

Modified rapid shallow breathing index as a predictor of extubating outcomes in critical care pediatric patients

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A B S T R A C T

Introduction: The decision for timely intubation and extubation of patients in need of mechanical ventilation is vital. In the Shifa Pediatric Intensive Care Unit (PICU) clinical criteria for spontaneous breathing trial (SBT) is used for extubations. However, no objective calculations are possible in this system. Therefore, the study was designed to find out if modified RSBI could be used reliably as an objective predictor.

Methodology: A single-center observational study was carried out in the PICU of Shifa International Hospital from June to December 2023. All children intubated were included after written consent, however, those with Cyanotic Congenital heart disease and congenital lung deformity were excluded. The patients were extubated using SBT, but modified RSBI was also calculated, a score of <6.7 predicted successful extubation while a score of >6.7 predicted failure. Successful and failed extubations were compared to RSBI predictions and accuracy was determined using Sensitivity, specificity, and positive and negative predictive values.

Results: In total 75 patients were included in the study, 46 males and 29 females. The mean age for male patients was 6.2 years while for females was 4.8 years. The mean weight was 22.1 kg for males and 17.2 kg for females. 68 patients were successfully extubated. The modified RSBI score had an overall sensitivity of 97.1% and specificity of 85.7% with a PPV of 98.5% and an NPV of 75% with a p-value of <.001.

Conclusion: Modified RSBI for Pediatric patients is a reliable and objective predictor of successful extubation in PICU patients undergoing mechanical ventilation.

Keywords: Modified Rapid Shallow Breathing Index; Spontaneous Breathing Trial; Successful extubation; Pediatric ICU Patients

Introduction

Pediatric critical care medicine is a newly evolving specialty in Pakistan with an estimate of only 1 bed available for every 500000 children under 14 years of age.¹ It is understood that only extremely critical patients requiring immediate interventions reach the Pediatric Intensive Care Unit (PICU). Although no reliable stats could be found for Pakistan estimates in the US and other parts of the world state that 1.5% of Paediatric patients seek ICU support and recently children presenting to critical care have had more complications than seen in the past.² Out

of total PICU admissions 40 to 60% require mechanical ventilation, however, up to 20% of intubations might end up as failed extubations.^{3,4} Here it is important to keep in consideration that mechanical ventilation is inevitable and lifesaving in many scenarios, but the job of the ventilator is not to cure a patient but to provide support to or give time for the treatment to become effective. However, it may lead to certain untoward effects like barotrauma lung injury, pneumonia, pneumothorax, subcutaneous emphysema, pneumomediastinum, and pneumoperitoneum especially if

used for a long time or if repeated intubations are tried.⁵ Therefore, it is of utmost importance to discontinue mechanical ventilation as soon as possible. Before 1991 the decision to extubate a patient generally depended upon hemodynamic stability and another clinical criterion like respiratory efforts, which were all subjective. Yang and Tobin introduced the Rapid Shallow Breathing Index (RSBI) to predict successful extubation by dividing the respiratory rate by the spontaneous tidal volume in Liters. The following formula was used to calculate RSBI in adults:

$$\text{RSBI} = \text{Respiratory rate/Tidal Volume (Breaths/min/L)}$$

The RSBI of <105 breaths/min/L was found to be a positive predictor for successful extubation.^{6,7}

The above-mentioned RSBI score predicts successful weaning from mechanical ventilation in adults, however, the criterion for the Pediatric population has not been established.⁸ A modified version considering the weight of the child in the equation is used in many parts of the world putting a cutoff point at 6.7 breaths/min/ml/kg⁹ with a score greater than this predicting a negative outcome while a score lesser than the said value predicting a positive outcome. However, the sensitivity and specificity of these criteria are still up for debate.¹⁰ Any reliable study based on Pakistani PICU setting could not be found to quote. In Shifa PICU a clinical-based criterion of spontaneous breathing trial is used for extubations where hemodynamic stability and effort to breathe independently are considered for attempting extubation, however, no objective calculations are possible in this system. Considering the critical condition in which usually the patients on mechanical ventilation are, and possible risks of premature extubation there is a need for introducing objective criteria for decreasing the frequency of failures and making extubation safer.

Methodology

A Single Center Observational Study was conducted in the Pediatric ICU of Shifa International Hospital Islamabad, after the Internal Review Board's approval with reference number IRB # 438-23. The aim was to find the accuracy of the modified RSBI as an objective predictor of successful extubation. All patients admitted to the PICU from June to December 2023 and who underwent mechanical

ventilation were included in the study after obtaining written consent from the parents/guardians. Patients with cyanotic congenital heart disease or a congenital lung deformity were excluded from the study. The patients were extubated as per the clinical criteria of spontaneous breathing trial (SBT) based on the criteria issued in guidelines by the Shifa International Hospital comprising of the following indicators.

1. Patients are awake, alert, and able to initiate inspirational efforts.
2. Airway protective reflexes intact (cough and gag reflex)
3. The suction requirement is less than every 6 hours
4. Hemodynamically stable and not getting vasopressor infusions
5. Positive End Expiratory Pressure (PEEP) set at 5 cm water or less

Along with SBT, the modified RSBI was also calculated using the following formula (Considering the weight of the child as an addition to the calculation of RSBI for adults):

$$(\text{Respiratory Rate/Tidal Volume in ml})/\text{Weight in Kg}$$

A score of <6.7 breaths/min/ml/kg was considered to predict a successful extubation while a score of > 6.7 breaths/min/ml/kg predicted a failed extubation.⁹ If after an extubation the patient could not maintain adequate minute ventilation and gas exchange without excessive respiratory effort and needed re-intubation within 48 hours of extubation, it was considered a failed extubation.¹¹ The modified RSBI score was compared to the extubation outcome, and its accuracy as an objective predictor was calculated using descriptive statistics including sensitivity, specificity, and positive and negative predictive values. Data was analyzed using IBM SPSS version 27 and a p-value of p<0.05 was considered significant.

Results

In total 80 patients were intubated, four were excluded as per the criteria while consent could not be obtained for one child, therefore 75 (n=75) were included in the study. The baseline characteristics of the subjects are given in Table 1, and the distribution of diseases is given in Figure 1.

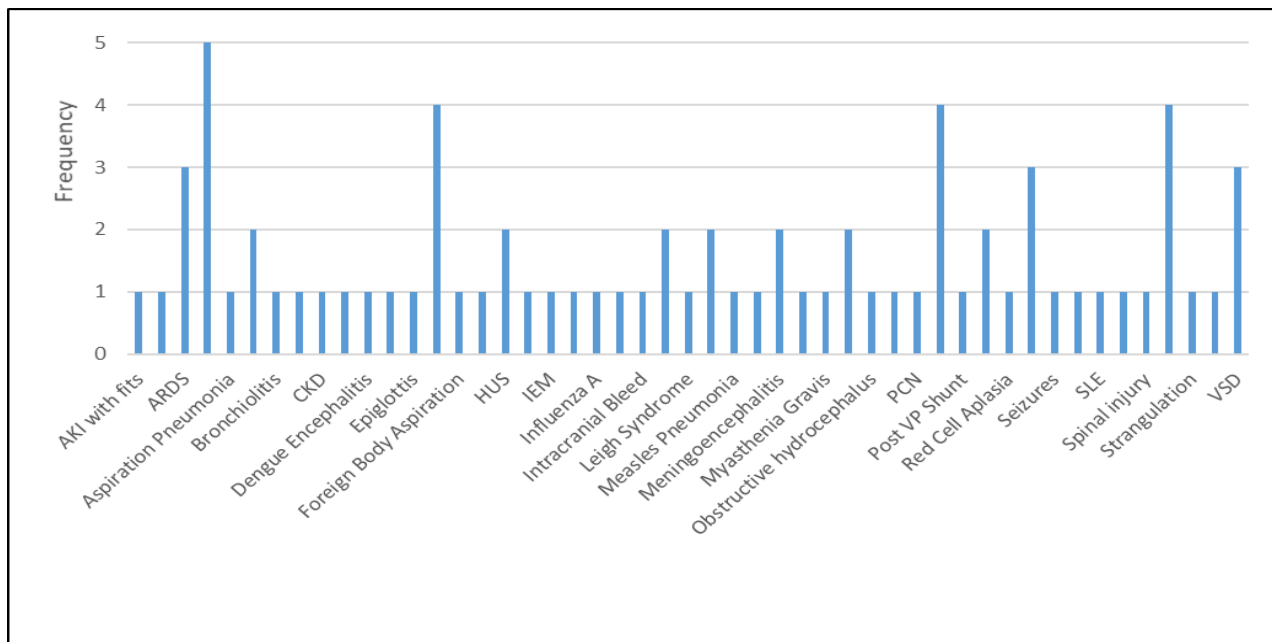


Figure 1: Distribution of diseases in subjects

In total 68 patients were successfully extubated, but 7 patients had to be re-intubated, RSBI was calculated for all 75 patients. The RSBI predictions were compared to the outcome and the chi-square test was applied. The comparison is shown in Table 2 and Sensitivity, Specificity, Positive and Negative predictive values are in Table 3.

Table 1: Basic Characteristics of the Subjects

Gender	Male	Female
Number	46	29
Mean Age (Years)	6.2 + 4.8	4.8 + 4.6
Mean Weight (Kgs)	22.1 + 16.2	17.8 + 12.4
Mean Intubation Duration (Days)	3.05 + 3.16	3.15 + 3.16

Table 2: Cross Tabulation between RSBI Prediction and successful extubation (Asymptomatic Significance is $p < 0.001$)

Count			
RSBI Grouping	Re intubation		Total
	No	Yes	
<6.7	66	1	67
>6.7	2	6	8
Total	68	7	75

Table 3: Accuracy of RSBI prediction capacity

Characteristics	Value (%)
Sensitivity	97.1
Specificity	85.7
Positive Predictive Value	98.5
Negative Predictive Value	75

Discussion

The use of mechanical ventilation is a vital part of the treatment in PICUs and plays an important role in saving lives¹¹ and providing time for the physicians to try to cure the underlying issues and for the body to recover.¹² The decision of intubation and timely extubation are both vital and although experienced medical practitioners use different methods to predict successful extubation according to their preferences, a generalized guideline is missing.^{8,13}

The Shifa International Hospital has been using the Spontaneous breathing trial (SBT) successfully in their ICU including the PICU, however with a subjective criterion the issue remains of uniformity. Also, some studies, primarily done in adult populations, found SBT to be of low predictive value in chronic respiratory failure patients.¹⁴ A study on Pediatric patients in Los Angeles also found a high failure rate of up to 32% for SBT.¹⁵ Therefore, the need for an objective criterion that can have a written protocol and can

be uniformly applied by different medical personnel is there. In this regard, studies suggested Rapid Shallow Breathing Index as the most reliable objective criteria^{3,9} which is also preferred for not requiring any calculations of complex ventilator mechanics. This index is based on the concept that better lung compliance associated with better gas exchange and lower respiratory rate results in a better chance to sustain spontaneous ventilation without the support of mechanical ventilation.¹⁶

However, RSBI, defined in 1991 for adults with acceptable sensitivity and specificity, is not reliable for the Pediatric population, therefore studies used a modification of the RSBI catering for the weight of the pediatric patient, and this study used the same.⁹ Although different studies have given different opinions regarding using RSBI as a predictor of extubation, a study referenced claimed that those without any predictor and those weaned with the predictor have similar results, however, in other studies and general opinion RSBI remains the best predictor available in adults.^{17,18}

The studies in the Pediatric population are limited, and most studies are retrospective cohort studies focused on high-risk procedures like cardiac surgeries or liver transplants. Intubation failure in such studies might also be due to specific organ failure.¹⁹ The criteria that can be generalized for safe extubation with acceptable sensitivity and specificity are yet to be decided. Therefore, this study was planned to include all medical and surgical patients being admitted to the PICU during the period of data collection to have generalized results. Similarly, some cross-sectional studies divide the subjects into disease groups, unlike these sister studies the subjects in this research were divided into gender groups. The sample size of 75 taken in this study is greater than the number of subjects taken in the Iranian study.³

The studies worldwide show different opinions about the reliability of the modified RSBI score. A study in Egypt showed lower sensitivity for RSBI as compared to other extubation predictors.²⁰ That study is also a single-center study with a sample size of 60 patients. Some studies carried out in Asian countries, especially the one carried out in Iran conclude that modified RSBI has a sensitivity of 73.1% and a specificity of 80.4%, which is good enough to consider RSBI as an accurate and reliable extubation predictor.³

The results of our study are comparable to that study with a sensitivity of 97.1% and specificity of 85.7%. However, the limitation of most studies discussed remains a small sample size and single-center nature of data collection. as the sample size of both the studies and the Egyptian study refuting these results is less than a hundred patients. More advanced multi-central, prospective studies are required for ascertaining the true sensitivity and specificity of modified RSBI, and studies with a larger sample size will also support in finding any exceptions where RSBI cannot accurately predict the extubation.

Future studies should also analyze the data of the same cohort in gender, disease, and other sub-groups to ensure the generalization of their findings. However, this study can be used to form the basis of further research and continued in the PICU for the collection of further data.

Conclusion

This study shows that modified RSBI is an objective and reliable predictor for successful extubation with high sensitivity, specificity, and positive predictive value, however, the sample size is small, and more prospective and advanced studies with a larger sample size should be planned preferably involving multiple centers.

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