Tracheostomy practice in adults with acute respiratory failure

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Objective: **Tracheostomy remains one of the most commonly performed surgical procedures in adults with acute respiratory failure and identifies a patient cohort which is among the most resource-intensive to provide care. The objective of this concise definitive review is the synthesis of current knowledge regarding tracheostomy practice in this context.**

Data Source: **Peer-reviewed, English language publications pertaining to tracheostomy indications, timing, technique, and management.**

Results: **Contemporary literature concerning tracheostomy use predominately focuses on two aspects: procedure timing and technical considerations. Three recent, large, randomized controlled trials failed to demonstrate an effect of "early" tracheostomy on mortality, infectious complications, intensive care unit, or hospital length of stay. Relative to continued translaryngeal intubation, tracheostomy was associated with less sedation use and earlier mobility. An accumulating body of literature suggests that, relative to conventional surgical methods, percutaneous dilational techniques are advantageous with respect to cost and complication profile. Literature addressing management following tracheostomy placement consists largely of single institution, nonrandomized reports, limiting the ability to formulate specific recommendations regarding this aspect of care.**

Conclusions: **In patients who otherwise lack indication for surgical airway, clinicians should defer tracheostomy placement for at least 2 wks following the onset of acute respiratory failure to insure need for ongoing ventilatory support. Subpopulations of patients (e.g., those with acute neurological injury or stroke) may benefit from earlier tracheostomy. Percutaneous dilational tracheostomy should be considered the preferred technique for this intervention in the appropriately selected individual. Future investigations should include efforts to optimize post-tracheostomy management and to quantify tracheostomy effects on patient-centric outcomes. (Crit Care Med 2012; 40:2890–2896)**

Key Words: acute respiratory failure; critical illness; intensive care units; randomized controlled trials; tracheostomy

Tracheostomy is one of the most commonly performed surgical procedures in the setting of acute respiratory failure (1–4). Although a minority of all individuals require respiratory support, tracheostomy patients place significant demands on ventilator, intensive care unit (ICU), hospital, and posthospital discharge resources (5–7). Financial expenditures to support the care of tracheostomy patients are among the highest of any diagnostic or procedural group (8). Efforts to refine tracheostomy practice have the potential to affect both the quality of care provided in this segment of the critically ill population, as well as the resources expended delivering this care (9, 10).

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Although a large body of literature has accumulated in recent years regarding benefits, risks, and technical aspects of this procedure, little consensus exists as to what constitutes optimal tracheostomy practice in the setting of acute respiratory failure (11, 12). This concise definitive review will summarize this literature for the adult ICU patient, formulate recommendations based on this evidence, and outline directions for future research.

Indications and Rationale for Tracheostomy Placement in the Setting of Acute Respiratory Failure

The presence of a "difficult airway" in a patient requiring prolonged mechanical ventilation constitutes one of the few absolute indications for tracheostomy (13). Patients with "difficult airways" include those with conditions such as significant maxillofacial trauma, angioedema, obstructing upper airway tumors, or other anatomic characteristics that would render translaryngeal intubation technically difficult to perform in the event of inadvertent airway loss (13). Such patients represent a small fraction of all individuals undergoing tracheostomy in most intensive care units (5). More commonly, patients requiring prolonged mechanical ventilation undergo this procedure in an effort to facilitate care (12–14). The presence of a tracheostomy may promote oral hygiene and pulmonary toilet, enhance patient comfort, provide airway security, and allow oral nutrition and speech (12, 14). Further, the presence of a tracheostomy has been postulated to facilitate weaning from mechanical ventilation due to a number of factors (15). Resistance to airflow in an artificial airway is proportional to air turbulence, tube diameter, and tube length (14–16). Air turbulence is increased in the presence of extrinsic compression and inspissated secretions (14–16). Because of its rigid design, shorter length, and removable inner cannula (to allow for evacuation of secretions), airflow resistance and associated work of breathing should theoretically be less with tracheostomies relative to endotracheal tubes (14–16). However, such an effect has not been consistently demonstrated in patients following tracheostomy (17–19). Further, the presence of a tracheostomy may allow clinicians to be more aggressive in weaning attempts (13). Specifically, if a patient with a tracheostomy in place does not tolerate liberation from mechanical ventilation, he or she may be reconnected to the ventilator circuit. In contrast, if a patient who is translaryngeally intubated does not tolerate extubation, he or she must be sedated and reintubated. Concern about extubation failure may represent a potential barrier to extubation in patients who are of marginal pulmonary status (20). Because many of the benefits of tracheostomy relative to prolonged translaryngeal intubation are either unproven or subjective, unambiguous criteria for selecting patients for tracheostomy are lacking. This ambiguity has resulted in significant variation as to how tracheostomy is applied (5, 11, 21, 22). (Fig. 1)

Timing of Tracheostomy in Acute Respiratory Failure

One of the most debated aspects of tracheostomy use concerns timing. In the 1960s, endotracheal tubes were composed of relatively inflexible material and used a low volume, high-pressure cuff (14, 15). During this time, it was common practice to perform tracheostomy "early"—within 48 hrs of initiating mechanical ventilation—in an effort to minimize laryngeal injury resulting from translaryngeal intubation (14, 15). Advances in material sciences lead to the manufacture of less rigid endotracheal tubes equipped with more pliable balloons, which produced less trauma following prolonged translaryngeal intubation (14, 15). Further, a prospective study conducted by Stauffer et al to examine risks associated with tracheostomy suggested a significant rate of morbidity (e.g., stomal hemorrhage and infection rates >30%, rates of tracheal stenosis >50%) as well as mortality rates as high as 4% (23). Accordingly, enthusiasm for the routine performance of tracheostomy diminished. With refinement in tracheostomy techniques, perioperative complication rates associated with this procedure diminished (24, 25). In addition, subsequent studies attempting to establish the relationship among prolonged translaryngeal intubation, prolonged tracheostomy, and laryngeotracheal damage have been conflicting (14, 15). At present no data clearly establish that translaryngeal intubation should be limited to any specific duration, or that tracheostomy should be performed at any specific point in a patient's course in an effort either to limit chronic laryngeal dysfunction or minimize tracheal injury (14, 15).

Recent clinical investigations examining the question of optimal tracheostomy

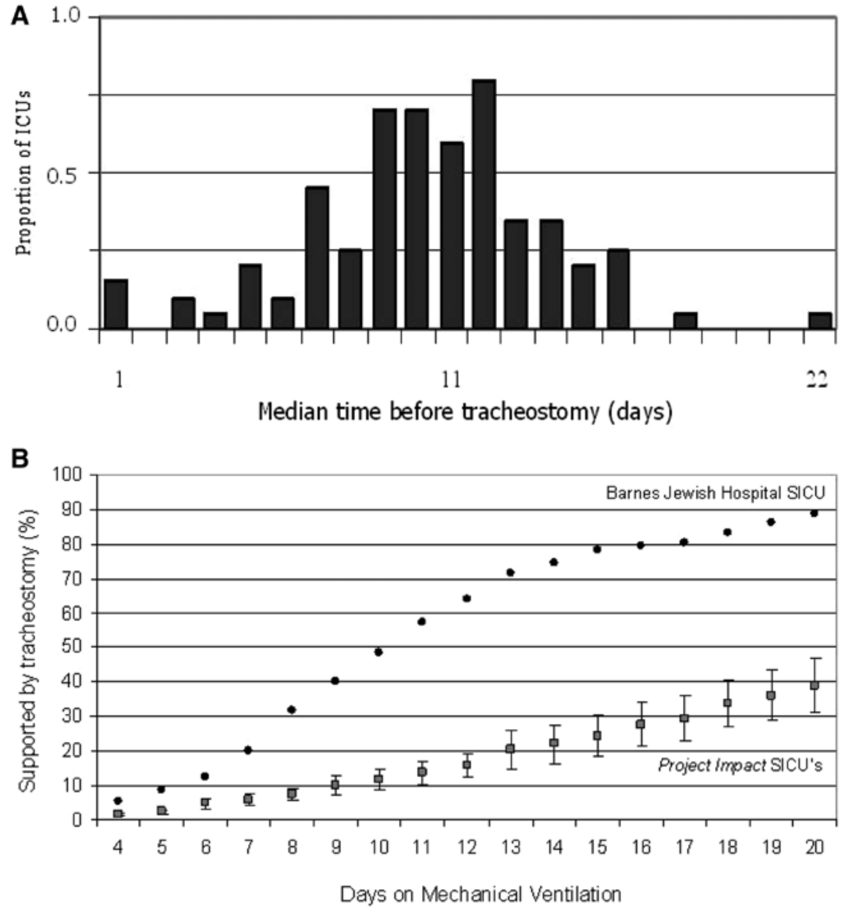

Figure 1. *A*, Distribution of tracheostomy timing (Project Impact administrative database analysis). Histogram of median tracheostomy timing in 109 intensive care units (*ICUs*) in this data set. Although tracheostomy occurred a median (interquartile range) of 9.0 (5.0–14.0) days following initiation of mechanical ventilation, ICUs displayed a broad range of practice, underlying the variable manner in which tracheostomy is currently used (4). *B*, Percentage of patients ventilated via tracheostomy comparing surgical ICUs The frequency with which tracheostomy is used also appears to vary substantially. We directly compared tracheostomy practice in 539 patients cared for in the Barnes-Jewish Hospital surgical ICU with 3,043 patients cared for in 18 comparable surgical ICUs participating in Project Impact. Overall rates of tracheostomy differed significantly 292 of 539 (54.2%) Barnes-Jewish Hospital surgical ICU vs. 422 of 3,043 (13.9%) project impact surgical ICUs ($p < .001$). Further, at each time point studied, the proportion of patients ventilated via tracheostomy in the Barnes-Jewish Hospital surgical ICU significantly exceeded those ventilated by tracheostomy in the surgical ICUs from Project Impact database (21). (*Used with permission*).

timing have centered on such end points as mortality, development of infectious complications, duration of mechanical ventilation, ICU length of stay (LOS), and hospital LOS (26–36). These studies produced conflicting findings due in part to small sample sizes, heterogeneity in populations enrolled, variation in the quality of study design, inconsistencies as to the end points examined, and lack of protocols to direct care (26–36). Recently, three studies have been reported, which add substantially to our knowledge in this area (37–39). (Table 1) In a large, multicenter Italian study, Terragni et al (37) randomized 419 patients to percutaneous tracheostomy following either 6–8 days or 13–15 days of mechanical ventilatory support. Tracheostomy timing had no effect on the primary outcome variable, prevalence of ventilator-associated pneumonia. Although early tracheostomy was associated with significantly shorter duration of mechanical ventilation and ICU LOS, there were no differences in hospital LOS, 28-day mortality, or proportion of patients requiring admission to a long-term care facility post discharge comparing treatment groups. In *TracMan*, a large multicenter study conducted in the United Kingdom, 909 patients were randomized to tracheostomy performed after either 1–4 days or >10 days of ventilatory support (39). Most tracheostomies (89%)

Table 1. Recent studies examining the effect of tracheostomy timing on clinically important endpoints

Reference	Intervention	Selection Criteria	Enrollment and Treatment Assignment
Terragni et al (37)	Tracheostomy following 6–8 days vs. 13–15 days of ventilatory support	Enrolled at 24 hrs if Simplified Acute Physiology Score II = 35–65, Sequential Organ Failure Assessment Score >5, and no pneumonia. Randomized at 72 hrs if PaO_2 <60 (FiO_2 = 0.5, PEEP = 8 cm H_2O), Sequential Organ Failure Assessment Score >5	600 patients enrolled; 419 randomized (209 assigned to early tracheostomy; 145 [66.2%] underwent early tracheostomy; 210 assigned to late tracheostomy, 119 [56.7%] underwent late tracheostomy)
Troullet et al (38)	Tracheostomy at 5 days vs. prolonged ventilatory support	Postcardiac surgery patients requiring mechanical ventilation at day 4 who fail screening test for weaning or spontaneous breathing trial.	216 patients enrolled (109 early tracheostomy, 107 prolonged intubation; 29 patients [27%] in the prolonged intubation group underwent tracheostomy)
TracMan (39)	Tracheostomy at 1–4 days vs. >10 days of ventilatory support	Enrolled on days 1–4 following ICU admission if clinician determines that there is a high likelihood of >7 days of continued ventilatory support	909 patients enrolled; (455 assigned to early tracheostomy; 454 assigned to late tracheostomy; 207 patients assigned to late tracheostomy [45.5%] underwent this procedure)

ICU, intensive care unit; LOS, length of stay.

were placed by percutaneous technique. Tracheostomy timing produced no effect on the primary end point (mortality) or secondary end points (ICU or hospital LOS). Early tracheostomy was associated with shortened duration of sedation (39). Trouillet et al (38) randomized patients postcardiac surgery to percutaneous tracheostomy following 5 days of ventilatory support vs. prolonged intubation. There was no effect of tracheostomy on the primary end points of either duration of mechanical ventilation or mortality. Further, treatment groups did not differ with respect to rates of ventilator-associated pneumonia, other infectious complications, ICU LOS, or hospital LOS. Patients undergoing tracheostomy experienced fewer unplanned extubations and required less sedative, analgesic, and antipsychotic use (for treatment of agitation and delirium) and were mobilized out of bed earlier in their ICU course. Twenty-seven percent of patients in the prolonged intubation group underwent tracheostomy.

These trials suggest that tracheostomy can be performed safely in critically ill patients; no deaths or serious complications related to tracheostomy placement were reported in >1,000 patients undergoing this procedure in these three studies (37–39). However, timing of this procedure had no effect on mortality, prevalence of ventilator-associated pneumonia, or length of hospitalization (37–41). Tracheostomy was associated with greater patient comfort, decreased sedative and antipsychotic drug administration, and lower prevalence of unplanned extubation (38). These studies had notable limitations. Terragni et al (37)excluded patients with chronic obstructive pulmonary disease, anatomic deformity of the neck, history of prior tracheostomy, and active pneumonia. Such patients would appear to constitute a large proportion of patients who undergo tracheostomy in most ICU environments, and who might derive benefit (or harm) from this procedure (5, 9, 21, 37). TracMan investigators assigned patients in the early tracheostomy arm to undergo this procedure following 1–4 days of mechanical ventilation (39). Previous data suggest that the majority of patients in this time frame would be liberated from mechanical ventilation without need for tracheostomy (5). (Fig. 2) Thus the early tracheostomy intervention in TracMan would appear difficult to implement in most clinical settings in the absence of sizeable benefit—it is unlikely that most intensivists would recommend it for their patients. Finally, the challenge of predicting continued need for ventilatory support is evidenced by large number of patients randomized to late tracheostomy but who failed to undergo this procedure due to successful weaning from mechanical ventilation or death (i.e., only 56.7% of patients in the study by Terragni et al (37) and 45.5% of patients in TracMan randomized to late tracheostomy ultimately underwent this procedure (37,39)). On the basis of the evidence provided by these three studies, clinicians should defer tracheostomy placement for at least 2 wks following the onset of acute respiratory failure to insure need for ongoing ventilatory support (37–40). Important caveats accompany this recommendation. Patients not addressed by these studies include those with multiple failed extubations; those that require multiple general anesthetics whereby a surgical airway may be more safe, secure, and comfortable than repeated translaryngeal intubations; those with difficult to manage agitation or significant although potentially reversible cognitive impairment who are at risk of aspiration if extubated; and those with significant comorbidities who are anticipated to require prolonged ventilatory support (37–39). Further, these studies do not address subpopulations (such as patients with acute neurological injury, stroke, or progressive neurological disorders) that may benefit from earlier tracheostomy. These and comparable considerations—including patient and family member preferences—will continue to factor prominently in individualizing the decision for tracheostomy.

Technique of Tracheostomy Placement

Traditionally, tracheostomies have been performed in the operating room according to standard surgical principles (42). In 1985, Ciaglia et al (43) described percutaneous dilational tracheostomy (PDT) in which tracheostomy is accomplished via modified Seldinger technique, typically with the aid of bronchoscopy (43). A number of clinical studies and secondary data analyses have compared tracheostomy placed by these two approaches and suggest several advantages of PDT relative to surgically created tracheostomy (44–63). PDT may be performed at the bedside, thus avoiding the inconvenience and risk associated with transporting a critically ill patient to the operating suite, as well as the expense of using these resources (10, 44, 49, 64). As a consequence, costs and charges associated with PDT are typically substantially

Primary Endpoint	Secondary Endpoints	Standardization of Care	Outcome
Ventilator-associated pneumonia	Duration of mechanical ventilation, ICU LOS, mortality	Weaning, sedation protocols standardized	No effect on prevalence of ventilator-associated pneumonia, ICU LOS, or mortality. Early tracheostomy associated with shortened duration of mechanical ventilation.
Duration of mechanical ventilation	ICU LOS, Hospital LOS, sedative use	Weaning, sedation protocols standardized	No effect on duration of mechanical ventilation, ICU LOS, or Hospital LOS. Early tracheostomy was associated with less use of sedation, less haloperidol use for agitation, and earlier mobility
Mortality	ICU LOS, Hospital LOS, sedative use	Not specified	No effect on mortality, ICU LOS, or hospital LOS. Early tracheostomy was associated with fewer days of sedation.

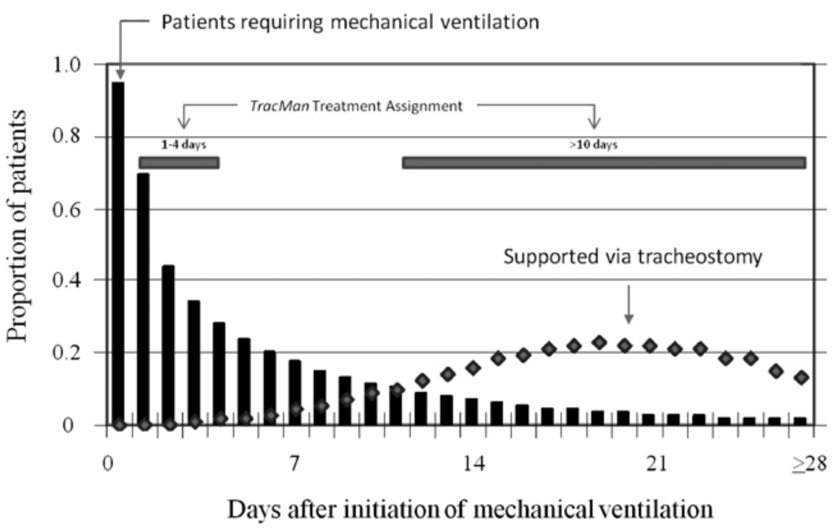

Figure 2. Pattern of liberation from mechanical ventilation and tracheostomy use in acute respiratory failure (Project Impact database analysis). Proportion of 43,916 patients with acute respiratory failure (*bar* graph) and proportion of patients maintained via tracheostomy (*diamonds*) are illustrated. The proportion of patients supported via tracheostomy increased with time up to 21 days (4). Patients in *TracMan* were randomized to undergo tracheostomy after either 1–4 days or >10 days of ventilatory support (39). We found that most patients requiring ventilatory support 1–4 days after the onset of acute respiratory failure were liberated without undergoing tracheostomy (4). Thus, the early tracheostomy intervention applied in TracMan would appear difficult to implement in a clinical setting unless it resulted in a sizeable benefit. *SICU,* surgical intensive care unit. Modified with permission.

less than those associated with surgical tracheostomy (44–47). (Of note, surgical tracheostomy may also be performed at the patient's bedside, offsetting these potential advantages of PDT). In addition, PDT is typically accomplished more quickly (reflecting the technical ease of this procedure) and is associated with less blood loss and lower rates of infectious complications (e.g., peristomal infection, cellulitis) relative to surgically created tracheostomies (49, 56, 59, 61, 62). These findings may reflect that there is minimal dead space separating the tracheostomy tube and adjacent pretracheal tissues following PDT, which may have a compressive effect on minor bleeding and serve as a barrier to infection (49). Longitudinal follow-up suggests that prevalence of delayed complications, such as clinically significant tracheal stenosis, are similar comparing these techniques (56, 57). The potential advantages of PDT notwithstanding this procedure has been associated with a significant number of highly morbid complications, many of which, such as tracheal laceration, aortic injury, and esophageal perforation, would be unusual following surgical tracheostomies (65–73).

Due to the above factors as well as to the ease of this technique, which enables individuals who have not received in-depth surgical training to become facile in its use, PDT has gained wide acceptance and has become the predominate method of tracheostomy creation in many centers (74–78). In the appropriately selected patient, PDT should be considered the preferred technique for tracheostomy creation (79, 80). Important caveats accompany this recommendation. Contraindications to PDT include ambiguous surface neck anatomy that precludes identification of structural landmarks, clinical conditions resulting in a "difficult" airway (described above), and the presence of an unstable cervical spine which limits the ability to achieve optimal neck positioning (9, 10, 13, 64). Further, PDT is an elective procedure and should not be used to establish an emergent airway (9, 10, 13, 64). Finally, although PDT is commonly performed competently by individuals not trained in surgical techniques, practitioners who are expert at surgical airway management should be immediately available in the event that significant complications arise (9, 10, 13, 64).

Management Following Tracheostomy Placement

Clinically significant outcomes (e.g., death, major infectious complications, length of hospitalization, comfort) for patients undergoing tracheostomy are highly dependent upon the nature of the care provided following this procedure. Optimal management of the tracheostomy patient with respect to assessment of aspiration risk and reinstitution of oral diet, phonation, reconditioning and rehabilitation, and decannulation are presently poorly defined, and appear to vary among institutions and practice environments (14, 81–85). It is difficult to formulate recommendations related to these areas based on available literature.

Conclusions and Future Directions

Although recent trials suggest that timing of tracheostomy does not influence duration of mechanical ventilation, ICU LOS, and similar endpoints, there does appear to be a beneficial effect of this intervention on sedation use, patient comfort, and mobility. Such outcomes are difficult to quantify in the ICU setting, particularly in relation to procedures such as tracheostomy, which have readily measurable costs and morbidity. One interpretation of studies reporting the prevalence of tracheostomy use is that clinicians recognize that tracheostomy enhances patient comfort and assign intrinsic value to this outcome (5, 22). Future tracheostomy studies should incorporate methodologies that enable valuation of qualitative and semiquantitative patient-centric variables so as to allow for accurate assessment of tracheostomy in relation to these effects. Similarly, intensivists may value tracheostomy because of its potential to facilitate optimization of ICU resources. Tracheostomy enables transfer of patients requiring prolonged ventilatory support to less resource-intensive settings (such as long-term weaning facilities or step-down units), effectively increasing the capacity of ICUs to provide care for more acutely ill individuals. Given that demand for critical care services is anticipated to continue to increase, understanding the manner in which tracheostomy (and comparable strategies) may facilitate throughput will take on increasing importance (86). Further, use of tracheostomy appears inextricably linked to many other facets of ICU care. Factors that would be expected to influence duration of mechanical ventilation and ICU LOS—such as the primary disease process, acuity of illness, comorbid conditions, use of and adherence to protocols directing weaning, sedation, and other aspects of care—would also be expected to influence the frequency with which tracheostomy is used (87–89). Although at present there are no benchmarks to define acceptable tracheostomy practice, one could envision use of this variable as a surrogate for quality of care (e.g., risk-adjusted comparison of rates of tracheostomy or in-hospital mortality of tracheostomy patients as an indicator for quality of care among institutions). Given that variability in practice represents a potential opportunity for quality improvement, future research should assess the feasibility of establishing such benchmarks (90). Finally, studies devoted to delineating optimal care following tracheostomy placement may enable more effective rehabilitation of patients recovering from prolonged periods of ventilatory support (91).

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