Original Research Article

Role of CT in Traumatic Brain Injury

Dr. Dhairya Rajkumar Malani[1] (Resident), Dr. Waseem Akhtar[2] (Associate Professor), Dr. Vandana Ahluwalia[3] (Professor & Head of department), Dr. Sheikh Tufail Ahmad[4] (Resident), Dr. Raza Khan[5*] (Resident) & Dr. Bansari Malani[6] (Resident)

[1,2,3,4*,5]Dept. of Radio diagnosis, F.H. Medical College, Agra.
[6]Dept. of General Medicine, F.H. Medical College, Agra.

Corresponding Author: Dr. Raza khan

Abstract

Background and Aims: Traumatic Brain Injury (TBI) is a significant global health concern, often referred to as the "silent epidemic" due to its widespread impact on mortality, disability, and socio-economic factors. CT imaging has revolutionized the diagnosis and management of TBI by enabling accurate detection of both primary injuries (e.g., hematomas and skull fractures) and secondary complications (e.g., cerebral edema). This study aimed to evaluate the role of CT imaging in TBI management by analyzing its diagnostic accuracy and identifying demographic and injury-related patterns to optimize clinical protocols and patient outcomes.

Methods: This observational study was conducted over two years in the Department of Radiodiagnosis in collaboration with the Department of Surgery at F.H. Medical College, Agra, Uttar Pradesh. Ethical clearance was obtained, and informed consent was collected. A total of 170 patients presenting with head injuries were included. Purposive sampling was used to ensure comprehensive data collection. CT scans were performed using a Toshiba Alexion 16-Slice CT scanner. Demographic data, injury mechanisms, Glasgow Coma Scale (GCS) scores, and CT findings were analyzed using statistical methods, including the calculation of mean, median, and confidence intervals.

Results: Young adults were the most affected, with males predominating. Motorbike accidents and falls were the leading causes. Temporal and parietal regions were the most commonly injured, while epidural and subdural hematomas were the most frequent lesions. Mild TBI was more prevalent, but moderate and severe cases required intensive care. CT imaging was crucial in diagnosing and managing injuries, guiding timely interventions, and improving outcomes.

Conclusion: CT imaging is indispensable in TBI management, offering rapid, accurate diagnosis and guiding effective treatment strategies. It plays a vital role in identifying both primary and secondary injuries, emphasizing the need for preventive measures and efficient emergency services to reduce TBI-related morbidity and mortality.

Keywords: Traumatic Brain Injury, Ct Imaging, Glasgow Coma Scale, Neurotrauma, Emergency Medicine.

1. INTRODUCTION

Traumatic Brain Injury (TBI) is a significant global health challenge often referred to as the "silent epidemic" due to its profound impact on mortality, disability, and socio-economic conditions worldwide. Annually, over 69 million people suffer from TBI, with the burden

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

disproportionately affecting low- and middle-income countries, where young adults and economically active populations are most at risk. Despite advancements in healthcare, the prevalence of TBI remains a critical concern, particularly in regions like Southeast Asia and Africa, where road traffic accidents and falls are leading causes. [1, 2]
In recent decades, diagnostic imaging has undergone a transformative evolution, with computed tomography (CT) emerging as the gold standard for evaluating TBI. Unlike traditional skull radiography, CT offers unparalleled speed and precision, enabling the rapid identification of primary injuries such as skull fractures, contusions, and intracranial hemorrhages, as well as secondary complications like cerebral edema and brain herniation. [3, 4] The ability of CT to produce detailed cross-sectional images has revolutionized the management of TBI, ensuring timely interventions and significantly improving patient outcomes. [5]
While the Glasgow Coma Scale remains a widely used clinical tool for classifying TBI severity, it primarily assesses consciousness and neurological function without addressing underlying structural damage. [6] This gap highlights the critical role of CT imaging, which not only diagnoses the extent of injury but also facilitates ongoing monitoring, enabling clinicians to detect changes and intervene promptly.
This study aims to comprehensively evaluate the role of CT in TBI management, focusing on its diagnostic accuracy, specificity, and sensitivity. It will analyze local epidemiological data, including causes, demographics, and symptoms, to identify patterns and improve resource allocation. By assessing the effectiveness of CT in guiding treatment decisions, the study intends to refine clinical protocols, optimize healthcare resources, and improve patient care outcomes. Through these efforts, this research seeks to underline the indispensable role of CT in enhancing the precision of TBI diagnosis and its pivotal contribution to modern neurotrauma care.

2. MATERIAL AND METHODS

This study was conducted in the Department of Radiodiagnosis in collaboration with the Department of Surgery at F.H. Medical College, Agra, Uttar Pradesh, over a two-year period (September 2022 to September 2024). All patients presenting with head injuries to the Emergency Department and referred for CT scans were included in the study.

Study Design

The study was observational, using purposive sampling to select cases. The inclusion of all eligible patients presenting with head trauma allowed for comprehensive data collection on the role of CT in the evaluation of traumatic brain injuries.

Sampling and Sample Size

All patients presenting to F.H. Medical College and Hospital with head injuries and referred for CT scans during the study period were included. Purposive sampling ensured that every eligible case was captured.
This methodical approach aimed to evaluate the role of CT imaging in diagnosing and managing traumatic brain injuries comprehensively, with a focus on detecting primary and secondary injuries and guiding clinical interventions effectively.
Sample Size: 170

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Selection Criteria

Inclusion Criteria

- Patients with head injuries of any cause presenting to the Emergency Department.
- Head trauma that occurred within 24 hours of presentation.
- Patients of all age groups.

Exclusion Criteria

- Cranial trauma sustained during childbirth.
- Patients with non-traumatic intracranial hemorrhages.

Procedure

After obtaining informed consent from the patient or their relatives, the following steps were undertaken:

1. **Detailed History:** Information about patient demographics, the mechanism of injury, and associated clinical symptoms were recorded.
2. **Clinical Examination:** Comprehensive physical examinations were conducted to document signs and symptoms such as loss of consciousness, confusion, altered sensation, recurrent vomiting, seizures, suspected open or depressed skull fractures, or basal skull fractures (evidenced by hemotympanum, periorbital ecchymosis, CSF leakage, or Battle's sign).
3. **CT Imaging:** Computed tomography was performed for all included patients. Key imaging findings were evaluated, including:

- Grey-white matter differentiation.
- Presence of hypo- or hyperdense lesions in the brain parenchyma.
- Evidence of midline shifts.
- Meningeal enhancement.

CT Equipment

CT scans were performed using the Toshiba Alexion 16-Slice CT scanner. This system provided high-resolution imaging, enabling accurate and rapid detection of traumatic brain injuries, including both soft tissue and bony injuries.

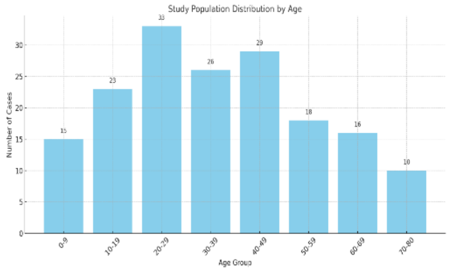
Staff Training and Quality Control

All patients were assessed by expert radiologists and surgeons. Rigorous quality control measures were implemented to ensure data completeness and consistency. Records were maintained in both local and English languages to enhance accessibility and accuracy. Patient identities and clinical histories were securely documented to maintain the integrity of the study.

3. RESULTS

Table 1 represents the distribution of the study population by age and gender. The majority of participants fall within the 20-29 age group (19.41%), and males dominate the population with 61.76% compared to females at 38.23%. This distribution highlights the demographic focus of the study.

Category	Sub-category	No. of Cases	Percentage (%)
Age Group	0-9	15	8.82
	10-19	23	13.52
	20-29	33	19.41
	30-39	26	15.29
	40-49	29	17.05
	50-59	18	10.58
	60-69	16	9.41
	70-80	10	5.88
	Total	**170**	**100**
Gender	Male	105	61.76
	Female	65	38.23
	Total	**170**	**100**



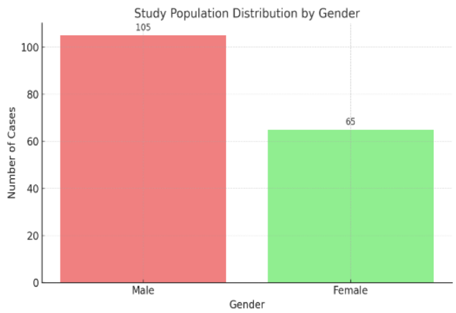


Table 2 shows the study population based on the mode of arrival and the duration between injury and CT scan. Private ambulances (22.35%) and transportation methods dominated the mode of arrival, while the majority of CT scans were performed 4–6 hours post-injury (28.23%).

Category	No. of Cases	Percentage
Mode of Arrival		
Public EMS	32	18.82
Private Transportation	36	21.17
Private Ambulance	38	22.35
Public Transportation	22	12.94
Walk-in	30	17.64
Others	12	7.05
Duration of Injury		
< 2 Hours	38	22.35
2-4 Hours	45	26.47

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

4-6 Hours	48	28.23
> 6 Hours	39	22.94
Total	170	100

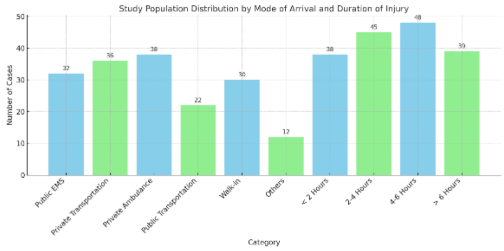
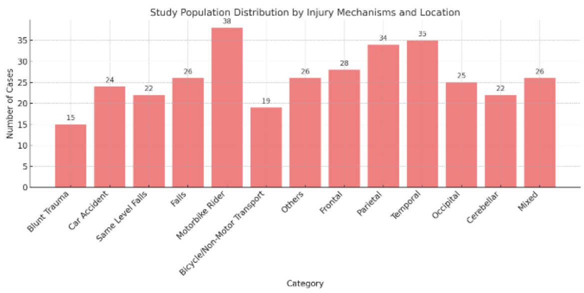


Table 3 represents the distribution of the study population based on injury mechanisms and anatomical injury locations. Motorbike accidents (22.35%) were the leading cause of injuries, while temporal (20.58%) and parietal (20%) regions were most frequently affected. The data underscores the significance of specific mechanisms and injury sites in managing traumatic injuries.

Category	**No. of Cases**	**Percentage**
Injury Mechanisms		
Blunt Trauma	15	8.82
Car Accident	24	14.11
Same Level Falls	22	12.94
Falls	26	15.29
Motorbike Rider	38	22.35
Bicycle/Non-Motor Transport	19	11.17
Others	26	15.29
Injury Location		
Frontal	28	16.47
Parietal	34	20.00
Temporal	35	20.58
Occipital	25	14.70
Cerebellar	22	12.94
Mixed	26	15.29
Total	170	100



ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Table 4 represents the distribution of the study population based on Glasgow Coma Scale (GCS) scores. The majority of cases fall under the mild category (42.35%), indicating a higher proportion of less severe injuries, while severe cases constitute 28.23%. The data is crucial for understanding injury severity patterns in the population.

GCS Score	No. of Cases	Percentage (%)
Mild (13-15)	72	42.35
Moderate (9-12)	50	29.41
Severe (3-8)	48	28.23
Total	170	100

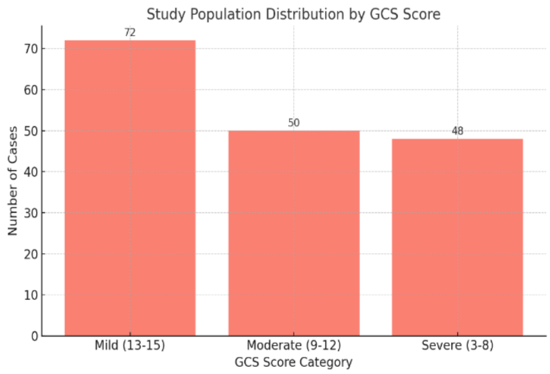
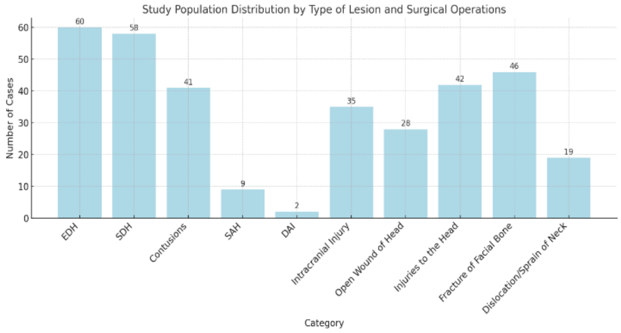


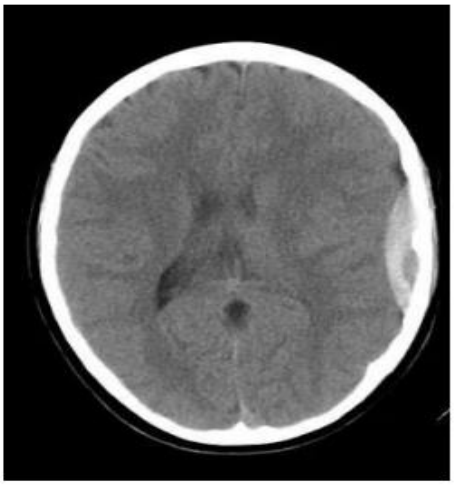
Table 5 represents the study population categorized by lesion types and surgical operations performed. Epidural hematomas (EDH) and subdural hematomas (SDH) are the most frequent lesions, while fractures of facial bones represent the highest percentage of surgical operations, emphasizing their significance in trauma cases.

Category	No. of Cases	Percentage
Type of Lesion		
EDH	60	35.29
SDH	58	34.11
Contusions	41	24.11
SAH	9	5.29
DAI	2	1.20
Surgical Operations		
Intracranial Injury	35	20.58
Open Wound of Head	28	16.47
Injuries to the Head	42	24.70
Fracture of Facial Bone	46	27.05
Dislocation/Sprain of Neck	19	11.17
Total	170	100

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

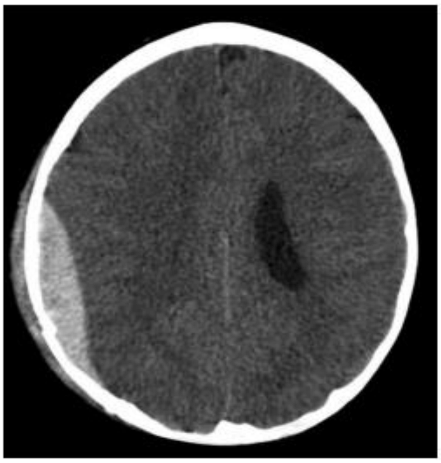


Case 1: Standard Axial Section of NCCT Head Showing Epidural Hematoma on Right Parietal Region.



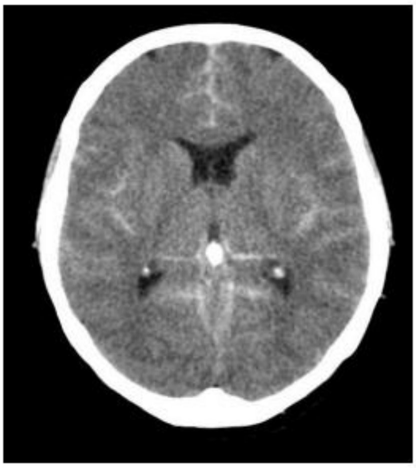
Case 2: Standard Axial Section of NCCT Head Showing Epidural Hematoma on Left Parietal Region.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024



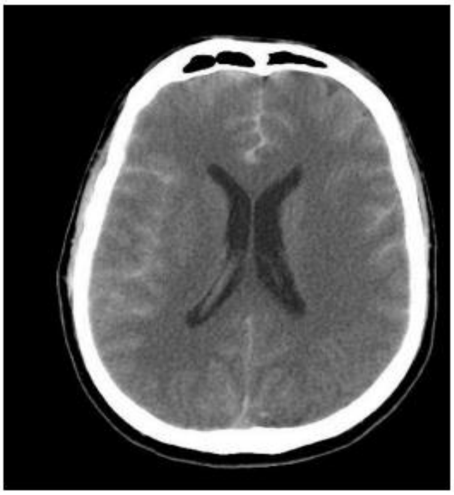
Case 3: Standard Axial Section of NCCT Head Showing Subdural Hematoma on Right Parietal Region

Case 4: Standard Axial Section of NCCT Head Showing Chronic Subdural Hematoma on Left Frontoparietal Convexity

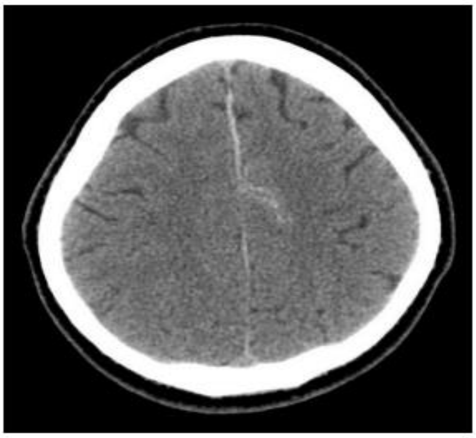


Case 5: Standard Axial Section of NCCT Head Showing Subarachnoid Hemorrhage

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024



Case 6: Standard Axial Section of NCCT Head Showing Subarachnoid Hemorrhage.



Case 7: Standard Axial Section of NCCT Head Showing Contusion in Left Parafalcine Region.

Case 8: Standard Axial Section of NCCT Head Showing Diffuse Axonal Injury.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

4. DISCUSSION

The study evaluates the role of computed tomography (CT) scans in traumatic brain injury (TBI) management, focusing on lesion progression, injury mechanisms, anatomical locations, and demographic patterns. The findings are compared with previous studies to highlight trends and validate the use of CT as a critical tool in guiding treatment decisions and monitoring outcomes.

The study revealed that young adults aged 20–29 years constituted the largest proportion of TBI cases (19.41%), followed by individuals aged 40–49 years (17.05%) and 30–39 years (15.29%). These findings align with studies by Mader and Jha DDk, [7] which also reported a high prevalence of TBI in economically active age groups. The youngest age group (0–9 years) accounted for 8.82% of cases, consistent with data from paediatric studies.

Gender analysis indicated a significant male predominance (61.76%) compared to females (38.23%), reflecting higher exposure of males to risk factors such as road traffic accidents and occupational hazards. This gender disparity is supported by studies conducted by Zadegan [8], MTBI [22], and Kirkwood [23] Comparative data from 2019 Statistics Korea also revealed a similar male dominance in younger age groups, with a shift toward female prevalence in individuals over 50 years, attributable to longer life expectancy and reduced exposure to external risks.

Motorcycle accidents (22.35%) emerged as the leading cause of TBI, followed by falls (15.29%) and car accidents (14.11%). These findings are consistent with Kim et al. [9], who reported similar mechanisms in paediatric and middle-aged populations. Blunt trauma and same-level falls accounted for a significant proportion of injuries in older adults, highlighting the need for preventive measures tailored to age-specific risks.

Anatomically, the temporal and parietal regions were the most frequently affected areas (20.58%), followed by mixed injuries (15.29%), occipital (14.70%), and cerebellar regions (12.94%). These findings corroborate Thompson et al.'s [10] observations of regional injury patterns and their impact on patient outcomes.

Epidural hematomas (EDH) were the most common lesions (35.29%), closely followed by subdural hematomas (SDH) at 34.11% and contusions at 24.11%. Subarachnoid hemorrhage (SAH) accounted for 5.29%, while diffuse axonal injuries (DAI) were the least frequent (1.2%). Similar trends were observed in studies by Gerard et al. [11], which highlighted EDH and SDH as predominant lesions in TBI cases. The study emphasizes the importance of early detection and management of these lesions to reduce the risk of complications such as intracranial pressure elevation.

The Glasgow Coma Scale (GCS) assessment revealed that 42.35% of cases were classified as mild, 29.41% as moderate, and 28.23% as severe. These findings align with Silver JM's [12] study, which also observed a higher prevalence of mild TBI cases. The GCS remains an essential tool for evaluating consciousness and neurological function, though it may not fully capture the extent of structural damage.

CT imaging was performed routinely in this study, enabling unbiased data collection and comprehensive monitoring. Routine repeat CT scans, while logistically and financially challenging, minimized selection bias and enhanced the detection of lesion progression. Rosen et al. [13], Almenawer et al. [14], and Wong et al.[15] have similarly emphasized the utility of repeat CT scans in high-risk patients, particularly those with significant intracranial hemorrhages (ICH), advanced age, or anticoagulant use.

Sifri et al. [16] and Narayan et al. [17] recommended repeat CT scans for patients with EDH or SDH, especially within six hours post-injury. Conversely, Washington [18] and Wang [19] found limited evidence for repeat CT scans in mild TBI cases without neurological deterioration. Gerard et al. [11] and Adatia et al. [20] identified factors such as frontal and contrecoup contusions as predictors of lesion progression, findings consistent with this study's observations. Kobeissy et al. [21] highlighted the limitations of CT in detecting axonal damage compared to T2-weighted MRI, which offers a sensitivity of 92%. This study underscores the importance of correlating clinical findings with imaging results to enhance diagnostic accuracy. The study identified facial bone fractures as the most prevalent injury requiring surgical intervention (27.05%), followed by head injuries (24.70%) and intracranial injuries (20.58%). These results underscore the importance of timely imaging and intervention to prevent complications such as intracranial pressure elevation. Similar findings were reported by Gerard et al. [11], who emphasized the need for surgical intervention in moderate to severe TBI cases.

Recommendations

Future studies should focus on exploring the long-term outcomes of CT imaging in traumatic brain injury (TBI) management, particularly its impact on patient recovery and healthcare costs. Emphasis should be placed on integrating advanced imaging modalities like MRI for detecting subtle injuries such as diffuse axonal damage, ensuring a more comprehensive evaluation of TBI cases.

Limitations

This study was limited by its observational design and reliance on a single-center dataset, which may restrict the generalizability of findings to other populations. Additionally, the absence of follow-up data on long-term patient outcomes and the exclusion of cases with non-traumatic intracranial hemorrhages limit the scope of the conclusions.

5. CONCLUSION

We concluded that traumatic brain injuries predominantly affect young adults, with males being more commonly impacted. Motorbike accidents, falls, and car accidents were identified as the leading causes, with the temporal and parietal regions most frequently involved. Timely CT imaging played a crucial role in diagnosing lesions such as hematomas and fractures, guiding effective treatment strategies. Mild injuries were more common, though moderate and severe cases highlighted the need for comprehensive trauma care. These findings emphasize the importance of preventive measures, efficient emergency services, and early interventions to improve outcomes in traumatic brain injury management.

Conflict of Interest: The authors declare no conflicts of interest.

Funding: No funding was received.

Consent: Written consent from participants has been obtained and preserved.

Ethical Approval: Ethical approval was obtained and documented as per institutional guidelines.

6. REFERENCES

1. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. NeuroRehabilitation. 2007; 22(5):341-53. PMID: 18162698.
2. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, Agrawal A, Adeleye AO, Shrime MG, Rubiano AM, Rosenfeld JV, Park KB. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018 Apr 27; 130(4):1080-97. doi: 10.3171/2017.10.JNS17352. PMID: 29701556.
3. Roozenbeek B, Maas AI, Menon DK. Changing patterns in the epidemiology of traumatic brain injury. Nat Rev Neurol. 2013 Apr; 9(4):231-6. doi: 10.1038/nrneurol.2013.22. PMID: 23443846.
4. Guan B, Anderson DB, Chen L, Feng S, Zhou H. Global, regional and national burden of traumatic brain injury and spinal cord injury, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. BMJ Open. 2023 Oct 6; 13(10):e075049. doi: 10.1136/bmjopen-2023-075049. PMID: 37802626; PMCID: PMC10565269.
5. Iaccarino C, Carretta A, Nicolosi F, Morselli C. Epidemiology of severe traumatic brain injury. J Neurosurg Sci. 2018 Oct; 62(5):535-41. doi: 10.23736/S0390-5616.18.04532-0. PMID: 30182649.
6. Harrington BM, Gretschel A, Lombard C, Lonser RR, Vlok AJ. Complications, outcomes, and management strategies of non-missile penetrating head injuries. J Neurosurg. 2020 Jun 19; 134(5):1658-66. doi: 10.3171/2020.4.JNS20122. PMID: 32559744.
7. Mader MM-D, Rotermund R, Lefering R, Westphal M, Maegele M, Czorlich P, et al. The faster the better? Time to first CT scan after admission in moderate-to-severe traumatic brain injury and its association with mortality. Neurosurg Rev. 2021; 44(5):2697-706.
8. Zadegan SA, Rahimi-Movaghar V. Indications for brain computed tomography scan after mild traumatic brain injury. In: Traumatic Brain Injury. InTech; 2014.
9. Kim HB, Kim DK, Kwak YH, et al. Epidemiology of traumatic head injury in Korean children. J Korean Med Sci. 2012; 27:437-42.
10. Thompson HJ, McCormick WC, Kagan SH. Traumatic brain injury in older adults: epidemiology, outcomes, and future implications. J Am Geriatr Soc. 2006; 54:1590-5.
11. Gerard C, Busl KM. Treatment of acute subdural hematoma. Curr Treat Options Neurol. 2014; 16(275):1-9. doi: 10.1007/s11940-013-0275-0.
12. Silver JM, McAllister TW, Arciniegas DB. Textbook of traumatic brain injury. 3rd ed. Washington (DC): American Psychiatric Publishing; 2019.
13. Rosengren D, Rothwell S, Brown AF, Chu K. The application of North American CT scan criteria to an Australian population with minor head injury. Emerg Med Australas. 2004; 16(3):195-200.
14. Almenawer SA, Bogza I, Yarascavitch B, Sne N, Farrokhyar F, Murty N, Reddy K. The value of scheduled repeat cranial computed tomography after mild head injury. Neurosurgery. 2013; 72:56-64. doi: 10.1227/NEU.0b013e318276f899.
15. Wong DK, Lurie F, Wong LL. The effects of clopidogrel on elderly traumatic brain injured patients. J Trauma. 2008; 65:1303-8. doi: 10.1097/TA.0b013e318185e234.
16. Sifri ZC, Homnick AT, Vaynman A, Lavery R, Liao W, Mohr A, et al. A prospective evaluation of the value of repeat cranial computed tomography in patients with minimal

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

head injury and an intracranial bleed. J Trauma. 2006; 61:862-7. doi: 10.1097/01.ta.0000224225.54982.90.

17. Narayan RK, Maas AIR, Servadei F, Skolnick BE, Tillinger MN, Marshall LF. Progression of traumatic intracerebral hemorrhage: a prospective observational study. J Neurotrauma. 2008; 25:629-39. doi: 10.1089/neu.2007.0385.
18. Washington CW, Grubb RL. Are routine repeat imaging and intensive care unit admission necessary in mild traumatic brain injury? J Neurosurg. 2012; 116:549-57. doi: 10.3171/2011.11.JNS111092.
19. Wang MC, Linnau KF, Tirschwell DL, Hollingworth W. Utility of repeat head computed tomography after blunt head trauma: a systematic review. J Trauma. 2006; 61:226-33. doi: 10.1097/01.ta.0000197385.18452.89.
20. Adatia S, Hwang SC, Kim BT, Jeong JH, Im SB, Shin WH. Serial brain CT scans in severe head injury without intracranial pressure monitoring. Korean J Neurotrauma. 2014; 10:26. doi: 10.13004/kjnt.2014.10.1.26.
21. Kobeissy FH. Brain neurotrauma: molecular, neuropsychological, and rehabilitation aspects. CRC Press; 2015.
22. MTBI C. Methodological issues and research recommendations for mild traumatic brain injury: the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004; 43:113–25.
23. Kirkwood MW, Yeates KO, Taylor HG, Randolph C, McCrea M, Anderson VA. Management of pediatric mild traumatic brain injury: a neuropsychological review from injury through recovery. Clin Neuropsychol. 2008; 22(5):769-800.