TIMING OF TRACHEOSTOMY

SUMMARY
The appropriate timing of tracheostomy in the patient suspected to require prolonged mechanical ventilation remains a subject of controversy. Multiple retrospective and prospective studies have been performed to evaluate this clinical question. These studies suggest that early tracheostomy (within 7-10 days of intubation), especially among patients with traumatic brain injury, is associated with significant improvements in duration of mechanical ventilation, intensive care unit and hospital length of stay, reduced ventilator-associated pneumonia, reduces hospital costs, and improves patient survival.

RECOMMENDATIONS

- **Level 1**
  - **None**
- **Level 2**
  - **The reason for mechanical ventilation should be considered when deciding the timing of tracheostomy.**
  - **Tracheostomy should be considered in patients who require more than 7-10 days of mechanical ventilation in order to reduce the duration of mechanical ventilation and decrease intensive care unit and hospital length of stay, duration of sedation, and hospital cost.**
- **Level 3**
  - **Tracheostomy before 7 days is contraindicated in patients with a probability of survival less than 25%.**
  - **Early tracheostomy may reduce the risk of ventilator-associated pneumonia and may improve patient survival.**

INTRODUCTION
Airway access for mechanical ventilation can be provided either by endotracheal or tracheostomy tube. During episodes of acute respiratory failure, patients are generally ventilated through an endotracheal tube. The transition to a tracheostomy tube is often considered when the need for mechanical ventilation is expected to be prolonged. The most common indications for tracheostomy are acute respiratory failure and need for prolonged mechanical ventilation and traumatic or catastrophic neurologic insult requiring airway control, mechanical ventilation or both. Upper airway obstruction is a less common indication for tracheostomy. Observational studies document that approximately 10% of mechanically ventilated patients will require tracheostomy, but there is significant variability with regard to optimal timing and patient selection.

LITERATURE REVIEW
There have been several retrospective and prospective studies performed to examine the issues of

EVIDENCE DEFINITIONS
- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS
- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

optimal timing of tracheostomy. Arabi et al. published a retrospective study of 531 mechanically ventilated subjects in a mixed medical/surgical intensive care unit (ICU). The mean time to tracheostomy was 12 days and mean ICU length of stay (LOS) was 23.1 days. Time to tracheostomy was associated with an increased duration of mechanical ventilation, ICU LOS, and hospital LOS for each day tracheostomy was delayed. Time to tracheostomy was not associated with increased ICU or hospital mortality (1).

Beltrame et al. performed a single-center study evaluating the outcomes of bedside percutaneous dilatational tracheostomy (PDT) and surgical tracheostomy (ST). Five hundred twenty eight mechanically ventilated patients underwent tracheostomy. 161 patients received ST and 367 underwent PDT. STs were performed significantly later than PDT (12.4 days vs. 8.7, p<0.05). Overall ICU LOS (18.4 vs. 23.3 days, p< 0.05) and mean duration of mechanical ventilation (14.2 vs. 20.1 days, p<0.05) were lower in the PDT than in the ST group (2).

Moller et al. performed a study to determine whether early tracheostomy (ET) of severely injured patients reduces duration of mechanical ventilation, the frequency of ventilator-associated pneumonia (VAP), and ICU LOS. The study was a retrospective review that included 185 surgical ICU patients with acute injuries requiring mechanical ventilation and tracheostomy. There were no differences in the rate of ARDS or lung injury between groups. ET was defined as ≤ 7 days, and late tracheostomy (LT) as > 7 days. The incidence of VAP was significantly higher in the LT group (42.3% vs. 27.2%, respectively; p<0.05). They also found that APACHE II scores, hospital and ICU LOS, and the number of ventilator days were significantly higher in the LT group (3).

In 2005, a systematic review and meta-analysis included 5 randomized controlled trials (RCT) evaluating the timing of tracheostomy in 406 adult patients on ventilatory support (4-9). Early tracheostomy did not significantly alter mortality (relative risk 0.79, 95% confidence interval 0.45 to 1.39) or the risk of pneumonia (0.90, 0.66 to 1.21). Early tracheostomy did however significantly reduce the duration of mechanical ventilation (weighted mean difference 8.5 days) and ICU LOS (weighted mean difference 15.3 days) (9).

In 2008, a large retrospective analysis from Ontario compared mechanically ventilated patients who underwent early versus late tracheostomy. A total of 10,927 patients received tracheostomy during the study of which one-third (n=3758) received early tracheostomy ≤ 10 days) and two-thirds (n=7169) received late tracheostomy (>10 days). Patients in the ET group had lower unadjusted 90-day (34.8% vs. 36.9%; p=0.032), 1 year (46.5% vs. 49.8%; p=0.001), and study mortality (63.9% vs. 67.2%; p<0.001) than patients in the LT group. Multivariate analyses showed that each additional day of delay in performing tracheostomy was associated with increased mortality equivalent to an increase in 90-day mortality from 36.2% to 37.6% per week of delay (relative risk increase 3.9%) (10).

Terragni et al. conducted a multicenter prospective RCT in 12 Italian ICUs from June 2004 to June 2008. The study enrolled 600 adult patients without pneumonia who had been ventilated for 24 hours. Subjects were monitored for 48 hours and those with worsening respiratory failure and no pneumonia were then randomized to either early (after 6–8 days of laryngeal intubation, n=209) or late tracheostomy (after 13–15 days of laryngeal intubation, n=210) (11). The study included both medical and surgical subjects with no demographic differences. Thirty-one percent in the early group and 43% of the late group did not undergo tracheostomy due to proximity to either extubation or death. In the early group, 69% underwent tracheostomy compared with 57% in the late group. All tracheostomies were performed using bedside percutaneous techniques (Griggs technique in 72% early vs. 73% late, PercuTwist technique in 25% vs. 22%). VAP developed in 14% of early vs. 21% of late tracheostomy patients (p=0.07). The number of ICU-free and ventilator-free days was higher in the early tracheostomy group, but the long-term outcome end point of 28-day survival (74% vs. 68%; p=0.25) did not differ. The authors concluded that early tracheostomy (performed after 6–8 days of endotracheal intubation) did not result in significant reduction in the incidence of VAP compared with late tracheostomy (performed after 13–15 days of endotracheal intubation) and was associated with an adverse event related to the tracheostomy procedure in more than one third of subjects (11). It should be noted that both of the percutaneous insertion techniques evaluated in this study have been noted in other studies to have an increased rate of procedural complications.

Another systematic literature review and meta-analysis was performed in 2011. Seven RCTs with a total of 1,044 patients were included, 3 of which were included in the 2005 meta-analysis by Griffiths et al. (12). When compared to late tracheostomy, early tracheostomy did not significantly reduce short-term mortality (relative risk [RR], 0.86; 95% CI, 0.65-1.13), long-term mortality (RR, 0.84; 95% CI, 0.68-1.04), or incidence of ventilator-associated pneumonia (RR, 0.94; 95% CI, 0.77-1.15) in critically ill patients. The timing of the tracheotomy was not associated with a markedly reduced duration of mechanical ventilation (weighted mean difference [WMD], −3.90 days; 95% CI, −9.71-1.91) days of sedation (WMD, −7.09 days; 95% CI, −14.64-0.45), ICU LOS (WMD, −6.93 days; 95% CI, −16.50-2.63) or hospital LOS (WMD, 1.45 days; 95% CI, −5.31-8.22).

Young et al. performed the largest open multi-center RCT on timing of tracheostomy (13). This study was conducted from 2004 through 2011 in 70 general adult and 2 cardiothoracic ICUs in 72 hospitals in the United Kingdom. Nine hundred nine patients were enrolled. Inclusion criteria were mechanically ventilated subjects in adult ICUs who were identified in the first 4 days after admission as likely to require at least an additional 7 days of mechanical ventilation. Exclusion criteria included those patients receiving immediate tracheostomy or were contraindicated due to anatomical or other reasons or those with respiratory failure due to chronic neurological diseases. Patients were then randomized to either early (within 4 days after intubation, n=455) or late tracheostomy (after 10 days if still indicated, n=454). Most subjects were admitted with a medical diagnosis (79.2%), with respiratory failure as the primary admission diagnosis (n=59.5%). Interestingly, in the early group, 91.9% of subjects received tracheostomy as planned as compared to the late group where only 45.5% of subjects required tracheostomy. Many subjects in the late tracheostomy group no longer required mechanical ventilation and were successfully extubated. Ninety percent of the tracheostomies were performed by the percutaneous technique, with 88.7% performed in the ICU at the bedside, and the majority (77.3%) performed by the single tapered dilator technique. There was no difference in 30-day mortality (30.8% early vs. 31.5% late), 2-year mortality (51.0% vs. 53.7%), or median ICU stay among survivors (13.0 days vs. 13.1 days). There was also no difference in hospital stay or duration of mechanical ventilation between the two groups. However, early tracheostomy was associated with significantly decreased sedation use. The median number of days during which any sedatives were received in survivors at 30 days after randomization was 5 days in the early group and 8 in the late group (p<0.001), with a mean difference between groups of 2.4 days (95% CI 1.6–3.6).

Patient selection is key factor in determining timing to tracheostomy. Barquist et al. performed one of the few prospective RCTs looking at timing to tracheostomy in trauma patients (14). This was a single-center trial comparing trauma patients who received a tracheostomy within 8 days of intubation versus those whose tracheostomy was delayed until after day 28. The study was halted after the first interim analysis (after 60 patients) as there was no significant difference between groups in number of mechanical ventilator days, ICU length of stay, incidence of VAP, or hospital mortality. They concluded that tracheostomy before day 8 post-injury in trauma patients did not reduce the number of days of mechanical ventilation, frequency of pneumonia or ICU length of stay as compared with a tracheostomy strategy involving the procedure at 28 days post-injury or more.

In 2009, however, Schauer et al. performed a retrospective multi-institutional study looking back over a 5-year period (January 2001 to December 2005) (15). They analyzed the relationship between the timing of tracheostomy in trauma patients and mortality, ICU and hospital LOS, and incidence of pneumonia. This relationship was investigated in the context of expected survival based on probability of survival (Ps) greater than 25%. The study examined 685 trauma patients who received tracheostomy and stratified patients into low and high probability of survival and early (0–3 days), early intermediate (4–7 days), late intermediate (8–12 days), and late (>12 days) tracheostomy. Early tracheostomy was associated with decreased ICU stay, hospital stay, total ventilator days, and rates of pneumonia among trauma patients with a high probability of survival. There was a significantly higher mortality rate (48.9%) associated with patients with low Ps (<25%) receiving tracheostomy less than 4 days injury. This study demonstrated that early tracheostomy in patients with low Ps may not be beneficial given the high mortality rate before post injury day 4. However, in patients with high probability of survival, there is an increased benefit to early tracheostomy.

Arabi et al., in a subsequent study, also showed a benefit to early tracheostomy (16). They evaluated trauma patients who received tracheostomy over a 5-year period. Tracheostomy was considered early if it was performed by day 7 of mechanical ventilation. Multivariate analysis was performed on duration of mechanical ventilation, ICU LOS, and outcome between early and late tracheostomy patients. Six hundred fifty three trauma ICU patients were identified, of which 21% required tracheostomy. Twenty-nine patients underwent early tracheostomy and 107 received late tracheostomy. Patients with early tracheostomy were more likely to have maxillofacial injuries and to have lower Glasgow Coma Scale score. Duration of mechanical ventilation was significantly shorter with early tracheostomy (mean 9.6 versus 18.7 days; *p*<0.0001). Similarly, ICU LOS was significantly shorter (10.9 vs. 21.0 days; p<0.0001). There was no significant difference with regard to ICU LOS after tracheostomy. ICU and hospital mortality rates were similar. Late tracheostomy was found to be an independent predictor of prolonged ICU stay (>14 days).

Hyde et al. also evaluated the timing of tracheostomy and outcomes in trauma patients (17). A chart review was performed from January 2010 to June 2012. Early tracheostomy (ET) was defined as a tracheostomy performed by the fifth hospital day. ET patients were matched to late tracheostomy patients (LT, tracheostomy after day 5) using propensity scoring and compared for multiple outcomes. Cost for services was calculated using average daily billing rates at the author's institution. One hundred and six patients were included, 53 each in the ET (mean day to tracheostomy=4) and the LT (mean day to tracheostomy=10) cohorts. The average age was 47 years and 94% suffered blunt injury, with an average Injury Severity Score of 24. Patients in the ET group had significantly shorter ICU LOS (21.4 vs. 28.6 days, p<0.0001) and significantly fewer ventilator days (16.7 vs. 21.9 days, p<0.0001) compared to the LT group. ET patients also had significantly less VAP (34% vs. 64.2%, p=0.0019). In the current era of increased healthcare costs, the authors concluded that early tracheostomy significantly decreased both pulmonary morbidity and critical care resource utilization translating to a cost savings of $52,173 per patient. They concluded that for trauma patients requiring prolonged ventilator support, early tracheostomy should be performed.

Patients with traumatic brain injury (TBI) are a common population of patients requiring tracheostomy. In 2004, Bouderka et al. published a study that evaluated whether early tracheostomy (by the fifth day post-injury) reduces duration of mechanical ventilation, ICU LOS, incidence of VAP, and mortality in comparison with prolonged intubation among patients with head injury (8). Randomization was performed on the fifth day into two groups: early tracheostomy (ET group, n = 31) and prolonged endotracheal intubation (PEI group, n = 31). The two groups were comparable in terms of age, sex, and Simplified Acute Physiologic Score (SAPS). The mean time of mechanical ventilation was shorter in the ET group (14.5 days) vs. PEI group (17.5 days) (p=0.02). After pneumonia was diagnosed, mechanical ventilatory time was 6 days for the ET group vs. 11.7 days for PEI group (p=0.01). There was no difference in frequency of pneumonia or mortality between the two groups.

Rizk et al. collected data from the Pennsylvania Trauma Society Foundation statewide trauma registry from January 1990 until December 2005 (18). 3,104 patients met criteria for inclusion in the study (GCS ≤ 8, documented head injury, and tracheostomy). Early tracheostomy (ET) was defined as tracheostomy performed during hospital days 1–7 and late tracheostomy (LT) as those performed >7 days after admission. Of note, patients in the ET group had higher ISS and lower GCS scores when compared to the LT group. The study showed a statistically significant decrease in ICU and hospital LOS and functional independence at discharge in the ET group when compared to the LT group. However, LT patients were more likely discharged alive (93% vs. 85%, p<0.0001). The authors concluded that a strategy of early tracheostomy (1-7) days, particularly when performed on patients with a reasonable chance of survival, results in a better overall clinical outcome than when the tracheostomy is performed in a delayed manner.

Approved 09/30/2015

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Last revision date: September 30, 2015

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