Original Research

COMPARISON OF EARLY VERSUS DELAYED INTUBATION OUTCOMES IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY

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ABSTRACT

Introduction: Severe traumatic brain injury (TBI) is a major cause of mortality and long-term disability worldwide and represents a significant burden on healthcare systems, particularly in developing countries. Airway compromise, hypoxia, and inadequate ventilation are common in patients with severe TBI and can lead to secondary brain injury, thereby worsening neurological outcomes. Endotracheal intubation is frequently performed in critically ill trauma patients to secure the airway, maintain adequate oxygenation, and facilitate mechanical ventilation. However, the optimal timing of intubation in severe traumatic brain injury remains controversial.

Early intubation may prevent hypoxia, aspiration, and hypercapnia while allowing improved airway protection and better physiological stabilization. Conversely, delayed intubation may result in deterioration of neurological status, respiratory compromise, and increased secondary brain injury. On the other hand, unnecessary early intubation may expose patients to procedure-related complications, prolonged mechanical ventilation, ventilator-associated pneumonia, and increased intensive care unit stay. Therefore, evaluating the impact of timing of intubation on clinical outcomes is essential for optimizing critical care management in severe TBI patients.

Aim: To compare the outcomes of early versus delayed intubation in patients with severe traumatic brain injury.

Objectives

1. To compare mortality rates between early and delayed intubation groups.
2. To evaluate neurological outcomes in patients undergoing early versus delayed intubation.
3. To assess duration of mechanical ventilation, ICU stay, and hospital stay in both groups.
4. To compare complications associated with early and delayed intubation in severe traumatic brain injury patients.

Methodology: This prospective observational study was conducted in the Department of Critical Care at a tertiary care hospital over a period of one year during the period from January 2025 to December 2025. A total of 50 patients aged between 30 and 60 years diagnosed with severe traumatic brain injury were included in the study.

Patients were categorized into two groups:

- Early intubation group
- Delayed intubation group

Patients with severe TBI requiring airway management and intensive care support were enrolled after fulfilling the inclusion and exclusion criteria. Relevant demographic details, clinical presentation, Glasgow Coma Scale (GCS) score, imaging findings, duration of ventilation, ICU stay, hospital stay, complications, and clinical outcomes were recorded and analyzed.

Statistical analysis was performed using appropriate descriptive and inferential statistical methods. A p-value less than 0.05 was considered statistically significant.

Results: Patients who underwent early intubation demonstrated improved airway stabilization, reduced episodes of hypoxia, shorter ICU stay, and better neurological outcomes compared to patients undergoing delayed intubation. Delayed intubation was associated with increased incidence of respiratory complications, prolonged mechanical ventilation, and higher mortality rates.

Early intubation also contributed to improved hemodynamic stabilization and reduced secondary brain injury. However, procedure-related complications and ventilator-associated events were observed in both groups.

Conclusion: Early intubation in patients with severe traumatic brain injury was associated with improved clinical outcomes, reduced secondary complications, shorter intensive care stay, and lower mortality compared to delayed intubation. Appropriate airway management and timely intervention remain critical components in the management of severe TBI patients.
Early recognition of airway compromise and prompt intubation in selected patients may significantly improve neurological recovery and overall survival outcomes in severe traumatic brain injury.

Keywords: Traumatic Brain Injury, Early Intubation, Delayed Intubation, Severe TBI, Mechanical Ventilation, Airway Management, Critical Care, Neurological Outcome, Intensive Care Unit, Mortality.

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 11-05-2026
Date Acceptance: 19-05-2026
Date of Publication: 21-05-2026

INTRODUCTION

Traumatic brain injury (TBI) is one of the leading causes of mortality, disability, and socioeconomic burden worldwide, particularly among young and middle-aged adults [1]. Severe traumatic brain injury constitutes a major public health problem and is associated with high rates of morbidity, mortality, prolonged hospitalization, and long-term neurological impairment [2]. The severity of traumatic brain injury is commonly assessed using the Glasgow Coma Scale (GCS), with severe TBI generally defined as a GCS score of 8 or less [3]. Patients with severe traumatic brain injury frequently require intensive care management because of impaired airway reflexes, altered consciousness, respiratory insufficiency, and risk of secondary brain injury [4].

Secondary brain injury occurring after the initial traumatic insult significantly contributes to poor neurological outcomes and increased mortality. Hypoxia, hypercapnia, hypotension, aspiration, cerebral edema, and impaired cerebral perfusion are important preventable causes of secondary brain injury in severe TBI patients. Among these factors, hypoxia remains one of the strongest predictors of adverse neurological outcome and mortality. Therefore, maintaining adequate oxygenation and ventilation is considered a critical component in the management of severe traumatic brain injury [5].

Endotracheal intubation is frequently performed in severe TBI patients to secure the airway, protect against aspiration, facilitate oxygenation and ventilation, and allow appropriate sedation and mechanical ventilation [9]. Timely airway management may help prevent secondary cerebral insults and improve neurological recovery. Current trauma and critical care guidelines recommend airway protection and mechanical ventilation in patients with severe traumatic brain injury who demonstrate impaired consciousness, respiratory compromise, or inability to maintain airway patency [6].

Despite widespread use of endotracheal intubation in severe TBI patients, the optimal timing of intubation remains controversial. Early intubation may provide rapid airway stabilization, prevent hypoxic episodes, reduce aspiration risk, and improve cerebral oxygen delivery. Prompt control of ventilation may additionally help regulate arterial carbon dioxide levels and reduce intracranial pressure. Early airway protection may therefore minimize progression of secondary brain injury and improve survival outcomes [7].

However, early intubation is not without risks. Intubation procedures may be associated with hemodynamic instability, hypotension, increased intracranial pressure during laryngoscopy, ventilator-associated pneumonia, prolonged mechanical ventilation, airway trauma, and sedation-related complications. Unnecessary early intubation may also contribute to increased healthcare costs and intensive care burden. Conversely, delayed intubation may expose patients to recurrent hypoxia, aspiration, respiratory fatigue, and neurological deterioration before definitive airway control is established [8].

Several studies have evaluated the relationship between timing of intubation and outcomes in traumatic brain injury patients; however, available evidence remains inconsistent [18]. Some studies have demonstrated improved neurological and survival outcomes with early airway intervention, whereas others have reported increased ventilator-related complications without significant mortality benefit. Variations in patient selection, injury severity, prehospital management, and institutional protocols have contributed to conflicting findings in the literature [9].

In critically ill patients with severe traumatic brain injury, timely identification of airway compromise and appropriate intubation strategy are essential components of neurocritical care management [10]. Understanding the impact of timing of intubation on mortality, neurological recovery, mechanical ventilation duration, and intensive care outcomes may assist clinicians in optimizing airway management protocols and improving patient outcomes.

Hence, the present study was undertaken to compare the outcomes of early versus delayed intubation in

patients with severe traumatic brain injury admitted to the Department of Critical Care in a tertiary care hospital.

AIM AND OBJECTIVES

Aim: To compare the outcomes of early versus delayed intubation in patients with severe traumatic brain injury admitted to a tertiary care hospital.

Objectives

1. To compare mortality rates between early and delayed intubation groups in severe traumatic brain injury patients.
2. To evaluate neurological outcomes among patients undergoing early versus delayed intubation.
3. To compare duration of mechanical ventilation, intensive care unit stay, and total hospital stay between the two groups.
4. To assess complications associated with early and delayed intubation in severe traumatic brain injury patients.
5. To determine the impact of timing of intubation on overall clinical outcome and survival in severe traumatic brain injury patients.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective observational comparative study.

Study Setting

The study was conducted in the Department of Critical Care at a tertiary care hospital.

Study Duration

The study was conducted over a period of one year during the period of January 2025 to December 2025.

Study Population

The study population included patients admitted with severe traumatic brain injury requiring critical care management and airway support.

Sample Size

A total of 50 patients were included in the study.

Study Groups

Patients were categorized into two groups based on timing of intubation:

- Group A: Early intubation group
- Group B: Delayed intubation group

Each group consisted of 25 patients.

Inclusion Criteria

1. Patients aged between 30 and 60 years.
2. Patients diagnosed with severe traumatic brain injury with Glasgow Coma Scale (GCS) score ≤8.
3. Patients requiring airway management and intensive care admission.
4. Patients admitted within 24 hours of injury.

Exclusion Criteria

1. Patients with polytrauma involving major thoracic or abdominal injuries.
2. Patients with pre-existing chronic neurological disorders.
3. Patients with severe cardiopulmonary instability unrelated to traumatic brain injury.
4. Patients with prior endotracheal intubation before hospital arrival.
5. Patients with documented do-not-resuscitate status.

Data Collection Procedure

Eligible patients fulfilling the inclusion and exclusion criteria were enrolled in the study. Detailed clinical history, demographic characteristics, mode of injury, Glasgow Coma Scale score, hemodynamic parameters, radiological findings, and associated clinical features were recorded using a structured proforma.

Patients were categorized according to timing of intubation:

- Early intubation group included patients intubated immediately or within the initial stabilization period following admission.
- Delayed intubation group included patients who underwent intubation after clinical deterioration or delayed respiratory compromise.

Patients were monitored throughout hospital stay for clinical progress, complications, and outcomes.

Outcome Measures

Primary Outcome Measures

1. Mortality rate
2. Neurological outcome based on Glasgow Outcome Scale

Secondary Outcome Measures

1. Duration of mechanical ventilation
2. Intensive care unit stay
3. Total hospital stay
4. Incidence of ventilator-associated pneumonia
5. Aspiration-related complications
6. Hemodynamic instability
7. Requirement for tracheostomy

Statistical Analysis

Data were entered into Microsoft Excel spreadsheet and analyzed using Statistical Package for Social Sciences (SPSS) software.

Descriptive statistics including mean, standard deviation, frequency, and percentage were used for data presentation. Inferential statistical methods including Chi-square test and Student's t-test were applied to compare outcomes between study groups. A p-value less than 0.05 was considered statistically significant.

Ethical Considerations

Institutional Ethics Committee approval was obtained prior to commencement of the study. Due consent was obtained from patient attendants or legally authorized representatives before enrollment. Confidentiality of patient information was strictly maintained throughout the study period. The study was conducted in accordance with ethical

principles and institutional guidelines for biomedical research.

RESULTS

A total of 50 patients with severe traumatic brain injury were included in the present prospective observational comparative study conducted in the Department of Critical Care of a tertiary care hospital over a period of one year. Patients were categorized into early intubation and delayed intubation groups with 25 patients in each group.

The study demonstrated that patients undergoing early intubation had comparatively better clinical outcomes, lower mortality, shorter duration of mechanical ventilation, reduced ICU stay, and improved neurological recovery compared to patients undergoing delayed intubation. Delayed intubation was associated with increased respiratory complications, prolonged hospitalization, and higher incidence of ventilator-associated complications.

The majority of patients belonged to the age group of 41–50 years, and male patients constituted the predominant proportion of the study population. Road traffic accidents were the most common mode of injury observed in both groups.

Neurological deterioration, hypoxic episodes, and aspiration-related complications were more frequently observed among delayed intubation patients. Early airway stabilization contributed to improved oxygenation and hemodynamic control, thereby reducing the risk of secondary brain injury.

Overall, early intubation demonstrated favorable outcomes in terms of mortality, neurological status, and intensive care management among severe traumatic brain injury patients.

Table 1: Age-Wise Distribution of Study Participants

Age group (years)	Early Intubation (n=25)	Delayed Intubation (n=25)	Total (%)
30–40	7	6	13 (26.0%)
41–50	11	12	23 (46.0%)
51–60	7	7	14 (28.0%)

The above table shows that the majority of patients belonged to the 41–50 years age group accounting for 46.0% of the total study population, followed by 51–60 years age group with 28.0% and 30–40 years age group with 26.0%. Similar age distribution was observed in both study groups.

Table 2: Gender Distribution among Study Participants

Gender	Early Intubation (n=25)	Delayed Intubation (n=25)	Total (%)
Male	18	19	37 (74.0%)
Female	7	6	13 (26.0%)

The above table shows that males constituted the majority of study participants accounting for 74.0%, while females represented 26.0% of the total study population.

Table 3: Mode of Injury among Study Participants

Mode of Injury	Early Intubation (n=25)	Delayed Intubation (n=25)	Total (%)
Road traffic accident	16	17	33 (66.0%)
Fall from height	6	5	11 (22.0%)
Assault	3	3	6 (12.0%)

The above table shows that road traffic accidents were the most common mode of injury accounting for 66.0% of cases, followed by fall from height in 22.0% and assault in 12.0% of patients.

Table 4: Glasgow Coma Scale (GCS) Score at Admission

GCS Score	Early Intubation (n=25)	Delayed Intubation (n=25)	Total (%)
3–5	10	11	21 (42.0%)
6–8	15	14	29 (58.0%)

The above table shows that 58.0% of patients had GCS scores between 6–8, while 42.0% demonstrated severe neurological impairment with GCS scores between 3–5 at admission.

Table 5: Duration of Mechanical Ventilation

Duration of Mechanical Ventilation	Early Intubation (n=25)	Delayed Intubation (n=25)
Mean duration (days)	5.8 ± 2.1	9.4 ± 3.5

The above table shows that patients in the delayed intubation group required significantly longer duration of mechanical ventilation compared to the early intubation group.

Table 6: ICU Stay among Study Participants

ICU Stay	Early Intubation (n=25)	Delayed Intubation (n=25)

Mean ICU stay (days)	7.2 ± 2.8	11.6 ± 4.2

The above table shows that patients undergoing delayed intubation had prolonged ICU stay compared to patients receiving early intubation.

Table 7: Incidence of Ventilator-Associated Pneumonia

Ventilator-associated Pneumonia	Early Intubation (n=25)	Delayed Intubation (n=25)
Present	4 (16.0%)	9 (36.0%)
Absent	21 (84.0%)	16 (64.0%)

The above table shows that ventilator-associated pneumonia was more frequently observed among delayed intubation patients accounting for 36.0% compared to 16.0% in the early intubation group.

Table 8: Aspiration-Related Complications among Study Groups

Aspiration-related Complications	Early Intubation (n=25)	Delayed Intubation (n=25)
Present	3 (12.0%)	10 (40.0%)
Absent	22 (88.0%)	15 (60.0%)

The above table shows that aspiration-related complications were significantly higher in the delayed intubation group compared to the early intubation group.

Table 9: Mortality among Study Participants

Mortality	Early Intubation (n=25)	Delayed Intubation (n=25)
Survived	20 (80.0%)	14 (56.0%)
Expired	5 (20.0%)	11 (44.0%)

The above table shows that mortality was higher among delayed intubation patients with mortality rate of 44.0% compared to 20.0% in the early intubation group.

Table 10: Neurological Outcome Based on Glasgow Outcome Scale

Glasgow Outcome Scale	Early Intubation (n=25)	Delayed Intubation (n=25)
Good recovery	11 (44.0%)	5 (20.0%)
Moderate disability	7 (28.0%)	6 (24.0%)
Severe disability	2 (8.0%)	3 (12.0%)
Death	5 (20.0%)	11 (44.0%)

The above table shows that good neurological recovery was more frequently observed among early intubation patients, while delayed intubation patients demonstrated higher mortality and poorer neurological outcomes.

Table 1 demonstrated that the majority of patients belonged to the 41–50 years age group accounting for 46.0% of the study population, followed by the 51–60 years age group at 28.0% and the 30–40 years age group at 26.0%. Age distribution was comparable between early and delayed intubation groups, indicating uniform baseline demographic characteristics. Table 2 showed that male patients constituted the predominant proportion of the study population with 74.0% cases, whereas females accounted for 26.0%. This finding reflects the higher incidence of traumatic brain injury among males, likely due to increased exposure to road traffic accidents and occupational injuries. Table 3 demonstrated that road traffic accidents were the most common mode of injury accounting for 66.0% of cases, followed by fall from height in 22.0% and assault in 12.0% of patients. The predominance of road traffic accidents highlights their major contribution to severe traumatic brain injury in critically ill patients. Table 4 revealed that 58.0% of patients presented with Glasgow Coma Scale scores between 6–8, while 42.0% had severe neurological impairment with GCS scores between 3–5 at admission. Both study groups demonstrated comparable severity of traumatic brain injury at baseline. Table 5 demonstrated that patients undergoing delayed intubation required prolonged mechanical ventilation with a mean duration of 9.4 ± 3.5 days compared to 5.8 ± 2.1 days in the early intubation group. This finding suggests that delayed airway stabilization may contribute to prolonged respiratory compromise and ventilatory dependence. Table 6 showed that delayed intubation patients had significantly longer intensive care unit stay with a mean duration of 11.6 ± 4.2 days compared to 7.2 ± 2.8 days among early intubation patients. Early airway management therefore appeared to contribute to improved stabilization and shorter critical care requirement. Table 7 demonstrated that ventilator-associated pneumonia occurred more frequently among delayed intubation patients accounting for 36.0% compared to 16.0% in the early intubation group. Increased respiratory complications among delayed intubation patients may be attributed to recurrent hypoxia, aspiration, and delayed airway protection. Table 8 revealed that aspiration-related complications were significantly more common in the delayed intubation group with

40.0% incidence compared to 12.0% among early intubation patients. Delayed airway control may therefore increase risk of aspiration and secondary pulmonary complications. Table 9 demonstrated that mortality was considerably higher among delayed intubation patients with mortality rate of 44.0% compared to 20.0% in the early intubation group. Early intubation was therefore associated with improved survival outcomes in severe traumatic brain injury patients. Table 10 showed that favorable neurological recovery was more frequently observed among early intubation patients, where 44.0% achieved good recovery compared to only 20.0% in the delayed intubation group. Delayed intubation patients demonstrated poorer neurological outcomes and higher mortality, indicating the beneficial role of timely airway management in severe traumatic brain injury.

DISCUSSION

The present prospective observational comparative study was conducted to compare the outcomes of early versus delayed intubation in patients with severe traumatic brain injury admitted to the Department of Critical Care at a tertiary care hospital. Severe traumatic brain injury remains one of the leading causes of mortality and neurological disability worldwide, and prevention of secondary brain injury through timely airway stabilization and adequate oxygenation remains a cornerstone of neurocritical care management [11,12].

In the present study, the majority of patients belonged to the 41–50 years age group, and male patients constituted the predominant proportion of the study population. Similar findings have been reported in previous traumatic brain injury studies where middle-aged males were more commonly affected due to increased exposure to road traffic accidents, occupational trauma, and high-risk activities [24]. Road traffic accidents were identified as the most common mode of injury in the present study, accounting for 66.0% of cases, which is consistent with epidemiological trends reported in developing countries [13].

The present study demonstrated that delayed intubation was associated with prolonged duration of mechanical ventilation and longer intensive care unit stay compared to early intubation. Patients undergoing delayed intubation required significantly prolonged ventilatory support and critical care monitoring. These findings suggest that delayed airway stabilization may contribute to worsening respiratory compromise, recurrent hypoxic episodes, and progression of secondary brain injury. Similar observations were reported by Wang et al., who demonstrated that delayed airway intervention in severe traumatic brain injury increased the risk of respiratory deterioration and prolonged intensive care requirement [14].

Early intubation provides rapid airway protection, improved oxygenation, controlled ventilation, and prevention of aspiration-related complications. Adequate control of oxygenation and arterial carbon dioxide levels is essential in severe traumatic brain injury to minimize intracranial hypertension and prevent cerebral ischemia. Davis et al. reported that early airway management significantly reduced episodes of hypoxia and secondary neurological insults among critically ill trauma patients [15].

In the present study, ventilator-associated pneumonia and aspiration-related complications were more frequently observed among delayed intubation patients. Delayed airway protection may expose patients to recurrent aspiration events, inadequate airway clearance, and pulmonary complications, thereby increasing morbidity and duration of hospitalization. Similar findings were observed by Bochicchio et al., who reported increased pulmonary complications and aspiration pneumonia among trauma patients with delayed airway stabilization [16].

Mortality was substantially higher among delayed intubation patients in the present study compared to the early intubation group. Early airway stabilization likely contributed to improved cerebral oxygen delivery, reduced secondary insults, and better hemodynamic stabilization. Hypoxia and hypotension are well-established predictors of poor neurological outcome and mortality in severe traumatic brain injury patients [17]. Prevention of secondary brain injury through timely airway management therefore plays a critical role in improving survival outcomes.

Neurological outcomes were comparatively more favorable among early intubation patients in the present study. A higher proportion of patients in the early intubation group achieved good neurological recovery based on Glasgow Outcome Scale assessment. Delayed intubation patients demonstrated poorer neurological recovery and higher mortality rates. Similar findings have been reported in previous neurocritical care studies where early airway control was associated with improved cerebral perfusion and neurological recovery [18].

The beneficial effect of early intubation may be explained by prevention of recurrent hypoxia, aspiration, hypercapnia, and respiratory fatigue. Controlled mechanical ventilation helps optimize cerebral oxygenation and reduces fluctuations in intracranial pressure [19]. Early sedation and airway stabilization may additionally facilitate safer transport, imaging, and critical care interventions in severe traumatic brain injury patients.

However, intubation itself is associated with certain risks including hypotension during induction, airway trauma, ventilator-associated pneumonia, prolonged sedation, and increased mechanical ventilation requirement [20]. Therefore, airway management decisions should be individualized

according to neurological status, respiratory compromise, hemodynamic stability, and overall clinical condition of the patient.

The findings of the present study emphasize the importance of timely airway assessment and early intervention in severe traumatic brain injury patients admitted to intensive care units. Early intubation may reduce secondary neurological injury, improve survival, shorten ICU stay, and enhance neurological recovery. These findings support the role of prompt airway stabilization as an essential component of neurocritical care management.

Limitations of the Study

1. The study was conducted in a single tertiary care centre with a relatively small sample size.
2. Long-term neurological follow-up was not assessed.
3. Variations in prehospital care and transport time were not evaluated separately.
4. Severity of associated extracranial injuries may have influenced outcomes.
5. The observational study design limits establishment of definitive causal relationship between timing of intubation and outcomes.

CONCLUSION

The present study demonstrated that early intubation in patients with severe traumatic brain injury was associated with better clinical outcomes compared to delayed intubation. Patients undergoing early airway stabilization showed reduced duration of mechanical ventilation, shorter intensive care unit stay, lower incidence of aspiration-related complications, reduced ventilator-associated pneumonia, improved neurological recovery, and lower mortality rates.

Delayed intubation was associated with increased respiratory complications, prolonged hospitalization, poorer neurological outcomes, and higher mortality. Recurrent hypoxia, aspiration, and delayed airway protection likely contributed to progression of secondary brain injury among delayed intubation patients.

Timely airway management plays a crucial role in preventing secondary cerebral insults and improving survival in severe traumatic brain injury patients. Early stabilization of oxygenation and ventilation may help optimize cerebral perfusion, reduce intracranial complications, and improve overall neurological recovery.

The findings of the present study highlight the importance of prompt airway assessment and early intubation in selected severe traumatic brain injury patients admitted to critical care units. Appropriate airway management protocols and timely intervention may significantly improve patient outcomes and reduce critical care burden.

Further large-scale multicentric studies with long-term neurological follow-up are recommended to better evaluate the impact of timing of intubation on outcomes in severe traumatic brain injury patients and to establish standardized airway management guidelines in neurocritical care practice.

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How to cite this article: Dr. Laxmi Deepak Nagul, Dr Potlapelly Vasu Prakash, Dr. Sushma Priyanka Tangella, COMPARISON OF EARLY VERSUS DELAYED INTUBATION OUTCOMES IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY, Asian J. Med. Res. Health Sci., 2026; 4 (2):404-411.

Source of Support: Nil, Conflicts of Interest: None declared.