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The Impact of Tracheostomy Timing on Clinical Outcomes in Intensive Care Patients with Acute Ischemic Stroke: A Retrospective Cohort Study

Yoğun Bakımda Takip Edilen Akut İskemik İnme Hastalarında Trakeostomi Zamanlamasının Klinik Sonuçlara Etkisi: Retrospektif Kohort Çalışması

Serpil Ekin[1], İlkay Ceylan[1], Gürcan Güler[1], Derful Gülen[1], Buket Özyaprak[1], Şermin Eminoğlu[1], Kübra Çanakçi[2],

[1]Bursa Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon, Bursa, Türkiye
[2]Gürsu Şehit Cüneyt Yıldız Devlet Hastanesi, Anesteziyoloji ve Reanimasyon, Bursa, Türkiye

Correspondence / Sorumlu yazar:
Serpil EKİN

Bursa Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon, Bursa, Türkiye

e-mail: erenserpil1454@hotmail.com

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Abstract: This study aimed to evaluate the association between tracheostomy timing and clinical outcomes in patients with acute ischemic stroke managed in the intensive care unit (ICU).In this retrospective cohort study, 136 mechanically ventilated patients with acute ischemic stroke who underwent tracheostomy between 2020 and 2023 were analyzed. Patients were categorized into three groups according to tracheostomy timing after intubation: very early (≤7 days), early (8–10 days), and late (>10 days). The primary outcomes were 28-day and 90-day mortality. Secondary outcomes included ICU and hospital length of stay, respiratory parameters, and post-tracheostomy pneumonia. Baseline demographic and clinical characteristics were comparable among the groups. Very early tracheostomy was associated with significantly shorter ICU and hospital length of stay (p<0.001 for both). No significant differences were observed among the groups in respiratory parameters or post-tracheostomy pneumonia. While 28-day mortality was similar across groups (p=0.866), 90-day mortality was higher in the late tracheostomy group (p=0.034). In multivariable analysis, late tracheostomy (OR 3.82, 95% CI 1.48–9.92, p=0.006) and chronic obstructive pulmonary disease (COPD) (OR 8.69, 95% CI 2.72–27.78, p<0.001) were independently associated with 90-day mortality. In ICU patients with acute ischemic stroke, very early tracheostomy was associated with shorter ICU and hospital length of stay, whereas late tracheostomy was associated with higher 90-day mortality. These findings should be interpreted cautiously because of the retrospective design, potential confounding by indication, and absence of detailed neurological severity data. Prospective studies are needed to confirm these associations.
Keywords: Intensive care units, Mechanical ventilation, Mortality, Stroke, Tracheostomy

Özet: Bu çalışmada, yoğun bakım ünitesinde takip edilen akut iskemik inme hastalarında trakeostomi zamanlaması ile klinik sonuçlar arasındaki ilişkinin değerlendirilmesi amaçlandı. Bu retrospektif kohort çalışmada, 2020–2023 yılları arasında akut iskemik inme tanısıyla yoğun bakımda izlenen, invaziv mekanik ventilasyon gereksinimi olan ve trakeostomi uygulanan 136 hasta değerlendirildi. Hastalar entübasyondan trakeostomiye kadar geçen süreye göre çok erken (≤7 gün), erken (8–10 gün) ve geç (>10 gün) trakeostomi olmak üzere üç gruba ayrıldı. Primer sonlanım noktaları 28 ve 90 günlük mortaliteydi. Sekonder sonlanım noktaları yoğun bakım ve hastane yatış süresi, solunumsal parametreler ve post-trakeostomi pnömoni gelişimiydi. Gruplar arasında başlangıç demografik ve klinik özellikler açısından anlamlı fark yoktu. Çok erken trakeostomi, yoğun bakım ve hastane yatış süresinin anlamlı olarak daha kısa olmasıyla ilişkiliydi (her ikisi için p<0.001). Solunumsal parametreler ve post-trakeostomi pnömoni gelişimi açısından gruplar arasında anlamlı fark saptanmadı. 28 günlük mortalite benzerdi (p=0.866); buna karşın 90 günlük mortalite geç trakeostomi grubunda daha yüksekti (p=0.034). Çok değişkenli analizde geç trakeostomi (OR 3.82, %95 GA 1.48–9.92, p=0.006) ve kronik obstrüktif akciğer hastalığı (KOAH) (OR 8.69, %95 GA 2.72–27.78, p<0.001) 90 günlük mortalite ile bağımsız olarak ilişkili bulundu. Yoğun bakımda takip edilen akut iskemik inme hastalarında çok erken trakeostomi daha kısa yoğun bakım ve hastane yatış süresi ile, geç trakeostomi ise daha yüksek 90 günlük mortalite ile ilişkili bulundu. Ancak retrospektif tasarım, endikasyon biası olasılığı ve ayrıntılı nörolojik şiddet verilerinin bulunmaması nedeniyle bu bulgular dikkatli yorumlanmalı ve prospektif çalışmalarla doğrulanmalıdır.
Anahtar Kelimeler: Yoğun bakım üniteleri, Mekanik ventilasyon, Mortalite, İnme, Trakeostomi

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1. Indroduction

Stroke is one of the leading causes of mortality and neurological disability worldwide. According to recent data from the Global Burden of Disease study, stroke imposes a substantial burden on healthcare systems (1). In patients with acute ischemic stroke, impaired consciousness and loss of airway protective reflexes frequently necessitate invasive mechanical ventilation, and these patients are commonly managed in the intensive care unit (2).

Prolonged endotracheal intubation is associated with complications such as ventilator-associated pneumonia, as well as laryngeal and tracheal injury. Therefore, tracheostomy is frequently preferred as an airway management strategy in patients anticipated to require prolonged mechanical ventilation (3). Tracheostomy may provide several potential advantages, including improved patient comfort, reduced need for sedation, and facilitation of weaning from mechanical ventilation (4). However, given the risk of serious complications such as bleeding, infection, tracheal stenosis, and fistula formation, the timing of the procedure remains clinically significant (3,4).

Although early tracheostomy in critically ill patients has been reported to reduce the duration of mechanical ventilation and length of intensive care unit stay, its impact on mortality and long-term functional outcomes remains a matter of debate (5). In the SETPOINT2 trial, which focused on patients with severe stroke, an early tracheostomy strategy did not demonstrate a significant survival benefit at 6 months (6). Some systematic reviews in the literature suggest that early tracheostomy may have favorable effects on certain short-term clinical outcomes. A review focusing on stroke patients reported that early tracheostomy may shorten both intensive care unit and hospital length of stay, although its effect on mortality remains unclear (7).

All these findings indicate that the impact of tracheostomy timing on clinical outcomes, particularly in patients with acute ischemic stroke, has not yet been fully elucidated. Therefore, the aim of this retrospective study was to investigate the association between tracheostomy timing and clinical outcomes in patients with acute ischemic stroke managed in the intensive care unit.

2. Materials and Methods

This study was designed as a retrospective observational cohort study conducted in the general intensive care unit of a tertiary care hospital. After obtaining approval from the local ethics committee, medical records of patients who were followed in the intensive care unit with a diagnosis of acute ischemic stroke between 2020 and 2023 were retrospectively reviewed.

Patients aged 18 years and older with a diagnosis of acute ischemic stroke who required mechanical ventilation in the intensive care unit, underwent tracheostomy during their ICU stay, and had a Glasgow Coma Scale (GCS) score ≤12 at ICU admission were included in the study.

Patients who had undergone tracheostomy prior to ICU admission, those younger than 18 years, and those with an ICU length of stay of less than 4 days were excluded.

Patients were divided into three groups according to the timing of tracheostomy after intubation: very early tracheostomy (≤7 days), early tracheostomy (8–10 days), and late tracheostomy (>10 days). The timing categories were selected based on commonly used thresholds in the tracheostomy literature, where early tracheostomy is frequently defined within the first 7–10 days of intubation or mechanical ventilation (6,7). Based on these commonly used thresholds, tracheostomy performed ≤7 days after intubation was defined as very early, tracheostomy performed between 8 and 10 days as early, and tracheostomy performed after 10 days as late.

Clinical and demographic data were obtained from the hospital electronic medical records and ICU patient follow-up charts. The recorded variables included demographic characteristics (age, sex), comorbidities (diabetes mellitus, hypertension, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, chronic kidney disease), history of prior stroke, Acute Physiology and Chronic Health Evaluation II (APACHE II) score at ICU admission, timing of intubation, timing of tracheostomy, fraction of inspired oxygen (FiO_2) and peripheral oxygen saturation (SpO_2) values before tracheostomy and 48 hours after tracheostomy, development of post-tracheostomy pneumonia, ICU length of stay, total hospital length of stay, and 28-day and 90-day mortality.

The primary outcome of the study was defined as the association between tracheostomy timing and 28-day and 90-day mortality. Secondary outcomes included ICU and hospital length of stay, respiratory parameters, and the development of post-tracheostomy pneumonia.

Pneumonia was defined as the presence of a new or progressive infiltrate on chest radiography or thoracic computed tomography, together with at least two of the following clinical findings: fever (>38°C), leukocytosis or leukopenia, and purulent tracheal secretions (8). Post-tracheostomy pneumonia was assessed retrospectively based on patient records, radiological findings, and electronic hospital data. Tracheostomy procedures were performed at the bedside in the ICU by ICU specialists. The decision and timing of tracheostomy were determined by the treating clinical team according to the patient's neurological status, respiratory course, anticipated need for prolonged mechanical ventilation, and overall clinical condition. No predefined protocol or random allocation was used for tracheostomy timing.

2.1. Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test and visual methods. Data with normal distribution were presented as mean ± standard deviation, whereas non-normally distributed data were expressed as median (interquartile range, IQR). Categorical variables were presented as counts and percentages (%). For comparisons of continuous variables among the three groups, one-way ANOVA was used for normally distributed data, and the Kruskal–Wallis test was applied for non-normally distributed data. When the Kruskal–Wallis test was significant, post hoc pairwise comparisons were performed using Bonferroni correction.

Categorical variables were compared using the Pearson chi-square test, and the Fisher–Freeman–Halton test was used when expected cell counts were low. The linear-by-linear association test was employed to evaluate ordinal trends across groups.

To identify independent risk factors associated with 28-day and 90-day mortality, multivariable logistic regression analysis was performed. Variables considered clinically relevant and those with potential confounding effects were included in the models. Results were reported as odds ratios (OR) with 95% confidence intervals (CI). In addition to categorical analyses, tracheostomy timing was also evaluated as a continuous variable in separate multivariable logistic regression models. Mortality was analyzed as a binary outcome at predefined 28-day and 90-day time points. Time-to-event analyses, including Kaplan–Meier survival curves and Cox proportional hazards regression, were not performed because exact time-to-death and censoring data after hospital discharge were not consistently available for all patients. A p-value<0.05 was considered statistically significant for all analyses.

3. Results

A total of 136 patients were included in the study. Patients were divided into three groups according to tracheostomy timing: very early tracheostomy (≤7 days, n=37), early tracheostomy (8–10 days, n=37), and late tracheostomy (>10 days, n=62).

The demographic and clinical characteristics of the patients are presented in Table 1. There were no significant differences among the groups in terms of age, sex, or comorbidities. Specifically, no statistically significant differences were observed between groups regarding diabetes mellitus, hypertension, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, chronic kidney disease, or history of prior stroke (all p-values>0.05). Similarly, APACHE II scores were comparable across groups (p=0.990).

Respiratory parameters before tracheostomy and at 48 hours after the procedure are shown in Table 2. Pre-tracheostomy FiO_2 values were similar among the groups (p=0.256), and no significant differences were observed in pre-tracheostomy SpO_2 values (p=0.774). Likewise, there were no significant differences between groups in FiO_2 (p=0.828) or SpO_2 (p=0.894) values at 48 hours after tracheostomy.

There was no statistically significant difference among the groups in terms of post-tracheostomy pneumonia (p=0.107) (Table 3). However, a statistically significant difference was observed in ICU length of stay (p<0.001). Bonferroni post hoc analysis revealed that ICU length of stay was significantly shorter in the very early tracheostomy group compared to both the early and late tracheostomy groups (p<0.001), whereas no significant difference was found between the early and late groups (p=0.742).

Similarly, total hospital length of stay differed significantly among the groups (p<0.001).

Bonferroni analysis demonstrated that the very early tracheostomy group had a significantly shorter hospital stay compared to both the early (p=0.006) and late tracheostomy groups (p<0.001), while no significant difference was observed between the early and late groups (p=0.709).

No significant difference was found among the groups in terms of 28-day mortality (p=0.866). In contrast, a statistically significant difference was observed for 90-day mortality (p=0.034). Additionally, a significant trend indicating increased mortality with delayed tracheostomy timing was identified (linear-by-linear association test, p=0.009).

In the multivariable logistic regression analysis for 28-day mortality, tracheostomy timing was not independently associated with mortality (Table 4). None of the variables included in the model were significant predictors of early mortality. Model calibration was acceptable (Hosmer–Lemeshow p=0.166).

In the multivariable analysis for 90-day mortality, late tracheostomy was independently associated with higher mortality compared with very early tracheostomy (OR 3.82, 95% CI 1.48–9.92, p=0.006). The presence of COPD was also independently associated with 90-day mortality (OR 8.69, 95% CI 2.72–27.78, p<0.001). No significant association was found between early tracheostomy and mortality. The model demonstrated good calibration (Hosmer–Lemeshow p=0.27) and moderate explanatory power (Nagelkerke R^2=0.25).

When tracheostomy timing was analyzed as a continuous variable, each one-day delay in tracheostomy was associated with a non-significant increase in the odds of 90-day mortality (adjusted OR 1.035, 95% CI 0.987–1.086, p=0.153).

Table 1. Baseline characteristics of patients according to tracheostomy timing groups

Variable	Very early (n=37)	Early (n=37)	Late (n=62)	p-value
Age, years, mean ± SD	71.5 ± 14	74.4 ± 11.8	73.6 ± 14.4	0.639
Male sex, n (%)	23 (62.2)	19 (51.4)	36 (58.1)	0.635
Diabetes mellitus, n (%)	9 (24.3)	12 (32.4)	16 (25.8)	0.695
Hypertension, n (%)	16 (43.2)	19 (51.4)	27 (43.5)	0.711
Coronary artery disease, n (%)	2 (5.4)	2 (5.4)	4 (6.5)	1.000
Congestive heart failure, n (%)	9 (24.3)	10 (27)	19 (30.6)	0.786
Chronic obstructive pulmonary disease, n (%)	6 (16.2)	10 (27)	8 (12.9)	0.197
Chronic renal failure, n (%)	1 (2.7)	2 (5.4)	6 (9.7)	0.463
Previous stroke, n (%)	0 (0)	2 (5.4)	2 (3.2)	0.381
APACHE II score, median (IQR)	25 (23–28)	26 (22–29)	26 (19–28.5)	0.990

Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range, IQR), as appropriate. Categorical variables are expressed as number (n) and percentage (%). APACHE II, Acute Physiology and Chronic Health Evaluation II.

Table 2. Respiratory parameters before and 48 hours after tracheostomy according to tracheostomy timing groups

Variable	Very early (n=37)	Early (n=37)	Late (n=62)	p-value
Pre-tracheostomy FiO_2, median (IQR)	42.7 (36.4–50)	43.8 (30.7–46.6)	40 (31–46.5)	0.256
Pre-tracheostomy SpO_2, median (IQR)	98 (96–98)	98 (95–98)	98 (97–99)	0.774
FiO_2 at 48 h after tracheostomy, median (IQR)	40 (30–45)	40 (35–50)	40 (30–45)	0.828
SpO_2 at 48 h after tracheostomy, median (IQR)	98 (97–99)	98 (97–99)	98 (97–99)	0.894

Continuous variables are presented as median (interquartile range, IQR). Comparisons among the three groups were performed using the Kruskal–Wallis test. FiO_2, fraction of inspired oxygen; SpO_2, peripheral oxygen saturation.

Table 3. Post-tracheostomy pneumonia and clinical outcomes according to tracheostomy timing groups

Variable	Very early (n=37)	Early (n=37)	Late (n=62)	p-value
Post-tracheostomy pneumonia, n (%)	8 (21.6)	11 (29.7)	26 (41.9)	0.107
ICU length of stay, days, median (IQR)	21 (16–31)	34 (28–59)	35.5 (26.75–53.25)	**<0.001**
Hospital length of stay, days, median (IQR)	30 (21–36)	41 (28.5–61)	42.5 (32.25–57)	**<0.001**
28-day mortality, n (%)	5 (13.5)	5 (13.5)	11 (17.7)	0.866
90-day mortality, n (%)	11 (29.7)	16 (43.2)	35 (56.5)	**0.034**

Continuous variables are presented as median (interquartile range, IQR), and categorical variables as number (n) and percentage (%). Comparisons among groups were performed using the Kruskal–Wallis test for continuous variables and the Pearson chi-square or Fisher–Freeman–Halton test for categorical variables, as appropriate. Post hoc pairwise comparisons for ICU and hospital length of stay were adjusted using Bonferroni correction. ICU, intensive care unit.

Table 4. Multivariable logistic regression analyses for 28-day and 90-day mortality

Variable	28-day mortality OR (95% CI)	p-value	90-day mortality OR (95% CI)	p-value
Early tracheostomy	0.73 (0.18–3.00)	0.666	1.38 (0.48–4.00)	0.549
Late tracheostomy	1.28 (0.40–4.13)	0.681	3.82 (1.48–9.92)	**0.006**
Age	1.03 (0.99–1.07)	0.180	1.02 (0.99–1.05)	0.310
APACHE II	0.95 (0.87–1.04)	0.300	1.01 (0.95–1.06)	0.878
Diabetes mellitus	1.84 (0.62–5.49)	0.274	2.21 (0.90–5.47)	0.085
Hypertension	0.95 (0.34–2.64)	0.920	1.24 (0.55–2.81)	0.601
COPD	2.55 (0.80–8.11)	0.114	8.69 (2.72–27.78)	**<0.001**

Two separate multivariable logistic regression models were constructed for 28-day and 90-day mortality. The very early tracheostomy group was used as the reference category for tracheostomy timing. Covariates were selected based on clinical relevance and their potential confounding effects. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test (28-day model: p=0.166; 90-day model: p=0.27). The 90-day mortality model demonstrated moderate explanatory power (Nagelkerke R^2=0.25). APACHE II, Acute Physiology and Chronic Health Evaluation II; COPD, chronic obstructive pulmonary disease.

4. Discussion

In this study, the association between tracheostomy timing and clinical outcomes was evaluated in patients with acute ischemic stroke managed in the ICU. The main finding was that very early tracheostomy was associated with significantly shorter ICU and hospital length of stay. In contrast, tracheostomy timing was not associated with 28-day mortality, whereas late tracheostomy was associated with higher 90-day mortality. These findings suggest that tracheostomy timing may be related to selected clinical outcomes; however, they should not be interpreted as evidence of causality.

Although measured baseline characteristics, including age, sex, comorbidities, and APACHE II score, were comparable among the groups, this does not eliminate the possibility of residual confounding. APACHE II reflects general physiological severity but does not adequately capture stroke-specific neurological injury. Therefore, unmeasured differences in neurological severity may have influenced both tracheostomy timing and mortality outcomes.

The definition of early tracheostomy varies across studies, with thresholds commonly ranging from 7 to 10 days after intubation or initiation of mechanical ventilation (6,7). Therefore, by separating patients into very early, early, and late groups, the present study aimed to explore whether a more granular timing classification could identify differences in clinical outcomes beyond a simple early-versus-late comparison.

When respiratory parameters were evaluated, no significant differences were observed among the groups in terms of FiO_2 and SpO_2 values either before tracheostomy or at 48 hours after the procedure. This finding suggests that tracheostomy timing may not have a substantial impact on short-term oxygenation parameters. Consistent with this, studies evaluating tracheostomy timing in the literature have reported that clinical outcomes such as duration of mechanical ventilation, ICU length of stay, and mortality are more prominently affected than oxygenation parameters (5,6,9).

In our study, ICU and hospital lengths of stay were significantly shorter in patients who underwent very early tracheostomy. Early application of tracheostomy may reduce the need for sedation, facilitate more effective clearance of airway secretions, and ease the process of weaning from mechanical ventilation (5,10,11). This finding is clinically important, as prolonged ICU stay is associated with an increased risk of complications and greater utilization of intensive care resources (12). A recent meta-analysis focusing on stroke patients also reported that early tracheostomy may be associated with reduced ICU and hospital length of stay (9). Our findings are consistent with these data and suggest that, in particular, very early tracheostomy may represent a potential strategy to reduce ICU resource utilization.

However, ICU and hospital length of stay findings should be interpreted with caution. Tracheostomy timing was not determined in a randomized manner, and patients who underwent late tracheostomy may have had a more complex clinical course, delayed stabilization, prolonged need for mechanical ventilation, or more severe neurological injury that was not fully captured by the available variables. Therefore, these findings should be interpreted as an association between tracheostomy timing and clinical outcomes rather than evidence of a direct causal effect.

No significant difference was observed among the groups regarding the development of post-tracheostomy pneumonia. Although some studies in the literature suggest that early tracheostomy may reduce the risk of ventilator-associated pneumonia, the results are inconsistent. Variations in patient populations, duration of mechanical ventilation, and differences in ICU practices may contribute to this heterogeneity (10,11). Therefore, the effect of tracheostomy timing on pneumonia development may vary depending on patient selection and clinical practice. In the present study, post-tracheostomy pneumonia was assessed retrospectively based on medical records, radiological findings, and clinical documentation. Although a predefined clinical and radiological definition was used, misclassification bias cannot be excluded.

Regarding mortality outcomes, our study demonstrated a significant trend toward increased mortality with delayed tracheostomy. While tracheostomy timing was not associated with 28-day mortality, it was significantly associated with 90-day mortality, with higher mortality rates among patients undergoing late tracheostomy. Furthermore, the presence of a significant linear trend between tracheostomy timing and mortality suggests that delays in tracheostomy may be associated with an increased risk of death. However, patients undergoing late tracheostomy may also differ in terms of unmeasured factors such as more severe neurological injury, a more complex clinical course, or a prolonged need for mechanical ventilation. Notably, the SETPOINT2 trial, which focused on patients with severe stroke, reported that an early tracheostomy strategy did not confer a significant survival advantage at 6 months (6). Similarly, some meta-analyses have indicated that while early tracheostomy may have limited effects on mortality, it may still provide benefits in certain clinical outcomes (5,9). Therefore, our findings should be interpreted as indicating an association between delayed tracheostomy and poorer long-term outcomes, rather than establishing a definitive causal relationship between late tracheostomy and increased mortality.

In our study, the presence of chronic obstructive pulmonary disease (COPD) was also identified as an independent risk factor for 90-day mortality. In patients with COPD, factors such as reduced pulmonary reserve, impaired secretion clearance, and increased susceptibility to infections may adversely affect the clinical course during the ICU stay. Studies conducted in critically ill populations have shown that the presence of COPD may be associated with prolonged duration of mechanical ventilation, difficulty in weaning, and increased mortality (13). Additionally, some studies in ICU populations have reported COPD comorbidity as an independent risk factor for short-term mortality (14). Therefore, the presence of COPD may represent an important comorbidity influencing the clinical course and prognosis in patients with severe stroke.

One of the strengths of our study is that it was conducted in a relatively homogeneous ICU population consisting of patients with acute ischemic stroke. In addition, the evaluation of tracheostomy timing across three distinct subgroups allowed for a more detailed analysis beyond a simple early-versus-late comparison. Notably, the finding of shorter ICU and hospital lengths of stay in the very early tracheostomy group is clinically relevant. We believe that these findings may contribute to clinical decision-making regarding the timing of tracheostomy in stroke patients requiring mechanical ventilation in the intensive care setting.

This study has several limitations. First, its retrospective, single-center design precludes causal inference. Because tracheostomy timing was determined by clinical judgment rather than randomization, confounding by indication and selection bias cannot be excluded. Patients who underwent late tracheostomy may have represented a more clinically complex subgroup, with more severe neurological injury, delayed stabilization, prolonged need for mechanical ventilation, or other unmeasured factors. Although multivariable regression was performed to adjust for measured confounders, residual confounding remains likely. Propensity score-based methods were considered; however, they were not performed because of the limited sample size, the three-group timing structure, and the absence of key neurological severity variables.

Another important limitation is the absence of detailed stroke-specific neurological severity measures. NIHSS scores, ASPECT scores, infarct volume, infarct localization, and anterior or posterior circulation involvement were not consistently available in the retrospective records. Although APACHE II was included as an indicator of general critical illness severity, it does not adequately reflect the severity of neurological injury in patients with acute ischemic stroke. Therefore, unmeasured differences in neurological severity may have influenced both tracheostomy timing and mortality outcomes. In addition, the primary reason for intubation, such as neurological deterioration versus respiratory failure, could not be reliably classified for all patients and was therefore not included in the analysis.

Mortality was evaluated as a binary outcome at 28 and 90 days. Although these were predefined clinically relevant endpoints, this approach does not account for exact survival time or censoring. Because precise time-to-death and post-discharge follow-up data were not consistently available for all patients, Kaplan–Meier survival analysis and Cox proportional hazards regression could not be performed. Finally, post-tracheostomy pneumonia was assessed retrospectively based on medical records, radiological findings, and clinical documentation; therefore, misclassification bias cannot be excluded.

Conclusion

In conclusion, this retrospective cohort study suggests that tracheostomy timing may be associated with selected clinical outcomes in ICU patients with acute ischemic stroke. Very early tracheostomy was associated with shorter ICU and hospital length of stay, whereas late tracheostomy was observed to be associated with higher 90-day mortality. However, given the observational design, potential confounding by indication, absence of detailed neurological severity data, and lack of time-to-event analysis, these findings should not be interpreted as causal. Larger prospective studies incorporating stroke-specific severity measures and survival analyses are needed to confirm these results.

REFERENCES

1. Feigin VL, Abate MD, Abate YH, Abd ElHafeez S, Abd-Allah F, Abdelalim A, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Neurol. 2024;23(10):973–1003.
2. Sič A, Tseriotis VS, Belanović B, Nemet M, Baralić M. Stroke management in the intensive care unit: ischemic and hemorrhagic stroke care. NeuroSci. 2025;6(4):121.
3. Wallace S, McGrath BA. Laryngeal complications after tracheal intubation and tracheostomy. BJA Educ. 2021;21(7):250–7.
4. Nyanzi DJ, Atwine D, Kamoga R, Birungi C, Nansubuga CA, Nyaiteera V, et al. Tracheostomy-related indications, early complications and their predictors among patients in low-resource settings: a prospective cohort study in the pre-COVID-19 era. BMC Surg. 2023;23(1):59.
5. Merola R, Iacovazzo C, Troise S, Marra A, Formichella A, Servillo G, et al. Timing of tracheostomy in ICU patients: a systematic review and meta-analysis of randomized controlled trials. Life (Basel). 2024;14(9):1165.
6. Bösel J, Niesen WD, Salih F, Morris NA, Ragland JT, Gough B, et al. Effect of early vs standard approach to tracheostomy on functional outcome at 6 months among patients with severe stroke receiving mechanical ventilation. JAMA. 2022;327(19):1899–909.
7. Qiu Y, Yin Z, Wang Z, Xie M, Chen Z, Wu J, et al. Early versus late tracheostomy in stroke-related patients: a systematic review and meta-analysis. J Clin Neurosci. 2023;114:48–54.

8. Kalil AC, Metersky ML, Klompas M, Muscedere J, Sweeney DA, Palmer LB, et al. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the infectious diseases society of America and the American thoracic society. Clin Infect Dis. 2016;63(5):e61–111.
9. Premraj L, Camarda C, White N, Godoy DA, Cuthbertson BH, Rocco PRM, et al. Tracheostomy timing and outcome in critically ill patients with stroke: a meta-analysis and meta-regression. Crit Care. 2023;27(1):132.
10. Siempos II, Ntaidou TK, Filippidis FT, Choi AMK. Effect of early versus late or no tracheostomy on mortality and pneumonia of critically ill patients receiving mechanical ventilation: a systematic review and meta-analysis. Lancet Respir Med. 2015;3(2):150–8.
11. Andriolo BN, Andriolo RB, Saconato H, Atallah ÁN, Valente O. Early versus late tracheostomy for critically ill patients. Cochrane Database Syst Rev. 2015;2015(1):CD007271.
12. Zhang G, Liu H, Xia R, Zhang L, Liu K, Zhou D, et al. Characteristics associated with length of stay in intensive care unit for cancer patients in China: a nationwide retrospective cohort study. J Multidiscip Healthc. 2025;18:6025–35.
13. Luo J, Zhang C, Deng R, Liu L, He C, Zhang R, et al. Risk factors for prolonged mechanical ventilation in critically ill patients with ischemic stroke. Neurotherapeutics. 2026;23(1):e00764.
14. Chen Y, Lu L, Li X, Liu B, Zhang Y, Zheng Y, et al. Association between chronic obstructive pulmonary disease and 28-day mortality in patients with sepsis: a retrospective study based on the MIMIC-III database. BMC Pulm Med. 2023;23(1):435.