Mechanical Ventilator Discontinuation Process

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KEYWORDS

• Critical illness • Mechanical ventilation • Weaning • Liberation • Protocol

KEY POINTS

- Ventilator discontinuation describes a process of both ventilator weaning and recognition of opportunities to assess for extubation.
- Protocol-driven weaning that incorporates the application of daily spontaneous breathing trials among eligible patients is currently the dominant management strategy.
- Weaning failure requires consideration of multiple contributing systemic factors.

DEFINITIONS

This article defines ventilator discontinuation as the process of removing the support of mechanical ventilation from a patient. This process may result in successful liberation or unsuccessful liberation requiring reintubation or reattachment of the ventilator to a tracheotomy tube (generally within 24–48 hours). Additionally, discontinuation may be viewed as a component of end-of-life care. As such, extubation may be performed in anticipation of short-term death or at least with a plan to avoid reintubation. Because of the consequences of potential failure and the multiple factors that can determine it, discontinuation of ventilation involves clinical judgment in every case.

Conceptually, ventilator discontinuation requires several elements. First is the process of weaning. Weaning refers to the gradual or stepwise reduction in the amount of ventilator support (ie, inspiratory pressure, mandatory breaths, Fio_2, positive end expiratory pressure [PEEP]) provided to the patient. Second is the recognition of opportunities to assess readiness for extubation in anticipation of performing spontaneous breathing trials (SBTs) or tracheotomy collar trials (TCTs). Specifically it means determining if critically ill patients have recovered sufficiently to handle the stress of these procedures (ie, Are they in shock? Are they tachypneic? Are they febrile?) These components of discontinuation in most centers are protocolized. Finally is the process of removing the artificial airway, a process guided by assessments of the patient's ability to protect the natural airway.

HISTORICAL CONTEXT

While ventilator management in 2016 is largely protocol-driven and focused on screening for readiness for spontaneous breathing trials, it was not always the standard. For many years, in fact, there was little evidence-based information to guide practitioners in the day-to-day management of mechanical ventilation, including its discontinuation.

For some time, clinicians used a number of strategies based generally on intuition. Some reduced the number of machine-delivered breaths in the synchronized intermittent mandatory ventilation (SIMV) mode. Others added pressure-supported (PS) breaths to IMV and gradually permitted

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patients to take spontaneous PS breaths in between mandatory machine breaths, weaning the inspiratory pressure over time. Still others would change from controlled modes (eg, volume control [VC] or pressure control [PC]) to PS as they felt progress was occurring. Some used trials of applying very low levels of support such as through T-pieces—oxygenated tubing connected to the endotracheal tube with either little or no PEEP—to predict how close patients were to a successful liberation.

A landmark multicenter, randomized prospective trial was published in 1995 that compared IMV, PS, multiple daily SBTs, and once-daily SBTs.[1] Spontaneous breathing was defined as using a T-piece or pressure support of 5 cm H_2O for up to 120 minutes. This study showed convincingly that patients weaned on daily SBTs were 3 times more likely to be extubated successfully than those weaned on SIMV and 2 times more likely than those weaned on PS. After a subsequent trial by Ely and colleagues[2] demonstrating superiority of a protocol incorporating daily SBTs, the field shifted away from SIMV for good, and the protocol-driven, SBT-focused era began. Although there seems to be no 1 superior method for performing SBTs (eg, low PEEP, T-piece), there is also currently no superior strategy for assessing extubation readiness.

CONCEPTS THAT ARE IMPORTANT BUT OFTEN NOT DISCUSSED

As alluded to in the introduction, all clinicians recognize that goals of ventilation, and its discontinuation may differ based on the patient's values, illness severity, and underlying condition. Although rarely discussed in reviews of this subject, they are clearly critical to the decision making involved in each case. Note that death among patients with mechanical ventilation is much more common after withdrawal of ventilation than due to an underlying medical condition while on mechanical ventilation.[3] Also, the contribution of clinical uncertainty is important to recognize. Even a successful 2-hour SBT has a significant extubation failure rate.[2] Last, the setting in which ventilator weaning and discontinuation are conducted is crucial. Poorly staffed ICUs in smaller hospitals may have limited physician oversight. The success of their clinical care may depend on the quality of their protocols, the numbers of respiratory therapists, and the staffing model of their hospital. Although evidence will be discussed in this review, these data may often diffuse into nonacademic settings less completely and slower.[4]

WHAT IS KNOWN ABOUT THE PROCESS?

The hospital mortality rate of patients who receive invasive mechanical ventilation is highly variable by age, underlying condition, and other factors. Generally speaking, approximately 60% to 65% of patients who receive mechanical ventilation survive the ICU stay.[3,5] Approximately 85% of mechanically ventilated patients in a medical ICU who are extubated are successfully liberated from the ventilator, whereas 15% or more require reintubation within approximately 48 hours.[6] As the duration of ventilation increases, the likelihood of liberation decreases.[7]

So what is the tradeoff between attaining a high pretest probability and unnecessarily delaying the weaning process? Although a target reintubation rate is unclear, many agree that a rate of about 10% to 15% is acceptable and that a very low rate (eg, 5%–10%) likely demonstrates timidity. Moreover, if a clinician's reintubation rate is close to zero, patients may in fact be systemically exposed to a higher risk of ventilator-associated lung injury. Yet reintubation is associated with longer ICU stays, length of hospitalization, need for long-term care and rehabilitation, and higher rates of mortality.[8] In fact, extubation failure is independently associated with increased mortality and need for stay in a long-term care facility if the patient survives.

WHY DO PEOPLE FAIL TO WEAN?

Successful weaning may be a physically stressful experience for critically ill, multimorbidity patients. It depends on the balance of function versus dysfunction of multiple organs. Seen in this light, failure to wean is often the result of a multifaceted array of dysfunctions affecting the lungs, muscles, nerves, heart, and brain. Other factors such as metabolic derangements, malnutrition, and unresolved infections are also important.

The most obvious and perhaps most prevalent cause of weaning failure is poor parenchymal lung function, whether due to chronic lung disease like chronic obstructive pulmonary disease (COPD) or acute lung injury. Airways-related issues such as bronchospasm may also be problematic. Yet less well appreciated to some extent is the impact of respiratory muscle weakness, itself part of a constellation of critical illness neuromyopathy.[9] Disuse atrophy of diaphragmatic myocytes begins within hours of mechanical ventilation.[10] Ventilator-induced diaphragmatic dysfunction (VIDD) in animal models is a well-described consequence of prolonged controlled ventilation.[11] In mice, controlled mechanical ventilator and diaphragmatic disuse