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RESEARCH ARTICLE

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C-reactive protein to albumin ratio and Glasgow Coma Scale score as the predictors for weaning outcomes in traumatic brain injury

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ABSTRACT

Objective: To identify the prognostic value of C-reactive protein to albumin ratio (CRP/ALB, CAR) and Glasgow Coma Scale (GCS) score in the weaning outcomes of mechanical ventilation (MV) in patients with traumatic brain injury (TBI).

Methods: Medical records of patients with TBI who were hospitalized at The Third Affiliated Hospital of Southern Medical University between January 2018 and September 2023 were collected and analysed. The patients were divided into the weaning success group and the weaning failure group. Data from the two groups were analysed to assess the predictive value of CAR and GCS score on weaning outcomes.

Results: CAR was an independent risk factor for weaning failure (p = .001, adjusted OR = 1.878, 95% CI: 1.283–2.750), while GCS score was a protective factor for weaning success (p = .006, adjusted OR = 0.629, 95% CI: 0.452–0.873). In the receiver operating characteristic (ROC) curve analysis, the area under the curve (AUC) of CAR predicted the weaning failure was 0.780 (p < .001), and predicted the weaning success by GCS score was 0.727 (p = .003). Moreover, the combination of the two predicted better with an AUC of 0.849 (p < .001).

Conclusions: TBI patients with higher CAR and lower GCS score were more likely to experience weaning failure, which can provide reliable guidance for patients with TBI to leave the ventilator.

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1. Introduction

Traumatic brain injury (TBI) is one of the common clinical critical syndromes in neurosurgical diseases caused by head trauma, with high disability and mortality rates [1], and it was estimated that more than 50 million people worldwide suffer from TBI each year [2]. In addition to primary brain tissue injury, a range of secondary injuries occur after trauma, with acute lung injury (ALI) being the most common complication [3]. The incidence of ALI in patients with severe TBI is as high as 30–50% [4]. In the early stages of patients with severe TBI, mechanical ventilation (MV) is usually required to improve ventilation [5,6]. However, prolonged MV status of TBI patients will also cause the development of associated clinical complications, such as ventilator related pneumonia (VAP) [7]; it will also prolong the length of hospital stay. Therefore, timely assessment of the timing of ventilator withdrawal is critical. Currently, in clinical practice, the timing of weaning in mechanically ventilated patients is mainly assessed using the spontaneous breathing trial (SBT), which is the gold standard for weaning recommended

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by current guidelines, but studies have shown that extubation failure rates in TBI patients remain as high as 25% [8]. The weaning process in patients with severe TBI is frequently prolonged and routinely applied extubation criteria are not always applicable [9]. Reduced levels of consciousness, including brainstem injury, neuromuscular dysfunction and abnormal respiratory mechanics secondary to brain injury, all of which may result in inadequate airway protection to clear respiratory secretions [10]. Accordingly, there is still a need to find some new indicators to predict weaning outcomes to better help mechanically ventilated patients with TBI to successfully escape from the ventilator.

The C-reactive protein to albumin ratio (CRP/ALB, CAR) is a novel inflammation-based prognostic score. Increased CAR represents greater inflammation and lower nutrition, which synergistically may be more predictive of prognosis in TBI, and studies showed that the inclusion of CAR into predictors could help to effectively predict the prognosis in adults with moderate to severe TBI [11]. In addition, studies demonstrated that critically ill patients undergoing general anaesthesia surgery requiring MV have significantly higher CAR compared to unintubated patients [12]. What's more, in an observational study, it was concluded that acute ischemic stroke patients with higher CAR levels on admission were more likely to develop stroke-associated pneumonia during hospitalization [13].

Acute neurologic dysfunction may lead to increased risk of respiratory failure due to impaired level of consciousness, breathing and swallowing [6]. In a cohort study, respiratory failure occurred in 17% of patients with brain trauma, and patients with acute neurological diseases used MV for longer periods of time compared with the patients with non-neurological disease [14]. The Glasgow Coma Scale (GCS) score is the score for assessing the severity of patients with TBI, reflecting the impairment of neurological function. Studies showed that the GCS score was an independent predictor for weaning failure, and was associated with increased in-hospital mortality in patients with acute stroke and brain trauma requiring MV [15,16].

CAR and GCS score are inexpensive parameters that can be quickly obtained through auxiliary examination and clinical manifestations. However, there have been no studies on the predictive value of CAR and GCS score for weaning outcomes in patients with TBI or researches on the prognostic value of combining the two. Therefore, the aim of this study is to investigate the predictive effect of CAR and GCS score on patients in order to better assist them in weaning.

2. Subjects and methods

2.1. Subjects

This study duly obtained approval from the ethics committee of The Third Affiliated Hospital of Southern Medical University (No. 2024-ER-001). The research was designed based on the relevant medical records of patients diagnosed with TBI who were hospitalized in The Third Affiliated Hospital of Southern Medical University between January 2018 and September 2023. The use of non-patient privacy medical records was fully explained to the patient or legal representative during the patient's admission informed consent and full written authorization were obtained.

This study was a single-centre, observational, retrospective cohort study. The inclusion criteria for TBI patients in this study encompassed the following: (1) patients were diagnosed with moderate to severe TBI, i.e. below the GCS score of 12; (2) all patients intubated and mechanically ventilated for not less than 48 h; (3) the weaning and screening conditions specified in the Guidelines for Clinical Application of MV were met [17]: resolution of causes of acute respiratory failure; adequate cough reflex; absence of excessive tracheobronchial secretions; resolution of disease acute phase for which the patient was intubated; adequate oxygenation (e.g. arterial oxygen saturation (SaO_2) > 90% or arterial oxygen tension/fraction of inspired oxygen (PO_2/FiO_2) ≥ 150 mmHg, both on the FiO_2 of ≤0.4 and the positive end-expiratory pressure (PEEP) of ≤8 cmH_2O); stable haemodynamics (e.g. heart rate (HR) < 140 beats/min; systolic blood pressure (SBP) 90–160 mmHg; and no or minimal vasopressors use; stable metabolic status); adequate ventilatory status (e.g. respiratory rate (RR) ≤35 breaths/min with tidal volume ≥ 5 mL/kg of predicted body weight and no significant respiratory acidosis); adequate mentation (no sedation or adequate mentation on sedation or stable neurological state); (4) those with complete case data. The exclusion criteria for TBI patients in this study encompassed the following: (1) prior presence of severe neurological diseases including brain tumours, symptomatic cerebral infarction, etc.; (2) combined lung tumours, prior lung resections or the presence of strictly severe lung disease, and other conditions that severely compromise respiratory function; (3) refusal of research authorization.

2.2. Weaning protocol

A 2 h SBT was performed in all patients eligible for withdrawal screening, which allowed the patients to breathe spontaneously through the oropharyngeal tube with the FiO_2 set at the same level used during MV. During the trial, basic vital signs were detected, such as RR, SBP, diastolic pressure (DBP), HR and SaO_2. Arterial blood gases were analysed at the beginning of the SBT.

The criteria for SBT failure were: (1) arterial hydrogen potential of hydrogen (pH) <7.32 with arterial carbon dioxide tension ($PaCO_2$) ≥ 10 mmHg higher than baseline; (2) RR >35 beats/min or ≥50% higher than baseline; (3) SaO_2 < 90% or PO_2 ≤ 60 mmHg at FiO_2 ≥ 0.4; (4) HR > 140 beats/min or ≥20% higher/lower than baseline; (5) SBP > 180 or <90 mmHg, or ≥20% higher/lower than baseline; (6) use of accessory respiratory muscles, or thoracic-abdominal paradoxical movement; decreased consciousness, agitation or diaphoresis. Patients without these characteristics at the end of SBT were considered to have successful SBT and were subsequently extubated [17,18]. The implementation of the above weaning protocols and the determination of weaning failure were the responsibility of experienced attending physicians or above at The Third Affiliated Hospital of Southern Medical University.

2.3. Study group

The primary objective of this study was to predict the weaning outcomes in mechanically ventilated patients with TBI. All patients enrolled in this study at The Third Affiliated Hospital of Southern Medical University, which were categorized into the weaning success group and the weaning failure group according to the weaning outcomes of patients. Standards for the weaning success group included: (1) successful SBT and remove endotracheal extubation; (2) no invasive or non-invasive ventilator support within 48 h after extubation; (3) survival for 48 h after extubation. Criteria for the weaning failure group included: (1) inability to pass SBT; (2) patients require invasive or non-invasive ventilator support within 48 h after extubation; (3) death within 48 h after extubation.

2.4. Data processing and analysis

2.4.1. Data collection

Patients' demographic and baseline characteristics were recorded at enrolment, including age, sex, acute physiology and chronic health evaluation (APACHE) II score at admission, sequential organ failure assessment (SOFA) score at admission, admission GCS, craniocerebral surgery before SBT, use of analgesic drugs in the first 48 h of SBT, antibiotic drug use in the first 48 h of SBT, vital signs (including RR, HR, SBP, DBP and SaO_2) and GCS score in the minute before SBT, arterial blood gases results (including PO_2, PCO_2, pH and oxygenation index (PO_2/FiO_2)) and test indicators (including white blood cell (WBC), percentage of neutrophils (NEUT), leukocyte count, ALB and CRP) in the morning of the day prior to the implementation of the SBT. After extubation, the following were recorded: success or failure of weaning, MV duration before weaning, length of stay in the intensive care unit (ICU), development of VAP.

2.4.2. Statistics

All statistical procedures and data analysis involved in this study were performed by SPSS software (version 26.0 for Windows, IBM Corp., Armonk, NY). For continuous variables, normal distribution was tested by the Shapiro–Wilk (SW) test. Normally distributed data were expressed as mean ± standard (m ± s) deviation and Student's *t*-test was used to compare differences between groups. The median (*M*) and first quartiles (Q25) and third quartiles (Q75) were used to express non-normally distributed data, and the Mann–Whitney *U*-test was used to compare the intergroup differences. Differences in clinical data and other categorical data between the two groups of patients were compared using the Chi-square test (χ^2) or Fisher's exact test and expressed as numbers and percentages. Box plots were drawn to visualize the distribution of CRP, ALB, CAR and pre-SBT GCS score in the two groups. Then, in order to determine the predictors affecting the weaning outcomes, the clinical indicators before weaning (vital signs, arterial blood gases, GCS score and test indicators) (as shown in Table 1) were subjected to univariate analysis, and the independent variables with $p < .05$ were screened out, and then these independent variables were subjected to multivariate logistic regression analysis using conditional forward stepwise regression models to obtain the 95% confidence intervals (CIs) of the adjusted odds ratios (ORs). Finally, we used receiver operating characteristics (ROCs) analysis to assess the sensitivity and specificity of CAR and GCS score, and calculated the area under the curve (AUC) to assess the validity of CRP, ALB, CAR and GCS score. AUC > 0.70 was considered better prediction ability. All analyses were two-tailed, and $p < .05$ was considered statistically significant.

3. Results

A total of 68 patients meeting the inclusion criteria participated in this study. Eight patients were excluded from the study because of only one day of MV. Finally, a total of 60 patients were included in this study. Among them, 28 patients failed to wean (25 patients failed SBT and three were successfully extubated but reintubated), the rate of weaning failure of TBI patients is 46.7%, and 32 patients successfully passed SBT and were taken off the ventilator (Figure 1).

Table 1. Vital signs, arterial blood gases, GCS score and test indicators before SBT in two groups of patients.

Items	Weaning failure (n = 28)	Weaning success (n = 32)	p
Vital signs			
RR	17 ± 5	16 ± 4	.258
HR	88 (80, 96)	86 (79, 98)	.824
SaO_2	100 (99, 100)	100 (99, 100)	.818
SBP	126 ± 17	125 ± 13	.947
DBP	73 ± 12	74 ± 9	.741
Arterial blood gases			
PO_2	121.4 ± 36.1	125.3 ± 45.3	.648
PCO_2	38.7 ± 5.8	39.2 ± 5.8	.995
pH	7.43 (7.40, 7.47)	7.44 (7.40, 7.48)	.833
PO_2/FiO_2	297.0 (254.2, 347.3)	299.0 (247.0, 457.0)	.537
Pre-SBT GCS score	6 (4, 8)	8 (6, 10)	.002
Test indicators			
WBC	12.9 (9.1, 15.6)	9.9 (8.0, 14.6)	.233
NEUT	82.8 (77.8, 85.1)	80.8 (75.7, 86.1)	.614
Leukocyte count, $\times 10^9$/L	1.0 (0.8, 1.2)	1.0 (0.7, 1.4)	.694
CRP	144.7 (89.3, 200.0)	78.7 (39.7, 119.1)	.001
ALB	31.6 ± 5.5	35.0 ± 5.3	.018
CAR	4.39 (2.87, 6.73)	2.27 (1.33, 3.26)	<.001

RR: respiratory rate; HR: heart rate; SaO_2: arterial oxygen saturation; SBP: systolic pressure; DBP: diastolic pressure; PO_2: oxygen partial pressure; PCO_2: carbon dioxide partial pressure; pH: potential of hydrogen; FiO_2: fraction of inspired oxygen; WBC: white blood cell; NEUT: percentage of neutrophils; CRP: C-reactive protein; ALB: albumin; CAR: CRP/ALB.

3.1. Patients' characteristics and weaning outcomes

Compared with patients in the weaning success group, the weaning failure group had a longer MV duration prior to weaning (17 [9–24] vs. 7 [4–12], $p < .001$) and ICU length of stay (29.0 [18.0–39.5] vs. 19.5 [13.5–25.0], $p = .010$). In addition, half of the 60 patients with TBI developed VAP during hospitalization, there were statistical differences in VAP between the two groups ($p < .001$), with the number of cases with VAP in the weaning failure group being significantly higher than that in the weaning success group (21 [75%] vs. 9 [28%], $p < .001$). While other baseline data, including sex, age, admission GCS score, analgesic medication and antibiotic use within 48 h before SBT, craniocerebral surgery, admission APACHE II score, admission SOFA score did not show significant differences between the two groups ($p > .05$) (Table 2).

3.2. Comparison of vital signs, arterial blood gases and test indicators before SBT between the two groups of patients

The commonly used vital signs, arterial blood gases and test indicators of 60 patients from both groups were collected and analysed, and no significant differences were found among these items, such as RR, HR, SaO_2, SBP, DBP, PO_2, PCO_2, pH, PO_2/FiO_2, WBC, NEUT

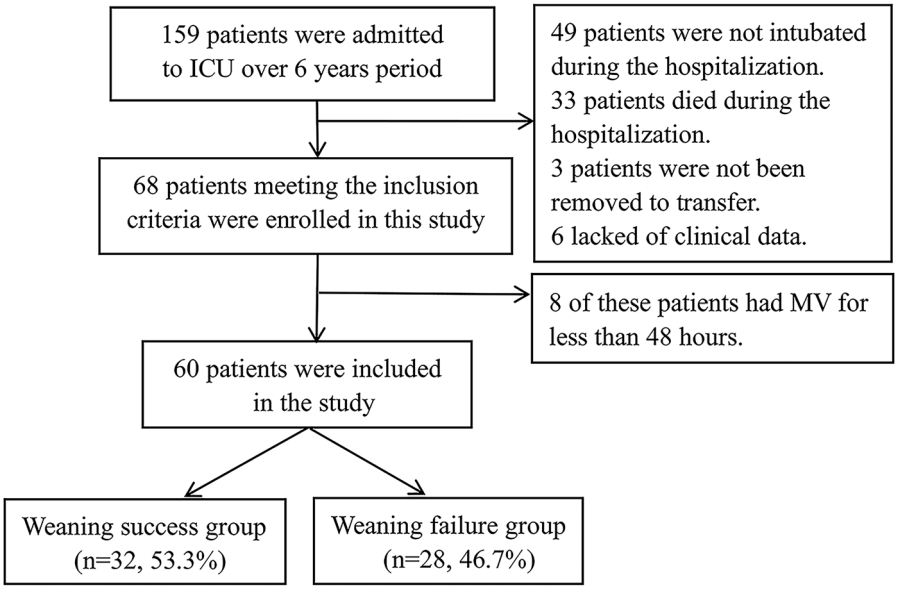

Figure 1. Weaning outcomes flowchart. ICU: intensive care unit; MV: mechanical ventilation.

and leukocyte count, etc. ($p > .05$) (Table 1). However, statistically significant differences in CRP, ALB, CAR and pre-SBT GCS score were found in both groups (Table 1, Figure 2). Therefore, we used the CRP, ALB, pre-SBT GCS score and CAR as predictors of MV weaning outcomes ability in patients with TBI.

Table 2. Comparison of the general clinical data of the two groups.

Items	Weaning failure (n = 28)	Weaning success (n = 32)	p
Male	25 (89.3%)	25 (78.1%)	.312
Age	47.3 ± 19.1	48.2 ± 21.9	.867
Admission GCS score	6 (3, 8)	6 (5, 9)	.164
Pre-SBT analgesic drug use	25 (89.3%)	31 (96.9%)	.331
Pre-SBT antibiotic administration	26 (92.9%)	29 (90.6%)	1.000
Brain craniocerebral surgery	8 (28.6%)	15 (46.9%)	.146
Days of ventilator	17 (9, 24)	7 (4, 12)	<.001
ICU length of stay	29.0 (18.0, 39.5)	19.5 (13.5, 25.0)	.010
VAP	21 (75%)	9 (28%)	<.001
Admission APACHE II score	22.1 ± 5.4	20.7 ± 6.2	.362
Admission SOFA score	7.0 (6.0, 8.0)	6.0 (5.0, 7.8)	.057

GCS: Glasgow Coma Scale; SBT: spontaneous breathing trial; VAP: ventilator associated pneumonia; APACHE: acute physiology and chronic health evaluation; SOFA: sequential organ failure assessment.

3.3. Univariate and multivariate analyses between CRP, ALB, CAR, pre-SBT GCS score and weaning outcomes

The univariate logistic regression analysis allowed to conclude that CRP (p = .003, OR = 1.014, 95% CI: 1.005–1.024), ALB (p = .024, OR = 0.885, 95% CI: 0.796–0.984), CAR (p = .001, OR = 1.735, 95% CI: 1.252–2.404) and the pre-SBT GCS score (p = .004, OR = 0.683, 95% CI: 0.528–0.882) were correlated to the weaning outcomes. Similarly, multivariate logistic regression analysis was used to eliminate the interactions between risk factors. The results suggested that high CAR (p = .001, OR = 1.878, 95% CI: 1.283–2.750) was an independent risk predictor of weaning failure. However, higher pre-SBT GCS score (p = .006, OR = 0.629, 95% CI: 0.452–0.873), was a protective factor in predicting weaning success (Table 3).

3.4. ROC curves analysis of CRP, ALB, CAR and GCS score before SBT between the two groups

Plotting ROC curves and calculating AUC to assess the predictive power of CRP, ALB, CAR and pre-SBT GCS score. The results showed that the AUC of weaning failure predicted by CRP was 0.754 (0.630–0.879) (p =.001), and the AUC of weaning success predicted

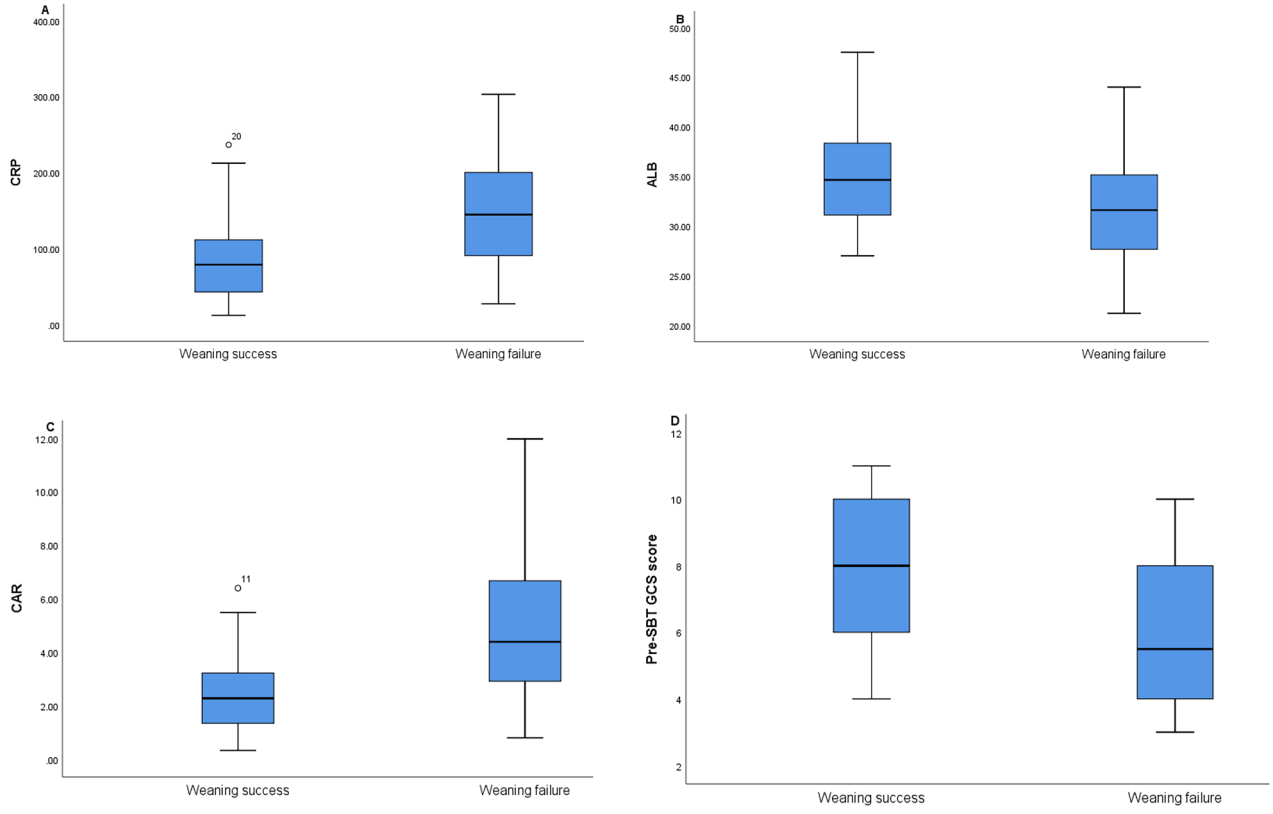

Figure 2. Box plots of CRP, ALB, CAR and pre-SBT GCS score in both groups.

by ALB was 0.672 (0.536–0.809) (p =.022). However, the AUC of weaning failure predicted by CAR was 0.780 (0.662–0.898) (p < .001). It can be seen that this ratio metric, CAR, has a higher predictive value than CRP or ALB alone for weaning in mechanically ventilated patients. Furthermore, CAR had the best predictive efficiency when the threshold was 2.6. The sensitivity and specificity of CAR were 82.1% and 65.6%, respectively, and the accuracy and Youden index of CAR were 70% and 0.477. And the results showed that the AUC of pre-SBT GCS score predicted weaning success was AUC = 0.727 (0.600–0.854) (p = .003). The pre-SBT GCS score had the best predictive efficiency when the threshold was 5.5. The sensitivity and specificity of the pre-SBT GCS score were 81.3% and 50.0%, and the accuracy and Youden's index of the pre-SBT GCS score were 53.3% and 0.313. What's more, the AUC of CAR combined with pre-SBT GCS score predicted weaning failure was 0.849 (0.750–0.949) (p < .001). The joint prediction efficiency of the two is best when the threshold is 0.6. The sensitivity and specificity of the combination were 64.3% and 93.7%, and the accuracy and Youden's index of the combination were 78.3% and 0.580 (Figure 3, Table 4).

Table 3. An univariate-multivariate logistic regression of general information for 60 patients.

	Univariate analysis			Multivariate analysis		
Items	Unadjusted OR	95% CI	p	Adjusted OR	95% CI	p
ALB	0.885	0.796–0.984	.024			
CRP	1.014	1.005–1.024	.003			
Pre-SBT GCS score	0.683	0.528–0.882	.004	0.629	0.452–0.873	.006
CAR	1.735	1.252–2.404	.001	1.878	1.283–2.750	.001

CI: confidence internal; OR: odds ratio.

4. Discussion

The main finding of this research was that CAR and GCS score accurately and reliably predicted the weaning outcomes of MV in patients with TBI, with better diagnostic efficacy of the combination of the two, including a Youden index of 0.580 and a high diagnostic accuracy of 78.3%. However, most of the general clinical data and test indicators included in this study had limited prognostic value for patients' weaning outcomes. In contrast to predictors derived from previous meta-analyses [8], this study was the first to explore the value of these two predictors on the prognosis of MV in patients with TBI.

Acute neurologic dysfunction may lead to increased risk of respiratory failure due to impaired level of consciousness, breathing and swallowing [6]. In a cohort study, respiratory failure occurred in 17% of patients with brain trauma, and patients with acute neurological diseases used MV for longer periods of time

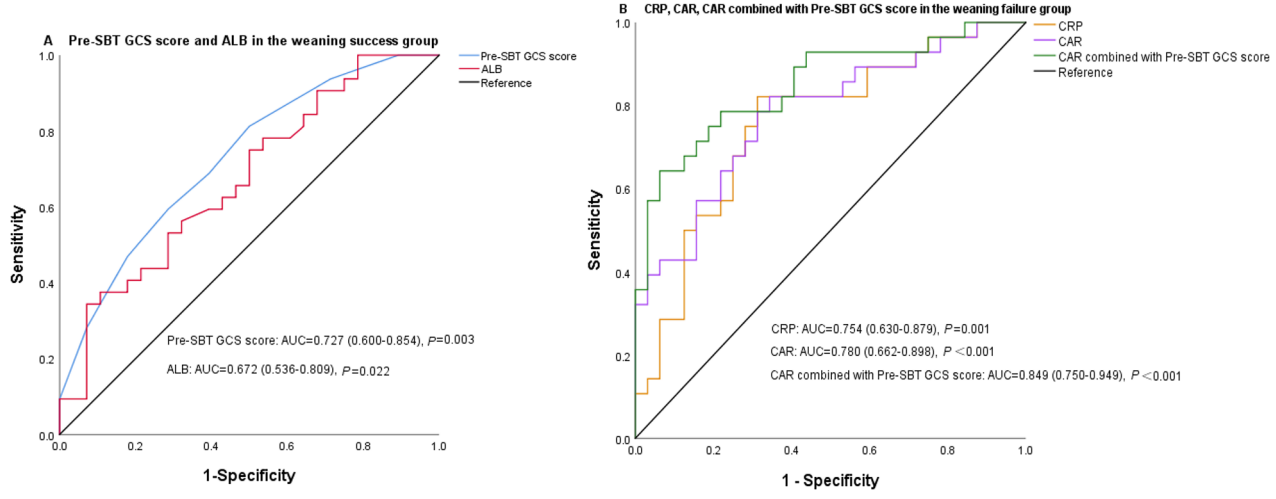

Figure 3. ROC (receiver operating characteristic) curves of the predicted effect of CRP, ALB, CAR, pre-SBT GCS score and their combination on weaning outcomes.

Table 4. ROC curves analysis of CAR, pre-SBT GCS score and their combination.

Items	Youden's index	Cutoff value	Sensitivity	Specificity	Diagnostic accuracy	AUC	95% CI
CAR	0.477	2.6	82.1	65.6	70.0	0.780	0.600–0.854
Pre-SBT GCS score	0.313	5.5	81.3	50.0	53.3	0.727	0.662–0.898
CAR combined GCS	0.580	0.6	64.3	93.7	78.3	0.849	0.750–0.949

compared with the patients with non-neurological disease [14]. In our study, we obtained consistent results showing that ventilator days and ICU stays were significantly longer in the weaning failure group than in the weaning success group.

VAP is one of the most serious complications in patients with TBI and is considered a risk factor for poor outcomes [7]. Patients with TBI typically experience severe suppression of the cellular immune system and impaired consciousness, often requiring endotracheal intubation and ventilator support both of which increase the incidence of VAP [19,20]. VAP is a nosocomial pneumonia that occurs at MV greater than or equal to 48 h. Studies have shown that VAP increases patients' mortality and morbidity [21]. The prevalence of VAP in patients with TBI ranges from 21% and 60% [22–24], with a pooled incidence of 36% [7]. In our study, the incidence of VAP was 50%, in which the weaning failure group had a greater probability of VAP due to prolonged intubation time compared to the weaning success group, with an incidence of 75%, nevertheless, VAP occurred in only 28% of patients in the weaning success group. Therefore, going for more predictive indicators is clinically valuable in reducing the incidence of pulmonary complications.

Extubation failure is still common in critically ill patients (10–15%) [25,26], and is as high as 25% in patients with neurologic illness [8,26]. SBT is currently the primary metric for assessing the timing of extubation, but previous studies showed that neurocritical ill patients present specific challenges when extubating, and due to the nature of their injuries (altered consciousness complicates safe extubation and aspiration prevention), the weaning process in patients with severe TBI is frequently prolonged and routinely applied extubation criteria are not always applicable [9,16,27]. Reduced levels of consciousness, including brainstem injury, neuromuscular dysfunction and abnormal respiratory mechanics secondary to brain injury, all of which may result in inadequate airway protection to clear respiratory secretions [10]. Therefore, it is clinically important to find more new predictors to synergistically help SBT to guide TBI patients off the ventilator and avoid further lung damage. In our research, the probability of weaning failure reached 46.7%, this may be related to the severe illness of most patients we included, with a median GCS score of 6. The lower the GCS score, the poorer the patient's neurological awareness, the poorer the airway protection and the greater the likelihood of post-extubation aspiration. In this study, we analysed the effect of pre-SBT GCS score on MV prognosis in patients with TBI. The results showed that the lower pre-SBT GCS score was a risk factor for weaning failure. The majority of TBI patients with weaning failure had lower pre-SBT GCS score compared with the weaning success group, which is similar to previous clinical findings. Previous studies showed that the GCS score was an independent predictor for weaning failure, and was associated with increased in-hospital mortality in patients with acute stroke and brain trauma requiring MV [15,16]. Therefore, the pre-SBT GCS score could be used as a predictor in this research to predict the weaning outcomes in mechanically ventilated patients with TBI. In addition, the score is obtained by a physical examination of only three areas: eye-opening response, verbal response and motor ability. It is simple and convenient to use and provides a quick and accurate guide to wean from the ventilator.

CRP is one of the most readily available and widely used predictors of inflammation, and elevated CRP is associated with severity and mortality in patients with TBI [28]. Previous studies have found that, CRP has predictive value for weaning failure in critically ill patients [18]. In our study, we also confirmed the findings of the above studies, CRP can predict the weaning failure in MV in patients with TBI. In addition, low ALB is a marker of malnutrition, and critical illness is a hyper-decomposed state that predisposes patients to malnutrition in the absence of appropriate nutritional interventions, leading to poor clinical outcomes [29]. In previous studies, hypoalbuminaemia is prevalent to varying degrees in patients with TBI, and that decreased ALB is strongly associated with mortality after TBI [30,31]. Moreover, previous researches showed that higher protein intake may benefit withdrawal in patients with long-term MV, with a daily protein intake of 1.2 g/kg/day and improved ALB being independent predictors of weaning success [29]. Our study also reached the consistent conclusion that higher ALB levels were associated with weaning success. Besides, in our study, a composite index, including inflammation and nutritional status, called CAR, was included as an indicator to predict the weaning outcomes of MV in patients with TBI. And the increase in CAR represents greater inflammation and lower nutrition, which may synergistically lead to worse outcomes after TBI, and it was also confirmed in our study that the predictive value of the composite indicator CAR was higher than CRP or ALB alone. The inclusion of CAR into predictors could help effectively predict the prognosis of moderate to severe TBI in adults [11,32]. Moreover, previous studies have shown that CAR was an independent risk factor for death in patients with TBI [33]. In our research, we found a strong correlation between the

level of CAR in serum before SBT and the weaning outcomes of MV in patients with TBI. In addition, CAR was found to be an independent risk factor for predicting MV weaning failure in TBI patients. Therefore, CAR was included as a predictor in this study, which may help to improve the accuracy of predicting the weaning outcomes of MV in patients with TBI. More importantly, the index is clinically inexpensive and readily available, can serve as a good tool for guiding MV patients to wean from the machine, and can play an important role in reducing patients' pulmonary complications.

Although the results of this study are promising, it does have some limitations. First, the study was limited by the single centre and small sample size which might lead to results bias. Second, due to the limitation of objective conditions, it was impossible to build a well-established prediction model to better predict the weaning outcomes. Therefore, prospective studies should be designed to include more independent variables and number of cases, and be conducted in multiple centres to more accurately and efficiently predict the weaning outcomes in patients with TBI.

5. Conclusions

In conclusion, TBI patients with higher pre-SBT CAR levels and lower GCS score are more likely to experience weaning failure during hospitalization, and these two indicators, which are readily available and favourably priced, allowing for easy, rapid and accurate assessment of the timing of MV discontinuation in patients with TBI, as well as better avoidance of pulmonary complications due to intubation. However, further exploration of additional factors affecting weaning outcomes is needed to provide further evidence for clinician decision-making.

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Author contributions

Jiaxuan Zeng: conceptualization, methodology, validation, formal analysis, data curation, writing – original Draft, writing – review and editing, project administration. Jiazhuo Liu, Jiali Chen, Yin Lu, Jiahui Fu, Dong Han, Zhimin Zou, Qin Li, Kun Zhang, Hongping Tan, Wenzhong Yu and Xiucai Wei: methodology, supervision, and writing-reviewing. Zhengtao Gu and Li Li: visualization, project administration, supervision and funding acquisition. All authors listed have reviewed and approved the version for submission.

Disclosure statement

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Data availability statement

Data supporting the findings of this research are available on request due to privacy/ethical restrictions.

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