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Original Research Article

RATE OF CHANGE OF RAPID SHALLOW BREATHING INDEX AS A PREDICTOR OF EXTUBATION OUTCOME IN MECHANICALLY VENTILATED PATIENTS – AN OBSERVATIONAL PROSPECTIVE STUDY

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ABSTRACT

Background: Successful liberation from mechanical ventilation requires accurate assessment of a patient's ability to sustain spontaneous breathing after removal of ventilatory support. The Rapid Shallow Breathing Index (RSBI) is widely used for weaning assessment; however, a single measurement may not adequately reflect evolving respiratory fatigue. Serial assessment and the rate of change in RSBI may provide better prediction of extubation outcome. The aim is to evaluate the rate of change of RSBI as a predictor of extubation outcome in mechanically ventilated patients.
Materials and Methods: This hospital-based prospective observational study was conducted in the Critical Care Unit of Ramkrishna Care Hospital, Raipur, from September 2024 to December 2025. A total of 201 mechanically ventilated patients were screened, of whom 180 completed the study protocol. RSBI was recorded at the 5th and 120th minutes of a spontaneous breathing trial, and the percentage rate of change was calculated. Patients were classified as extubation success, extubation failure, or weaning failure. ROC analysis was performed to assess predictive accuracy.
Results: Extubation success occurred in 89 (49.44%) patients, extubation failure in 38 (21.11%), and weaning failure in 53 (29.44%). Mean RSBI at 120 minutes was 62.98±7.75, 74.16±3.69, and 85.02±9.4 in the three groups, respectively ($p<0.001$). Corresponding RSBI 5–120 rates were 21.1±3.61%, 33.42±6.87%, and 38.42±8.65% ($p<0.001$). The AUC was 0.94 for RSBI at 120 minutes and 0.96 for RSBI rate.
Conclusion: The rate of change of RSBI during a 120-minute spontaneous breathing trial showed excellent predictive ability for extubation outcome. Serial RSBI assessment may provide a simple and useful bedside tool for identifying patients at risk of extubation or weaning failure.
Keywords: Rapid Shallow Breathing Index; Extubation; Mechanical Ventilation; Spontaneous Breathing Trial; Weaning Failure.

INTRODUCTION

Invasive mechanical ventilation is an essential component of modern critical care and provides life-sustaining respiratory support to patients unable to maintain adequate ventilation, oxygenation, or airway protection. Although indispensable during acute critical illness, prolonged ventilatory support is associated with complications including ventilator-associated pneumonia, airway injury, respiratory muscle weakness, ventilator-induced lung injury, increased sedation exposure, and prolonged intensive care unit stay. Consequently, liberation from mechanical ventilation should be considered once the underlying cause of respiratory failure has improved and the patient can sustain spontaneous breathing. Current clinical practice emphasizes structured assessment of readiness for liberation followed by an appropriately conducted spontaneous breathing trial (SBT).[1] The transition from assisted ventilation to spontaneous breathing is a complex physiological process. Successful weaning requires adequate respiratory drive, satisfactory gas exchange, cardiovascular stability, sufficient respiratory muscle strength, preserved neurological status, effective cough, and the ability to clear airway secretions. Passing an SBT is an important step; however, it does not invariably guarantee successful extubation. The decision to remove an endotracheal tube therefore remains challenging because both premature extubation and unnecessary delay may adversely affect the patient. Contemporary approaches increasingly favor integration of respiratory and non-respiratory variables rather than dependence on a single measurement.[2] Among the bedside indices used to assess readiness for liberation, the rapid shallow breathing index (RSBI) remains one of the most familiar and easily obtainable parameters. RSBI is calculated as the ratio of respiratory frequency in breaths per minute to tidal volume expressed in litres. It reflects the breathing pattern adopted during spontaneous or minimally supported breathing. A relatively low RSBI represents slower breathing with an adequate tidal volume, whereas an increasing RSBI reflects rapid, shallow respiration that may indicate inability to sustain the respiratory workload after withdrawal of ventilatory assistance. Its simplicity, non-invasive nature, and rapid availability have supported its continued bedside use.[3] Nevertheless, extubation readiness is multifactorial, and the predictive value of a single RSBI measurement can be influenced by measurement technique, timing, level of ventilatory assistance, endotracheal tube characteristics, respiratory muscle performance, neurological status, and underlying pulmonary pathology. Patients with airway disease, parenchymal lung disease, or apparently normal lungs may respond differently when ventilatory support is reduced. Contemporary research has therefore examined RSBI together with physiological markers such as diaphragm excursion, diaphragm thickening, cough strength, oxygenation indices, respiratory mechanics, and clinical variables. Such approaches emphasize that the response during an SBT is dynamic rather than a fixed physiological state.[4,5] The temporal behavior of RSBI during an SBT may provide information not captured by an isolated value. A patient may initially demonstrate an acceptable breathing pattern but subsequently develop respiratory muscle fatigue, increased respiratory frequency, reduced tidal volume, or respiratory distress as the trial continues. Conversely, another patient may maintain a stable breathing pattern throughout the observation period. Measuring RSBI at more than one time point allows this change to be quantified. The rate of change of RSBI can be expressed as the percentage change between an initial and a later measurement, describing whether respiratory efficiency remains stable or progressively deteriorates during spontaneous breathing.[6]

MATERIALS AND METHODS

This hospital-based observational study was conducted using a prospective study design in the Critical Care Unit of Ramkrishna Care Hospital, Raipur. The total study period extended from September 2024 to December 2025, of which 12 months were allotted for data collection. Prior to initiation of the study, approval was obtained from the Institutional Ethics Committee (IEC) of Ramkrishna Care Hospital, Raipur. 180 patients were included in this study.

Eligibility Criteria and Sampling Method: Adult patients aged 18 years or above who had received invasive mechanical ventilation for more than 24 hours and were undergoing their first attempt at weaning were considered eligible for inclusion. Patients were included when there was resolution of the acute phase of the disease responsible for mechanical ventilation, an endotracheal tube with an internal diameter of 7.5 mm or more was in situ, the patient was conscious and neurologically stable, and cardiovascular stability was present, defined as a heart rate below 120 beats/min and systolic blood pressure above 90 mmHg with minimal or no vasopressor requirement. Patients younger than 18 years, those ventilated for less than 24 hours, patients with tracheostomy, an endotracheal tube internal diameter of less than 7.5 mm, second or subsequent weaning attempts, hemodynamic instability, or underlying neuromuscular disease were excluded.

Methodology: All adult patients admitted to the ICU and receiving invasive mechanical ventilation for more than 24 hours were screened for eligibility. All enrolled patients continued to receive standard ICU management, and the decision regarding readiness for spontaneous breathing trial (SBT) and extubation was made according to the existing ICU protocol. Before initiation of the SBT, oxygenation and ventilation status, airway adequacy, cough and gag reflexes, hemoglobin level, cardiovascular and hemodynamic stability, neurological status and neuromuscular status were assessed. Patients were maintained in a semi-recumbent position with the head end elevated to approximately 30–45°. Endotracheal and oral suctioning was performed before starting the SBT, and endotracheal tube cuff pressure was maintained at approximately 25 cm H_2O. Ventilators and flow sensors were periodically calibrated and checked for leaks, and appropriate apnea backup, tidal volume, respiratory rate, minute ventilation and airway pressure alarms were ensured. Arterial blood gas analysis, when clinically required, was performed at the discretion of the treating physician and was not included as a study variable.

For the spontaneous breathing trial, the ventilator was switched to spontaneous pressure support ventilation with pressure support of 5–8 cm H_2O, positive end-expiratory pressure (PEEP) of 5 cm H_2O and fraction of inspired oxygen (FiO_2) not exceeding 40%. The patient was observed closely during the initial five minutes for evidence of respiratory distress, hypoxemia, reduced respiratory effort, restlessness or hemodynamic deterioration. Patients who failed to tolerate the first five minutes were returned to their previous controlled mode of ventilation and were not included in further RSBI analysis. In patients who tolerated the initial period, the first RSBI value was recorded directly from the ventilator display at the fifth minute. The spontaneous breathing trial was continued for up to 120 minutes while monitoring for respiratory muscle fatigue and clinical deterioration. Patients who could not tolerate the trial during this period were managed by increasing pressure support or returning to controlled ventilation according to the treating physician's decision and were categorized as weaning failures. Glasgow Coma Scale score, systolic blood pressure, heart rate, respiratory rate and tidal volume were recorded at 30-minute intervals throughout the SBT.

At the completion of 120 minutes, the second RSBI value was recorded. The rate of change of RSBI between the fifth and 120th minute was calculated using the formula: RSBI 5–120 (%) = $[(RSBI_{120} - RSBI_5)/RSBI_5] \times 100$, where $RSBI_5$ represented the RSBI measured at the fifth minute and $RSBI_{120}$ represented the value measured at the end of the 120-minute spontaneous breathing trial. RSBI was obtained directly from the mechanical ventilator display and represented the ratio of respiratory frequency to tidal volume expressed in litres. Patients who remained alert, obeyed commands, maintained stable respiratory and hemodynamic parameters, had adequate cough and gag reflexes and had minimal airway secretions at the end of the SBT were considered suitable for extubation. Patients who were successfully extubated received supplemental oxygen, nebulized bronchodilators when required, chest physiotherapy, deep-breathing exercises and incentive spirometry according to routine ICU practice.

Outcome Assessment and Definitions: Patients were followed for 24 hours following completion of the spontaneous breathing trial and were classified into three outcome categories. Weaning failure was defined as inability to proceed with extubation after the 120-minute spontaneous breathing trial because of respiratory, neurological, hemodynamic or other clinical concerns as determined by the treating ICU physician. Extubation failure was defined as the requirement for reintubation and reinstitution of invasive mechanical ventilation within 24 hours after extubation. Extubation success was defined as successful maintenance of spontaneous breathing without the requirement for reintubation or invasive airway support during the first 24 hours following extubation. Following extubation, all patients remained under close ICU observation for at least 24 hours, during which respiratory status, neurological status, oxygenation and hemodynamic parameters were monitored. Supplemental oxygen and non-invasive ventilation were provided whenever clinically indicated. Patients who developed respiratory, neurological, cardiac or hemodynamic deterioration necessitating reintubation within the observation period were classified as having extubation failure. The primary study variables were RSBI measured at the fifth and 120th minutes and the percentage rate of change in RSBI between these two time points.

Statistical Analysis and Ethical Considerations: Data were analyzed using SPSS version 21.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages; ANOVA with Tukey's post hoc test and ROC analysis were applied as appropriate. Sensitivity, specificity, predictive values, likelihood ratios, and diagnostic accuracy were calculated, with $p<0.05$ considered statistically significant. Ethical approval was obtained from the Institutional Ethics Committee of Ramkrishna Care Hospital, Raipur, and written informed consent was obtained while maintaining confidentiality and anonymity.

RESULTS

A total of 201 patients were initially enrolled in the study. Of these, 21 patients were excluded because they failed to tolerate the spontaneous breathing trial (SBT). Therefore, the final analysis was carried out on 180 patients who completed the required study assessment. A total of 201 patients were initially enrolled in the study. Of these, 21 patients were excluded because they failed to tolerate the spontaneous breathing trial (SBT). Therefore, the final analysis was carried out on 180 patients who completed the required study assessment.

[Table 1] Demographic Distribution of Study Participants According to Age and Sex

[Table 1] shows the age and sex distribution of the 180 study participants. The largest proportion of patients belonged to the 51–60 years age group, comprising 51 (28.33%) patients, followed by 42 (23.33%) patients in the 61–70 years age group. The 41–50 years age group included 33 (18.33%) patients, while 21 (11.67%) patients were aged 71–80 years and 18 (10%) patients were aged 31–40 years. Eight (4.44%) patients belonged to the 81–90 years age group, 5 (2.78%) were aged ≤30 years, and only 2 (1.11%) patients were older than 90 years. Regarding sex distribution, 99 (55%) participants were male and 81 (45%) were female, showing a slight male predominance in the study population.

[Table 2] Distribution of Study Participants According to Disease Group and Comorbidities

[Table 2] presents the distribution of patients according to lung disease group and associated comorbidities. Of the 180 patients, 63 (35%) belonged to the parenchymal disease group, 62 (34.44%) belonged to the airway disease group, and 55 (30.56%) had normal lungs. Thus, the three lung-status groups were relatively evenly distributed, with parenchymal disease constituting the largest group.

Among the recorded comorbidities, hypertension was the most common and was present in 43 (23.89%) patients, followed by diabetes mellitus in 17 (9.44%) patients and coronary artery disease in 10 (5.56%) patients.

[Table 3] Distribution of Extubation Outcomes among Study Participants

[Table 3] demonstrates the final extubation and weaning outcomes among the 180 patients. Extubation success was observed in 89 (49.44%) patients, representing the largest outcome group. Extubation failure occurred in 38 (21.11%) patients, whereas 53 (29.44%) patients were categorized as having weaning failure. Therefore, nearly half of the study participants achieved successful extubation, while the remaining patients experienced either extubation failure or failure to proceed successfully through the weaning process.

[Table 4] Demographic and Clinical Characteristics of the Patients According to Outcome

[Table 4] compares demographic and clinical characteristics across the extubation success, extubation failure, and weaning failure groups. The mean age was 56.8±14.64 years among patients with extubation success, 58±12.83 years among those with extubation failure, and 57.38±14.64 years among patients with weaning failure. The difference in mean age among the three groups was not statistically significant (p=0.61). Among patients with successful extubation, 55 (61.8%) were male and 34 (38.2%) were female. In the extubation failure group, 17 (44.74%) were male and 21 (55.26%) were female, while among patients with weaning failure, 27 (50.94%) were male and 26 (49.06%) were female. The difference in sex distribution among the outcome groups was also not statistically significant (p=0.16). With respect to lung status, among the 89 patients with extubation success, 24 (26.97%) had normal lungs, 21 (23.6%) had airway disease, and 44 (49.44%) had parenchymal disease. Among the 38 patients with extubation failure, 15 (39.47%) had normal lungs, 16 (42.11%) had airway disease, and 7 (18.42%) had parenchymal disease.

[Table 5] Comparison of RSBI at 120 Minutes and RSBI Rate (5–120 Minutes) According to Extubation Outcome and Lung Status

[Table 5] compares RSBI measured at 120 minutes and the rate of change in RSBI from 5 to 120 minutes across the three outcome groups. Considering all patients, the mean RSBI at 120 minutes was 62.98±7.75 in the extubation success group, 74.16±3.69 in the extubation failure group, and 85.02±9.4 in the weaning failure group. The difference among these groups was highly statistically significant (p<0.001). Thus, progressively higher mean RSBI values at 120 minutes were recorded across extubation success, extubation failure, and weaning failure groups.

In patients with normal lungs, the mean RSBI at 120 minutes was 62.13±8.19 among 24 patients with extubation success, 73.46±3.9 among 15 patients with extubation failure, and 84.93±10.28 among 16 patients with weaning failure, with a highly significant difference (p<0.001). In the airway disease group, corresponding mean RSBI values were 62.69±7.97, 74.46±3.83, and 85.23±9.21 in the extubation success, extubation failure, and weaning failure groups, respectively (p<0.001). Similarly, among patients with parenchymal disease, mean RSBI at 120 minutes was 63.59±7.52 in the extubation success group, 74.97±3.07 in the extubation failure group, and 84.68±8.98 in the weaning failure group. This difference was also highly statistically significant (p<0.001).

[Table 6] Combined ROC Analysis of RSBI at 120 Minutes and RSBI Rate (5–120 Minutes) for Prediction of Extubation Failure in Overall and Lung Disease Groups

[Table 6] presents the receiver operating characteristic analysis of RSBI at 120 minutes and the RSBI rate from 5 to 120 minutes for prediction of extubation failure. In the overall study population, RSBI at 120 minutes demonstrated an area under the curve (AUC) of 0.94 with a standard error of 0.016 and 95% confidence interval of 0.912–0.975. The RSBI rate from 5 to 120 minutes demonstrated an AUC of 0.96 with a standard error of 0.013 and 95% confidence interval of 0.94–0.99. Both ROC findings were statistically significant (p<0.001).

In the normal lung group, the AUC for RSBI at 120 minutes was 0.923 with a standard error of 0.035 and 95% confidence interval of 0.85–0.99, whereas the RSBI rate from 5 to 120 minutes had an AUC of 0.96 with a standard error of 0.028 and 95% confidence interval of 0.90–0.99. Both parameters showed statistically significant ROC results (p<0.001).

Table 1: Demographic Distribution of Study Participants According to Age and Sex (N=180)

Variable	Category	N	%
Age group	≤30 years	5	2.78
	31–40 years	18	10
	41–50 years	33	18.33
	51–60 years	51	28.33
	61–70 years	42	23.33
	71–80 years	21	11.67
	81–90 years	8	4.44
	>90 years	2	1.11
	Total	180	100
Sex distribution	Male	99	55
	Female	81	45
	Total	180	100

Table 2: Distribution of Study Participants According to Disease Group and Comorbidities

Variable	Category	N	%
Lung Group	Normal	55	30.56
	Airway	62	34.44
	Parenchymal	63	35
	Total	180	100
Co-morbidity	HTN	43	23.89
	DM	17	9.44
	CAD	10	5.56
	CKD	7	3.89
	COPD	5	2.78
	CVA	5	2.78
	Hypothyroid	5	2.78
	CLD	4	2.22
	Chromic pancreatitis	2	1.11
	OSA	1	0.56

Table 3: Distribution of Extubation Outcomes among Study Participants (N=180)

Extubation outcome	N	%
Extubation Success	89	49.44
Extubation Failure	38	21.11
Weaning Failure	53	29.44
Total	180	100

Table 4: Demographic and Clinical Characteristics of the Patients According to Outcome

Patient characteristics and outcomes	Extubation Success (N=89)	Extubation Failure (N=38)	Weaning Failure (N=53)	P value
Age (Mean ± SD)	56.8±14.64	58±12.83	57.38±14.64	0.61 NS*
Sex (M:F)	55(61.8%):34(38.2%)	17(44.74%):21(55.26%)	27(50.94%):26(49.06%)	0.16 NS**
Lung status				
Normal lung	24(26.97%)	15(39.47%)	16(30.19%)	0.37 NS**
Airway	21(23.6%)	16(42.11%)	25(47.17%)	0.009 HS**
Parenchymal	44(49.44%)	7(18.42%)	12(22.64%)	<0.001 HS**

*One-way ANOVA; **Chi-square test; NS = Not significant; HS = Highly significant.

Table 5: Comparison of RSBI at 120 Minutes and RSBI Rate (5–120 Minutes) According to Extubation Outcome and Lung Status

Parameter / Group	Extubation Success N	Mean ± SD	Extubation Failure N	Mean ± SD	Weaning Failure N	Mean ± SD	P value
RSBI 120							
All patients	89	62.98±7.75	38	74.16±3.69	53	85.02±9.4	<0.001 HS
Normal lung	24	62.13±8.19	15	73.46±3.9	16	84.93±10.28	<0.001 HS
Airway	21	62.69±7.97	16	74.46±3.83	25	85.23±9.21	<0.001 HS
Parenchymal	44	63.59±7.52	7	74.97±3.07	12	84.68±8.98	<0.001 HS
RSBI 5–120							
All patients	89	21.1±3.61	38	33.42±6.87	53	38.42±8.65	<0.001 HS
Normal lung	24	21.1±4.04	15	32.08±6.93	16	38.54±7.86	<0.001 HS
Airway	21	21.45±2.83	16	34.99±6.52	25	38.13±9.21	<0.01 HS
Parenchymal	44	20.93±3.75	7	32.72±7.84	12	38.86±9.06	<0.01 HS

Table 6: Combined ROC Analysis of RSBI at 120 Minutes and RSBI Rate (5–120 Minutes) for Prediction of Extubation Failure in Overall and Lung Disease Groups

Study Group	Parameter	Area Under Curve (AUC)	Std. Error	Asymptotic Sig.	95% CI Lower Bound	95% CI Upper Bound
All patients	RSBI at 120 minutes	0.94	.016	.000	0.912	0.975
	RSBI Rate (5–120 minutes)	0.96	0.013	.000	0.94	0.99
Normal Lung Group	RSBI at 120 minutes	0.923	.035	.000	0.85	0.99
	RSBI Rate (5–120 minutes)	0.96	.028	.000	0.90	0.99
Airway Disease Group	RSBI at 120 minutes	0.95	0.026	.000	0.90	1.00
	RSBI Rate (5–120 minutes)	0.98	.027	.000	0.96	1.00
Parenchymal Disease Group	RSBI at 120 minutes	0.96	.022	.000	0.915	1.000
	RSBI Rate (5–120 minutes)	0.955	.034	.000	0.88	1.00

DISCUSSION

The present study included 180 mechanically ventilated patients after exclusion of 21 of the initially enrolled 201 patients who could not tolerate the spontaneous breathing trial. The study population was predominantly middle-aged to elderly, with the largest proportion belonging to the 51–60-year age group (28.33%), followed by 61–70 years (23.33%), while males constituted 55% and females 45% of the population. These demographic findings were comparable to those reported by Karthika et al.

(2023), who initially enrolled 193 patients, excluded 33 because of intolerance to the 120-minute SBT, and finally analyzed 160 patients. Their mean age was 58±15.55 years, and 99 (62%) patients were male and 61 (38%) were female. Their patients were distributed into normal lung (n=49), airway disease (n=55), and parenchymal disease (n=56) groups. The present study similarly included 55 normal-lung, 62 airway-disease, and 63 parenchymal-disease patients, indicating a broadly comparable distribution of respiratory phenotypes despite a slightly lower male predominance in the present cohort.[7] In the present study, parenchymal disease constituted the largest lung group at 35%, closely followed by airway disease at 34.44%, while 30.56% of patients had normal lungs. Hypertension was the commonest associated comorbidity (23.89%), followed by diabetes mellitus (9.44%), coronary artery disease (5.56%), chronic kidney disease (3.89%), and COPD (2.78%). Saravanan et al. (2022) prospectively evaluated 200 mechanically ventilated patients and also demonstrated a heterogeneous clinical population, including 16 patients with chronic kidney disease and 12 with acute exacerbation of COPD; acute pulmonary edema was recorded in 20 patients. Of their 200 patients, 171 were successfully weaned and 29 experienced weaning failure. Thus, although the proportions of CKD and COPD in their cohort were approximately 8% and 6%, respectively, compared with 3.89% and 2.78% in the present study, both studies included patients with diverse pulmonary and extrapulmonary illnesses rather than a narrowly selected respiratory population.[8] Regarding clinical outcomes, extubation was successful in 89 (49.44%) patients in the present study, while 38 (21.11%) developed extubation failure and 53 (29.44%) had weaning failure. Frutos-Vivar et al. (2006) evaluated 900 mechanically ventilated adults who had successfully completed an SBT and reported extubation failure in 121 patients, corresponding to a rate of 13.4%. Their extubation failure rate was therefore lower than the 21.11% observed in the present study. Importantly, Frutos-Vivar et al. found that RSBI was independently associated with reintubation, with an odds ratio of 1.009 for every unit increase in RSBI (95% CI: 1.003–1.015). They further showed that patients with RSBI >57 breaths/min/L together with a positive fluid balance had an approximately threefold increased risk of extubation failure. The higher extubation failure rate in the present study may partly reflect differences in patient characteristics and the definition of the observation window, while both studies demonstrate an association between increasing RSBI and an unfavorable extubation outcome.[9] The mean age in the present study was similar across outcome categories: 56.8±14.64 years in the extubation-success group, 58±12.83 years in the extubation-failure group, and 57.38±14.64 years in the weaning-failure group, with no statistically significant difference (p=0.61). Sex distribution was also not significantly different among the three groups (p=0.16). Similar observations regarding age were reported by Turhan et al. (2024) in a prospective observational study of 86 mechanically ventilated ICU patients. Their study population had a mean age of 54.51±12.1 years and comprised 54 males and 32 females; extubation was successful in 53 patients and unsuccessful in 33 patients. They found no statistically significant difference in age between successful and unsuccessful extubation groups (p=0.246). These findings correspond closely with the present results and indicate that age alone did not discriminate between successful and unsuccessful liberation from mechanical ventilation in either population.[10]

The present study demonstrated important differences according to underlying lung status. Airway disease was present in 23.6% of the extubation-success group compared with 42.11% of the extubation-failure and 47.17% of the weaning-failure groups (p=0.009). Furthermore, among patients with airway disease, RSBI at 120 minutes progressively increased from 62.69±7.97 in successfully extubated patients to 74.46±3.83 in those with extubation failure and 85.23±9.21 in those with weaning failure (p<0.001). The corresponding RSBI 5–120 rates were 21.45±2.83%, 34.99±6.52%, and 38.13±9.21%, respectively (p<0.01). Goharani et al. (2019) specifically investigated 90 COPD patients with hypercapnic respiratory failure, of whom 43 (48%) achieved successful extubation and 47 (52%) failed extubation. They identified an RSBI threshold of ≤85 breaths/min/L as the best predictor of extubation success, with an AUC of 0.91, sensitivity of 95.6%, specificity of 90.4%, and diagnostic accuracy of 91.7%. Their results reinforce the present finding that RSBI has substantial discriminatory value among patients with underlying airway disease.[11] A progressive rise in RSBI at 120 minutes was one of the most prominent findings in the present study. For the whole cohort, mean RSBI at 120 minutes was 62.98±7.75 among patients with successful extubation, increased to 74.16±3.69 among patients with extubation failure, and reached 85.02±9.4 among patients with weaning failure (p<0.001). The same pattern was observed independently in normal-lung, airway-disease, and parenchymal-disease groups. Verceles et al. (2012) similarly found that repeated RSBI measurements differentiated patients who could and could not be successfully liberated from prolonged mechanical ventilation. In their cohort of 52 patients, 25 were successfully weaned. Mean RSBI was significantly lower among successfully weaned patients than those who failed weaning (78.7±14.2 vs 99.3±30.2; p=0.007), while the final RSBI was 71.7±31.2 in successfully weaned patients compared with 123.3±92.5 in unsuccessful patients (p=0.005). They also documented a rate of RSBI change of −3.40±9.40 points/day in successfully weaned patients compared with +4.40±11.1 points/day in those who failed (p=0.005). These findings parallel the progressive increase in RSBI associated with poorer outcomes in the present study.[12] The rate of change in RSBI between 5 and 120 minutes provided even clearer separation of the outcome groups in the present investigation. Among all patients, the mean RSBI 5–120 rate was 21.1±3.61% in the extubation-success group, compared with 33.42±6.87% in the extubation-failure group and 38.42±8.65% in the weaning-failure group ($p<0.001$). Similar highly significant differences were observed within normal-lung, airway, and parenchymal groups. This finding is strongly supported by Segal et al. (2010), who prospectively evaluated serial RSBI measurements every 30 minutes during a 2-hour SBT in 72 patients. Sixty-three patients remained successfully extubated at 24 hours and nine required reintubation. Although initial RSBI was similar between successful and failed extubation groups, RSBI remained stable or declined among successfully extubated patients, whereas it increased in every patient who subsequently failed extubation. Eight of the nine patients with extubation failure demonstrated an RSBI increase of ≥20%, compared with only 7 of 63 successfully extubated patients. A 20% increase during the 2-hour SBT predicted extubation outcome with sensitivity and specificity of approximately 89% each, closely supporting the dynamic RSBI pattern demonstrated in the present study.[13] ROC analysis in the present study demonstrated excellent discriminatory performance for both RSBI at 120 minutes and the RSBI 5–120 rate. In the overall population, RSBI at 120 minutes produced an AUC of 0.94 (95% CI: 0.912–0.975), while the RSBI rate produced a slightly higher AUC of 0.96 (95% CI: 0.94–0.99). The RSBI-rate AUC remained high in the normal-lung (0.96), airway-disease (0.98), and parenchymal-disease (0.955) groups. Pirompanich et al. (2018) evaluated RSBI in 34 mechanically ventilated patients, of whom 25 were successfully weaned and nine experienced weaning failure. RSBI alone yielded an AUC of 0.709, and an RSBI threshold ≤105 demonstrated sensitivity of 96%, specificity of 44.4%, positive predictive value of 82.8%, negative predictive value of 80%, and overall accuracy of 82.4%. When RSBI was combined with right diaphragmatic thickening fraction ≥26%, specificity increased to 77.8% and overall accuracy to 88.2%. Compared with their single RSBI measurement, the substantially higher AUC of 0.96 obtained for RSBI 5–120 in the present study indicates that assessment of the change in RSBI over the duration of the SBT provided particularly strong discrimination of extubation outcome in this cohort.[14]

CONCLUSION

The rate of change of the Rapid Shallow Breathing Index (RSBI) during a 120-minute spontaneous breathing trial was a strong predictor of extubation outcome in mechanically ventilated patients. Higher RSBI values at 120 minutes and greater RSBI 5–120 changes were significantly associated with extubation and weaning failure. The RSBI rate demonstrated excellent predictive accuracy across normal lung, airway disease, and parenchymal disease groups. Thus, serial RSBI assessment may serve as a simple and useful bedside tool to support extubation decision-making.

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