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Association between the rapid shallow breathing index and extubation success in patients with traumatic brain injury

Associação entre o índice de respiração rápida e superficial e o sucesso da extubação em pacientes com traumatismo cranioencefálico

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ABSTRACT

Objective: To investigate the association between the rapid shallow breathing index and successful extubation in patients with traumatic brain injury.

Methods: This study was a prospective study conducted in patients with traumatic brain injury of both genders who underwent mechanical ventilation for at least two days and who passed a spontaneous breathing trial. The minute volume and respiratory rate were measured using a ventilometer, and the data were used to calculate the rapid shallow breathing index (respiratory rate/tidal volume). The dependent variable was the extubation outcome: reintubation after up to 48 hours (extubation failure) or not (extubation success). The independent variable was the rapid shallow breathing index measured after a successful spontaneous breathing trial.

Results: The sample comprised 119 individuals, including 111 (93.3%) males. The average age of the sample was 35.0±12.9 years old. The average duration of mechanical ventilation was 8.1±3.6 days. A total of 104 (87.4%) participants achieved successful extubation. No association was found between the rapid shallow breathing index and extubation success.

Conclusion: The rapid shallow breathing index was not associated with successful extubation in patients with traumatic brain injury.

Keywords: Brain injuries; Respiration, artificial; Intensive care units; Weaning

INTRODUCTION

Traumatic brain injury (TBI) is a non-degenerative, non-congenital lesion caused by trauma or triggered by high-energy acceleration or deceleration of the brain inside the skull that causes anatomical damage to or has functional effects on the scalp, skull, meninges or encephalon.[1,2] A study conducted in 2001 found that 555 of 11,028 TBI victims admitted to the emergency department of a public hospital in *Salvador* (BA) required hospitalization for specialized care.[3]

Traumatic brain injury victims commonly require mechanical ventilation (MV) to maintain ventilation, optimize oxygenation, and protect their airways. Such patients might require MV for long periods of time and develop complications such as ventilator-associated pneumonia or lung injury, diaphragmatic dysfunction, barotrauma, and volutrauma.[4-7]

Weaning patients of MV involves two different processes: (1) ventilator discontinuation; and (2) removal of the orotracheal tube (extubation).

This study was conducted at the Intensive Care Unit of the Hospital Geral do Estado da Bahia - Salvador (BA), Brazil.
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Conflicts of interest: None.

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The decision regarding whether a patient can tolerate the removal of the orotracheal tube is crucial because both extubation delay and failure are associated with adverse effects and increased mortality.[4,8-12] Therefore, accurate knowledge of the risk factors and predictors of extubation failure is needed.

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.[8-10,12] The aim of the present study was to establish the association between the RSBI and extubation success in patients with TBI.

METHODS

This study was a prospective cohort study conducted in patients with TBI admitted to intensive care units (ICUs) of the *Hospital Geral do Estado da Bahia* from September 2009 to June 2010. The study was approved by the ethics committee of the *Escola Bahiana de Medicina e Saúde Pública*, no. 83/2008, and the participants were included in the study after their guardians signed an informed consent form.

Individuals with TBI aged ≥18 years of both genders who underwent MV via orotracheal tube for at least two days, had Glasgow coma scale (GCS) scores ≥8 at the time of extubation, whose guardians signed informed consent, and who passed a spontaneous breathing trial (SBT) were included in the study. Patients with spinal cord injury, unplanned extubation, or MV lasting <48 hours were excluded.

As a function of the observational nature of the present study, decision-making on weaning, extubation, reintubation and the use of noninvasive ventilation (NIV) was left to the staff of each participating unit, without interference by the investigators. The participants were considered fit to start SBTs by the healthcare staff when the event that led to the MV was reversed or controlled, gas exchange was adequate (PaO_2 ≥60mmHg with a fraction of inspired oxygen (FiO_2) ≤0.4 and a positive end-expiratory pressure (PEEP) ≤5 at 8cmH_2O), the patients were not subjected to continuous sedation, were hemodynamically stable (signs of satisfactory tissue perfusion, no need for or low doses of vasopressors, absence of coronary insufficiency or arrhythmias with hemodynamic repercussion) and were able to perform inspiratory efforts. The ICU staff interrupted the SBTs whenever any of the following signs of intolerance appeared: respiratory rate >35 cycles/minute, ≤90% arterial oxygen saturation, heart rate >140bpm, systolic arterial pressure >180mmHg or <90mmHg, agitation, sweating, or altered level of consciousness. The ICU staff initiated NIV whenever post-extubation respiratory failure occurred (defined by the presence of clinical signs suggestive of respiratory muscle fatigue and/or increased respiratory effort and increased respiratory rate). The patients were extubated when they could tolerate the SBT over 30 to 120 minutes and exhibited neurological stability with a GCS score ≥8.

The RSBI was measured with the headboard raised to 30º to 45º and with the patient in the dorsal decubitus position while monitoring the patients' vital signs. Tracheal aspiration was performed, and 15 minutes later, the artificial airway was connected to a properly calibrated ventilometer (Ferraris Mark 8 Wright Respirometer®, United Kingdom) for one minute under spontaneous breathing. The respiratory rate and minute volume were measured over one minute, and these data served to calculate the tidal volume by dividing the minute volume by the respiratory rate as well as the RSBI by dividing the respiratory rate by the tidal volume (in liters). The RSBI was expressed as cycles/min/L. The decision to extubate was not influenced by the RSBI because the ICU staff were unaware of the results. The volunteers were divided in two groups: RSBI ≤105 cycles/min/L and >105 cycles/min/L.

For the purposes of the analysis, the extubation outcome was considered the dependent variable and was rated successful when reintubation was not needed within 48 hours. The RSBI measured after a successful SBT was considered the independent variable.

When reintubation was needed within 48 hours after extubation, its cause was registered under one of the following categories: upper airway obstruction, respiratory failure (tachypnea, use of the accessory muscles of respiration, paradoxical breathing, or hypoxemia), reduced level of consciousness, bronchospasm, aspiration of lung secretions, excessive lung secretions, and other causes.

The results were expressed as the mean and standard deviation, median and interquartile range, or proportions as befitting. Student's *t* test or the Mann-Whitney U test was used in the comparison of the RSBI between the groups with successful and failed extubation, and the chi-squared or Fisher's exact test were used to compare proportions. The area under the ROC (receiver operating characteristic) curve of the

RSBI was analyzed. Statistical analysis was performed using the software Statistical Package for the Social Science (SPSS) version 12.0 with $p<0.05$ as the significance level.

RESULTS

Of 129 consecutive patients with TBIs who were eligible for extubation during the study period, 119 passed the SBT and were included in the study. Ten patients were excluded due to self-extubation in 3 cases, MV lasting <48 hours in 4 cases, and spinal cord injury in 3 cases. Most of the volunteers were male (93.3%), the average age of the sample was 35.0±12.9 years old, and the MV lasted 8.1±3.6 days on average. With respect to treatment, 86 volunteers (72.3%) underwent surgery, and 33 volunteers (27.7%) received conservative treatment. Upon admission to the ICU, volume and pressure assist-control were the ventilation modes most frequently used in 71 (59.6%) and 46 (38.7%) participants, respectively. The demographic data, duration of MV, and clinical characterization of the 119 analyzed volunteers are described in table 1.

Extubation was successful in 104 patients (87.4%), while 15 patients (12.6%) required reintubation. The causes for reintubation were as follows: respiratory failure in 7 cases (46.7%), laryngospasm in 4 cases (26.7%), reduced level of consciousness in 2 cases (13.3%), excessive secretions in 1 case (6.7%), and sepsis in 1 case (6.7%). Comparison between the successful and failed extubation groups did not find any differences with respect to age, type of accident, GCS score upon admission to the hospital, duration of MV, or ventilation mode upon admission. The successful extubation group comprised a larger proportion of males (96.2% versus 73.33%; p=0.009) (Table 1).

Following extubation, 8 of the 119 patients (6.7%) needed NIV, of whom 6 (5.8%) were in the group with successful intubation, and 2 (13.3%) were in the group that required reintubation; the intergroup difference was not statistically significant (p=0.26). No difference was found in the RSBI between patients who needed NIV and patients who did not: 86.1±23.7 cycles/min/L and 74.0±32.4 cycles/min/L, respectively; p=0.3.

Table 1 - Characteristics of patients classified according to extubation outcomes

Variable	Total (N=119)	Extubation success (N=104)	Extubation failure (N=15)	p value
Age (years)	35.0±12.9	34.5±11.9	38.5±18.7	0.44
Male gender	111 (93.3)	100 (96.2)	11 (77.3)	0.009
Cause of trauma				0.47
Motorcycle accident	34 (28.6)	29 (27.9)	5 (33.3)	
Physical aggression	19 (16)	18 (17.3)	1 (6.7)	
Run over	16 (13.4)	15 (14.4)	1 (6.7)	
Car accident	8 (6.7)	7 (6.7)	1 (6.7)	
Firearm wound	7 (5.9)	7 (6.7)	0	
Bladed weapon injury	3 (2.5)	3 (2.9)	0	
Other	32 (26.9)	25 (24)	7 (46.7)	
GCS upon admission	8.9±3.5	8.8±3.5	9.3±3.7	0.66
Duration of MV (days)	8.1±3.6	7.8±3.3	9.8±5.1	0.16
Ventilatory mode upon admission				0.33
Volume assist-control	71 (59.6)	64 (61.6)	7 (46.7)	
Pressure assist-control	46 (38.7)	39 (37.5)	7 (46.7)	
Support pressure ventilation	2 (1.7)	1 (1.0)	1 (6.7)	
RR/TV (RSBI) (cycles/min/L)	74.8±32.0	73.5±33.1	83.8±21.3	0.25
RSBI				
≤105 cycles/min/L	101 (84.9)	88 (84.6)	13 (86.7)	1.0
>105 cycles/min/L	18 (15.1)	16 (15.4)	2 (13.3)	

GCS - Glasgow coma scale; MV - mechanical ventilation; RR - respiratory rate; TV - tidal volume; RSBI - rapid shallow breathing index. The results are expressed as number (%) or mean±standard deviation.

The average RSBI of the sample was 74.8±32.0 cycles/min/L. The RSBI did not exhibit a difference between the groups with successful and failed extubation; the average values were 73.5±33.1 cycles/min/L and 83.8±21.3 cycles/min/L, respectively (p=0.25). Among the 15 patients that needed reintubation, only 2 patients (13.3%) exhibited an RSBI >105 cycles/min/L. In the present study, no association was found between the RSBI categories (≤105 cycles/min/L and >105 cycles/min/L) and extubation success (Table 1).

The ROC curve constructed based on the graphical representation of the sensitivity and specificity values is depicted in figure 1. The area under the ROC curve corresponding to the RSBI was 0.64 (95% confidence interval (CI): 0.52-0.76; p=0.08), which indicated a lack of clinical value to the RSBI to predict successful extubation in patients with TBI.

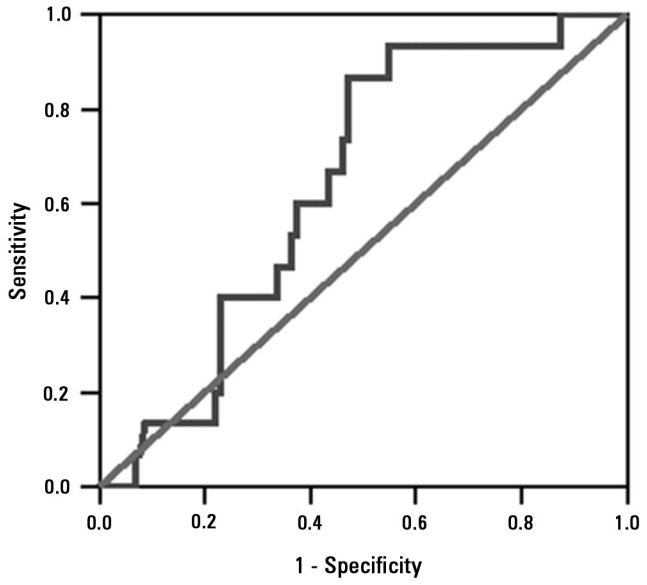

Figure 1 - Area under the ROC curve relative to the rapid shallow breathing index. Area: 0.64 (95% confidence interval: 0.52-0.76; p=0.08).

DISCUSSION

The present study assessed a cohort comprising 119 individuals to investigate the association between the RSBI and extubation success in patients with TBI. No association was found in the investigated population.

The investigated sample mostly comprised young male individuals, which agreed with the literature.[13-16] With respect to the cause of the trauma, motorcycle accidents were the most frequent, followed by physical aggression and being run over by a car, which also agreed with the reports by other authors.[3,13,14] In the present study, a association was found between male gender and extubation success. Among authors who have reported on the association between gender and extubation outcomes in patients with TBI, some found more favorable results in males,[17] while others found better outcomes in females,[18] which indicated the need for further studies to clarify this matter.

The study by Yang and Tobin[19] included a cohort comprising 100 patients and found that an RSBI ≤105 cycles/min/L was predictive of extubation success. That result disagreed with the result of the present study. A possible explanation for that discrepancy is that the sample population in the study by Yang and Tobin was heterogeneous.

In a study with a prospective cohort comprising 92 neurosurgical patients, an RSBI ≤105 cycles/min/L was not associated with successful extubation, and among the 15 participants who needed reintubation, only 1 patient exhibited an RSBI >105 cycles/min/L.[12] Those findings agreed with the findings of the present study, which did not find a association between the traditional RSBI cutoff point and extubation success in individuals with TBI. In addition, other studies have found this threshold to be unable to predict extubation success, and thus the identification of a more accurate cutoff point is needed.[20-22]

A prospective study was conducted with 80 patients subjected to general anesthesia to assess the use of the RSBI as a predictor of extubation outcomes. The results showed that participants with an RSBI of 80 to 100 cycles/min/L exhibited clinical complications following extubation. However, they did not need reintubation.[23]

In another case series with 73 heterogeneous patients, the traditional RSBI cutoff point failed to detect 80% of the participants who needed reintubation, which further pointed to the inefficacy of that threshold.[24] Authors who assessed heterogeneous samples from two surgical ICUs were not able to find an association between the RSBI and extubation failure.[25]

One study conducted with clinical and surgical patients that included serial measurements of the RSBI at the first minute and then at 30, 60, 90, and 120 minutes later found that the RSBI percent variation during an STB was a better predictor of extubation success compared with any single measurement.[26]

According to the literature, successful extubation might be influenced by factors such as age, duration of MV, hemoglobin concentration, arterial carbon dioxide partial pressure, amount of endotracheal secretions, and particularly among neurological patients, airway

protection and patency parameters,[9,10,21-23,25,26] which might have interfered with the results of the present study. Although the ability to wean patients off mechanical ventilation is assessed in a similar manner in patients with and without neurological disorders, the assessment of the risk of extubation failure is not equally well standardized. Patients with brain injury might easily tolerate spontaneous breathing without ventilation support; nevertheless, they might require an artificial airway as a function of their reduced level of consciousness. The factors associated with extubation success in such cases have not yet been fully elucidated. Therefore, further studies are needed to assess the association between the RSBI with other predictors of extubation success in patients with TBI.

The present study had some limitations. First, because it was an observational study, its results should only be used to formulate hypotheses. In addition, it was conducted in a single center, the sample size was small, and the sample size was not calculated before the initiation of the study. Nevertheless, the multidisciplinary staff that assisted the patients was not informed about the data resulting from the present study, and the staff's decisions with respect to extubation were not influenced by the latter. Then, as a function of the lack of clinical value of the RSBI to predict success of extubation in patients with TBI, no cutoff point was selected in the present study for that variable. For that reason, further studies are needed to establish and validate a cutoff point for the RSBI in patients with TBI. In addition, other parameters that can influence extubation outcomes might not have been assessed in the present study. Finally, scores to establish the prognosis based on severity were not used. However, the GCS score upon admission was used as indicator of the severity of the neurological state. In spite of the abovementioned issues, the present study supplied data with respect to the association between the RSBI and extubation success in a specific sample of individuals with TBI at the ICUs of a public hospital that is a referral center for trauma patients.

CONCLUSION

As indicated by these results, the rapid shallow breathing index was not associated with successful extubation in the present sample of patients with traumatic brain injury.

RESUMO

Objetivo: Verificar a associação entre o índice de respiração rápida e superficial e o sucesso da extubação em pacientes com traumatismo cranioencefálico.

Métodos: Estudo prospectivo, formado por pacientes com traumatismo cranioencefálico, de ambos os gêneros, ventilados mecanicamente por pelo menos 2 dias, que obtiveram sucesso no teste de respiração espontânea. Foram mensurados, por meio da ventilometria, o volume-minuto e a frequência respiratória, sendo calculado o índice de respiração rápida e superficial (frequência respiratória/volume corrente). A variável dependente foi o resultado da extubação: reintubação em 48 horas (falha da extubação) ou não (sucesso da extubação). A variável independente foi o índice de respiração rápida e superficial mensurado após o sucesso no teste de respiração espontânea.

Resultados: A amostra foi constituída por 119 pacientes, sendo 111 (93,3%) do gênero masculino. A média da idade foi de 35,0±12,9 anos. O tempo médio de ventilação mecânica foi de 8,1±3,6 dias. Cento e quatro (87,4%) pacientes obtiveram sucesso na extubação. Não foi observada associação entre o índice de respiração rápida e superficial e o sucesso da extubação.

Conclusão: O índice de respiração rápida e superficial não esteve associado ao sucesso da extubação em pacientes com traumatismo cranioencefálico.

Descritores: Traumatismos encefálicos; Respiração artificial; Unidades de terapia intensiva; Desmame

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