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Predictive accuracy of lung and diaphragmatic ultrasound in weaning from mechanical ventilation: a comparison with the Rapid Shallow Breathing Index

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Abstract

Predicting weaning outcomes from mechanical ventilation remains a clinical challenge. Conventional indices such as the Rapid Shallow Breathing Index (RSBI) have limitations. This study evaluates diaphragmatic ultrasound parameters alongside RSBI and modified lung ultrasound score (mLUS) to improve the prediction of weaning success. A total of 50 adult patients requiring invasive mechanical ventilation for more than 24 hours were prospectively enrolled. All underwent a spontaneous breathing trial (SBT), and parameters including RSBI, mLUS, diaphragmatic excursion (DE), and diaphragmatic thickening index (DTI) were recorded. Weaning outcome was defined as successful extubation without need for reintubation within 48 hours. Associations were analyzed using receiver operating characteristic curves and multivariate logistic regression. Of the 50 patients, 34 (68%) passed SBT, and 27 (54%) had successful weaning. RSBI and mLUS were significantly lower, and DE and DTI significantly higher, in the weaning success group. Among all, DTI showed the highest predictive value (area under the curve: 0.948). On multivariate regression, DTI and DE were independent predictors of weaning success. A combination of RSBI and DTI yielded the highest diagnostic accuracy (94%). Diaphragmatic ultrasound parameters, particularly DTI, serve as strong, non-invasive predictors of weaning success. Integration of DTI with conventional indices like RSBI enhances predictive accuracy and may be valuable in guiding weaning protocols.

Key words: mechanical ventilation, weaning, diaphragmatic ultrasound, RSBI, extubation.

Introduction

Invasive mechanical ventilation is a commonly used modality of advanced care in critical care units worldwide. Though life-saving in many cases, it comes with inherent complications some of which can be life threatening too. In that sense, it has been aptly called 'a necessary evil' [1]. Ventilator-associated complications like Ventilator associated pneumonia, ventilator induced lung injury, ICU acquired weakness and post intensive syndrome, all rise directly in proportion to the time spent on the ventilator [2]. Hence, it is recommended to initiate weaning, that is gradual withdrawal of ventilatory support, once the patient stabilizes. Weaning involves various stages like, treating the underlying illness, assessing readiness, conducting a spontaneous breathing trial(SBT) and finally extubation. Although 40 to 50 % of the total time on mechanical ventilatory support is occupied by the process of weaning but still weaning failure occurs in approximately 20 to 30% of patients as per one of the earliest estimates [3,4]. Both early and delayed weaning can be hazardous to the patient and thus optimal weaning is therefore of utmost importance and helps in reducing both morbidity and mortality. A closer look at the deranged physiology underlying weaning failure reveals that it is multifactorial and complicated. Diaphragmatic dysfunction is a major contributor to weaning failure [5]. In critically ill patients, it is most commonly caused by Ventilator Induced Diaphragm Dysfunction (VIDD) or myotrauma and Infection induced Diaphragm dysfunction. Traditional tools for the diagnosis of diaphragm dysfunction are invasive and complex. An alternative method available to assess the diaphragm is the bedside ultrasound. Ultrasound is real time, dynamic, radiation free and provides not only morphologic but also functional information about the diaphragm. Diaphragmatic Ultrasound therefore can be useful as a weaning predictor [6]. The parameters assessed by ultrasound of the diaphragm are its excursion and thickening index. Complementing this, Lung Ultrasound Score (LUS) is a validated tool that can be used to determine the aeration of the lungs and identifying the risk of post extubation distress [7]. Together, diaphragm and lung ultrasound provide simple, non-invasive, bedside approach to guide weaning decisions and predict its success. Despite extensive research on optimal weaning strategies and reliable predictors, no clear consensus has been reached. It is largely due to varied study designs, heterogenous population and the complexity or inaccessibility of some assessment tools. Bedside ultrasound offers a quick, easy and non- invasive method of examining the lungs and diaphragm to determine weaning readiness. Moreover, studies in this field are limited in Indian context, and none of the foreign studies has succeeded in determining absolute cutoff values for the various ultrasonic parameters. The current study intends to expand the small body of knowledge that already exists on the topic and also examines the application to Indian scenarios.

Our study aims to evaluate the predictive accuracy of Lung and Diaphragmatic Ultrasound Parameters in weaning from mechanical ventilation and compare it with that of Rapid Shallow Breathing Index (RSBI).

Materials and Methods

It was a prospective cohort study conducted at a tertiary care hospital in North India over a period of one and a half years. All patients who underwent mechanical ventilation for > 24 hours and were ready for weaning were included in the study. Sample size, calculated on the basis of 76% diagnostic accuracy of mLUS score in an earlier study done by Gok et al assuming a 95% confidence coefficient and 12% absolute precision, came out to be 50 [8].

Inclusion criteria

All patients aged > 18 years who were receiving mechanical ventilation for respiratory ailments for > 24 hours and were ready for weaning as per standard criteria were included in the study [9,10].

Exclusion criteria

1) Patients who underwent intubation for elective surgeries.
2) Patients with known diaphragmatic injuries/paralysis
3) Spinal cord injury higher than T8
4) Pregnant patients
5) Patients with neuromuscular disease
6) Post-pneumonectomy/lobectomy status

Methodology

The study was conducted after taking approval from the institutional ethics committee. In patients who met the inclusion criteria, informed written consent in vernacular language was taken from the first degree relative of the patient. Detailed demographical and clinical parameters, medical history, various lab values, APACHE score, duration of mechanical ventilation, length of hospital stay and ICU stay were noted in every patient. Patients who were ready for weaning as per standard criteria, were taken on SBT with Pressure support ventilation [9,10]. While on Pressure Support of 5 to 8 cm and PEEP of 5 cm, RSBI was calculated as RR/VT after a minimum period of spontaneous breathing of 3 mins. On the same ventilatory settings, Diaphragmatic Ultrasound and Lung Ultrasound were done and respective parameters obtained within a time span of 15 to 30 minutes after starting SBT. Patients were kept on SBT for a minimum period of 30 minutes up to a maximum of 2 hours and an arterial blood gas sample was obtained at the end of the trial. If the patient failed SBT, they were returned on assisted or controlled ventilation. However, if the SBT was successful then the patient was extubated as per standard guidelines and routine clinical practice. Extubated patients were then observed for a period of 48 hours· Weaning failure was considered when there was either failure of SBT or failure of extubation [9,10].

SBT failure was identified using standard criteria, including clinical signs of intolerance (increased work of breathing, agitation, diaphoresis, cyanosis) and physiological deterioration (SpO_2 <90% on FiO_2 > 0.5, PaO_2 <50 – 60mmHg, rising $PaCO_2$ with acidosis, RR >35/min, significant heart rate or blood pressure changes, or new arrythmias). Extubation failure was defined as the need for reintubation due to post-extubation deterioration or death within 48 hours.

Compiled data was used to determine the sensitivity, specificity, positive predictive value and negative predictive value of modified lung ultrasound score and diaphragmatic ultrasound parameters in predicting successful weaning both individually and combined. Also, the sensitivity, specificity and predictive values of mLUS score and diaphragmatic ultrasound parameters were compared to that of RSBI.

Modified lung ultrasound score

Lung ultrasound was performed using a portable Alpinion E CUBE 7 system with a 2-5 MHz convex probe in B-mode. The modified Lung ultrasound score (mLUS), a semiquantitative method of assessing lung aeration based on standardized ultrasound pattern, was calculated by dividing each hemithorax into four regions- anterosuperior, anteroinferior, lateral and posterobasal- using the anterior and posterior axillary lines as boundaries. A total of eight lung zones were therefore assessed and lung aeration in each zone was graded based on ultrasound patterns as depicted in Table 1, yielding a total score that reflects the extent of aeration loss.

Ultrasound of the diaphragm

Estimation of diaphragmatic thickening index (DTI)

By using 7 to 10 MHz linear probe on the M mode, the right hemidiaphragm was visualized between the 8^{th} and 10^{th} intercostal spaces in the semi- decubitus position. The diaphragm thickness was measured at the end of inspiration and expiration. DTI was calculated as DTI=Diaphragmatic thickness at end-inspiration-Diaphragmatic thickness at end- expiration/ Diaphragmatic thickness at end-expiration x 100. A total of three measurements were taken and the average DTI obtained**.**

Estimation of diaphragmatic excursion (DE)

A 2.5 to 5 MHz phased array transducer was placed between the midclavicular and midaxillary lines in subcoastal region using liver as an acoustic window. M mode was used to display the motion of the diaphragm along the selected line. The inspiratory and expiratory cranio-caudal displacements of the diaphragm were obtained. A total of three measurements were taken and the average DE calculated.

Statistical analysis

Categorical variables were presented as number and percentage (%), while quantitative data were presented as the mean ± SD or median with 25th and 75th percentiles (interquartile range), based on distribution. The data normality was checked by using Shapiro-Wilk test. Non parametric tests were used for non-normally distributed data. Independent t test was applied for normally distributed quantitative variables, while, Mann-Whitney Test was used for non-normally distributed variables. Receiver operating characteristic (ROC) curve was used to assess cut off point, sensitivity, specificity, positive predictive value and negative predictive value of RSBI, mLUS score, DTI and DE. Multivariate logistic regression was used to assess prediction of combination of RSBI with each of the other parameters namely mLUS score, DTI (%) and DE (cm) and for all the parameters combined for predicting weaning success. The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 25.0. A p value of less than 0.05 was considered statistically significant.

Results

The mean age of the study population was 52.32±18.5 years with equal gender distribution. Majority of the patients had pneumonia (n=10, 20%) and COPD (n=8, 16%) as the underlying ailment and hypertension was the most common comorbidity (n=22, 44%). Among the total 50 patients, 34(68%) had successful spontaneous breathing trials, and 27 (79.41%) among them were successfully extubated. Thus, the overall weaning success rate was 54% (n=27). The flow of patients and their outcomes is depicted in Figure 1. The APACHE II score and length of hospital stay were significantly lower in the weaning success group, indicating that lower illness severity and shorter hospitalization correlate with better outcomes. However, no significant difference was observed in age, gender, presence of comorbidities, duration of mechanical ventilation, or BMI between the two groups. The association of different patient characteristics and their outcomes have been shown in Table 2.

Key physiological predictors such as RSBI, mLUS, DE, and DTI were significantly different between groups. Specifically, RSBI and mLUS scores were lower, while DE and DTI values were higher in the weaning success group as shown in Table 3. Among all, DTI emerged as the strongest individual predictor of weaning success with an AUC of 0.948. Combined predictor models showed highest diagnostic accuracy for RSBI + DTI (94%), followed by RSBI + DE (90%) and RSBI + mLUS (88%) as depicted in Table 4. Multivariate logistic regression analyses were performed to assess the independent predictive value of each parameter after adjusting for confounding variables. In separate models, DTI and DE were found to be significant independent predictors of weaning success. Specifically, DTI had an adjusted odds ratio (aOR) of 1.115 (95% CI: 1.019 to 1.220), indicating increased likelihood of success with higher DTI values. Similarly, DE had an aOR of 21.643 (95% CI: 1.761 to 266.044), suggesting a strong association between greater DE and weaning success. As depicted in ROC curves (Figure 2), all parameters demonstrated significant discriminatory power for predicting weaning success, with DTI showing an outstanding performance (AUC 0.948 ; 95% CI = 0.873 – 1.000), followed by DE (AUC 0.817 ; 95% CI = 0.697 – 0.937) with excellent, and RSBI (AUC 0.746 ; 95 % CI = 0.570-0.923) and mLUS (AUC 0.722 ; 95% CI = 0.573-0.871) with acceptable predictive accuracy. A comprehensive model including RSBI, mLUS, DTI, and DE showed excellent predictive performance with an AUC of 0.92 (95% CI = 0.80-0.98) and overall diagnostic accuracy of 92%. Thus, diaphragmatic ultrasound parameters, particularly DTI, provide robust, non-invasive tools to predict weaning success and should be incorporated into weaning protocols.

Discussion

Weaning from mechanical ventilation remains a multifactorial and challenging aspect of critical care, traditionally guided by clinician judgement and standard physiological parameters, including the RSBI. However, limitations in the predictive accuracy of RSBI have prompted the exploration of novel, non-invasive modalities such as lung and diaphragmatic ultrasound. In the present prospective study involving 50 adult patients who received mechanical ventilation for more than 24hrs, the overall weaning success rate was 54%, while 46% experienced weaning failure, defined as failure of the spontaneous breathing trial or extubation. Comparative analysis of demographic variables-including age, gender, BMI and comorbidities did not reveal any significant association with weaning outcomes. This is in line with various previous studies indicating limited predictive value of these parameters [11-15]. In contrast, successful weaning was significantly associated with lower APACHE II scores and a reduced length of stay underscoring the importance of physiological severity and recovery trajectory [13,16,17]. The predominant cause of respiratory failure in the study population was acute exacerbation of obstructive airway disease, accounting for 36% of cases, similar to findings of previous studies. However, this differs from global patterns where cardiac causes dominate, possibly due to our study being conducted in Respiratory ICU [13,14,18].

RSBI ranged from 31 to 133 in our study, with a significantly lower mean in the successful weaning group (50.71 ± 7.95) compared to the failure group (90.14 ± 36.85) with p value of <0.0001. A cut off value of ≤66.66 showed an AUC of 0.746, with a 100% sensitivity, 69.57% specificity, and a diagnostic accuracy of 86%. These findings are consistent with Okabe et al, who reported a similar cut-off of 72 on pressure support ventilation [19]. The lower RSBI values observed on PSV, as opposed to the original T-piece method by Yang and Tobin (cut-off 105), may account for the variation [20]. Since RSBI reflects the balance between respiratory load and muscle endurance, a higher value indicates a higher risk of weaning failure. Our results reinforce the utility of RSBI as a practical and reliable predictor in clinical settings.

The mLUS ranged from 1 to 14, with a mean of 5.64±2.97. The score was significantly lower in the successful weaning group (mean 4.56±2.06) compared to the failure group (mean 6.91±3.38) (p=0.004). A cut-off value of mLUS of ≤ 6 predicted successful weaning with AUC of 0.722, sensitivity of 85.2%, specificity of 56.5%, PPV of 69.7%, NPV of 76.5%, and overall diagnostic accuracy of 72%. These findings are in line with previous studies, such as Tenza Losano et al., who reported a similar cut-off (<7) [21]. Variations in cut-off values across studies may reflect differences in methodology; for example, Soummer et al. and Osman and Hashim used the original LUS protocol assessing 12 lung zones (maximum score 36), whereas our simplified mLUS protocol assessed 8 zones (maximum score 24), prioritizing bedside feasibility and patient comfort [7,22].

Diaphragmatic parameters included in the study were DE and DTI, assessed exclusively on the right hemidiaphragm due to technical limitations and difficulty associated with left-sided evaluation [22,23]. DE, measured via M-mode in the right subcoastal window, ranged from 0.33 to 2.76cm (mean 1.83±0.53), and was significantly higher in the successful weaning group (p< 0.0001). A DE cut-off value >1.58 cm predicted successful weaning with an AUC of 0.817, sensitivity of 100%, specificity of 56.5%, PPV of 73%, NPV of 100%, and diagnostic accuracy of 80%. Prior studies have reported variable DE cut-offs, from >1.05 cm to >2.5cm, likely due to differences in posture, abdominal compliance and technical factors [22,24,25]. These findings highlight the need for standardization in methodology to enhance the predictive value of DE in clinical practice. DTI was measured from the right intercoastal window using M-mode ultrasound in the semi-recumbent position at the zone of apposition, where the muscular diaphragm is best visualized. Since the diaphragm thicken during inspiration, DTI serves as a dynamic marker of diaphragmatic contractility, often compared to the cardiac ejection fraction [26]. In our study, mean diaphragmatic thickness at the end inspiration was 0.32 ± 0.09 cm, and at end-expiration (dte) was 0.21 ± 0.05 cm. DTI, calculated as (dti–dte)/dte × 100, ranged from 16.2% to 100% with a mean of 46.92 ± 21.47%. It was significantly higher in the successful weaning group ($P < 0.0001$). A DTI cut-off > 38.79% predicted successful weaning with an AUC of 0.948, sensitivity of 100%, specificity of 86.96%, PPV of 90%, NPV of 100%, and diagnostic accuracy of 94%. These findings align with previous studies: DiNino et al reported a cut-off ≥30%, while Ferrari et al and Farghaly et al found thresholds of > 36% and > 34.2% respectively [15,25,27]. The strong concordance across studies underscores DTI as a reliable, reproducible ultrasound-based predictor of weaning success.

DTI demonstrated the highest diagnostic accuracy (94%) among all parameters, followed by RSBI (86%), DE (80%), and modified Lung Ultrasound Score (mLUS) (72%). The superior performance of DTI can be attributed to its direct assessment of diaphragmatic contractility, whereas RSBI, influenced by accessory muscle activity, may appear normal despite underlying diaphragmatic weakness. Since accessory muscles fatigue easily, reliance on them can lead to weaning failure despite apparently acceptable RSBI values.

When RSBI was combined with DE, the diagnostic accuracy improved to 90%, with increased specificity and positive predictive value. Similarly, combining RSBI with mLUS enhanced accuracy to 88%. Combining RSBI with DTI further improved predictive performance, although DTI alone remained superior. When all four parameters—RSBI, DTI, DE, and mLUS—were combined, the AUC reached 0.92 (95% CI = 0.80-0.98), with a diagnostic accuracy of 92%, sensitivity of 96.3% (95% CI = 81.3-99.91%), specificity of 86.96% (95% CI = 66.41-97.22%), PPV of 89.66%, and NPV of 95.24%. However, even this comprehensive combination did not surpass DTI alone in diagnostic accuracy.

These results align partially with findings by Saravanan et al., where DTI outperformed RSBI. In their study, DE was the best standalone parameter, but combined parameters did not significantly exceed the performance of DTI or DE alone [28]. Our study supports the use of ultrasound-based indices as valuable, non-invasive, and cost-effective tools that enhance weaning prediction, either as standalone markers or in conjunction with traditional methods like RSBI. The integration of lung and diaphragmatic ultrasound into weaning protocols may facilitate more accurate clinical decisions, ultimately minimizing complications associated with both delayed and premature extubation.

Conclusions

Our study demonstrates that both lung and diaphragm ultrasound are valuable adjuncts in assessing patients undergoing weaning from mechanical ventilation. Parameters such as the Modified Lung Ultrasound Score (mLUS), Diaphragmatic Excursion (DE), and Diaphragmatic Thickening Index (DTI) showed good predictive utility, with DTI outperforming the traditional RSBI. These findings support the routine incorporation of diaphragmatic and lung ultrasound alongside comprehensive clinical assessment during weaning. Wider availability of ultrasound equipment in ICUs and focused training of clinicians in critical care ultrasonography can significantly enhance weaning decisions and overall patient outcomes.

Limitations

Despite demonstrating the utility of both diaphragmatic and lung ultrasound as effective weaning predictors, this study has certain limitations. As the study population predominantly included patients with acute exacerbation of obstructive airway disease and pneumonia, the results may not be generalizable to patients with other etiologies of respiratory failure, such as postoperative or cardiogenic causes. Additionally, only the right hemidiaphragm was assessed due to technical challenges in visualizing left hemidiaphragm. As functional asymmetry between hemidiaphragms may occur, restricting assessment to the right side constitutes a methodological limitation. This was a single-center study with a relatively small sample size, which further limits external validity. Furthermore, the absence of concurrent measurements such as transdiaphragmatic pressure or maximal inspiratory pressure limited the ability to further validate diaphragmatic strength.

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Table 1. Lung ultrasound aeration patterns and corresponding modified lung ultrasound score.

Pattern	**Description and assigned score**
N pattern	Normal Aeration: presence of lung sliding with A lines and fewer than 2 isolated B lines. **Score - 0**
B1 pattern	Moderate loss of pulmonary ventilation: >2 well-defined B lines. **Score - 1**
B2 pattern	Severe loss of pulmonary ventilation: multiple coalescing B lines. **Score - 2**
C pattern	Pulmonary Consolidation: presence of a tissue pattern or dynamic air bronchogram. **Score - 3**
Total mLUS score	Ranges from **0 to 24** points

Table 2. Consolidated comparison of clinical parameters between weaning success and failure groups.

Variable	Successful (n=27)	Failure (n=23)	p	Test used
Age (Mean ± SD)	53.56 ± 19.02	50.87 ± 18.21	0.614	Independent t-test
Age Median (IQR)	62 (44–67)	60 (36–66)		
Gender (Female)	16 (59.26%)	9 (39.13%)	0.156	Chi-square test
Comorbidities (Present)	19 (70.37%)	11 (47.83%)	0.105	Chi-square test
APACHE II Score (Mean ± SD)	9.63 ± 5.06	12.48 ± 3.8	0.031*	Independent t-test
APACHE II Median (IQR)	8 (5.5–13)	13 (10–15.5)		
Length of Hospital Stay (days)	11.48 ± 10.87	17.3 ± 13.01	0.021*	Mann-Whitney U test
Hospital Stay Median (IQR)	8 (5.5–13)	12 (8.5–22.5)		
MV Duration (days)	8.07 ± 5.8	9.04 ± 5.1	0.276	Mann-Whitney U test
MV Duration Median (IQR)	6 (4.5–9.5)	8 (6–11.5)		
BMI (Mean ± SD)	22.19 ± 3.75	22.01 ± 2.53	0.847	Independent t-test
BMI <18.5 (Underweight)	4 (14.81%)	1 (4.35%)	0.645	Fisher's exact test
BMI 18.5–22.99 (Normal)	13 (48.15%)	14 (60.87%)		
BMI 23–24.99 (Overweight)	5 (18.52%)	3 (13.04%)		
BMI ≥25 (Obese)	5 (18.52%)	5 (21.74%)		
*statistically significant (p <0.05)				

Table 3. Comparison of RSBI and diaphragmatic ultrasound parameters between weaning success and failure groups.

Parameter	Successful (n=27)	Failure (n=23)	Total	P-value
RSBI (breaths/min/L)				
Mean ± SD	50.71 ± 7.95	90.14 ± 36.85	68.85 ± 32.21	< 0.0001*
Median (IQR)	51 (44.1–56)	100 (52.4–124.9)	55.1 (43.7–91.1)	
Range	33.3–66.7	31–133	31–133	
Modified LUS Score (mLUS)				
Mean ± SD	4.56 ± 2.06	6.91 ± 3.38	5.64 ± 2.97	0.004*
Median (IQR)	5 (3–6)	7 (4.5–9)	6 (4–7)	
Range	1–8	1–14	1–14	
Diaphragmatic Thickening Index (DTI) (%)				
Mean ± SD	59.62 ± 19.28	32.01 ± 12.55	46.92 ± 21.47	< 0.0001*
Median (IQR)	51 (44.8–69.2)	31.3 (24.4–35.2)	43.1 (33–54.1)	
Range	40.3–100	16.2–77.8	16.2–100	
Diaphragmatic Excursion (cm)				
Mean ± SD	2.12 ± 0.28	1.49 ± 0.55	1.83 ± 0.53	< 0.0001*
Median (IQR)	2.13 (1.95–2.21)	1.53 (1.08–1.98)	1.98 (1.61–2.16)	
Range	1.69–2.76	0.33–2.22	0.33–2.76	

*Statistically significant (p < 0.05); Independent t-test used for comparison between groups. IQR, Interquartile Range

Table 4. Sensitivity, specificity, positive predictive value and negative predictive value of combination of RSBI with mLUS score, Diaphragmatic thickening index, Diaphragmatic excursion individually for predicting weaning success.

Variables	**Combination of RSBI and mLUS score**	**Combination of RSBI and Diaphragmatic Thickening Index (DTI)**	**Combination of RSBI and Diaphragmatic Excursion (DE)**
Sensitivity (95% CI)	100.00% (87.23 % to 100.00%)	100.00% (87.23% to 100.00 %)	100.00% (87.23% to 100.00%)
Specificity (95% CI)	73.91% (51.59% to 89.77%)	86.96% (66.41% to 97.22%)	78.26% (56.30% to 92.54%)
AUC* (95% CI)	0.87 (0.74 to 0.95)	0.93 (0.83 to 0.99)	0.89 (0.77 to 0.96)
PPV* (95% CI)	81.82% (64.54% to 93.02%)	90.00% (73.47% to 97.89%)	84.37% (67.21% to 94.72%)
NPV* (95% CI)	100.00% (80.49 % to 100.00%)	100.00% (83.16% to 100.00%)	100.00% (81.47% to 100.00%)
Diagnostic accuracy	88.00%	94.00%	90.00%
*AUC – Area Under Curve, PPV – Positive Predictive Value, NPV – Negative Predictive value			

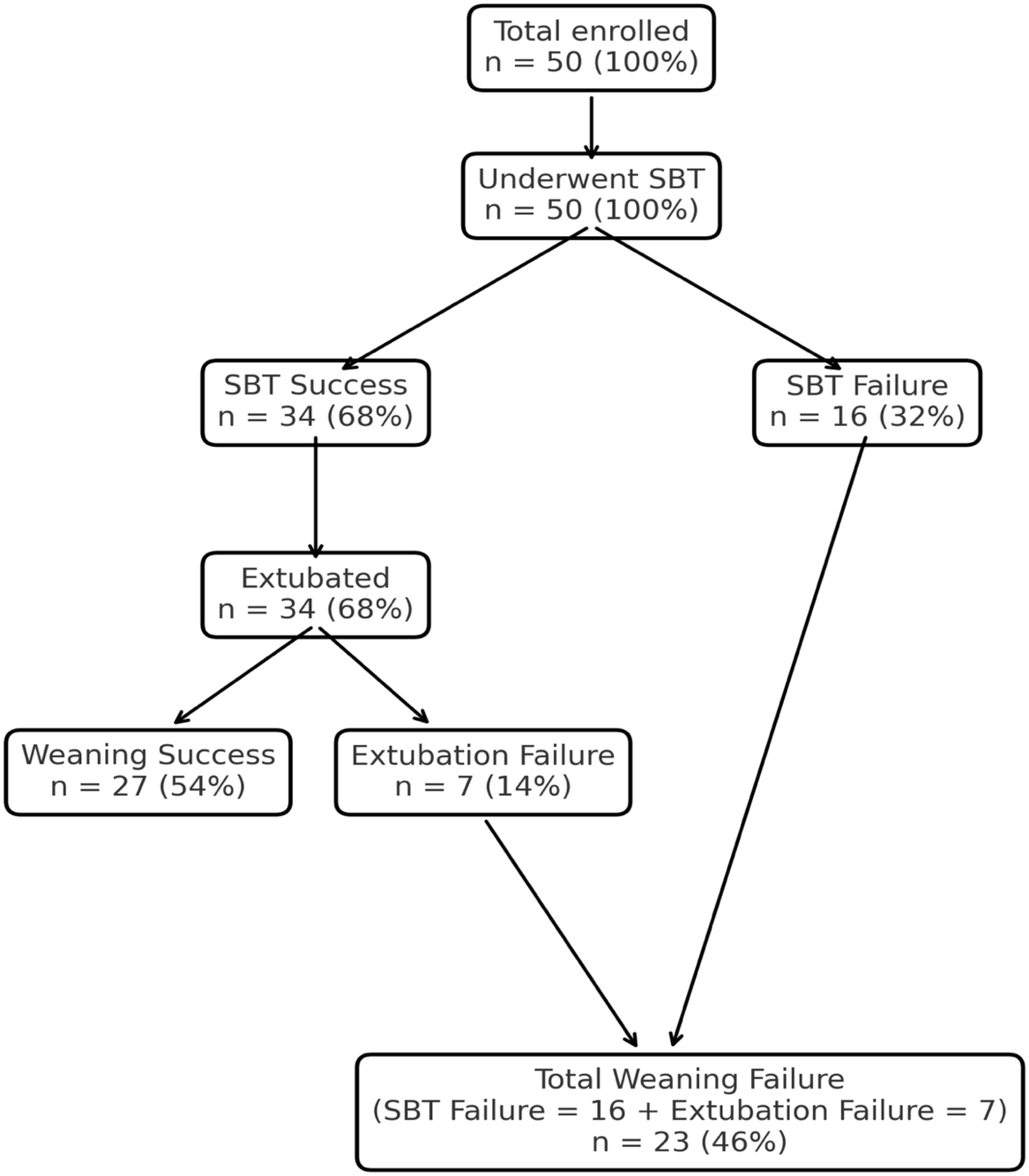

Figure 1. Flow diagram of patient enrollment, spontaneous breathing trial (SBT) outcomes, and final weaning outcomes.

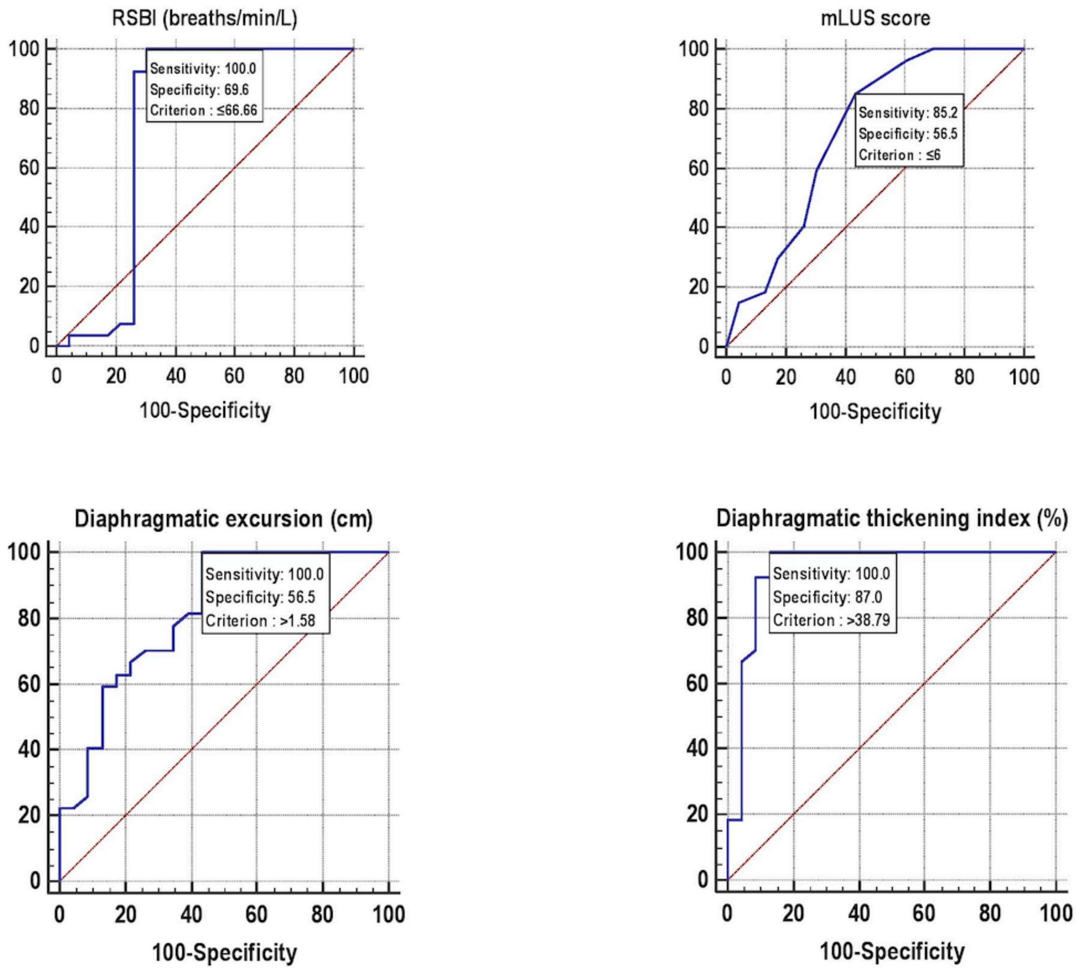

Figure 2. Receiver operating characteristic (ROC) curves with AUC values and corresponding 95% confidence intervals for RSBI, mLUS, Diaphragmatic thickening index and Diaphragmatic excursion for predicting weaning success.