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ORIGINAL ARTICLE

# Role of Computerized Tomography as Prime Imaging Modality in the Evaluation of Traumatic Brain Injury

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## ABSTRACT

**Introduction:** Trauma is the most common worldwide cause of death and disability in young adults. Neurotrauma is one of the most frequent indications for emergent neuroimaging because imaging plays such a key role in patient triage and management.

**Aims and objectives:** (1) To assess the role of computed tomography (CT) in patients with traumatic head injury. (2) To localize trauma to a particular extraaxial and intraaxial compartment and to delineate various spectrum of hemorrhages that occur in craniocerebral trauma with the aid of CT. (3) To evaluate the value of early CT imaging with patient prognosis.

**Materials and methods:** This is a prospective study carried out in 100 patients with traumatic brain injury, referred to the Department of Radiodiagnosis, Rohilkhand Medical College & Hospital, Bareilly, Uttar Pradesh, India, for CT scan during a period of 1 year. The patients were scanned using GE Bright Speed 16-Slice multidetector CT.

**Conclusion:** Computed tomography is the single-most informative diagnostic modality in the evaluation of a patient with a head injury and should be considered the first imaging of choice in acute head injury as it forms the cornerstone for rapid and effective diagnosis.


**Keywords:** Computed tomography, Extradural hemorrhage, Glasgow coma scale score, Head trauma, Intracranial hemorrhage, Subarachnoid hemorrhage, Subdural hemorrhage.

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## INTRODUCTION

Trauma is the most common worldwide cause of death and disability in young adults. Neurotrauma is responsible for the vast majority of these cases and is a worldwide public health problem that carries enormous personal, societal, and financial impact.

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Traumatic brain injury (TBI) causes a spectrum of brain injuries ranging from transient physiological dysfunction, manifested by short periods of confusion and amnesia to severe immediate irreversible neuronal damage and death.

Of all head-injured patients, approximately 10% sustain fatal brain injury, and an additional 5 to 10% have serious permanent neurologic deficits, while 20 to 40% of TBI survivors have moderate disability.[1]

Trauma is one of the most frequent indications for emergent neuroimaging because imaging plays such a key role in patient triage and management.

Computed tomography (CT) is the single-most informative diagnostic modality in the evaluation of a patient with head injury. Besides facilitating rapid implementation, it can demonstrate significant primary traumatic injuries including extradural hemorrhage (EDH), subdural hemorrhage (SDH), intracerebral hematomas, subarachnoid hemorrhage (SAH), and intraventricular hemorrhage (IVH), skull fractures, cerebral edema, contusions, and cerebral herniations. Contribution of CT is crucial to complete injury assessment and forms the basis of patient management.[2]

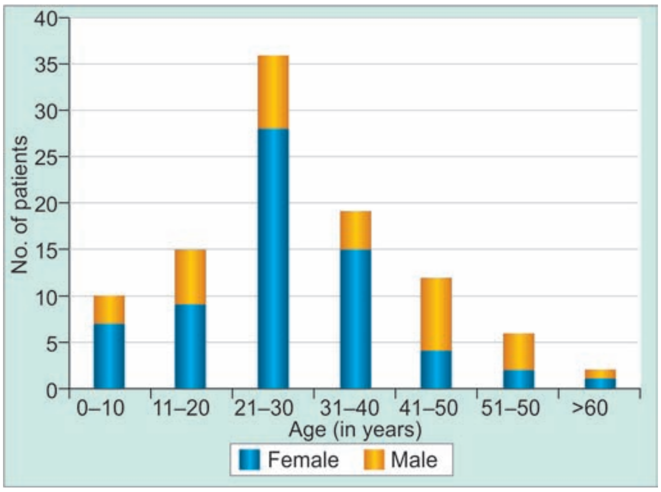
Computed tomography is widely available, rapid, permits close monitoring of unstable patients, compatible with respirators and other mechanical support devices, and can be used in patients with unknown medical history. It is very sensitive in detecting acute hematomas and depressed fractures that require emergency surgery. However, CT is less sensitive in detecting white matter injuries and posterior fossa lesions due to beam hardening artifacts, from the surrounding bones. Moreover, CT aids in surgical planning, prognosticating outcome, and recovery time.

This study highlights the role of CT in early diagnosis, thus aiding a better prognosis in patients with traumatic head injury.

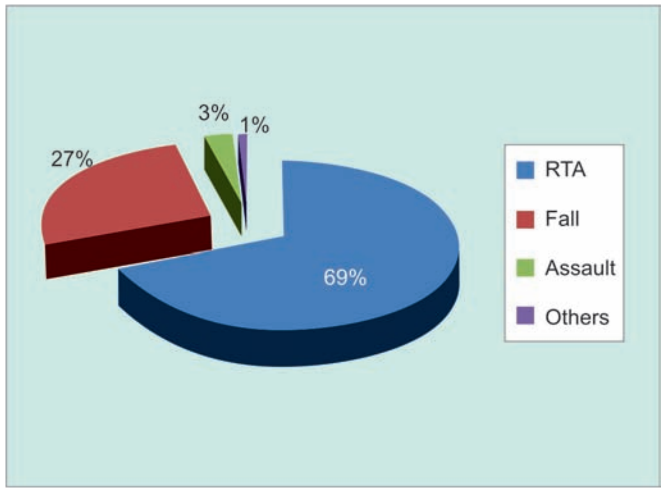
## AIMS AND OBJECTIVES

The aims and objectives of the study are:

1. To assess the role of computed tomography (CT) in patients with traumatic head injury.
2. To localize trauma to a particular extraaxial and intraaxial compartment and to delineate various spectrum of hemorrhages that occur in craniocerebral trauma with the aid of CT.
3. To evaluate the value of early CT imaging with patient prognosis.




**Graph 1:** Sex-wise and age-wise distribution in craniocerebral injury




**Graph 2:** Incidence of different modes of injury

## MATERIALS AND METHODS

This is a prospective study carried out in 100 patients with TBI, referred to the Department of Radiodiagnosis, Rohilkhand Medical College & Hospital, Bareilly, Uttar Pradesh, India, for CT scan during a period of 1 year from January 2015 to December 2015.

Patients of any age and sex admitted in Rohilkhand hospital with TBI that has occurred within 24 hours and having Glasgow coma scale (GCS) score <15 were included in the study. Patients with GCS score – 15, with no positive CT findings, and with cranial trauma that occurred during childbirth were excluded from the study.

A complete clinical history of the patients was noted, which included age, sex, type of injury, principal presenting complaints. The type of trauma was further classified into road traffic accidents (RTA), falls, assaults, and miscellaneous. Follow-up of patients during their hospital stay was performed.

The patients were scanned using GE Bright Speed 16-Slice multidetector CT.

### Computed Tomography Protocol

The patients were examined with CT scanner in the supine position. The Gantry tilt was in the range of ±0 to 20°, so as to parallel the scan plane to the orbitomeatal line.

Bone algorithms and wide window settings were studied to visualize the various craniocerebral changes.

### Technical Factors

Matrix size – 512, slice thickness – 5 mm, Kilo voltage – 80 to 120, and Milli ampere second – 50 to 270.

### Statistical Methods

Rates, ratios, and percentages of different findings on CT and outcome will be computed, compiled, and studied.

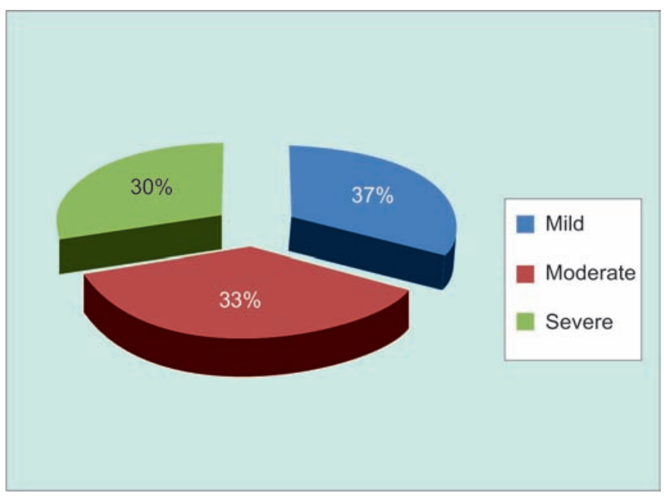
## RESULTS

A total of 100 patients with TBI with positive findings on CT scan were included in the present study.

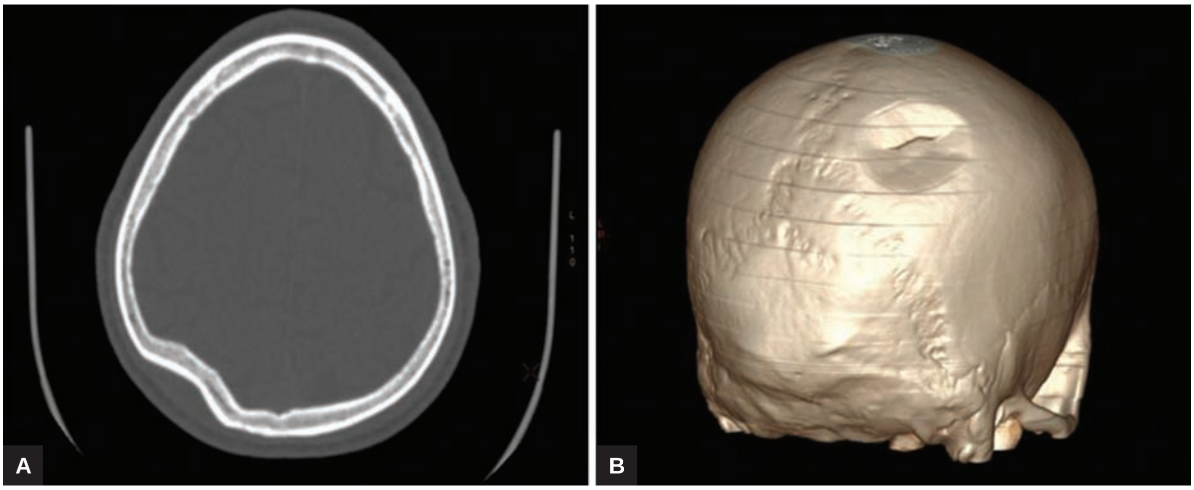
Male population dominated the study, with 66% of patients being male and 34% being female.

The peak incidence of head injury was found in the age group of 21 to 30 years, i.e., 36%. Incidence in other age groups was 19% in age group of 31 to 40, 15% in 11 to 20, 12% in 41 to 50, 10% in 0 to 10, 6% in 51 to 60, and 2% patients aged above 60 years (Graph 1). In our study, RTA was found to be the commonest mode of head injury with an incidence of 69%, followed by other modes of injury, such as falls with an incidence of 27%, assaults 3%, and miscellaneous 1%. But in children (0–15 years age group), fall was found to be the commonest mode of head injury, with an incidence of 83.33% followed by RTA – 16.6% (Graph 2).

According to the study, cases with moderate head injury with GCS score of 9 to 12 were the commonest, accounting for 37% of all cases, followed by cases with mild head injury with GCS score of 13 to 14 accounting for 33% cases, and with severe head injury were least common accounting for 30% (Graph 3).




**Graph 3:** Grading of head injury based on GCS score




**Figs 1A and B:** Axial bone window: (A) Volume rendering; and (B) depressed fracture of right parietal bone

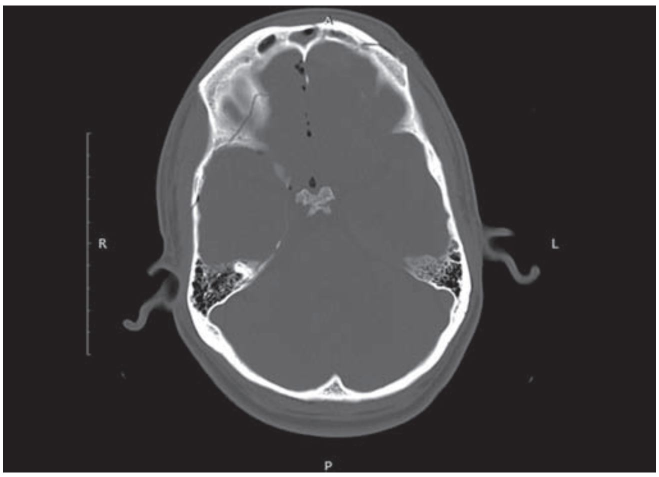



**Fig. 2:** Fracture of right orbital roof involving the frontal sinus with hemosinus and pneumocephalus

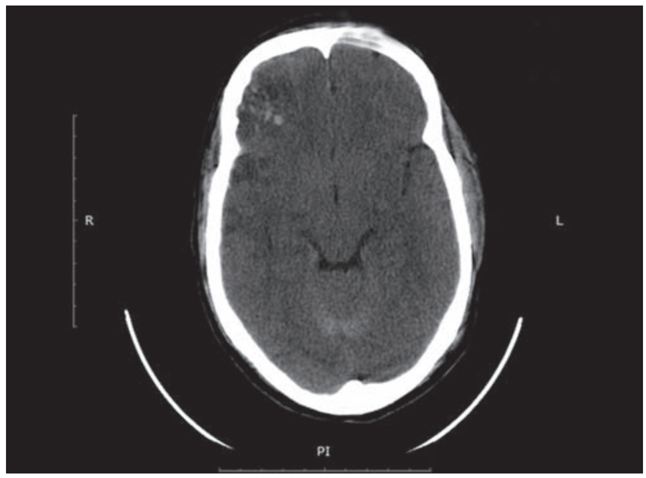
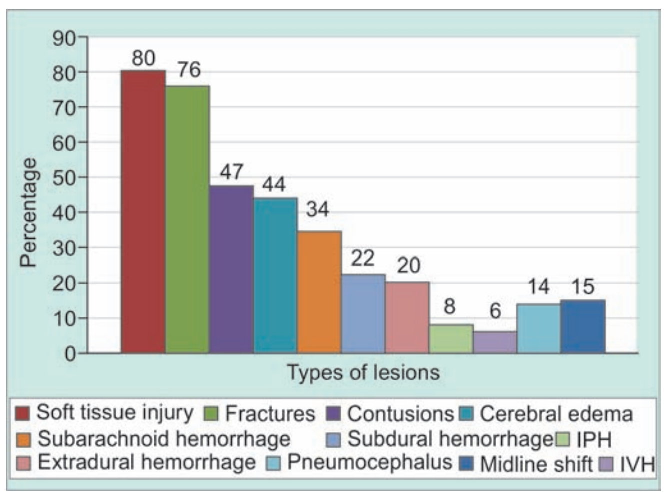



**Fig. 3:** Hemorrhagic contusions with surrounding edema in right frontal lobe

In the present study, calvarial bone fracture was seen in 76 patients; out of these commonest type of fractures were linear fractures accounting for 50 (65.8%) cases, followed by depressed fracture 14 (18.4%) (Figs 1A and B) and skull base fractures (Fig. 2) accounting for 12 (15.8%) cases.In the present study, contusions (Fig. 3) were the commonest intracranial lesion noted in 47 patients (47%) and soft tissue swelling/injury (80%) and fractures (76%) were the commonest of all lesions. Other lesions which were seen on CT scan are cerebral edema 44%, SAH 34% subdural hematoma 22%, extradural hematoma 20%, intracerebral hematoma 9%, and IVH 6%, midline shift 15%, and pneumocephalus 14% (Graph 4).

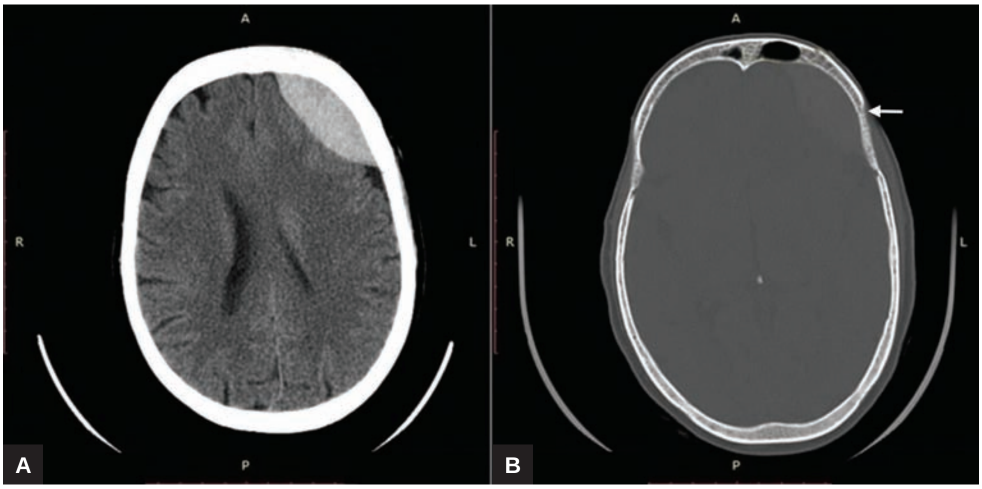



**Graph 4:** Incidence of various lesions as observed on CT scan

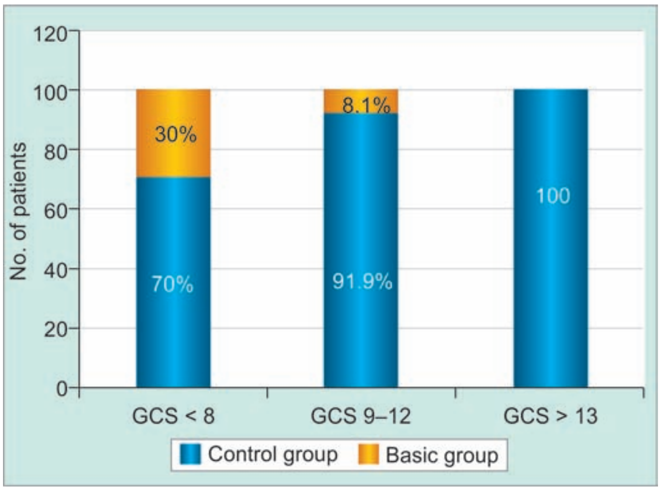
As described in the literature, in our study also EDH is usually associated with fracture of overlying bone (Figs 4A and B). Out of 20 patients with EDH, 17 patients had an overlying associated fracture.

Poor outcome was noted in patients with a GCS score of <8. Patients with GCS score of <8 had a mortality of 30%, followed by 8.1% in patients with GCS of 9 to 12, and no mortality was found in patients with 13 to 14 GCS score (Graph 5).

$\chi^2 = 14.23$ and $p < 0.001$, which shows that the relationship is highly significant and GCS score is a good indicator of outcome.




**Figs 4A and B:** Hyperdense, lentiform-shaped EDH in left frontal region (A) with overlying frontal bone fracture (B)




**Graph 5:** Outcome based on the GCS score

According to the present study, SDH (41.6%) (Figs 5A, B and 6) was the most common extraaxial bleed noted in patients who expired, followed by SAH of 33.3%; EDH with 16% was the least common hemorrhage noted in these patients.

Diffuse cerebral edema, midline shift, intraparenchymal bleed (Fig 6), and IVH are indicators of poor prognosis. Increased incidence of contusions was also noted in patients who expired.

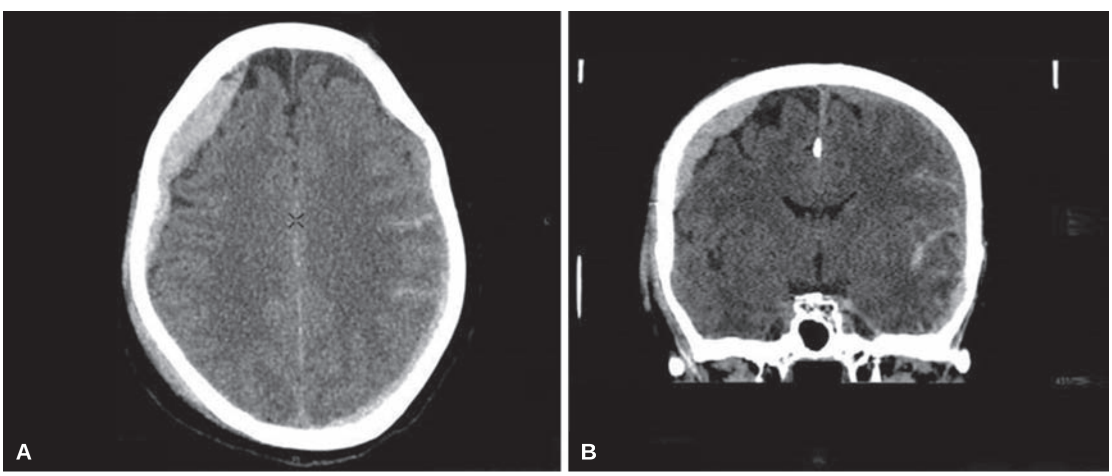
In patients with EDH, timely diagnosis and prompt surgical decompression surgery improve prognosis with reduction in mortality rate from 10 to 0%. Significant reduction in mortality is also noted in surgically managed patients of intraparenchymal bleed from 55 to 25%. Therefore, timely diagnosis and early surgical management significantly improves outcome.

## DISCUSSION

Males were found to be more predominant than females in the present study.

Incidence reported in other studies were Zimmerman et al[3] 79%, Saboori et al[4] 78.2%, and Holmes et al[5] 65%. This male preponderance can be attributed to the increased outdoor activity and travel by males.

In the present study, patients in the age group of 21 to 30 years formed the bulk of the study. Khan et al[6] also




**Figs 5A and B:** Noncontrast CT axial: (A) Reformatted coronal; and (B) image showing acute SDH in right frontoparietal region and SAH in left parietotemporal region

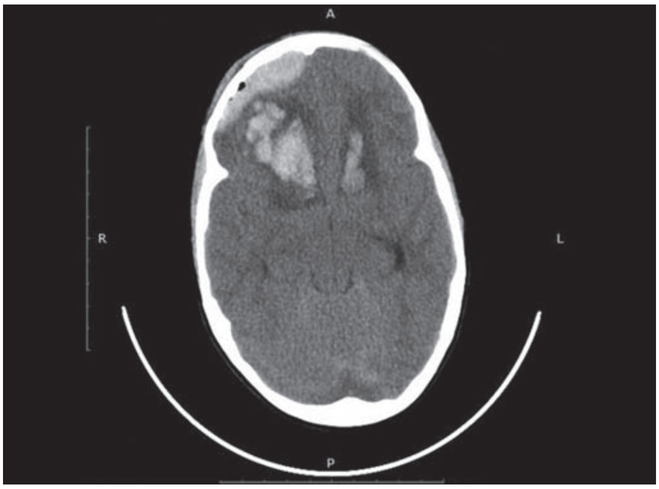



**Fig. 6:** Noncontrast CT axial image showing large acute SDH in right frontal region and intraparenchymal hematoma with surrounding edema in bilateral frontal lobe

mentioned in their study that peak incidence of TBIs was between 15 and 35 years age group, and Saboori et al[4] reported a mean age of 29 years for patients of head injury. Study by Ogunseyinde et al[7] also stated that head injury was common in patients younger than 35 years.

By these studies, it is noted that head injury is seen commonly in socially and economically productive age group of the population, and hence has an impact on the financial aspect of the family.

Road traffic accidents were found to be the commonest mode of injury in the present study accounting for 69%. Zimmerman et al[3] also reported RTA as the major cause, albeit in a lesser population (39%). Gururaj[8] in his study reported vehicular accidents as the major mode of head injury with an incidence of 60% and Ziya Ahmad and Karmakar[9] reported 85.9%. This increased incidence due to RTA can be attributed to the increased vehicular movement because of rapid urbanization, economic growth, and lifestyle changes.

In younger patients (<15 years), fall was found to be the most common mode of injury (83.33%), followed by RTAs (16.66%), which is consistent with other previous studies.

Linear fractures were found to be the commonest type of fracture with an incidence of 65.8%, followed by depressed fractures accounting for 18.4%, and skull base fracture 15.8%. Study by Lloyd et al[10] showed an incidence of linear fractures of 84% and that of depressed fractures to be 9%. Goyal et al[11] also stated that linear fracture (77%) is the most common followed by depressed fracture (13%).

In the present study, patients classified as moderate head injury with a GCS score of 9 to 12 formed the bulk of the study accounting for 37%, followed by 33% of patients with mild head injury with GCS score of 13 to 14, and 30% of patients with severe head injury with GCS score of <8. This increase in incidence of moderate and severe head injury seen is probably due to exclusion of patients with normal CT findings in the present study conducted.

Contusion was found to be the commonest intracranial lesion detected on CT accounting for 47% in the present study. Dublin et al[12] also reported similar observation (40%).

Subdural hematoma was found in 22% cases in the present study. Incidence reported in other studies were Ogunseyinde et al[7] (28.7%) and Gupta et al[13] (19%).

Intraparenchymal bleed accounted for 9% of lesions in the present study, whereas higher incidence of 26.3% was noted in the study conducted by Ogunseyinde et al.[7]

Intraventricular hemorrhage was the least common lesion noted with an incidence of 6% in the present study. LeRoux et al[14] in their studies had stated that IVH is noted in 1 to 5% of all patients with head injury. Gupta et al[13] reported incidence of 10.7%. Traumatic IVH is thus relatively uncommon and usually reflects severe injury.

Extradural hematoma was found to be associated with an overlying fracture in 85% of cases in the present study. Igun[15] reported 100% association of EDH with an overlying fracture. A blow to the calvarium resulting in fracture of the adjacent bone causes displacement of dura away from the inner table of skull, resulting in damage to underlying vessel, thus causing extradural hematoma.

The commonest hemorrhage found in patients who expired was subdural hematoma and intraparenchymal hemorrhage with an incidence of 41% each. This can be attributed to the more severe impact of trauma to cause the hemorrhage and also the significant midline shift noted in these patients leading to a grave prognosis. Cooper[16] in his study stated that mortality due to subdural hematoma was between 35 and 50%, and SDH is also associated with worse outcome because it is generally caused by high velocity injuries resulting in more primary brain injury. Midline shift, if present, carries poor prognosis and found in 75% patients who expired.

In addition, EDH was seen in 16% of patients who expired. Bricolo and Pasut[17] and Smith and Miller[18] in their studies stated that mortality with EDH is approximately 5%. Since EDH is usually associated with low velocity injury, it results in little primary injury to brain and causes poor outcome only if the expanding hematoma is allowed to compress the brain. Increased association of EDH with mortality is found in our study because of other associated intra- or extraaxial lesions.

In the present study, poor outcome was noted with a GCS score of <8 with a mortality of 30%, followed by 8.1% in patients with GCS of 9 to 12, and no mortality was found in patients with 13 to 14 GCS score. Study conducted by Stuart et al[19] reported an incidence of 34.50% mortality with a GCS score of <8.

p-value is calculated using chi-square test and found to be <0.001, which shows that the relationship is highly significant and GCS score is a good indicator of outcome. This increased mortality in a patient with a reduced GCS score is due to more severe primary brain insult associated.

Operative decompression was carried out in six patients with extradural hematoma and four patients with intraparenchymal hematoma. All operated patients had good prognosis except in one patient with intraparenchymal hematoma who expired. Traumatic extradural hematoma is a neurosurgical emergency and timely surgical intervention for significant extradural hematoma is gold standard as stated by Cheung et al[20] in their study. According to Bullock et al,[21] patients who had EDH with thickness >15 mm, midline shift >5 mm should be surgically managed regardless of GCS score, and craniotomy provides a more complete evacuation of hematoma.

Khaled et al[22] also found in their study that surgical intervention in EDH is associated with the best prognosis. Out of many factors affecting the outcome, the most important one is the duration of time between accident and surgery; mortality can be close to 0% if this time interval can be minimized.

Chowdhury et al[23] stated that EDH is one of the most rewarding neurosurgical emergencies. It must be diagnosed in the early period of the trauma and evacuated early to prevent potential mortality and morbidity.

Therefore, early diagnosis is very crucial in patient prognosis.

## CONCLUSION

Head injury is a major neurological cause of death and disability in young and middle-aged patients, with RTAs being the most common cause in adults and fall in children.

Neuroimaging technique provides vital diagnostic, prognostic, and pathophysiological information in the management of brain injury. Radiological imaging modalities help in the assessment of intracranial hemorrhage, fractures, and other structural lesions. Apart from the correct diagnosis, the time to establish a diagnosis is very crucial for successful management and favorable outcome in patients with TBI.

Computed tomography is widely available, relatively inexpensive, highly sensitive, and safe imaging modality and provides the ability to rapidly evaluate patients with acute head injuries. Contribution of CT is crucial to complete injury assessment and forms the basis of patient management.

In addition, CT aids in surgical planning, prognosticating outcome, and recovery time. It can demonstrate significant primary traumatic injuries including extradural, subdural, intracerebral hematomas, SAH, and IVHs, skull fractures, cerebral edema, contusions, and cerebral herniations.

Moreover, CT is one of the most comprehensive diagnostic modality for early and accurate diagnosis, thus aiding a better prognosis in patients with head injury.

Thus, it is justifiable to conclude that CT is the singlemost informative diagnostic modality in the evaluation of a patient with a head injury and should be considered the first imaging of choice in acute head injury as it forms the cornerstone for rapid and effective diagnosis.

## REFERENCES

1. Renlund Ashley, R. Trauma overview. Osborn's brain: imaging, pathology and anatomy. Canada: Amirsys; 2013. p. 1.
2. Besenski N. Traumatic injuries: imaging of head injuries. Eur Radiol 2002 Jun;12(6):1237-1252.
3. Zimmerman RA, Bilaniuk LT, Gennerelli T, Bruce D, Dolinskas C, Uzzell B. Cranial computed tomography in diagnosis and management of acute head trauma. AJR Am J Roentgenol 1978 Jul;131(1):27-34.
4. Saboori M, Ahmadi J, Farajzadegan Z. Indications for brain CT scan in patients with minor head injury. Clin Neurol Neurosurg 2007 Jun;109(5):399-405.
5. Holmes JF, Hendey GW, Oman JA, Norton VC, Lazarenko G, Ross SE, Hoffman JR, Mower WR; NEXUS group. Epidemiology of blunt head injury victims undergoing ED cranial computed tomographic scanning. Am J Emerg Med 2006 Mar; 24(2):167-173.
6. Khan F, Baguley IJ, Cameron ID. 4: rehabilitation after traumatic brain injury. Med J Aust 2003 Mar;178(6):290-295.
7. Ogunseyinde AO, Obajimi MO, Ogundare SM. Radiological evaluation of head trauma by computer tomography in Ibadan, Nigeria. West Afr J Med 1999 Jan-Mar;18(1):33-38.
8. Gururaj G. Epidemiology of traumatic brain injuries: Indian scenario. Neurol Res 2002 Jan;24(1):24-28.
9. Ziya Ahmad M, Karmakar RN. An epidemiological study of acute head injury and it's evaluation by CT. J Indian Acad Forensic Med 2014 Apr-Jun;36(2):173-175.
10. Lloyd DA, Carty H, Patterson M, Butcher CK, Roe D. Predictive value of skull radiography for intracranial injury in children with blunt head injury. Lancet 1997 Mar;349(9055):821-824.
11. Goyal MK, Verma R, Kocher SR, Asawa SS. Correlation of CT scan with post mortem findings of Acute Head Trauma cases at SMS Hospital, Jaipur. JIAFM 2010;32(3):208-211.
12. Dublin AB, French BN, Rennick JM. Computed tomography in head trauma. Radiology 1977 Feb;122(2):365-369.
13. Gupta PK, Krishna A, Dwivedi AN, Gupta K, Madhu B, Gouri G, Shivani A. CT scan findings and outcomes of head injury patients: a cross sectional study. JPMS 2011 Oct-Dec;1(3):78-82.
14. LeRoux PD, Haglund MM, Newell DW, Grady MS, Winn HR. Intraventricular hemorrhage in blunt head trauma: an analysis of 43 cases. Neurosurgery 1992 Oct;31(4): 678-684.
15. Igun GO. Predictive indices in traumatic intracranial haematomas. East Afr Med J 2000 Jan;77(1):9-12.

16. Cooper, PR. Head injury: post traumatic intracranial mass lesions. 2nd ed. Baltimore: Williams and Wilkins; 1987.
17. Bricolo AP, Pasut LM. Extradural hematoma: toward zero mortality. A prospective study. Neurosurgery 1984 Jan;14(1): 8-12.
18. Smith HK, Miller JD. The danger of an ultra-early computed tomographic scan in a patient with an evolving acute epidural hematoma. Neurosurgery 1991 Aug;29(2):258-260.
19. Stuart G, Yelland JD, Balderson G. 3000 head injuries: a prospective study of patients admitted to Brisbane neurosurgical units. J Clin Neurosci 1998 Oct;5(4):402-405.
20. Cheung PS, Lam JM, Yeung JH, Graham CA, Rainer TH. Outcome of traumatic extradural haematoma in Hong Kong. Injury 2007 Jan;38(1):76-80.
21. Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, Servadei F, Walters BC, Wilberger JE; Surgical Management of Traumatic Brain Injury Author Group. Surgical management of acute epidural hematomas. Neurosurgery 2006 Mar;58(Suppl 3):S7-S15.
22. Khaled CN, Raihan MZ, Chowdhury FH, Ashadullah AT, Sarkar MH, Hossain SS. Surgical management of traumatic extradural haematoma: experiences with 610 patients and prospective analysis. Indian J Neurotrauma 2008 Dec;5(2): 75-79.
23. Chowdhury SN, Islam KM, Mahmood E, Hossain SK. Extradural haematoma in children: surgical experiences and prospective analysis of 170 cases. Turk Neurosurg 2012;22(1):39-43.