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Hospital Variation in Early Tracheostomy in the United States: A Population-Based Study

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Abstract

Objective—Controversy exists regarding perceived benefits of early tracheostomy to facilitate weaning among mechanically-ventilated (MV) patients, potentially leading to significant practice-pattern variation with implications for outcomes and resource utilization. We sought to determine practice-pattern variation and outcomes associated with tracheostomy timing in the United States.

Design—In a retrospective cohort study, we identified mechanically-ventilated patients with the most common causes of respiratory failure leading to tracheostomy: pneumonia/sepsis and trauma. ‘Early tracheostomy’ was performed within the first week of MV. We determined between-hospital variation in early tracheostomy utilization and the association of early tracheostomy with patient outcomes using hierarchical regression.

Setting—2012 National Inpatient Sample.

Patients—6,075 pneumonia/sepsis patients and 12,030 trauma patients with tracheostomy.

Interventions—None

Measurements and Main Results—Trauma patients were twice as likely as pneumonia/sepsis patients to receive early tracheostomy (44.5% vs 21.7%, $p < 0.001$). Admission to hospitals with higher early tracheostomy-to-total-tracheostomy ratios was associated with increased risk for

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tracheostomy among MV trauma patients (adjusted OR=1.04, 95% CI 1.01–1.07) but not pneumonia/sepsis (adjusted OR=1.00, 95% CI 0.98–1.02). We observed greater between-hospital variation in early tracheostomy rates among trauma patients (21.9% to 81.9%) compared to pneumonia/sepsis (14.9% to 38.3%) ($p<0.0001$). We found no evidence of improved hospital mortality. Pneumonia/sepsis patients with early tracheostomy had fewer feeding tube procedures and higher odds of discharge home.

Conclusion—Early tracheostomy is potentially overused among mechanically-ventilated trauma patients, with nearly half of tracheostomies performed within the first week of MV and large unexplained hospital variation, without clear benefits. Future studies are needed to characterize potentially differential benefits for early tracheostomy between disease subgroups and to investigate factors driving hospital variation in tracheostomy timing.

Keywords

Tracheostomy; Respiration, Artificial; Pneumonia; Wounds/Injuries; United States; Outcome Assessment (Health Care)

Introduction

Nearly 1 million adults in the United States (US) required invasive mechanical ventilation (MV) in 2012.¹ Many patients who require MV for more than 48 hours will require prolonged MV² (≥ 21 days³ or continued after hospital discharge⁴). Prolonged MV generally necessitates tracheostomy; the decision to place a tracheostomy has substantial implications for quality of life, costs, morbidity, and mortality.^{2,5–8}

The optimal timing of tracheostomy for patients who may face prolonged MV is unclear. Some studies suggest potential benefits to early tracheostomy [e.g. improved respiratory physiology⁹, decreased sedative use^{10,11}, and increased mobility¹²]. However, recent randomized controlled trials have failed to show short- or long-term mortality benefits to early tracheostomy^{13,14}. Given our current inability to accurately predict which patients will require prolonged MV¹⁵, delaying the decision to pursue tracheostomy may allow patients at high risk for prolonged MV to be liberated from the ventilator and avoid unnecessary tracheostomy. Although little evidence currently supports patient-centered clinical outcome benefits to early tracheostomy for patients at risk for prolonged MV, rates of early tracheostomy have been on the rise in the United States¹⁶.

Controversy surrounding the optimal timing of tracheostomy for patients predicted to require prolonged MV may lead to substantial practice-pattern variation in timing of the tracheostomy, a procedure with potentially substantial implications for patient quality of life, hospital and societal costs. How real-world variation in tracheostomy timing relates to tracheostomy utilization and outcomes is unclear. Using a nationally representative, population-based database, we sought to quantify between-hospital variation in early tracheostomy utilization and identify factors associated with between-hospital variation in tracheostomy timing. Further, we investigated the association between early tracheostomy rates and total tracheostomy utilization rates within hospitals, and explored patient outcomes associated with early tracheostomy. Some have theorized^{17–19} that a heterogeneous case-mix

of patients included in studies of tracheostomy timing^{11,20–28} may obscure potential benefits of early tracheostomy; therefore, we evaluated utilization and outcomes separately among patients with the two most common indications for tracheostomy – trauma and pneumonia/sepsis.

Methods

Data Source

We used the US Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project's (HCUP) National Inpatient Sample (NIS) from 2012. The NIS represents a stratified probability sample of all non-federal, US, acute care hospitalizations and contains de-identified administrative claims data extrapolated from 20% of all discharges from more than 4,000 hospitals across 44 states.²⁹

Patients

We identified adult (≥ 18 years) patients who required MV³⁰ and tracheostomy³¹ via *International Classification of Disease, Ninth Revision, Clinical Modification (ICD9-CM)* procedure codes. We excluded patients with a Diagnosis Related Group for tracheostomy related to face, head, and neck pathology. Please refer to the Online Supplement Methods for specific codes and details for inclusion and exclusion criteria.

We stratified analyses based on the most common causes of prolonged respiratory failure for medical and surgical patients, determined by a frequency analysis of principal diagnoses. Pneumonia/sepsis was the most common “medical condition,” defined by an *ICD9-CM* principal diagnosis of pneumonia or sepsis³² without a major therapeutic operating room procedure other than tracheostomy³³. Trauma was the most common “surgical condition” defined by any *ICD9-CM* codes for trauma.³⁴ (Table E2)

Outcomes

We determined patient and hospital characteristics that were associated with early tracheostomy. We calculated hospital risk-adjusted early tracheostomy rates (# of early tracheostomy/# total tracheostomies) to determine between-hospital variation in timing of tracheostomy. We investigated whether MV patients admitted to hospitals utilizing more early tracheostomies were at greater risk for tracheostomy and whether hospitals with high early tracheostomy rates performed more total tracheostomy procedures among MV patients. Finally, we explored associations between early tracheostomy and hospital mortality, hospital length of stay (LOS) among survivors, discharge home, and surgical/endoscopic placement of feeding tube.

Statistical Analysis

We used survey-weighted methods to generate national estimates for variables of interest. We compared categorical variables using Chi-Square tests, and continuous variables with Student's t-test or Wilcoxon Rank Sum tests as indicated. We used multivariable hierarchical logistic regression models³⁵ with hospital-level random intercepts to 1) quantify between-hospital variation with individual hospital risk-adjusted early tracheostomy rates, 2) to

determine factors associated with between-hospital variation, and 3) to identify outcomes associated with early tracheostomy. We measured unexplained hospital variation in early tracheostomy with intra-class correlation coefficients³⁶ and compared between-hospital variation for trauma and pneumonia/sepsis using coefficients of variation.³⁷ We used similar models to calculate hospital risk-adjusted total tracheostomy rates and determine the association between hospital risk-adjusted early tracheostomy rates and hospital risk-adjusted total tracheostomy rates. We used Spearman correlation coefficients with linear regression to demonstrate associations. With the exception of analysis of the association between hospital early tracheostomy rates and risk for receiving tracheostomy (conducted among all mechanically ventilated patients), other analyses were performed among patients receiving tracheostomy. Please refer to the Online Supplemental Methods for further details.

Sensitivity Analyses

We performed a sensitivity analysis using time-stamped procedure codes for organ supportive therapies instituted prior to tracheostomy as an alternative method to adjust for severity of illness. We performed a second sensitivity analysis excluding patients with head injuries from the trauma cohort (Online Supplemental Methods).

Statistical testing was two-tailed with $\alpha=0.05$ conducted with SAS v9.3 (Cary, NC). This study was deemed exempt from review by the Boston University Medical Campus Institutional Review Board.

Results

We identified 82,350 (16,470 unweighted) patients who received a tracheostomy in 2012. Among the 48,920 (9,784 unweighted) cases receiving tracheostomy in 2012 who met our inclusion/exclusion criteria, we identified 12.4% (6,075 weighted; 1,215 unweighted patients) with pneumonia/sepsis among 573 hospitals and 24.6% (12,030 weighted; 2,406 unweighted patients) with trauma across 491 hospitals (Figure E1).

Factors Associated with Early Tracheostomy

Trauma patients were twice as likely as pneumonia/sepsis patients to receive an early tracheostomy (44.5% vs 21.7%, $p<0.0001$). Among pneumonia/sepsis cases, patient and hospital characteristics did not differ by tracheostomy timing. However, trauma patients who received an early tracheostomy tended to be younger, more likely to be white, and have fewer comorbidities than trauma patients receiving routine tracheostomy (Table 1). In multivariable analysis for both conditions, generally markers of acute illness severity (e.g. shock and acute renal failure) were associated lower odds of early tracheostomy. (Table 2, Table E4a and E4b).

Hospital-Level Early Tracheostomy Variation

We identified greater between-hospital variation in hospital risk-adjusted early tracheostomy rates for patients with trauma (risk adjusted early tracheostomy rate range: 21.9 to 81.9%, coefficient of variation 22.7%, 95% CI 21.3–24.3%) than patients with pneumonia/sepsis (range: 14.9 to 38.3%, coefficient of variation 17.3% 95% CI 16.3–18.4%) ($p<0.0001$ for

comparison of coefficients of variation) (Figure 1). After adjusting for patient and hospital characteristics, we found that 16.0%, (95% CI 12.1–22.1%) of between-hospital variation in early tracheostomy rates was unexplained by measured patient or hospital factors for trauma patients and 11.2%, (95% CI 5.9–27.5%) of variation was unexplained for patients with pneumonia/sepsis ($p=0.33$).

Hospital with higher risk-adjusted early tracheostomy rates tended to have higher risk-adjusted total tracheostomy rates for patients with trauma ($r=0.17$, $p<0.0001$) but not pneumonia/sepsis ($r=-0.07$, $p=0.11$) (Figure 2). Additionally, MV trauma patients admitted to a hospital with higher early tracheostomy rates were more likely to receive tracheostomy than MV patients at hospitals with lower early tracheostomy rates (adjusted OR per 10% increase in early tracheostomy rate = 1.04, 95% CI 1.01–1.07) but not MV pneumonia/sepsis patients (adjusted OR per 10% increase in early tracheostomy rate = 1.00, 95% CI 0.98–1.02).

Outcomes

In-hospital mortality did not differ based on tracheostomy timing for either trauma or pneumonia/sepsis (Table 3). Among pneumonia/sepsis patients, we observed higher odds of discharge home (adjusted OR=1.75, 95% CI 1.02–3.01), and lower odds of surgical/endoscopic feeding tube procedures (adjusted OR=0.64, 95% CI 0.48–0.86) with early tracheostomy compared to routine tracheostomy, findings that were not observed among patients with trauma. We also identified significantly shorter hospital LOS among survivors for early tracheostomy compared to routine tracheostomy for pneumonia/sepsis (median 17.0 vs 26.0 days; adjusted RR=0.75, 95% CI 0.69–0.81) and trauma (median 23.0 vs 31.0 days; adjusted RR 0.82, 95% CI 0.78–0.86).

Sensitivity Analysis

Sensitivity analyses adjusting for organ support procedures instituted prior to tracheostomy (Table E5 and Figure E2) or excluding trauma patients with head injuries (Table E6 and Figure E3) showed similar results as our primary analysis.

Discussion

In a representative, population-based sample of patients hospitalized in the US, we investigated hospital-level variation in early tracheostomy utilization and patient outcomes associated with early tracheostomy. In order to reduce confounding by case-mix that may have affected previous studies^{13,14,38,39}, we separately examined patient populations that represent the most common indications for tracheostomy (pneumonia/sepsis and trauma). Among MV patients hospitalized with trauma, we found high utilization and wide variation in use of early tracheostomy. Although nearly half of tracheostomies placed among trauma patients were performed within the first week of MV, we did not find associations between early tracheostomy and improved patient outcomes. MV trauma patients admitted to hospitals with high early tracheostomy rates were more likely to receive a tracheostomy than similar patients admitted to hospitals performing more routinely timed tracheostomy. Thus,

our findings suggest potential overuse of early tracheostomy among MV patients hospitalized with trauma.

Compared to patients with trauma, MV patients with pneumonia/sepsis underwent lower rates of early tracheostomy, with less between-hospital variation in early tracheostomy rates, and no association identified between hospital early tracheostomy rate and hospital total tracheostomy utilization. Our results also suggest higher rates of discharge home and lower rates of feeding tubes placed among patients with pneumonia/sepsis who received early tracheostomy. However, potential benefits for early tracheostomy observed for patients with pneumonia/sepsis should be viewed as hypothesis-generating: we were unable to identify patients predicted early during hospitalization to be at risk for prolonged MV who ultimately were liberated from MV prior to receiving tracheostomy. Differences in outcomes based on indication for tracheostomy suggest the need for future studies to stratify analyses based on the indication for MV.

Few studies have examined population-based, real-world tracheostomy timing practices. Nathens et al²⁷ investigated hospital variation in tracheostomy rates (but not timing), speculating that observed variation was the result of between-hospital differences in tracheostomy timing. Our data provide support for the assertion that hospitals conducting earlier tracheostomy generally conduct more tracheostomies. Our results differed substantially from those of Scales et al,⁴⁰ Villwock et al,⁴¹ and Shaw et al,⁴² who found that hospital mortality was lower among patients receiving early tracheostomy. Similar to results of multiple clinical trials^{23–26,43}, we found no association between early tracheostomy and mortality. Further contrasting with findings of Villwock et al⁴¹ and Shaw et al,⁴² we did not identify significant racial or demographic characteristics associated with early tracheostomy, a difference likely explained by our use of methods to account for hospital-level clustering of patient characteristics.⁴⁴ Differences between prior studies and our findings also reflect the importance of defining etiology of acute respiratory failure when evaluating tracheostomy practice patterns and outcomes.

High early tracheostomy rates, wide between-hospital variability, and lack of observed patient-centered outcome benefits raise concern for potential overuse of early tracheostomy among patients with trauma. Importantly, patients admitted to hospitals with high use of early tracheostomy were more likely to receive a tracheostomy, an observation that further suggests potential overuse of early tracheostomy among MV patients with trauma. Our real-world results are consistent with clinical trials demonstrating that more than 40% of patients presumed to require prolonged MV who were randomized to late tracheostomy arms were liberated from MV prior to their assigned tracheostomy date^{13,14}, obviating need for tracheostomy. Thus, increasing rates of early tracheostomy in the United States¹⁶ may result in a substantial number of unnecessary tracheostomies, and expose patients to potential complications (adverse event rates associated with tracheostomy range from 7–39%)^{13,14} without strong evidence for benefits.

Hospital tracheostomy practice-patterns and outcomes differed between patients with pneumonia/sepsis and patients with trauma. Among patients with pneumonia/sepsis, fewer received early tracheostomy and between-hospital variation was lower. Although early

tracheostomy rates for pneumonia/sepsis were lower than trauma, nearly one-fourth of patients with pneumonia/sepsis who received a tracheostomy had one placed early, and in some hospitals the early tracheostomy rate approached 40%. Based on our exploratory analysis of clinical outcomes, potentially patient-centered clinical outcomes following tracheostomy such as discharge home and need for a feeding tube should be evaluated in future clinical trials as we found potentially improved outcomes in these areas that have not previously been described. Differences in tracheostomy practice-patterns between mechanically ventilated patients with pneumonia/sepsis and trauma may be driven by multiple factors, including fundamental differences in underlying physiology, access to tracheostomy proceduralists, severity of illness early during hospitalization, or different views regarding tracheostomy among surgical and medical specialties. Our analysis contrasting pneumonia/sepsis and trauma demonstrated different practice-patterns and outcomes arising from the indication for tracheostomy and suggests that stratification by disease be considered for future tracheostomy studies.

In both trauma and pneumonia/sepsis, early tracheostomy was associated with shorter hospital LOS. However, whether acute care hospital LOS after tracheostomy reflects an outcome that benefits patients or society is currently unclear and warrants further study. First, we could not measure the outcomes of patients who were spared tracheostomy by waiting > 1 week to perform tracheostomy. Second, shorter acute care hospital LOS was coupled with higher rates of discharge to long-term care facilities; whether overall burdens on the health care system are reduced by shorter acute hospital LOS^{45,46} when patients who received early tracheostomy spend unknown lengths of time in long term care hospitals is also unclear. Patients with tracheostomy and prolonged mechanical ventilation have significant morbidity and mortality after acute care hospital discharge⁷; because the ‘full picture’ of patients’ trajectories post-discharge is unavailable in the NIS data, we cannot currently advocate for increased early tracheostomy rates with the goal of shorter acute care hospital LOS.

Factors driving the potential overuse of early tracheostomy are unclear. We speculate that a number of processes may result in high early tracheostomy utilization. Although mortality has not been shown to be improved with early tracheostomy, some physicians may pursue early tracheostomy for other perceived benefits such as improved respiratory physiology⁹, decreased sedative use^{10,11}, and increased mobility¹². Future studies should investigate outcomes of tracheostomy that are most important to patients, as well as how use of shared decision-making tools for patients facing prolonged mechanical ventilation^{47,48} may affect variation in tracheostomy timing practices. We also encourage further studies to investigate how regional differences in healthcare economics or local availability of long term care hospitals may potentially contribute to variation in tracheostomy timing.

Our study has several limitations. We used administrative data which relies on *ICD9-CM* and DRG coding to identify patients and may suffer from misclassification biases. However, MV and tracheostomy receive high levels of reimbursement and are unlikely to be misclassified.⁴⁹ While the NIS’s strength is the large sample size and national estimates, it lacks granularity which can lead to unmeasured confounding. Our findings regarding a lack of mortality benefits and potentially beneficial outcomes among patients with pneumonia/

sepsis should be further interpreted in light of a potential bias towards improved outcomes for patients receiving early tracheostomy, who appeared to have lower severity of illness. Greater severity of illness identified among patients with later tracheostomy may also indicate a decision to delay the procedure until patients were more stable, thus unmeasured severity of illness between hospitals has potential to confound our estimates of hospital variation. Furthermore, outcomes measured at the time of hospital discharge may inadequately capture patient-centered outcomes as multiple significant events in the care of patients with tracheostomy occur post-discharge⁷. Furthermore, several trials and meta-analyses related to tracheostomy timing^{14,17,19,50} were published after 2012 and could have affected tracheostomy timing practice-patterns after our study period; changes in practice patterns after 2012 require further study. Additionally, conditions suspected at the time of admission which could have affected decisions regarding tracheostomy timing but were ultimately not confirmed, such as suspected cervical spine injury, could not be captured by the NIS. Finally, unmeasured differences in case-mix among trauma patients may also have contributed to our findings. However, reducing heterogeneity of case-mix by excluding patients with head trauma did not substantively change our results.

Conclusion

We investigated practice-patterns and outcomes associated with early tracheostomy in a nationally representative sample of US patients with two of the most common indications for tracheostomy. We observed wide between-hospital variation in early tracheostomy utilization without mortality benefits. Our findings suggest large variation and potential overuse of early tracheostomy for trauma patients, with high hospital rates of early tracheostomy associated with increased risk for receiving any tracheostomy. Drivers of decisions to pursue earlier tracheostomy are unclear and future studies are needed to investigate clinician and local health system factors that may influence large variation regarding tracheostomy timing in the US. Observed differences in non-mortality outcomes for early tracheostomy based on etiology of respiratory failure also require further study. Future studies should examine non-mortality outcomes of prolonged mechanical ventilation that matter most to patients, and focus on long-term, patient centered outcomes among patients at risk for prolonged mechanical ventilation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Between-Hospital Variation in Risk-Adjusted Early Tracheostomy Rates. (A) Patients with trauma. (B) Patients with pneumonia/sepsis. The x-axis intersects the y-axis at the national unadjusted early tracheostomy rate for each condition. The error bars indicate 95% confidence for hospital risk-adjusted early tracheostomy rates towards the national average early tracheostomy rate only for hospitals whose practice-patterns significantly deviated from the national average.

Figure 2.

Risk-Adjusted Early Tracheostomy Rates versus Risk-Adjusted Total tracheostomy Rates.

We determined the correlation of hospital risk-adjusted early tracheostomy rates with hospital risk-adjusted total tracheostomy rates. (A) Trauma – $r = 0.17$, $p < 0.0001$. (B) Pneumonia/Sepsis – $r = -0.07$, $p = 0.11$.

Table 1

Patient and Hospital Characteristics Based on Tracheostomy Timing

	Trauma			Pneumonia/Sepsis		
	Early Tracheostomy (n=5,280)	Routine Tracheostomy (n=6,580)	p-value	Early Tracheostomy (n=1,300)	Routine Tracheostomy (n=4,685)	p-value
Tracheostomy Time *, days, median (IQR)	4.0 (4.0)	11.5 (6.0)	<0.0001	5.0 (3.0)	14.0 (6.0)	<0.0001
Age (y), mean (SE)	49.9 (0.6)	52.9 (0.5)	0.0002	64.9 (0.9)	64.1 (0.5)	0.46
Female (%)	25.0	28.5	0.06	44.6	46.7	0.55
Race/Ethnicity (%)			0.01			0.98
White	64.9	61.0		58.1	59.2	
Black	15.2	13.4		21.5	21.1	
Hispanic	9.4	12.3		9.2	9.2	
Other [‡]	10.5	13.3		11.2	10.5	
Payer (%)			0.0008			0.29
Medicare	23.7	29.6		69.2	63.2	
Medicaid	20.3	19.7		15.4	16.4	
Private Insurance	34.8	35.0		12.3	14.8	
Self-Pay	10.6	9.0		2.3	3.5	
Other [‡]	10.6	6.8		0.8	2.0	
Median Income of Zip Code (%)			0.11			0.34
\$1–38,999	38.1	35.5		34.9	33.2	
\$39,000–47,999	24.8	23.7		28.2	24.6	
\$48,000–62,999	21.1	21.0		21.6	22.6	
>\$63,000	15.9	19.8		15.3	19.6	
Comorbidities (#), median (IQR)	2.0 (3.0)	3.0 (2.0)	<0.0001	5.0 (3.0)	5.0 (3.0)	0.75
Hospital Bed Size (%)			0.28			0.16

	Trauma			Pneumonia/Sepsis		
	Early Tracheostomy (n=5,280)	Routine Tracheostomy (n=6,580)	p-value	Early Tracheostomy (n=1,300)	Routine Tracheostomy (n=4,685)	p-value
Small	2.6	3.7		6.5	4.9	
Medium	20.5	20.1		18.8	23.9	
Large	77.0	76.1		74.6	71.2	
Hospital Location/Teaching Status (%)			0.03			0.39
Rural	0.7	0.8		2.3	1.2	
Urban Non-Teaching	11.6	15.4		35.4	35.3	
Urban Teaching	87.7	83.8		62.3	63.5	
Hospital Region (%)			<0.0001			0.16
Northeast	13.1	19.5		21.1	27.7	
Midwest	17.4	16.0		18.1	14.8	
South	52.5	44.2		37.3	35.3	
West	17.0	20.2		23.5	22.1	
Hospital Control (%)			0.16			0.33
Government	22.6	23.9		8.5	8.0	
Private (Non-Profit)	70.0	66.9		70.8	75.0	
Private (Invest-Own)	7.4	9.3		20.8	17.0	

Abbreviations: IQR – interquartile range. y – years. SE – standard error

* Defined as time from initiation of invasive mechanical ventilation to tracheostomy

‡ Includes patients with missing data

Table 2

Patient and Hospital Factors Associated with Early Tracheostomy

	Adjusted Odds Ratio * (95% Confidence Interval)	
	Trauma	Pneumonia/Sepsis
Age	1.00 (0.99–1.01)	1.00 (0.99–1.02)
Female Gender	0.80 (0.64–0.99)	0.89 (0.65–1.22)
Race/Ethnicity		
White	Ref	Ref
Black	1.26 (0.94–1.71)	1.03 (0.68–1.55)
Hispanic	0.87 (0.62–1.22)	1.00 (0.56–1.77)
Other [‡]	0.90 (0.66–1.23)	1.24 (0.74–2.09)
Payer		
Medicare	Ref	Ref
Medicaid	1.08 (0.77–1.51)	0.95 (0.59–1.53)
Private Insurance	1.06 (0.80–1.41)	0.77 (0.47–1.27)
Self-Pay	1.22 (0.82–1.82)	0.62 (0.23–1.69)
Other [‡]	1.46 (0.98–2.18)	0.37 (0.08–1.84)
Median Income of Zip Code		
\$1–38,999	Ref	Ref
\$39,000–47,999	1.01 (0.79–1.30)	1.14 (0.77–1.70)
\$48,000–62,999	1.01 (0.77–1.32)	0.97 (0.63–1.49)
>\$63,000	0.99 (0.73–1.34)	0.87 (0.53–1.42)
Major Operating Room Procedure	0.88 (0.69–1.12)	N/A
Hospital Bed Size		
Small	Ref	Ref
Medium	1.52 (0.75–3.08)	0.57 (0.27–1.19)
Large	1.54 (0.80–2.99)	0.74 (0.37–1.48)
Hospital Location/Teaching Status		
Rural	Ref	Ref
Urban Non-Teaching	1.15 (0.32–4.13)	0.44 (0.13–1.52)
Urban Teaching	1.29 (0.37–4.42)	0.49 (0.15–1.65)
Hospital Region		
Northeast	Ref	Ref
Midwest	1.78 (1.17–2.70)	1.36 (0.80–2.30)
South	1.57 (1.07–2.29)	1.28 (0.80–2.04)
West	1.48 (0.96–2.27)	1.31 (0.79–2.23)

	Adjusted Odds Ratio * (95% Confidence Interval)	
	Trauma	Pneumonia/Sepsis
Hospital Control		
Government	Ref	Ref
Private (Non-Profit)	1.11 (0.79–1.56)	0.83 (0.44–1.57)
Private (Invest-Own)	0.87 (0.50–1.52)	1.00 (0.53–2.10)
Shock	0.67 (0.53–0.85)	0.58 (0.42–0.79)
Renal Failure	0.61 (0.47–0.79)	0.55 (0.39–0.77)
Hematologic Failure	0.78 (0.60–1.02)	0.90 (0.60–1.33)
Hepatic Failure	0.40 (0.18–0.92)	0.94 (0.51–1.70)
Neurologic Failure	1.04 (0.82–1.31)	0.92 (0.67–1.27)
Metabolic Acidosis	0.90 (0.68–1.18)	0.98 (0.68–1.40)

* Hierarchical logistic regression models with hospital-level random effects were adjusted for patient demographics (age, gender, race/ethnicity, primary insurance payer, and median income of patient's zip code), hospital characteristics (bed size, location/teaching status, region, and hospital control/ownership), presence of a major therapeutic operating room procedure in the trauma cohort, Elixhauser comorbidities, and acute organ failures

& Includes patients with missing data

Table 3

Association of Early Tracheostomy with Patient-Centered Outcomes

	Trauma				Pneumonia/Sepsis		
	Early Tracheostomy (n=5,995)	Routine Tracheostomy (n=7,045)	aOR* (95% CI)		Early Tracheostomy (n=1,600)	Routine Tracheostomy (n=5,185)	aOR* (95% CI)
Survivor Length of Stay, median d, (IQR)	23.0 (17.0)	31.0 (21.0)	0.82 ⁺ (0.78–0.86)		17.0 (12.0)	26.0 (16.0)	0.75 ⁺ (0.69–0.81)
Hospital Mortality (%)	6.4	9.1	0.98 (0.69–1.41)		14.2	17.2	0.93 (0.61–1.42)
Discharged Home (%)	18.5	13.6	1.09 (0.86–1.39)		9.2	7.0	1.75 (1.02–3.01)
Feeding Tube (%)	51.0	51.9	1.15 (0.94–1.40)		39.2	50.7	0.64 (0.48–0.86)

Abbreviations: aOR – adjusted odds ratio. CI – confidence interval. d – days. IQR=interquartile range

* Hierarchical logistic regression models with hospital-level random effects were adjusted for patient demographics (age, gender, race/ethnicity, primary insurance payer, and median income of patient's zip code), hospital characteristics (bed size, location/teaching status, region, and hospital control/ownership), and presence of a major therapeutic operating room procedure in the trauma cohort, Elixhauser comorbidities, and acute organ failures

[‡] Adjusted mean length of stay calculated for survivors only

⁺ Indicates adjusted Relative Risk (RR)