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EDITORIAL

Scott K. Epstein

Putting it all together to predict extubation outcome

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S. K. Epstein (✉)
Department of Medicine,
Caritas-St. Elizabeth's Medical Center,
736 Cambridge Street, Boston, MA, 02135, USA
e-mail: scott.epstein@tufts.edu
Tel.: +1-617-7893000

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The last few decades of research on weaning from mechanical ventilation have established a number of key concepts including: the importance of determining readiness for spontaneous breathing trials (SBT); the minor role of weaning predictors in this aspect of decision-making; the equivalency of SBTs conducted with T-piece, CPAP, or low levels of pressure support; the inferiority of IMV weaning; and the beneficial role of protocol-directed weaning [1]. More recently increasing attention has turned to improving extubation decision-making. Unnecessarily delayed extubation is associated with increased risk for ventilator-associated pneumonia, increased ICU and hospital length of stay, and increased mortality [2]. On the other hand, failed extubation (which may occur in up to 20% of patients) is also associated with increased ICU and hospital length of stay, increased costs, need for tracheotomy, need for long-term acute care, and, in some studies, increased mortality [3, 4, 5] The observation that delayed reintubation is associated with increased mortality [6] and non-randomized studies of successful prevention of extubation failure by non-invasive ventilation [7] raised the possibility that NIV could reverse the poor outcome for post-extubation respiratory failure. Unfortunately, two recent randomized controlled trials indicate that for heterogeneous patients experiencing extubation failure, non-invasive ventilation is unable to improve outcome [8, 9].

The negative results of both delayed and premature extubation, and the findings that NIV may not be sufficiently effective in this setting, has rekindled efforts to improve the prediction of extubation outcome. Traditional weaning predictors (e.g., negative inspiratory force, frequency-tidal volume ratio) are not accurate predictors of extubation outcome [10]. This, in part, derives from the fact that extubation failure often results from upper airway obstruction, excess respiratory secretions, inadequate cough, and depressed neurologic status, that is, factors that influence the ability to protect the airway. Bedside tests designed to identify the presence of these risk factors have the potential to improve prediction of extubation outcome. As an example, it has been demonstrated that the quantitative cuff leak test (the difference between inspired and expired tidal volume during volume-cycled ventilation with the endotracheal tube cuff deflated) can identify patients at increased risk for post-extubation stridor [11, 12].

In contrast, until recently, assessments of cough strength and secretions have been, at best, semi-quantitative. Coplin and colleagues used a six-part semi-quantitative Airway Care Score finding that two individual components (suction frequency and spontaneous cough), measured at the time that ventilatory support was no longer required, were predictive of extubation outcome in brain-injured patients [2]. Khamiees et al. extended these findings by observing that a semi-quantitative assessment of cough strength and secretion volume was predictive of extubation outcome in a cohort of medical patients [13]. Specifically, moderate/abundant secretions [relative risk (RR) of extubation failure of 8], every 2-h suctioning (RR of 16), and weak cough (RR of 4) were strongly associated with the need for reintubation. The effects were additive as those with weak cough and increased secretions

were at highest risk for extubation failure. These authors subsequently demonstrated that an objective measure of cough strength (peak cough flow) was predictive of extubation outcome [14]. These investigations of the capacity to protect the airway did not systematically include an assessment of neurologic function. Indeed, studies comparing objective measures of neurologic status (e.g., Glasgow Coma Score) and extubation outcome have reached conflicting conclusions and have not comprehensively integrated measurements of cough and secretions [2, 15].

In this edition of *Intensive Care Medicine*, Salam et al. importantly extend previous work in the field by combining objective assessments of peak cough flow, secretion volume, and neurological status obtained just prior to extubation in a cohort of medical patients who had passed a trial of spontaneous breathing [16] Peak cough flow was measured using a calibrated peak flow meter attached to the endotracheal tube. Patients were in the 30–45 degree position and coached to cough with maximum effort (the best of three attempts was recorded). Secretion volume was determined by collecting all secretions in a suction trap after patients were suctioned at least once per hour in the 2–3 h preceding extubation. Decreased peak cough flow (CPF $\leq$60 l/min, RR 4.8) and increased secretion volume (>2.5 ml/h, RR 3.0) were associated with extubation failure. With regards to neurologic status, patients unable to complete four simple tasks (open eyes, follow with eyes, grasp hand, stick out tongue) had a relative risk for extubation failure of 4.3. Yet, neurologic status assessment alone, though specific, was fairly insensitive in identifying patients who developed extubation failure. The strength of prediction comes in putting all the risk factors together. Indeed, the presence of any two risk factors yielded a likelihood ratio of nearly 4 in predicting extubation failure. More significantly, a synergistic interaction between all three factors was noted (100% extubation failure if all three are present, 3% if no risk factors, RR 23). Although these are encouraging results, widespread utilization should wait until the findings can be reproduced in larger cohorts of critically ill patients, with a broader array of disease processes. Follow-up studies should focus on the reproducibility of peak cough flow and secretion volume measurements and also quantify the time needed to perform the tests.

Based on the findings of Salam et al. what should be done with patients who have two or three factors predictive of extubation failure? This would seem to depend on whether those factors can be corrected and the time frame for reversibility. For example, it would seem prudent to delay extubation for several days if substantial improvement is expected during that time period. In contrast, if the deficits are fixed or only reversible after many days then direct extubation may actually be the best option. Under these conditions little is gained by delay (e.g., the probability of extubation success does not improve) while the risks of prolonged invasive ventilation continue to accrue. For patients, at highest risk for extubation failure, the option of tracheotomy exists.

In conclusion, Salam and coworkers have shown us that extubation outcome can be accurately predicted by putting together various components of the capacity to protect the airway. How we effectively use that information at the bedside awaits further investigations.

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