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Association of early tracheostomy with length of stay and mortality in critically ill patients

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Abstract

Background. The timing of tracheostomy for intensive care unit patients is controversial, with conflicting findings on early versus late tracheostomy.
Methods. Patients undergoing tracheostomy from 2001through 2012 were identified from the Medical Information Mart for Intensive Care-III database. Early tracheostomy was defined as less than the 25th percentile of time from intensive care unit admission to tracheostomy (time to tracheostomy). Statistical analysis for tracheostomy timing on intensive care unit length of stay and mortality were conducted.
Results. Of the 1,566 patients that were included, patients with early tracheostomy had shorter intensive care unit length of stay (27.32 *vs* 12.55 days, $p < 0.001$) and lower mortality (12.9 per cent *vs* 9.0 per cent, $p = 0.039$). Multivariate logistic regression analysis found an association between increasing time to tracheostomy and mortality (odds ratio: 1.029, 95 per cent confidence interval 1.007–1.051, $p = 0.009$).
Conclusion. Our analysis revealed that patients with early tracheostomy were more likely to have shorter intensive care unit lengths of stay and lower mortality. Our data suggest that early tracheostomy should be given strong consideration in appropriately selected patients.

Introduction

Tracheostomy is a commonly performed procedure in patients who are admitted to the intensive care unit (ICU). Among ICU patients, 24–28 per cent may undergo tracheostomy.[1,2] Patients in the ICU may require tracheostomy when prolonged mechanical ventilation is anticipated or in the case of a difficult airway.[3] A 1989 consensus statement recommended endotracheal intubation when mechanical ventilation is expected to last up to 10 days while tracheostomy is recommended for patients with anticipated mechanical ventilation greater than 21 days.[4–8] Convention is that patients often receive a tracheostomy for expected mechanical ventilation of 14 days.[8] Purported benefits of tracheostomies over endotracheal intubation include patient comfort, ease of pulmonary toilet and the facilitation of mechanical ventilation weaning.[3]

Although commonly performed, the optimal timing of tracheostomy is controversial. Conflicting conclusions on the benefits of early tracheostomy versus prolonged endotracheal intubation have been reported. Adly *et al*. found that patients undergoing early tracheostomy within seven days of intubation had better outcomes, including decreased duration of mechanical ventilation, ICU length of stay and mortality.[1] A 2015 Cochrane review analysing eight randomized controlled trials cautiously endorsed early tracheostomy, noting that there was a suggested mortality benefit to early tracheostomy, as well as decreased ventilator time, decreased ICU stay and lower likelihood of pneumonia.[9] However, there are opposing views to some benefits of early tracheostomy. Terragni *et al*. performed a large, randomized analysis in 12 ICUs and found an observed benefit in ICU length of stay and mechanical ventilation for those receiving early tracheostomy but did not find differences in overall hospital length of stay or 28-day mortality.[10] We aim to add to the growing body of literature examining the benefits of early versus late tracheostomy in critically ill patients.

Methods

The Medical Information Mart for Intensive Care database (MIMIC-III) is a single-centre database from Beth Israel Deaconess Medical Center, a large, tertiary care teaching hospital affiliated with Harvard Medical School. This database includes data from over 50,000 critical care admissions from 2001through 2012.[11] MIMIC-III includes detailed patient information with data ranging from imaging reports with radiologist interpretation to various interventions and laboratory results with time stamps. The Institutional Review

Boards of Beth Israel Deaconess Medical Center and the Massachusetts Institute of Technology approved use of these data, which are freely accessible. Because MIMIC-III is a de-identified database, approval from the Rutgers New Jersey Medical School Institutional Review Board was not required.

MIMIC-III was queried for all patients that received a tracheostomy during their stay within the ICU via the World Health Organization's International Classification of Disease, 9th revision procedure codes. The procedure codes included were 31.1, 31.2, 31.21, 31.29 and 31.74. The chart date and time for the tracheostomy International Classification of Disease codes were identified for each patient and defined as the start time. Patients that had a start time prior to their ICU admission or after downgrade were excluded. The time from ICU admission to tracheostomy was calculated for each patient.

Patient demographic information included sex, ethnicity and age. In compliance with the Health Insurance Portability and Accountability Act, MIMIC-III recodes all patient ages over 89 years to greater than 300 years. These patients were identified and had their ages changed to 90 years. Additional variables included type of admission (elective, urgent or emergency), mortality during hospital stay and various comorbid conditions reported within the database. Included comorbidities were congestive heart failure, cardiac arrythmias, valvular disease, peripheral vascular disease, hypertension, uncomplicated diabetes mellitus, complicated diabetes mellitus, hypothyroidism, renal failure, liver disease, metastatic cancer, rheumatoid arthritis, coagulopathy, obesity and fluid electrolyte imbalance.

Patients were also categorized as having a prolonged length of stay in the ICU if they had a stay greater than the 75th percentile. Patients were grouped into early and late tracheostomy groups. Patients were defined to have received an early tracheostomy if their time to tracheostomy was less than or equal to the 25th percentile. Univariate and multivariate analyses were conducted to find associations between patient characteristics, time to tracheostomy, ICU length of stay and mortality. Multivariate logistic regression analyses adjusted for all demographic information and comorbidities significantly associated with the outcome of interest on univariate analyses. The threshold for statistical significance was set at $p < 0.05$. All tests were performed using SPSS version 24 (IBM, Armonk, NY, USA).

Results

A total of 1566 patients met inclusion criteria. Table 1 details information of patients between the early and late tracheostomy group. Overall, patients had an average age of 61.85 years. Patients were most frequently male ($n = 924$, 59.0 per cent), of white race ($n = 1095$, 69.9 per cent), and admitted emergently ($n = 1362$, 87.0 per cent); 11.9 per cent of the cohort died during their hospital stay. Patients had an average 12.22 days from ICU admission to tracheostomy. The 25th percentile cutoff for early versus late time to tracheostomy groups was 6.82 days. The average time to tracheostomy for the early group was 3.28 days compared to 15.20 for the late group ($p < 0.001$). A total of 391 patients (25 per cent) met criteria for ICU prolonged length of stay (75th percentile = 30.21 days), of which 94.1 per cent were patients that had a late tracheostomy. Patients in the late tracheostomy group had significantly longer ICU lengths of stay (27.32 days *vs* 12.55 days, $p < 0.001$).

Late tracheostomy group patients had a higher average age (63.18 *vs* 57.88 years, $p < 0.001$). Significant comorbidity differences existed between the early and late tracheostomy groups. Patients receiving a delayed tracheostomy had higher rates of congestive heart failure (30.2 per cent *vs* 17.6 per cent, $p < 0.001$), cardiac arrhythmias (36.3 per cent *vs* 23.8 per cent, $p < 0.001$), valvular disease (36.3 per cent *vs* 23.8 per cent, $p < 0.001$), renal failure (12.7 per cent *vs* 7.9 per cent, $p = 0.011$), a coagulopathy (18.8 per cent *vs* 7.4 per cent, $p < 0.001$) or a fluid electrolyte disorder (38.3 per cent *vs* 28.9 per cent, $p = 0.001$). Table 2 reflects a multivariate regression analysis to identify factors associated with early tracheostomy within this patient population. Analyses demonstrated that patients with metastatic cancer (odds ratio: 2.590, $p = 0.001$) and rheumatoid arthritis (odds ratio: 2.789, $p = 0.006$) were more likely to have an early tracheostomy. In contrast, patients with congestive heart failure (odds ratio: 0.673, $p = 0.020$), cardiac arrhythmia (odds ratio: 0.730, $p = 0.048$), coagulopathy (odds ratio: 0.334, $p < 0.002$), or a fluid electrolyte disorder (odds ratio: 0.696, $p = 0.009$) were less likely to receive an early tracheostomy.

Patients with a delayed tracheostomy had a higher rate of death (12.9 per cent *vs* 9.0 per cent, $p = 0.039$). Table 3 reports factors associated with mortality. This analysis demonstrated that increased time to tracheostomy was associated with an increased risk for death (odds ratio: 1.029, $p = 0.009$). Similarly, increased time to tracheostomy was associated with having an ICU prolonged length of stay (odds ratio: 1.246, $p < 0.001$) (Table 4). Examining the linear relationship between time to tracheostomy and ICU length of stay, we found that a 1-day increase in time to tracheostomy was associated with a 1.27-day increase in ICU length of stay (95 per cent confidence interval = 1.203–1.333, $p < 0.001$) (Table 5).

Discussion

Our study elucidates the effect of tracheostomy time on outcomes for patients admitted into a single-centre ICU. Understanding optimal times for tracheostomy has clinical significance.[10,12] Early tracheostomy has been hypothesized to offer significant benefits because early tracheostomy patients may benefit from shorter duration of mechanical ventilation and decreased exposure to sedating medications.[12] Unfortunately, prospective trials on tracheostomy are difficult to conduct, as explained by Scales and Kahn, due to difficulty in patient enrollment.[12] Consequently, several studies suffer from limited sample size which affects their ability to reach significant associations for certain outcomes.[12] The MIMIC-III database offers a robust sample to potentially detect these relationships, if they exist. Our study suggests an association of early tracheostomy with both shorter ICU length of stay and lower mortality.

The cutoff for early tracheostomy in our study was 6.82 days. However, there is heterogeneity in the classification of early versus late tracheostomy within the literature. For example, different studies have used demarcation points of 4 days[13–15]7 days[16–19], and 10 days[4,6,9,20–22] to identify early tracheostomy. Our estimation therefore aligns with previous studies. Furthermore, we decided to proceed with an approximately 7-day cutoff given the findings of Liu *et al.*'s systematic review on early versus late tracheostomy.[8] Specifically, Liu *et al.*'s data suggested that early tracheostomy (less than 7 days) was associated with a decrease in ICU length of stay.[8] In an earlier systematic review from 2005, Griffiths *et al.*

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Table 1. Demographic information of patients in early *vs* late tracheostomy groups

	Time to Tracheostomy			
	Early (%)	Late (%)	Total	*p*-Value
Overall	391 (25.0)	1175 (75.0)	1566	
Age, mean (standard deviation)	57.88 (18.92)	63.18 (16.85)	61.85 (17.54)	< 0.001
Sex				0.115
– Female	147 (37.6)	495 (42.1)	642 (41.0)	
– Male	244 (62.4)	680 (57.9)	924 (59.0)	
Race				0.989
– White	281 (80.5)	814 (80.6)	1095 (80.6)	
– Black	34 (9.7)	96 (9.5)	130 (9.6)	
– Other	34 (9.7)	100 (9.9)	134 (9.9)	
Admission Type				0.117
– Elective	44 (11.3)	101 (8.6)	145 (9.3)	
– Emergency	337 (86.2)	1025 (87.2)	1362 (87.0)	
– Urgent	10 (2.6)	49 (4.2)	59 (3.8)	
Death				0.039
– No	356 (91.0)	1024 (87.1)	1380 (88.1)	
– Yes	35 (9.0)	151 (12.9)	186 (11.9)	
Time to Tracheostomy, mean (standard deviation), days	3.28 (2.21)	15.20 (7.00)	12.22 (8.04)	< 0.001
ICU Length of Stay				< 0.001
– ≤ 75th percentile	368 (94.1)	807 (68.7)	1175 (75.0)	
– > 75th percentile	23 (5.9)	368 (31.3)	391 (25.0)	
ICU Length of Stay, mean (standard deviation)	12.55 (10.21)	27.32 (14.07)	23.63 (14.68)	< 0.001
Comorbidities				
– Obesity	28 (7.2)	82 (7.0)	110 (7.0)	0.903
– Congestive Heart Failure	69 (17.6)	355 (30.2)	424 (27.1)	< 0.001
– Cardiac Arrhythmias	93 (23.8)	427 (36.3)	520 (33.2)	< 0.001
– Valvular Disease	17 (4.3)	129 (11.0)	146 (9.3)	< 0.001
– Peripheral Vascular Disease	24 (6.1)	100 (8.5)	124 (7.9)	0.132
– Hypertension	32 (8.2)	128 (10.9)	160 (10.2)	0.125
– Diabetes, uncomplicated	75 (19.2)	247 (21.0)	322 (20.6)	0.436
– Diabetes, complicated	18 (4.6)	76 (6.5)	94 (6.0)	0.179
– Hypothyroidism	40 (10.2)	93 (7.9)	133 (8.5)	0.155
– Renal Failure	31 (7.9)	149 (12.7)	180 (11.5)	0.011
– Liver Disease	16 (4.1)	65 (5.5)	81 (5.2)	0.265
– Metastatic Cancer	25 (6.4)	32 (2.7)	57 (3.6)	0.001
– Rheumatoid Arthritis	14 (3.6)	20 (1.7)	34 (2.2)	0.027
– Coagulopathy	29 (7.4)	221 (18.8)	250 (16.0)	< 0.001
– Fluid Electrolyte Disorder	113 (28.9)	450 (38.3)	563 (36.0)	0.001

also concluded that early tracheostomy may reduce duration of ICU length of stay.[23] Similarly, in a meta-analysis specifically on trauma patients, Cai *et al.* found that early tracheostomy was associated with a significantly lower ICU length of stay.[24]

Our study supports these findings. Patients with early tracheostomy had significantly shorter ICU length of stay (27.3 days *vs* 12.6 days, $p < 0.001$). Our results also suggest that delaying tracheostomy by one day is associated with a 1.27-day increase in total ICU length of stay. Of course, there are several factors that influence the clinical decision to proceed with a tracheostomy such as severity of disease and anticipated ICU course. The confluence of these factors may result in delayed tracheostomy being considered the ideal treatment option for select patients. However, it is important to be aware of certain benefits of tracheostomy which may result in a shortened ICU stay. Specifically, tracheostomy facilitates better oral and airway care and results in reduced airway resistance.[25,26] With a lowered work of breathing, patients can benefit from shorter mechanical ventilation periods, thereby reducing their rate of complications such as airway injuries.[25]

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Table 2. Multivariate logistic regression on factors associated with early tracheostomy

Variable	Odds Ratio	*p*-value	95% Confidence Interval Lower	95% Confidence Interval Higher
Age	0.990	0.014	0.983	0.998
Race				
– White	REF	—	—	—
– Black	0.982	0.936	0.634	1.521
– Other	0.858	0.484	0.559	1.317
Sex				
– Female	REF	—	—	—
– Male	1.251	0.096	0.961	1.628
Comorbidities				
– Congestive Heart Failure	0.673	0.020	0.481	0.940
– Cardiac Arrhythmias	0.730	0.048	0.534	0.998
– Valvular Disease	0.585	0.078	0.322	1.063
– Renal Failure	0.984	0.944	0.627	1.545
– Metastatic Cancer	2.590	0.001	1.440	4.661
– Rheumatoid Arthritis	2.789	0.006	1.349	5.769
– Coagulopathy	0.334	< 0.001	0.212	0.525
– Fluid Electrolyte Disorder	0.696	0.009	0.530	0.913

The REF entries indicate the variable that served as the reference value in the multivariable logistic regression for the calculation of the odds ratio.

Table 3. Multivariate regression for factors associated with mortality

Variable	Odds Ratio	*p*-value	95% Confidence Interval Lower	95% Confidence Interval Higher
Age	1.027	< 0.001	1.013	1.041
Race				
– White	REF	—	—	—
– Black	1.177	0.599	0.641	2.162
– Other	0.637	0.248	0.297	1.369
Sex				
– Female	REF	—	—	—
– Male	0.964	0.846	0.667	1.393
Time to Tracheostomy	1.029	0.009	1.007	1.051
Comorbidities				
– Congestive Heart Failure	1.223	0.323	0.820	1.825
– Cardiac Arrhythmias	1.128	0.549	0.760	1.674
– Peripheral Vascular Disease	1.019	0.952	0.559	1.854
– Renal Failure	1.359	0.220	0.833	2.216
– Liver Disease	3.267	< 0.001	1.825	5.849
– Metastatic Cancer	3.124	0.002	1.496	6.526
– Coagulopathy	2.231	< 0.001	1.477	3.369
– Fluid Electrolyte Disorder	1.322	0.132	0.920	1.899

The REF entries indicate the variable that served as the reference value in the multivariable logistic regression for the calculation of the odds ratio.

Shortening ICU length of stay is an important consideration in the current climate with limited ICU bed availability. Prolonged ICU length of stay is a significant financial burden on the healthcare system.[4,27] Previous studies have demonstrated that early tracheostomy can lead to significant cost savings.[4,28–30] In a systematic review on this topic, Herritt *et al.* reported that early tracheostomy had an average cost saving of $4316, indicating that early tracheostomy may be a financially prudent decision if patient outcomes are not jeopardized.[28]

Identifying patients requiring extended ventilatory support is a significant challenge and an important factor in determining tracheostomy timing. Physicians have a limited ability to accurately gauge the required time for mechanical ventilation, and many clinical tools to aid decision making have low predictive value.[13,31] As such, several studies rely on the clinical acumen of physicians to accurately project mechanical ventilation time.[8] Our study sheds light on certain clinical risk factors that may be influencing physician decisions to perform a tracheostomy. In this study, early tracheostomy was associated with metastatic cancer and rheumatoid arthritis. Metastatic cancer has been shown to be associated with early tracheostomy, however, we present this relationship with rheumatoid arthritis.[4] In a study utilizing the Nationwide Inpatient Sample (https://hcup-us.ahrq.gov/nisoverview.jsp), Villwock *et al.* reported predictors of late tracheostomy which included fluid/electrolyte disorders.[4] Our study aligns with their findings and reports additional predictors. Specifically, patients with cardiac abnormalities, coagulopathy, and a fluid/electrolyte disorder were significantly more likely to have a delayed tracheostomy. This may be due to patients being unsuitable for surgical intervention early in their ICU course. As such, physicians may have delayed tracheostomy until patients were surgically cleared. Alternatively, these patients may have had more severe disease and been given a more dire prognosis on admission. As such, tracheostomy may not have been considered appropriate at admission, given the anticipated clinical course, and only reconsidered after the patient survived for more than 7 days. This phenomenon is an important consideration when interpreting this study's results.

Patients with early tracheostomy had a decreased incidence of mortality (12.9 per cent *vs* 9.0 per cent). Previous studies have reached conflicting conclusions on this relationship. Koch *et al.* noted that early tracheostomy did not decrease mortality in critically ill patients.[30] However, they used early and late tracheostomy time definitions as 4 days and 6 days, respectively, which may be too short of a duration to detect a mortality difference.[30] Ben-Avi *et al.* found that early tracheostomy, defined as less than 14 days, was associated with reduced mortality in cardiac surgery patients.[32] Also in cardiovascular surgery patients, Okada *et al.* reported decreased morbidity and mortality in early tracheostomy patients, which was defined as less than 7 days.[16] Tong *et al.*, using a 7-day cutoff, found that early tracheostomy patients did not have reduced mortality.[17] These studies reflect the lack of consensus on the relationship between early tracheostomy and mortality. This finding is likely partly influenced by differences in disease severity upon presentation. Similarly, heterogeneity amongst study populations and parameters across different analyses also likely contributed to the conflicting literature.

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Table 4. Multivariate regression for factors associated with prolonged ICU length of stay

Variable	Odds Ratio	*p*-value	95% Confidence Interval	
			Lower	Higher
Age	0.992	0.130	0.982	1.002
Sex				
– Male	1.014	0.929	0.74	1.39
Race				
– White	REF	—	—	—
– Black	0.978	0.936	0.57	1.678
– Other	0.744	0.306	0.422	1.311
Admission Type				
– Emergency	REF	—	—	—
– Elective	1.728	0.038	1.031	2.894
– Urgent	2.986	0.023	1.165	7.655
Time to Tracheostomy	1.246	< 0.001	1.211	1.281
Comorbidities				
– Congestive Heart Failure	1.384	0.073	0.97	1.974
– Cardiac Arrhythmia	0.874	0.459	0.611	1.249
– Valvular Disease	1.015	0.957	0.599	1.718
– Peripheral Arterial Disease	1.821	0.025	1.077	3.079
– Renal Failure	0.878	0.589	0.547	1.408
– Coagulopathy	1.828	0.002	1.246	2.68
– Obesity	2.393	0.001	1.399	4.092

The REF entries indicate the variable that served as the reference value in the multivariable logistic regression for the calculation of the odds ratio.

Our study did find an association between mortality and early tracheostomy after accounting for potential confounding comorbid conditions. While this analysis could not judge disease severity, which is especially difficult given its partially subjective nature, our findings do attempt to account for differences between patient groups. In this context, our study suggests that patients with early tracheostomy did experience a mortality benefit.

Ventilator-acquired pneumonia is a significant cause of in hospital mortality and is a manifest risk of prolonged mechanical ventilation.[1,16,33–36] As such, one of the purported advantages of early tracheostomy is decreased risk for pneumonia acquisition. Villwock *et al.* noted that early tracheostomy was associated with a 1.5 per cent decrease in ventilator-acquired pneumonia incidence.[4] This may result from tracheostomy reducing airway resistance and the resulting decrease in tracheobronchial bacterial colonization.[1,4,17,30] Several studies have noted this relationship between early tracheostomy and decreased ventilator-acquired pneumonia incidence; however, there has been no clear link to mortality. In a systematic review of ventilator-acquired pneumonia and mortality by Melsen *et al.*, ventilator-acquired pneumonia was found to be significantly associated with increased risk of death.[37] However, they did note high levels of heterogeneity among the outcomes of the various included observational studies.[37] When Melsen *et al.* sub-selected for studies solely concerning trauma or acute respiratory distress syndrome, there was no mortality attributable to ventilator-acquired pneumonia.[37]

Table 5. Linear regression analysis for association between time to tracheostomy and ICU length of stay

Variable	Coefficient	*p*-value	95% Confidence Interval	
			Lower	Higher
Constant	8.133	< 0.001	7.180	9.086
Time to Tracheostomy	1.268	< 0.001	1.203	1.333

These findings indicate specific subgroup analysis is needed to clarify the nature of the relationship between ICU mortality and ventilator-acquired pneumonia. Our study includes patients with a variety of indications, likely reflecting a similar heterogeneity with our patient cohort. Given database limitations, our study was unable to monitor pneumonia incidence, however our results demonstrated that patients in the late tracheostomy group did have higher rates of death. Associations between ventilator-acquired pneumonia and mortality for a potentially significant portion of our patient cohort may be responsible for our findings.

Surgical interventions, such as tracheostomy, inherently present risk for patient morbidity. As such, physicians are cautious about subjecting patients to additional, potentially unnecessary, procedures. Early tracheostomy does carry complication risks that our study was unable to evaluate. For example, a potential complication for early tracheostomy is laryngotracheal stenosis. Studies have reported laryngotracheal stenosis incidence rates of 0.0–20.8 per cent.[38,39] Rumbak *et al.* suggested a potential increase in tracheal stenosis amongst early tracheostomy patients, but their data were not significant.[36] Similarly, in a systematic review, Curry *et al.* concluded that patients were at higher risk for laryngotracheal stenosis if undergoing conversion of endotracheal intubation to tracheostomy within 7 days.[38] However, Liu *et al.* did not find a significant association between laryngotracheal injury and early tracheostomy, but noted concerns about sample size.[8] As such, further study on the relationship between early tracheostomy and complications is needed.

- Optimal timing of tracheostomy is controversial, with conflicting conclusions on the benefits of early tracheostomy versus prolonged endotracheal intubation
- Patients with early tracheostomy had significantly shorter intensive care unit length of stay and lower mortality than patients with late tracheostomy
- Significant predictors for patients receiving early versus late tracheostomy were metastatic cancer and rheumatoid arthritis
- Our data suggest that early tracheostomy should be given strong consideration in appropriately selected patients

Our study has several limitations such as our inability to identify patient indication for ICU admission. Relationships between tracheostomy timing and many patient outcomes have been found to have no statistical significance when sub-selecting for specific patient groups.[37] However, understanding general themes may inform areas of future investigation because statistically non-significant relationships may have clinical significance. Furthermore, our study was unable to compare tracheostomy complication rates between the early

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and late tracheostomy groups. This is an important piece of information as it could help elucidate driving factors for the observed differences in outcomes for our cohort. We were also unable to assess disease severity at admission, which likely drove the clinical decision-making process on when tracheostomy could be considered or performed. Unfortunately, this limitation is common to several studies in the literature given the difficulty in accurately predicting ventilation needs amongst patients.[13,31] Our study, however, does attempt to account for patient characteristics at admission via the inclusion of patient comorbidities in our multivariate analysis.

Conclusion

Our study found that early tracheostomy is associated with reduced ICU length of stay and mortality. These results persisted even after accounting for potential confounding comorbid conditions. We also highlight significant predictors for patients receiving early versus late tracheostomy, helping identify which factors can aid physician decision making when assessing ventilatory needs. Our findings do not conclusively support early tracheostomy in all patients due to our heterogenous population but do promote a strong consideration of early tracheostomy. Given conflicting findings in the literature amongst different subgroups of patients, further research on specific populations is necessary to answer the question of optimal tracheostomy timing.

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References

1 Adly A, Youssef TA, El-Begermy MM, Younis HM. Timing of tracheostomy in patients with prolonged endotracheal intubation: a systematic review. *Eur Arch Otorhinolaryngol* 2018;**275**:679–90
2 Hong SB, Oh BJ, Kim YS, Kang EH, Kim CH, Park YB *et al.* Characteristics of mechanical ventilation employed in intensive care units: a multicenter survey of hospitals. *J Korean Med Sci* 2008;**23**:948–53
3 Freeman BD. Tracheostomy update: when and how. *Crit Care Clin* 2017;**33**:311–22
4 Villwock JA, Jones K. Outcomes of early versus late tracheostomy: 2008–2010. *Laryngoscope* 2014;**124**:1801–6
5 Sugerman HJ, Wolfe L, Pasquale MD, Rogers FB, O'Malley KF, Knudson M *et al.* Multicenter, randomized, prospective trial of early tracheostomy. *J Trauma* 1997;**43**:741–7
6 Brook AD, Sherman G, Malen J, Kollef MH. Early versus late tracheostomy in patients who require prolonged mechanical ventilation. *Am J Crit Care* 2000;**9**:352–9
7 Plummer AL, Gracey DR. Consensus conference on artificial airways in patients receiving mechanical ventilation. *Chest* 1989;**96**:178–80
8 Liu CC, Livingstone D, Dixon E, Dort JC. Early versus late tracheostomy: a systematic review and meta-analysis. *Otolaryngol Head Neck Surg* 2015;**152**:219–27
9 Andriolo BNG, Andriolo RB, Saconato H, Atallah ÁN, Valente O. Early versus late tracheostomy for critically ill patients. *Cochrane Database Syst Rev* 2015;(1):CD007271
10 Terragni PP, Antonelli M, Fumagalli R, Faggiano C, Berardino M, Pallavicini FB *et al.* Early vs late tracheotomy for prevention of pneumonia in mechanically ventilated adult ICU patients: a randomized controlled trial. *JAMA* 2010;**303**:1483–9
11 Johnson AEW, Pollard TJ, Shen L, Lehman LWH, Feng M, Ghassemi M *et al.* MIMIC-III, a freely accessible critical care database. *Sci Data* 2016;**3**:160035
12 Scales DC, Kahn JM. Tracheostomy timing, enrollment and power in ICU clinical trials. *Intensive Care Med* 2008;**34**:1743–5
13 Young D, Harrison DA, Cuthbertson BH, Rowan K, TracMan Collaborators. Effect of early vs late tracheostomy placement on survival in patients receiving mechanical ventilation: the TracMan randomized trial. *JAMA* 2013;**309**:2121–9
14 Bickenbach J, Fries M, Offermanns V, Von Stillfried R, Rossaint R, Marx G *et al.* Impact of early vs. late tracheostomy on weaning: a retrospective analysis. *Minerva Anestesiol* 2011;**77**:1176–83
15 Hosokawa K, Nishimura M, Egi M, Vincent JL. Timing of tracheotomy in ICU patients: a systematic review of randomized controlled trials. *Crit Care* 2015;**19**:424
16 Okada M, Watanuki H, Masato T, Sugiyama K, Futamura Y, Matsuyama K. Impact of tracheostomy timing on outcomes after cardiovascular surgery. *J Cardiothorac Vasc Anesth* 2022;**36**:2335–8
17 Tong CCL, Kleinberger AJ, Paolino J, Altman KW. Tracheotomy timing and outcomes in the critically ill. *Otolaryngol Head Neck Surg* 2012;**147**:44–51
18 Möller MG, Slaikeu JD, Bonelli P, Davis AT, Hoogeboom JE, Bonnell BW. Early tracheostomy versus late tracheostomy in the surgical intensive care unit. *Am J Surg* 2005;**189**:293–6
19 Rodriguez JL, Steinberg SM, Luchetti FA, Gibbons KJ, Taheri PA, Flint LM. Early tracheostomy for primary airway management in the surgical critical care setting. *Surgery* 1990;**108**:655–9
20 Devarajan J, Vydyanathan A, Xu M, Murthy SM, McCurry KR, Sessler DI *et al.* Early tracheostomy is associated with improved outcomes in patients who require prolonged mechanical ventilation after cardiac surgery. *J Am Coll Surg* 2012;**214**:1008–16.e4
21 Jeon YT, Hwang JW, Lim YJ, Lee SY, Woo KI, Park HP. Effect of tracheostomy timing on clinical outcome in neurosurgical patients: early versus late tracheostomy. *J Neurosurg Anesthesiol* 2014;**26**:22–6
22 Scales DC, Thiruchelvam D, Kiss A, Redelmeier DA. The effect of tracheostomy timing during critical illness on long-term survival. *Crit Care Med* 2008;**36**:2547–57
23 Griffiths J, Barber VS, Morgan L, Young JD. Systematic review and meta-analysis of studies of the timing of tracheostomy in adult patients undergoing artificial ventilation. *BMJ* 2005;**330**:1243
24 Cai SQ, Hu JW, Liu D, Bai XJ, Xie J, Chen JJ *et al.* The influence of tracheostomy timing on outcomes in trauma patients: a meta-analysis. *Injury* 2017;**48**:866–73
25 Mahafza T, Batarseh S, Bsoul N, Massad E, Qudaisat I, Al-Layla AE. Early vs. late tracheostomy for the ICU patients: experience in a referral hospital. *Saudi J Anaesth* 2012;**6**:152–4
26 Durbin CG. Indications for and timing of tracheostomy. *Respir Care* 2005;**50**:483–7
27 Halpern NA, Goldman DA, Tan KS, Pastores SM. Trends in critical care beds and use among population groups and Medicare and Medicaid beneficiaries in the United States: 2000–2010. *Crit Care Med* 2016;**44**:1490–9
28 Herritt B, Chaudhuri D, Thavorn K, Kubelik D, Kyeremanteng K. Early vs. late tracheostomy in intensive care settings: impact on ICU and hospital costs. *J Crit Care* 2018;**44**:285–8
29 Trouillet JL, Luyt CE, Guiguet M, Ouattara A, Vaissier E, Makri R *et al.* Early percutaneous tracheotomy versus prolonged intubation of mechanically ventilated patients after cardiac surgery: a randomized trial. *Ann Intern Med* 2011;**154**:373–83
30 Koch T, Hecker B, Hecker A, Brenck F, Preuß M, Schmelzer T *et al.* Early tracheostomy decreases ventilation time but has no impact on mortality of intensive care patients: a randomized study. *Langenbecks Arch Surg* 2012;**397**:1001–8
31 Sanabria A, Gómez X, Vega V, Domínguez LC, Osorio C. Prediction of prolonged mechanical ventilation in patients in the intensive care unit A cohort study. *Colomb Med* (*Cali*) 2013;**44**:184–8
32 Ben-Avi R, Ben-Nun A, Levin S, Simansky D, Zeitlin N, Sternik L *et al.* Tracheostomy after cardiac surgery: timing of tracheostomy as a risk factor for mortality. *J Cardiothorac Vasc Anesth* 2014;**28**:493–6
33 Nieszkowska A, Combes A, Luyt CE, Ksibi H, Trouillet JL, Gibert C *et al.* Impact of tracheotomy on sedative administration, sedation level, and comfort of mechanically ventilated intensive care unit patients. *Crit Care Med* 2005;**33**:2527–33
34 Hosseinian L, Chiang Y, Itagaki S, Polanco A, Rhee A, Chikwe J. Earlier versus later tracheostomy in patients with respiratory failure after cardiac surgery in the United States. *J Cardiothorac Vasc Anesth* 2014;**28**:488–92

35 Yavas S, Yagar S, Mavioglu L, Cetin E, Iscan HZ, Ulus AT *et al*. Tracheostomy: how and when should it be done in cardiovascular surgery ICU? *J Card Surg* 2009;**24**:11–8

36 Rumbak MJ, Newton M, Truncale T, Schwartz SW, Adams JW, Hazard PB. A prospective, randomized, study comparing early percutaneous dilational tracheotomy to prolonged translaryngeal intubation (delayed tracheotomy) in critically ill medical patients. *Crit Care Med* 2004;**32**:1689–94

37 Melsen WG, Rovers MM, Bonten MJM. Ventilator-associated pneumonia and mortality: a systematic review of observational studies. *Crit Care Med* 2009;**37**:2709–18

38 Curry SD, Rowan PJ. Laryngotracheal stenosis in early vs late tracheostomy: a systematic review. *Otolaryngol Head Neck Surg* 2020;**162**:160–7

39 Goldenberg D, Ari EG, Golz A, Danino J, Netzer A, Joachims HZ. Tracheotomy complications: a retrospective study of 1130 cases. *Otolaryngol Head Neck Surg* 2000;**123**:495–500

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