Mobilizing the Patient in the Intensive Care Unit: The Role of Early Tracheotomy

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Tracheotomy has been suggested to avoid the complications of prolonged translaryngeal intubation, which include oral and labial damage, laryngeal and tracheal damage, and patient discomfort. Tracheotomy allows for oral feedings, enhanced communication, and earlier ambulation and facilitates pulmonary toilet. Complications related to tracheotomy include stomal infections, pneumothorax, subcutaneous emphysema, tracheomalacia and granulation tissue, and—rarely—death [1–27]. Some studies have shown a decrease in oral and labial pathology, decreased incidence of self-extubation, and decreased days of sedation in patients randomized to early tracheotomy [15]. Equally important, in all the studies reviewed there was no short- or long-term statistically adverse tracheal or laryngeal pathology associated with tracheotomy. Many studies have been conducted to evaluate the benefits of early tracheotomy; however, heterogeneity in the various studies reviewed in this article is apparent, with early tracheotomy ranging from one to several days, and benefits regarding incidence of pneumonia and mortality are variable. An additional factor likely contributing to the differing results relates to the varied patient populations in the individual studies, which ranged from burn patients to medical ICU patients to trauma patients and head trauma patients. These results support tracheotomy as a safe, well-tolerated clinical procedure [1–27].

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Length of stay in the ICU and hospital

The benefits of early tracheotomy with respect to total length of ICU and hospital stay have been evaluated. Rumbak and colleagues [15] noted decreased duration of ICU stay with early tracheotomy (4.8 versus 16.2 days). Rodriguez and colleagues [13] also noted decreased duration of ICU and hospital length of stay in patients undergoing early tracheotomy (16 versus 37 days and 34 versus 51 days, respectively). Similarly, Armstrong and colleagues [12] noted decreased ICU and hospital length of stay in patients undergoing early tracheotomy (15 versus 29 days and 33 versus 68 days, respectively). Arabi and colleagues [11] reported decreased length of ICU stay with early tracheotomy (10.9 versus 21 days). D’Amelio and colleagues [10] noted decreased length of ICU and hospital stay in patients undergoing early tracheotomy (12.6 versus 26.2 days and 34.1 versus 49.6 days, respectively).

In contrast, Kluger and colleagues [1] did not note any differences in the mean length of ICU stay in patients undergoing early tracheotomy. The Glasgow Coma Scale score was statistically lower in the early tracheotomy group when compared with the late tracheotomy group. Bouderka and colleagues [3] also did not report any benefit of early tracheotomy in regard to ICU length of stay. This study did note benefit of early tracheotomy in regard to total days of mechanical ventilator support, which suggested that other variables may have prolonged ICU stay. Saffle and colleagues [14] similarly did not note any benefit of early tracheotomy, but the initial lung injury and burn characteristics were different between the two study populations. Sugerman and colleagues [2] also found no benefit of early tracheotomy regarding ICU length of stay, but there are major problems with the conduct of this study. The better designed studies with fewer confounding variables support the evidence that early tracheotomy decreases ICU and hospital stays significantly.

Days on mechanical ventilation

Many workers have evaluated the benefits of early tracheotomy with regard to days of mechanical ventilation. Rumbak and colleagues [15] noted significant decrease in the days of mechanical ventilation with early tracheotomy (7.6 versus 17.4 days) and a decrease in sedation accompanying the early removal of the endotracheal tube. Rodriguez [13] noted similar findings (12 versus 32 days). Once pneumonia was diagnosed, tracheotomy was associated with fewer days of mechanical ventilation after diagnosis of pneumonia (6 versus 23 days). Bouderka and colleagues [3] noted significantly shorter days on mechanical ventilation with early tracheotomy (14.5 versus 17.5 days). They also found that after the diagnosis of pneumonia was made, the duration of mechanical ventilation was strikingly less in patients randomized to early tracheotomy (6 versus 11.7 days). Arabi and
colleagues [11] reported that early tracheotomy was associated with fewer days of mechanical ventilation (10.9 versus 18.7 days) despite statistically significant lower Glasgow Coma Scale score in the early tracheotomy study population. Lesnik and colleagues [5] and D’Amelio and colleagues [10] reported fewer days of mechanical ventilation with early tracheotomy (6 versus 20.6 days and 4.6 versus 11.7 days, respectively).

In contrast, Boynton and colleagues [6] noted a decrease in the median duration of weaning but not total days of mechanical ventilation in patients undergoing early tracheotomy. This finding may reflect the study population and study design. The early tracheotomy group consisted of patients who underwent tracheotomy before any associated weaning attempts. The late tracheotomy group of patients underwent tracheotomy only after failing initial attempts at weaning from mechanical ventilation. The patients selected for early tracheotomy may have represented a patient population expected to do poorly or have prolonged need for ventilation support. Saffle and colleagues [14] did not note any benefit of early tracheotomy in regard to days of mechanical ventilation. Patients undergoing early tracheotomy had significantly lower PaO$_2$/FiO$_2$ ratios and larger amount of full-thickness burns. These variables may have impacted study results, with patients undergoing early tracheotomy having more extensive lung and burn injuries. With increased amount of full-thickness burns, the early tracheotomy group also may have required more surgical débridement during their hospital course, which is something that the authors do not comment on.

Most studies suggest that time on mechanical ventilation is significantly reduced with early tracheotomy compared with prolonged translaryngeal intubation. A recent meta-analysis confirms this finding. If tracheotomy is performed early, then time of resolution of subsequent ventilator-associated pneumonia (VAP) is reduced.

Hospital costs and outcomes

Freeman and colleagues [8] evaluated tracheotomy practice in the setting of critical illness to determine the relationship between tracheotomy timing, duration of mechanical ventilation, ICU length of stay, and hospital length of stay. Data from 43,916 patients, which were compiled from 101 hospitals and 130 ICUs, were reviewed. Elective tracheotomy was performed in 2473 patients. The tracheotomized patients incurred disproportionate amount of health care resources and were more likely to incur a higher level of supportive care at discharge (ie, skilled nursing or physical rehabilitation facility). This multicenter study showed several variables affecting tracheotomy practice, including the admitting diagnosis, prior failed attempt at extubation, hospital characteristics, and ICU specialty. Because this study was a retrospective, observational study, qualitative benefits and complication from tracheotomy could not be assessed. Promising benefits of improved survival with tracheotomy were noted in the study, but findings for decreased level of
independence in patients undergoing tracheotomy prompt concern for long-term functional outcomes of these patients.

Armstrong and colleagues [12] calculated that as a result of decreased ICU and hospital stays, the health care–related cost of the hospital per room and ventilator care was $36,609 for patients undergoing early tracheotomy and $73,714 for patients undergoing late tracheotomy. The disease related diagnosis for a patient having a tracheotomy is five times more than one who does not. Kollef and colleagues [9] prospectively studied a cohort from a single institution and evaluated clinical predictors and outcomes for patients requiring tracheotomy in the ICU. Tracheotomy was associated with decreased hospital mortality. The length of ICU stay and duration of mechanical ventilation were higher in patients undergoing tracheotomy. This outcome might have been caused by longer duration of ICU stays among nonsurvivors who underwent tracheotomy. Among the 44 survivors who received tracheotomy, 86% were alive 30 days after hospital discharge and 70.5% were living at home.

In most studies that compare tracheotomy to prolonged translaryngeal intubation, the patients who have poorer prognoses are not tracheotomized. The mortality rate is higher in patients who are left intubated translaryngeally. Patients who are left are tracheotomized and tend to use more health care resources. This is an example of how early mortality is associated with fewer overall health care costs. Studies that compared early tracheotomy to delayed tracheotomy patients found a decrease in ICU and total hospital stay. Early tracheotomy may benefit the patients and reduce hospital costs. There are large savings if patients are in the ICU or hospital for a shorter length of time. The disease related diagnosis when a tracheotomy is performed in critically ill patients is, on average, five times greater in value. Important aspects of tracheotomy use include impact on duration of hospital and ICU stay. Benefits of tracheotomy in terms of shortening either of these variables include long-term benefits to overall health care cost and use of limited health care resources. Most studies supported benefit of early tracheotomy regarding these two variables; however, an equally important component of early mobilization of patients from the ICU relates to the long-term outcomes of these patients.

Mortality

Rumbak and colleagues [15] evaluated the benefits of early tracheotomy (within the first 2 days) versus late tracheotomy (days 14–16) in critically ill medical patients. They found a statistically significant reduction in mortality with early tracheotomy (31.7% versus 61.7%, respectively). Rodriguez and colleagues [13] conducted a prospective, randomized, controlled trial to evaluate the benefits of early tracheotomy in patients admitted to the surgical ICU. Early tracheotomy in this patient population ranged up to 7 days, which is longer than that of Rumbak and colleagues’ study. No
significant difference was noted in mortality. Bouderka and colleagues [3] conducted a similar study to evaluate the benefits of early tracheotomy in patients who had severe head injuries. In this study, early tracheotomy was performed on day 5 or 6 after intubation and there was no difference in mortality. Sugerman and colleagues [2] also looked at mortality, but this study has many confounding variables. Saffle and colleagues [14] evaluated the benefit of early versus delayed tracheotomy in intubated and acutely burned patients. Early tracheotomy was performed at a mean of 4 days after burn and late tracheotomy at day 14 or more after burn. No mortality benefit was noted in the early tracheotomy group. One key aspect of the study was the finding that patients in the early tracheotomy group had more severe burns and lower PaO$_2$/FiO$_2$ ratios than patients in the late tracheotomy group, which may have affected the mortality.

Chintamani and colleagues [16] studied early tracheotomy on an average 2.18 days of hospitalization in patients who have head injury. The control group constituted patients who had similar injury but did not undergo tracheotomy during the hospitalization. Mortality in the early tracheotomy group was 36% compared with 58% in the non-tracheotomy group. Boynton and colleagues [6] conducted a similar study of trauma patients to evaluate the impact of tracheotomy timing. Median timing of early tracheotomy was 4 days compared with 14 days for the late tracheotomy group. This study showed decreased mortality in the early tracheotomy group. Arabi and colleagues [11] conducted a prospective cohort study on the benefits of early tracheotomy (up to 7 days) in trauma patients. No mortality benefit was noted in this study. A notable finding was that the Glasgow Coma Scale score was statistically significantly lower in the patients selected for early tracheotomy, which suggested that more critically injured patients were selected for early tracheotomy.

Kluger and colleagues [1] studied the benefits of early tracheotomy in trauma patients. Three study populations were analyzed: early tracheotomy (within 0–3 days), intermediate tracheotomy (within 4–7 days), and late tracheotomy (after 7 days). No mortality benefit was noted in this study. In reviewing the data, the early tracheotomy group did have lower mean Glasgow Coma Scale scores and slightly—but not statistically significant—higher injury severity scores than the late tracheotomy group. Armstrong and colleagues [12] evaluated early tracheotomy up to 6 days in patients admitted with blunt trauma. No benefit was shown. Kollef and colleagues [9] conducted a prospective cohort study to evaluate clinical predictors and outcomes for patients who required tracheotomy. The hospital mortality rate of patients with tracheotomy was 13.7% versus 26.4% for patients not undergoing tracheotomy. Freeman and colleagues [8] found that the median days of mechanical ventilation before patients undergoing tracheotomy was 9 days. Data analysis showed that tracheotomy was associated with improved ICU and hospital survival (78.1% versus 71.8%). Frutos-Vivar and colleagues [7] evaluated the outcome of mechanically ventilated
patients who required tracheotomy. In the study, mortality benefit was noted in the ICU (odds ratio 2.22, 95% confidence interval, 1.72–2.86) but not regarding overall hospital mortality, which was similar in both study populations.

In summary, some of the studies comparing early with delayed tracheotomies found no decrease in mortality in the early group. These studies had more confounding variables and the tracheotomies were performed later. Tracheotomies performed before day 3 may reduce mortality compared with tracheotomies performed after day 14. The three latter studies consisted of a diverse study populations and had nonrandomized design, and the design of the studies was not specific to elicit differences between tracheotomy and conventional translaryngeal intubation. The associated improved survival may reflect bias selection of patients for tracheotomy to those expected to survive hospitalization.

Ventilator-associated pneumonia

Rumbak and colleagues [15] looked at VAP in early tracheotomy. The early tracheotomy was performed within the first 2 days of hospitalization. An ICU protocol for prevention of was established. VAP was diagnosed by bronchoscopy using semi-quantitative cultures from protected brushes or bronchoalveolar lavage. The authors reported a decrease in the prevalence of VAP by 80%. Rodriguez and colleagues [13] used a clinical diagnosis of VAP. The study did not describe a protocol for the prevention of VAP. There was no decreased prevalence of VAP in the early group compared with the late group. When subgroup analysis was conducted, statistically significant decreased incidence of VAP was noted if tracheotomy was performed within the first 2 days of intubation, which is consistent with the data reported by Rumbak and colleagues.

Sugerman and colleagues [2] studied early tracheotomy between days 3 and 5. No protocol for prevention of VAP was referenced. Diagnosis of VAP was clinical. There was no benefit with regard to VAP incidence with early tracheotomy. Saffle and colleagues [14] conducted a study to evaluate benefits of early tracheotomy in acutely burned patients. The prevention and diagnosis of VAP was not documented. No decrease in the prevalence of VAP was noted. Bouderka and colleagues [3] studied the effect of VAP in patients with early tracheotomy performed on day 5 or 6. VAP was diagnosed by Centers for Disease Control and Prevention guidelines for nosocomial infections. No protocol for prevention of VAP was referenced. They did not note any decrease in the prevalence of VAP with early tracheotomy either.

Kluger and colleagues [1] looked at the benefits of early tracheotomy in trauma patients. Three study populations were analyzed as follows: early tracheotomy (within 0–3 days), intermediate tracheotomy (within 4–7 days), and late tracheotomy (after 7 days). No protocol for prevention of
VAP was referenced. Criteria for VAP were clinical. Significant differences in the prevalence of VAP were noted between the various study groups (14%, 23%, and 43%, respectively). Boyton and colleagues [6] studied early tracheotomy (up to 4 days) on the prevalence of VAP tracheotomy (mean of 4 days). No protocol for prevention of VAP was referenced. VAP was defined clinically with a positive nonbronchoscopic bronchoalveolar lavage culture $\geq 10^8$ colony-forming units/mL. This study noted a favorable effect with early tracheotomy.

The major findings when the various studies are compared in regard to VAP are that timing and protection against VAP were noted only if the tracheotomy was performed within the first few days. One important point to consider when reviewing these studies is that few studies detailed ICU protocols or practices implemented to try to prevent pneumonia. In conclusion, most of the studies—prospective and retrospective—tend to suggest that the earlier tracheotomies are performed, the higher the chance of preventing VAP in patients who require prolonged mechanical ventilation.

**Upper and lower airway damage**

Rumbak and colleagues [15] assessed oral and laryngotracheal complications by physical examination with a clearly defined scoring algorithm, fiberoptic bronchoscopy, and linear radiographic topography. More damage was noted to the larynx and lips in the group randomized to delayed tracheotomy. There were also fewer extubations in the early tracheotomy group. There was no difference in the damage to the lower airway up to 8 weeks after the initial intubation. There was a trend toward less lower airway injury noted in the early tracheotomy group; however, statistical significance may have been hampered by a type II error. Bouderka and colleagues [3] used clinical but not endoscopic evaluation to assess for laryngotracheal complication related to translaryngeal as compared with tracheotomy. No difference was noted in this study. No clear standardized algorithm for assessing translaryngeal complications was followed; rather, clinical symptoms were scored and patients were evaluated with laryngotracheal endoscopy only if there was clinical suspicion of a problem.

Dunham and LaMonica [4] evaluated patients undergoing early (3–4 days) or late (after 14 days) tracheotomy for laryngotracheal complications. All patients in the study were subject to repeated flexible laryngoscopy and set intervals. Patients were also interviewed for quality of voice and respiratory difficulty. No difference was noted between the two study populations. Sugerman and colleagues [2] evaluated for differences in laryngotracheal pathology in regard to timing to tracheotomy. All patients were subject to flexible laryngoscopy only within 24 hours of tracheotomy. Repeat examination was to be conducted at 3 to 5 months in all symptomatic patients and patients with a predetermined, documented pathologic injury on the first examination. There was no statistical difference between the two study
populations; however, a trend toward more vocal cord ulceration and subglottic inflammation was noted in the prolonged translaryngeal intubated group. D’Amelio and colleagues [10] noted no evidence of significant complications of tracheal stenosis in regard to early versus late tracheotomy. In the studies regarding airways, there is no significant difference in lower airway damage between the early and late tracheotomy groups. There is less damage to the upper airways and fewer unplanned extubations in the early group, however. Risk of upper or lower airway damage does not seem to be a reason to withhold an early tracheotomy, however.

Summary

Many studies have evaluated the benefits of early tracheotomy; however, heterogeneity in the various studies reviewed in this article is apparent, with early tracheotomy ranging from 1 to several days, and benefits regarding incidence of pneumonia and mortality are variable. An additional factor likely contributing to the differing results relates to the varied patient populations in the individual studies, which ranged from burn patients to medical ICU patients to trauma patients and head trauma patients. A close look at the studies with the least confounding variables suggests that early tracheotomy has some merit. Most studies suggest that time in the ICU, on mechanical ventilation, and in hospital is reduced. There is less damage to the upper airway, fewer unwanted extubations, and at least similar lower airway changes (short- and long-term). VAP and mortality also may be reduced. Early tracheotomy reduces the length of stay in the ICU.

References