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Early Tracheostomy versus Late Tracheostomy in Patients with Moderate-to-Severe Traumatic Brain Injury

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Abstract

Objective The aim of this article was to study the impact of early versus late tracheostomy on clinical outcomes of moderate-to-severe traumatic brain injury (TBI).

Materials and Methods A retrospective cross-sectional study was conducted in the Neurosurgery Department, Mayo Hospital, Lahore, in which a sample size of 50 cases was calculated over a period of 6 months from January 1, 2022, to June 30, 2022. The included cases were patients who suffered from moderate-to-severe TBI, isolated TBI, needed elective ventilation, required intensive care unit (ICU) admission during their hospital stay, and were between the ages of 18 and 65 years. All the rest were excluded. A structured proforma was used by the physician to collect data after the informed consent of the patient. The results were computed and analyzed statistically using *Statistical Package for Social Sciences*, version 26.

Results The median age of patients was 40 (interquartile [IQ] range 34) years and were predominantly male (72%). The most common mode of injury was road traffic accidents (58%). The median Glasgow Coma Scale (GCS) score at arrival was 8 (IQ range 6) and the most common pupillary light reflex at presentation was bilaterally equally responsive to light (68%). Neurologic deficits were mostly absent or cannot be assessed on presentation (86%) and in 38% of the cases multiple findings were noted on computed tomography (CT) scan while among single findings seen on CT scan, subdural hematoma was the most common (22%). Multiple regression analysis was done through two separate models using age, gender, mode of injury, presenting GCS score, number of CT-scan findings, number of days after endotracheal intubation after which tracheostomy was done, and the timing of tracheostomy (early vs. late) as predictors, and a significant relationship was noted between the timing of tracheostomy (early vs. late) and GCS at discharge ($p = 0.001$) as well as extended Glasgow Outcome Score (GOS) at discharge ($p = 0.013$).

Conclusion This study suggests that moderate-to-severe TBIs are most common in middle-aged males and mostly involve road traffic accidents. In most cases, multiple CT-scan findings are seen as compared with a single predominant finding. In such patients, early tracheostomy is superior to late tracheostomy as it results in significantly better GCS and GOS scores at discharge as well as a decreased duration of mechanical ventilation and ICU stay.

Keywords

- traumatic brain injury
- early versus late tracheostomy
- severe TBI
- multiple CT scan findings
- road traffic accident
- high-energy brain trauma
- brain

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Introduction

Traumatic brain injury (TBI) is a nondegenerative, acquired insult to the brain resulting from an external mechanical force.[1] TBI may be caused by a simple bump of the head or may be caused by trauma as severe as a penetrating injury. The resulting TBI not only depends on the mechanism of injury, but also involves the demographics of the patient as well the underlying comorbidities that affect the outcome of the patient after TBI.[2]

TBI is one of the leading causes of mortality and morbidity worldwide. It is estimated approximately 1.7 million head injuries are encountered every year in the United States alone. There were approximately 223,135 TBI-related hospitalizations in 2019 and 64,362 TBI-related deaths in 2020.[3] This represents approximately 611 TBI-related hospitalizations and 176 TBI-related deaths per day. These are the estimates even when many TBIs that are only treated in the emergency department, primary care, and urgent care, or those that go untreated are not included.[4] Such an impact is much worse in developing countries like Pakistan, where the per capita income is low and the dependence ratio is high. Moreover, there are more cases of frequent delays in the acquisition of medical attention and negligence, which usually leads to the exacerbation of the sequelae of TBI.[5]

Pakistan is a low-income country with a population of over 180 million and a high rate of TBIs. It was reported in 2022 that nearly 800,000 people suffer from TBI in Pakistan, out of which nearly 60,000 to 70,000 people suffer from significant morbidity and mortality leading to long-term disability, morbidity, and mortality.[6] TBI is the main cause of death in severely injured trauma patients and contributes to at least 30% of deaths caused by trauma.[7] The severity of TBI can be classified according to factors such as computed tomography (CT) scan findings, duration of loss of consciousness and altered state of consciousness, as well as the duration of posttraumatic amnesia. Glasgow Coma Scale (GCS) score also plays a vital role in the classification of the severity of TBI.[8] Most patients with moderate-to-severe TBI face difficulties such as neurologic deficits followed by the need for endotracheal tube (ET) intubation and ultimately tracheostomy.[9]

Furthermore, both ET intubation and tracheostomy are associated with their respective complications such as excessive cuff pressure causing tracheal injury, inability to seal the airway, laryngeal injury, and difficulty in suctioning tracheobronchial secretions in case of ET intubations. Whereas, in the case of tracheostomy, complications including stoma infection, stoma hemorrhage, and subcutaneous emphysema can be seen.[10] Therefore, there is a need to specify the timing of tracheostomy by analyzing the outcomes of patients in cases of moderate-to-severe TBI. This has been in debate for a long time and there have been studies that highlight the importance of early tracheostomy over late tracheostomy but it has been limited to the outcome of ventilator-free days, due to which the overall relationship remains unproven.[11,12]

Therefore, to ascertain this relationship between the timing of tracheostomy after moderate-to-severe TBI and the overall outcome of the patient, we will be focusing on the condition of the patient on arrival with the help of variables including the score on GCS, pupillary reaction, loss of consciousness, and CT scan findings, while also focusing on the outcome of the patient using variables including GCS score at discharge, extended Glasgow Outcome Score (eGOS) at discharge (where 1 denotes dead patient and 8 denotes good recovery), and duration of intensive care unit (ICU) stay. In this way, we want to study the impact of early versus late tracheostomy on the clinical outcome of moderate-to-severe TBI.

Materials and Methods

A retrospective cross-sectional study was conducted in the Neurosurgery Department, Emergency Complex, Mayo Hospital, Lahore, for 6 months, from January 1, 2022, to June, 30, 2022. The sample size of our study was 50 participants.

The patients who were included in the study were patients who suffered from moderate-to-severe TBI (commonly associated with prolonged hospitalization, complications, low GCS score, and mechanical ventilation, which has been associated with a need for tracheostomy), isolated TBI (to exclude other causes of declining GCS score and other clinical parameters that can ultimately affect outcomes, such as GCS and GOS scores at discharge as well as duration of hospital and ICU stay), needed elective ventilation as well as ICU admission during their hospital stay (as tracheostomy is done to improve outcomes associated with prolonged ET intubation, such as duration of ventilation, hospital stay, ICU stay, and overall mortality; the setting necessary for these parameters is intensive care at least until the patient can be weaned off the ventilator, which is also facilitated by tracheostomy),[13] and patients between ages of 18 and 65 years (multiple clinical trials are going on to study the impact of age on TBI and they usually divide age into three categories, that is, 0 to 17 years, 18 to 65 years, and more than 65 years; following this trend, we decided to include the cohort with the maximum representation of our population).[14] The patients who were excluded from the study were patients who had a spontaneous or metabolic event due to comorbidities leading to a non-TBI, polytrauma patients who presented with multiple injuries (additional factors are associated with polytrauma; for example, oral and maxillofacial injuries might act as a separate indication for tracheostomy), patients with tracheobronchial injuries (unable to secure airway with the help of tracheostomy), patients who underwent chest intubation following trauma (associated with chest trauma and hemorrhage as a part of polytrauma cases), and patients aged less than 18 years and more than 65 years (there is an increased risk of TBI in the young and elderly due to the involvement of varied mechanisms and differences in pathogenesis, which can act as confounding factors).[14]

The indications for tracheostomy in our study included declining or persistently low GCS score (<8) despite active management, difficulty weaning off from mechanical ventilation, and management of aspiration pneumonia and/or ventilator-associated pneumonia. For this study, the duration/timing of tracheostomy was divided into early (defined as ≤ 5 days after ET intubation) and late tracheostomy (defined as >5 days after ET intubation). A structured proforma highlighting demographics, clinical–radiological findings, and outcomes of the patients in regard to the timing of the tracheostomy was used to collect data along with consent from the participant in the regional language after proper disclosures.

The data were analyzed using the latest version of the *Statistical Package for Social Sciences*, version 26 (IBM SPSS Statistics for Windows, Version 26.0, released 2019; IBM Corp., Armonk, New York, United States). It was represented graphically using different tables and charts. Moreover, statistical tests including the chi-squared test and Mann–Whitney *U*-test were used to assess the significance of different quantitative and qualitative variables with the respective early and late tracheostomy groups. Furthermore, multiple regression analysis was used to confirm the influence of the timing of tracheostomy on the outcome variables in the presence of different confounding variables.

Results

Overall Population

The median age of patients included in our study was 40 (interquartile [IQ] range 34) years. The greatest percentages were seen at the two extremes of the age groups, that is, 16 to 25 years (32%) and 56 to 65 years (24%). Moreover, the patients were predominantly male (72%; $n = 36$) and the most common mode of injury was a road traffic accident, which was seen in 58% of cases ($n = 29$; ►**Fig. 1**).

The clinical–radiological findings seen at the presentation in the hospital included GCS score, pupillary size and reaction to light, neurological deficit, and CT scan findings. The median GCS score at arrival was 8 (IQ range 6) whereas the most common pupillary light reflex at presentation was bilaterally equally responsive to light (68%; $n = 34$) followed by bilaterally equal and sluggishly reactive to light (22%; $n = 11$; ►**Fig. 2**). Neurologic deficits were mostly absent or could not be assessed on presentation (86%; $n = 43$).

In 38% ($n = 19$) of the cases multiple findings were noted on CT scan while among cases in which a single finding was seen on CT scan, subdural hematoma was the most common (22%; $n = 11$; ►**Fig. 3**). In 52% of cases ($n = 26$) early tracheostomy was done while in 48% of cases ($n = 24$) late tracheostomy was done.

Early Tracheostomy versus Late Tracheostomy

The cases in which early tracheostomy was done showed better GCS score at discharge (7.96 ± 3.376), better GOS at discharge (3.04 ± 1.483), decreased duration of mechanical ventilation (8 ± 4.508), decreased duration of ICU stay (10.88 ± 3.421), and decreased duration of overall hospital stay (16.42 ± 4.785) as compared with the cases in which late tracheostomy was done (►**Table 1**).

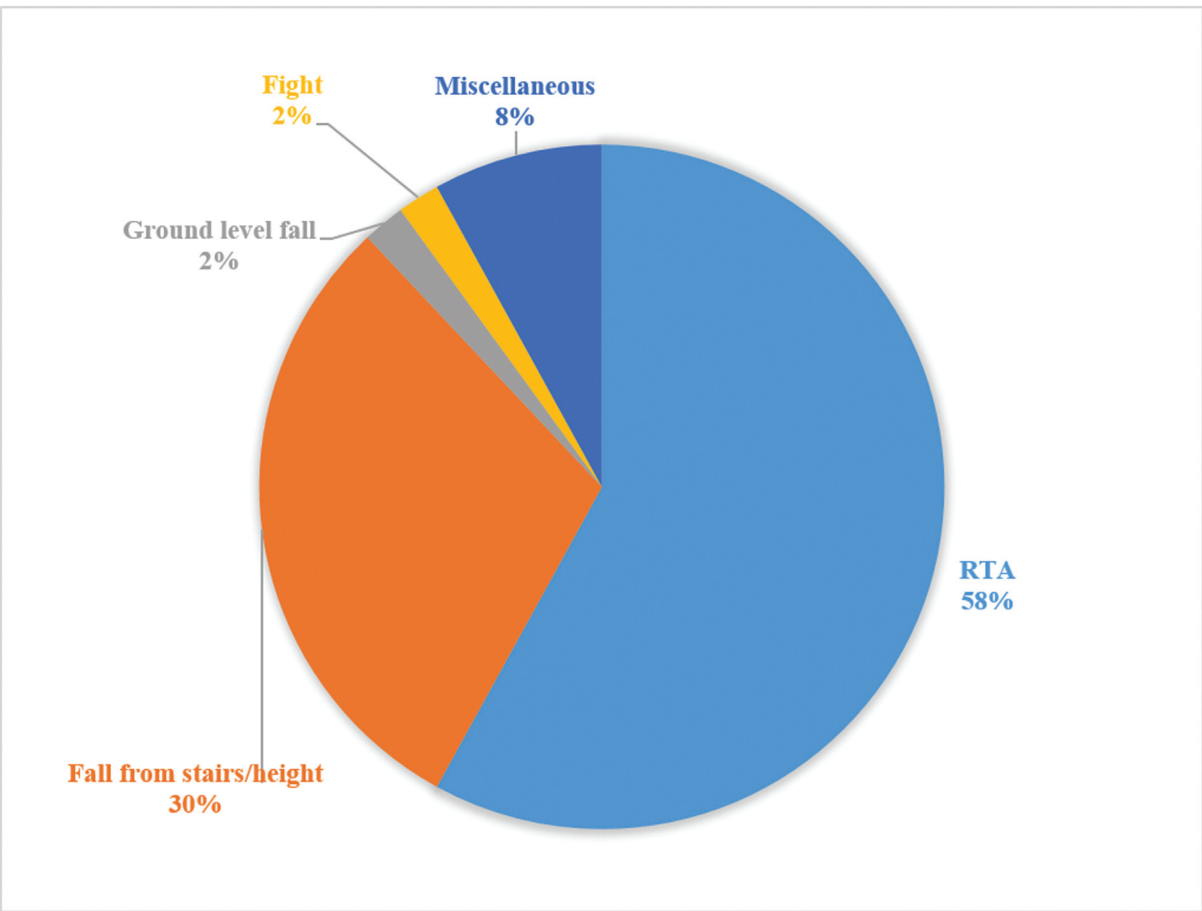

Fig. 1 Mechanism of injury (percentages) of the patients suffering from moderate-to-severe traumatic brain injury. RTA, road traffic accident.

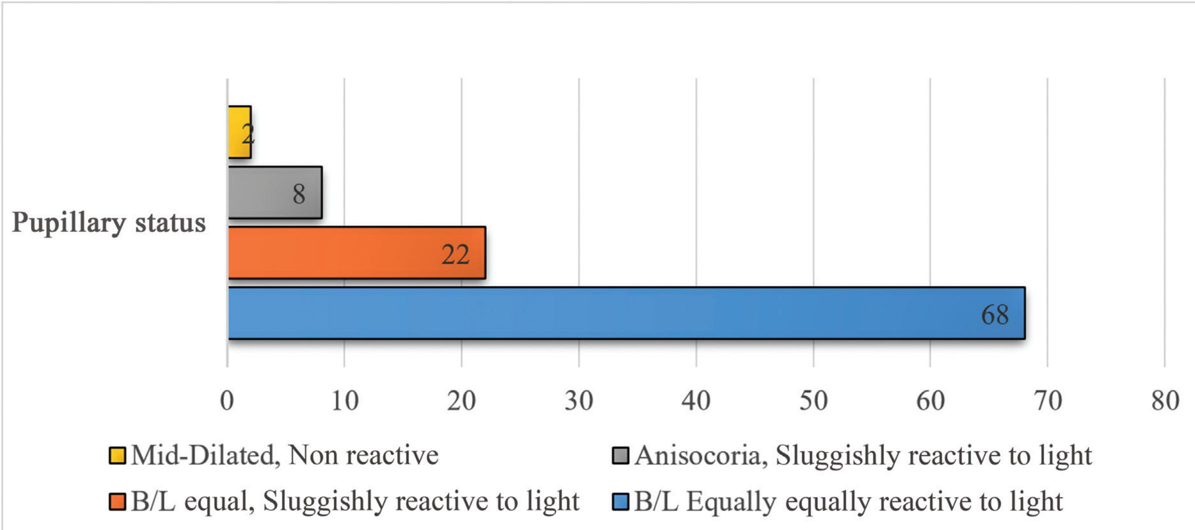

Fig. 2 Reaction of pupils to light noted at presentation of patients to the hospital (percentages).

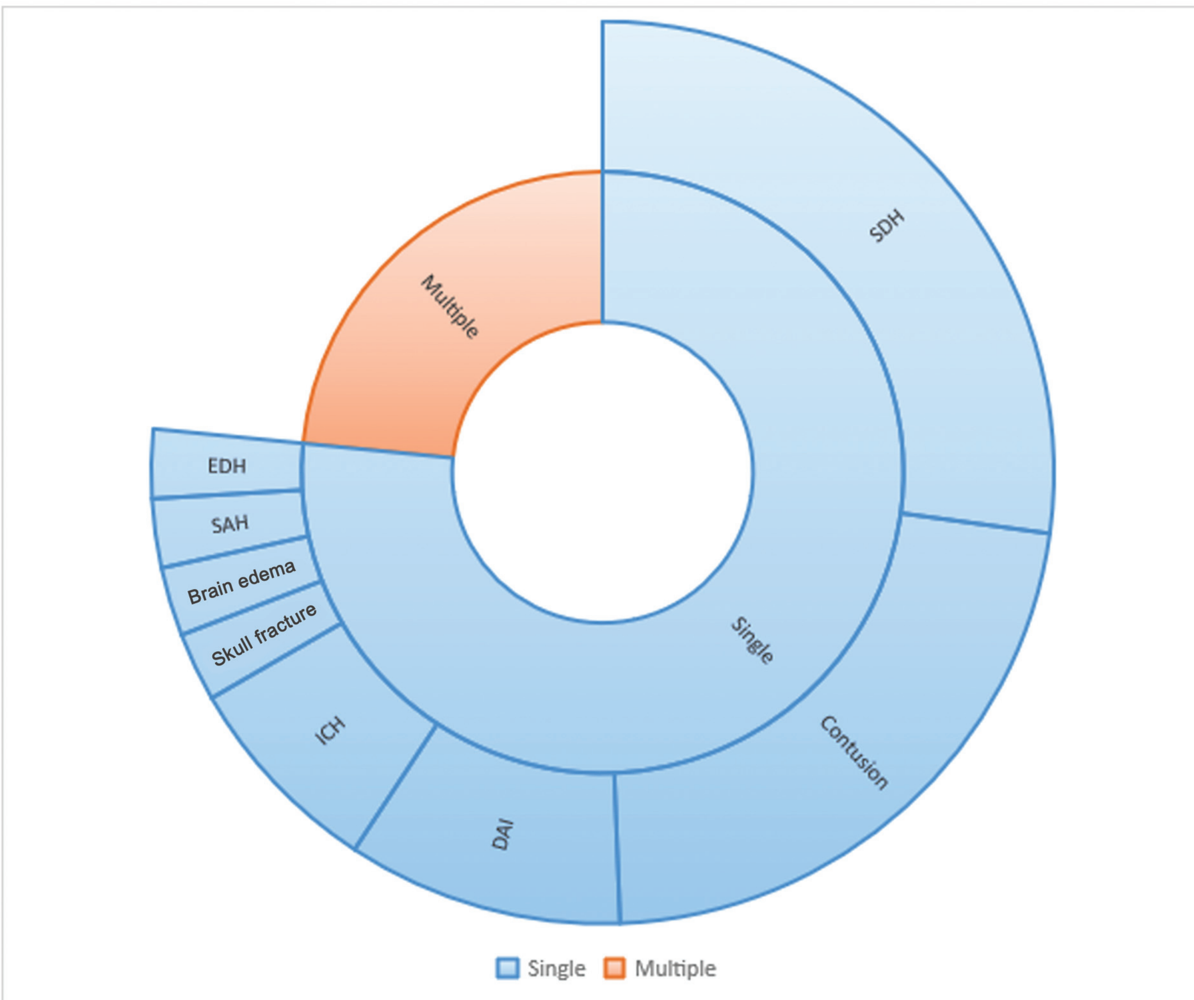

Fig. 3 Computed tomography (CT) scan findings of patients suffering from moderate-to-severe traumatic brain injury. Multiple CT scan findings, 19 cases; and single CT scan finding, 31 cases (subdural hematoma, 11; contusion, 9; diffuse axonal injury [DAI], 4; intracranial hemorrhage [ICH], 3; extradural hematoma [EDH], 1; subarachnoid hemorrhage [SAH], 1; depressed skull fracture, 1; and brain edema, 1).

Table 1 Comparison of early versus late tracheostomy in patients with severe traumatic brain injury

Variables	Early tracheostomy	Late tracheostomy	*p*-Value
Number of patients (*N*)	26	24	–
Age of patients (years): median (IQ range)	32.5 (32)	43.5 (34)	0.117
Gender of patients: male/female	18/8	18/6	0.650
Mechanism of injury: RTA/non-RTA	15/11	14/10	0.963
GCS at presentation: median (IQ range)	8 (5)	8 (8)	0.545
Pupillary response: reactive/nonreactive	18/8	16/8	0.846
Neurological deficit: present/absent	2/24	5/19	0.181
CT scan findings: single/multiple	16/10	14/10	0.817
Days after ET intubation when tracheostomy was done: median (IQ range)	4 (2)	7.5 (6)	<0.001[a]
Duration of mechanical ventilation (days): median (IQ range)	7 (6)	14.5 (15)	<0.001[a]
Duration of ICU stay (days): median (IQ range)	11.5 (5)	16.5 (15)	<0.003[a]
Duration of hospital stay (days): median (IQ range)	16 (6)	22 (18)	0.102
GCS at discharge: median (IQ range)	9 (8)	3 (0)	<0.001[a]
eGOS at discharge: median (IQ range)	**3 (3)**	**1 (0)**	**<0.001[a]**

Abbreviations: CT, computed tomography; ET, endotracheal tube; eGOS, extended Glasgow Outcome Score; GCS, Glasgow Coma Scale; ICU, intensive care unit; IQ, interquartile; RTA, road traffic accident.
[a]Statistically significant *p*-Value (<0.05) as calculated by Mann–Whitney *U*-test or chi-squared test, as appropriate.

Multiple Regression Analysis

Linear multiple regression analysis was used and two models were tested using eGOS at discharge and GCS score at discharge as the dependent variables, respectively, whereas age, gender, mode of injury, GCS score at arrival, number of CT scan findings, number of days after ET intubation after which tracheostomy was done, and timing of tracheostomy (early vs. late tracheostomy) were used as predictors.

In the first model, there was a significant relationship between eGOS at discharge and the age of the patient ($p = 0.041$), GCS score of the patient at arrival ($p = 0.022$), and timing of tracheostomy (early vs. late tracheostomy) ($p = 0.013$) when other predictors were accounted for. This model had overall an intermediate power of prediction (R^2 value = 0.353).

In the second model, there was only a significant relationship between GCS score at discharge and the timing of tracheostomy (early vs. late tracheostomy) ($p = 0.001$) when the same predictors were accounted for. Overall, this model also had intermediate power of prediction (R^2 value = 0.410).

Therefore, multiple regression analysis shows that the timing of tracheostomy (early vs. late tracheostomy) has a significant relationship with both GCS and eGOS scores at discharge when age, gender, mode of injury, GCS score at arrival, number of CT scan findings, and number of days after ET intubation after which tracheostomy was done were accounted for as confounding variables.

Discussion

Demographics

The age of subjects in our study population mostly lay in the extremities of age groups: older adolescents (15–19 years) and older adults (≥60 years). Moreover, the male-to-female ratio of our study population was approximately 2.5 to 1, which correlates with the epidemiological studies conducted on TBI.[15] However, there was a significant difference between the ages of our population and a retrospective study conducted by Skaansar et al on TBI, which comprised more than 1,500 participants ($p < 0.001$).[16] This change can be attributed to nearly half of the participants of that study being those who received mild TBI whereas our study only included those patients who received moderate-to-severe TBI. More than half of the patients in our study reported road traffic accidents to be the source of TBI. Another study conducted in Pakistan also highlighted the predominant role of road traffic crashes in TBI highlighting road traffic accidents to be the cause in 48.6% of the cases.[17] This highlights the need for the education of the masses regarding the issue as well as the implementation of strict traffic regulations to decrease the incidence of road traffic accidents, ultimately causing a decrease in the incidence of TBIs.

Findings at Presentation

The overall GCS score of the patients on presentation in our study was low (<9). This can be associated with factors such as an ineffective referral system to specialist care centers, the prolonged time duration between injury and hospital presentation, inefficient transportation means, and insufficient emergency at the site of primary presentation after trauma. Moreover, multiple CT scan findings were found in two-fifths of the study population indicating the severity of the trauma, and among single CT scan findings, a subdural hematoma was the most common finding followed by intracerebral contusion. A similar study conducted in a tertiary care hospital in Pakistan reported different results as compared with our study, with intracerebral contusion being the most common finding that can be attributed to differences in demographics between the two studies.[5]

Comparison of Early versus Late Tracheostomy

The number of patients in both groups was similar and the patients who underwent early tracheostomy showed better GCS score at discharge, better GOS at discharge, decreased duration of mechanical ventilation, decreased duration of ICU stay, and decreased duration of overall hospital stay. Similar results were reported by a CENTER-TBI study conducted by Robba et al.[9] Moreover, late tracheostomy and prolonged ET intubation are also associated with a higher incidence of ventilator-associated pneumonia, prolonged ventilation as well as ICU stay, increased rate of complications, and ultimately increased mortality according to another study conducted in Pakistan.[18]

Limitations

The study highlighted the importance of early tracheostomy in patients with moderate-to-severe TBI, but it was limited to a single center and data were collected retrospectively to study the outcomes in patients. Moreover, there was a lack of proper follow-up of the patients and a lack of discussion regarding the reversal of tracheostomy and its implications. Therefore, there is a need to conduct a multicenter study involving different tertiary care facilities with specialist centers to establish a protocol for the selection of patients for an early tracheostomy to decrease the overall mortality and morbidity associated with TBIs.

Conclusion

The study suggests that moderate-to-severe TBIs are most common in middle-aged males and mostly involve road traffic accidents. In most cases, multiple CT scan findings are seen as compared with a single predominant finding. In such patients, early tracheostomy is superior to late tracheostomy as it results in significantly better GCS and GOS scores at discharge as well as a decreased duration of mechanical ventilation and ICU stay.

Authors' Contributions

U.N. was involved in the data collection, data analysis, and arranging as well as writing the final manuscript. T.F. was involved in conception of the idea of the study and review of the final manuscript. A.F. helped in data collection as well as writing the final manuscript. U.H. contributed to data analysis and review of the final manuscript. A.A. helped in the final review of the manuscript and providing scientific revisions to the manuscript.

Ethical Approval

This study conforms to the principles outlined in the Declaration of Helsinki. All research involving human participants was conducted ethically, with the approval of the institutional review board, and in accordance with applicable regulations and guidelines.

Conflict of Interest

None declared.

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