

Comparison between High and Low Rapid Shallow Breathing Indexes with Weaning of Patients in Prolonged Mechanical Ventilation

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Abstract

Background: *The rapid shallow breathing index is crucial considering the weaning of patients in prolonged mechanical ventilation.*

Objective: *The purpose of the present study was to compare the high and low rapid shallow breathing indexes with weaning of patients in prolonged mechanical ventilation.*

Methodology: *This cohort study was conducted in the Department of Anesthesia, Pain Palliative & Intensive Care Unit of Dhaka Medical College Hospital, Dhaka, Bangladesh from January 2014 to December 2015 for a period of two (02) years. Patients of ICU on mechanical ventilation more than 48 hours with the age of 18 to 60 years were included in this study. Standard weaning criteria was considered as resolution of the primary cause of respiratory failure, state of alertness, cooperation, response to commands and Glasgow coma scale (GCS) scores ≥ 9 . Primary and daily setting of ventilators and the decision to weaning of the patient was made by the ICU consultants. RSBI was then measured. The decision of weaning was not influenced by the RSBI. After measuring RSBI, patients was separated from mechanical ventilator and given T-piece trial (1 to 4 hours) and finally extubated as per advice of ICU consultant and observed for 48 hours. The patients were divided in two groups low RSBI ≤ 105 breath/min/L and high RSBI >105 breath/min/L. These patients were prospectively followed up to 48 hours in ICU and HDU.*

Result: *A total of 117 patients were included in this study. The mean age was found 35.42 ± 13.66 years with range from 18 to 60 years. The mean mechanical ventilation was found 9.6 ± 6.4 days in low RSBI group and 8.6 ± 4.5 days in high RSBI group ($p > 0.05$). The association between RSBI and success in weaning of the patients was recorded. In low RSBI group 94.6% patient's sustained extubation (success) and high RSBI group 76.0% patients' sustained extubation. Success was significantly higher in patients with low RSBI group ($p = 0.001$). The association between RSBI and weaning failure of the patients was measured. In high RSBI group failure was 6(24.0%) and success was 19(76.0%). On the other hand in low RSBI group failure was found 5(5.4%) and success was 87(94.6%) ($p = 0.011$).*

Conclusion: *In conclusion significant association is found between high and low rapid shallow breathing indexes with weaning of patients in prolonged mechanical ventilation.*

Keywords: *Comparison; high and low; rapid shallow breathing indexes; weaning of patients; prolonged mechanical ventilation.*

Introduction

Weaning from mechanical ventilation involves two different processes ventilator discontinuation and extubation. Weaning from mechanical ventilation is more complex than the mere manipulation of MV in an attempt to decrease support.¹ Scheinhorn et al² suggested that the key to successful weaning from mechanical ventilation is the reversal or significant improvement of the underlying condition that necessitated mechanical ventilation.³ One also requires technical competence, extensive knowledge of respiratory and cardiovascular physiology and pathophysiology, their associated interactions and fluid mechanics for successful weaning timely.⁴

Often weaning can be achieved easily, but may be difficult in up to 25% of patients, especially the critically ill who have been ventilated for a prolonged period of time.⁵⁻⁶ Shorter MV time can reduce complications by as much as 50%, and decrease the number of re-intubations.⁷

There are traditional criteria used in weaning of patients from mechanical ventilation which are resolution of the primary cause of respiratory failure, state of alertness, cooperation, response to commands and Glasgow coma scale (GCS) scores ≥ 9 , tidal volume during spontaneous breathing $V_T \geq 5$ ml/kg, PaO_2 (on $FiO_2 < 0.4$) > 60 mm of Hg, arterial pH > 7.3 and positive end expiratory pressure (PEEP) 5cm of H_2O or less.⁶ There are also other criteria of discontinuing mechanical ventilation such as body temperature $< 38^\circ C$, the patients not subjected to continuous sedation and hemodynamically stable.⁵

The rapid shallow breathing index was calculated by finding the respiratory frequency and tidal volume of the patient⁷. The physicians need to take prompt decision about weaning the patients from prolonged mechanical ventilation. Therefore, researcher planned to compare the high and low rapid shallow breathing indexes with weaning of patients in prolonged mechanical ventilation.

Methodology

This was a prospective cohort study. This study was conducted in the Department of Anesthesia, Pain Palliative & Intensive Care Unit of Dhaka Medical College Hospital, Dhaka, Bangladesh. This study was carried out from January 2014 to December 2015 for a period of two (02) years. The samples were collected by non-purposive sampling technique. Patients of ICU on mechanical

ventilation more than 48 hours with the age of 18 to 60 years were included in this study. Patients with tracheotomy, patients with spinal cord injury, self extubation or unplanned extubation, patients who expired before spontaneous breathing trial, patients shifted to another hospital before weaning and within 48 hours of weaning were excluded from this study. Ethical clearance certificate from Ethical Review Committee of Dhaka Medical College was obtained. Standard weaning criteria was considered. Single type of ventilator (eVent Medical) was used in all patients. Primary and daily setting of ventilators and the decision to weaning of the patient was made by the ICU consultants. During the weaning process, the arterial blood gases (ABG) values was checked and the patients was separated from mechanical ventilation by gradually decreasing the respiratory rate and pressure support (PS) in SIMV (synchronized intermittent mandatory ventilation) and PSV (pressure support ventilation) modes. Then spontaneous breathing trial was induced while the patient was attached to the ventilator with a low level of PS (7 cm of H_2O) and low PEEP (5 cm of H_2O or less). After one hour of spontaneous breathing trial (SBT) respiratory frequency (f) and exhaled tidal volume (EV_T) in one minute was recorded from the ventilator scales. Throughout the weaning trial, the FiO_2 setting was variable while vital signs, pulse oximetry, oxygen saturation (SPO_2) and hemodynamic status monitoring. The RSBI is expresses as breath/min/L. The decision of weaning was not influenced by the RSBI. Tracheal suction was performed as per need. After measuring RSBI, patients was separated from mechanical ventilator and given T-piece trial (1 to 4 hours) and finally extubated as per advice of ICU consultant and observed for 48 hours. If any patient was failed to T-piece trial then reconnected with mechanical ventilator and prepared the patient for further weaning. The patients were divided in two groups low RSBI ≤ 105 breath/min/L and high RSBI > 105 breath/min/L. These patients were prospectively followed up to 48 hours in ICU and HDU. Those groups of patients who were not reintubated within 48 hours are considered as success and those who needed reintubation or expired within 48 hours was considered as failure. Statistical analyses were carried out by using the Statistical Package for Social Sciences version 20.0 for Windows (SPSS Inc., Chicago, Illinois, USA). The mean values were calculated for continuous variables. The

qualitative observations were expressed by frequencies and percentages. Chi-Square test was used to analyze the categorical variables. Student Unpaired t-test was used for continuous variables such as age, RSBI etc. P value <0.05 was considered as statistically significant.

Result

A total of 117 patients were included in this study. Majority patients belonged to age 21 to 30 years which was 43(36.8%) cases and only 13(11.1%) patients belonged to age 50 to 60 years. The mean age was found 35.42±13.66 years with range from 18 to 60 years (Table I).

Table I: Distribution of the patients according to age (n=117)

Age Group	Frequency	Percent
18 to 20 Years	15	12.8
21 to 30 Years	43	36.8
31 to 40 Years	24	20.5
41 to 50 Years	22	18.8
51 to 60 Years	13	11.1
Total	117	100.0
Mean±SD	35.42±13.66	
Range (min-max)	18 to 60	

The duration of mechanical ventilation and rapid shallow breathing index of the patients was recorded. It was observed that majority patients had mechanical ventilation ≤7 days in low RSBI group which was 45(48.9%) cases and 15(60.0%) cases were in high RSBI group. The mean mechanical ventilation was found 9.6±6.4 days in low RSBI group and 8.6±4.5 days in high RSBI group. The mean duration of mechanical ventilation was not statistically significant between two groups (p>0.05) (Table II).

Table II Comparison of Duration of Mechanical Ventilation and Rapid Shallow Breathing Index (n=117)

Duration of MV (days)	Low RSBI	High RSBI	P value
≤7 Days	45(48.9%)	15(60.0%)	
8 to 14 Days	27(29.3%)	7(28.0%)	
15 to 21 Days	20(21.7%)	3(12.0%)	
Total	92(100.0%)	25(100.0%)	
Mean±SD	9.6±6.4	8.6±4.5	0.465
Range (min, max)	3 to 21	4 to 21	

P value was calculated by unpaired t-test; RSBI= rapid shallow breathing index

The association between RSBI and success in weaning of the patients was recorded. In low RSBI group 94.6% patient's sustained extubation (success) and high RSBI group 76.0% patients' sustained extubation. Success was significantly higher in patients with low RSBI group (p=0.001) (Table III).

Table III Association between rapid shallow breathing index (RSBI) and success in weaning (n=117)

RSBI	Success	Failure	Total	P value
Low RSBI	87(94.6%)	5(5.4%)	92(100.0%)	0.001
High RSBI	19(76.0%)	6(24.0%)	25(100.0%)	
Total	106	11	117(100.0%)	

Low RSBI (≤105 breath/min/L); High RSBI (>105 breath/min/L); the level of statistical significance was calculated by Chi square test.

The association between RSBI and weaning failure of the patients was measured. In high RSBI group (>105 breath/min/L) failure was 6(24.0%) and success was 19(76.0%). On the other hand in low RSBI group (≤105 breath/min/L) failure was found 5(5.4%) and success was 87(94.6%). Failure was significantly higher in patients with high RSBI group (p=0.011) (Table IV).

Table IV Comparison between Rapid Shallow Breathing Indexes and Weaning Failure (n=117)

RSBI	Failure	Success	Total	P value
High RSBI	6(24.0%)	19(76.0%)	25(100.0%)	0.011
Low RSBI	5(5.4%)	87(94.6%)	92(100.0%)	
Total	11	106	117(100.0%)	

Low RSBI (≤105 breath/min/L); High RSBI (>105 breath/min/L); Chi square test was performed to see the level of statistical significance.

Discussion

Mechanical ventilation in critically ill patients or post-surgical patients is the most important support in ICU.⁸ After mechanical ventilatory support, weaning from ventilator is the main challenge in ICU. Weaning of patients from MV involves two different processes which are ventilator discontinuation and removal of the

endotracheal tube⁹. The decision regarding the removal of the endotracheal tube is crucial because both failed extubation and delay extubation associated with a lot of complications and adverse effects.

In a developing country like Bangladesh, most of the critically ill patients are not able to bear the expenses of ICU. Other hand there is no cost to measure the RSBI; it can measure just with the help of mechanical ventilator.¹⁰ The data and result generated from the study might be helpful for weaning of patients from MV timely who will cut cost, reduce length of hospital stay and mortality and morbidity. A total of 117 patients of ICU who fulfilled the criteria of extubation after 48 hours in mechanical ventilation under Anesthesia, Pain, Palliative and Intensive Care unite of Dhaka Medical College Hospital, Dhaka, during January 2015 to September 2015 were included in this study. Patients with spinal cord injury, self extubation, unplanned extubation, or MV lasting <48 hours and patients or attendants not agreeing to participate in the study were excluded from the study. The present study findings were discussed and compared with previously published relevant studies.

In this present study it was observed that 36.8% patients were in 3rd decade and only 11.1% patient were in 6th decade. The mean age was found 35.42 ± 13.66 years with range from 18 to 60 years. Goncalves et al⁷ and Berg et al⁸ showed the mean ages were 61.47 ± 14.54 years and 70 ± 16 years respectively. In another study Fadaii et al⁹ found that the mean age was 69.4 ± 13.1 years varying from 40 to 91 years, which all are higher with the current study. Similarly, higher mean age was also observed by Bien et al¹⁰, Patel et al¹¹ and Chao and Scheinhorn¹². The higher mean ages and age ranges obtained by the above authors due to geographical variations, racial, ethnic differences, genetic causes, different lifestyles, and increased life expectancy may have significant influence of their study patients.

In this present study it was observed that more than half (53.0%) patients had MV in duration of ≤ 7 days. The mean duration of MV was found 10.0 ± 6.7 days with range from 3 to 21 days. Similarly, Bien et al¹⁰ observed the mean duration of MV was 11.0 ± 10.0 days, which is consistent with

the current study. On the other hand Fadaii et al⁹ found that the mean duration of mechanical ventilation was 17 days varied from 2 to 45 days, which is higher with the current study.

The rapid shallow breathing index (RSBI) is one of the most widely investigated predictors of extubation failure. Values ≤ 105 cycles/min/L are considered predictive of extubation success reported by Boles et al,¹³ Mokhlesi et al¹⁴ and Vidotto et al¹⁵. In this current study it was observed that low RSBI (≤ 105 breath/min/L) was found 92(78.6%) patients and high RSBI (>105 breath/min/L) was 25(21.4%) patients. The mean RSBI was found 86.74 ± 16.16 breath/min/L with range from 60.97 to 119 breath/min/L.

In this current study it was observed that majority 45(48.9%) patients had mechanical ventilation <7 days in low RSBI group and 15(60.0%) in high RSBI group. The mean MV was found 9.6 ± 6.4 days in low RSBI group and 8.6 ± 4.5 days in high RSBI group. The mean duration of MV was not statistically significant ($p > 0.05$) between two groups. Mahoori et al¹⁶ found 10(20.0%) patients had RSBI >105 breath/min/L and 40(80%) patients were RSBI <105 breath/min/L from mechanical ventilation. Indeed, a gradual transition is only required in less than 30% of patients receiving mechanical ventilatory support. Kuo et al¹⁷ studies have shown that RSBI measured upon termination of SBT is a superior predictor to RSBI measured at the start of SBT in determining the likelihood of successful liberation from mechanical ventilation in critically ill patients. Although a small number of patients require prolonged ventilatory support after open cardiothoracic surgeries, growing experience in critical care settings and use of mechanical ventilation lead to favorable outcomes. Weaning is more likely to be successful if RSBI is less than 105 (breath/min/L), and this index is more valuable and more accurate for prediction than other weaning predictors.

In this study it was observed that in low RSBI group 94.6% patient's sustained extubation (success) and high RSBI group 76.0% patients' sustained extubation. Success was significantly ($p < 0.05$) higher in patients with low RSBI group. In this series it was observed that High RSBI group (>105 breath/min/L) failure was 6(24.0%)

and success was 19(76.0%). Low RSBI group (≤ 105 breath/min/L) failure was found 5(5.4%) and success was 87(94.6%). Failure was significantly ($p < 0.05$) higher in patients with high RSBI group. The mean RSBI was found 98.23 ± 17.23 breath/min/L in failure group and 85.55 ± 15.66 breath/min/L in success group. The mean RSBI difference was significantly higher in failure group. Fadaii et al⁹ showed 90.0% patients had RSBI ≤ 105 breath/min/L, among them 77.0% patients had successful weaning and did not need reintubation while the remaining had unsuccessful weaning ($P < 0.05$). The mean weaning index for patients with successful extubation was 66 ± 57.2 and 76.9 ± 28.1 for patients with unsuccessful extubation, which was higher in unsuccessful extubation but the difference was not significant between the means ($P > 0.05$). Mahoori et al¹⁶ showed the mean RSBI values were significantly different between the failure (103.5 ± 21.9 breath/min/L) and success groups (80.4 ± 15.3 breath/min/L, $p < 0.05$). There was no significant difference regarding the values of other prediction criteria between the two groups. 10 patients had an RSBI greater than 105 (breath/min/L), within 1 hour of starting their spontaneous breathing trials. In this group three patients were successfully weaned from the ventilator. Of the 40 patients who had an RSBI less than 105 (breath/min/L), 3 patients failed weaning. 10 (20.0%) patients had failed weaning and 80.0% patients were successfully weaned from mechanical ventilation. The average RSBI values were significantly different among the failure (103.5 ± 21.9 breath/min/L) and success groups (80.4 ± 15.3 breath/min/L), $p < 0.05$. There was no significant difference regarding the values of other prediction criteria between the two groups. Kuo et al¹⁷ have reported that RSBI is significantly higher in patients with extubation failure (95.9 ± 20.6) and trial failure (98.0 ± 50.0) than in patients with weaning success (64.6 ± 26.3) ($p < 0.05$). The above findings are consistent with the current study.

Conclusion

In conclusion significant association is found between high and low rapid shallow breathing indexes with weaning of patients in prolonged mechanical ventilation. Therefore, it has been established that the association between RSBI and

success in weaning of the patients is statistically significant.

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