Am J Transl Res 2025;17(6):4622-4630
www.ajtr.org /ISSN:1943-8141/AJTR0163306

Original Article

Factors influencing weaning success from mechanical ventilation in Emergency department patients with acute respiratory failure

Peng Huang[1*], Fuguo Cao[2*], Haibo Zhou[1], Zhuangzhi Xiong[1], Bo Chen[2], Hongping Hu[1]

[1]*Department of Emergency Medicine, Wuhan Hankou Hospital, Wuhan 430012, Hubei, China;* [2]*Department of Emergency Medicine, Suizhou Central Hospital (Suizhou Hospital, Hubei University of Medicine), Suizhou 441300, Hubei, China.* [*]*Equal contributors.*

Received January 14, 2025; Accepted May 28, 2025; Epub June 15, 2025; Published June 30, 2025

Abstract: Objectives: To identify the clinical and physiological factors associated with successful weaning from mechanical ventilation (MV) in patients with acute respiratory failure (ARF) treated in the Emergency department, and to evaluate their short-term prognosis. Methods: This retrospective study analyzed data from 248 ARF patients who underwent MV in the Emergency department from July 2021 to June 2024. Patients were categorized into weaning success and failure groups based on their ability to maintain spontaneous breathing for over 48 hours post-extubation. Collected variables included demographic characteristics, body mass index, MV duration, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, blood gas parameters, and diaphragm function metrics. Multivariate logistic regression was used to identify independent predictors of weaning success. Results: Among the 248 patients, 165 (66.5%) were successfully weaned. Independent predictors of successful weaning included shorter MV duration, lower APACHE II scores, higher tidal volumes, and lower respiratory rates during spontaneous breathing trials. Diaphragmatic excursion was negatively associated with weaning failure, as was arterial oxygen partial pressure (PaO_2). Patients in the failure group had longer hospital stays and higher rates of complications, invasive interventions, and readmissions (all $P<0.05$). Conclusion: Weaning success in ARF patients managed in the Emergency department is influenced by a combination of clinical severity, ventilatory parameters, and diaphragm function. Recognition of these factors may aid in optimizing weaning strategies and improving patient prognosis.

Keywords: Weaning, mechanical ventilation, acute respiratory failure, Emergency department, predictors, diaphragm function

Introduction

Acute respiratory failure (ARF) is a critical condition in which the respiratory system fails to maintain adequate gas exchange, leading to hypoxemia, hypercapnia, or both. ARF may result from various causes, including chronic obstructive pulmonary disease, pneumonia, pulmonary edema, and acute respiratory distress syndrome, each posing unique clinical management challenges [1]. In critically ill patients, mechanical ventilation (MV) serves as a vital life-support intervention, maintaining oxygenation and ventilation while the underlying pathology is addressed. However, prolonged MV is associated with serious complications, including ventilator-associated pneumonia, diaphragmatic dysfunction, and increased mortality [2]. Consequently, timely and successful weaning from MV is essential to improve patient outcomes.

The decision to initiate weaning from MV is complex and requires careful evaluation of multiple clinical factors. Weaning involves the gradual reduction of ventilatory support to determine whether a patient can sustain spontaneous breathing. In Emergency department (ED) settings-where rapid assessment and decision-making are critical, identifying predictors of weaning success is particularly important. Several physiological indicators, underlying etiologies of ARF, and patient specific variables such as age and comorbidities have been proposed as potential predictors [6-9]. However, due to the heterogeneity of clinical presenta-

https://doi.org/10.62347/ISME5144

tions, predictive accuracy remains limited, highlighting the need for further investigation.

Weaning failure is typically defined as the inability to maintain adequate spontaneous ventilation following extubation within a defined observational period. It is associated with longer hospital stays and worse prognoses, including increased morbidity and mortality. Studies have suggested that underlying conditions such as sepsis and heart failure, as well as indicators like the rapid shallow breathing index, may influence weaning outcomes [10-12]. Moreover, both the timing and method of weaning, whether gradual withdrawal or immediate extubation can impact success rates [3, 13-15]. These factors underscore the necessity of individualized weaning strategies tailored to each patient's clinical status and care context.

In ED settings, the diversity of ARF etiologies and severity, coupled with time-sensitive decision-making, complicates the weaning process. Emergency physicians must balance optimal clinical outcomes with logistical constraints, making reliable predictors of weaning success especially valuable. Despite a growing body of literature on weaning in intensive care units (ICUs), few studies focus specifically on ED patients. Exploring weaning predictors in the ED is essential to inform clinical decision-making, reduce complications, and improve long-term outcomes, including respiratory failure recurrence and post-extubation survival. This study aimed to systematically investigate the factors associated with successful weaning from MV among ARF patients in the ED and to evaluate their subsequent prognoses.

Materials and methods

Case selection

This retrospective cohort study included 248 patients with ARF who received mechanical ventilation in the ED of Wuhan Hankou Hospital from July 2021 to June 2024. Patients were stratified into the success group and the failure group, based on their ability to maintain spontaneous breathing for more than 48 hours following extubation without signs of respiratory distress, including dyspnea, tachycardia, diaphoresis, or agitation [5]. A total of 165 patients met the criteria for successful weaning. Patients who died within 48 hours of extubation or required reintubation within that period were categorized as weaning failures (n=83) [16].

This study was approved by the Institutional Review Board and Ethics Committee of Wuhan Hankou Hospital. The requirement for informed consent was waived due to the retrospective nature of the study and use of anonymized patient data, in accordance with institutional and ethical guidelines.

Inclusion criteria: (1) Age ≥18 years; (2) Received tracheal intubation and mechanical ventilation; (3) Diagnosed with ARF [3]; (4) Underwent planned weaning and extubation after meeting clinical criteria; (5) Complete and accessible medical records.

Exclusion criteria: (1) Pre-existing, irreversible airway dysfunction (e.g., tumors, congenital malformations, burns, or post-surgical airway damage) [17]; (2) Long-term MV (>21 days); (3) Incomplete clinical data; (4) Failure to enter a formal weaning program (e.g., extubation due to death or other non-clinical factors); (5) Pregnancy or lactation; (6) Acute neurological disorders.

Data collection

Clinical data were retrieved from the hospital's electronic medical records. Recorded variables included sex, age, ethnicity, body mass index (BMI), median MV duration [18], nutrition scores, and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores [19]. Additional information such as smoking and alcohol history, comorbidities, level of consciousness, use of vasoactive drugs, and hospital readmissions within the previous six months was also collected.

Outcome measurements

Prior to weaning, arterial blood samples (5 mL) were obtained and analyzed using a Roche Cobas b 123 blood gas analyzer (Roche Group, Switzerland). Parameters measured included pH, partial pressures of oxygen (PaO_2) and carbon dioxide ($PaCO_2$), potassium, sodium, lactate, and PaO_2/FiO_2 ratio.

Ventilator settings, including tidal volume (TV), pressure support (PS), and positive end-expiratory pressure (PEEP), were recorded before weaning and compared between groups.

Table 1. Comparison of basic data between the two groups

	Success group (n=165)	Failure group (n=83)	t/χ^2	P
Age (years)	65.63±8.54	67.06±7.57	1.291	0.198
Female/Male	63 (38.18%)/102 (61.82%)	32 (38.55%)/51 (61.45%)	0.003	0.955
Ethnicity (Han/Other)	158 (95.76%)/7 (4.24%)	76 (91.57%)/7 (8.43%)	1.119	0.290
Body Mass Index (kg/m^2)	22.35±2.55	23.25±2.84	2.533	0.012
Smoking history (Yes/No)	96 (58.18%)/69 (41.82%)	40 (48.19%)/43 (51.81%)	2.225	0.136
Drinking history (Yes/No)	85 (51.52%)/80 (48.48%)	37 (44.58%)/46 (55.42%)	1.063	0.302
Hypertension (Yes/No)	105 (63.64%)/60 (36.36%)	45 (54.22%)/38 (45.78%)	2.050	0.152
Diabetes (Yes/No)	100 (60.61%)/65 (39.39%)	42 (50.6%)/41 (49.4%)	2.258	0.133
Educational level (high school or below/college or above)	46 (27.88%)/119 (72.12%)	16 (19.28%)/67 (80.72%)	2.179	0.140
Marital Status (Married /Unmarried)	147 (89.09%)/18 (10.91%)	69 (83.13%)/14 (16.87%)	1.744	0.187
Median duration of MV (days)	4.36±0.35	6.20±1.20	13.572	<0.001
APACHE II	21.03±2.25	22.06±2.60	3.245	0.001
Consciousness			16.711	0.002
Lethargy	2 (1.21%)	6 (7.23%)		
Somnolence	1 (0.61%)	0 (0%)		
Coma	10 (6.06%)	9 (10.84%)		
Confusion	22 (13.33%)	21 (25.3%)		
Alertness	130 (78.79%)	47 (56.63%)		
Vasoactive drugs			None	0.011
None	146 (88.48%)	61 (73.49%)		
Norepinephrine	14 (8.48%)	13 (15.66%)		
Dopamine	1 (0.61%)	2 (2.41%)		
Dobutamine	0 (0%)	1 (1.2%)		
Epinephrine	3 (1.82%)	6 (7.23%)		
Epinephrine and dopamine	1 (0.61%)	0 (0%)		

APACHE II: Acute Physiology and Chronic Health Evaluation II; MV: mechanical ventilation.

Spontaneous breathing trials (SBTs) were conducted to assess weaning readiness [20]. During SBTs, continuous monitoring of core temperature, heart rate (HR), blood pressure (BP), and respiratory rate (RR) was performed.

Ultrasound evaluation of the right hemidiaphragm was performed with the patient in a semi-recumbent position (20°-40°), using 2D and M-mode imaging to measure diaphragmatic excursion and contraction velocity during tidal breathing, both before and after extubation [4].

Statistical analysis

All statistical analyses were conducted using SPSS version 29.0. Continuous variables are reported as mean ± standard deviation (SD) and compared using the independent samples t-test. Categorical variables are expressed as proportions and analyzed using the chi-square test. Pearson correlation was used for continuous variables, while Spearman correlation was applied to ordinal data. Univariate and multivariate logistic regression analyses were conducted to identify independent predictors of weaning success. A two-sided *p*-value <0.05 was considered statistically significant.

Results

Comparison of basic characteristics

There were no significant differences between the weaning success and failure groups in terms of age, gender distribution, ethnicity, smoking history, alcohol use, or marital status (all P>0.05; **Table 1**). However, the failure group had a significantly higher BMI, longer median MV duration, and higher APACHE II scores (all P<0.05), indicating greater illness severity. A greater proportion of patients in the success group were alert at the time of assessment (P=0.002), and the use of vasoactive drugs was more frequent in the failure group (P=0.011).

Comparison of arterial blood gas parameters

Analysis of arterial blood gases showed that PaO_2 levels were significantly higher in the success group compared to the failure group (P=0.022; **Table 2**), suggesting that better oxygenation is associated with successful weaning

Table 2. Comparison of blood gas analysis between the two groups

	Success group (n=165)	Failure group (n=83)	T	P
PH	7.44±0.05	7.45±0.04	1.204	0.230
PaO_2	126.81±35.06	116.37±30.44	2.309	0.022
$PaCO_2$	37.23±5.96	38.36±6.84	1.350	0.178
Serum potassium	3.75±0.35	3.73±0.29	0.358	0.720
Serum sodium	137.49±4.79	137.75±5.00	0.390	0.697
Lac	1.41±0.41	1.40±0.35	0.078	0.938
PaO_2/FiO_2	312.54±95.03	294.41±85.82	1.463	0.145

PH: Potential of Hydrogen; PaO_2: Partial Pressure of Arterial Oxygen; $PaCO_2$: Partial Pressure of Arterial Carbon Dioxide; Lac: Lactate.

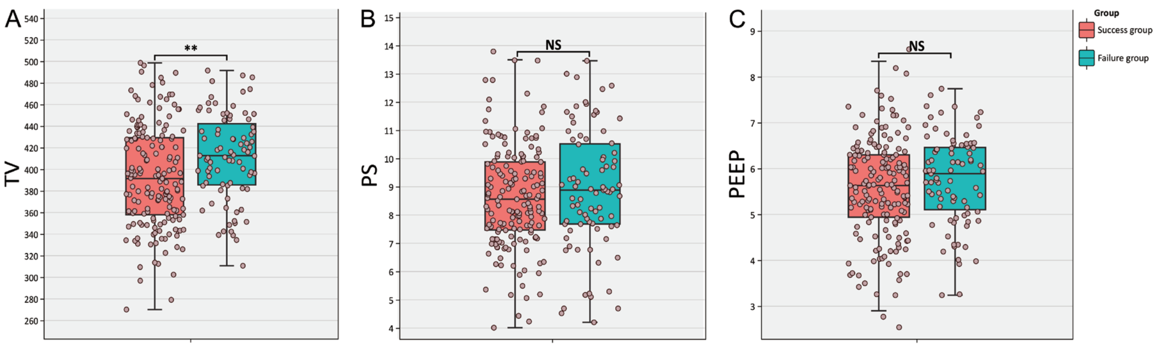

Figure 1. Comparison of respiratory mechanics parameters between the two groups. A. TV; B. PS; C. PEEP. TV: tidal volume; PS: pressure support; PEEP: positive end-expiratory pressure; ns: no statistically significant difference; **: P<0.01.

from MV. No statistically significant differences were found between groups in $PaCO_2$, serum potassium, serum sodium, lactate levels, or PaO_2/FiO_2 ratio (all P>0.05), highlighting the primary importance of oxygenation status in predicting weaning success.

Comparison of respiratory mechanics parameters

Regarding respiratory mechanics prior to weaning, TV was significantly higher in the failure group (P=0.003; **Figure 1**). However, PS and PEEP did not differ significantly between the groups (both P>0.05).

Comparison of SBT results

During the SBT, respiratory rate was the only parameter showing a statistically significant difference between groups, with higher values in the failure group (P=0.027; **Figure 2**), suggesting its role as a predictor of weaning failure. Other measured parameters, including temperature, heart rate, systolic blood pressure, and diastolic blood pressure, did not show significant differences between the groups (all P>0.05). These findings suggest that an increased respiratory rate during the SBT could be indicative of weaning failure.

Comparison of diaphragm function during weaning

Ultrasound assessment during SBT revealed that the success group exhibited significantly greater diaphragm excursion than the failure group (P=0.037; **Figure 3**). This difference remained significant after extubation (P=0.004). However, diaphragmatic contraction velocity did not differ significantly between groups either during SBT (P=0.161) or post-extubation (P=0.871).

Correlation analysis

Correlation analysis identified several variables significantly associated with weaning outcomes (**Table 3**). A positive correlation was observed between longer MV duration and higher weaning failure rates. APACHE II score and TV were also positively correlated with failure. In con-

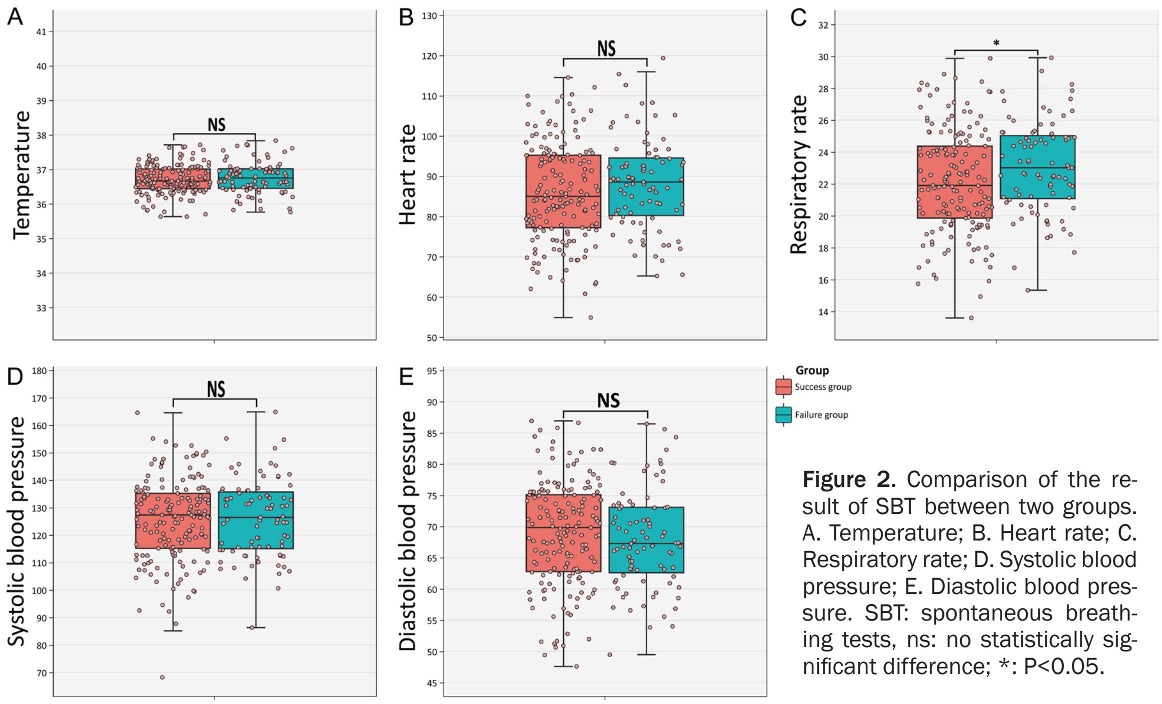

Figure 2. Comparison of the result of SBT between two groups. A. Temperature; B. Heart rate; C. Respiratory rate; D. Systolic blood pressure; E. Diastolic blood pressure. SBT: spontaneous breathing tests, ns: no statistically significant difference; *: P<0.05.

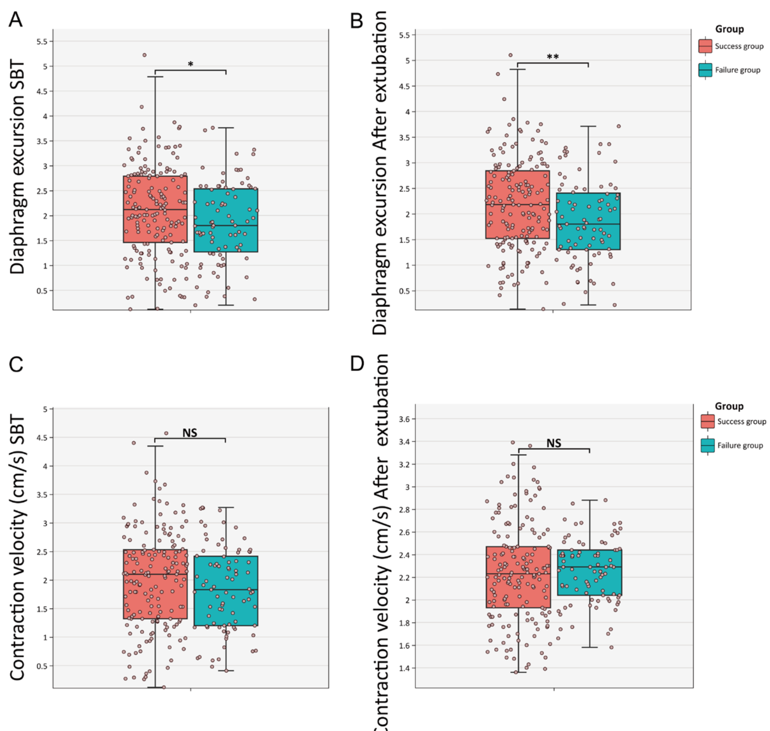

Figure 3. Comparison of diaphragm function between the two groups during weaning. A. Diaphragm excursion SBT; B. Diaphragm excursion After extubation; C. Contraction velocity SBT; D. Contraction velocity After extubation. SBT: spontaneous breathing tests. ns: no statistically significant difference; *: P<0.05; **: P<0.01.

trast, diaphragm excursion (during both SBT and after extubation) was negatively correlated with failure, indicating that greater excursion was associated with success. BMI and RR showed modest positive correlations with failure, while PaO_2 was slightly negatively correlated.

Multivariate logistic regression analysis

Multivariate logistic regression identified median MV duration as a strong independent predictor of weaning failure, with longer durations significantly increasing failure risk (**Table 4**). Similarly, higher TV was associated with increased odds of failure. PaO_2, on the other hand, was inversely associated with failure risk, indicating that higher oxygenation improves weaning success.

Notably, BMI, APACHE II score, RR, and diaphragm excursion, although significant in univariate analysis were not independently associated with weaning outcomes in the multivariate model.

Table 3. Correlation analysis between clinical factors and weaning success

	rho	P
Body Mass Index (kg/m^2)	0.138	0.030
Median duration of MV (days)	0.722	P<0.001
APACHE II	0.194	0.002
PaO_2	-0.136	0.032
TV	0.194	0.002
respiratory rate	0.144	0.023
Diaphragm excursion (SBT)	-0.132	0.038
Diaphragm excursion (After extubation)	-0.175	0.006

APACHE II: Acute Physiology and Chronic Health Evaluation II; PaO_2: Partial Pressure of Arterial Oxygen; TV: tidal volume; SBT: spontaneous breathing.

Comparison of in-hospital outcomes

The failure group experienced significantly more sputum aspiration events than the success group (P=0.001; **Table 5**). Post-weaning hospital stay was also significantly longer in the failure group (P=0.006). Additionally, complications including deep vein thrombosis, urinary tract infections, and pressure ulcers were more frequent in the failure group (P<0.001), although individual complication-specific statistics were not provided. The failure group also had a higher rate of rehospitalization (P=0.025).

Discussion

This study offers valuable insights into the multifactorial determinants of weaning success from MV in patients with ARF within the ED setting. A key finding was the association between prolonged MV duration and weaning failure. This strong correlation underscores the clinical challenge of balancing necessary ventilatory support against the risk of ventilator-induced diaphragmatic dysfunction (VIDD). Prolonged MV can lead to respiratory muscle atrophy and reduced contractility, particularly affecting the diaphragm, which is essential for spontaneous respiration post-extubation [21, 22]. These findings are consistent with the work of Zhang et al. [23], who reported that sustained mechanical support contributes to VIDD through muscle disuse and oxidative stress [24, 25]. Strategies such as minimizing MV duration, incorporating early mobilization, and implementing respiratory muscle training protocols may enhance weaning outcomes.

The predictive value of the APACHE II score further emphasizes the role of overall disease severity in determining weaning readiness. Higher scores reflect greater physiological stress and systemic instability, which complicate the weaning process. These patients may experience a range of complications, including cardiovascular dysfunction and impaired oxygen delivery that increase the likelihood of weaning failure. This finding aligns with prior research suggesting that critically ill patients benefit from comprehensive, multidisciplinary care strategies integrating hemodynamic stabilization, nutritional optimization, and individualized weaning protocols [26-28].

Respiratory mechanics also emerged as significant predictors of weaning success. Specifically, TV and RR during the SBT, were associated with outcomes. A higher TV in the failure group may reflect compensatory effort in the setting of poor lung compliance or airway resistance, which imposes a greater respiratory load [29-31]. Similarly, an elevated RR may signify rapid, shallow breathing, a hallmark of respiratory muscle fatigue and impending weaning failure, consistent with findings by Pande et al. [5].

Arterial blood gas analysis revealed that higher PaO_2 was significantly associated with weaning success, reinforcing the importance of adequate oxygenation during and after ventilatory support. Optimal ventilator settings, combined with adjunctive therapies such as bronchodilators and corticosteroids, may promote improved oxygen exchange and facilitate the transition to spontaneous breathing. These results are in line with findings by Farghaly et al. [33], who noted that higher PaO_2 values were predictive of successful extubation.

Ultrasound-based evaluation of diaphragmatic function revealed that diaphragm excursion, both during SBT and post-extubation, was a significant predictor of weaning success. Patients with greater excursion demonstrated stronger diaphragmatic performance, underscoring the value of dynamic diaphragmatic assessment in weaning decisions. These findings support the use of inspiratory muscle training and early

Table 4. Multivariate logistic regression analysis of independent predictors of weaning success

	Coefficient	Std Error	Wald Stat	P	OR	OR CI Lower	OR CI Upper
Body Mass Index (kg/m^2)	0.146	0.116	1.264	0.206	1.158	0.923	1.453
Median duration of MV (days)	3.689	0.639	5.773	<0.001	40.005	11.434	139.970
APACHE II	0.126	0.111	1.136	0.256	1.134	0.913	1.408
PaO_2	-0.019	0.009	-2.182	0.029	0.981	0.965	0.998
TV	0.024	0.008	3.099	0.002	1.024	1.009	1.039
respiratory rate	0.088	0.098	0.900	0.368	1.092	0.902	1.323
Diaphragm excursion (SBT)	-0.347	0.349	-0.995	0.320	0.707	0.357	1.400
Diaphragm excursion (After extubation)_	-0.421	0.364	-1.155	0.248	0.656	0.321	1.341

APACHE II: Acute Physiology and Chronic Health Evaluation II; PaO_2: Partial Pressure of Arterial Oxygen; TV: tidal volume; SBT: spontaneous breathing.

Table 5. Comparison of in-hospital outcomes between the two groups

	Success group (n=165)	Failure group (n=83)	t/χ^2	P
Frequencies of sputum aspirations	23.21±4.77	25.07±3.84	3.304	0.001
Length of stay postweaning,	6.90±1.07	7.52±1.88	2.808	0.006
Complications	5 (3.03%)	15 (18.07%)	16.852	<0.001
Deep venous thrombosis	1 (0.61%)	2 (2.41%)		
Urinary tract infection	0 (0%)	3 (3.61%)		
Pressure ulcers	1 (0.61%)	3 (3.61%)		
Others	3 (1.82%)	7 (8.43%)		
Rehospitalization rates	6 (3.64%)	9 (10.84%)	5.048	0.025

mobilization to enhance respiratory muscle function during the weaning process.

BMI also showed a significant, albeit indirect, association with weaning outcomes. Patients with higher BMI were more prone to weaning failure, potentially due to comorbidities such as obstructive sleep apnea, obesity hypoventilation syndrome, or reduced diaphragmatic mobility caused by central obesity. These findings support the integration of nutritional management and weight reduction strategies in ventilated obese patients [34, 35].

An elevated respiratory rate during SBT was additionally linked to weaning failure, likely reflecting increased respiratory workload and inadequate ventilatory reserve. Timely identification of this pattern is essential for preventing full weaning failure. Implementation of structured SBT protocols and early intervention may reduce respiratory fatigue, lower complication rates, and shorten hospital stays.

The clinical implications of this study are considerable. First, the identification of key predictors: MV duration, APACHE II score, PaO_2 levels, and diaphragm excursion, may assist clinicians in determining optimal weaning timing. Second, the application of bedside tools such as ultrasound offers a noninvasive means of evaluating respiratory muscle function in real time. Finally, a multidisciplinary, individualized approach that includes emergency physicians, intensivists, and respiratory therapists is vital for improving weaning outcomes in ED patients.

Nevertheless, this study has several limitations. As a retrospective, single-center analysis, the findings may be affected by selection bias and may not be fully generalizable to other institutions with differing clinical practices or patient populations. In addition, variations in weaning protocols and operator expertise were not controlled for, which may have influenced outcomes. Future prospective, multicenter studies employing standardized weaning protocols are warranted to validate and expand upon these findings.

Conclusion

This study identified critical clinical and physiological factors associated with weaning success in ARF patients managed in the Emergency department. Key predictors-including MV duration, APACHE II score, oxygenation status, and diaphragmatic function, underscore the importance of a comprehensive, individualized approach to the weaning process. Future research should focus on refining predictive models, incorporating novel biomarkers, and developing personalized strategies to optimize weaning outcomes. Ultimately, the implementation of robust, evidence-based protocols may reduce complication rates, lower healthcare burdens, and improve the quality of life for patients following ventilator weaning.

Disclosure of conflict of interest

None.

Address correspondence to: Hongping Hu, Department of Emergency Medicine, Wuhan Hankou Hospital, Erqi Side Road, Jiang'an District, Wuhan 430012, Hubei, China. E-mail: pparticle2024 @163.com

References

[1] Kaku S, Nguyen CD, Htet NN, Tutera D, Barr J, Paintal HS and Kuschner WG. Acute respiratory distress syndrome: etiology, pathogenesis, and summary on management. J Intensive Care Med 2020; 35: 723-737.

[2] Chen L and Rackley CR. Diagnosis and epidemiology of acute respiratory failure. Crit Care Clin 2024; 40: 221-233.

[3] Zapata L, Blancas R, Conejo-Márquez I and García-de-Acilu M. Role of ultrasound in acute respiratory failure and in the weaning of mechanical ventilation. Med Intensiva (Engl Ed) 2023; 47: 529-542.

[4] Itagaki T. Diaphragm-protective mechanical ventilation in acute respiratory failure. J Med Invest 2022; 69: 165-172.

[5] Bittner E and Sheridan R. Acute respiratory distress syndrome, mechanical ventilation, and inhalation injury in burn patients. Surg Clin North Am 2023; 103: 439-451.

[6] Özsancak Uğurlu A and Ergan B. How do I wean a patient with acute hypercapnic respiratory failure from noninvasive ventilation? Pulmonology 2023; 29: 144-150.

[7] Lin SH, He YP, Lian JJ and Chu CK. Procalcitonin kinetics to guide sequential invasive-noninvasive mechanical ventilation weaning in patients with acute exacerbation of chronic obstructive pulmonary disease and respiratory failure: procalcitonin's adjunct role. Libyan J Med 2021; 16: 1961382.

[8] Hsu PC, Lin YT, Kao KC, Peng CK, Sheu CC, Liang SJ, Chan MC, Wang HC, Chen YM, Chen WC and Yang KY. Risk factors for prolonged mechanical ventilation in critically ill patients with influenza-related acute respiratory distress syndrome. Respir Res 2024; 25: 9.

[9] Chabert P, Bestion A, Fred AA, Schwebel C, Argaud L, Souweine B, Darmon M, Piriou V, Lehot JJ and Guérin C. Ventilation management and outcomes for subjects with neuromuscular disorders admitted to ICUs with acute respiratory failure. Respir Care 2021; 66: 669-678.

[10] Trivedi V, Chaudhuri D, Jinah R, Piticaru J, Agarwal A, Liu K, McArthur E, Sklar MC, Friedrich JO, Rochwerg B and Burns KEA. The usefulness of the rapid shallow breathing index in predicting successful extubation: a systematic review and meta-analysis. Chest 2022; 161: 97-111.

[11] Routsi C, Stanopoulos I, Kokkoris S, Sideris A and Zakynthinos S. Weaning failure of cardiovascular origin: how to suspect, detect and treat-a review of the literature. Ann Intensive Care 2019; 9: 6.

[12] Pham T, Heunks L, Bellani G, Madotto F, Aragao I, Beduneau G, Goligher EC, Grasselli G, Laake JH, Mancebo J, Peñuelas O, Piquilloud L, Pesenti A, Wunsch H, van Haren F, Brochard L and Laffey JG. Weaning from mechanical ventilation in intensive care units across 50 countries (WEAN SAFE): a multicentre, prospective, observational cohort study. Lancet Respir Med 2023; 11: 465-476.

[13] Stivi T, Padawer D, Dirini N, Nachshon A, Batzofin BM and Ledot S. Using artificial intelligence to predict mechanical ventilation weaning success in patients with respiratory failure, including those with acute respiratory distress syndrome. J Clin Med 2024; 13: 1505.

[14] Huo Y, Zhang K, Li B, Li X, Shang J, Ma L and Hu Z. Predictive efficacy of weaning index on mechanical ventilation evacuation. Ann Palliat Med 2021; 10: 646-656.

[15] Gerhardinger F, Fisser C, Malfertheiner MV, Philipp A, Foltan M, Zeman F, Stadlbauer A, Wiest C, Lunz D, Müller T and Lubnow M. Prevalence and risk factors for weaning failure from venovenous extracorporeal membrane oxygenation in patients with severe acute respiratory insufficiency. Crit Care Med 2024; 52: 54-67.

[16] Grieco DL, Maggiore SM, Roca O, Spinelli E, Patel BK, Thille AW, Barbas CSV, de Acilu MG, Cutuli SL, Bongiovanni F, Amato M, Frat JP, Mauri T, Kress JP, Mancebo J and Antonelli M. Non-invasive ventilatory support and high-flow nasal oxygen as first-line treatment of acute hypoxemic respiratory failure and ARDS. Intensive Care Med 2021; 47: 851-866.

[17] Yan Y and Hu C. Influential factors for mechanical ventilation offline in patients with severe pneumonia. Zhong Nan Da Xue Xue Bao Yi Xue Ban 2015; 40: 107-111.

[18] Liu ZB, Wang LY, Zhao L, Pang YT, Liu YS, Xu W and Li HL. Clinical effect of pulmonary rehabilitation combined with diaphragm pacemaker therapy in the treatment of severely ill patients with mechanical ventilation. Int J Rehabil Res 2022; 45: 195-200.
[19] Xu H, Ma Y, Zhuang Y, Zheng Y, Du Z and Zhou X. Machine learning-based risk prediction model construction of difficult weaning in ICU patients with mechanical ventilation. Sci Rep 2024; 14: 20875.
[20] Ricard JD, Roca O, Lemiale V, Corley A, Braunlich J, Jones P, Kang BJ, Lellouche F, Nava S, Rittayamai N, Spoletini G, Jaber S and Hernandez G. Use of nasal high flow oxygen during acute respiratory failure. Intensive Care Med 2020; 46: 2238-2247.
[21] Le Marec J, Hajage D, Decavèle M, Schmidt M, Laurent I, Ricard JD, Jaber S, Azoulay E, Fartoukh M, Hraiech S, Mercat A, Similowski T and Demoule A. High airway occlusion pressure is associated with dyspnea and increased mortality in critically Ill mechanically ventilated patients. Am J Respir Crit Care Med 2024; 210: 201-210.
[22] Blackwood B, Tume LN, Morris KP, Clarke M, McDowell C, Hemming K, Peters MJ, McIlmurray L, Jordan J, Agus A, Murray M, Parslow R, Walsh TS, Macrae D, Easter C, Feltbower RG and McAuley DF. Effect of a sedation and ventilator liberation protocol vs usual care on duration of invasive mechanical ventilation in pediatric intensive care units: a randomized clinical trial. JAMA 2021; 326: 401-410.
[23] Zhang J, Feng J, Jia J, Wang X, Zhou J and Liu L. Research progress on the pathogenesis and treatment of ventilator-induced diaphragm dysfunction. Heliyon 2023; 9: e22317.
[24] Shen W, Jiang Y, Xu Y, Qian X, Jia J, Ding Y, He Y, Pan Q, Zhuang J, Ge H and Xu P. Cellular senescence contributes to mechanical ventilation-induced diaphragm dysfunction by upregulating p53 signalling pathways. BMC Pulm Med 2023; 23: 509.
[25] Molina Peña ME, Sánchez CM and Rodríguez-Triviño CY. Physiopathological mechanisms of diaphragmatic dysfunction associated with mechanical ventilation. Rev Esp Anestesiol Reanim (Engl Ed) 2020; 67: 195-203.
[26] Xiao K, Liu B, Guan W, Yan P, Song L, Wang Y and Xie L. Prognostic analysis of elderly patients with multiple organ dysfunction syndrome undergoing invasive mechanical ventilation. J Healthc Eng 2020; 2020: 6432048.
[27] Chu Y, Guo C and Fu H. Correlation between diaphragmatic-rapid shallow breathing index and lung ultrasound score in elderly patients with mechanical ventilation and its predictive value for weaning results. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 2024; 36: 152-155.
[28] Chen S, Liao SF, Lin YJ, Huang CY, Ho SC and Chang JH. Outcomes of different pulmonary rehabilitation protocols in patients under mechanical ventilation with difficult weaning: a retrospective cohort study. Respir Res 2024; 25: 243.
[29] Sage M, See W, Nault S, Morin C, Michalski C, Chabot B, Marouan S, Lavoie PM, Micheau P, Praud JP and Fortin-Pellerin É. Effect of low versus high Tidal-Volume total liquid ventilation on pulmonary inflammation. Front Physiol 2020; 11: 603.
[30] Meregildo-Rodríguez ED, Vásquez-Tirado GA, Quispe-Castañeda CV, Del Carmen Cuadra-Campos M, Contreras-Cabrera JM and Pinedo-Portilla JL. High vs. low tidal volume and pulmonary complications in patients with cervical spinal cord injury on mechanical ventilation: systematic review. Front Med (Lausanne) 2024; 11: 1362318.
[31] Hatton GE, Mollett PJ, Du RE, Wei S, Korupolu R, Wade CE, Adams SD and Kao LS. High tidal volume ventilation is associated with ventilator-associated pneumonia in acute cervical spinal cord injury. J Spinal Cord Med 2021; 44: 775-781.
[32] Pande RK and Sharma J. Heart rate, acidosis, consciousness, oxygenation, and respiratory rate: a perfect weaning index or just a new kid on the block. Indian J Crit Care Med 2022; 26: 887-888.
[33] Farghaly S, Galal M, Hasan AA and Nafady A. Brain natriuretic peptide as a predictor of weaning from mechanical ventilation in patients with respiratory illness. Aust Crit Care 2015; 28: 116-121.
[34] Nogueira J, Freitas R, Sousa JE and Santos LL. VV-ECMO in critical COVID-19 obese patients: a cohort study. J Anesth Analg Crit Care 2024; 4: 55.
[35] Er B, Simsek M, Yildirim M, Halacli B, Ocal S, Ersoy EO, Demir AU and Topeli A. Association of baseline diaphragm, rectus femoris and vastus intermedius muscle thickness with weaning from mechanical ventilation. Respir Med 2021; 185: 106503.