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ORIGINAL ARTICLE

Semi-quantitative Cough Strength Score as a Predictor for Extubation Outcome in Traumatic Brain Injury: A Prospective Observational Study

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Abstract

Background: Between 25 and 40% of extubated patients with traumatic brain injury (TBI) in the intensive care unit at our hospital (Assiut University Hospital–Assiut–Egypt) require reintubation. This reflects the importance of developing better criteria for predicting successful extubation in TBI. We evaluated the accuracy of semi-quantitative cough strength score (SCSS) and Glasgow coma scale (GCS) in predicting extubation outcomes in TBI.

Methods: This prospective observational study included patients (18–65 years), with TBI on mechanical ventilation more than 24 h who were ready to be weaned off. Three tools were used. Tool I: Patient assessment sheet, this tool used to assess socio-demographic and clinical data of patients. Tool II: Semi-quantitative cough strength score (0–5). Tool III: Factors affecting successful extubation, this tool used to confirm the presence or absence of factors that can interfere with the results of extubation outcomes. After extubation, patient was followed up for 72 h to check for extubation success. Multivariate logistic binary regression test was used to calculate odds ratio for different clinical data collected before extubation as independent factors and successful extubation as a dependent factor.

Results: Among 80 patients of mean age 40.6 (± 16.1), 34% were female, median admission GCS was 8 (4–13), extubation occurred on mean post-injury day 6.5 (± 4), and 46.3% required reintubation. Successfully extubated patients had higher semi-quantitative cough scores and GCS. 81.3% patients with SCSS 5 were successfully extubated, while all patients with SCSS 0 were reintubated. All patients with GCS 15 were successfully extubated, and all patients with GCS < 12 required intubation.

Conclusion: SCSS has shown promise in predicting successful extubation in TBI.

Keywords: Semi-quantitative cough strength score, Mechanical ventilation, Extubation, Traumatic brain injury

Introduction

Traumatic brain injury (TBI), according to the World Health Organization, will be the major cause of death and disability by the year 2020 [1]. It has been estimated that TBI affects over 10 million people annually leading to either mortality or hospitalization [2].

Patients with acute brain injury and impaired consciousness without other indication for mechanical ventilation (MV) might benefit from continued intubation through the prevention of aspiration and the ability to suction secretions [3]. Extubation of these patients, directed by existing readiness criteria for weaning from mechanical ventilation, may decrease the incidence of

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pneumonia and reduce intensive care unit (ICU) and hospital stays and charges [4].

Commonly used predictors of successful weaning [5, 6] do not examine the ability of the TBI patients to clear respiratory tract secretions or to protect lungs from aspiration and therefore cannot provide full information about extubation outcome [4].

Premature extubation may lead to reintubation, sometimes emergent and uncontrolled, with several possible unfavourable outcomes [7]; in these situations, tracheostomy may be reasonable option. Therefore, there is a need for parameters that are more accurate in order to make weaning decisions in such patients. Semi-quantitative cough strength score (SCSS) is an easy and applicable method to be recorded by health providers at the bedside to evaluate cough strength. Duan et al. (2015) found the cough strength score, graded from 0 to 5, a strong predictor in anticipating an extubation outcome [5].

Between 25 and 40% of extubated patients in the trauma ICU at our hospital (Assiut university hospital–Assiut–Egypt) require reintubation. This reflects the importance of developing better criteria for predicting successful extubation. The aim of the present study was to answer the research question about the accuracy of SCSS in predicting failure or success of extubation in TBI, in patients that were ready to be weaned off from MV after successful spontaneous breathing trial (SBT).

Patients and Methods

Research Design

A prospective, observational research design was conducted in the trauma ICU at Assiut university hospital, from September 2016 to March 2017. The study protocol was approved by our local Institutional Review Board (Faculty of Medicine ethical committee, Assiut University) and was registered with the Clinical trials.gov ID: (NCT03031860). Patients' guardians were provided with complete information about the study protocol and an informed written consent was obtained from each patient's guardian.

Study Population

The study included 80 adult male and female patients aged between 18 and 65 years admitted to trauma ICU with TBI on MV more than 24 h, and they were ready to be weaned off from MV after successful SBT. Patients with tracheostomy, Glasgow coma scale (GCS) at extubation < 9, chest wall trauma (ribs fracture and lung contusion) and patients with chronic chest disease (chronic obstructive pulmonary disease, tuberculosis and lung cancer) were excluded from the study.

Study Tools

Three tools were used in this study.

Tool One: Patient Assessment Sheet

This tool was developed by the researcher based on related literature [8] and was used to evaluate the sociodemographic and clinical data of patients. It consists of three parts:

- Part I: Personal characteristics which include age and sex.
- Part II: Clinical data which include medical diagnosis, past history of disease, length of stay in ICU and MV, acute physiology and chronic health evaluation (APACHE II) score, arterial blood gases (pH, PaO_2, $PaCO_2$ and FiO_2) and patient's vital signs 1 h before and 1 h after extubation.
- Part III: MV parameters which include mode of ventilation, tidal volume (ml), minute ventilation (L), rapid shallow breathing index (RSBI) and PaO_2/FiO_2.

Tool Two: Semi-quantitatve Cough Strenth Score

The SCSS tool was adopted from Duan et al. (2015) [5] and used to evaluate the patient's ability to generate a cough for predicting reintubation after planned extubation. The scoring cough pattern is as follows:

- 0 = no cough on command.
- 1 = audible movement of air through the endotracheal tube, but no audible cough.
- 2 = weakly (barely) audible cough.
- 3 = clearly audible cough.
- 4 = stronger cough.
- 5 = multiple sequential strong coughs.

If the patient does not obey the command to cough (SCSS = 0), we examine the cough response by introducing a catheter into the tracheal tube and stimulating the carina, an adjustment to the SCSS.

Tool Three: Factors Affecting Successful Extubation

This tool was developed by the researcher after reviewing the related literature [8] and used to confirm the presence or absence of factors that can interfere with the results of extubation outcomes by using SCSS. These factors are: hypoxaemia, hypercapnia, hemodynamic instability, diminished consciousness, respiratory muscle fatigue, high WBCs, fever, copious secretions and anaemia.

All patients were seen daily for assessment of GCS, and the SBT was performed with a T-tube with oxygen (FiO_2 40%) for 1 h after disconnection of the ventilator. The patient who met the criteria for extubation was

positioned at 30°–45°, and a single observer (respiratory therapist) asked the patient to cough using full power up to three to four times or the patient was stimulated with a suction catheter just prior to endotracheal extubation. SCSS was measured (0–5), and prior to extubation by a physician. One hour after extubation, vital signs and arterial blood gases were assessed and any patient who remained extubated at 72 h was classified as having successful extubation.

Neurologic assessment of GCS before extubation was done by the previously derived method [9] of calculating the verbal score from the eye and motor scores as follows: Derived Verbal Score = − 0.3756 + [Motor Score X (0.5713)] + [Eye Score X (0.4233)].

Variables

The independent variable was application of SCSS on patients and the dependent variable was extubation outcomes (successful extubation or reintubation).

Data Collection

Patient characteristics and clinical data were collected, including age, sex, type of brain injury, associated medical diseases, APACHE II score, GCS on admission and before extubation, SCSS, length of ICU stay, duration of MV and factors affecting extubation outcome.

Statistical Analysis

Statistical analysis was performed using the software package SPSS, version 20. Data were presented as mean ± standard deviation, median (range) or number (percentage) as appropriate. Data were analysed using independent *t* test, Mann–Whitney test or Chi-square test according to data type. We calculated the odds ratio for the various clinical data collected prior to extubation (independent factors) and successful extubation (dependent factor) by multivariate logistic binary regression test. $P < 0.05$ was considered statistically significant.

Results

Eighty patients with TBI were included in the study. All the patients completed the study period of 72 h after tracheal extubation. The demographic and clinical data among the studied group are collected in Table 1. Comparison between demographic data in successfully extubated and reintubated patients revealed that age of the patients and the length of hospital stay were significantly higher in reintubated patients ($P < 0.05$), and other data showed insignificant differences ($P > 0.05$) as shown in Table 1.

Table 1 Personal characteristics and clinical data among the studied group

Item	Overall patients	Successfully extubated patients (*n* = 43)	Reintubated patients (*n* = 37)	*P* value
Age (years)	40.56 ± 16.14	35.8 ± 14.5	44.3 ± 16.3	0.01*
Gender (male/female)	53/27	25/15	23/17	0.84
Length of hospital stay	11.9 ± 6.7	9.1 ± 3.8	14.9 ± 7.7	0.001*
APACHE II score on admission	7.9 ± 3.7	7.38 ± 3.2	8.39 ± 4.09	0.223
GCS before on admission	8 (7)	8 (7)	9 (7)	0.695
Associated medical diseases				
Non	54	30	24	0.773
HTN	11	6	5	
DM	6	4	2	
HTN + DM	5	2	3	
HTN + DM + CRF	1	0	1	
COPD	3	1	2	
Types of brain injury				
I.C. haemorrhage	21	11	10	0.912
Concussion	16	9	7	
Brain oedema	23	11	12	
Skull fracture	11	6	5	
Diffuse axonal injury	9	6	3	

Data were expressed as mean ± SD, median (range) or number

APACHE acute physiology and chronic health evaluation, *COPD* chronic obstructive pulmonary disease, *CRF* chronic renal failure, *DM* diabetes mellitus, *GCS* Glasgow coma scale, *HTN* hypertension, *I.C.* intracranial

*$P < 0.05$ is considered statistically significant

Table 2 Bivariate analysis of some factors at the time of extubation

Clinical variable	Overall patients	Successfully extubated patients ($n=43$)	Reintubated patients ($n=37$)	*P* value
SCSS before extubation	5 (5)	5 (3)	3 (3)	0.003*
GCS before extubation	13 (6)	13 (6)	12 (6)	0.001*
Duration of MV (days)	6.46 ± 3.96	5.26 ± 2.7	7.79 ± 4.66	0.022*
RSBI (breaths/min/L)	58.55 ± 22.35	58.9 ± 22.3	57.8 ± 23.3	0.83
PaO_2/FiO_2 before extubation	303.5 ± 133.7	300.9 ± 128.7	306.4 ± 140.8	0.86
Hemodynamic instability	0	0	0	–
Copious secretions	14	6	8	0.72
Anaemia	0	0	0	–
Leukocytosis	35	19	16	0.56
Fever	26	14	12	0.59

Data were expressed as median (range), mean ± SD, and numbers

GCS Glasgow coma scale, *MV* mechanical ventilation, *RSBI* rapid shallow breathing index, *SCSS* semi-quantitative cough strength score

**P* < 0.05 is considered statistically significant

Table 2 describes a bivariate analysis of the clinical factors that can confound the results of extubation outcomes. SCSS and GCS before extubation were significantly higher in successfully extubated patients ($P<0.05$), while the duration of mechanical ventilation was significantly shorter in successfully extubated patients ($P<0.05$). Other clinical factors such as RSBI, PaO_2/FiO_2 ratio, copious secretions, leukocytosis and fever showed insignificant difference between successfully extubated and reintubated patients ($P>0.05$). No patients with hemodynamic instability or anaemia were recorded at the time of extubation.

As shown in Table 3, from all parameters collected before extubation, which may affect the success of the extubation, SCSS and GCS were independently associated with successful extubation. The odds ratio for SCSS was [OR 2.29; 95% CI (1.46–3.6)] ($P=<0.001$), and for GCS it was [OR 1.85; 95% CI (1.23–2.97)] ($P=0.03$). The overall rate of reintubation was 46.25%, where 37 patients were reintubated within the first 3 days post-extubation.

Of the studied group, 54.1% developed multiple sequential strong coughs (SCSS = 5) in comparison with 6.25% of them developed no cough on command (SCSS = 0). As shown in Fig. 1, 81.3% of patients who had SCSS = 5 successfully extubated, in comparison with 0% of patients who developed SCSS = 0. The majority of patients (30%) before extubation had GCS = 12 in comparison with 25% of them had GCS = 13 and 9% had GCS 15. All patients with GCS 15 successfully extubated, while all patients who had GCS 9, 10 and 11 were reintubated within 72 h after extubation (Fig. 2).

Table 3 Association between different clinical data collected before extubation and the success of extubation

	Odds ratio	95% CI		*P* value
		Lower	Upper	
Age (year)	0.97	0.93	1.01	0.175
Gender (male/female)	0.63	0.16	2.52	0.518
APACH II on admission	0.83	0.69	1.01	0.065
SCSS before extubation	2.29	1.46	3.6	<0.001*
GCS before extubation	1.85	1.23	2.97	0.03*
Duration of MV (days)	0.83	0.69	1	0.054
RSBI (breaths/min/L)	1.01	0.98	1.04	0.405
PaO_2/FiO_2 before extubation	1	0.99	1.01	0.97

Data were expressed as odds ratio and 95% confidence interval (lower and upper) of odds ratio

ABG arterial blood gases, *APACHE* Acute physiology and chronic health evaluation, *GCS* Glasgow coma scale, *RSBI* rapid shallow breathing index, *SCSS* semi-quantitative cough strength score

**P* < 0.05 is considered statistically significant

Discussion

This prospective observational study evaluated the accuracy of SCSS and GCS as predictors of extubation success in mechanically ventilated patients with severe TBI.

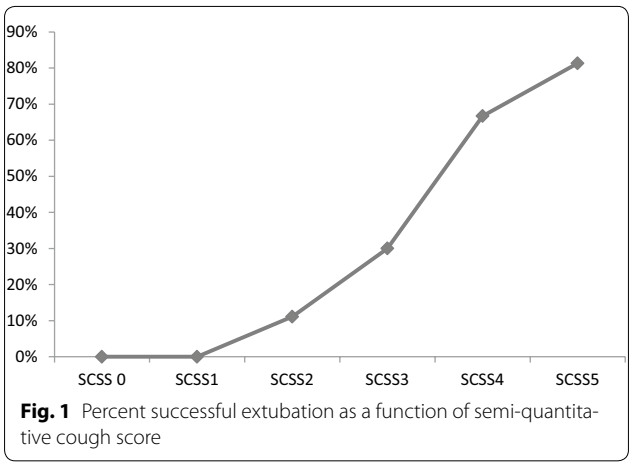

Fig. 1 Percent successful extubation as a function of semi-quantitative cough score

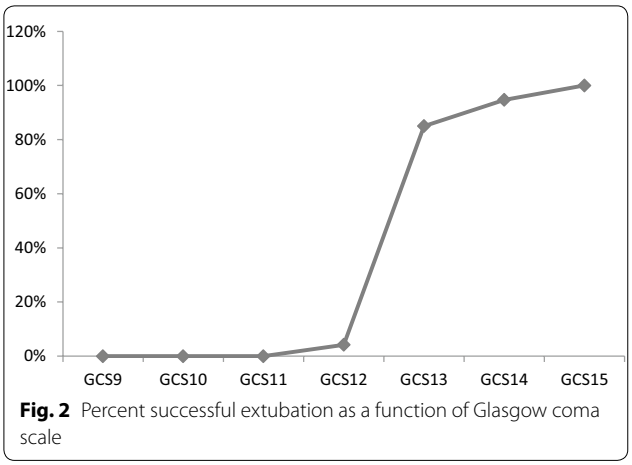

Fig. 2 Percent successful extubation as a function of Glasgow coma scale

Our data revealed that patients with high cough strength score were more often successfully extubated (OR 2.29; 95% CI [1.46–3.6] for each point increase in SCSS). All patients with a SCSS of 0 ($n=5$) were reintubated compared to only 20% that of patients with SCSS of 5 ($n=43$). This aligns with the work of Duan et al. (2015 and 2016) who reported high reintubation rates with low SCSS [5, 11]. Additionally, all patients with GCS < 12 required reintubation. It is reasonable to conclude that in addition to cardiopulmonary evidence of weaning readiness, a strong cough is required for safe extubation. While the need for GCS > 8 remains controversial, our extubated patients with GCS 9-11 did very poorly when extubated, despite prior published evidence suggesting low GCS is not a risk factor for reintubation [4].

Kulkarni and Agarwal (2008) concluded that poor cough and inability of the patient to protect airway increase the risk of extubation failure [10]. Also Thille et al. (2011) considered a poor cough with secretion retention is the most common causes of extubation failure [11]. Extubation trial in a sample of neurocritical care patients with traditional weaning parameters does not predict extubation failure [12], and the ability to follow four commands (close eyes, show two fingers, wiggle toes, cough to command) was associated with extubation success in the neurocritical care unit [13].

Initially, Coplin and his colleagues (2000) evaluated brain-injured patients by using a semi-quantitative airway care score which comprised six parts and they assigned four points each: spontaneous cough, gag, sputum quantity, sputum viscosity, suctioning frequency and sputum character [4]. After that, Khamiees et al. (2001) extended these findings by observing that semi-quantitative assessment of cough strength and secretion volume was predictive of extubation outcomes in a cohort of medical patients [14]. Duan et al. (2015) evaluated the cough strength on command (0–5) in patients passing SBT [5]. Since then, SCSS was used by many researchers. One major problem with the application of the SCSS in TBI is that it requires the tested patient to have language function. If the patient does not obey the command to cough or if SCSS = 0, we examined the cough response by introducing a catheter into the tracheal tube and stimulating the carina, consider this technique as a modification to SCSS.

Extubation failure in our work reached 46% within the first 3 days after extubation, this result is extremely high in patients with TBI compared to the results of the systematic review and meta-analysis of Wang et al. (2014) which included nine studies and involving 928 participants in neurocritical care (extubation failure was 20–40%) [15]. We attributed this to the study population and their level of consciousness where 42.5% of patients had GCS from 9 to 12. Also, this may be explained by the results of other studies in medical, neurological or mixed ICUs, which concluded that many variables have been identified as risk factors for extubation failure and reintubation, such as age and underlying diseases [16], severity of acute illness [11] impairment of oxygenation [17], the amount of secretions [18], cough strength [19] or mental status [20]. Secretions and perhaps cough status are the most important parameters to predict success or failure of extubation in myasthenic crisis [15].

Our study revealed that GCS was another predictor of the success of reintubation in TBI (OR 1.85; 95% CI [1.23–2.97] for each degree increase in GCS). All patients with GCS 15 were successfully extubated, while patients with GCS 9, 10 and 11 were reintubated; this result is grossly at odds with the study of Coplin's et al. (2000) [4], who cited that 80% of patients with GCS < 8 and 91% with GCS < 4 were successfully extubated. This dispute can be explained by the fact that we only included patients with TBI whereas Coplin's study included all patients with TBI, aneurysmal subarachnoid haemorrhage, stroke, global cerebral ischaemia, status epilepticus and encephalitis. Also in Coplin's study, patients with a GCS > 9 on extubation readiness day had delayed extubation which improved the neurologic status and decrease the rate of reintubation.

Namen et al. (2001) examined clinical characteristics of patients undergoing weaning and revealed that patients with successful extubation had a higher GCS score [21]. Rabinstein and his colleagues also concluded that the GCS might be important in predicting successful extubation in middle cerebral artery acute ischaemic stroke patients [22], while Coplin (2000) found that there was no correlation between GCS and need for reintubation [4].

We observed about 30% of the reintubated patients were suffering from tachycardia and tachypnea within 72 h post-extubation. On revision of the laboratory results, we found that anaemia (Hb < 7gm/dl) was a possible cause of cardio-respiratory instability. The body compensates for anaemia by increasing cardiac output, oxygen unloading and oxygen extraction [23]. McEvoy et al. (2013) showed increased risk of reintubation or weaning failure from MV [24]. Khamiees et al. found anaemia to be associated with extubation failure in a mixed medical-surgical ICU population [14]. Anecdotal cases have been reported by patients with severe anaemia presenting with symptoms of increased ICP and signs of papilledema, which resolve with treatment of the anaemia [25]. The mechanism is thought to be related to the marked increase in cerebral blood flow that is required to maintain cerebral oxygen delivery when anaemia is severe [26].

Limitations of the Study

While there was an association between the SCSS and the likelihood of successful extubation, the score by itself does not distinguish between patients who will succeed or fail, except at the extremes of the ranges. Only 80 patients were included, whereas several references have a larger number of patients; however, our study focused on one type of neurocritical care patients which is TBI, while others included patients with acute brain injury (TBI and other pathology).

Conclusion

SCSS has shown promise in predicting successful extubation in TBI but will have to be further tested, likely in combination with other factors, to create a robust prediction model.

Recommendation

The current study recommended further research to help determine accurate predictors of extubation success or failure in traumatic brain-injured patients.

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Compliance with Ethical Standards

Conflict of Interest
The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval
The study was approved by our local institutional review board (IRB), Faculty of medicine, ethical committee, Assiut University, Assiut, Egypt. Approval date: May 4 2016. Organization's Unique Protocol ID: 17100390.

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