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Development of a risk score to predict extubation failure in patients with traumatic brain injury

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ABSTRACT

Purpose: To identify predictors and develop a risk score for the prediction of extubation failure in TBI patients.
Materials and methods: We prospectively evaluated 311 TBI adults receiving mechanical ventilation for >48 h in the intensive care unit. Epidemiological, ventilatory, airway protective, laboratory, and hemodynamic predictors were evaluated. A multiple logistic regression model was developed to predict the extubation failure risk. A score was developed using the arithmetic sum of the points for each independent predictor, whose scores were proportional to the regression coefficient. The accuracy of the model was determined using the C statistic.
Results: Extubation failure occurred in 43 patients (13.8%). Five independent predictors were identified: female sex (4 points) Glasgow Coma Scale motor score ≤ 5 (4 points), moderate-to-large secretion volume (4 points), absent or weak cough (3 points), and mechanical ventilation ≥ 10 days (2 points). We calculated the risk score for patients and three risk categories were defined: low (0–3 points), moderate (4–7 points), high (8–17 points). The extubation failure rates in the three groups were 3.5%, 21.2%, and 42.9%, respectively.
Conclusion: The score developed to predict extubation failure in TBI patients can identify three risk categories and can be easily applied in the ICU.

1. Introduction

Despite numerous studies on protocols for discontinuation of mechanical ventilation in intensive care unit (ICU) patients [1,2], the extubation failure rate varies, ranging from 2% to 25% according to the population studied. Patients with neurological impairment are at increased risk of extubation failure [3-5]. The optimal extubation timing for brain injury patients with satisfactory weaning parameters is controversial. Concerns regarding factors such as the level of consciousness and ability to maintain the airway can delay extubation in this population and increase the rate of complications due to prolonged mechanical ventilation [6,7]. Extubation failure may be associated with prolonged mechanical ventilation and ICU and hospital length of stay, and may increase the need for tracheotomy [8-11].

Vital capacity, minute ventilation, maximal inspiratory pressure, and the rapid shallow breathing index are variables commonly used as predictors of weaning success. These parameters represent the patient's ability to breathe without ventilatory support; however, they do not provide information on the need for maintenance of the artificial airway [12-14]. Other variables, such as neurological impairment, age, duration of mechanical ventilation before extubation, anemia, and disease severity at the time of extubation, have been identified as risk factors for extubation failure; however, they are limited and may vary according to the study population [5]. Although some findings suggest an increased rate of reintubation in patients with neurological impairment, few studies have specifically evaluated the evolution of and factors associated with the weaning process in patients with traumatic brain injury (TBI). The identification of risk factors for extubation failure and the development of a risk score that allows the classification of TBI patients may be useful to predict the individual risk of extubation failure in TBI patients and may guide treatment decisions.

Thus, the aim of this study was to identify predictors of extubation failure and to develop a risk score for the prediction of extubation failure risk in patients with TBI.

2. Methods

A prospective study was conducted among patients with TBI admitted to the ICU, who required at least 48 h of mechanical ventilation. All

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hospitalized patients with TBI admitted to the ICU of the General Hospital of Bahia between November 2008 and December 2010, were screened. The General Hospital is a trauma referral hospital in the State of Bahia.

TBI patients aged >18 years old, of both sexes, receiving mechanical ventilation for at least 48 h, and with a successful spontaneous breathing trial (SBT) and a Glasgow Coma Scale (GCS) score ≥ 8 at the time of extubation, were included. Patients with spinal cord injuries associated with TBI, patients who were accidentally extubated, and those for whom tracheostomy was performed before the first extubation attempt, were excluded. For patients who were extubated more than once, the first extubation attempt was analyzed. The protocol was approved by the Ethics Committee for Medical Research and written informed consent was obtained from participants.

Potential predictors were subdivided into five categories. The first comprised epidemiological and treatment variables: age (years), sex (male/female), and treatment (surgical or conservative management). The second comprised ventilatory variables: duration of mechanical ventilation (days), partial pressures of arterial blood gases (mm Hg), oxygenation index (PaO_2/FiO_2), type of weaning technique (ventilation with pressure support [PSV] of 7 cm H_2O or T tube), maximal respiratory pressure (cmH_2O), and rapid shallow breathing index.

The third comprised airway protection variables: level of consciousness, according to the GCS (however, because patients were intubated and mechanically ventilated, the verbal response, normally assessed on a scale of 1–5 [maximum score, 5] was set at 1 for all patients, and the best motor and ocular response were evaluated); the volume of pulmonary secretions (absent, minimum: need for suctioning every 2–4 h, moderate: need for suctioning every 1–2 h, and large need for suctioning over once per hour); cuff leak test (positive: without air leak or negative: with air leak: without air leak); and cough strength (0 = no cough; 1 = audible movement of air through the airways; 2 = cough audible, but weak; 3 = clearly audible cough; 4 = strong cough; 5 = multiple sequential strong coughs). The fourth category comprised laboratory variables: hemoglobin (g/dL), and the fifth comprised hemodynamic variables: systolic and diastolic blood pressure (mm Hg) and heart rate (HR).

The dependent variable was the result of the extubation. Extubation failure was defined as the need for reinstitution of the artificial airway within 48 h of extubation. All decisions on weaning and extubation were taken by the support staff of the participating units, without involvement of the researchers. Eligibility criteria for SBT were as follows: reversion or control of the event that resulted in mechanical ventilation, adequate gas exchange, and hemodynamic stability. Patients were extubated when they could tolerate between 30 and 120 min of SBT.

The following variables were collected from re-intubated patients: date and time of reintubation, reason for reintubation (obstruction of the upper airway, excessive respiratory distress, decreased level of consciousness, excessive pulmonary secretions, bronchospasm, and other causes), and whether tracheostomy was performed.

Categorical variables are expressed as absolute and relative frequencies (percentages). Continuous variables are expressed as the mean ± standard deviation (SD). Normality was tested using the Shapiro–Wilk test. The chi-square test or Fisher's exact test were used to compare categorical variables between groups. Student's *t*-test or the Mann-Whitney test was used to compare means or medians between the groups. A multiple logistic regression model was used to evaluate the predictive ability of each independent variable in the event of extubation failure. After univariate analysis, the independent variables with a $p < 0.10$ were included in the multivariate logistic model and were retained if in the model they remained significant ($p < 0.05$). We adopted the model building procedure of manual insertion and removal of variables.

The model's discrimination power was determined by the C statistic and calibration was verified using the Hosmer and Lemeshow test. To calculate the risk score, each independent predictor was assigned a proportional score based on its regression coefficient. The coefficient of each variable was divided by the lower value of the β coefficient, multiplied by a constant, and rounded to the nearest whole number. To assess whether the developed scoring system measured the risk of extubation failure, we calculated scores for each patient. Patients were divided into three categories of risk of extubation failure: low (0–3 points), moderate (4–7 points), high (8–17 points). The alpha level was set at $p < 0.05$. Statistical analyses were performed using SPSS software (version 20, SPSS Inc., Chicago, Illinois, U.S.A.).

3. Results

Out of a total of 629 patients consecutively admitted and requiring mechanical ventilation, 311 were eligible for the study after tolerating SBT (Fig. 1). Table 1 summarizes the demographic and clinical characteristics of the sample. Extubation failure occurred in 43 patients (13.8%). Of these, 31 patients (72.1%) were re-intubated within 24 h of extubation and 12 (27.9%) were re-intubated 24–48 h after extubation. The reasons for reintubation were as follows: respiratory

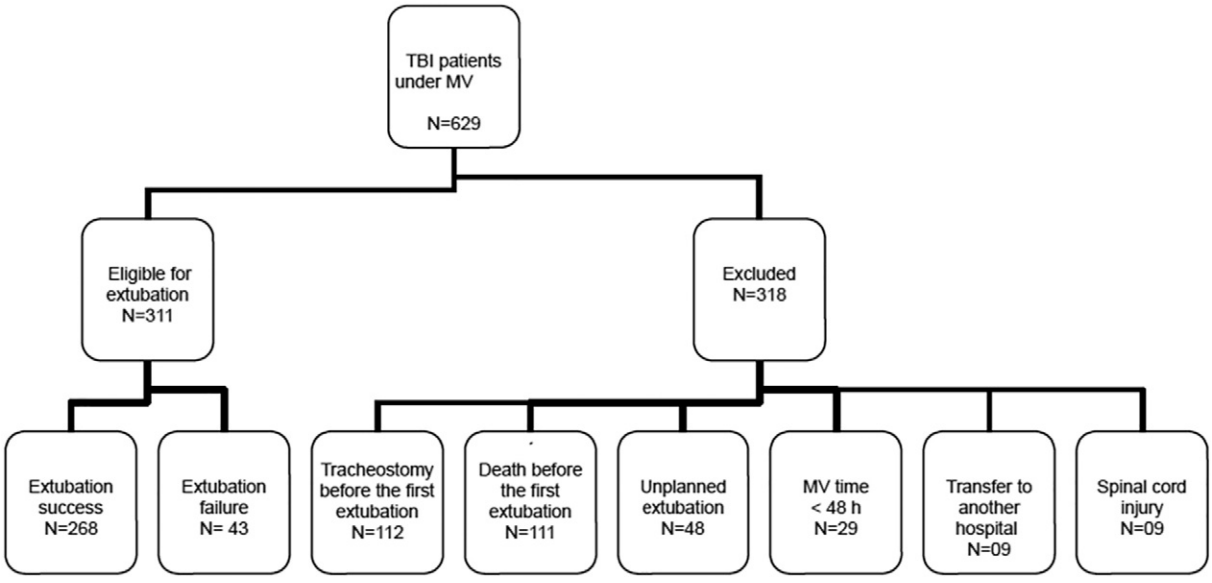

Fig. 1. Extubation results of patients with traumatic brain injury (TBI) under mechanical ventilation (MV).