

Original Research Article

Impact of Early Versus Late Tracheostomy on Neurocritical Care Outcomes in Severe Traumatic Brain Injury: An Observational Study

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ABSTRACT

Background: Prolonged mechanical breathing and specialized neurocritical care are frequently necessary for patients with severe traumatic brain injury (TBI). The best time to have a tracheostomy is still debatable, but it helps with ventilator weaning and airway management. While delayed tracheostomy may save needless treatments in patients with early neurological recovery, early tracheostomy may lower ventilator-related problems and ICU stay.

Objectives: To evaluate the results of early versus late tracheostomy in NeuroICU patients who have suffered severe traumatic brain injury.

Methods: The medical records of severe traumatic brain injury (TBI) patients (GCS ≤ 8) who needed tracheostomy and mechanical ventilation at Balaji Hospital between January 2023 and December 2025 were examined in this retrospective observational study. Patients were divided into two groups for tracheostomy: early (performed within 7 days) and late (executed beyond 7 days). Student's t-test and Chi-square test were used to analyze demographic information, admission GCS, Rotterdam CT score, ventilator days, length of ICU stay, incidence of ventilator-associated pneumonia (VAP), length of hospital stay, and Glasgow Outcome Scale (GOS) at discharge. A p-value of less than 0.05 was deemed statistically significant.

Results: The study had 62 individuals in total, including 31 participants in each group. Compared to the late tracheostomy group, patients having early tracheostomy showed a significantly shorter NeuroICU stay, a shorter duration of mechanical ventilation, and a decreased incidence of ventilator-associated pneumonia.

Conclusion: In patients with severe traumatic brain injury, an early tracheostomy may shorten their time on mechanical ventilation, shorten their stay in the NeuroICU, and lower their risk of ventilator-associated pneumonia. For certain severe TBI patients who need long-term ventilatory support, early tracheostomy may be a useful tactic.

Keywords: Traumatic Brain Injury, Tracheostomy Timing, NeuroICU, Mechanical Ventilation, Ventilator-Associated Pneumonia, Glasgow Outcome Scale, Rotterdam CT Score.

INTRODUCTION

One of the major global causes of illness, mortality, and long-term disability is traumatic brain injury (TBI), which disproportionately affects developing countries. An estimated 1.5 to 2 million people in India alone suffer traumatic brain injury (TBI) each year, with car crashes accounting for over 60% of all instances, followed by assault and falls.^[1] TBI

primarily strikes young men in their prime working years, placing a heavy financial strain on both families and healthcare systems.^[2]

Due to decreased consciousness, loss of airway protective reflexes, and increased intracranial pressure, patients with severe traumatic brain injury (TBI), as defined by a Glasgow Coma Scale (GCS) score of 8 or lower, often require extended mechanical

ventilation. Tracheostomy has become an essential tool in the management of neurocritical care in this context, helping with ventilator weaning, airway protection, pulmonary toilet, and early rehabilitation.^[3,4] However, there is still much clinical disagreement over the best time to conduct a tracheostomy, whether it should be done early (within 7 days of intubation) or late (beyond 7 days).^[5,6]

Early tracheostomy proponents contend that it shortens ICU stays, lessens the need for mechanical ventilation, and decreases the risk of ventilator-associated pneumonia (VAP), which is linked to prolonged ventilation, longer hospital stays, and higher mortality rates in TBI patients.^[3,7,8] Early tracheostomy dramatically shortens ICU stays and mechanical breathing times, according to meta-analyses of randomized controlled trials in general ICU populations.^[9,10] Early tracheostomy has also been linked to lower VAP rates and shorter NeuroICU stays in observational studies, particularly in severe TBI groups.^[11-14]

Others, on the other hand, support a watchful-waiting strategy, pointing out that some TBI patients show early neurological improvement and may be effectively extubated, avoiding a needless operation.^[5] Additionally, the Rotterdam CT Score and admission GCS have been shown to be significant prognostic indicators for identifying patients who are most likely to benefit from an early tracheostomy because they will need prolonged ventilatory assistance.^[15,16] There is still a dearth of evidence from the Indian neurocritical care setting, despite an increasing amount of research. In order to inform context-specific clinical practice guidelines, this retrospective observational study was conducted to assess the results of early versus late tracheostomy in patients with severe TBI admitted to the NeuroICU at Balaji Hospital, Hubli.^[2,17]

MATERIALS AND METHODS

Study design and settings

The Neurocritical Care Unit (NeuroICU) at Balaji Hospital in Hubli, Karnataka, India, a tertiary care facility with a specialized neurosurgical intensive care unit, was the site of this retrospective observational study. We examined the medical records of qualified patients who were admitted between January 2023 and December 2025. The Institutional

Ethics Committee approved the study, which was carried out in compliance with the Declaration of Helsinki's tenets.

Study Population

Adult patients with severe traumatic brain injury (TBI) who were admitted to Balaji Hospital's NeuroICU during the study period, needed mechanical ventilation, and underwent tracheostomy made up the study population. With 31 patients in each group (early and late tracheostomy), a total of 62 patients who satisfied the eligibility requirements were found and added to the final analysis.

Inclusion Criteria

Patients were included in the study if they fulfilled all of the following criteria:

- Age ≥ 18 years
- Diagnosis of severe traumatic brain injury, defined as a Glasgow Coma Scale (GCS) score of ≤ 8 on admission
- Requirement for invasive mechanical ventilation following injury
- Underwent tracheostomy (either early or late) during the index NeuroICU admission
- Availability of complete medical records including neuroimaging (CT scan of the brain) and clinical outcome data

Exclusion Criteria

Patients were excluded from the study if any of the following applied:

- Age < 18 years
- Penetrating traumatic brain injury
- Polytrauma with significant concurrent thoracic, abdominal, or major orthopaedic injuries likely to independently affect ventilator dependence or ICU course
- Pre-existing neurological conditions (e.g., prior stroke, neurodegenerative disease, or cognitive impairment) that may confound functional outcome assessment
- Prior tracheostomy or significant upper airway abnormality
- Patients who died within 48 hours of admission (before tracheostomy decision could be made)
- Incomplete or missing medical records
- Transfer to another facility before completion of ICU care

Definition of Early and Late Tracheostomy

For the purposes of this study, tracheostomy timing was defined based on the interval between endotracheal intubation and the performance of the tracheostomy procedure:

- **Early tracheostomy:** Tracheostomy performed within 7 days of endotracheal intubation.
- **Late tracheostomy:** Tracheostomy performed after 7 days of endotracheal intubation.

This cutoff aligns with the definitions found in recent research on the time of tracheostomy in patients with traumatic brain injury and the intensive care unit.^[3,5,6] The treating neurosurgeon and intensivist team made the decision to conduct tracheostomy in clinical practice based on clinical judgment, expected length of mechanical breathing, and neurological trajectory; the study protocol had no bearing on this decision.

Data Collection

Retrospective data were extracted from electronic medical records and paper case files of eligible patients by trained data abstractors using a standardised data collection proforma. The following variables were recorded:

- **Demographic data:** Age, sex, mechanism of injury (road traffic accident, fall, assault, other)
- **Clinical data on admission:** Glasgow Coma Scale (GCS) score and Rotterdam CT Score
- **Tracheostomy-related data:** Day of intubation, day of tracheostomy, type of tracheostomy (surgical vs. percutaneous)
- **Ventilatory data:** Total duration of mechanical ventilation (days)
- **ICU and hospital data:** Duration of NeuroICU stay (days), total duration of hospital stay (days)
- **Infectious complications:** Occurrence of ventilator-associated pneumonia (VAP), defined per standard NHSN/CDC criteria (new or worsening infiltrate on chest radiograph, fever, leucocytosis, and purulent tracheal secretions, occurring ≥ 48 hours after intubation)
- **Outcome data:** Glasgow Outcome Scale (GOS) score recorded at the time of hospital discharge

Outcome Measures

Primary Outcomes

- Duration of mechanical ventilation (days from intubation to successful extubation or decannulation)
- Duration of NeuroICU stay (days)
- Incidence of ventilator-associated pneumonia (VAP)

Secondary Outcomes

- Total duration of hospital stay (days)
- Neurological outcome at discharge, assessed using the Glasgow Outcome Scale (GOS), categorised as: GOS 1 (Death), GOS 2 (Vegetative state), GOS 3 (Severe disability), GOS 4 (Moderate disability), GOS 5 (Good recovery)
- In-hospital mortality

Statistical Analysis

IBM SPSS Statistics (Version 26.0) (or an equivalent) was used for all statistical analyses. Frequency and percentage were used for categorical data, while mean $\pm$ standard deviation (SD) was used for continuous variables. The Shapiro-Wilk test was used to determine whether continuous variables were normal.

The independent samples Student's t-test for normally distributed data or the Mann-Whitney U test when the assumption of normality was broken were used to compare continuous variables between the early and late tracheostomy groups. The Chi-square (χ^2) test or Fisher's exact test were used to compare categorical variables when cell counts were less than five.

For every analysis, a two-tailed p-value of less than 0.05 was deemed statistically significant. Because this retrospective study was exploratory and hypothesis-generating, no multiple comparison adjustment was used.

Ethical Considerations

The Institutional Ethics Committee (IEC) of Balaji Hospital in Hubli approved the study before it was carried out. The IEC waived informed consent because the study was retrospective, observational, and did not involve any intervention or departure from usual clinical care. To maintain anonymity, patient data was anonymized before analysis. Every technique was carried out in compliance with the 1964 Helsinki Declaration and its subsequent amendments, as well as the institutional and national research committee's ethical requirements.

RESULTS

A total of 62 patients with severe TBI (GCS ≤ 8) requiring mechanical ventilation and tracheostomy were included - 31 in the early group (tracheostomy ≤ 7 days) and 31 in the late group (tracheostomy > 7 days). All patients were analysed without exclusions.

Mean day of tracheostomy was 3.8 ± 1.7 days in the early group and 11.5 ± 2.3 days in the late group.

Baseline Characteristics

The two groups were well-matched at baseline. No statistically significant differences

were found in age, sex, admission GCS, or mechanism of injury, confirming comparability between groups. The Rotterdam CT Score was marginally higher in the late group (3.0 ± 0.9 vs. 2.5 ± 1.1 ; $p = 0.029$), though this did not translate into GCS differences.

Parameter	Early (n=31)	Late (n=31)	p-value	Significance
Age (years), mean $\pm$ SD	44.3 ± 18.2	45.5 ± 12.7	0.766	NS
Male sex, n (%)	27 (87.1%)	30 (96.8%)	0.351	NS
Admission GCS, mean $\pm$ SD	5.6 ± 1.0	5.1 ± 0.8	0.059	NS
Rotterdam CT Score, mean $\pm$ SD	2.5 ± 1.1	3.0 ± 0.9	0.029	*Significant
Day of tracheostomy, mean $\pm$ SD	3.8 ± 1.7	11.5 ± 2.3	<0.001	Significant
RTA, n (%)	20 (64.5%)	16 (51.6%)	—	NS
Fall, n (%)	9 (29.0%)	11 (35.5%)	—	NS
Assault, n (%)	2 (6.5%)	4 (12.9%)	—	NS

Table 1. Baseline Characteristics

Student's t-test for continuous variables; Chi-square for categorical. NS = not significant. * Rotterdam CT Score was marginally higher in the late group. Mechanism of injury distribution did not differ significantly between groups ($\chi^2 p = 0.519$)

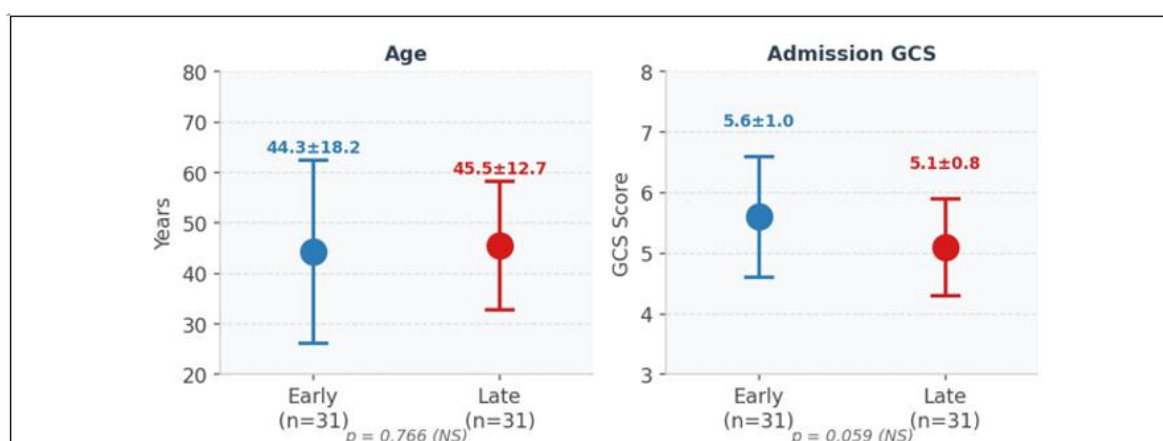


Figure 1. Dot plots comparing age and admission GCS between groups. Error bars represent ± 1 SD. Neither parameter showed a statistically significant difference ($p > 0.05$)

Clinical Outcomes

Early tracheostomy was associated with significantly shorter duration of mechanical ventilation, NeuroICU stay, and total hospital

stay compared to the late group. All three differences were statistically significant ($p < 0.001$)

Outcome Parameter	Early (n=31) Mean $\pm$ SD	Late (n=31) Mean $\pm$ SD	Difference	p-value	Significance
Duration of MV (days)	12.9 ± 6.1	20.1 ± 4.9	-7.2 days	<0.001	Significant
NeuroICU stay (days)	17.9 ± 9.7	26.4 ± 5.4	-8.5 days	<0.001	Significant
Hospital stay (days)	27.0 ± 8.2	38.5 ± 5.7	-11.5 days	<0.001	Significant

Table 2. Clinical Outcomes - Duration of Mechanical Ventilation, NeuroICU Stay, and Hospital Stay
All $p < 0.001$ by Student's t-test. MV = mechanical ventilation. Values expressed as mean $\pm$ SD

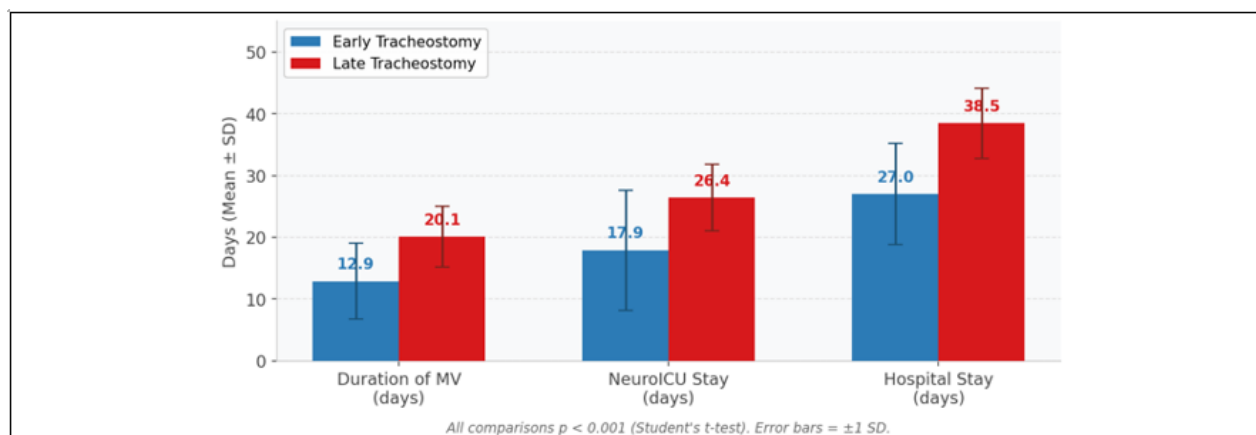


Figure 2. Grouped bar chart comparing mean duration of mechanical ventilation, NeuroICU stay, and hospital stay

Error bars represent ± 1 SD. All comparisons $p < 0.001$

Ventilator-Associated Pneumonia (VAP)

The incidence of VAP was significantly lower in the early tracheostomy group - 6 of 31 patients (19.4%) - compared to the late group where 17 of 31 patients (54.8%) developed VAP ($p = 0.009$). This represents approximately a 2.8-fold higher risk of developing VAP in patients undergoing late

tracheostomy compared with those undergoing early tracheostomy.

Pseudomonas aeruginosa was the predominant causative organism in both groups. The late tracheostomy group had a higher proportion of multi-drug resistant organisms (*Acinetobacter*, MRSA).

VAP	Early (n=31)	Late (n=31)	p-value	Significance
VAP incidence, n (%)	6 (19.4%)	17 (54.8%)	0.009	Significant
No VAP, n (%)	25 (80.6%)	14 (45.2%)	—	—

Table 3. Ventilator-Associated Pneumonia Incidence

p -value by Chi-square test. VAP = ventilator-associated pneumonia

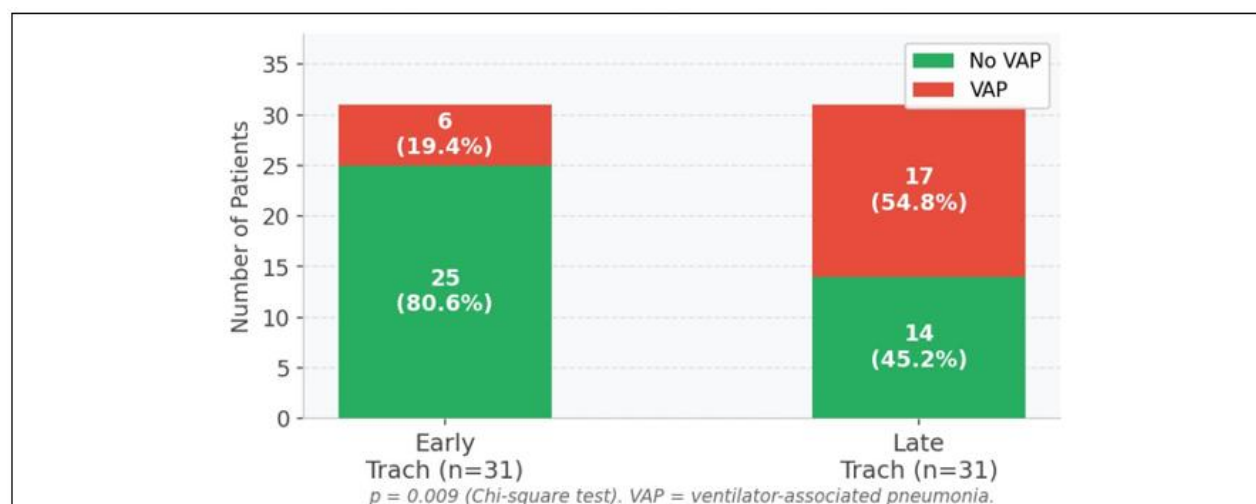


Figure 3. Stacked bar chart showing VAP vs. no-VAP proportions in each group

$p = 0.009$ (Chi-square test)

Neurological Outcome (GOS at Discharge)

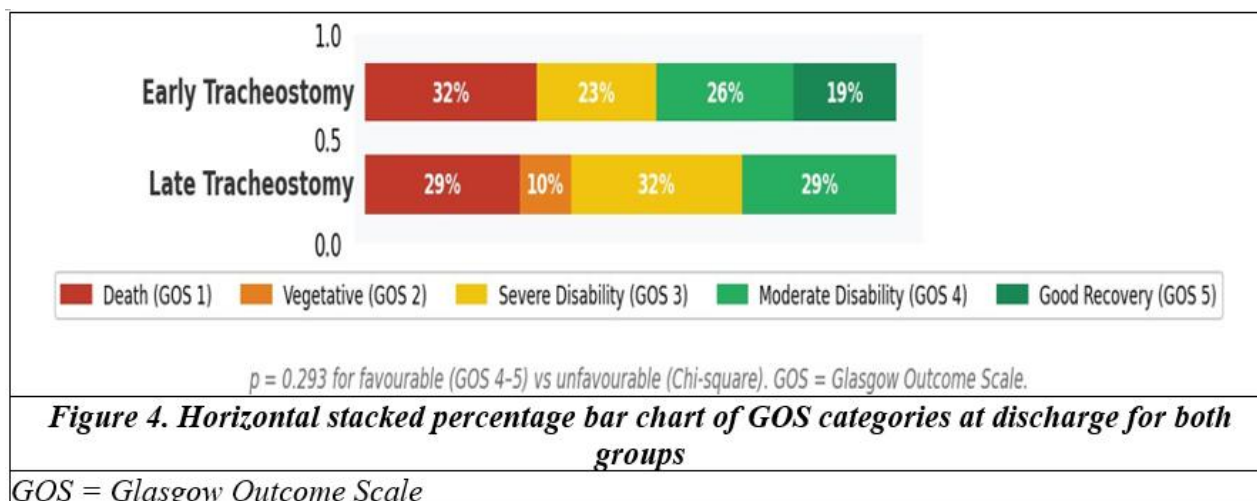
Favourable neurological outcome (GOS 4–5) was observed in 14 patients (45.2%) in the early group versus 9 patients (29.0%) in the late group. While clinically notable, this

difference did not reach statistical significance ($p = 0.293$). Importantly, no patient in the late group achieved good recovery (GOS 5), compared to 6 patients (19.4%) in the early group

GOS Category	GOS Score	Early (n=31)	Late (n=31)	p-value
Death	1	10 (32.3%)	9 (29.0%)	—
Vegetative state	2	0 (0.0%)	3 (9.7%)	—
Severe disability	3	7 (22.6%)	10 (32.3%)	—
Moderate disability	4	8 (25.8%)	9 (29.0%)	—
Good recovery	5	6 (19.4%)	0 (0.0%)	—
Favourable GOS (4–5)	4–5	14 (45.2%)	9 (29.0%)	0.293 (fav vs unfav)

Table 4. Neurological Outcome — Glasgow Outcome Scale (GOS) at Discharge

GOS = Glasgow Outcome Scale. Favourable outcome = GOS 4–5. p-value by Chi-square test. Good recovery (GOS 5) was exclusive to the early tracheostomy group (6 vs. 0 patients)



Mortality

In-hospital mortality was comparable between the two groups — 10 of 31 patients (32.3%) in the early group and 9 of 31 patients (29.0%) in the late group died during the

index hospitalisation ($p = 1.000$, not significant). Tracheostomy timing did not independently influence survival to discharge.

Discharge Status	Early (n=31)	Late (n=31)	p-value	Significance
Alive, n (%)	21 (67.7%)	22 (71.0%)	1.000	NS
Expired, n (%)	10 (32.3%)	9 (29.0%)	—	—

Table 5. In-Hospital Mortality

Mortality calculated as in-hospital death. p-value by Fisher's exact test

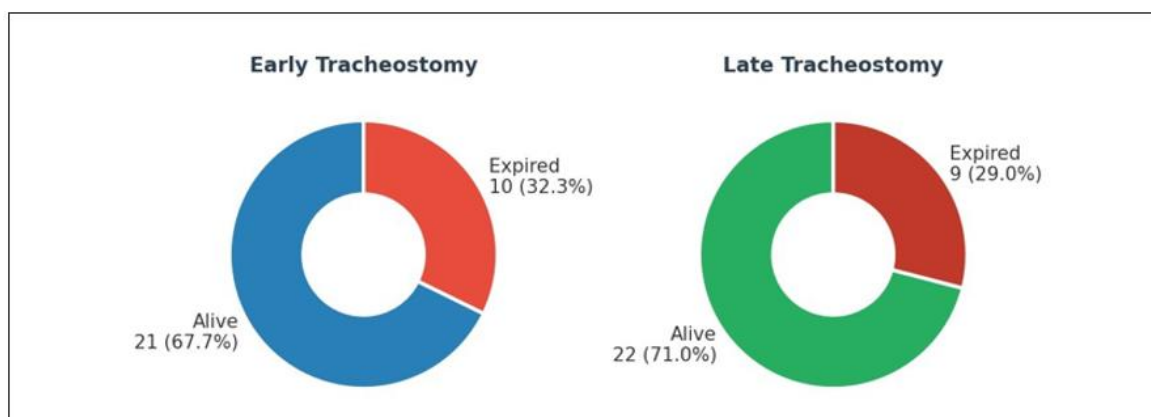


Figure 5. Donut charts comparing alive vs. expired proportions in early and late tracheostomy groups

$p = 1.000$ (Fisher's exact test); no significant difference in mortality

DISCUSSION

In this retrospective observational study, 62 patients with severe TBI (GCS ≤ 8) in a tertiary neurocritical care facility in South India were compared between early (≤ 7 days) and late (> 7 days) tracheostomy. Road traffic accidents were the leading mechanism of injury in both arms (64.5% in the early group and 51.6% in the late group; $\chi^2 p = 0.519$), which is similar with the national TBI epidemiology reported by Gururaj and Sinha et al. The two groups were well matched in terms of age, sex, admission GCS, and injury etiology.^[1,2] The Rotterdam CT Score, a validated TBI prognostic measure according to Javeed et al. and Saini et al., was slightly higher in the late group (3.0 ± 0.9 vs. 2.5 ± 1.1 ; $p = 0.029$). This could be a residual confounding factor due to the retrospective design.^[15,16]

Early tracheostomy was linked to considerably shorter hospital stays (-11.5 days), NeuroICU stays (-8.5 days), and mechanical ventilation stays (-7.2 days; all $p < 0.001$). These results are consistent with the systematic review and meta-analysis by Marra et al., which found that early tracheostomy significantly reduced ICU stay and ventilation duration in TBI patients. Rashid et al.'s Malaysian cohort also showed similar shorter ventilation and ICU duration.^[3,11] The separate meta-analyses of Villemure-Poliquin et al. and Rodrigues de Menezes et al. in TBI and neurological cohorts, as well as Han et al.'s meta-analysis of randomized trials in general ICU populations, came to similar findings.^[6,9,18] Arabi et al. also showed that early tracheostomy improved resource utilization in trauma ICU patients, which is consistent with the shorter stays noted here.^[4] Our 11.5-day decrease in hospital stay is consistent with both Morakami et al.'s focus on the cost-effectiveness of lower hospitalization and Azari Jafari et al.'s US statewide investigation that links early tracheostomy to shorter hospitalizations and fewer nosocomial infections.^[10,19]

Early tracheostomy significantly reduced the VAP rate (19.4% vs. 54.8%; $p = 0.009$), indicating a roughly 2.8-fold risk decrease. This is in line with the TBI-specific findings of Marra et al. and the meta-analysis of RCTs by Kyriakides et al., both of which link early tracheostomy to decreased VAP.^[3,7] Our late-group VAP incidence is higher than Yin et al.'s pooled incidence of 41.7%, highlighting the unique vulnerability of patients with

delayed tracheostomy in this cohort.^[8] Battaglini et al.'s ENIO observational study, which found prolonged ventilation and ICU stay as independent risk factors for MDR VAP in neurocritical patients, is consistent with the late group's increased prevalence of multidrug-resistant organisms (MRSA, Acinetobacter).^[20]

Although the overall comparison did not achieve significance ($p = 0.293$), perhaps due to sample size, favorable neurological result (GOS 4–5) was more common with early tracheostomy (45.2% vs. 29.0%) and good recovery (GOS 5) occurred only in the early group. Villemure-Poliquin et al.'s meta-analysis revealed a non-significant tendency toward improved neurological outcomes with early tracheostomy, and Giannakoulis et al. showed a similar direction of effect using target trial emulation.^[5,6]

The groups' in-hospital mortality rates were comparable (32.3% vs. 29.0%; $p = 1.000$), which is in line with the larger body of research that revealed no discernible mortality advantage from tracheostomy timing (Marra et al., Villemure-Poliquin et al., Rodrigues de Menezes et al., and Azari Jafari et al.).^[3,6,18,19] According to Javeed et al. and Saini et al.^[15,16] this probably indicates that damage severity-measured by admission GCS and Rotterdam CT Score-rather than tracheostomy timing itself drives in-hospital death. The approximately 30% mortality in both arms is similar to what Sinha et al., Rashid et al., and Nadeem et al. reported.^[2,11,17]

There is still a dearth of information about tracheostomy scheduling in India. Our results are consistent with those of Mittal et al., Ahmed and Kuo, and Nadeem et al.'s cohort of moderate-to-severe TBI patients, who found lower VAP and better resource use with early tracheostomy in head-injured patients.^[12,13,17] Similar to our findings, Gandía-Martínez et al.'s neurocritical care series discovered decreased pneumonia and resource utilization with early tracheostomy, without a change in mortality.^[14] The retrospective design with possible selection bias, the single-center setting, the modest sample size limiting power for GOS and mortality comparisons, the discharge-only (as opposed to long-term) GOS assessment, and the absence of multivariate adjustment for confounders like the Rotterdam CT Score imbalance are some of the limitations. To validate these results, prospective, multi-center studies with long follow-up are

required.

CONCLUSION

When compared to late tracheostomy, this retrospective observational study shows that early tracheostomy (within 7 days of intubation) in patients with severe traumatic brain injury is associated with a significantly lower incidence of ventilator-associated pneumonia and a significantly shorter duration of mechanical ventilation, NeuroICU stay, and overall hospital stay. These advantages were attained without a rise in in-hospital mortality. Additionally, there was a clinically significant tendency toward improved neurological outcomes at discharge, including satisfactory recovery that was unique to the early tracheostomy group. However, this trend did not approach statistical significance, perhaps due to sample size limits.

The results align with and reinforce the increasing amount of global data supporting early tracheostomy in neurocritically unwell traumatic brain injury patients. The simultaneous benefit of lower VAP and shorter hospital stays bears significant clinical and health-economic weight in the particular setting of Indian neurocritical care, where antibiotic resistance is a serious concern and healthcare resources are limited.

According to this study's findings, early tracheostomy-ideally within the first seven days of intubation-should be the recommended course of action for carefully chosen patients with severe traumatic brain injury (TBI) who are expected to need prolonged mechanical ventilation, as determined by radiological stratification (Rotterdam CT Score) and neurological severity (GCS ≤ 8). The neurosurgeon and intensivist team should continue to use individualized patient assessment in clinical decision-making.

To more conclusively determine the ideal timing and patient selection criteria for tracheostomy in severe TBI, future research should concentrate on prospective, multi-center, randomized controlled trials in the Indian and South Asian neurocritical care setting with longer-term functional outcome assessment. For tracheostomy timing in neurocritically sick patients throughout India, such data would serve as the basis for context-specific clinical practice guidelines.

REFERENCES

1. Gururaj G. Epidemiology of traumatic

brain injuries: Indian scenario. *Neurol Res* 2002;24(1):24-8.

2. Sinha S, Raheja A, Samson N, Bhoi S, Subramanian A, Sharma BS, et al. Epidemiology, clinical characteristics and outcomes of traumatic brain injury: Evidences from integrated level 1 trauma center in India. *Neurol India* 2016;64(5):1076-83.

3. Marra A, Vargas M, Buonanno P, Iacovazzo C, Coviello A, Servillo G. Early vs. late tracheostomy in patients with traumatic brain injury: systematic review and meta-analysis. *J Clin Med* 2021;10(15):3319.

4. Arabi Y, Haddad S, Shirawi N, Al Shimemeri A. Early tracheostomy in intensive care trauma patients improves resource utilization: a cohort study and literature review. *Crit Care* 2004;8(5):R347-52.

5. Giannakoulis VG, Psychogios G, Routsis C, Dimopoulou I, Siempos II. Effect of early versus delayed tracheostomy strategy on functional outcome of patients with severe traumatic brain injury: a target trial emulation. *Crit Care Explor* 2024;6(8):e1145.

6. Villemure-Poliquin N, Costerousse O, Lessard Bonaventure P, Audet N, Lauzier F, Moore L, et al. Early versus late tracheostomy for traumatic brain injury: a systematic review and meta-analysis. *Can J Anaesth* 2023;70(9):1516-26.

7. Kyriakides C, Tsagkaris C, Papazafeiropoulou MC, Mavridis T, Mourtou A, Tsamakias K, et al. Timing of tracheostomy in ICU patients: a systematic review and meta-analysis of randomized controlled trials. *Life (Basel)* 2024;14(9):1165.

8. Yin Z, Si X, Su K, Yu H, Ding L, Li K. Incidence, risk factors, and outcomes of ventilator-associated pneumonia in traumatic brain injury: a meta-analysis. *Neurocrit Care* 2019;31(3):567-77.

9. Han R, Gao X, Gao Y, Zhang J, Ma X, Wang H, et al. Effect of tracheotomy timing on patients receiving mechanical ventilation: a meta-analysis of randomized controlled trials. *PLoS One* 2024;19(7):e0307267.

10. Morakami FK, Mezzaroba AL, Larangeira AS, Cardoso LTQ, Camillo CAM, Grion CMC. Early tracheostomy may reduce the length of hospital stay. *Biomed Res*

- Int 2023;2023:8456673.
11. Rashid MF, Mustafa MS, Ruslan SR, Mohamad Nor F, Azman AZ, Zahir MZ, et al. Comparing the outcomes of early and late tracheostomy in severe traumatic brain injury patients. *Malays J Med Sci* 2021;28(4):73-82.
12. Ahmed N, Kuo YH. Early versus late tracheostomy in patients with severe traumatic head injury. *Surg Infect (Larchmt)* 2007;8(3):343-7.
13. Mittal V, Tewari M, Singh GP. Clinical outcome and cost effectiveness of early tracheostomy in isolated severe head injury patients. *J Neurosci Rural Pract* 2015;6(3):376-80.
14. Gandía-Martínez F, Martínez-Gil I, Andaluz-Ojeda D, Bobillo de Lamo F, Parra-Morais L, Díez-Gutiérrez F. Analysis of early tracheostomy and its impact on development of pneumonia, use of resources and mortality in neurocritically ill patients. *Med Intensiva* 2010;34(7):452-9.
15. Javeed F, Rehman L, Masroor M, Khan M. The prediction of outcomes in patients admitted with traumatic brain injury using the Rotterdam score. *Cureus* 2022;14(9):e29787.
16. Saini RV, Tiwari A, Saini V, Kaur P. Prediction of in-hospital mortality in patients with traumatic brain injury using the Rotterdam and Marshall CT scores: a retrospective study from Western India. *Cureus* 2023;15(7):e42157.
17. Nadeem U, Fatima T, Farooq A, Hassan U, Ahmed A. Early tracheostomy versus late tracheostomy in patients with moderate-to-severe traumatic brain injury. *Asian J Neurosurg* 2024;19(3):439-44.
18. Rodrigues de Menezes M, da Silva Siqueira I, Scarin Candido T, de Camargo Jogo Alves MK, Rodrigues Bento Lima F. Early tracheostomy versus late tracheostomy in severe traumatic brain injury or stroke: a systematic review and meta-analysis. *Aust Crit Care* 2023;36(4):624-31.
19. Azari Jafari A, Mirmoeeni S, Momtaz D, Kotzur T, Murtha G, Garcia C, et al. Early versus late tracheostomy in patients with traumatic brain injury: a US nationwide analysis. *Neurocrit Care* 2024;40(2):551-61.
20. Battaglini D, Parodi L, Cinotti R, Asehnoune K, Taccone FS, Orengo G, et al. Ventilator-associated pneumonia in neurocritically ill patients: insights from the ENIO international prospective observational study. *Respir Res* 2023;24(1):146.