Role of Spontaneous Breathing Trial as Predictors in Extubation Failure in Preterm Infants

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ABSTRACT
Background: Invasive respiratory support is associated with risk and complications including mortality and neurological impairments. Consequently, extubation of a ventilated infant should be as early as possible.
Objective: This study aimed to assess the efficacy of spontaneous breathing trial as indicator for the success of extubation in mechanically ventilated preterm infants.
Patients and methods: A prospective cohort study included 62 preterm born infants who were maintained on mechanical ventilation. They were divided into: (32 infants) group for whom a spontaneous breathing trial was carried out for 5 minutes. Second (30 infants) group for whom a spontaneous breathing test was carried out for 3 minutes. Then, rapid Shallow Breathing Index (RSBI) was calculated for each patient. At the end of the test, the newborns were extubated and placed on continued positive airway pressure (CPAP) or just oxygen, as needed, according to the unit's routine protocol.
Results: On multivariate logistic regression of factors associated with failure of weaning, APGAR at 5 minutes was > 6, absence of maternal PIH, birth weight > 400 gm. Pre-extubation MAP < 5.5 and preextubation PO_2 > 28 were protective against failure of weaning. On the other hand, lower preextubation PCO_2 was a predictor of weaning failure (increase risk of failure by about 63 times). Failure of weaning forecated in RSBI trial can predict actual failure of weaning with sensitivity of 97.9%, specificity of 73.3%, positive predictive value of 92%, negative predictive value of 91.7% and accuracy of 91.9%.
Conclusion: Failure of weaning associated with lower birth weight, PO2, PCO2 and higher pre-extubation MAP. 3 minutes and 5 minutes spontaneous breathing trial (SBT) can predict actual failure of weaning with sensitivity 97.9%, specificity 73.3%.
Keywords: Spontaneous Breathing Trial, Preterm Infants, Extubation Failure.

INTRODUCTION

Respiratory distress syndrome (RDS) is the commonest morbidity following preterm birth, and a major contributor to early neonatal death and long-term sequelae. RDS, and resulting respiratory failure, occurs in these infants secondary to immature lung development, surfactant deficiency and immaturity in other organs. In those infants presenting with RDS, a substantial proportion go on to develop chronic lung disease (CLD), and remain at high risk of on-going respiratory morbidity into childhood and adulthood [1].

Preterm infants born with insufficient pulmonary surfactant have respiratory distress that manifests clinically by laboured, rapid breathing, grunting, and central cyanosis. Respiratory distress typically becomes more severe during the first few days after birth as the airways progressively collapse because of increased surface tension. If infants survive the first few days, the lungs start to produce surfactant, the respiratory distress stabilises and then abates as the lungs reinflate. Effective treatment for respiratory distress syndrome was limited to supplemental oxygen therapy [2].

Ventilators are machines that breathe for a patient, either through a tracheostomy or endotracheal tube. The ventilator can have oxygen delivery titrated to specific patient needs, and delivered through positive pressure to the patient. Endotracheal tubes possess the added advantage of occluding the airway, thus preventing aspiration of blood, secretions, etc. in patients unable to protect their own airways [3].

Mechanical ventilation (MV) is considered one of the major advances in neonatal medicine and is a widely used method of treatment, especially in the extremely preterm population. In a large cohort analysis of extremely low-birth-weight infants (ELBW), 89% were treated with MV during the first day of life, and, almost 95% of survivors were invasively ventilated during their hospital stay. In a large cohort of infants born at less than 28 weeks' gestational age (GA), 74% were intubated and received surfactant therapy during their hospital stay [4].

Prolonged mechanical ventilation is a risk for morbidity and mortality in critical ill patients. Weaning failure is frequently associated with development of a rapid shallow breathing pattern. Measurement of the rapid shallow breathing index (RSBI) is a simple bedside determinant that may be utilized to identify this respiratory pattern classically thought to predict respiratory failure. However, despite being widely used and extensively studied, RSBI has variable sensitivity

and specificity for predicting outcome following extubation [5].

Therefore, when caring for extremely premature infants, clinicians should focus on weaning and removing MV as expeditiously as possible. Success of extubation is only 60% to 73% in ELBW infants. Higher success rates (80%–86%) have been reported in some series that include all preterm infants. Infants who fail and require reintubation, with its attendant risks, may experience deterioration of their respiratory status because of atelectasis [6].

The current study aimed to assess the efficacy of spontaneous breathing trial as indicator for the success of extubation in mechanically ventilated preterm infants.

PATIENTS AND METHODS

A prospective cohort study performed on 62 preterm mechanically ventilated infants (All enrolled preterm infants were less than 37 weeks of gestation and were fit for extubation). The infants were classified into: First group (32) for whom a spontaneous breathing trial (SBT) were carried out for 5 minutes. Second group (30) for whom a spontaneous breathing test were carried out for 3 minutes.

Inclusion criteria: Preterm infants less than 37 weeks of gestation, mechanically ventilated infants and fit for extubation.

Exclusion criteria: Preterm infants more than 37 weeks of gestation, non-mechanically ventilated infants and unfit for extubation.

According to Rapid Shallow Breathing Index (RSBI) infants were subdivided into 4 groups: 1st group who had a SBT for 5 minutes and result of RSBI more than 8 breaths/ml/kg, 2nd group comprised who had a SBT for 5 minutes and result of RSBI less than 8 breaths/ml/kg, 3rd group who had a SBT for 3 minutes and result of RSBI more than 8 breaths/ml/kg and 4th group who had a SBT for 3 minutes and result of RSBI less than 8 breaths/ml/kg.

Extubation assessment:

Extubation was carried out for all patients as recommended by their treating physician. Patients were followed up regarding failure of extubation. Failure of extubation is defined as the need for re-intubation within 72 hours after extubation.

Spontaneous breathing trial were performed under continued positive airway pressure (CPAP) with 5 cm H_2O end-expiratory pressure (PEEP), inspiratory flow 10 L/min for 5 minutes for patients of the first group, and for 3 minutes for patients of the second group. The mean airways pressure and the inspired oxygen fraction were directly collected from the mechanical ventilator monitor before the SBT.

A SBT failure was recorded if the infant had either a bradycardia lasting longer than 15 s, defined as a drop in heart rate below 100 beats per minute, and/or a fall in oxygen saturation below 85% despite a 15% absolute increase in the fraction of inspired oxygen. Physician responsible for the care of the infant, those who were not present at the time of SBT. The RSBI is defined as the ratio of respiratory frequency to tidal volume (f/VT). At the end of the test, the newborns were extubated and placed on CPAP or just oxygen, as needed, according to the unit's routine protocol.

Ethical Consideration:
 The study was approved by the Ethical Committee of Zagazig Faculty of Medicine. An informed consent was obtained from every patient in this research. Every patient received an explanation for the purpose of the study. All given data were used for the current medical research only. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

IBM's SPSS statistics (Statistical Package for the Social Sciences) for windows (version 25, 2017) was used for statistical analysis of the collected data. Shapiro-Wilk test was used to check the normality of the data distribution. All tests were conducted with 95% confidence interval. P (probability) value ≤ 0.05 was considered statistically significant. Charts were generated using SPSS' chart builder and Microsoft Excel for windows 2019. Quantitative variables were expressed as mean and standard deviation, median, inter-quartile range, minimum and maximum as appropriate while categorical variables were expressed as frequency and percentage. Fisher exact and Chi square tests were used for inter-group comparison of nominal data using the crosstabs function. Bivariate correlations were assessed using Pearson's or Spearman's correlation coefficient depending on the nature of data.

RESULTS

There was statistically non-significant difference between the studied groups regarding age or gender (**Table 1**). There was statistically non-significant difference between the studied groups regarding fate of weaning (**Table 2**).

On multivariate logistic regression of factors associated with failure of weaning, APGAR at 5 minutes > 6, absence of maternal PIH, birth weight >1400 gm, preextubation MAP < 5.5 and preextubation PO_2 > 28 were protective against failure of weaning. On the other hand, lower preextubation PCO_2 was a predictor of weaning failure (increased risk of failure by about 63 times) (**Table 3**).

Failure of weaning forecasted in RSBI trial can predict actual failure of weaning with sensitivity of 97.9%, specificity of 73.3%, positive predictive value of 92%, negative predictive value of 91.7% and accuracy of 91.9% (**Table 4**).

Table (1): Comparison between the studied groups regarding demographic data

Parameter	Groups				Test	
	5 min SBT +RSBI>8 group	5 min SBT+RSBI<8 group	3 min SBT+RSBI>8 group	3 min SBT+RSBI<8 group	F/χ^2	p
	N=18 (%)	N=14 (%)	N=13 (%)	N=17 (%)		
Age(years) Mean ± SD	8.17 ± 0.92	7.1 ± 2.59	8.15 ± 1.68	7.47 ± 1.28	1.143	0.21
Gender: Male Female	12 (66.7) 6 (33.3)	11 (78.6) 3 (21.4)	7 (53.8) 6 (46.2)	10 (58.8) 7 (41.2)	2.132	0.564

F One way ANOVA χ^2 chi square test

Table (2): Comparison between the studied groups regarding fate of weaning

Parameter	Groups				Test	
	5 min SBT+RSBI>8 group	5 min SBT+RSBI<8 group	3 min SBT+RSBI>8 group	3 min SBT+RSBI<8 group	χ^2	p
	N=18 (%)	N=14 (%)	N=13 (%)	N=17 (%)		
Fate: Fail Success	5 (27.8) 13 (72.2)	4 (28.6) 10 (71.4)	2 (15.4) 11 (84.6)	4 (23.5) 13 (76.5)	0.827	0.897

χ^2 chi square test

Table (3): Multivariate regression analysis of factors associated with failure of weaning among the studied patients

	β	p	AOR	95% C.I.	
				Lower	Upper
APGAR at 5 minutes >6(1)	-71.711	.994	.001	.001	.
Maternal PIH (absent)	-81.182	.993	.001	.001	.
Preextubation Pco2	-4.178	.994	65.266	.001	.
BW >1400 gm	-46.151	.994	.001	.001	.
MAP<5.5	-51.990	.994	.001	.001	.
PO2>28	-123.511	.992	.001	.001	.

AOR adjusted odds ratio

Table (4): Validity of outcome predicted by and actual outcome on weaning

Factor	Value
Sensitivity	97.9%
Specificity	73.3%
PPV	92%
NPV	91.7%
Accuracy	91.9%

DISCUSSION

Extubation bundle with modified spontaneous breathing trial (MODIFIED SBT) prior to elective extubation is recommended to be used in predicting successful extubation in premature babies. Guidelines for extubation among premature babies are needed in order to reduce unnecessary exposure to adverse effects of mechanical ventilation [7].

Assessment of extubation readiness in mechanically ventilated children remains challenging despite the relatively low failed extubation rate (2–20%). Patients who failed extubation may experience prolonged intensive care stay and even increased mortality. This signifies the importance of appropriately identifying when the patient is ready for extubation [8].

Thus, identifying techniques for predicting successful extubation attempts may reduce mortality and morbidity associated with ill-timed extubation attempts.

The present study revealed that there was statistically non-significant difference between the studied groups regarding age, gender. **Khamiees et al.** [9] found that age, severity of illness, duration of mechanical ventilation and vital signs during SBTs did not differ between patients with successful extubations vs patients with unsuccessful extubations.

There was significant association between fate of weaning and all of age at extubation, gestational age, birth weight, APGAR at 5 minutes < 6, history of maternal PIH, pre-extubation MAP, PO2, and PCO2. Failure of weaning was associated with younger age,

younger gestational age, lower birth weight, history of maternal PIH, higher pre-extubation MAP, lower PO_2, and PCO_2. In agreement with our results **Chawla et al.** [10] conducted prospective observational study to perform respiratory compliance (Crs) along with SBT prior to elective extubations within 3 weeks of age in premature infants ≤ 32 weeks. Spontaneous breathing trial was done after measurement of Crs and before extubation, for up to 5 min. Infants who were successfully extubated were more mature and had larger weight at extubation, compared to infants who failed extubation. There were no statistically significant differences in birth weight, race, gender, mode of delivery, use of antenatal steroids, age at extubation, use of caffeine therapy between infants who failed and those who were successfully extubated. Infants, who were successfully extubated had higher ETSMV/TMV and were more likely to pass SBT, compared to infants, who failed extubation [10].

The present study conducted multivariate logistic regression of factors associated with failure of weaning, APGAR at 5 minutes > 6, absence of maternal PIH, birth weight > 1400 gm, preextubation MAP < 5.5 and preextubation PO_2>28 were protective against failure of weaning. On the other hand, lower preextubation PCO2 was a predictor of weaning failure (increase risk of failure by about 63 times).

RSBI has been the most often employed index to evaluate MV withdrawal, even in more severely ill patients. The decision to withdraw MV is not always simple or easy to take. Currently, some institutions rely exclusively on the value of RSBI measured once a day before submitting the patient to SBT or extubation [11]. However, a cutoff value that defined RSBI as a predictor of failure was not presented. RSBI value of $\leq$ 8 breaths/ml/kg had a sensitivity of 74% and specificity of 74% [12]. Therefore, in this study, we decided to measure the RSBI after the SBT and compared between infants who need more than 8 breaths/ml/kg and those who need less than 8 breaths/ml/kg.

The present study revealed that failure of weaning forecasted in RSBI trial can predict actual failure of weaning with sensitivity of 97.9%, specificity of 73.3%, positive predictive value of 92%, negative predictive value of 91.7% and accuracy of 91.9%. This variation might be due to the heterogeneity of the study samples, given that the proportions of patients with neurological disease, neuromuscular disease, or prolonged ventilation vary across studies. The use of the RSBI as a predictor of weaning success has been widely studied in the intensive care setting [13]. The performance of the RSBI has been shown to range from moderate to good (AUC, 0.72-0.89) [14].

CONCLUSION

Failure of weaning was associated with lower birth weight, PO_2, PCO_2 and higher pre-extubation MAP. 3 minutes and 5 minutes SBT can predict actual failure of weaning with sensitivity of 97.9% and specificity of 73.3%.

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