



Peculiar Predictors for Failed Extubation among Patients Undergoing Elective Cranial Neurosurgical Procedures at Neuro-Critical Care Unit (NCCU): A Systemic Review

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Abstract

To predict “extubation failure” is essential, as both delayed and failed extubation have detrimental consequences such as prolonged ventilation and long Intensive Care Unit (ICU) stay, need for tracheostomy, increased cost of treatment and mortality. However, it is not an easy task to predict which patients are to fail with the extubation process merely based on the conventional parameters of extubation for any critical patient in an ICU setting in general and neurocritical patient in particular. Hence, this paper will review and summaries the current available evidences to develop a better guideline that improves the success rate of extubation process. In conclusion, balancing risk of early vs delayed extubation is needed by using all the risks incriminated for extubation failure in neurosurgical patients & patients’ general condition besides to the conventional indications for extubation as none of the predictors accurately predicts extubation failure. In addition, good communication among inter-departments taking care of neurocritical patients is of paramount importance. Lastly, future better quality and multicentric studies that predicts and guide extubation failure is recommended.

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Abbreviations: BP: Blood Pressure; GCS: Glasgow Coma Scale; ICU: Intensive Care Unit; LCN: Lower Cranial Nerve; LOS: Length of Stay; MV: Mechanical Ventilation; NCCU: Neuro-Critical Care Unit; PCF: Peak Cough Flow; POPCs: Post-Operative Pulmonary Complications; PPC: Post-Operative Pulmonary Complications; PEF: Peak Expiratory Flow; SBT: Spontaneous Breathing Trial.

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Introduction

Intubation and extubation of patients are parts of the airway managements of neurosurgical patients of its need [1] approximately 20% of all patients requiring mechanical ventilation suffer from neurological dysfunction [2-3] However; there is no single universal approach to mechanical ventilation in critically ill neurosurgical patients. Hence, weaning the neurosurgical patient from mechanical ventilation is largely a matter of judgment and experience as there is no specific weaning protocols or extubation criteria that can be applied to this population [4].

Weaning process

It is a daily screening of patients to off of mechanical ventilator support when they fulfilled the following criteria: a) resolved need for sedatives and vasoactive drugs; b) hemodynamic stability; c) adequate respiratory drive, with absence of apnea or tachypnea (respiratory rate less than 35 rpm); d) no immediate upcoming surgery scheduled; e) laboratory exam results within normal ranges; f) arterial blood gases within normal ranges (pH between 7.35 and 7.45; PaCO₂ between 30 to 40 mmHg); g) PaO₂ >60 mmHg, with FiO₂ ≤0.4 and PEEP ≤5 cmH₂O; h) resolution of conditions requiring maintenance of the patient on MV after surgery; i) Glasgow Coma Scale equal to or greater than 8, and j) agreement by the neurosurgeon in charge [5].

Patients who fulfilled the weaning criteria will be subjected to a Spontaneous Breathing Trial (SBT). The SBT usually performed once a day and consisted of 30- to 120-min trials of spontaneous breathing performed on a T-tube or pressure support of ≤8 cmH₂O and a PEEP level of ≤5 cmH₂O. All patients ultimately passed an SBT will be extubated. The criteria used to define failure to tolerate the SBT are: a) oxygen saturation <90%; b) respiratory rate of >35 breaths/min for >10 min; c) a >20% decrease or increase in systolic blood pressure; d) signs of increased breathing efforts for >15 min, and e) diaphoresis or agitation. An SBT is considered to have failed if any 2 of the above-listed criteria are met, in which case, SBT must be stopped and Mechanical Ventilation (MV) is reinstated at the original settings.

Extubation failure

Though there is variation in the definition, extubation failure is considered when patients who successfully completed SBT & extubated needed reintubation within 48 hours of their extubation while prolonged Mechanical Ventilation (MV) is considered when patients needed ventilatory support for more than 48 h after the completion of surgery [5].

To predict “extubation failure” is essential, as both delayed and failed extubation have detrimental consequences such as prolonged ventilation and ICU stay, need for tracheostomy, increased cost of treatment and mortality [6].

Despite there exist rough clinical guidelines for intubation and extubating patients, when to extubate neurosurgical patients is not free of controversy specifically among departments and physicians because of fear of mechanical ventilation related and extubation failure related complications. Hence, this paper will try to review the up-to-date evidences and come up with a better guideline to help improve patient outcome [7].

Incidence of failed extubation

Weaning and extubation in neurocritical patients poses unique challenges, and, indeed, the incidence of extubation

failure and reintubation in such patients has been observed to be approximately 10%–15% [8].

Consequence of failed extubation

Patients who need reintubation present higher rates of mechanical ventilator-associated pneumonia, longer stay in Intensive Care Units (ICUs), tracheostomy, reoperation, post-operative pulmonary complications and longer hospital stay [1-5]. Extubation failure was associated with increase in mortality with (OR 8.05 [1.88; 34.36], Post-Operative Pulmonary Complications (PPC) (OR = 11.18 [2.27; 55.02]) and tracheostomy (OR = 7.8 [1.12; 55.07]). Similarly, prolonged MV increased PPC (OR = 4.87 [1.3; 18.18]) but with no increased mortality [5].

Why failed extubation?: Pathophysiology

There are lots of explanation on why an extubated patient failed, and includes deconditioned muscles, poor nutrition, upper airway edema due to prolonged translaryngeal intubation, inability to clear secretions, decreased level of consciousness due to persistent effects of sedative and analgesics and critical illness polyneuropathy & absent/depressed gag & cough reflexes altogether lead to either poor mechanics of lung or aspirations into airways & blockage of airways ; it ultimately leads to extubation failure [9].

Risk factors of extubation failure

While weaning predictors identify the imbalance between respiratory capacity and load, extubation failure can occur due to other causes as well and not always predictor of extubation success/failure. Accordingly, there are adjunct factors that better be considered whether or not a patient is extubated succeeds in extubation or not. Here are the most commonly employed parameters mentioned in literatures.

Absent/depressed/gag reflex

According to a multicenter prospective observational study which assessed status of gag reflexes before planned extubation in subjects with prolonged ventilation (mechanically ventilated for >6 d), the presence of one or both gag reflexes could predict a reduction in extubation failure related to aspiration or excessive upper airway secretions. Accordingly, the risk of extubation failure related to aspiration or excessive upper airway secretion was reduced with a normal right or left gag reflex (OR 0.12, 95% CI, 0.03-0.59, P .01; and OR 0.13, 0.03-0.63, P .01, respectively), with a negative predictive value of 0.98 regardless of the location of the pharyngeal gag reflex (i.e, right or left) [10-12].

Absent/ depressed/ Cough reflex

Assessing extubation failure by measuring Peak Cough Flow (PCF) with a peak flow meter before planned patient extubation among neurosurgical patients showed that PCF was significantly lower in those in whom extubation failed than in those in whom extubation was successful. Although there exist a variation in the cut of value for PCF for predicting extubation failure, a reflex cough PEF of < 80 L/min was shown to have a relative risk of 3.6 (95% CI: 2.0-6.7) extubation failure. Hence, the use of cough reflex (peak expiratory flow, PEF) as a predictor of successful extubation in neurological patients is a good adjunct predictor of extubation failure for patients who are candidates for weaning from MV [13].

Low Glasgow coma scale score (GCS)

For patients who are candidates for weaning from MV, the

final Glasgow Coma Scale score (Glasgow Coma Scale score at extubation) showed a relative risk of 0.64 (95% CI: 0.51-0.83; $p < 0.001$) of extubation failure as for every 1-point increase in a Glasgow Coma Scale score of 8, there was a 36% reduction in the risk of extubation failure [13]. Similarly, GCS was found to be the best independent factor associated with extubation failure with GCS greater than or equal to 8 indicating good extubation success (AUC, 0.681; OR, 4.9; 95% CI, 2.8 to 8.3; $P < 0.001$) [14]. This is in contrast to preliminary prospective cohort done to identify risk factors and development of a prediction score of extubation failure in neurosurgical patients. According to this study, GCS was not independently associated with extubation failure as GCS lacks information to differentiate subtle disorders of consciousness, does not assess brainstem reflexes, and is not evaluable in intubated patients [15]. Rather, extubation of brain injured patients relies more importantly on maintenance of airway protective reflexes (gag reflex, cough, and deglutition). A randomized control trial in neuro-ICU patients having SBT and favorable airway characteristics according to the airway care score to early or delayed extubation regardless of GCS also showed that early extubation of patients with impaired mental status was feasible, without increase in neither reintubation rate nor mortality. So, if airway is functional, low consciousness level does not alter extubation tolerance [16].

Cuff leak test and prophylactic steroid?

While a recent meta-analysis does not show any advantages in employing the cuff leak test prior to extubation in neurocritical patients, recent data suggest the usefulness of employing corticosteroids, especially low doses of methyl prednisolone (15–20 mg/kg), before planned extubation of difficult-to-wean patients [17-18].

Fluid overload + blood transfusion?

In a meta-analysis on perioperative fluid therapy, liberal fluid administration was found to be associated with risk of pneumonia, pulmonary edema, and a longer hospital stay compared with restrictive use [19-20] though the analysis to assess the occurrence of Post-Operative Pulmonary Complications (POPCs) with respect to restrictive and liberal regimes (<3,000, 3,000-5,000, >5,000 mL) didn't show association with POPCs. An intraoperative blood loss >1400 mL was found to be a significant risk for POPC (OR = 4.5). Patients who developed POPC received more blood transfusion. Patients who received massive intraoperative blood transfusion were more likely to develop POPCs (OR = 4.6) [19].

Neurosurgical patients

According to a study done among patients who underwent elective infratentorial craniotomy, the extubation failure rate was 98 (4.4%), which is much higher than the range of 0.06% to 0.83% observed in general surgery, indicating that patients undergoing infratentorial craniotomy are a high-risk population for suffering postoperative extubation failure [21-23].

Perioperative predictors of extubation failure

Preoperative predictors: According to a study conducted to look for the relationship between extubation failure among 2118 patients who underwent elective infratentorial craniotomy, history of craniotomy, Preoperative lower cranial nerve dysfunction, Tumor size 3 cm, tumors with brain stem compression & tumors arising from brain stem were found to be predictors of extubation failure with odds ratio and I(95% CI) of 2.992 (1.644,

5.446), 2.620 (1.696,4.046), 2.289 (1.201, 4.365), 2.138 (0.903, 5.062) and 6.681 (2.531, 17.637) respectively. This make sense as a normal integrity of lower cranial nerves is important in preventing respiratory and swallowing dysfunction and its sequela; that is silent aspiration, pneumonia and respiratory failure [24]. Another study also found that brain stem and lower cranial nerve function were the main factors affecting extubation decision-making for infratentorial neurosurgical procedures [25].

Intraoperative and post-operative predictors of extubation failure

Intraoperative maximum Blood Pressure (BP) fluctuation 41.3 (36.4-57.0) had higher extubation failure compared to 39.3 (30.3–49.7) with P value of <0.001 [24]. In addition, intraoperative injury of cranial nerve &/postoperative Lower Cranial Nerve (LCN) dysfunction which occurred in 4.8% of patients who underwent infratentorial craniotomy, and immediate postoperative brain stem edema can directly affect the respiratory may lead to extubation failure after surgery [24, 26-27].

Supratentorial vs infratentorial craniotomy

Though there is paucity of literatures the failure rate of patients undergoing elective cranial neurosurgical procedures, one retrospective study showed a 3.8% and 6.6% risk of composite primary outcome (reintubation within 30 days, failure to wean from mechanical ventilation within 48 hours and death within 30 days postoperatively) to supratentorial and infratentorial procedures respectively [28].

Timing of extubation

According to a retrospective cohort study US ICUs, approximately one-fifth of patients with MV in undergo overnight extubation. These patients have higher rates of ICU and hospital mortality than patients undergoing extubation during the daytime [3]. For MV duration of less than 12 hours, reintubation rates were similar for overnight and daytime extubations (5.9% and 5.6%, respectively; $P = .50$), but mortality was increased for patients undergoing overnight extubation (ICU, 5.6% vs 4.6%, $P = .03$; hospital, 8.3% vs 7.0%, $P = .01$). The ICU Length of Stay (LOS) was shorter for overnight vs daytime extubations (median [interquartile range], 1.1 [0.8-2.3] vs 1.4 [0.9-2.5] days; $P < .001$), and hospital LOS was similar (median [interquartile range], 7.0 [4.0-12.0] vs 7.0 [3.0-12.0] days; $P = .03$). Patients with MV duration of at least 12 hours who underwent overnight extubation had more frequent reintubation in the ICU (14.6% vs 12.4%; $P < .001$) and higher mortality in the ICU (11.2% vs 6.1%; $P < .001$) and in the hospital (16.0% vs 11.1%; $P < .001$), with no differences in LOS.

What to do with patients with failed extubation?

Urgent reversal of patients back to the mechanical ventilation support and other time trial of weaning can be done. In patients for whom extubation is tough to be difficult, tracheostomy should be done [1-28].

Conclusion

- Balancing risk of early vs delayed extubation is needed by using all the risks incriminated for extubation failure in neurosurgical patients & patients' general condition besides to the conventional indications for extubation as none of the predictors accurately predicts extubation failure.

- Good communication among interdepartments taking care of neurocritical patients is of paramount importance.
- Future multi-centric focused study that predicts & guide extubation failure is recommended.

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