

EFFECT OF CUMULATIVE FLUID BALANCE AND B-LINE SCORE IN LUNG ULTRASOUND ON OUTCOME OF EXTUBATION

Silpa Kshetrimayum¹, Asim Kumar Kundu², Samik Pramanik³, Puja Trigunait⁴, Tanweer Qamar⁵

Received : 05/08/2025
Received in revised form : 22/09/2025
Accepted : 10/10/2025

Keywords:
Cumulative fluid balance, B-line score, extubation.

Corresponding Author:
Dr. Silpa Kshetrimayum,
Email: ksh.silpa@gmail.com

DOI: 10.47009/jamp.2025.7.5.214

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (5); 1134-1138



¹Assistant Professor, Department of Critical Care Medicine, Shija Hospitals and Research Institute, Langol, Manipur, India

²Professor and Head of Department, Department of Critical Care Medicine, Institute of Post Graduate Medical Education and Research (IPGMER), Kolkata, India

³Assistant Professor, Department of General Medicine, Deben Mahata Government Medical College, Purulia, West Bengal, India

⁴Consultant, Department of Critical Care, Desun Hospital, Kolkata, West Bengal, India

⁵Assistant Professor, Department of Critical Care Medicine, Nalanda Medical College and Hospital, Agamkuan, Patna, India

ABSTRACT

Background: Though early fluid resuscitation is the backbone of critical care management, definite volume targets are not well defined. This study attempts to establish an objective criteria using CFB and B-line score to predict extubation outcomes. **Materials and Methods:** Patients undergoing mechanical ventilation for >24hrs were enrolled. CFB, defined as total fluid intake minus total output since intubation to the time of extubation was calculated. Lung ultrasound was done to calculate B-line score before extubation. Effect of these variables on extubation outcome was analysed. **Result:** 26 of 80(32%) patients had extubation failure. CFB was significantly higher in those who failed extubation (6166±2239.62ml versus 4443.75±2401.47ml), p-value=0.004. The area under the curve for CFB to predict extubation failure was 0.73(95%CI:0.62-0.84) with optimal cut-off of 4567ml(sensitivity 73%, specificity 55.6%, p=0.016). B-line score was significantly higher in the extubation failure group(8.42±4.20) compared to those with successful extubation(5.61±3.14), p=0.001. Area under the curve for B-line score to predict extubation failure was 0.7(95%CI:0.57-0.83) with a cut-off score of 7(sensitivity 58%, specificity 91%, p=0.003). Combining CFB>4567ml and B-line score≥7 had a better predictability of extubation failure than either indices alone (p=0.002). **Conclusion:** The study supports the association of high CFB with adverse outcomes in the ICU. A higher CFB and hence a higher B-line score is significantly associated with extubation failure irrespective of diagnosis. Further studies are required to evaluate if active de-resuscitation should be initiated when CFB and B-line score exceeds a certain cut-off value to facilitate successful liberation from mechanical ventilation.

INTRODUCTION

Early fluid resuscitation to expand intravascular volume and maintain organ perfusion is a fundamental concept in the management of critically ill patients.^[1] However, positive cumulative fluid balance is known to be associated with increased adverse outcomes in the critically ill.^[2-4] Studies have shown that excess fluids may induce organ dysfunctions, prolong intensive care unit (ICU) and hospital length of stay and even increase mortality.^[3,5] However, fluids are routinely administered without a safety ceiling. Despite

evidence of harmful effects of overhydration, there are no standardised methods to administer optimum amount of fluid and targeted endpoints are not specified. This can be attributed to limitations of currently used volume assessment methods.^[4]

A positive cumulative fluid balance leads to increased capillary leak, increase in extravascular lung water (EVLW), and decrease in lung compliance and may result in respiratory failure in the immediate post-extubation period.^[2] Not only the lungs, congestion and increased venous pressure lead to increased renal subcapsular pressure and lowered

renal blood flow and glomerular filtration rate (GFR) and other organ dysfunction.^[5,6]

There are many studies that have tried to establish the relationship between fluid balance and outcome of weaning. Negative fluid balance 24 hours prior to extubation and negative net cumulative balance since intubation have been found to be independently associated with successful weaning.^[7] On the contrary, positive fluid balance 24 hours before extubation has also been linked to extubation failure.^[8]

Lung ultrasound used to detect B-lines has proven to be a dependable tool to assess EVLW and quantify lung congestion. These lines are appreciated on the ultrasound as dynamic sliding lung comets. B-lines are the radiological equivalents of an interstitial syndrome secondary to pulmonary edema, interstitial pneumonia or pneumonitis, or diffuse parenchymal lung disease such as pulmonary fibrosis.^[9]

With this background, this prospective observational study was planned to study the association between cumulative fluid balance and extubation outcome. We incorporated lung ultrasound to assess the contribution of lung congestion versus other organ dysfunction in extubation failure.

MATERIALS AND METHODS

This was a prospective observational study conducted in a 34 bedded Intensive Care unit (ICU) of Institute of Post Graduate Medical Education and Research (IPGMER), Kolkata. All medical and surgical patients above 12 years admitted in the study period from January 2022 to December 2023 fulfilling inclusion criteria were enrolled.

Inclusion Criteria

1. Age >12 years
2. Invasive mechanical ventilation for >24hrs
3. Successful completion of spontaneous breathing trial and hence having planned extubation

Exclusion Criteria

1. Age <12 years
2. Already intubated at the time of admission
3. Patients having unplanned extubation
4. Mechanical ventilation for <24hrs
5. Patients not giving consent

Baseline characteristics of all patients were recorded. Cumulative fluid balance (CFB), defined as total fluid intake minus total fluid output since intubation to the time of extubation was calculated. Lung ultrasound to calculate B-line score using the 28-sector protocol,^[10,11] was done before extubation using (ECUBE-8 LE USG Machine). Patients were extubated after a successful spontaneous breathing trial (SBT). SBT was performed as per hospital protocol using either T-piece or pressure support ≤ 8 cm H₂O with PEEP ≤ 5 cm H₂O in patients who were ready to wean. Need for ventilatory support again or death within 72 hrs was used to define extubation failure. The reason for extubation failure and time duration from first planned extubation was

recorded. Secondary outcomes in the form of mortality and ICU/hospital length of stay were recorded.

Statistical analysis: Statistical analysis was done using Statistical Package of the Social Sciences (SPSS) version IBMSPSS 20. Data was summarised by routine descriptive statistics, namely mean and standard deviation for numerical variables and counts and percentages for categorical variables. For normal distribution, numerical variables were compared between groups by Student's independent samples t-test. Fisher's exact test or Pearson's Chi-square test was employed for intergroup comparison of categorical variables. Statistical significance level was set at $p < 0.05$ for all comparisons. A value less than 0.001 was assigned as highly significant.

Association between numerical variables were explored through scatter plots and if the linearity assumption was satisfied, strength of the association was quantified by Pearson's 'r' or Spearman's Rho coefficient, as appropriate. A cut-off value for the cumulative fluid balance and B-line score that can predict extubation failure with a high degree of sensitivity and specificity through receiver operating characteristic (ROC) curve analysis was also done.

RESULTS

80 patients who fulfilled inclusion criteria were enrolled. 32% patients (26 of 80) had extubation failure and required reintubation. Table 1 lists the comparative characteristics of the study patients who had extubation failure versus those with successful extubation.

The difference in mean CFB between extubation failure and success groups was statistically significant (p -value=0.004) as shown in [Figure 1]. Though difference in CFB at 72 hours was not found to be statistically significant ($p=0.38$), negative fluid balance 24 hours prior to extubation was found to be significantly associated with successful extubation ($p < 0.001$).

The difference in B-line score between the two groups was found to be statistically significant (p -value =0.001).

The area under the receiver operator curve (ROC) for cumulative fluid balance to predict extubation failure was 0.732 (95% confidence interval: 0.62-0.84) with the best sensitivity and specificity obtained at a cutoff value of 4567ml (sensitivity and specificity 73.08% and 55.56% respectively). [Figure 2]. Significantly higher percentage of patients in the failure group had CFB >4567ml (73%) compared to that in the successful group (44.4%), with a P -value=0.016.

The area under the ROC for B-line score to predict extubation failure was 0.701 (95% CI: 0.573-0.829) with the best sensitivity and specificity obtained at a cutoff value of 7 (sensitivity 58% and specificity 91%) [Figure 3]. Significantly higher percentage of patients in the failure group had B-line score ≥ 7

(58%) compared to that in the successful group (30%), with a P-value=0.003.

Logistic regression was used to find the combined effect of CBF (ml) and B-line score on extubation outcome. The Omnibus model of coefficients showed that combining CFB (>4567ml) and B-line score ≥ 7 had a better predictability of extubation failure than either index used alone (p-value=0.002).

There was non-significant positive correlation between CFB and B-line score, correlation

coefficient was 0.198, p-value=0.078. The regression coefficient was positive for both CFB >4567ml and B-line score ≥ 7 and the odds ratio was more than 1 for both showing the significant influence of these variables on extubation outcome. [Table 2]

Regarding outcome, 85% (22) of the patients with failed extubation died in the hospital (p<0.001). All the patients with successful extubation were discharged home.

Table 1: Comparative parameters between extubation failure and success groups

Parameter	Extubation failure	Extubation success	p-value
Age (years)	51.03±20.78	46.9±18.17	0.294
Male	17(65%)	29(54%)	0.322
APACHE II	36.8462±8.47911	26.1296±7.10314	<0.001
Duration of MV(days)	7.0000±3.42929	5.6481±3.53504	0.110
Source of admission			
Ward	21	43	0.905
ER	5	11	
Category			
Medical	22	45	0.884
Surgical	4	9	
Comorbidities			
Sepsis	25(96%)	33(61%)	<0.001
CAD	3(12%)	5(9%)	0.750
CKD	5(19.2%)	5	0.207
T2DM	11(42.3%)	12	0.063
HTN	12(46.2%)	20	0.436
AKI	19(73%)	14	<0.001
Type of SBT			
PS-PEEP	6(23%)	14(26%)	0.783
T-piece	20(77%)	40(74%)	
Length of stay (days)			
ICU	16.31±6.44	8.22±4.14	<0.001
Hospital	18.00±6.69	11.39±4.46	<0.001
CFB(ml)	6165.96±2239.62	4443.75±2401.47	0.004
B-line score	8.42±4.20	5.61±3.14	0.001
Blood markers			
Hb	8.95±1.81	10.01±1.95	0.02
Procalcitonin	11.90±4.43	4.04±2.74	<0.001
CRP	133.57±93.38	86.44±72.23	0.015

ER-emergency room, CAD-coronary artery disease, CKD-chronic kidney disease, T2DM-type 2 diabetes mellitus, HTN-hypertension, SBT-spontaneous breathing trial, PS-PEEP-pressure support-positive end expiratory pressure, AKI-acute kidney injury, APACHE-acute physiology and chronic health evaluation, CFB-cumulative fluid balance, CRP-C-reactive protein.

Table 2: Correlation between CFB and B-line score

Independent factors	Regression coefficient	S.E.*	Wald Statistics	P-value	Odd-Ratio(95% CI**)
CBF	1.09	0.542	4.05	0.044	2.98(1.03-8.62)
B-line Score	1.32	0.520	6.44	0.011	3.74(1.35-10.35)

*S.E.- Standard error

**CI- confidence interval

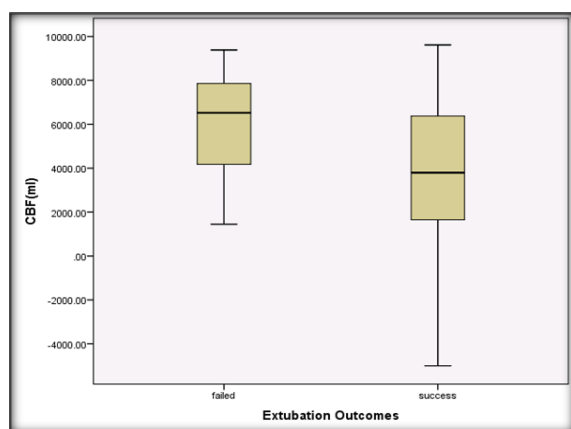


Figure 1: Mean cumulative fluid balance in extubation failure and success groups

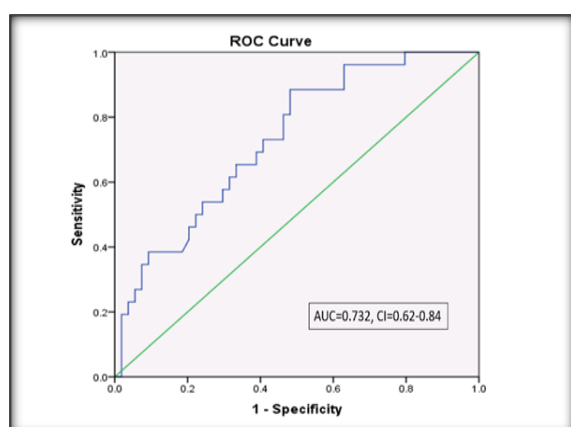


Figure 2: Receiver operator curve (ROC) for cumulative fluid balance to predict extubation failure

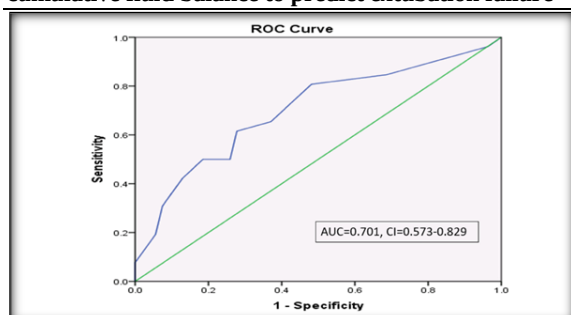


Figure 3: Receiver operator curve (ROC) for B-line score to predict extubation failure

DISCUSSION

Mean CFB was significantly higher in the extubation failure group in our study. In a similar study by Ghosh et al., mean CFB was significantly higher in the patients with extubation failure with a p-value of 0.0362. This is consistent with earlier studies which explored the association of negative net CFB with successful weaning.^[7] A cut off value of 4567ml net CFB was established above which extubation failure could be predicted with good sensitivity and specificity. The study by Ghosh et al. had established a cutoff of 3490ml. The higher value in our study could be explained by the fact that mean number of

days of mechanical ventilation was higher in our study.

All patients with negative fluid balance 24 hours prior to extubation had successful extubation. In an earlier study by Frutos-vivar et al., they found that positive fluid balance 24 hours prior to extubation was an independent predictor of extubation failure.^[8] A higher B-line score in lung ultrasound (LUS) was found to be significantly associated with extubation failure in our study. Sonographic visualization of B-lines is an excellent non-invasive method of assessing lung water. It correlates well with EVLW which in turn may be influenced by inappropriate fluid therapy and higher cumulative fluid balance. The study by Tenza-Lozano et al. found lung ultrasound scoring to be a good predictor of extubation outcome with good interobserver agreement.^[12] Similar conclusion was drawn in the study by Yadav et al.^[13] Wang et al. also concluded that LUS score measured at the end of 60-min SBT could be used to predict distress post-extubation in patients with ARDS.^[14] In our study we could establish a cutoff value of 7 for B-line score above which extubation failure could be predicted with good sensitivity and specificity.

Use of diuretics was not found to be associated significantly with extubation success in our study. Li et al. in their study also found that the degree of negative fluid balance was not associated with extubation outcome.^[15] They found that use of diuretics rather than simple fluid restriction was in fact associated with extubation failure. The use of diuretics, thus, remains a matter of debate. Upadya et al. in their study, found that giving diuretics led to negative fluid balance but it did not affect outcomes of weaning.^[7]

Among other parameters, presence of sepsis and AKI were significantly associated with extubation failure. 96% patients in the extubation failure group had sepsis/septic shock. This relationship was found to be highly significant ($p=0.001$). According to literature, approximately 80% of sepsis/septic shock patients experience respiratory failure and require mechanical ventilation.^[16] Moreover, when patients improve and are extubated, approximately 19% experience extubation failure.^[17] The high proportion of extubation failure among sepsis patients may be attributed to fluid overload that follows resuscitation often done in septic shock, the decline in kidney function often seen in sepsis and uncommonly septic cardiomyopathy.^[18,19] Presence of AKI has also been found to be an independent predictor of extubation failure in many earlier studies.^[20]

Presence of no prior comorbidity was found to significantly predict extubation failure in our study. In a recent meta-analysis by Torrini et al, history of prior cardiac or respiratory disease was significantly associated with extubation failure.^[21] In the study by Ghosh et al., presence of chronic kidney disease and chronic neurological disease was found to be a risk factor for extubation failure.^[2]

The most common cause of extubation failure in this study was poor Glasgow Coma Scale (GCS) score.

Previous studies have shown that in medical patients, the most common reasons for re-intubation are respiratory distress due to either primary respiratory failure or secondary causes such as congestive heart failure, hemodynamic instability, airway obstruction, inability to clear airway secretions, or altered mental status.^[20]

Significant elevation of procalcitonin and also C-reactive protein was seen in the group with extubation failure. This correlates with our finding of more extubation failures in patients who had sepsis. This is in keeping with all earlier studies which found more extubation failures in patients with sepsis.^[16,17] Mortality, length of stay in the ICU and hospital were all significantly higher in the extubation failure group. There is ample literature on the association of these outcomes with extubation failure and reintubation.^[22,23]

CONCLUSION

The study establishes the association of high CFB with adverse outcomes in the ICU. A higher CFB and correspondingly, a higher B-line score is notably associated with failure of extubation, notwithstanding the diagnosis. We could establish a cut-off value of 4567ml for CFB and 7 for B-line score above which extubation failure could be predicted. Further studies are required to evaluate if active de-resuscitation in the form of fluid restriction or diuresis should be initiated when CFB and B-line score exceeds a certain cut-off value to facilitate successful liberation from mechanical ventilation.

REFERENCES

- Wang N, Jiang L, Zhu B, Wen Y, Xi XM. Fluid balance and mortality in critically ill patients with acute kidney injury: A multicenter prospective epidemiological study. *Crit Care*. 2015;19:371. <https://doi.org/10.1186/s13054-015-1085-4>.
- Ghosh S, Chawla A, Mishra K, Jhalani R, Salhotra R, Singh A. Cumulative fluid balance and outcome of extubation: A prospective observational study from a general intensive care unit. *Indian J Crit Care Med* 2018;22:767-72.
- Boyd JH, Forbes J, Nakada T, Walley KR, Russell JA. Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality. *Crit Care Med* 2011;39:259-65.
- Rusu DM, Siroopol I, Grigoras I, et al. Lung Ultrasound Guided Fluid Management Protocol for the Critically Ill Patient: study protocol for a multi-centre randomized controlled trial. *Trials*. 2019;20:236. <https://doi.org/10.1186/s13063-019-3345-0>
- Child DL, Cao Z, Seiberlich LE, Brown H, Greenberg J, Swanson A, et al. The costs of fluid overload in the adult intensive care unit: Is a small-volume infusion model a proactive solution? *Clinicoecon Outcomes Res*. 2014;7:1-8. <https://doi.org/10.2147/CEOR.S72776>.
- Payen D, DePont AC, Sakr Y, Spies C, Reinhart K, Vincent JL, et al. A positive fluid balance is associated with a worse outcome in patients with acute renal failure. *Crit Care*. 2008;12:R74.
- Upadya A, Tilluckdharry L, Muralidharan V, Amoateng-Adjepong Y, Manthous CA. Fluid balance and weaning outcomes. *Intensive Care Med* 2005;31:1643-7.
- Frutos-Vivar F, Ferguson ND, Esteban A, Epstein SK, Arabi Y, Apezteguia C, et al. Risk factors for extubation failure in patients following a successful spontaneous breathing trial. *Chest* 2006;130:1664-71.
- Saad et al.: Relevance of B-Lines on Lung Ultrasound in Volume Overload and Pulmonary Congestion: Clinical Correlations and Outcomes in Patients on HD. *Cardiorenal Med* 2018;8:83-91.DOI: 10.1159/000476000
-
- Mayr U, Lukas M, Habenicht L, Weissner J, Heilmaier M, et al. B-Lines Scores Derived From Lung Ultrasound Provide Accurate Prediction of Extravascular Lung Water Index: An Observational Study in Critically Ill Patients. *J Intensive car Med*. 2022;37(1): 21-31.
- Frassi F, Gargani L, Tesorio P, Raciti M, Mottola G, Picano E. Prognostic value of extravascular lung water assessed with ultrasound lung comets by chest sonography in patients with dyspnoea and/or chest pain. *J Card Fail*. 2007;13(10):830-5.
- Tenza Lozano E, Llamas-Alvarez A, Jaimez-Navarro E, Fernandez-Sanchez J. Lung and diaphragm ultrasound as predictors of success in weaning from mechanical ventilation. *Crit Ultrasound J*. 2018;10:12. <https://doi.org/10.1186/s13089-018-0094-3>.
- Yadav MK, Pal A, Pant C, Shrestha BK. Lung ultrasound score before and after extubation for predicting weaning outcome.2019;9(30):15-17.
- Wang R, Qi B, Zhang X, Meng L, Wu X. Prophetic values of lung ultrasound score on post-extubation distress in patients with acute respiratory distress syndrome. *European Journal of Medical Research*. 2022;27:27 <https://doi.org/10.1186/s40001-022-00652-9>.
- Li T, Zhou D, Zhao D, Lin Q, Wang D, Wang C. Association between fluid intake and extubation failure in intensive care unit patients with negative fluid balance: a retrospective observational study *BMC Anesthesiology*. 2022;22:170.
- Angus DC, Linde-Zwirble WT, Lidicker J, Lidicker J, Clermont G, Carcillo J, Pinsky MR. Epidemiology of severe sepsis in the United States: analysis of incidence, outcome, and associated costs of care. *Crit Care Med*. 2001;29:1303-10.
- Teixeira C, Frederico Tonietto T, Cadaval Gonçalves S, Viegas Cremonese R, Pinheiro de Oliveira R, Savi A, et al. Noradrenaline use is not associated with extubation failure in septic patients. *Anaesth Intensive Care*. 2008;36:385-90. <https://doi.org/10.1177/0310057X0803600310>
- Chayakul W, Tongyoo S, Permpikul C. Incidence and outcomes of sepsis related cardiomyopathy: a prospective cohort study. *J Med Assoc Thai*. 2021;104:497-505.
- Bellomo R, Kellum JA, Ronco C, Wald R, Martensson J, Maiden M, et al. Acute kidney injury in sepsis. *Intensive Care Med*. 2017;43(6):816-28.
- Piriyapatsom A, Williams EC, Waak K, Ladha KS, Eikermann M, Schmidt UH. Prospective Observational Study of Predictors of Re-Intubation Following Extubation in the Surgical ICU. *Respiratory Care* March 2016; 61(3):306-15.DOI: <https://doi.org/10.4187/respcare.04269>
- Torrini F, Gendreau S, Morel J, Carteaux G, Thille AW, Antonelli M, Dessap AM. Prediction of extubation outcome in critically ill patients: a systematic review and meta-analysis. *Critical Care*. 2021;25:391. <https://doi.org/10.1186/s13054-021-03802-3>.
- Kulkarni A, Agarwal V. Extubation failure in intensive care unit: Predictors and management. *Indian J Crit Care Med*. 2008; 12(1): 1-9. doi: 10.4103/0972-5229.40942.
- Seymour, C.W., Martinez, A., Christie, J.D. et al. The outcome of extubation failure in a community hospital intensive care unit: a cohort study. *Crit Care*. 2004;8:R322. <https://doi.org/10.1186/cc2913>.