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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 (ICU) patients is controversial, with conflicting findings on early versus late tracheostomy.

Methods: Patients undergoing tracheostomy from 2001-2012 were identified from the Medical Information Mart for Intensive Care-III database. Early tracheostomy (ET) was defined as less than the 25th percentile of time from ICU admission to tracheostomy (TTT). Statistical analysis for tracheostomy timing on ICU length of stay (LOS) and mortality were conducted.

Results: A total of 1,566 patients were included. Patients with ET had shorter ICU LOS (27.32 vs. 12.55 days, $p<0.001$) and lower mortality (12.9% vs. 9.0%, $p=0.039$). Multivariate logistic regression analysis found an association between increasing TTT and mortality (OR: 1.029, 95% CI 1.007-1.051, $p=0.009$).

Conclusions: Our analysis revealed that patients with ET were more likely to have shorter ICU LOS and lower mortality. Our data suggests that ET should be given strong consideration in appropriately selected patients.

Keywords: Tracheostomy, airway management, intensive care units, length of stay, mortality

INTRODUCTION

Tracheostomy is a commonly performed procedure in patients who are admitted to the intensive care unit (ICU). Among ICU patients, 24-28% may undergo tracheostomy.[1,2] Patients in the ICU may require tracheostomy when prolonged mechanical ventilation (MV) is anticipated or in the case of a difficult airway.[3] A 1989 consensus statement recommended endotracheal intubation when MV is expected to last up to 10 days while tracheostomy is for patients with anticipated MV greater than 21 days.[4-8] Convention is that patients often receive a tracheostomy for expected MV 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 7 days of intubation had better outcomes, including decreased duration of mechanical ventilation, ICU length of stay, and mortality.[1] A 2015 Cochrane review analyzing 8 randomized controlled trials cautiously endorsed early tracheostomy (ET), noting that there was a suggested mortality benefit to ET, as well as decreased ventilator time, decreased ICU stay, and lower likelihood of pneumonia.[9] However, there are opposing views to some benefits of ET. 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 ET, 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 center 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 2001-2012.[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 have approved use of this data, which are freely accessible. As MIMIC-III is a deidentified 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 International Classification of Disease 9th edition (ICD-9) procedure codes. ICD-9 procedure codes included were 31.1, 31.2, 31.21, 31.29, and 31.74. The chart date and time for the tracheostomy ICD-9 codes was 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 LOS (PLOS) in the ICU if they had a stay >75th percentile. Patients were grouped into early and late tracheostomy groups. Patients were defined to have received an ET if their time to tracheostomy (TTT) time was ≤25th percentile. Univariate and multivariate analyses were conducted to find associations between patient characteristics, TTT, ICU LOS, 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).

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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%), of White race (n=1095, 69.9%), and admitted emergently (n=1362, 87.0%). 11.9% of the cohort died during their hospital stay. Patients had an average 12.22 days from ICU admission to tracheostomy. The 25^{th} percentile cutoff for the early versus late TTT groups was 6.82 days. The average TTT for the early group was 3.28 days compared to 15.20 for the late (p<0.001). A total of 391 patients (25%) met criteria for ICU PLOS (75^{th} percentile = 30.21 days), of which 94.1% were patients that had a late tracheostomy. Patients in the late tracheostomy group had significantly longer ICU LOS (27.32 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 vs. 17.6%, p<0.001), cardiac arrhythmias (36.3% vs. 23.8%, p<0.001), valvular disease (36.3% vs. 23.8%, p<0.001), renal failure (12.7% vs. 7.9%, p=0.011), a coagulopathy (18.8% vs. 7.4%, p<0.001), or a fluid electrolyte disorder (38.3% vs. 28.9%, p=0.001). **Table 2** reflects a multivariate regression analysis to identify factors associated with ET within this patient population. Analyses demonstrated that patients with metastatic cancer (OR: 2.590, p=0.001) and rheumatoid arthritis (OR: 2.789, p=0.006) were more likely to have an ET. In contrast, patients with congestive heart failure (OR=0.673, p=0.020), cardiac arrhythmia (OR: 0.730, p=0.048), coagulopathy (OR: 0.334, p<0.002), and a fluid electrolyte disorder (OR: 0.696, p=0.009) were less likely to receive an ET.

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Patients with a delayed tracheostomy had a higher rate of death (12.9% vs. 9.0%, $p=0.039$). **Table 3** reports factors associated with mortality. This analysis demonstrated that increasing TTT was associated with an increased risk for death (OR: 1.029, $p=0.009$). Similarly, increased TTT was associated with having an ICU PLOS (OR: 1.246, $p<0.001$) (**Table 4)**. Examining the linear relationship between TTT and ICU LOS, we found that a 1 day increase in TTT was associated with a 1.27 day increase in ICU LOS (95% Confidence Interval=1.203-1.333, $p<0.001$) (**Table 5)**.

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DISCUSSION

Our study elucidates the impact of tracheostomy time on outcomes for patients admitted into a single center ICU. Understanding optimal times for tracheostomy has clinical significance.[10,12] ET has been hypothesized to offer significant benefits as 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 impacts their ability to reach significant associations for certain outcomes.[12] The MIMIC database offers a robust sample to potentially detect these relationships, if they exist. Our study suggests an association of ET with both shorter ICU LOS and lower mortality.

The cutoff for ET in our study was 6.82 days. There exists heterogeneity in the classification of early versus late tracheostomy within the literature. For example, certain studies have used demarcation points of 4[13-15], 7[16-19], and 10 days[4,6,9,20-22] to identify ET. Our estimation therefore aligns with previous studies. Furthermore, we decided to proceed with an approximately 7 day cutoff given the findings of Liu and colleagues' systematic review on early versus late tracheostomy.[8] Specifically, Liu et. al's data suggested that ET, less than 7 days, was associated with a decrease in ICU LOS.[8] In an earlier systematic review from 2005, Griffiths et. al also concluded that ET may reduce duration of ICU LOS.[23] Similarly, in a meta-analysis specifically on trauma patients, Cai and colleagues found that early tracheostomy was associated with a significantly lower ICU LOS.[24] Our study supports these findings. Patients with ET had significantly shorter ICU LOS (27.3 vs. 12.6 days, p<0.001), and our results suggest that delaying tracheostomy by one day is associated with a 1.27 day increase in total ICU LOS. Of

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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 MV periods, thereby reducing their rate of complications such as airway injuries.[25] Shortening ICU LOS is an important consideration in the current climate with limited ICU bed availability. Prolonged ICU LOS is a significant financial burden on the healthcare system.[4,27] Previous studies have demonstrated that ET can lead to significant cost savings.[4,28-30] In a systematic review on this topic, Herritt et. al reported that ET had an average cost saving of $4316, indicating ET 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 MV, 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 MV 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 previously been shown to be associated with ET, however, we present this relationship with rheumatoid arthritis.[4] In a study utilizing the Nationwide Inpatient Sample, Villwock et. al reported predictors of late tracheostomy which included fluid/electrolyte disorders.[4] Our study aligns with this finding and

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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 needed to delay 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 have not been considered appropriate at admission, given the anticipated clinical course, and only reconsidered after the patient survived for >7 days. This phenomenon is an important consideration when interpreting this study's results.

Patients with ET had a decreased incidence of mortality (12.9% vs. 9.0%). Previous studies have reached conflicting conclusions on this relationship. Koch et. al noted that ET did not decrease mortality in critically ill patients.[30] However, they used early and late tracheostomy time definitions as 4 and 6 days, respectively, which may be too early of a time frame to detect a mortality difference.[30] Ben-Avi et. al found that ET, 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 ET patients, defined as less than 7 days.[16] Tong et. al, using a 7 day cutoff, found that ET patients did not have reduced mortality.[17] These studies reflect the lack of consensus on the relationship between ET 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 has also likely contributed to the conflicting literature. Our study did find an association between mortality and ET after accounting for potential confounding comorbid conditions. While this analysis could not judge disease severity, especially difficult given its partially subjective nature, our findings

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do attempt to account for differences between patient groups. In this context, our study suggests that patients with ET did experience a mortality benefit.

Ventilator-acquired pneumonia (VAP) is a significant cause of in hospital mortality and is a manifest risk of prolonged MV.[1,16,33-36] As such, one of the purported advantages of ET is decreased risk for pneumonia acquisition. Villwock et. al noted that ET was associated with a 1.5% decrease in VAP 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 ET and decreased VAP incidence; however, there has been no clear link to mortality. In a systematic review of VAP and mortality by Melsen and colleagues, VAP was found to be significantly associated with increased risk of death.[37] However, they did note high levels of heterogeneity among the various included observational studies' outcomes.[37] When they sub-selected for studies solely concerning trauma or acute respiratory distress syndrome, there was no attributable mortality to VAP.[37] These findings indicate specific subgroup analysis is needed to clarify the nature of the relationship between ICU mortality and VAP. Our study includes patients with a variety of indications, likely reflecting a similar heterogeneity with our patient cohort. While, given database limitations, our study was unable to monitor pneumonia incidence, our results did demonstrate that patients in the late tracheostomy group did have higher rates of death. Associations between VAP 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 to subject patients to additional, potentially unnecessary, procedures. ET does carry complication risks that our study was unable to evaluate. For example, a potential complication for ET is laryngotracheal stenosis. Studies have reported

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incidence rates of laryngotracheal stenosis between 0.0-20.8%.[38,39] Rumbak et. al suggested a potential increase in tracheal stenosis amongst ET patients, but their data was 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 ET, but noted sample size concerns.[8] As such, further study on the relationship between ET and complications is needed.

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 not have statistical significance when sub-selecting for specific patient groups.[37] However, understanding general themes may inform areas of future investigation because statistically insignificant relationships may have clinical significance. Furthermore, our study was unable to compare tracheostomy complication rates between the early 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 either 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.

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CONCLUSION

Our study found that ET is associated with reduced ICU LOS 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 study's findings do not conclusively support ET in all patients due to our heterogenous population, but do promote a strong consideration of ET. 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 S-B, 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 L-WH, 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

https://doi.org/10.1017/S0022215124000537 Published online by Cambridge University Press

15. Hosokawa K, Nishimura M, Egi M, Vincent J-L. 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**:1008-1016.e4

21. Jeon Y-T, Hwang J-W, Lim Y-J, Lee S-Y, Woo K-I, Park H-P. 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 S-Q, Hu J-W, Liu D, Bai X-J, Xie J, Chen J-J, 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 J-L, Luyt C-E, 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 C-E, Ksibi H, Trouillet J-L, 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? *Journal of Cardiac Surgery* 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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Table I: 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 (Std. Dev)	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 (Std. Dev), days	3.28 (2.21)	15.20 (7.00)	12.22 (8.04)	**<0.001**
ICU Length of Stay				**<0.001**
≤75th	368 (94.1)	807 (68.7)	1175 (75.0)	
>75th	23 (5.9)	368 (31.3)	391 (25.0)	
ICU Length of Stay, mean (Std. Dev)	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**

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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**

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Table II: Multivariate Logistic Regression on Factors Associated with Early Tracheostomy

Variable	Odds Ratio	P-Value	95% Confidence Interval	
			Lower	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

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Table III: Multivariate Regression for Factors Associated with Mortality

Variable	**Odds Ratio**	**P-Value**	**95% Confidence Interval**	
			Lower	**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

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Table IV: 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

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Table V: 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

SUMMARY

- 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 ICU 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 suggests that early tracheostomy should be given strong consideration in appropriately selected patients.

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