Evidence-Based Assessments in the Ventilator Discontinuation Process

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The ventilator discontinuation process is an essential component of overall ventilator management. Undue delay leads to excess stay, iatrogenic lung injury, unnecessary sedation, and even higher mortality. On the other hand, premature withdrawal can lead to muscle fatigue, dangerous gas exchange impairment, loss of airway protection, and also a higher mortality. An evidence-based task force has recommended a daily discontinuation assessment and management process for most ICU patients requiring at least 24 hours of mechanical ventilator support. This process focuses on assessments on the causes for ventilator dependence, assessments for evidence of disease stability/reversal, use of regular spontaneous breathing trials (SBTs) as the primary assessment tool for ventilator discontinuation potential, use of separate assessments to evaluate the need for an artificial airway in patients tolerating the SBT, and the use of comfortable, interactive ventilator modes (that do not need to be "weaned") in between regular SBTs. More recent developments have focused on the utility of computer decision support to guide these processes and the importance of linking sedation reduction protocols to ventilator discontinuation protocols. These guidelines are standing the test of time, and practice patterns are evolving in accordance with them. Nevertheless, there is still room for improvement and need for further clinical studies, especially in the patient requiring prolonged mechanical ventilation. *Key words: mechanical ventilation; discontinuation; iatrogenic; lung injury; sedation; mortality, ventilator dependence; spontaneous breathing trial; SBT; ventilator discontinuation; weaning*. [Respir Care 2012;57(10):1611–1618.

Introduction

In the ICU, as respiratory failure stabilizes and begins to reverse, clinical attention should shift to the ventilator withdrawal process. These discontinuation assessments are critical for optimal outcomes. Failure to recognize discontin-

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uation potential will result in undue delay in ventilator withdrawal, leading to increased stay, higher costs, excessive sedation needs, longer exposure to potentially "toxic" airway pressures/volumes, and increased infection risks.[1–4] On the other hand, discontinuation assessments leading to overly aggressive ventilator withdrawal attempts carry their own hazards. Specifically, premature ventilator withdrawal can lead to airway loss, compromised gas exchange, aspiration, and inspiratory muscle fatigue.[5,6] Indeed, a failed extubation is associated with an 8-fold higher odds ratio for nosocomial pneumonia and a 6-fold to 12-fold increased mortality risk.[7,8]

The clinical challenge then is to balance aggressiveness with safety. A common quality indicator addressing this balance is the reintubation rate (ie, patients needing reintubation/total number of patients extubated). A value too low suggests unnecessary delays in ventilator removal; a value too high suggests inappropriate aggressiveness in support removal. Reported reintubation rates range from 4–23% for different ICU populations, and may be as high as 33% in patients with mental status changes and neurologic impairment.[3,8–15] Although never subjected to rigorous cost/benefit analyses, reintubation rates of 5–20% are generally considered reasonable.

The remainder of this paper will review the evidence supporting current recommendations for ventilator discontinuation assessments in the ICU. Importantly, these assessments are of 2 fundamental types. One focuses on the need for mechanical ventilation; the other focuses on the need for an artificial airway. What will not be discussed is the concept of "weaning," a process of gradual support reduction using various partial support modes (eg, pressure support or intermittent mandatory ventilation). These have never been shown to be superior to the daily formal assessments for discontinuation described below.[1,16] Also not discussed is the approach to ventilator discontinuation in patients requiring prolonged mechanical ventilation. Prolonged mechanical ventilation patients generally are defined as requiring ventilatory support for > 21 days, usually with a tracheostomy in place. Excellent reviews on the management of the prolonged mechanical ventilation population can be found elsewhere.[1,17,18]

Analyzing the Evidence Base for the Ventilator Discontinuation Process in the ICU

The important clinical questions facing the clinician in the ICU are: When can efforts to discontinue ventilation be initiated? What assessment strategies will best identify the patient who is ready for ventilator discontinuation? When should extubation be carried out? Evidence to answer these questions comes largely from observational studies in which a certain parameter (or set of parameters) is compared in a group of patients who either successfully or unsuccessfully have been removed from the ventilator. The general goal of these studies is to find "predictors" of outcome.

Evaluating results from these types of studies can be difficult for several reasons. First, the "aggressiveness" of the clinician/investigator's discontinuation philosophy needs to be understood, as it will affect the performance of a given predictor. Second, patients are recruited into these studies because investigators believe there is some reasonable chance of success for ventilator discontinuation. These "entry" criteria often include some form of clinical judgment or intuition, making results from one study difficult to compare to another. Third, methodological problems inherent to observational studies include different measurement techniques of a given parameter from study to study, large coefficients of variation of a given parameter with repeated measurements from study to study, and different patient populations (eg, long-term vs short-term ventilator dependence).[19] Fourth, assessed outcomes differ from study to study. Some investigators have examined successful tolerance of a spontaneous breathing trial (SBT), others have used permanent discontinuation of the ventilator, and others have combined successful discontinuation and extubation. In addition, different studies use different durations of ventilator discontinuation or extubation to define success or failure. Although 24 to 48 hours of unassisted breathing often is considered to define the successful discontinuation of ventilator support, many studies use shorter time periods to indicate success and often do not report subsequent reintubation rates or the need to reinstitute mechanical ventilatory support.

Developing Evidence-Based Guidelines: 2001–2002

In 1999, McMaster University, funded by a large grant from the United States Agency for Health Care Policy Research, published a comprehensive evidence-based review of the world's literature pertaining to ventilator discontinuation (over 5,000 publications).[20] This report found evidence in the literature supporting a possible role for 66 specific measurements as predictors of successful ventilator discontinuation. To evaluate the role of these parameters, the McMaster University report used likelihood ratios (LRs), an expression of the odds that a given test result will be present in a patient with a given condition, compared to a patient without the condition. An LR > 1 indicates that the probability of success increases, while values < 1 indicate that the probability of failure increases. LRs between 0.5 and 2 indicate that a discontinuation parameter is associated with only small, clinically unimportant changes in the post-test probability of success or failure. In contrast, LRs from 2 to 5 and from 0.3 to 0.5 correlate with small but potentially important changes in probability, while ratios of 5 to 10 or 0.1 to 0.3 correlate with more clinically important changes in probability. Ratios of > 10 or < 0.1 correlate with very large changes in proba-

Table 1. Eight Parameters Found in the McMaster Review[20] With Significant Likelihood Ratios for Predicting Ventilator Discontinuation Success*

Parameter	Number of Studies	Threshold Value	Range of Positive Likelihood Ratios
Measured on Ventilator			
$\dot{V}_E$	20	10–15 L/min	0.81–2.37
Negative inspiratory force	10	−20 to −30 cm H_2O	0.23–2.45
$P_{I_{max}}$	16	−15 to −30 cm H_2O	0.98–3.01
$P_{0.1}/P_{I_{max}}$	4	0.30	2.14–25.3
CROP	2	13	1.05–19.74
Measured During a 1–2 Min Period of Spontaneous Breathing			
f	24	30–38	1.00–3.89
V_T	18	325–408 mL (4–6 mL/kg)	0.71–3.83
f/V_T	20	60–105 breaths/min/L	0.84–4.67

* Depicted are the parameters, the number of studies evaluating that parameter, the threshold variable with the best discriminatory power, and the range of reported likelihood ratios. Note that most likelihood ratios, though statistically significant, are not high enough to serve as "stand alone" criteria for clinical decision making.
$\dot{V}_E$ = minute volume
$P_{I_{max}}$ = maximum inspiratory pressure
$P_{0.1}$ = airway-occlusion pressure 0.1 s after the start of inspiratory flow
CROP = compliance, rate, oxygenation, and pressure index
f = respiratory frequency
V_T = tidal volume
(From Reference 20.)

bility. With this approach, the McMaster group identified 8 parameters that had consistently significant LRs to predict successful ventilator discontinuation in several studies. Some of these measurements are made while the patient is still receiving ventilatory support; others require an assessment during a brief period of spontaneous breathing. These parameters, their threshold values, and the range of reported LRs are given in Table 1. It should be noted that despite the statistical significance of these parameters, the generally low LRs indicate that the clinical applicability of these parameters alone to individual patients is low.

Following the publication of the McMaster report, the American College of Chest Physicians (ACCP), the Society for Critical Care Medicine (SCCM), and the American Association for Respiratory Care (AARC) assembled a task force to issue evidence-based guidelines for clinicians to follow in the ventilator discontinuation process.[1] These guidelines were based largely on the McMaster review of the clinical evidence base, but, by necessity, also incorporated evidence from basic science work, lung model studies, animal studies, non-outcome-based human studies, and even "expert opinion" to fill in the gaps in the clinical evidence base. In the end, 12 guidelines were described, 7 of which relate to the ventilator discontinuation process in the ICU (Table 2). These are reviewed in more detail below.

The Evidence-Based Formal Discontinuation Assessment Guidelines

The first step in the discontinuation process is to assess the status and trajectory of underlying cause(s) for mechanical ventilatory support in a given patient (see Table 2, Recommendation 1). Determining which factor or factors may be involved in a given patient requires both clinical awareness of these factors as well as focused clinical assessments. Among the more important factors impacting ventilator dependence are neurologic abnormalities affecting the brainstem ventilatory control system, respiratory muscle capability/mechanical load imbalances, impaired ventilation-perfusion matching in the lungs, abnormal cardiac function, lung edema, metabolic derangements (eg, glucose homeostasis and adrenal function), ultimate oxygen delivery, and even psychological factors. The search for the underlying causes for ventilator dependence may be especially important in "difficult to discontinue" patients, as previously unrecognized, but reversible, conditions may be discovered.[21]

Importantly, iatrogenic factors, such as excessive sedation use, inappropriate ventilator settings causing lung injury and/or discomfort, inappropriate fluid management, inadequate nutrition, and lack of patient physical activity, may also contribute to ventilator dependence. And, of course, a failure to recognize ventilator discontinuation potential will also lead to iatrogenic ventilator dependence.

The criteria used by clinicians to define disease "reversal," however, have been neither defined nor prospectively evaluated in a randomized controlled trial. Rather, various combinations of subjective assessment and objective criteria (eg, usually gas exchange improvement, mental status improvement, neuromuscular function assessments, and radiographic signs) that may serve as surrogate markers of recovery have been employed (see Table 2, Recommen-

Table 2. Recommendations Regarding Management of Mechanically Ventilated ICU Patients From the ACCP/SCCM/AARC Ventilator Discontinuation Evidence Based Guidelines Task Force[1]*

Recommendation 1

In patients requiring mechanical ventilation for > 24 hours, a search for all the causes that may be contributing to ventilator dependence should be undertaken. This is particularly true in the patient who has failed attempts at withdrawing the mechanical ventilator. Reversing all possible ventilatory and nonventilatory issues should be an integral part of the ventilator discontinuation process.

Recommendation 2

Patients receiving mechanical ventilation for respiratory failure should undergo a formal assessment of discontinuation potential if the following criteria are satisfied:

- Evidence for some reversal of the underlying cause for respiratory failure
- Adequate oxygenation ($P_{aO_2}/F_{IO_2} > 150$–200 cm Hg, requiring PEEP $\leq$ 5–8 cm H_2O, $F_{IO_2} \leq 0.4$–0.5), and pH ≥ 7.25
- Hemodynamic stability, as defined by the absence of active myocardial ischemia and the absence of clinically important hypotension (ie, a condition requiring no vasopressor therapy or therapy with only low-dose vasopressors such as dopamine or dobutamine, < 5 μg/kg/min)
- The capability to initiate an inspiratory effort

The decision to use these criteria must be individualized. Some patients not satisfying all of the above criteria (eg, patients with chronic hypoxemia values below the thresholds cited) may be ready for attempts at the discontinuation of mechanical ventilation.

Recommendation 3

Formal discontinuation assessments for patients receiving mechanical ventilation for respiratory failure should be performed during spontaneous breathing rather than while the patient is still receiving substantial ventilatory support. An initial brief period of spontaneous breathing can be used to assess the capability of continuing onto a formal spontaneous breathing trial (SBT). The criteria with which to assess patient tolerance during SBTs are the respiratory pattern, the adequacy of gas exchange, hemodynamic stability, and subjective comfort. The tolerance of a 30–120 min SBT should prompt consideration for permanent ventilator discontinuation.

Recommendation 4

The removal of the artificial airway from a patient who has successfully been discontinued from ventilatory support should be based on assessments of airway patency and the ability of the patient to protect the airway.

Recommendation 5

Patients receiving mechanical ventilation for respiratory failure who fail an SBT should have the cause for the failed SBT determined. Once reversible causes for failure are corrected, and if the patient still meets the criteria in Recommendation 2, SBTs should be performed every 24 hours.

Recommendation 6

Patients receiving mechanical ventilation for respiratory failure who fail an SBT should receive a stable, nonfatiguing, comfortable form of ventilatory support.

Recommendation 8

Weaning/discontinuation protocols that are designed for nonphysician healthcare professionals should be developed and implemented by ICUs. Protocols aimed at optimizing sedation also should be developed and implemented.

* Only 7 of the 12 guidelines relate to the ventilator discontinuation process and are thus listed here.
(From Reference 1.)

dation 2).[3,9–11,13,14,22] It should be noted, however, that some patients who have never met one or more of these criteria still have been shown to be capable of eventual liberation from the ventilator.[11]

Clinical assessments of the status of the patient's respiratory failure described above are usually not enough to make decisions on the discontinuation of support. Indeed, in 2 large trials,[13,14] despite the presence of apparent disease stability/reversal, the managing clinicians did not recognize that discontinuation was feasible in almost two thirds of the subjects. Thus, the conclusion is that some evidence of "clinical" stability/reversal is a key first step in assessing for discontinuation potential, but that a more focused assessment is needed before deciding to continue or discontinue ventilatory support.

The ACCP/SCCM/AARC guidelines (see Table 2, Recommendation 3) state that this formal assessment be an SBT. This is based on the very strong evidence that, although assessments that are performed while a patient is receiving substantial ventilatory support or during a brief period of spontaneous breathing can yield important information about discontinuation potential (see Table 1), assessments that are performed during a formal, carefully monitored SBT appear to provide the most useful information to guide clinical decision making regarding discontinuation.[1] In concept, the SBT should be expected to perform well, as it is the most direct way to assess a patient's performance without ventilatory support. Multiple studies have found that patients tolerant of SBTs were found to have successful discontinuations at least 77% of the time.[1,3,9,13,15,20,23] However, because patients failing the SBTs in these studies were not systematically removed from ventilatory support, the ability of a failed SBT to predict the need for ventilator dependence (ie, negative predictive value) cannot be formally assessed. Indeed, it is conceivable that iatrogenic factors such as endotracheal tube discomfort or demand-valve insensitivity/unresponsive-

ness, rather than true ventilator dependence, caused the failure of the SBT in at least some of these patients.[3,15,24–27] Thus, it is unclear how many patients who are unable to tolerate an SBT would still be able to tolerate long-term ventilator discontinuation. Although the number is likely to be small, it is probably not zero, and this needs to be considered when dealing with patients who repeatedly fail an SBT.

The criteria used to define SBT "tolerance" are often integrated indexes, since, as noted above, single parameters alone perform so poorly. These integrated indexes usually include several physiologic parameters as well as clinical judgment, incorporating such difficult-to-quantify factors as "anxiety," "discomfort," and "clinical appearance." Interestingly, in the 11 years since the publication of the original ACCP/SCCM/AARC guidelines, the criteria to assess SBT success/failure remained largely unchanged, essentially an integrated index of clinical assessments that do not rely on rigid numbers. Indeed, one important recent study addressing this issue showed clearly that the use of a rigid threshold of the ratio of respiratory frequency (f) to tidal volume (V_T) of < 105 to define SBT success in fact slowed the discontinuation process.[25] This observation has implications both for written management protocols as well as computer driven protocols.

The evidence is strong supporting the recommendation that an SBT should be at least 30 min but no longer than 120 min to allow proper assessment of ventilator discontinuation potential.[1] This means that clinicians should wait at least 30 min to assure SBT tolerance but terminate the trial at 120 min if SBT tolerance is still unclear. There is evidence that the detrimental effects of ventilator muscle overload, if it is going to occur, often occur early in the SBT.[3,15,26,27] Thus, the initial few minutes of an SBT should be monitored closely before a decision is made to continue (this is often referred to as the "screening" phase of an SBT).

Controversy exists on the "best" technique used to do the SBT. Options include a simple "T-piece" where only supplemental O_2 is supplied at the proximal end of the endotracheal tube; setting the ventilator to a CPAP level equivalent to the previous PEEP setting; or setting a low level of assistance (eg, pressure support of 5–8 cm H_2O or the use of "automatic" tube or airway compensation). The T-piece approach comes closest to mimicking the situation the patient will experience when extubated, and it is recommended by some for maximizing the specificity of the test (ie, lowest number of false positives). However, because the endotracheal tube is still present with its associated discomfort, the sensitivity of the SBT (ie, detecting true positives) may be somewhat compromised. In contrast, supplying a low level of inspiratory and/or expiratory pressure may hide a patient's inability to tolerate complete ventilator removal (excessive false positive tests), although it may relieve some of the iatrogenic discomfort of the endotracheal tube (fewer false negative tests). In large population studies, all 3 approaches appear to perform well, but the T-piece approach might be considered if there is concern about borderline SBT performance with other techniques or there is concern about the potential effects from a loss of PEEP.[9,28–32]

A potential concern about the SBT is safety. Although unnecessary prolongation of a failing SBT conceivably could precipitate muscle fatigue, hemodynamic instability, discomfort, or worsened gas exchange,[33–37] there are really no data showing that SBTs contribute to any adverse outcomes if terminated promptly when failure is recognized. Indeed, in a cohort of $> 1{,}000$ patients in whom SBTs were routinely administered and properly monitored as part of a protocol, only one adverse event was thought to be even possibly associated with the SBT.[11]

While ICU patients who are judged tolerant of the SBT should move on to assessments of the need for continued use of the artificial airway (see below), the patient who is judged not tolerant of the SBT requires a different approach. In these patients, Table 2, Recommendations 5 and 6 indicate 3 courses of action. First, a careful search once again should be undertaken for ongoing (and potentially reversible) causes of ventilatory dependence. Second, a comfortable interactive form of ventilatory support should be provided that encourages respiratory muscle activity but does not overload muscles nor compromise gas exchange. Importantly, there are few (if any) data demonstrating that attempts to "wean" this support rather than keep it constant are beneficial.[16] Third, every 24 hours the patient should be reassessed for another SBT. Importantly, all of these procedures can be carried out through protocols run by skilled clinicians (eg, respiratory therapists) (see Table 2, Recommendation 8).[11,22]

Since the publication of the original ACCP/SCCM/AARC guidelines, 2 important developments have occurred that build on the SBT approach. The first has been the application of computer driven assessments and clinician feedback tools that remind clinicians when SBTs are needed.[38,39] Importantly, the benefits of these computer driven protocols appear to be a result of aggressive use of SBTs rather than any ventilator manipulation strategy.[16] Second, and perhaps more importantly, has been the linkage of the SBT strategy to a sedation optimization strategy.[40] As noted above, excessive sedation use has been recognized for years to be a barrier to effective SBT performance and efficient ventilator withdrawal. Optimizing patient-ventilator synchrony with appropriate ventilator settings can help minimize sedation use, but several recent studies have emphasized that focused protocols aimed at reducing sedation usage further can add to this. Indeed, the concept of routine "spontaneous awakening trials" and routine sedation cessation trials, coupled with routine SBTs, can markedly accelerate the ventilator withdrawal process.[40]

Assessing the Need for an Artificial Airway

Once a patient has been deemed to no longer need mechanical ventilatory support (or perhaps is deemed a candidate for noninvasive ventilation, as described elsewhere),[41] attention then turns to the assessments of the need for the artificial airway (see Table 2, Recommendation 4). Extubation failure can occur for reasons distinct from those that cause discontinuation failure. Examples include upper-airway obstruction or the inability to protect the airway and to clear secretions.

The risk of post extubation upper-airway obstruction increases with the duration of mechanical ventilation, female sex, trauma, and repeated or traumatic intubation.[3] The detection of an air leak during mechanical ventilation when the endotracheal tube balloon is deflated can be used to assess the patency of the upper airway (cuff leak test).[42] In a study of medical patients, a cuff leak of < 110 mL (ie, average of 3 values on 6 consecutive breaths) measured during assist control ventilation within 24 hours of extubation identified patients at high risk for post-extubation stridor.[43] Although others have not confirmed the utility of the cuff leak test for predicting post-extubation stridor,[44] many patients who develop this can be treated with steroids and/or epinephrine (and possibly with noninvasive ventilation and/or heliox) and do not necessarily need to be reintubated. Steroids and/or epinephrine also could be used 24 hours prior to extubation in patients with low cuff leak values. It is also important to note that a low value for cuff leak may actually be due to encrusted secretions around the tube rather than to a narrowed upper airway.

The capacity to protect the airway and to expel secretions with an effective cough would seem to be vital for extubation success, although specific data supporting this concept are few. Airway assessments generally include noting the quality of cough with airway suctioning, the absence of "excessive" secretions, or the frequency of airway suctioning (eg, every 2 h or more).[3,45,46] One approach uses an "airway care score" that semiquantitatively assesses cough; gag; suctioning frequency; and sputum quantity, viscosity, and character; and that predicts extubation outcomes.[4] Peak cough flows of > 160 L/min predict successful translaryngeal extubation or tracheostomy tube decannulation in neuromuscular or spinal cord-injured patients.[47] Cough velocities of 0.5–1.0 L/s have also been shown in other studies to be compatible with successful extubation.[48]

The importance of intact cognitive function on extubation success is controversial. Successful extubations have been reported in a select group of brain-injured, comatose patients who were judged to be capable of protecting their airways.[4] However, it is difficult to extrapolate this experience to more typical ICU patients, and many would argue that some capability of the patient to interact with the care team should be present before the removal of an artificial airway. Nevertheless, a review of the literature suggests that a Glasgow coma score above 8 is compatible with successful extubation, provided that adequate airway protection capabilities exist.[49]

How Has the Evolving Evidence Base Impacted Clinical Practice and Outcomes?

It has been over a decade since the first comprehensive set of evidence-based guidelines for the ventilator discontinuation process was issued.[1] The most interesting assessments of the impact of these guidelines were 2 re-analyses of a large observational study from Europe involving 4,559 mechanically ventilated patients from 349 ICUs in 2004.[50] In the first re-analysis[51] the use of SBTs as the first assessment technique was found to increase from 58% to 62% from a similar survey in 1998 ($P = .09$). In contrast, discontinuation strategies using gradual support reductions switched significantly from synchronized intermittent mandatory ventilation (SIMV) or SIMV + pressure support from 11% and 26%, respectively, in 1998, to 1.6% and 15%, respectively, in 2004 ($P < .001$). Importantly, time devoted to the discontinuation process decreased from 50% to 40% of total ventilation time over the same period ($P < .001$).

In the second re-analysis,[52] a newly described classification system of discontinuation difficulty was used: "Simple" (ventilator discontinued after the first assessment); "Difficult" (ventilator discontinued from 2–7 d after initial assessment); and "Prolonged" (ventilator discontinued in > 7 d after initial assessment). In this re-analysis 2,714 patients were successfully discontinued over the 28 day study period.[53] Fifty-five percent were simple discontinuation; 39% were difficult discontinuation; and 6% were prolonged discontinuation. Of interest is that SBTs were used 82% of the time in the simple discontinuation patients but only 47% and 38% of the time in the difficult and prolonged discontinuation patients, respectively. The remaining patients were "weaned" with gradual support reduction strategies, usually stand alone pressure support but also SIMV + pressure support. An unanswered question is whether the lower use of SBTs in the difficult/prolonged discontinuation patients contributed to the need for longer periods of support.[16] Not surprisingly, patients needing prolonged discontinuation processes were sicker, had longer stay, and had higher mortality than the simple discontinuation patients.

Taken together, these data suggest that clinical use of SBTs is commonplace and gradually increasing, especially in patients judged to be clinically ready for discontinuation. However, there still appears to be a persistent aversion to SBTs in the majority of patients about whom clinicians have concerns. This may not be optimal, and, indeed,

the evidence would suggest that patients should not be labeled difficult or prolonged discontinuation problems until they have failed more than one SBT. Even in these patients, subsequent SBTs would still seem appropriate, although attempts at these might be delayed until improvement in the underlying disease processes occurs.[1,5] As noted above, the additional role of gradual support reduction strategies in these patients remains unsupported by evidence (especially modes involving SIMV), but this clearly needs more study.

Summary

The ventilator discontinuation process is an essential component of overall ventilator management. Undue delay leads to excess stay, iatrogenic lung injury, unnecessary sedation, and even higher mortality. On the other hand, premature withdrawal can lead to muscle fatigue, dangerous gas exchange impairment, loss of airway protection, and also a higher mortality.

An evidence-based task force has recommended a daily assessment process for most ICU patients requiring at least 24 hours of mechanical ventilator support:

1. Consider a patient a candidate for withdrawal *if*:

- The lung injury is stable/resolving
- The gas exchange is adequate with low PEEP/F_{IO_2} requirements
- Hemodynamics are stable without a need for pressors, and
- There is the capability to initiate spontaneous breaths

2. In these patients, perform an SBT (using T-piece, CPAP, or 5–8 cm H_2O pressure support) for 30–120 min. Assessments should include the ventilatory pattern, gas exchange, hemodynamics, and comfort. Patients "passing" this trial should be considered for ventilator withdrawal.

3. In patients passing the SBT, separate assessments are required to determine if the artificial airway can be removed. These involve the evaluation of cough strength, suctioning frequency, and, to a certain extent, the ability to follow commands.

4. In patients failing the SBT, careful reevaluation of the need(s) for ongoing ventilatory support should be coupled with a daily reassessment for the appropriateness of repeat SBTs. Ventilatory support between SBTs should be comfortable interactive support that does not necessarily have to be "weaned."

5. All of these efforts should be coupled with aggressive strategies to reduce sedation, ideally conducted with written or computerized protocols.

The ACCP/SCCM/AARC guidelines stating these principles are standing the test of time, and practice patterns are evolving in accordance with them. Nevertheless, there is still room for improvement and need for further clinical studies, especially in the patient requiring prolonged mechanical ventilation.

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