Tracheostomy and Weaning

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No hypothesis relating to respiratory care in the intensive care unit has proved more difficult to study in an objective fashion than the commonly held belief that tracheostomy hastens weaning from ventilatory support. Tracheostomy might facilitate weaning by reducing dead space and decreasing airway resistance, by improving secretion clearance, by reducing the need for sedation, and by decreasing the risk of aspiration. Available evidence indicates that dead space and airway resistance are in fact reduced, although whether the magnitude of these reductions explains the clinical observation of more rapid weaning after tracheotomy is less certain. Most of the data on this subject come from laboratory experiments and short-term physiologic studies on clinically stable patients, and the available evidence from clinical trials with weaning as a primary end point is scant. One large multicenter trial showed no advantage to early tracheotomy but demonstrated how difficult it is to get clinicians to manage their patients with regimens that go against their strongly held opinions. The most recent clinical trial found that percutaneous dilational tracheotomy performed in the first 2 days in patients projected to need > 14 days of ventilatory support greatly reduced ventilator and intensive care unit days, and decreased both the incidence of pneumonia and overall mortality, in comparison with tracheostomy done after day 14. Conducting such trials is difficult because of investigator and clinician bias, the inability to predict which patients will actually require prolonged mechanical ventilation, and several other factors discussed in this article. Tracheotomy probably does aid in liberating some patients from ventilatory support, but this may be as much from its effect on clinician behavior as from any physiologic impact. *Key words: tracheostomy, tracheotomy, acute respiratory failure, mechanical ventilation, weaning, extubation, work of breathing, dead space, complications*. [Respir Care 2005;50(4):526–533. © 2005 Daedalus Enterprises]

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Table 1. Possible Reasons Why Tracheostomy Might Facilitate Weaning

Reduced dead space
Less airway resistance
Decreased work of breathing
Better secretion removal with suctioning
Less likelihood of tube obstruction
Improved patient comfort
Less need for sedation
Better glottic function, with less risk of aspiration
Ability to move patient out of the intensive care unit
Changes in clinician behavior

Introduction

Clinicians managing patients in both medical and surgical intensive care units (ICUs) are familiar with the following scenario: A patient, often elderly and with serious underlying medical problems, requires intubation for acute respiratory failure or major surgery, and thereafter remains on the ventilator for many days, despite repeated attempts at weaning. A tracheotomy is performed, and within a day or 2 the patient is off the ventilator and can leave the ICU. Having repeatedly observed this sequence of events, it is hard for clinicians to avoid the general conclusion that, for patients who require prolonged mechanical ventilation, a tracheostomy hastens liberation from ventilatory support and facilitates transfer out of the ICU.

This article examines the above conclusion from the standpoints of theoretical rationale, relevant physiology, and clinical evidence. After listing the potential reasons why a tracheostomy might facilitate weaning, it reviews the physiologic concepts involved and the available literature, and discusses possible explanations for the lack of definitive studies on this topic. It deals with tracheostomy as typically performed in ICU patients, and not with the permanent procedure done in connection with total laryngectomy for cancer. Although there is literature on tracheostomy in infants and children, this article deals primarily with the management of adult patients. The word *tracheotomy* is used here for the surgical procedure of creating an opening in the trachea, and *tracheostomy* for the opening so created, as well as in referring to artificial airways inserted into it.

Why a Tracheostomy Might Facilitate Weaning

For patients requiring prolonged mechanical ventilation, performing a tracheotomy might facilitate weaning for a number of reasons (Table 1). Although liberation from ventilatory support may not be possible because of inadequate ventilatory drive or impaired oxygenation, these mechanisms can readily be identified and usually do not prevent weaning in the long-term setting. Most patients who repeatedly fail attempts at weaning do so because of the inability to keep up with the work load required by unassisted breathing.[1,2] Such inability arises from excessive ventilatory demand, from impairment of the function of the ventilatory pump, or from a combination of these factors.[3] Increased dead space and elevated airway resistance can both lead to ventilatory requirements that are excessive for the patient, and decreasing them by means of a tracheostomy might make the difference between ventilator dependence and successful weaning.

Tracheostomy might facilitate weaning in less dramatic ways, such as by making it easier to clear airway secretions, by thus decreasing the likelihood that the tube will become partially obstructed by inspissated mucus, by making the patient more comfortable (and hence requiring less sedation), or by reducing the likelihood of aspiration through improved glottic function. In some institutions, patients with tracheostomies can be managed on ventilators outside the ICU, while those who are endotracheally intubated cannot. In such settings, tracheostomy could facilitate weaning by permitting the patient to be moved to a less intense environment where more gradual withdrawal of ventilatory support could be accomplished. Finally, as discussed below, it is possible that clinicians tend to manage patients with endotracheal tubes (ETTs) and tracheostomies differently, and that this could account for the more rapid weaning often seen with the latter.

The Physiologic Impact of a Tracheostomy

Breathing humidified air through a tracheostomy tube differs from normal breathing via the intact upper airway primarily with respect to the volume of dead space and the impact of airway resistance. These factors are the usual ones cited in explaining why a difficult-to-wean patient might be able to breathe unassisted through a tracheostomy tube but not through a trans-laryngeal ETT or, by inference, following extubation.

Impact on Dead Space

Medical students and respiratory therapists are taught that anatomic dead space, contained in the upper airway and the intrathoracic conducting airways, is about 2 mL/kg, or roughly 150 mL in an average-size adult.[4] One study in cadavers determined the extrathoracic dead space (not including the trachea and main bronchi) to be approximately 75 mL.[5] This is clearly more than the volume in a tracheostomy tube (Fig. 1, A and B). Davis et al[6] found a standard 12-cm cuffed tracheostomy tube with inside diameter (ID) 7.0 mm to have a volume of 5 mL, whereas that of an 8.5-mm ID tube of the same length was 6 mL. This 15-fold difference in dead space between the 7-mm

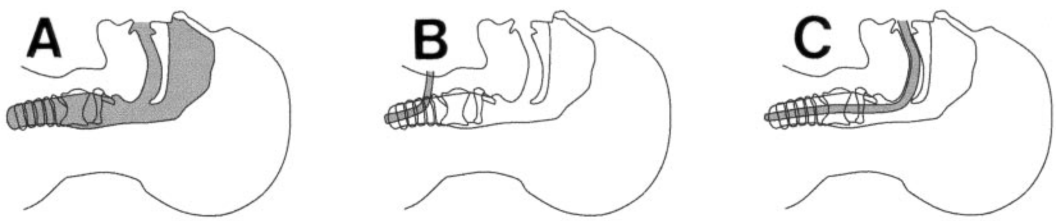

Fig. 1. Diagrams of the dead-space volume of the upper airway (A), a tracheostomy tube (B), and an oral endotracheal tube (C).

tracheostomy tube and the nonintubated state is reduced slightly by any additional dead space in connecting tubing, T-piece, tracheostomy collar, or other appliance used to provide humidified air.

Clinical studies on the effects of this difference in dead space between the nonintubated state and a tracheostomy tube are few. Davis et al[6] noted a reduction in mean tidal volume (V_T) of 51 mL following tracheotomy when spontaneous breathing during a brief period of extubation was compared to spontaneous breathing after tracheotomy in 4 patients, although respiratory rate and minute ventilation ($\dot{V}_E$) also changed in these clinically unstable patients and physiological dead space was not measured. Chadda et al studied 9 adult patients with neuromuscular disease who had undergone tracheotomy and were recovering from acute respiratory failure.[7] These patients no longer required continuous ventilatory support and were able to breathe comfortably through their mouths for at least 24 hours with the tracheostomy tubes plugged. In these patients, the investigators determined physiological dead space to be 156 ± 67 mL when breathing through the tracheostomy tube and 230 ± 82 mL during mouth breathing; arterial P_{CO_2} and respiratory rate did not change, while V_T and $\dot{V}_E$ increased by mean values of 70 mL and 1.6 L/min, respectively.[7]

Most reported studies of the effect of tracheostomy on weaning, including available information on dead space, have not dealt with the nonintubated state, but have instead compared findings before and after tracheotomy in patients who already have had translaryngeal ETTs in place, as shown in Figure 1, (B) versus (C). This comparison is more relevant to the observation that patients may fail spontaneous breathing trials (SBTs) while endotracheally intubated but promptly wean from ventilatory support once a tracheotomy has been performed—and also to the question of whether differences in dead space between ETTs and tracheostomy tubes could explain this observation.

Davis et al[6] measured the internal volume (dead space) of standard ETTs and tracheostomy tubes of various sizes, and found the differences to be < 20 mL. Table 2 compares the volumes of the tubes in that study that had the same ID. It seems unlikely that in vivo measurements of mechanics and gas exchange could detect effects of such small volume differences, and this has recently been confirmed by a clinical study by Mohr et al.[8] These investigators studied 42 difficult-to-wean patients in a surgical ICU who underwent tracheotomy after a mean of 13 days of ventilatory support. Within 24 hours of performance of tracheotomy, before and after the procedure, they determined the physiological dead-space fraction (V_D/V_T), using single-breath capnograms, as well as spontaneous respiratory rate, V_T, $\dot{V}_E$, peak inspiratory and end-inspiratory airway pressures during mechanical ventilation, and arterial blood gases. Comparing values obtained with an ETT with those following tracheotomy, no differences were found in any physiologic study variable. Mean V_D/V_T was 0.51 ± 0.10 before the procedure and 0.51 ± 0.11 afterwards; $\dot{V}_E$, respiratory rate, and V_T remained the same, as did all arterial blood gas values. The authors concluded that tracheostomy must facilitate weaning from ventilatory support by some mechanism other than improvement in ventilatory mechanics and gas exchange.

Table 2. Dead Space Volume in Endotracheal Versus Tracheostomy Tubes

Inside Tube Diameter (mm)	Type	Length (cm)	Dead Space (mL)
7.0	ETT	34.5	15
7.0	TT	12.0	5
8.5	ETT	36.5	24
8.5	TT	12.0	6

ETT = endotracheal tube
TT = tracheostomy tube
(Data from Reference 6.)

Impact on Airway Resistance and Work of Breathing

Perhaps a more plausible reason why tracheostomy might benefit a patient in terms of weaning would be reduced work of breathing (WOB) because of a decrease in gas flow resistance in a tracheostomy tube, as compared to an ETT. This potential mechanism is discussed both theoretically and practically in a previous review in this journal by Jaeger et al.[9] These authors list a number of factors that affect resistance when comparing different types of artificial airways:

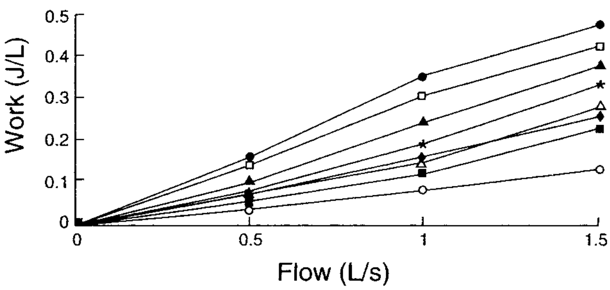

Fig. 2. Imposed work of breathing for endotracheal tubes and tracheostomy tubes of different sizes, as determined under laboratory conditions, using an intubation mannequin, a simulated trachea, and a 2-chamber test lung.[10] Tidal volume used with all tubes was 0.40 L, with constant inspiratory flows of 0.5, 1.0, and 1.5 L/s, as shown. Tubes are designated by inside diameter in millimeters. ETT = endotracheal tube. TT = tracheostomy tube. ETT 6 = black circle. TT 5 = white square. ETT 7 = black triangle. ETT 8 = asterisk. ETT 8.5 = white triangle. TT 7 = black diamond. TT 8.5 = black square. TT 9 = white circle. Imposed work of breathing was significantly higher ($p < 0.05$) in endotracheal tubes of 7 and 8.5 mm inside diameter than in tracheostomy tubes of those diameters at flows of 1.0 and 1.5 L/s. (From Reference 10.)

- The larger the diameter, the lower the resistance
- The shorter the tube, the lower the resistance
- Irregular tube walls (as with secretions) increase the resistance
- The sharper any curve in the tube, the greater the resistance
- Higher gas flows require geometrically increased pressure

These factors must be taken into account when comparing aspects of resistance and WOB with different tubes and under different circumstances; they complicate interpretation of the existing literature comparing tracheostomy and ETTs or examining the effects of tracheostomy on weaning.

In a laboratory study using an intubation mannequin and artificial trachea in an attempt to duplicate the normal curvature of the upper airway, Davis et al[10] determined imposed WOB for ETTs and tracheostomy tubes of various sizes. They found that imposed WOB varied inversely with ID and directly with inspiratory flow, as shown in Figure 2. Under all conditions studied, imposed WOB was lower with a tracheostomy tube than with an ETT of equivalent ID, and the disparities increased with increasing inspiratory flows, although the observed differences were not large from the clinical perspective.

These same investigators, in a clinical study cited previously,[6] found no statistically significant differences in spontaneous V_T, respiratory rate, or $\dot{V}_E$ in 20 patients evaluated within a few hours before and after tracheotomy (Table 3). However, as shown in the table, when WOB was expressed in J/min (but not in J/L), there was a significant difference favoring tracheostomy tubes. Intrinsic positive end-expiratory pressure was also slightly (mean difference 1.3 cm H_2O) but statistically significantly lower after tracheotomy. Four of the patients in this study were studied before extubation, while temporarily extubated, and again following tracheotomy (Table 4).[6] In these 4 patients, all variables measured were increased when they were breathing spontaneously while extubated, although there were no differences in any variable when findings with endotracheal versus tracheostomy tubes were compared.

In a study of the work of spontaneous breathing at different levels of pressure support, Diehl et al[11] studied 8 patients with prolonged ventilator dependence after acute respiratory failure, before and after they underwent tracheotomy. The ID of the endotracheal and tracheostomy tubes were the same in each patient. Overall WOB at the patients' baseline levels of pressure support fell from 0.9 ± 0.4 J/L to 0.4 ± 0.2 J/L ($p < 0.05$) after tracheotomy. Both resistive and elastic work were significantly reduced, as were intrinsic positive end-expiratory pressure and ventilatory drive as measured by airway occlusion pressure. In contrast, Lin and associates,[12] in a study of 20 patients with chronic obstructive pulmonary disease, found no differences in airways resistance, WOB, or pressure-time product after tracheotomy, in comparison to mechanical ventilation through an ETT, although peak inspiratory pressure decreased slightly.

The above studies compared breathing through ETTs to breathing through tracheostomy tubes. Some aspects of spontaneous WOB have also been examined with mouth breathing in comparison with breathing through a tracheostomy tube. In the previously-cited study of patients breathing spontaneously with their tracheostomy tubes removed, Chadda et al[7] found that WOB increased by 30%. Similar findings were reported by Moscovici da Cruz et al, who studied the WOB and its components in 7 patients undergoing tracheotomy because of upper airway neoplasms.[13] In these patients, during spontaneous breathing, there was a trend toward lower resistive WOB, and a reduction in elastic WOB, intrinsic positive end-expiratory pressure, and pressure-time product after tracheotomy.

Clinical Studies of Tracheostomy and Weaning

Most published discussions of the impact of tracheostomy on weaning have been based on the results of studies with surrogate end points, such as its effects on dead space or WOB, rather than on data on actual liberation from ventilatory support. This is because very few studies have been done

Table 3. Changes in Respiratory Variables During Spontaneous Breathing Before and After Tracheotomy in 20 Difficult-to-Wean Patients With Acute Respiratory Failure

Variable	Breathing Through Endotracheal Tube	Breathing Through Tracheostomy Tube	p
Tidal volume (mL)	329 ± 104	312 ± 119	0.47
Respiratory rate (breaths/min)	28 ± 5	26 ± 6	0.51
Minute ventilation (L/min)	9.2 ± 3.0	8.1 ± 3.1	0.26
Intrinsic PEEP (cm H_2O)	2.9 ± 1.7	1.6 ± 1.0	0.02
Work of breathing (J/L)	0.97 ± 0.32	0.81 ± 0.46	0.09
Work of breathing (J/min)	8.9 ± 2.9	6.6 ± 1.4	0.04

PEEP = positive end-expiratory pressure
(Data from Reference 6.)

Table 4. Changes in Respiratory Variables During Spontaneous Breathing Via Endotracheal Tube, While Briefly Extubated, and After Tracheotomy in 4 Difficult-to-Wean Patients With Acute Respiratory Failure*

Variable	Endotracheal Tube	Extubated	Tracheostomy Tube
Tidal volume (mL)	383 ± 107	429 ± 124	378 ± 81
Respiratory rate (breaths/min)	29 ± 8	34 ± 6	28 ± 5
Minute ventilation (L/min)	11.1 ± 3.1	14.5 ± 4.2	10.6 ± 2.7
Work of breathing (J/L)	0.8 ± 0.2	1.2 ± 0.2	0.8 ± 0.2
Work of breathing (J/min)	9.0 ± 2.7	17.2 ± 2.8	8.2 ± 2.2

*There were no differences in any variable during spontaneous breathing via endotracheal versus tracheostomy tubes. All variables were increased while the patients were extubated, although the comparability of the circumstances cannot be fully assessed in the absence of arterial blood gas values.
(Data from Reference 6.)

on the effects of tracheostomy on the duration of mechanical ventilation, ICU stay, morbidity, or mortality.[14]

One such study that has been widely cited is that of Sugerman et al.[15] This was a multicenter, randomized controlled trial conducted by the Western Trauma Association Multi-Institutional Study Group. Its objectives were to determine the effects on mechanical ventilation duration and ICU length of stay, the incidence of pneumonia, and mortality, of tracheostomy performed early (after 3–5 d) or late (days 10–14), versus continued endotracheal intubation, in patients with acute respiratory failure who were judged according to a priori criteria to require an artificial airway for at least 7 days. Patients at 5 participating Level I trauma centers were stratified according to whether they had major head trauma, less severe head trauma, or nontraumatic surgical illness. The incidence and severity of short- and long-term pharyngeal, laryngeal, and tracheal injury were also examined. One hundred fifty-seven patients were entered into the study, although completion of required data entry and adherence to the protocol were highly problematic, as will be discussed in the next section.

Sugerman et al found no differences in any of the outcome variables examined, either overall or in any of the identified subgroups.[15] Although fewer post-extubation airway examinations were carried out than intended, the incidence of airway complications was low, with no significant differences between the groups. There was, however, a trend toward more vocal-cord ulceration and subglottic inflammation in the continued intubation group than in the 2 tracheostomy groups.

More recently, Rumbak et al reported a 3-center clinical trial of early tracheotomy versus delayed tracheotomy in 120 medical ICU patients who were considered to need prolonged mechanical ventilation.[16] Patients were enrolled if they were projected during their first day after intubation to need ventilatory support for more than 14 days. Such patients were randomized either to percutaneous dilational tracheotomy within the first 48 hours or to delayed tracheotomy (technique not specified) at day 14–16 following intubation. The study end points were time in the ICU and on mechanical ventilation, and the cumulative frequency of pneumonia, mortality, and accidental extubation.

In contrast to the findings of Sugerman et al,[15] Rumbak et al found marked differences in the study outcomes between the 2 groups.[16] The duration of mechanical ventilation was 7.6 ± 4.0 days in the early tracheotomy group, as compared to 17.4 ± 5.3 days in the late tracheotomy group ($p < 0.001$). Corresponding days in the ICU were 4.8 ± 1.4 and 16.2 ± 3.8, respectively ($p < 0.001$). Pneumonia developed in 3 of 60 patients (5%) in the early tracheotomy group, versus 15 of 60 (25%) in the late tracheotomy group ($p < 0.005$). Nineteen of the early tracheotomy patients died (32%), as compared to 37 of the late tracheotomy patients (62%, $p < 0.005$). Among survivors, examination of the trachea while still in the hospital and at 10 weeks showed no significant differences between the 2 groups.

The early and late tracheotomy groups in this study were not significantly different at study entry in terms of demographics, comorbidities, or Acute Physiology and Chronic Health Evaluation II scores, and from the information provided in the article there is no obvious difference in management protocol or other study design feature that would bias the findings in favor of the early tracheotomy group. Nonetheless, the differences in outcomes in the 2 treatment groups—a reduction in mortality by half and of pneumonia by three fourths, as well as a 10-day mean reduction in the need for ventilatory support—are so striking as to raise concern for other, unknown confounding factors, and to emphasize the need for additional studies to confirm the findings.

Why Good Clinical Studies of Tracheostomy and Weaning Are So Difficult to Do

No hypothesis relating to respiratory care in the ICU has proved more difficult to study in an objective fashion than the commonly held tenet that tracheostomy facilitates ventilator weaning. The most striking finding in the study of Sugerman et al,[15] discussed above, is not that the investigators were unable to demonstrate differences in any study outcome with early versus late tracheostomy versus prolonged intubation, but rather how difficult it proved to be to do the study at all. Problems with inducing the investigators to adhere to the protocol and to maintain their patients in the study are discussed candidly by the authors in the paper's Discussion:

> This was a very difficult study to carry out. Several major trauma centers. . . refused to participate because they felt strongly that either all severely injured patients should undergo tracheostomy within 2 to 3 days after injury or tracheostomy was not necessary for as long as 4 weeks after injury. At some participating centers, including that of the principal investigator, attending surgeons and residents continued to believe that their patients would be able to be extubated before 7 days and prevented entry into the study or felt that the patient should undergo tracheostomy without the risk of randomization to the continued intubation arm of the study.[15]

These comments illustrate some of the reasons why good clinical studies on the effects of tracheostomy on weaning have been so few and far between (Table 5). It is not possible to blind either the investigators or the managing clinicians (physicians, nurses and respiratory therapists) to the treatment group to which each patient is assigned. As implied in the above quotation, the "true" answer about tracheostomy and weaning may not be known, but every clinician managing ventilated patients in the ICU holds a strong opinion on the matter. This means that, in any given time during a study in which half of the patients underwent early tracheotomy and half did not, the clinicians managing half of them would believe that they were not delivering the best possible care to those patients. For clinical research in the ICU to be carried out successfully, those involved must have equipoise with respect to the modality under investigation.[17,18] When opinions are strongly held, as is the case with tracheostomy and weaning, truly objective research with clinically meaningful end points may not be possible.

Table 5. Potential Obstacles to Successful Clinical Studies on Tracheostomy and Weaning

Inability to blind investigators (and clinicians) as to groupings
Bias of clinicians managing patients
Inability to predict which patients will require prolonged ventilatory support
Varying weaning protocols
Varying criteria for weaning success and failure
Funding and reimbursement factors
Varying specialties performing procedure
Varying levels of training and experience among operators

A major obstacle to studying the effects of tracheostomy on weaning is the inability to predict which patients will require prolonged ventilatory support. While such prediction may be relatively straightforward in conditions that impair airway protection, such as bulbar weakness, or ventilatory bellows function, such as high cervical spinal cord injury, it is woefully inaccurate in the absence of these things. In the study of Rumbak et al,[16] a requirement for enrollment was that each patient was projected to require more than 14 days of mechanical ventilation, yet the great majority of those who received early tracheostomy were liberated from the ventilator well before 14 days, suggesting that at least some of them might not have needed prolonged ventilatory support. Impaired consciousness may not by itself be a reliable predictor of the need for prolonged airway protection,[19] yet this is one of the most commonly invoked justifications for tracheostomy.

Although increasing adoption of evidence-based weaning guidelines[1,2] may diminish the magnitude of the problem, the fact that liberation from ventilatory support is approached so variably by different clinicians and in different institutions constitutes another barrier to the performance of good clinical studies. Similarly, criteria for determining the success or failure of weaning vary widely, and in much of the literature it is hard to tell whether what is being discussed is weaning (the discontinuation of mechanical ventilatory support) or extubation (the removal of the ETT).[20] This distinction is particularly important in studies comparing tracheostomy to continued endotracheal intubation: if weaning success requires removal of the artificial airway in one group and not in another, then it is unclear whether the ability to ventilate or to protect the airway and clear secretions is actually being studied.

In many hospitals, administrative policy permits patients to be moved out of the ICU if they have a tracheostomy, but not if they have an ETT. This nonmedical factor can affect study results if ICU length of stay is an outcome variable. Depending on regional regulations and a given patient's funding sources, transfer to a long-term acute-care facility or regional weaning center may require that a tracheotomy be performed prior to transfer—or, in other settings, may preclude physicians at the transferring institutions from performing the procedure. Such influences affect the duration of intubation and introduce factors that could confound the results of a clinical study of tracheostomy and weaning.

Two other variables that would affect the performance of any study seeking to clarify the role of tracheostomy in weaning are who performs the procedure and how experienced they are in performing it. In the mid-1990s, a study of tracheotomy practice from one large urban teaching hospital determined that the procedure was currently performed there by 5 different clinical specialties: general surgery, burn surgery, otolaryngology, neurosurgery, and oromaxillofacial surgery.[21] With the introduction of percutaneous dilational tracheotomy into many ICUs, to this list must be added pulmonologists and intensivists from internal medicine, anesthesiology, and pediatrics. Practitioners with different training and practice contexts may approach the procedure differently. Most likely there is also a difference between an experienced surgeon who has performed hundreds of tracheotomies and a resident or fellow performing the procedure for the second time, with respect to technical aspects and the likelihood of complications.

Do Clinicians Manage Intubated Patients and Patients With Tracheostomies Differently?

It may be that a main reason for more rapid weaning after tracheostomy is that clinicians cannot help looking at patients in a somewhat different way than they did when they were intubated with ETTs. The management of respiratory failure has distinct components—oxygenation, ventilation, airway protection, and secretion clearance—and yet it is difficult to keep these separate when dealing with patients. When dealing with intubated patients, it is hard not to conflate ventilation with airway and secretion management, and to think about extubation as the desired end point. With a tracheostomy, however, since removing the tube is not of immediate concern, attention can be given to discontinuing ventilatory support. If weaning and extubation are thought of together, then an unsuccessful attempt may mean reintubation, which is inconvenient, uncomfortable, and potentially dangerous for the patient. On the other hand, if an SBT is unsuccessful in a patient with a tracheostomy, the artificial airway remains in place and resuming ventilatory support is quick and easy.

Because of concerns about the possible need for reintubation, and because ventilatory support and maintenance of an artificial airway are often thought of as a package rather than separately, patients who are capable of breathing spontaneously may remain on the ventilator and thus be subjected to tracheotomy because they are "unweanable." These same patients, once the tracheostomy tube is in place, can often be placed on a T-piece or tracheostomy collar. While it seems clear that there are differences between tracheostomy and ETTs with respect to dead space and resistance, for most patients these differences are unlikely to explain the ready conversion to spontaneous breathing that often occurs following tracheostomy. The latter may say more about how clinicians approach patient management than about the breathing capabilities of their patients.

Current recommendations for weaning emphasize the importance of SBTs for determining when patients are ready for discontinuation of ventilatory support.[1,2] This is because clinicians are grossly inaccurate in identifying patients who are ready to resume spontaneous ventilation—particularly in the case of patients considered to be hard to wean. The 2 largest and most-cited studies of weaning techniques for hard-to-wean patients[22,23] both started by screening patients whose physicians considered them difficult to wean. The screening procedure included an SBT, and study entry required each patient to "fail" this trial, thus demonstrating that further ventilatory support was needed. Despite the fact that all screened patients were identified by their physicians as "hard to wean," in each study about two thirds of those who were screened "passed" the SBT and could thus be liberated from the ventilator without further intervention.

The experience in these 2 multicenter weaning trials emphasizes the importance of allowing patients to demonstrate whether they are able to resume spontaneous breathing, rather than waiting for the clinicians managing them to decide they are ready. This experience should definitely also be applied to the process of determining whether patients should undergo tracheotomy because of difficulty weaning. However, SBTs demonstrate that patients can breathe without assistance, but do not necessarily mean that they can safely be extubated. Determination of that requires some assessment of the abilities to maintain a patent upper airway, to avoid aspiration, and to clear lower-respiratory-tract secretions. Patients may thus benefit from tracheotomy who no longer need ventilatory support. However, a determination of the continued need for mechanical ventilation, separate from the need for an artificial airway, should be made whenever tracheotomy is contemplated because of the perceived need for prolonged mechanical ventilation.

Summary

Tracheostomy reduces dead space, in comparison with the nonintubated state, but the difference between an ETT and a tracheostomy tube with respect to dead space is very small. Work of breathing through a tracheostomy tube is less than that through an ETT of the same ID, although whether this difference accounts for the ability of some patients who previously failed extubation to be successfully weaned from ventilatory support is uncertain. Resistance and WOB through a tracheostomy tube tend to be less than in the nonintubated state, although there are a number of variables that may influence these differences. Well done prospective clinical studies on the effects of tracheostomy on weaning, as opposed to laboratory and short-term physiologic studies, are few. A recent clinical trial on early versus delayed tracheotomy found dramatic reductions in ventilator and ICU days, the incidence of pneumonia, and overall mortality.[16] Several factors make carrying out clinical research in this area problematic, however, and it remains uncertain whether patients with acute respiratory failure are benefited by early tracheostomy as opposed to delayed tracheostomy or prolonged endotracheal intubation. The tendency of clinicians to manage patients with ETTs differently from those with tracheostomies, and to discontinue ventilatory support more readily in the latter group, further compounds the uncertainty about the best application of tracheostomy as an aid to weaning.

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