusion duration ECMO treatment. Firstly, we analyzed the correlation of laboratory indicators by using Spearman's method, and the result found that 10 variables such as RBC transfusion, PT, INR, APTT, PLT, AST, ALT, CREA, UA, and LDH were correlated with FFP transfusion ($R^2 > 0.3$, $pvalue < 0.5$, Fig. 8). Secondly, we further divided FFP transfusion into high transfusion group and low transfusion group by the optimal threshold of 2.5 mL/kg/d, and investigate the difference between the two groups. The results showed that 13 clinical variables included patients' status, severe pneumonia, anemia, RBC transfusion, PLT count, CREA, UA, AST, LDH, ALT, PT, INR, and APTT were significantly different between the two groups (Supplementary Table S4).

Next, we performed a stepwise multiple linear regression analysis to explore the influencing factors of FFP transfusion. Before analysis, we performed a multicollinearity index elimination by the method of Variance Inflation Factor (VIF) in these 13 variables to reduce the collinear interference between variables. According to the standard of VIF less than 10, we finally selected 8 indicators including severe pneumonia, PLT, CREA, UA, ALT, PT, INR and APTT for further analysis. The associations were identified by building multiple linear regression models with stepwise backward variable selection. The results showed that PLT counts, UA and APTT remained the significant factor for predicting FFP transfusion (Fig. 9), especially PLT and APTT (Supplementary Fig. S2).

Discussion

Extracorporeal membrane oxygenation (ECMO) has been exponentially increasing over the last decade and is now considered a mainstream lifesaving treatment modality in critical care medicine(15). Although ECMO has traditionally been used in end-stage lung disease and circulatory collapse, it is being adopted for use in heart failure, as a bridge to heart and lung transplantation, and as rescue therapy for both sepsis and post-

organ transplantation(15). Complications are frequent during the management of patients on ECMO and the main complications reported are thrombosis, acute mechanical failure, coagulopathy, intracranial hemorrhage, acute kidney injury (AKI) and infections(16). Main laboratory tests such as PT, APTT, PLT, Hb, D-Dimer and PaCO2 were used for the management of patients on ECMO, and the levels of these tests can be measured daily to monitor clot formation and degradation and to predict the development of ECMO failure(16). However, which of these clinical parameters can effectively predict the in-hospital mortality of ECMO patients is still an unclear. So, it is important for us to find out the key parameters, and provides more effective prediction of patient survival, which might convert to clinical application.

It has been described that older age, higher body mass index, coronary artery disease, elevated total bilirubin were promoted for patients receiving ECMO(17, 18). Moreover, myocardial infarction, diabetes, prolonged ECMO support, and pulmonary dysfunction were also reported strongly predicted in-hospital mortality after ECMO weaning(19). In our research, we found high levels of age, coronary heart disease, multiple organ failure, bleeding complications, anemia, DBIL, LDH, APTT, and ECMO duration time are strongly associated with worse in-hospital survival of ECMO treated patients, and these clinical markers could as independent predictors for patient in-hospital mortality, hence it would further support previous findings.

Patients who need ECMO support are critically ill and require substantial blood transfusions(9). However, ECMO often causes hemostatic derangements that can predispose patients to both bleeding and thrombotic complications, which means convey both risks and benefits (9, 20, 21). Studies have demonstrated that blood transfusion is significantly associated with both mortality and thrombotic events(7, 9, 20). It is suggested that blood transfusion is associated with an increased risk of adverse outcomes, and blood should be transfused prudently in ECMO patients (7, 9). We found the proportion of cryoprecipitate, FFP and PLT transfusion in the dead group was higher than in the survival group, and high FFP and PLT transfusion were markedly related to adverse clinical outcomes in ECMO-treated patients with the risk contribution values were 1.070 (95% CI, 1.01–1.14; p = 0.026) and 1.150 (95% CI, 1.01–1.30; p = 0.030), respectively.

Although elevated levels of RBC transfusion and PLT transfusion have been correlated to worse survival(10, 13, 22, 23), there is limited evidence for a potential role of FFP transfusion as a predictor marker for ECMO treatment. This is mainly because FFP was almost always transfused with RBC and PLT, which can confuse any attempt to determine the effect of a single blood product(24). Multiple studies have found that the simultaneous transfusion of FFP and RBC leads to significantly higher mortality and morbidity than RBC transfusion alone(25). Furthermore, patients receiving FFP transfusion have a higher incidence of mortality and infection than those who did not receive FFP transfusion in different diseases (26, 27). Recently, McMichael *et al* (28) demonstrated that there was no difference in FFP transfusion between ECMO treatment and control group. Interestingly, we found age, FFP transfusion, and ECMO duration time were the top three important indexes among all variables in the selection of feature importance. Importantly, FFP transfusion was the most important index which is correlated to mortality of ECMO patients. Increased FFP transfusion was significantly associated with poor clinical outcomes in ECMO patients. To our best knowledge, this is the first study showing FFP transfusion correlated with in-hospital mortality in ECMO-treated patients.

FFP was mainly used to correct coagulopathy in ECMO patients, as well as prophylactically in non-bleeding patients with significant anemia and thrombocytopenia(29). Adult ECMO patients with lower Hb require more daily RBC and FFP, and Hypertension could increase daily FFP requirements(6). Moreover, patients supported with ECMO developed AVWS required transfusions of blood, FFP and/or platelet concentrates(14). The roles of FFP transfusion have been described above as increased levels have been associated with an unfavorable clinical outcome, and high values of FFP more importantly tend to facilitate the prediction of mortality. To our best knowledge, this is the first study showing how patient characteristics contribute positively or negatively to the prediction of in-hospital mortality. Furthermore, we found APTT, UA and PLT counts were significantly associated with FFP transfusion, and the detection of these three indices would help to predict the FFP usage. It is known that ECMO patients usually receiving heparin for anticoagulant therapy, and the APTT is a routine detection indicator for anticoagulant intensity. Higher APTT was independently associated with greater risk of bleeding complications in ECMO patients(30), which increased transfusion requirements(31, 32). Moreover, ECMO patients are often accompanied by acute renal failure and required more daily transfusion(32), and increased CREA levels and secondary impaired platelet function significantly increased transfusion requirement(31). Interestingly, we found that UA markedly related with FFP transfusion, which may another novel predictor of transfusion requirement in ECMO patients. Platelet counts was a bleeding risk factor, which was reported to contribute the increased of FFP transfusion(33). So, Better management of patients' coagulation system and kidney function may reduce utilization of FFP, thus improving ECMO patients’ outcomes.

Conclusions

We have identified that age, FFP transfusion and ECMO duration were the top three important predictive factors for in-hospital mortality among patients receiving ECMO. FFP transfusion over 2.5 mL/kg/d, age over 48 years old and ECMO duration time over 15 days or lower than 1.5 days more likely dead in ECMO patients. Moreover, PLT counts, UA and APTT values were predictors of FFP transfusion in ECMO treatment patients, which indicated that monitoring of these indicators can better reflect the control of coagulation and renal function, thereby improving ECMO patients’ outcomes. However, data from the included studies are still limited, further and more systematic validation with larger cohorts is required.

Declarations

Acknowledgments

We would like to thank the members of the research group who are not listed in the authors.

Authors' contributions

ZL, KZ, LQ and CH designed the study. ZL, XS, YX, and PZ gathered the data. KZ analyzed the data. All the authors read and approved the final manuscript.

Funding

This research was funded by the Science and Technology of Sichuan Province, China (No. 2021JDRC0152), Health Commission of Sichuan Province, China (No.20PJ115).

Competing interests

The authors have no competing of interest in relation to this manuscript.

Availability of Data and Materials

The datasets generated and/or analysed during the current study are not publicly available due the reasons of sensitivity of human data but are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Ethics Approval and Consent to Participate

The study was approved by the Regional Ethics Committee of West China Hospital of Sichuan University, and conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all individual participants before data collection(No. 2022/185).

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Figures

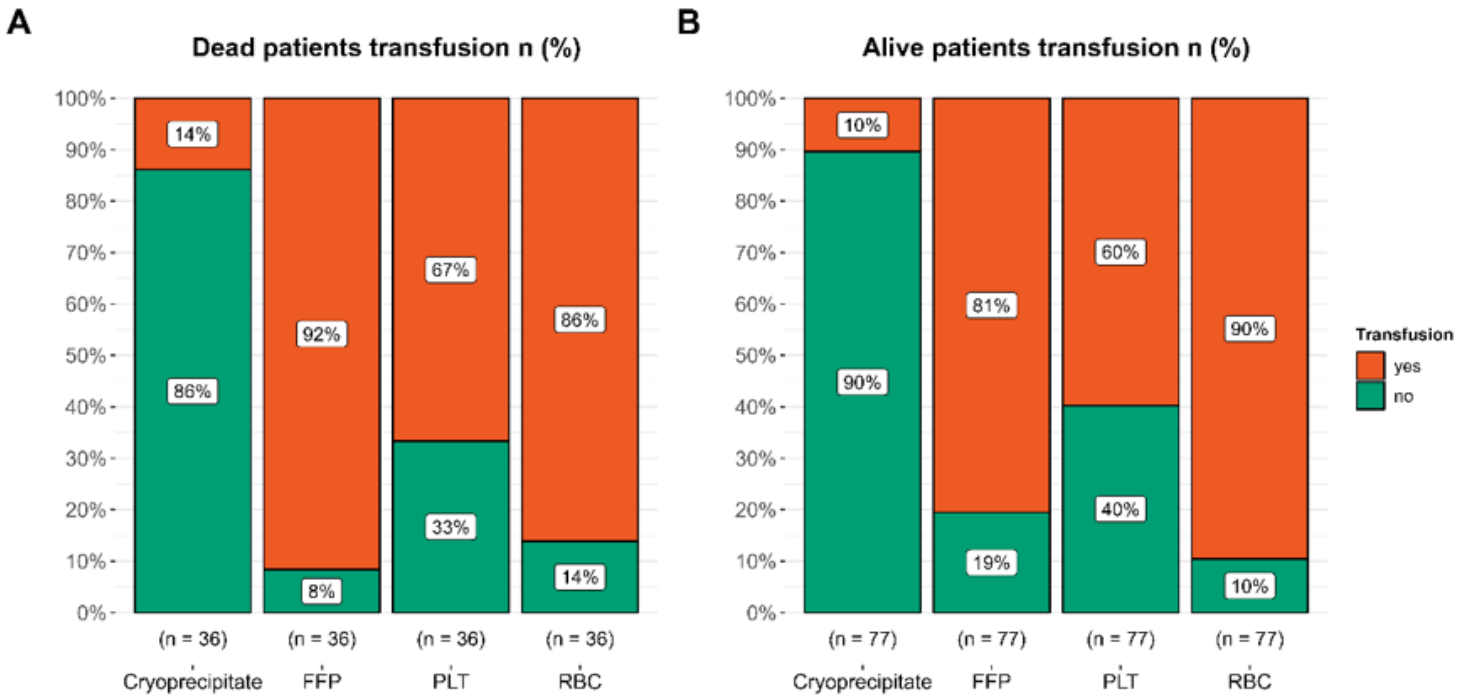

Figure 1

The proportion of blood product transfusion in ECMO patients. (A) The proportion of blood transfusion in dead group of ECMO patients. (B) The proportion of blood transfusion in survival group of ECMO patients.

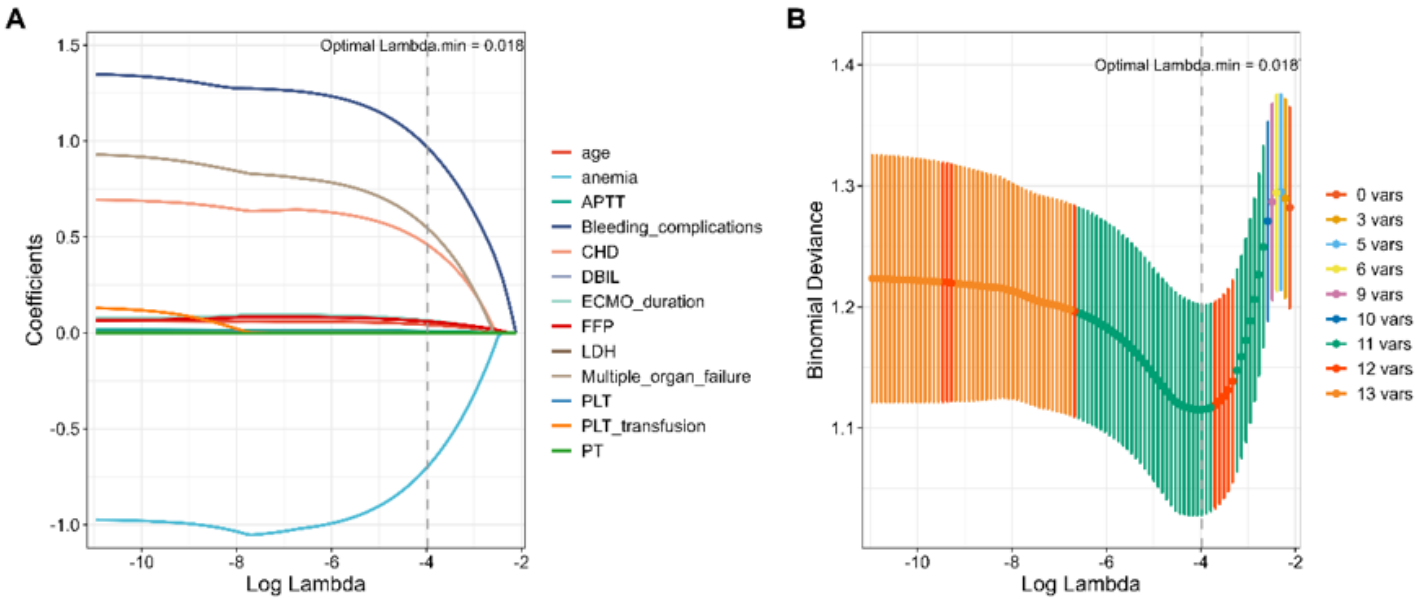

Figure 2

Feature selection for the patient's clinical index by the LASSO binomial regression algorithm. (A) A coefficient profile plot of the LASSO model. (B) Cross validation plot for the feature selection with the optimal lambda value.

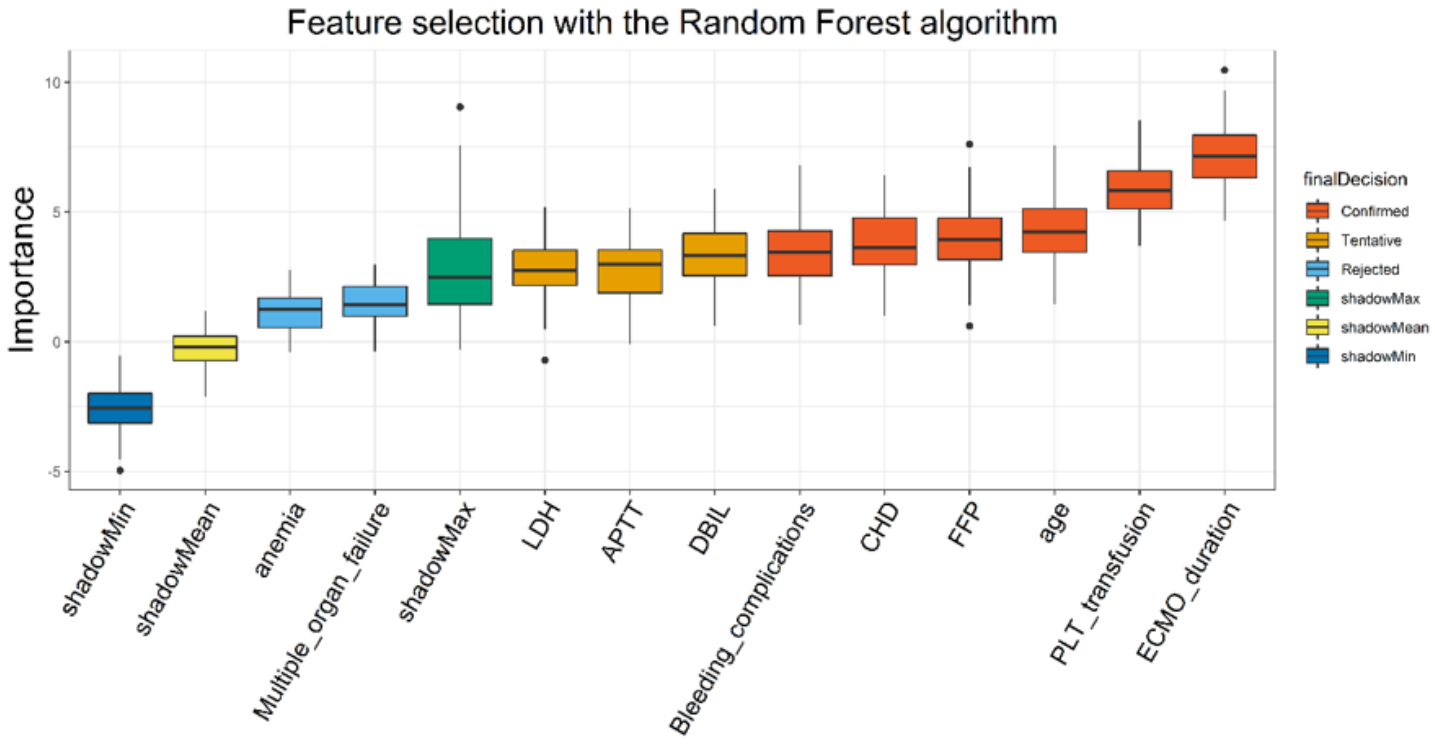

Figure 3

Feature Importance for Random Forest model.

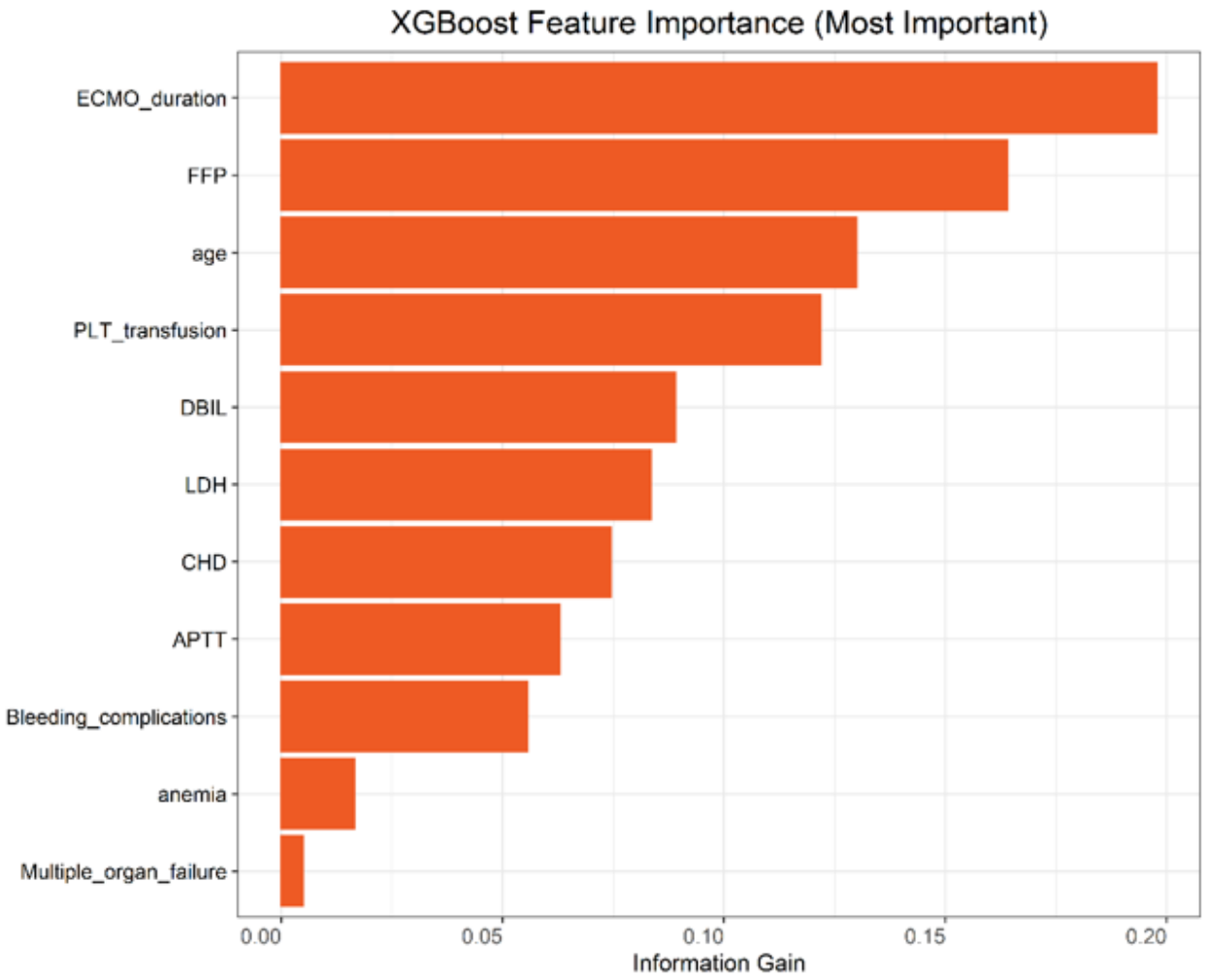

Figure 4

Feature Importance Scores for XGBoost model.

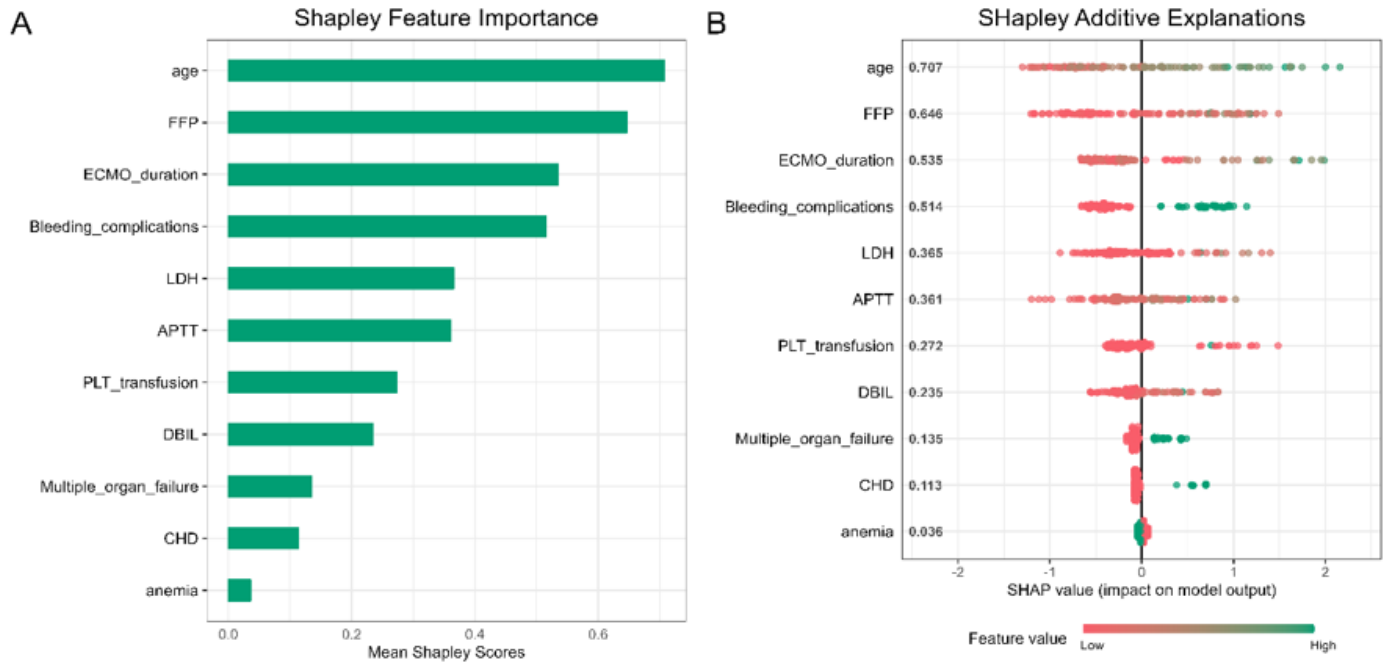

Figure 5

The explanations of feature importance on Shapley values. (A) Average Shapley scores for the important variables in the model. (B) The positive or negative relationship between each variable and patient mortality prediction.

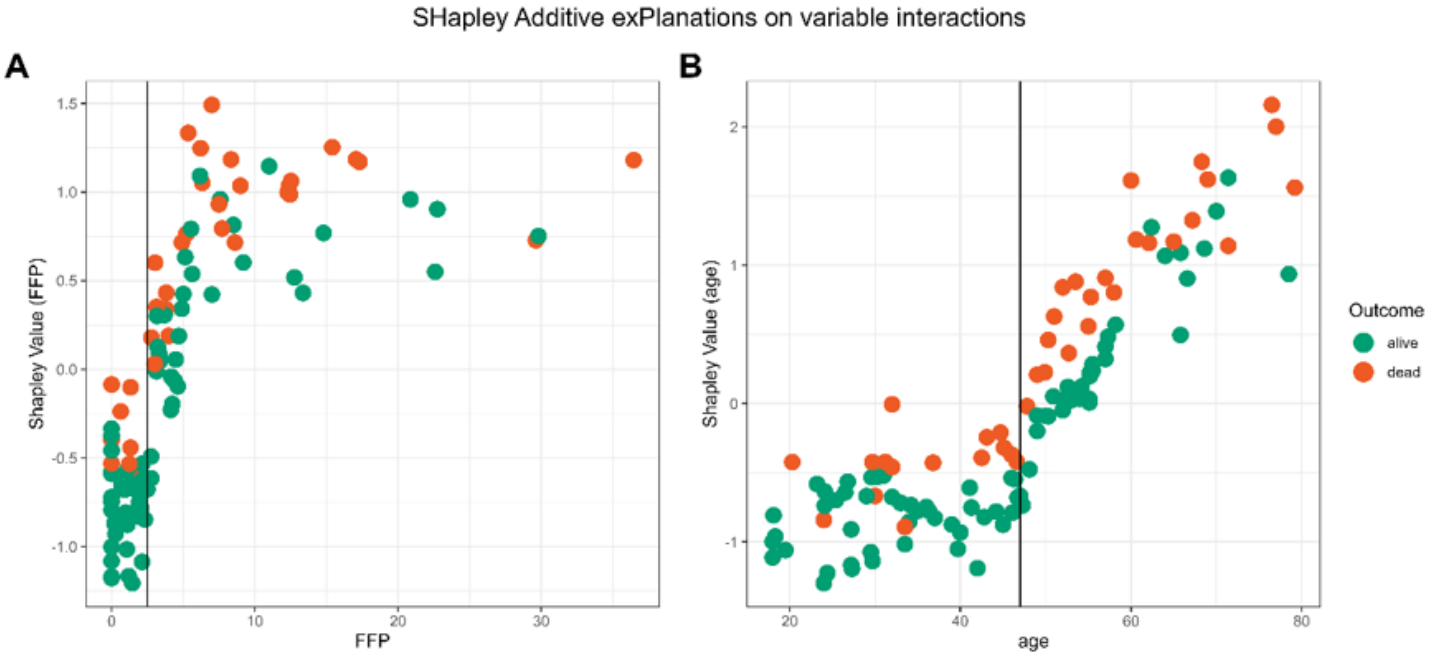

Figure 6

Non-linear variable interaction with Shapley values. (A) The variable interaction of FFP. (B) The variable interaction of age.

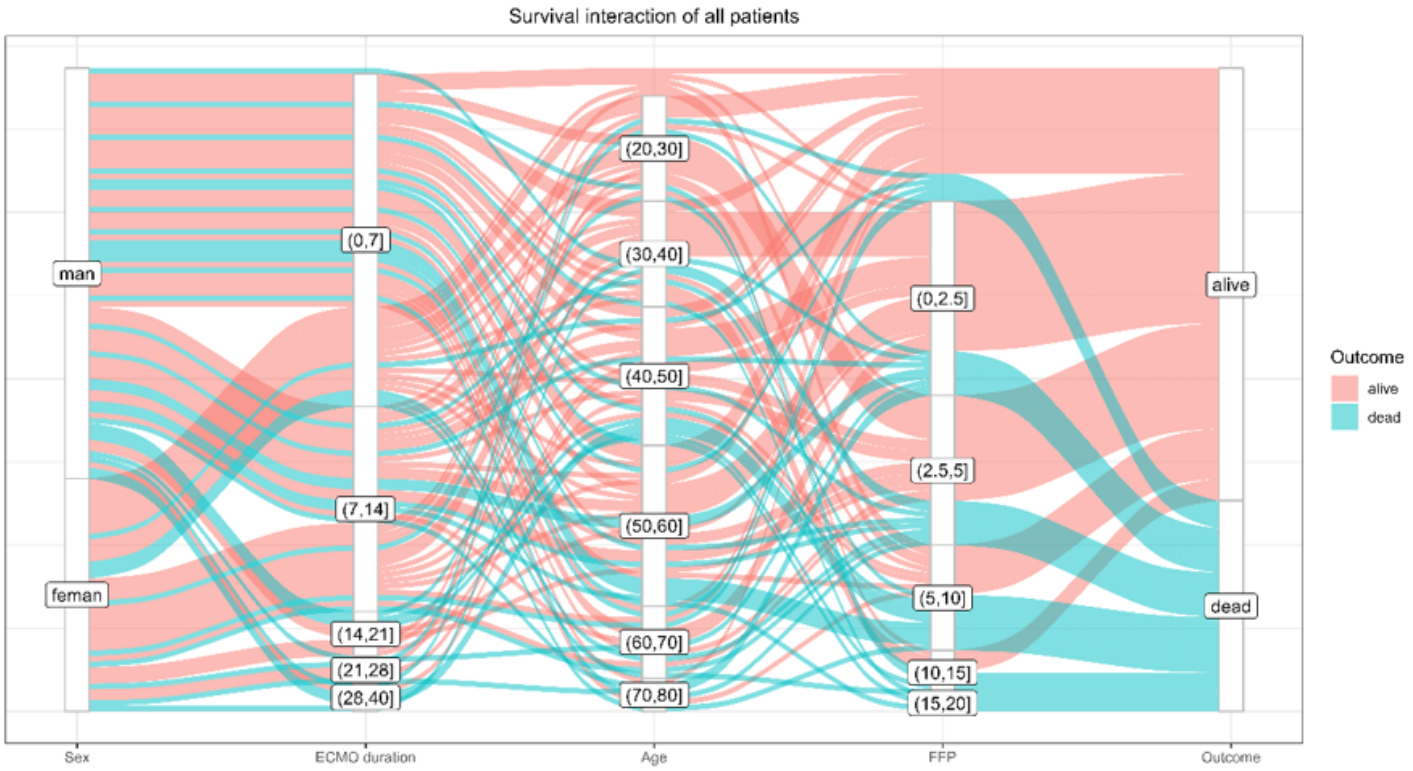

Figure 7

The Sankey plot of interaction between the distribution of patient's characteristics and patient outcome.

Figure 8

The Spearman correlation of the laboratory indicators.

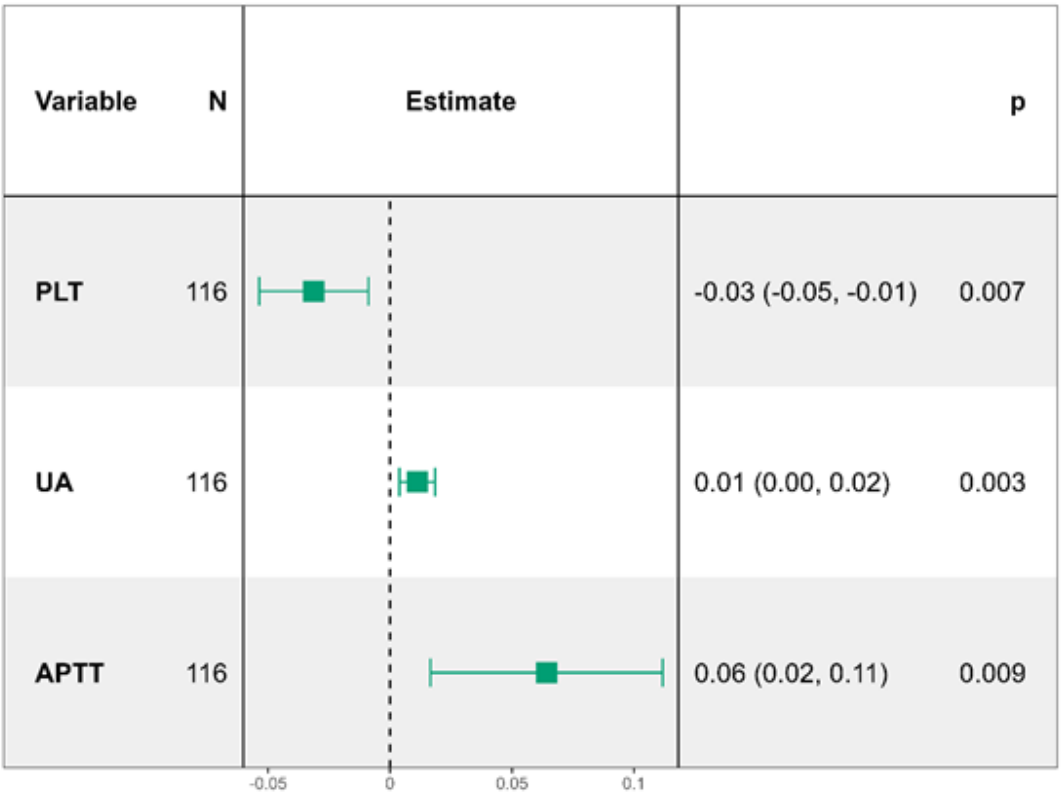

Figure 9

The forest model of FFP transfusion during ECMO treatment.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFigureS1.NonlinearvariableinteractionwithShapleyvaluesofECMOduration.pdf
- SupplementaryFigureS2.TheassociationbetweenFFPtransfusionandclinicalvariables.pdf
- SupplementaryTableS1.Populationcharacteristics.docx
- SupplementaryTableS2.LaboratoryparametersduringECMOtreatment.docx
- SupplementaryTableS3.Univariatelogisticregressionanalysis.docx
- SupplementaryTableS4.TheassociationofcharacteristicsandFFPtransfusionduringECMOtreatment..docx