E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.01.594

Research Article

Incidence and Outcomes of Traumatic Subarachnoid Hemorrhage in Traumatic Brain Injury Patients at a Tertiary Care Hospital

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Received: 09.05.2026, Revised: 19.06.2026, Accepted: 21.06.2026

ABSTRACT
Introduction: Traumatic subarachnoid hemorrhage (tSAH) is a frequent intracranial complication of traumatic brain injury (TBI) and is a risk factor for morbidity and mortality. Early recognition is key to appropriate management and better clinical outcomes.
Objective: To estimate the prevalence of traumatic subarachnoid hemorrhage and its clinical outcomes in patients with traumatic brain injury who attend a tertiary care hospital.
Methods: The descriptive cross-sectional study was carried out in the Department of Neurosurgery, Saidu Group of Teaching Hospitals, from November, 2025 to April, 2026. All 196 adult patients who had been diagnosed with TBI on clinical and radiological bases were recruited by non-probability consecutive sampling. Data from the clinical, radiological, and outcome data were analyzed using IBM SPSS Statistics version 27.0.
Results: Fifty-eight (29.6%) patients had traumatic subarachnoid hemorrhage. The study population consisted of 77.0% males, and road traffic accidents were the most predominant cause of injury (54.6%). Patients with tSAH were much more likely to experience adverse outcomes and in-hospital mortality compared to patients without tSAH. Higher age, more severe level of TBI, and the presence of tSAH were significantly correlated with poorer outcomes.
Conclusion: TBI commonly presents with traumatic subarachnoid hemorrhage, and it can be a poor prognosticator. Early diagnosis and timely multidisciplinary management can enhance the prognosis of the patient.

Keywords: Traumatic Subarachnoid Hemorrhage, Traumatic Brain Injury, Morbidity and Mortality, Tertiary Care Hospital.

INTRODUCTION

Traumatic brain injury (TBI) is an important public health issue and a major cause of death and chronic disability in all age groups globally. Each year, millions of people suffer a head injury, resulting in physical, cognitive, psychological and social impacts. This effect is particularly strong in LMICs, where the rapid urbanization, increased motorization, inadequate road safety infrastructure, and insufficient access to specialized trauma care contribute to increased incidence and reduced outcomes from TBI. One of the most frequent abnormalities on computed tomography (CT) scan following head trauma is traumatic subarachnoid hemorrhage (tSAH), which is considered to be a major indicator of head trauma severity. A recent study done at a tertiary care hospital in Karachi found that traumatic subarachnoid haemorrhage was found in a considerable number of the patients with traumatic brain injury and was associated with poor clinical outcome, making early diagnosis and management essential (1).

Epidemiology of TBI is geographically and system of care dependent and mechanism of injury dependent. Road traffic accidents are the most common cause of TBI in many developing countries, and falls are a significant cause in elderly people in developed countries. Young adult males are reported to be the most commonly affected group at all times because they have more exposure to occupational hazards, high-speed travel and outdoor activities. A large tertiary care study in Bangladesh found road traffic accidents as the major cause of head injury, and severe head injury was associated with longer hospital stay and increased mortality (2). Similarly, in Ethiopia, a retrospective cohort study revealed that traumatic brain injury (TBI) was among the most important causes of trauma-related death,

and low Glasgow Coma Scale (GCS) score, hypotension, and delayed presentation were important risk factors for mortality (3).

Traumatic subarachnoid hemorrhage occurs when the blood vessels of the cortex or pial surface of the brain are disrupted by blow or penetrating trauma of the head resulting in blood in the subarachnoid space. May occur as a single lesion, but is frequently accompanied by cerebral contusions, subdural hematoma, epidural hematoma and diffuse axonal injury. Blood in the CSF pathways initiates secondary processes like cerebral vasospasm, inflammatory reaction, decreased cerebral perfusion, and increased ICP, further exacerbating neurological deterioration. A retrospective study in a tertiary care center demonstrated that the radiological findings in the initial evaluation of traumatic brain injury (tBI) have prognostic significance, with patients with traumatic intracranial hemorrhage (tICH) having significantly worse neurological outcomes than those without intracranial lesions (4).

Patient factors also impact the prognosis of TBI. Advanced age has been continually associated with higher morbidity and mortality rates, which has been attributed to loss of physiological reserve, multiple comorbidities, cerebral atrophy and the use of anticoagulants. A retrospective study of geriatric traumatic brain injury (TBI) in developing countries revealed significantly poorer outcomes in older patients with longer hospital stays and increased mortality (5). Likewise, in a tertiary care center of a large patient population in India, even with better management in the neurosurgical and intensive care units, the severity of injury, intracranial injuries, and systemic complications were significant factors in determining the outcome of the patient (6).

Treatment of TBI has come a long way in the past few decades and the use of standardized trauma protocols, rapid neuro-imaging, specialized neurosurgical care and multidisciplinary critical care has had a dramatic effect on treatment. Secondary brain injury caused by hypoxia, hypotension, cerebral edema and intracranial hemorrhage, however, continues to be a negative impact on survival and neurological outcome. In a trauma referral hospital cohort study, the mortality rate in the intensive care unit (ICU) was strongly associated with severe neurological involvement and intracranial bleeding, highlighting the importance of intensive care unit monitoring and early intervention (7). Similarly, in Ethiopia, a multi-center study revealed that severe TBI, delayed hospital arrival and intracranial bleeding were independent risk factors for hospital mortality (8).

It is important to recognise the burden and outcomes of traumatic head injuries to develop effective prevention and management strategies. In a cohort study conducted in the Sidama region of Ethiopia, the authors reported high rates of morbidity and mortality among patients with trauma injuries to the head and the need for epidemiological data on traumatic head injuries at the institution to guide clinical practice and healthcare planning (9). In adults with traumatic brain injury (TBI), the severity of the injury and associated intracranial lesions was important determinants of poor outcome in a similar study conducted in Ethiopia (10). The studies highlight the ongoing importance of thorough investigation of selected intracranial trauma, including traumatic subarachnoid hemorrhage.

The importance of traumatic subarachnoid hemorrhage has increased with the possible prognostic value. A recent study in Nangararb Province has revealed many patients with head trauma having suffered traumatic subarachnoid hemorrhage and the importance of early CT scanning in diagnosis and management (11). In the same way, an epidemiological study from South India revealed that intracranial hemorrhagic lesions, including traumatic subarachnoid hemorrhage, were a frequent occurrence in head injuries sustained in road traffic accidents (12). The findings confirm a growing understanding that tSAH is an important component of TBI, and should be carefully assessed in the clinic.

The effects of a traumatic brain injury are unpredictable based on the severity of the TBI, patient characteristics and available health care resources. A tertiary care study in Bangladesh showed that outcome was significantly poorer in severely injured patients with traumatic brain injury (TBI) and associated intracranial hemorrhage (ICH) (13). In the same way, a clinico-epidemiological study carried out in two tertiary care hospitals in Dhaka reported that the patients with intracranial bleeding had to stay longer in the hospital and had more neurological disability compared to those with less severe injuries (14). The observations emphasize the importance of early detection of the haemorrhagic lesions and their aggressive treatment for improved prognosis in the patients.

Most studies to date that have evaluated the prognosis of subarachnoid hemorrhage have been conducted in the context of aneurysmal disease, but there is evidence that subarachnoid hemorrhage, regardless of its etiology, has a high mortality rate when massive or associated with neurologic deterioration. In patients with subarachnoid hemorrhage, the importance of early diagnosis, intensive monitoring in the ICU and prompt treatment in improving survival was emphasised in a retrospective study of deaths (15). Furthermore, in geriatric patients with traumatic brain injury (TBI), older age remained an independent predictor of mortality and neurological failure in patients with TBI (16).

Trauma centers are a part of modern neurotrauma care. Patients are treated in specialized trauma centers with immediate neuroimaging, timely neurosurgical intervention, a uniform intensive care unit (ICU) treatment plan, and a multidisciplinary rehabilitation program. In the past few years, a multicenter study demonstrated that patients with TBI were more likely to have favourable clinical outcomes if they were referred to a specialized trauma centre as opposed to a non-specialist centre, highlighting the role of organized trauma systems in reducing mortality and disability (17). Despite all these advances, there is limited data specifically dealing with the incidence and outcome of traumatic subarachnoid hemorrhage in many tertiary hospitals, especially in developing countries. For this reason, the present study was undertaken to determine the incidence and clinical outcomes of patients with traumatic subarachnoid hemorrhage (tSAH) among those with traumatic brain injury (TBI) admitted to a tertiary care hospital to generate local evidence for improved management of tSAH patients and for future trauma care.

Objective: To assess the prevalence of traumatic subarachnoid hemorrhage and its clinical outcomes in patients with traumatic brain injury who presented to a tertiary care hospital.

MATERIALS AND METHODS

Study Design: A descriptive cross-sectional study.

Study Setting: Department of Neurosurgery, Saidu Group of Teaching Hospitals.

Study Duration: Six months, from November, 2025 to April, 2026.

Sample Size: 196 patients.

Sampling Technique: Non-probability consecutive sampling.

Inclusion Criteria: The study included patients aged 18 years or older who came to the emergency department with traumatic brain injury (TBI) confirmed clinically and radiologically by computed tomography (CT) scan. Patients with traumatic subarachnoid hemorrhage (tSAH) on the initial computed tomography (CT) scan, regardless of sex or mechanism of injury, and admitted during the study period, were enrolled after meeting the inclusion criteria.

Exclusion Criteria: Patients who had non-traumatic (aneurysmal or spontaneous) subarachnoid hemorrhage, a history of intracranial hemorrhage or neurosurgical intervention, penetrating head trauma, bleeding disorders, intracranial hemorrhage related to anticoagulant use, and patients with incomplete medical records or death before radiological evaluation were excluded from the study to reduce potential confounding factors.

Methods

All patients who presented with traumatic brain injury (TBI) during the study period were included, regardless of their willingness to participate, and using non-probability consecutive sampling, all eligible patients were enrolled after obtaining approval from the Institutional Review Board (IRB) and permission from the Department of Neurosurgery. A structured proforma was used to record baseline demographic, mechanism of injury, Glasgow Coma Scale (GCS) score at presentation, clinical findings, and comorbidities. All the patients had non-contrast computed tomography (CT) of the brain, and the diagnosis of traumatic subarachnoid hemorrhage was confirmed by a consultant radiologist and neurosurgeon. Treatment was carried out according to the institutional protocol, with conservative treatment or surgery when necessary. The clinical outcome was judged during the hospital stay and classified as favorable (hospital discharge with neurological improvement) and unfavorable (neurological deterioration, long intensive care unit (ICU) stay, or in-hospital death). IBM SPSS Statistics 27.0 was used to enter and analyze data. Data on quantitative variables were reported as mean ± standard deviation and on qualitative variables as frequencies and percentages. Chi-square test was used to evaluate the associations, and a p-value < 0.05 was considered statistically significant.

RESULTS

There was a total of 196 patients with traumatic brain injury (TBI). The mean age of the participants was 36.8 ± 15.2 years (range: 18–79 years). The study population consisted of 151 males (77.0%) and 45 females (23.0%). The most frequently affected age group was 21–40 years (42.9%), followed by 41–60 years (28.1%). Road traffic accident was the most common mechanism of injury (54.6%), followed by falls (24.5%), assault (12.2%), and other (8.7%) (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics

Variable	Frequency	%
18–20 y	28	14.3
21–40 y	84	42.9
41–60 y	55	28.1
>60 y	29	14.7
Male	151	77.0
Female	45	23.0
RTA	107	54.6
Fall	48	24.5
Assault	24	12.2
Others	17	8.7

Of the 196 patients, 58 (29.6%) had a traumatic subarachnoid hemorrhage (tSAH) on initial non-contrast computed tomography (CT) brain scan, and 138 (70.4%) had a traumatic brain injury without subarachnoid hemorrhage (tBI). According to the Glasgow Coma Scale (GCS), 45.4% of the patients had mild TBI, 29.1% moderate TBI, and 25.5% severe TBI. The prevalence of tSAH was higher with increasing injury severity and was most common in those with severe TBI (Table 2).

Table 2. Incidence by Severity

GCS	Total	tSAH	No tSAH
Mild	89	12	77
Moderate	57	18	39
Severe	50	28	22
Total	196	58	138

Overall, 149 (76.0%) had favorable outcomes, whereas 47 (24.0%) experienced unfavorable outcomes. Patients who developed tSAH were more likely to experience neurological deterioration and mortality compared to patients who did not develop tSAH.

Table 3. Outcomes

Outcome	tSAH	No tSAH
Favorable	36	113
Unfavorable	22	25
Mortality	9	7

Advanced age (>60 years), severe TBI (GCS ≤8), and traumatic subarachnoid hemorrhage were significantly associated with poor clinical outcomes ($p<0.05$) on further analysis. The most severe cases of TBI (60.0%) were most likely to have an unfavorable outcome, while the mildest cases (92.1%) were most likely to have a favorable outcome.

Table 4. Factors

Factor	Unfavorable	P value
>60 years	14 (48.3%)	0.018
Severe TBI	30 (60.0%)	<0.001
tSAH	22 (37.9%)	0.006
RTA	30 (28.0%)	0.041

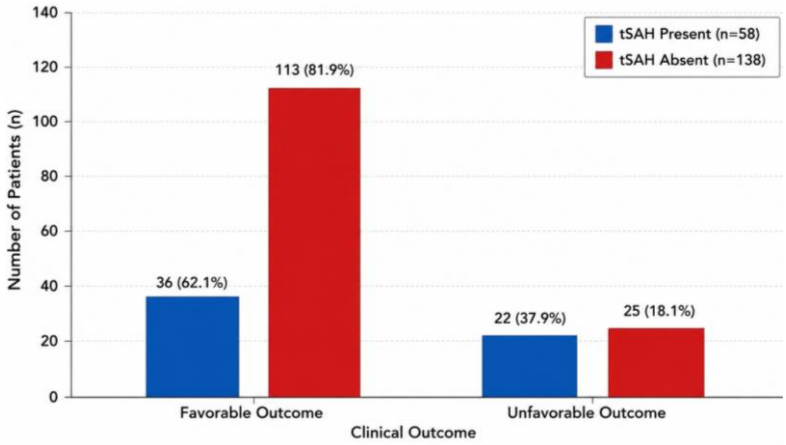

Figure 1. Clinical Outcomes among Patient with and Without Traumatic Subarachnoid Hemorrhage

Likewise, those injured in road traffic accidents experienced relatively poor outcomes compared to those injured in falls or assault. These results indicate that traumatic subarachnoid hemorrhage is a significant risk factor for poor hospital outcomes in patients with traumatic brain injury.

DISCUSSION

The current study aimed to assess the incidence and clinical outcomes of traumatic subarachnoid hemorrhage (tSAH) in patients with traumatic brain injury (TBI) in a tertiary care hospital. About one-third of the patients were found to have traumatic subarachnoid hemorrhage (tSAH), which was associated with worse clinical outcomes including longer intensive care unit (ICU) stay, neurological deterioration, and increased in-hospital mortality rates. The results emphasize the importance of tSAH as an indicator of injury severity and the need for early recognition of tSAH in the acute evaluation of TBI patients. Similar was observed by Qadir et al., who found that traumatic subarachnoid hemorrhage occurs in patients with TBI and has significant correlation with poor clinical outcome (1). Likewise, Das et al. found that the morbidity and mortality rates were significantly greater among patients with severe head injury at tertiary care centers, particularly those with intracranial hemorrhagic lesions (2).

The rate of traumatic subarachnoid hemorrhage (tSAH) in the present study is similar to that reported from other developing countries. Tegegne et al. demonstrated that Glasgow Coma Scale (GCS) scores and intracranial hemorrhage were significant factors during the prediction of mortality in patients with traumatic brain injury, which is why early assessment of neurological condition is important (3). Similarly, in the study by Shah et al., those patients with more severe TBI had poorer neurological outcome and mortality compared to those with less severe TBI, highlighting the prognostic significance of brain haemorrhages (4). The findings of the present study are similar to those of these studies, and indicate that traumatic subarachnoid hemorrhage could be considered a high-risk radiological finding for which close clinical follow-up is indicated.

The demographic profile showed that young adult males constituted the majority of the patients and the most common mechanism of injury was road traffic accidents (RTA). This is consistent with the study by Al-Taei et al., which reported that TBI was one of the most common causes of hospitalisation in both young adults and the elderly and that the elderly had poorer outcomes in terms of functional outcomes and mortality rates than the younger population, partly because of the presence of multiple comorbidities (5). Similarly, Steinruecke et al. reported that the severity of the injury, intracranial lesions associated with the injury and systemic complications were important factors in clinical outcome, even with advances in neurocritical care and neurosurgical treatment (6). The disproportionately high number of males in the present study is because males are at a higher risk of being exposed to high-risk occupations and motor vehicle accidents.

This study showed that severe traumatic brain injury and traumatic subarachnoid hemorrhage were significantly related to poor outcomes. Patients with Glasgow Coma Scale scores < 15 tended to have longer intensive care unit stays and greater mortality compared with patients with mild and moderate injuries. Similar results were seen by Réa-Neto et al., who found that

severe neurological injury and intracranial hemorrhage were significant predictors of death in the intensive care unit in trauma referral hospitals (7). Demlie et al. (8) also found that delayed hospital presentation, severe traumatic brain injury, and associated intracranial hemorrhage were also factors associated with increased risk of death in hospitalized patients. In a similar manner, Abebe et al. found both severe head injury and hemorrhagic brain injury were independently associated with poor clinical outcome and prolonged hospital stay, underscoring the importance of early intervention (9).

The other important result of the present study was the association of TSBH and poor neurological outcome. Patients with tSAH were much more likely to have neurological deterioration and in-hospital mortality than those without hemorrhage. In adults with TBI, intracranial hemorrhage, severe injury and low admission GCS score were significant risk factors for poor outcome, as demonstrated by G/Michael et al. (10). Safi and Mahboob also reported that the most common radiological finding after head trauma is traumatic subarachnoid hemorrhage and emphasized the need for early CT scan of the head in those patients who have a poor prognosis (11). Furthermore, Shanmugaiah and Rajkumar reported that road traffic accidents were the most common cause of traumatic brain injury, representing a large percentage of fatalities and neurological disability in tertiary care centres (12).

The findings of the present study also support the findings of tertiary-care centres in South Asia which have evaluated the outcomes following traumatic brain injuries. Manik et al. showed that patients with an intracranial hemorrhage had significantly worse functional recovery and mortality compared to patients without intracranial hemorrhagic lesions (13). Likewise, Islam et al. reported that the patients with severe traumatic brain injury had longer hospital stays, neurological disability, and a higher level of utilization of health services, highlighting the importance of early diagnosis and standard trauma management (14). These studies support the present findings, which accentuate the importance of early recognition and intensive management of TSAH.

The other major determinant of the outcome in this study was age with elderly patients having worse recovery and mortality compared to younger patients. Sindi et al. also reported that early intervention was important, as they found that the severity of the subarachnoid haemorrhage and the delay in treatment were significant factors that were correlated with mortality rates in the patients (15). Likewise, Kumar et al. demonstrated that geriatric patients with traumatic brain injury (TBI) had significantly worse neurological outcomes from the decreased physiological reserve and presence of multiple comorbidities (16). Last but not least, Bhogadi et al. showed that the prompt use of neuroimaging and the multidisciplinary approach to the neurocritical patient, with timely neurosurgical intervention, played an important role in improving TBI survival in patients transferred to specialized trauma centers (17).

The present study offers important data about the incidence of traumatic subarachnoid hemorrhage in patients with TBI, but there are some limitations to be noted. The study was performed in one tertiary care hospital and may not be representative of other hospitals. Furthermore, the relatively small number of patients and the brief study period could have affected the accuracy of the estimated incidence and outcomes. Neurological recovery and functional status in the long term after discharge were not assessed. Future multicenter prospective studies with larger numbers and longer follow-up are recommended to confirm these findings, to determine other prognostic factors, and to establish evidence-based strategies to improve outcomes in patients with traumatic subarachnoid hemorrhage.

CONCLUSION

Neurological deterioration, prolonged intensive care unit (ICU) stay, and in-hospital mortality are significantly higher in patients with traumatic subarachnoid (tSAH) than those without when presenting with traumatic brain injury (TBI). The present study showed that the incidence of traumatic subarachnoid hemorrhage was significant and that older age and severe traumatic brain injury were associated with a higher incidence. Prompt neurological assessment and multidisciplinary management are key to improving outcomes for patients with traumatic subarachnoid hemorrhage, which can be identified early by computed tomography. The results highlight the prognostic importance of traumatic subarachnoid hemorrhage as a marker for the severity of the injury and the importance of prompt referral to specialized trauma centers. Additional multicenter prospective studies with

larger numbers of patients and longer follow-up are recommended to confirm these results, to identify further prognostic factors, and to establish evidence-based strategies for minimizing morbidity and mortality in patients with traumatic brain injury.

REFERENCES

1. Qadir R, Fatima K, Rubiya A, Zulqarnain MM, Jummani MM, Bokhari I, Hasan M. Frequency and outcome of traumatic subarachnoid hemorrhage in patients presenting with traumatic brain injury at tertiary care hospital, Karachi. Pakistan Journal of Medical & Health Sciences. 2024;17(9):5300-5305.
2. Das S, Chaurasia B, Ghosh D, Sarker AC. Epidemiology and treatment outcomes of head injury in Bangladesh: Perspective from the largest tertiary care hospital. Indian Journal of Neurotrauma. 2023;20(1):11-17.
3. Tegegne NG, Fentie DY, Tegegne BA, Admassie BM. Incidence and predictors of mortality among patients with traumatic brain injury at University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia: A retrospective follow-up study. Patient Related Outcome Measures. 2023;14:73-85.
4. Shah RN, Roka YB, Thapa AJ, Jha A, Sah CN, Zha A, Sah C. Epidemiology and outcome of traumatic brain injuries: A retrospective study in a tertiary care center. Cureus. 2025;17(8).
5. Al-Taei O, Al-Mirza A, Ali M, Al-Kalbani H, Al-Saadi T. Prevalence and outcomes of geriatric traumatic brain injury in developing countries: A retrospective study. Indian Journal of Neurotrauma. 2023;20(2):101-106.
6. Steinruecke M, Nair S, Venturini S, Siannis F, Hutchinson PJ, Kolias A, Joseph M. Clinical characteristics and outcomes of traumatic brain injury in a high-volume tertiary care center in India: A prospective observational cohort study. Neurosurgery. 2025;97(2):436-447.
7. Réa-Neto Á, da Silva Júnior ED, Hassler G, Dos Santos VB, Bernardelli RS, Kozesinski-Nakatani AC, Martins-Junior MJ, Reese FB, Cosentino MB, Oliveira MC, Teive HA. Epidemiological and clinical characteristics predictive of ICU mortality of patients with traumatic brain injury treated at a trauma referral hospital: A cohort study. BMC Neurology. 2023;23:101.
8. Demlie TA, Alemu MT, Messelu MA, Wagnew F, Mekonen EG. Incidence and predictors of mortality among traumatic brain injury patients admitted to Amhara Region Comprehensive Specialized Hospitals, Northwest Ethiopia, 2022. BMC Emergency Medicine. 2023;23:55.
9. Abebe T, Alemu T, Sorato MM. Incidence, risk factors and outcomes of traumatic head injury among trauma patients visited at the Yanet Trauma and Surgery Specialized Centre, Sidama Region, Hawassa, Ethiopia: Cohort study. Frontiers in Neurology. 2024;15:1431999.
10. G/Michael S, Terefe B, Asfaw MG, Liyew B. Outcomes and associated factors of traumatic brain injury among adult patients treated in Amhara Regional State Comprehensive Specialized Hospitals. BMC Emergency Medicine. 2023;23:109.
11. Safi KI, Mahboob SS. Incidence of traumatic sub-arachnoid hemorrhage in Nangarhar Province. Journal of Medical Science, Biology, and Chemistry. 2024;1(2):1-8.
12. Shanmugaiah A, Rajkumar R. Epidemiology of head injury in a tertiary care hospital in South India. Romanian Neurosurgery. 2023:312-316.
13. Manik AH, Chowdhury RU, Chowdhury AU, Salek AA, Ali A. Outcomes of traumatic brain injury in a tertiary care hospital in Bangladesh. TAJ: Journal of Teachers Association. 2025;38(2):181-187.
14. Islam MJ, Islam MS, Haseen F, Ashadullah AT, Hossain MZ, Salam MA, Uddin K, Rashid MM, Mustofa MG. Clinico-epidemiological study in admitted patients with traumatic brain injury in two selected tertiary care centers in Dhaka City. Journal of National Institute of Neurosciences Bangladesh. 2022;8(2):105-111.
15. Sindi AA, Abushoshah I, Bokhary DH, Banser SM, Bedaiwi WH, Bajuneid KM, Algethamy HM. Mortality among patients with subarachnoid hemorrhage: A retrospective study. Anaesthesia, Pain & Intensive Care. 2023;27(4):545-552.
16. Kumar A, Jaiswal S, Ojha BK, Chandra A, Srivastava C, Bajaj A, Yadav A. Retrospective outcome analysis of

geriatric traumatic brain injury treated at a tertiary care center in India. Indian Journal of Neurosurgery. 2025;14(1):34-43.

17. Bhogadi SK, Stewart C, Hosseinpour H, Nelson A, Ditillo M, Matthews MR, Magnotti LJ, Joseph B. Outcomes of patients with traumatic brain injury transferred to trauma centers. JAMA Surgery. 2024;159(11):1282-1288.