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NEUROCRITICAL CARE SOCIETY

VIEWPOINT

Extubation After Acute Brain Injury: An Unsolved Dilemma!!

Daniel Agustin Godoy[1], Maximiliano Rovegno[2*] and Manuel Jibaja[3,4]

Introduction

Mechanical ventilation (MV) is a critical support for patients with severe neurological pathologies, and the processes of liberation or weaning and extubation require careful attention and consideration. Epidemiological studies have shown that neurological pathology is the second most common reason for MV in these patients [1]. However, there is limited information available about the weaning and extubation processes for individuals with severe neurological injuries [1–4]. The strategies used have been extrapolated from research and protocols obtained from populations without neurocritical disease [1, 2, 5].

Most patients with brain injury are not ventilated because of primary respiratory failure but rather because of compromised consciousness, leading to an inability to maintain an open airway. Consequently, the primary goal of MV is to prevent cerebral secondary damage by addressing factors such as hypoxemia, hypercapnia, and hypocapnia [3, 4]. It is worth noting that neurocritical patients often experience prolonged periods of MV and intubation [2, 3].

During the process of weaning from MV and subsequent extubation, it is frequently observed that patients present a compromised level of consciousness, resulting in an inability to "obey commands." Nonetheless, these patients still meet the standard respiratory and hemodynamic criteria required to initiate the weaning process [5, 6]. The percentage of time dedicated to weaning from MV is high in the neurological patient population, comparable to that seen in nonneurological patients (Fig. 1).

*Correspondence: maxrovegno@uc.cl
[2] Departamento de Medicina Intensiva, Facultad de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile
Full list of author information is available at the end of the article

A recently published review by Rabinstein et al. on weaning in neurocritical care concluded with a true statement: "Deciding when it is safe to start weaning the patient from mechanical ventilation, particularly when it is safe to attempt extubation, is a common clinical dilemma" [7].

Epidemiology of Weaning from MV in Neurocritical Care

Despite the high incidence of respiratory complications in neurocritical patients, available data on weaning from MV remain scarce [1, 2, 4]. The accepted criteria for initiating weaning from MV is the resolution of the primary cause, which is rarely met in neurocritical patients [4, 6, 8]. A multicenter prospective observational study revealed that neurocritical patients are ventilated for longer periods and experience higher rates of ventilator-associated pneumonia and mortality compared with the general population [2]. Weaning from MV was difficult in almost half of the cases and prolonged in 10% of them. Interestingly, the duration of weaning, as well as the reintubation rates, was similar to that in the population without neurological pathological conditions [2]. Navalesi et al. [9] in a randomized controlled trial, evaluated the weaning and extubation processes using a protocolized, multidisciplinary, and controlled approach. The study found a significant reduction in failure rates of extubation using the protocolized approach compared with the control group [9]. Summarizing the extubation failure rate reported in neurocritical patients fluctuates between 5 and 20%, in lastly two decades of literature (Table 1).

These heterogeneous results probably explain why the recommended MV weaning criteria cannot be applied to neurocritical patients given their compromised state of consciousness [4, 6]. Several studies have shown that the usual respiratory criteria used for weaning from MV and extubation are poor predictors in neurocritical patients [5, 6, 10–12].

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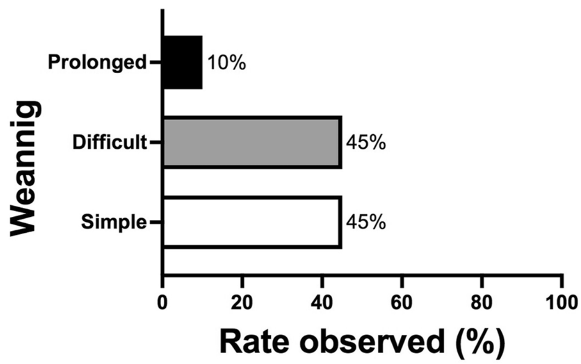


Fig. 1 Data of the neurocritical patient according to the classification of mechanical ventilation weaning. This classification considers the complexity and time of weaning. Each of these groups has its prognostic characteristics. Weaning categories: (1) simple weaning: the patient passes the first spontaneous breathing attempt (SBT) and is successfully extubated; this occurs in approximately 70% of cases; (2) difficult weaning: the patient does not tolerate the first SBT and requires up to three additional trials or up to 7 days from the first attempt for successful extubation; and (3) prolonged weaning: extubation is achieved after more than 7 days from the first SBT. Adapted from ref. [2]

Table 1 Extubation failure in studies of neurocritical patients

Author (year)	Number of patients included	Failed extubation, %
Coplin (2000)	146	17.2
Namen (2001)	100	38.0
Manno (2008)	16	12.5
Ko (2009)	62	12.4
Karanjia (2011)	1,265	10.0
Anderson (2011)	285	16.8
McCredie (2017)	152	21.0
Asehnoune (2017)	437	22.6
Cinotti (2022)*	1,512	19.4

Adapted from ref. [19]

*The ENIO (Extubation strategies and in Neuro-Intensive care unit patients and associations with Outcomes) study

Role of the Level of Consciousness

Extubation in individuals with altered mental status or "not following commands" is a complex and controversial issue [13]. The term "inability to follow commands" is not clearly defined, and the evaluation employing the Glasgow Coma Scale (GCS) in the intubated patient poses challenges and may lead to errors. Moreover, the cutoff point to establish when a patient can be safely extubated varies and is often arbitrarily defined [5, 6, 10, 11, 14].

Namen et al. [15] reported that patients with a GCS score ≥ 8 had an extubation failure rate of 25%, whereas in those with a GCS score < 8 had a significantly higher failure rate of 63%. A GCS score ≥ 10 was associated with successful extubation in another study [13].

Currently, recommendations state that starting the MV weaning process requires the patient to be awake and capable of obeying orders [14]. However, in the case of brain injury, these criteria may not be strictly necessary [3–6, 10, 11]. Coplin et al. reported successful extubation rates of 80% for patients with a GCS score ≤ 8 and 91% for those with a GCS score ≤ 4 [16]. Ko et al. [10] used the Full Outline of Unresponsiveness score scale to assess neurological status and found no significant difference in mean scores between patients with failed extubation and those with successful extubation. Similar results were reported by Anderson et al., who used the GCS to assess neurological status [11]. McCredie et al. [14] also showed that the GCS score was not significantly associated with successful extubation.

Role of Stridor and Laryngeal Edema Post Extubation

After extubation, it is crucial to consider the occurrence of stridor, which can vary between 1.5% and 26.3%, and the rate of laryngeal edema, ranging from 5% to 54.4%. These variable findings can be attributed to the lack of clear diagnostic criteria [17, 18].

Reintubation rates in critically ill patients generally range from 18 to 69% because of stridor and 15% because of laryngeal edema [19]. A reliable tool to predict these complications is the cuff leak test developed by Miller et al. [20]. Subsequent meta-analyses and clinical practice guidelines have also confirmed the usefulness of the cuff leak test [21–23].

Current evidence suggests that administering steroids for a limited duration (up to 24 h) before extubation in patients with risk factors for postextubation stridor can significantly reduce its occurrence and subsequent reintubation rates. Studies conducted by Kuriyama et al. have found that this strategy, including the use of the cuff leak test, is effective in reducing extubation failure [24, 25].

Risks Factor for Extubation Failure

The current predictors for successful extubation used in general intensive care unit (ICU) patients are not fully valid in patients with brain injury [5, 10, 16]. Here, the rate of extubation failure is around 20% [13], and there has been no improvement in the last 20 years [13, 16, 26] (see Table 1). Additionally, the weaning process of MV is more complex in patients with brain injury. In a post hoc analysis of three multicenter prospective studies involving more than 12,618 mechanically ventilated patients in 1,262 ICUs across 45 countries, Tejerina et al.

reported lower rates of successful extubation after the first attempt, higher rates of unplanned extubation, and increased reintubation rates in 1,722 patients with acute brain injury [27].

Several extubation prediction scores have been proposed, but their general acceptance remains limited because of validation issues and concerns about representativeness. A definitive consensus on the factors that determine extubation success has not been reached. However, airway patency and neurological status are frequently identified as common denominators in the literature. In this section, we will explore the main scores used to predict successful extubation in patients with acute brain injury, with a focus on airway care, and discuss their strengths and limitations.

Scores for Extubation Prediction

Coplin Score

Coplin et al. published in 2000 an observational cohort study of 136 patients with acute brain injury [16]. Among them, 37 (27%) experienced delayed extubation, occurring more than 48 h after meeting the readiness criteria for extubation. These patients experienced a higher incidence of pneumonia, longer stays in the ICU and hospital, increased costs, and higher mortality rates. Criteria were used for general ICU patients together with the evaluation of neurologic status. Demanding a physical examination not deteriorating and ICP $\leq$ 20 mm Hg with cerebral perfusion pressure $\geq$ 60 mm Hg (when ICP was measured). Coma (GCS score $\leq$ 8) occurred in 31% of patients with no delay in extubation compared with 78% of those with delayed extubation ($p < 0.001$). Surprisingly, of the 37 patients with delayed extubation, 16 (43%) experienced no changes or decline in neurological status on the day of extubation. The authors designed an airway care score (ACS) that consists of six categories, including assessments of cough, gag reflex, sputum description, and the need for suctioning frequency (Table 2). The ACS was found to be higher in patients with delayed extubation, indicating poorer airway patency in these individuals.

Pros

It is the first study that evaluated weaning success in neurocritical care and shed light on factors associated with delayed extubation. Notably, the ACS remains a reference score for the care of the airway.

Cons

Cons are that the study had an observational design, it was conducted in a single center, and the ACS was not prospectively evaluated to predict success of extubation.

Modified Semiquantitative Airway Score

Steidl et al. [28] conducted a prospective cohort study involving 185 ventilated patients with either stroke or intracerebral hemorrhage to analyze the risk factors associated with extubation failure and the need for primary tracheostomy. Extubation failure occurred in 36 (37%) patients and was independently associated with prior neurosurgical treatment or worse airway score on a binary logistic regression (odds ratio [OR] 15.8, 95% confidence interval [CI] 3.1–80.5, $p < 0.001$, and OR 1.4, 95% CI 1.07–1.96, respectively). In this case, the airway scale was a modification of the Coplin score [16] in which sputum viscosity (watery: 0, frothy: 1, thick: 2) and character (clear: 0, tan/yellow: 1) were shortened. Interestingly, age, National Institutes of Health Stroke Scale score on admission, the GCS score before extubation, and neurologic capacity to follow commands were not associated with extubation failure in the multivariate analysis.

Pros

This study produced a simplified version of the airway score as well as a multivariate analysis to reduce bias. Moreover, the airway score proved to be useful in identifying patients at risk of failing extubation.

Cons

Cons are the study's observational design, that it was conducted in a single center, and that only patients with stroke and intracranial hemorrhage were admitted.

dos Reis Score

dos Reis et al. [29] published in 2017 a score to estimate extubation failure based on 311 mechanically ventilated patients with traumatic brain injury. Extubation failure was defined as the need for artificial airway reinstitution within 48 h of extubation. Forty-three (13.8%) patients

Table 2 Semiquantitative airway score [16]

Score	Spontaneous cough	Gag	Sputum quantity	Sputum viscosity	Sputum character	Suction frequency
0	Vigorous	Vigorous	None	Watery	Clear	> 3 h
1	Moderate	Moderate	1 pass	Frothy	Tan	q 2–3 h
2	Weak	Weak	2 passes	Thick	Yellow	q 1–2 h
3	None	None	≥ 3 passes	Tenacious	Green	≤ q 1 h

experienced extubation failure. Using a multivariate analysis, the factors independently associated with extubation failure were female sex (4 points), motor response ≤ 5 points on the GCS (4 points), moderate or high volume of tracheal secretion (4 points), weak or absent cough (3 points), and MV ≥ 10 days (2 points). The authors found three risk categories to predict extubation failure: low (0–3 points), moderate (4–7 points), and high (8–17), with 3.5%, 21.2%, and 42.9%, respectively. The C statistic for the scoring system was 0.81 (95% CI 0.74–0.87; $p < 0.001$), indicating good accuracy in predicting extubation failure.

Pros

This is a simple score to predict extubation failure, and it was developed in a Latin America country that allows external validation for a population not studied previously.

Cons

Cons are the study's observational design, that it was conducted in a single center, and that only patients with traumatic brain injury were included. Furthermore, the high-risk category only predicts a < 50% chance of extubation failure.

VISAGE Score

Asehnoune et al. [13] published in 2017 a prospective observational study involving four ICUs to develop a predictive score for successful extubation in patients with brain injury. A total of 437 patients mainly with traumatic brain injury, subarachnoid hemorrhage, and intracranial hemorrhage were included. Extubation failure, defined as the need for reintubation in the first 48 h after extubation, occurred in 99 cases (22.6%). Using a multivariate analysis, the study identified several factors independently associated with extubation success: visual pursuit (OR 2.79, 95% CI 1.61–4.82, $p = 0.0002$), swallowing attempts spontaneous and/or demand (OR 2.90, 95% CI 1.67–5.03, $p = 0.0001$), age < 40 years old (OR 2.27, 95% CI 1.21–4.26; $p = 0.0109$), and GCS score > 10 (OR 2.40, 95% CI 1.38–4.18, $p = 0.0019$). Each factor counted as one point for the extubation score (VISAGE), and a score of ≥ 3 points was associated with a 90% extubation success rate. The area under the curve was 0.75 (95% CI 0.69–0.81), indicating good accuracy in predicting extubation success.

Pros

This study changes the literature because it produces a simple score useful to predict successful extubation in neurocritical care patients. Also, it was larger than the previous one and included four centers.

Cons

Unfortunately, the VISAGE score has not been validated in other cohorts.

ENIO Score

Cinotti et al. published in 2022 the ENIO study. It was a multicenter observational study conducted in 73 ICUs across 18 countries aimed at validating a predictive score for extubation success [26]. Neurocritical care patients with a baseline GCS score ≤ 12 and MV for ≥ 24 h were included. Extubation failure was defined as reintubation in the first 5 days after extubation. The score was designed with two thirds of the patients randomly allocated to the training cohort and one third randomly allocated to the validation cohort. A total of 1,512 patients were included, of whom 231 (19.4%) experienced extubation failure. The score was composed of 20 variables independently associated with extubation success. However, for simplification, the authors retained seven predictors: traumatic brain injury diagnosis, vigorous cough, gag reflex, swallowing attempts, endotracheal suctioning frequency ≤ 2 q h, GCS motor score = 6, and body temperature. The areas under the curve were 0.79 (95% CI 0.71–0.86) in the training cohort and 0.65 (95% CI 0.53–0.76) in the validation cohort. Interestingly, the primary cause of extubation failure was neurological only in 39.8% of cases. The majority of failures were related to respiratory failure and airway patency (54.5% and 37.7%, respectively).

Pros

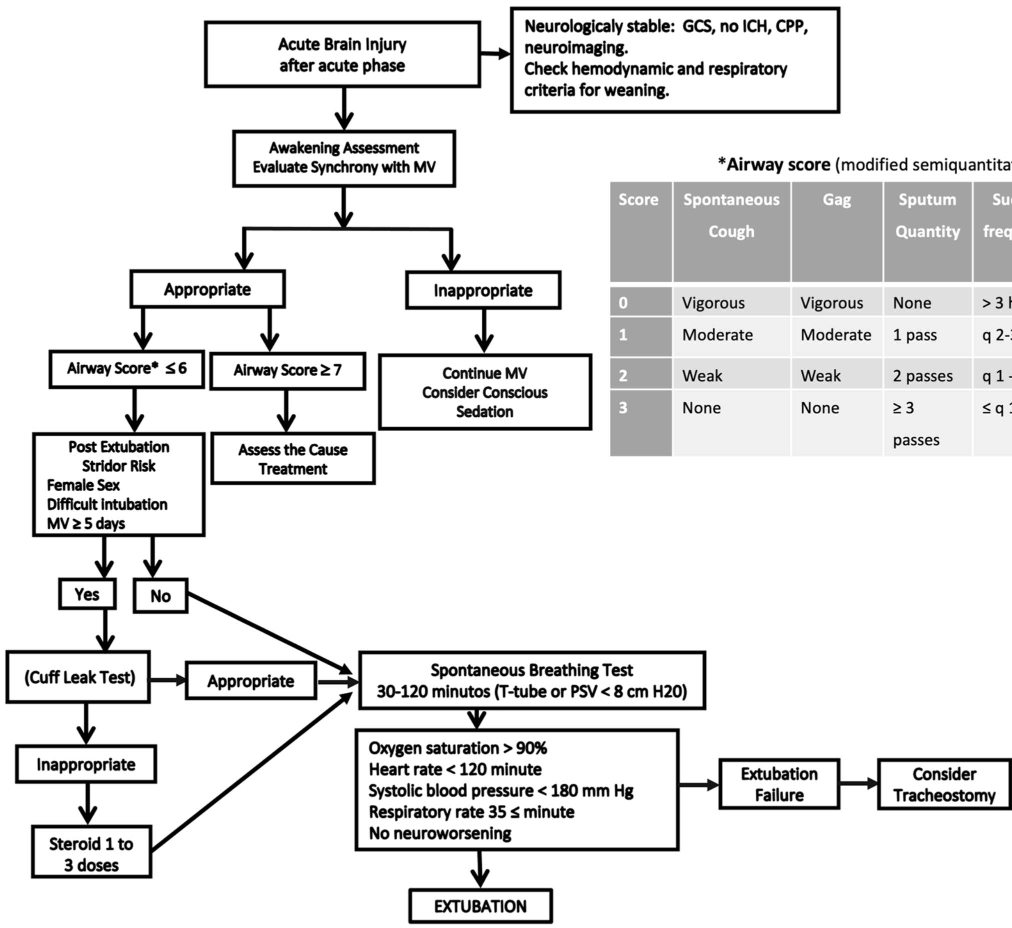
The ENIO score addresses several limitations observed in previous studies. Being the largest study in terms of patient inclusion, as well as being multicenter and international, it encompassed diseases that are often excluded in other trials, such as brain tumors and central nervous system infections. Additionally, the score was validated using a split design, enhancing its reliability and applicability.

Cons

The calculation of the score is not straightforward and requires an electronic spreadsheet.

Conclusions

Given the substantial time dedicated to MV weaning in neurological cases, in addition to longer ICU/hospital stays and higher rates of nosocomial pneumonia and mortality for those patients with weaning failure, it becomes increasingly crucial to focus on targeted research efforts to optimize patient outcomes. A deeper understanding of the complexities involved in liberating neurological patients from MV will lead to improved



***Airway score** (modified semiquantitative, 15 points max.)

Score	Spontaneous Cough	Gag	Sputum Quantity	Suction frequency	Sputum Viscosity	Sputum Character
0	Vigorous	Vigorous	None	> 3 h	Watery	Clear
1	Moderate	Moderate	1 pass	q 2-3 h	Frothy	Tan/Yellow
2	Weak	Weak	2 passes	q 1 - 2 h	Thick	-
3	None	None	≥ 3 passes	≤ q 1 h	-	-

Fig. 2 Proposed algorithm for weaning and extubation of neurocritically ill patients. Modified from ref. [19]. CPP cerebral perfusion pressure, GCS Glasgow Coma Scale, ICH intracranial hypertension, MV mechanical ventilation, PSV pressure support ventilation. *Coplin score or another similar

management strategies and better overall patient care. By addressing these unique challenges, we can enhance the success rate of weaning and extubation, ultimately improving outcomes. To the best of our knowledge, the decision to extubate a neurocritical care patient remains in three basic conditions:

1. General ICU predictors include hemodynamic and respiratory stability, together with a positive spontaneous breath test result.
2. Neurologic state according to support spontaneous ventilation: brain injury in process of resolution, no surgery planned, considering the trajectory of the neurological condition and the level of consciousness without establishing a minimum GCS score threshold.
3. Airway patency, which is the assessment of the "ability to protect the airway" and "handle secretions," both evaluated with the Coplin score or similar.

Algorithm Proposed

Taking into consideration these conditions signaled, we have previously developed a specific management algorithm with the intention of addressing the issues analyzed, as illustrated in Fig. 2 [19]. It is a priority and it is necessary, as soon as possible, to carry out quality studies that help define an adequate strategy for weaning from MV and especially for extubation in neurocritical patients. The Latin American Brain Injury Consortium (LABIC) is determined within its objectives to generate or collaborate with this type of research.

Author details
[1] Neurointensive Care Unit, Sanatorio Pasteur, Catamarca, Argentina. [2] Departamento de Medicina Intensiva, Facultad de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile. [3] Escuela de Medicina, Universidad San Francisco de Quito, Quito, Ecuador. [4] Unidad de Cuidados Intensivos, Hospital de Especialidades Eugenio Espejo, Quito, Ecuador.

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