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Original Research Article

Computed Tomography Evaluation of Traumatic Brain Injury with Clinical Correlation (GCS Score)

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Conflict of interest: Nil

Abstract:

The health scenario in India has changed immensely in the last few decades. Among the present health problems, injuries due to urbanization, motorization, and human behavioural changes form a major bulk of the problems. This study aims to assess the pattern of CT findings in the head injury patients with possible traumatic brain injury and correlate the CT findings with the Glasgow coma scale score of the patient. The present study is a hospital-based cross-sectional analytical study that was carried out in the department of Radiodiagnosis, FAAMCH, Barpeta, Assam for a period of 1 year. GCS score of the patient was recorded at the time of presentation and grading of craniocerebral trauma was done based on GCS score. The patients were scanned by Philips MX 16-slice CT machine. The most common mode of TBI in our study was RTA, followed by physical assault and self-falls. Based on GCS, 62.4% of the study population in our study was in the mild TBI group, 16.3% patients were in the moderate TBI group and 21.2 % in severe TBI group. Positive CT findings were noted in 202 out of total 306 cases i.e., 66% of total cases. The most common intracranial lesion was contusion haemorrhage seen in 24.5% cases followed by SDH in 22.5% cases, SAH in 21.2% cases and EDH in 17%. In our present study a very strong, positive correlation was noted between extra-axial haemorrhages, three or more findings with GCS score (TBI groups). NECT brain gives us a vivid picture regarding the pattern of injury with appropriate location and size of lesion. The NECT brain findings correlated well with the severity of head injury clinically assessed by GCS Score, particularly in patients with more than one finding. NECT brain can be used as a tool.

Keywords: Computed tomography, GCS, Head injury, NECT brain, RTA, Traumatic brain injury

Key Messages: NECT brain gives us a vivid picture regarding the pattern of injury with appropriate location and size of lesion. The NECT brain findings correlated well with the severity of head injury clinically assessed by GCS Score, particularly in patients with more than one finding.

Introduction

Health scenario in India has changed immensely in the last few decades with the shift of the health problems from communicable diseases to non-communicable diseases and injury. Among the present health problems, injuries due to urbanization, motorization and human behavioural changes forms a major bulk of the problems.

In India, injuries are the seventh leading cause of mortality contributing 11% of total deaths, 78% due to road accidents alone.[1] So, early evaluation of these TBI patients with the available imaging modality will help in the further management of the patient and thus reducing the mortality as well as morbidity.

Objective: The purpose of this study is to assess the pattern of CT findings in the head injury patients with possible traumatic brain injury and correlate the CT findings with the Glasgow coma scale score of the patient.

Materials and Methods:

Study design: Hospital-based cross-sectional analytical study.

Source of data: The main sources of data for this study were the patients of head injury referred to the department of Radiodiagnosis, Fakhruddin Ali Ahmed Medical College and Hospital (FAAMCH), Barpeta, Assam.

Place and Period of Study: The present study was carried out in the department of Radiodiagnosis, FAAMCH, Barpeta, Assam for a period of one year from September 2019-August 2020.

Patient selection:

Inclusion criteria:

- History of head injury with possible traumatic brain injury in patients aged > 5 years
- Patients presenting within 12 hours of injury.

Exclusion criteria:

- Patients with major trauma (including airway or cervical spine injury, penetrating trauma to trunk or abdomen, fall from height greater than 12 feet, significant trauma above and below diaphragm)
- Altered mental status of unclear etiology.
- Known previous intracranial pathology.
- History of coagulation disorders, seizures, previous history of neurosurgery.
- Patients with known history of Cerebrovascular accidents.

Sampling: -

$N= (Z^2p(1-p))/d^2$

Assuming population proportion as 0.5 and unlimited population size, sample size is calculated by the above given equation where,

N-sample size
p=population proportion
Value of Z= 1.75 for confidence interval of 92 %
d -relative precision =20% of p.

Using this formula, the minimum sample size was calculated to be 306.

A total of 306 patients with head injury and suspected TBI who were referred to the department of Radiodiagnosis and satisfied the inclusion and exclusion criteria were included in the study.

Data Acquisition:

A structured pre-prepared case proforma was used to enter the patient details and history. Clinical status of patients at admission was assessed using Glasgow coma scale and severity was determined. The Glasgow Coma Scale divides into three parameters: best eye response (E), best verbal response (V) and best motor response (M). The levels of response in the components of the Glasgow Coma Scale are 'scored' from 1, for no response, up to normal values of 4 (Eye-opening response) 5 (Verbal response) and 6 (Motor response). The total Coma Score thus has values between three and 15, three being the worst and 15 being the highest.[2] The severity of the craniocerebral trauma was graded with the help of Glasgow coma scale (GCS) and were classified as severe (GCS 3–8), moderate (GCS 9–13), or mild (GCS 14–15) TBI. The CT findings were then correlated with GCS of the patients at admission.

Technique:

Equipment- The patients were scanned using Philips MX 16-slice CT machine with the following parameters.

- Matrix size - 512
- Slice thickness - 5 mm.
- kVp - 120.
- mAs – 200- 300

CT Protocol: After the examination of the cervical spine for any evidence of injury, the patients were examined with CT scanner in the supine position. The Gantry tilt was given in the range of ± 0-20 degrees, so as to parallel the scan plane to the orbito-meatal line. Contiguous axial sections of slice thickness 5 mm were taken for the posterior fossa study and supratentorial region.

Thinner sections were also obtained in the region of interest. Bone algorithms & wide window settings were studied to visualize the various craniocerebral changes. CT images of all patients enrolled in the study were collected and assessed from PACS.

Data Processing and Statistical Methods:

All the acquired data was entered into a spread sheet using MS EXCEL 2019 MSO version 2109 and a master chart was prepared. Mean and standard deviation of continuous data (age) was calculated. Descriptive statistical analysis (frequency, percentage,) was carried out in this study after collecting all the clinical and radiological data. The data were categorized into few predefined groups such as mild, moderate and severe TBI based on GCS score, extra-axial haemorrhage based on EDH, SDH and SAH. Prevalence of the CT findings of TBI was calculated. To calculate association between various data groups spearman correlation "ρ" was used and its significance was calculated with the help of IBM SPSS Statistics 28.0.

Results and Observations:

A total of 306 patients were included in the study based upon the inclusion and exclusion criteria. The observations of this study are depicted with the aid of tables, bar diagrams and, pie charts in this section.

Table 1: Gender wise distribution in craniocerebral injury

Gender	No. of cases	Percentage
Male	201	65.7 %
Female	105	34.3 %
Total	306	100

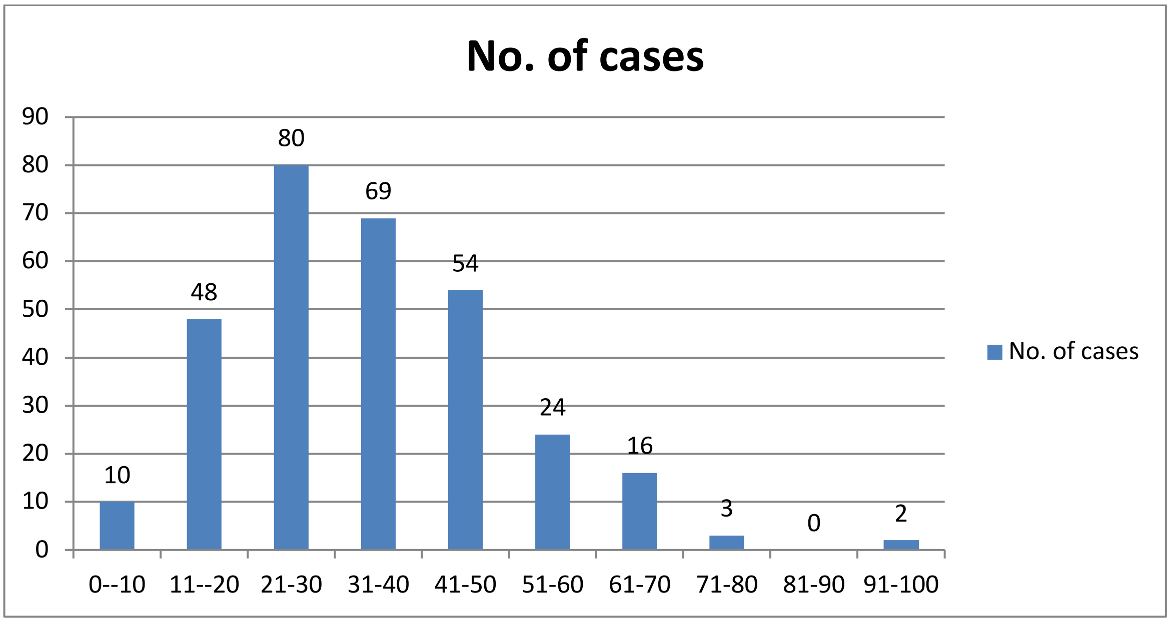

Figure 1: Age wise distribution of craniocerebral injury

The study included patients ranging from age of 5 years to 95 years with a mean age of 34.6 ±15.5 years. The peak incidence of head injury was seen in the age group of 21-40 years which included 149 individuals i.e., 48.7 % of our total cases, followed by the age group of 41-50 years which included 54 individuals as depicted in table-1 and figure-1.

Mode of injury

Most common mode of injury was Road traffic accident as depicted in table-2 and figure-2.

Table 2: Mode of injury in patients of craniocerebral injury

		Frequency	Percentage %
Mode of injury	Fall from height	3	1.0
	Physical assault	77	25.2
	Penetrating injury	1	.3
	Road traffic accident	156	51.0
	Self-fall	69	22.5
	Total	306	100.0

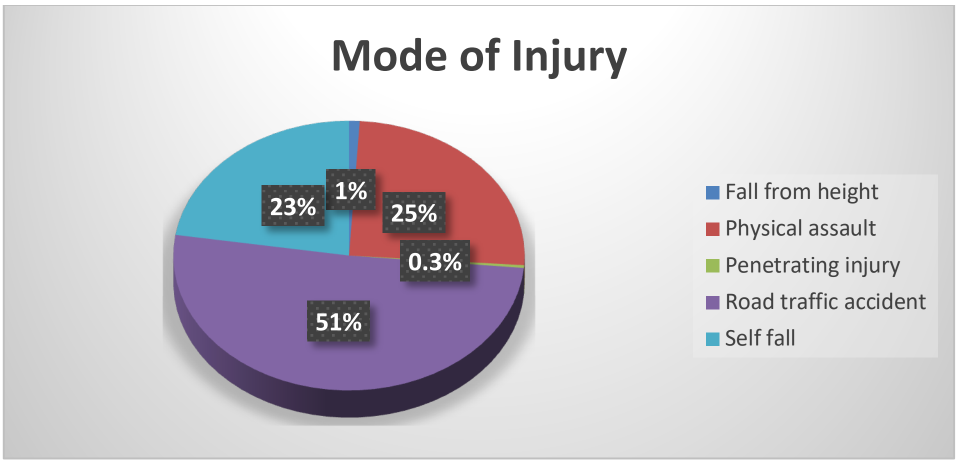

Figure 2: Mode of injury in patients of craniocerebral injury

Distribution of study population based on GCS score

Table 3: TBI groups based upon GCS score

		Frequency	Percent
TBI groups	MILD TBI	191	62.4
	MODERATE TBI	50	16.3
	SEVERE TBI	65	21.2
	Total	306	100.0

Table 4: Distribution of patients of craniocerebral injury based on GCS score

GCS			
		Frequency	Percent (%)
GCS score	3	2	.7
	4	5	1.6
	5	11	3.6
	6	10	3.3
	7	14	4.6
	8	23	7.5
	9	12	3.9
	10	16	5.2
	11	10	3.3
	12	9	2.9
	13	3	1.0
	14	22	7.2
	15	169	55.2
	Total	306	100.0

It was observed that a total of 169 patients have a GCS score of 15, accounting for 55.2 percent of the total study population (Tables 3,4).

CT findings in patients of TBI

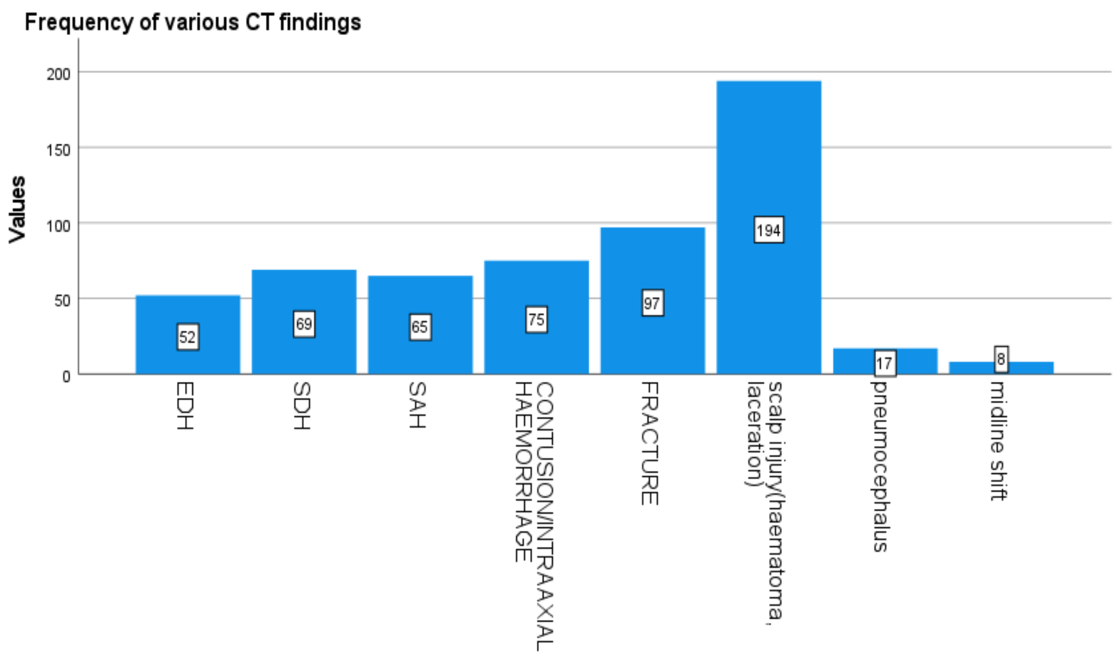

Figure 3: Prevalence of various CT findings in patients of TBI

Regarding type of lesion in the patients with TBI, most common intracranial lesion was contusion hemorrhage(figure-4,5,6) seen in 75 out of 306 cases (24.5%) followed by SDH(figure-7,8) in 69(22.5%) cases, SAH(figure-5,7) in 65(21.2%) cases, EDH(figure-9) in 52(17%). Linear/comminuted skull fracture (figure 10-15) was noted in 97 out of 306 cases (31.7%). Midline shift (figure 8) and pneumocephalus (figure-13) was noted in 8(2.6%) and 17(5.6%) cases respectively. Scalp injury (figure-16,17) was noted in a maximum of 194 patients with TBI.

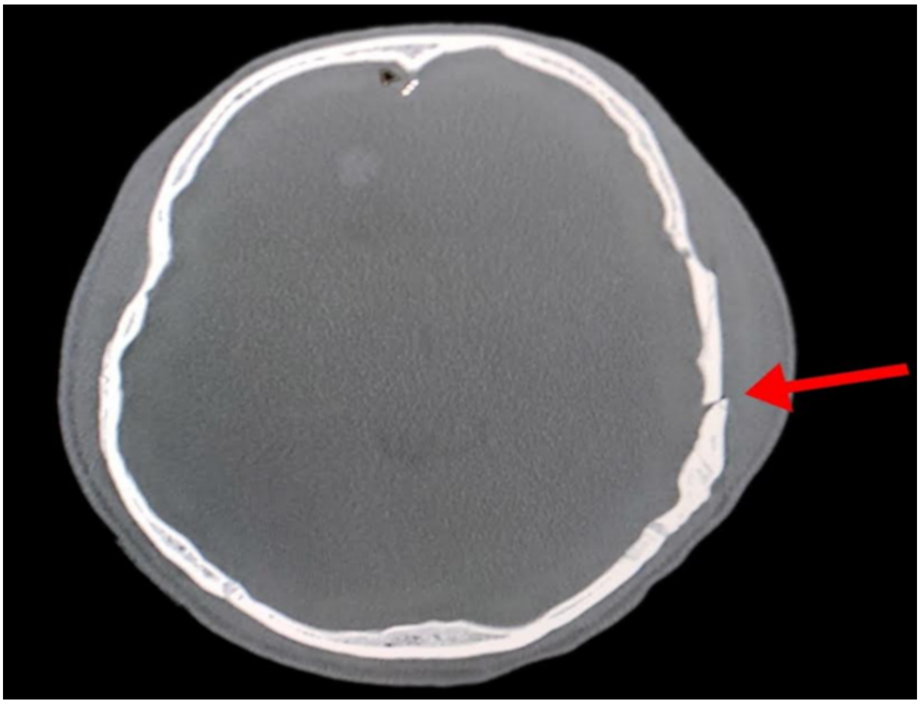

Figure 4: Axial CT in the bone window shows a linear minimally displaced fracture of left parietal bone (Red arrow) with adjacent soft tissue swelling. Contra coup contusion and SDH was also noted in the patient.

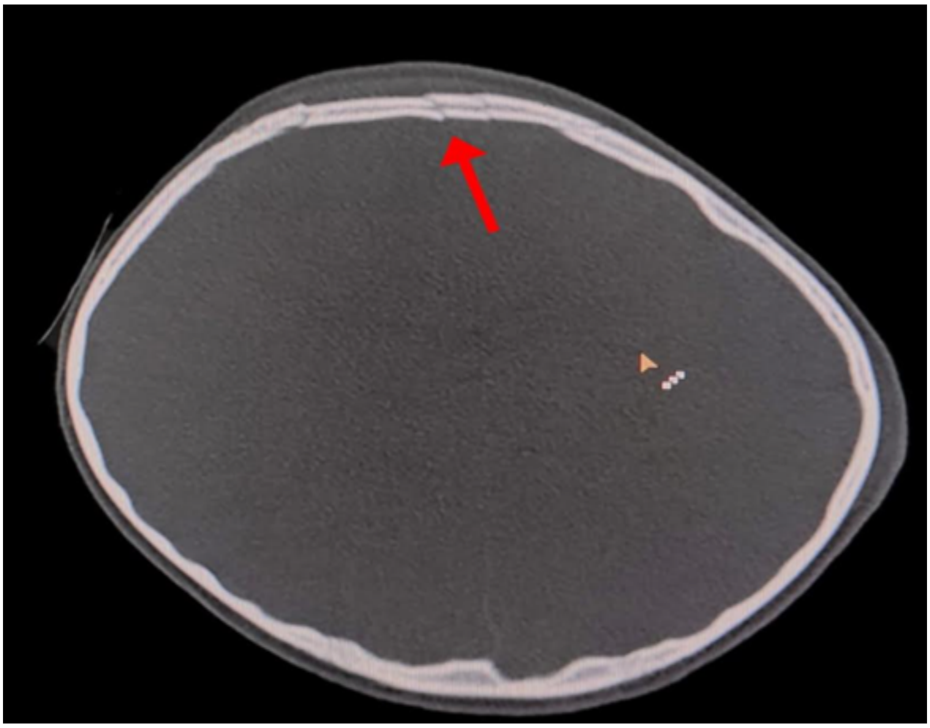

Figure 5: Axial CT in the bone window shows a comminuted displaced fracture of the frontal bone (Red arrow)

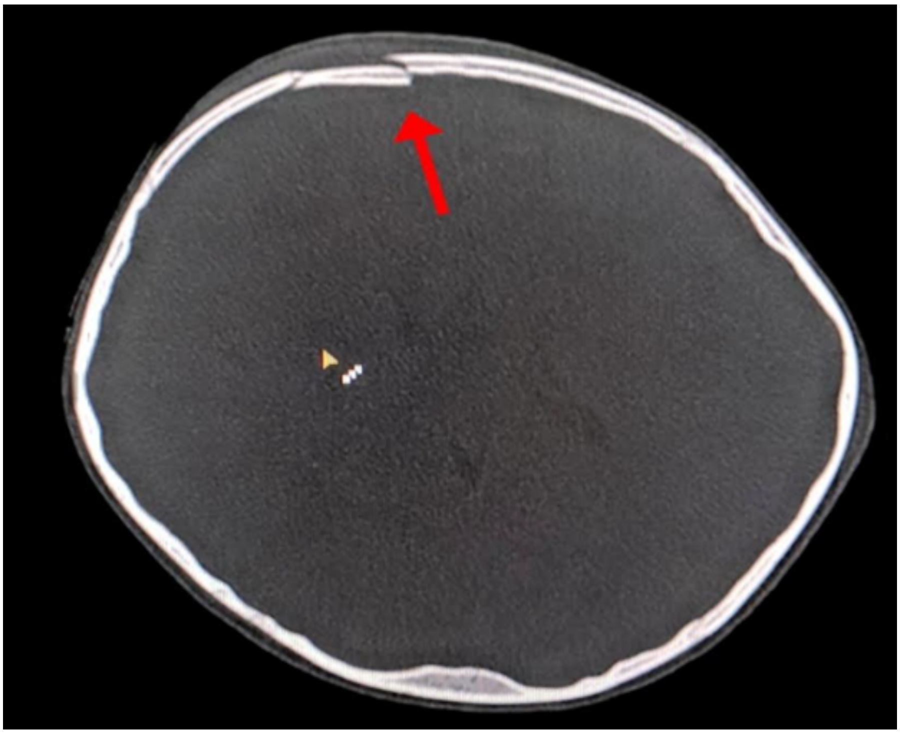

Figure 6: Axial CT in the bone window shows a comminuted depressed fracture of the frontal bone (Red arrow) with adjacent subgaleal hematoma

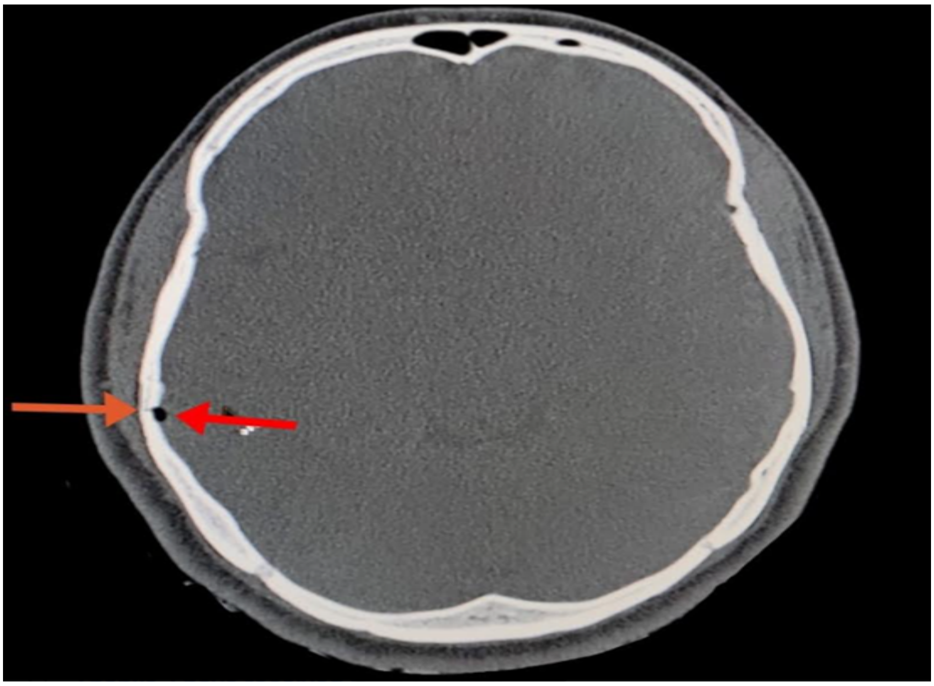

Figure 7: Axial CT in the bone window shows a linear un-displaced fracture of the right parietal bone (Orange arrow) with adjacent pneumocephalus (Red arrow)

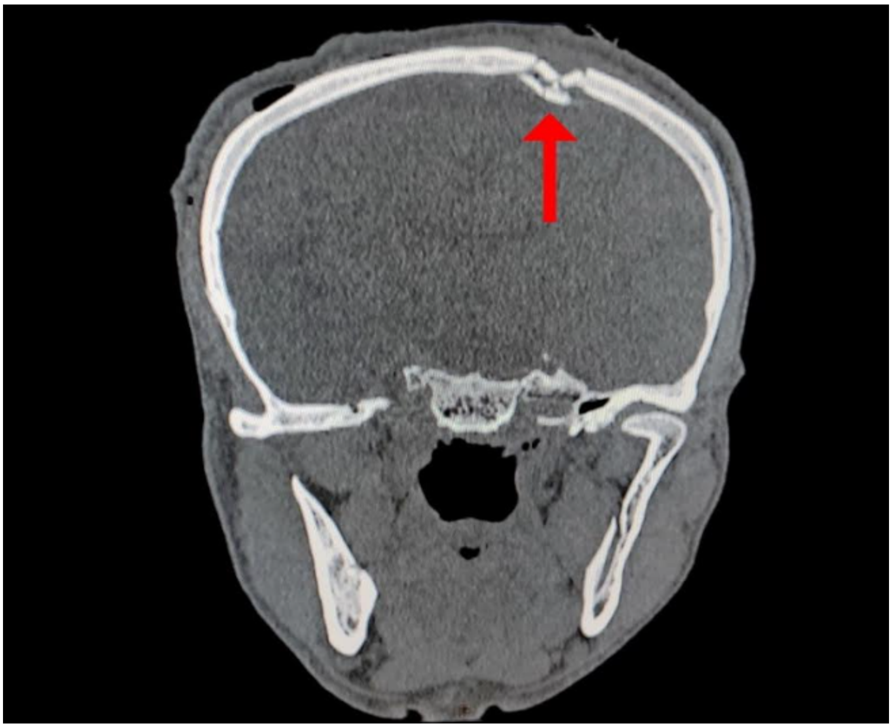

Figure 8: Coronal CT reformatted from the axial source data in the bone window shows depressed skull fracture of left parietal bone (Red arrow) with adjacent scalp hematoma and subgaleal air

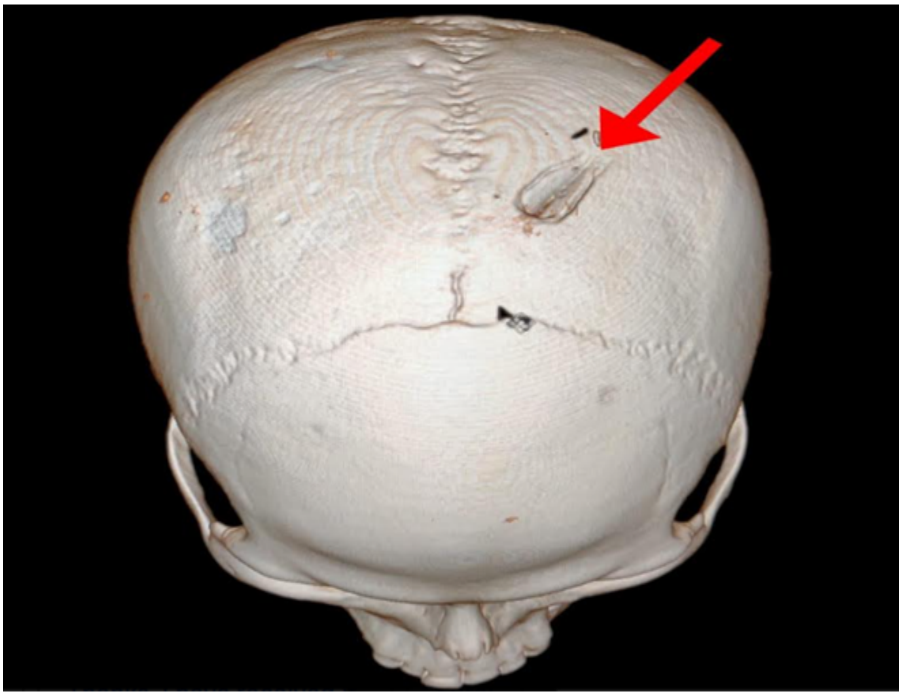

Figure 9: 3D surface shaded display in the same patient as in figure 25 shows the depressed skull fracture of left parietal bone. (Red arrow)

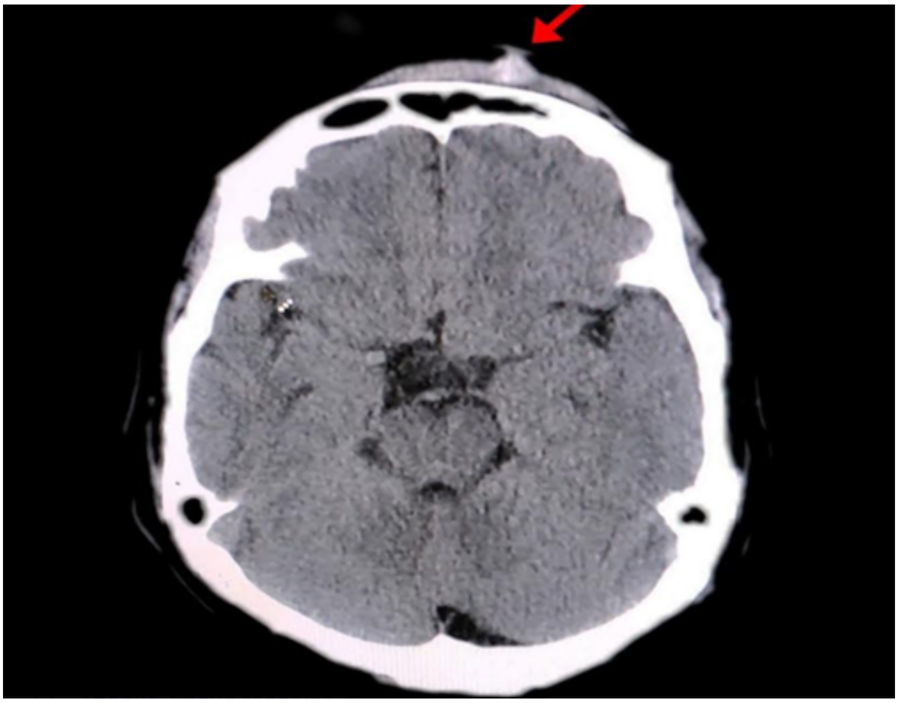

Figure 10: Axial CT in the brain window shows a hyperdense collection in the subgaleal location of scalp over the frontal location suggestive of subgaleal hematoma (Red arrow)

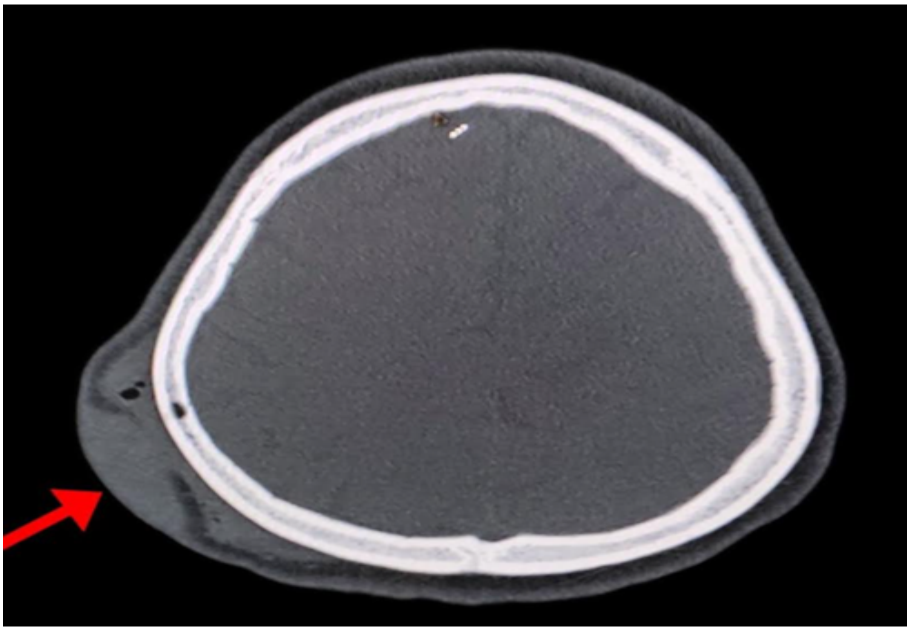

Figure 11: Axial CT in the bone window shows a scalp hematoma over the right parietal location (Red arrow) with air foci in the scalp suggestive of laceration

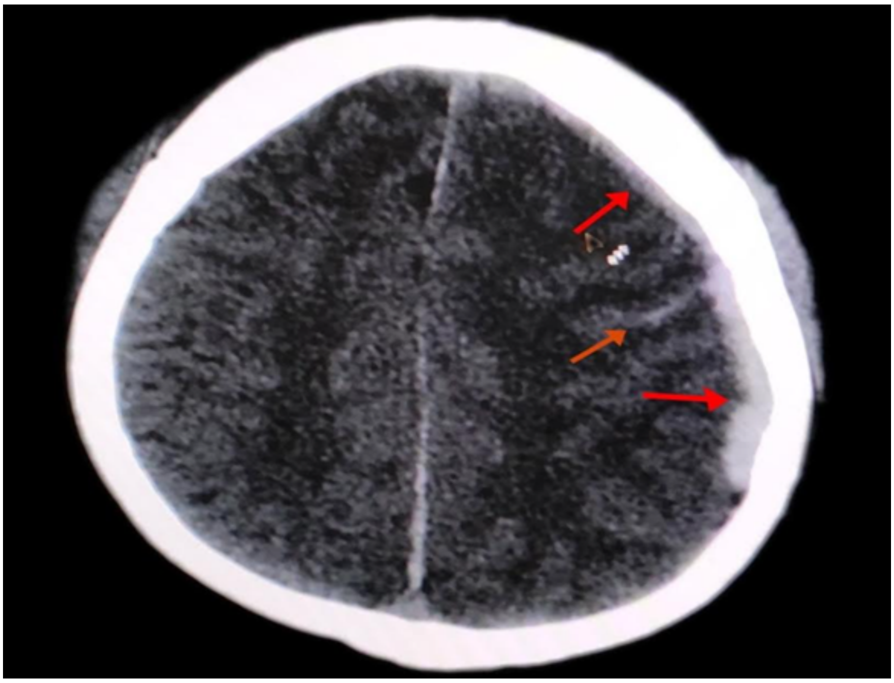

Figure 12: Axial CT brain shows a crescentic hyperdense extra-axial collection over the left fronto-parietal lobe-Subdural Haemorrhage (Red arrows) with linear hyper density in the sulci of left parietal lobe-Subarachnoid haemorrhage (Orange arrow). Hyper density also noted along the falx cerbri-SDH. Scalp hematoma is also evident in the left fronto-parietal location

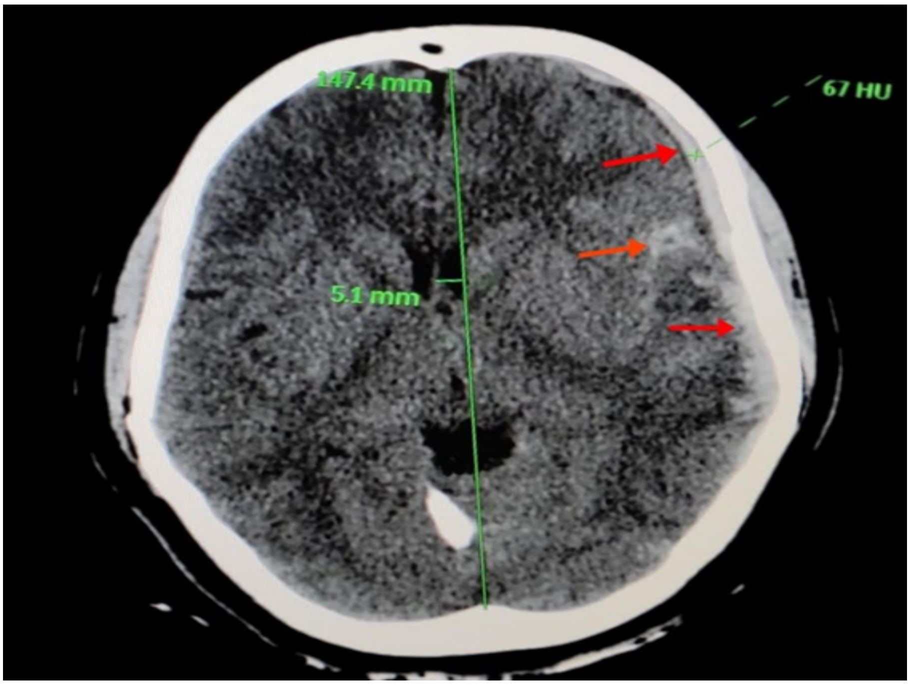

Figure 13: Subdural hematoma (Red arrows) and cortical contusion (Orange arrow) in left parietal lobe with a midline shift of 5.1 mm towards right

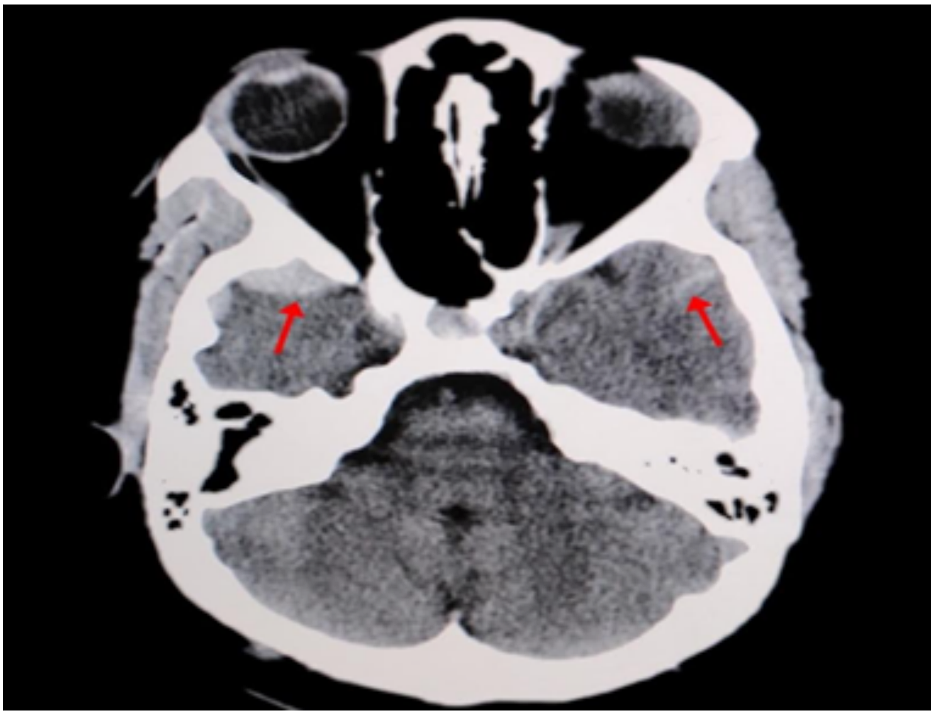

Figure 14: Axial CT brain shows an extra-axial hyperdense biconvex collection in the right middle cranial fossa anterior to the temporal lobe suggestive of epidural hematoma (EDH). Linear hyperdensity in the left temporal lobe suggestive of SAH

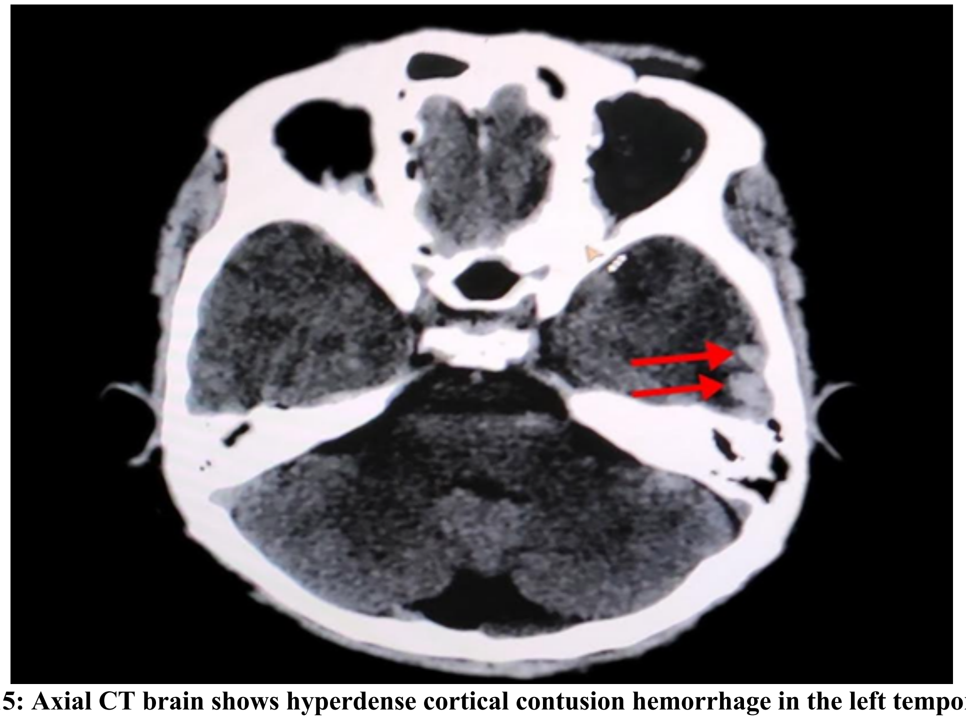

Figure 15: Axial CT brain shows hyperdense cortical contusion hemorrhage in the left temporal lobe. (Red arrows)

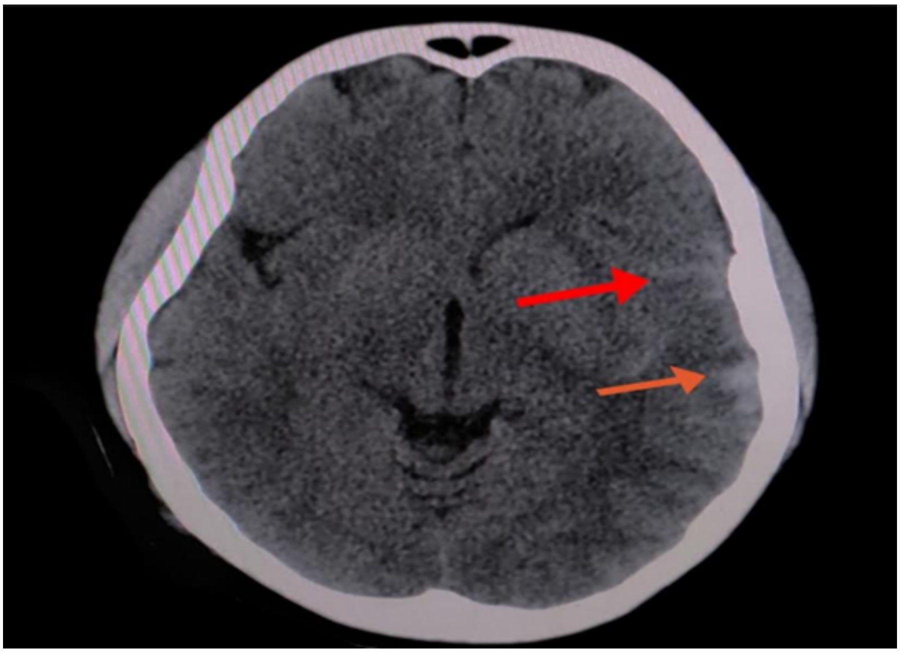

Figure 16: Axial CT brain shows cortical contusion hemorrhage (Orange arrow) in the left parietal lobe and adjacent SAH. (Red arrow)

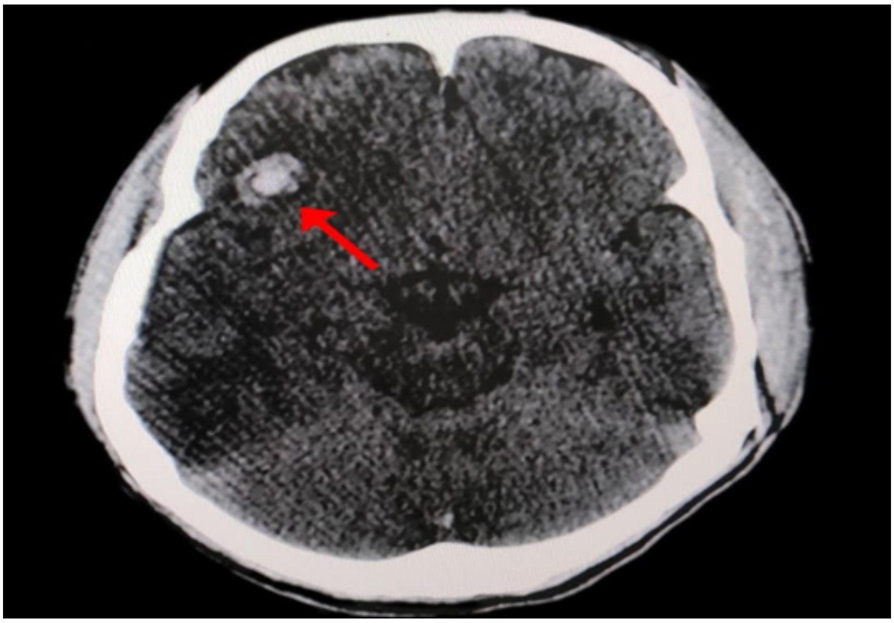

Figure 17: Axial CT brain shows a hyperdense lesion with perilesional edema in the right inferior frontal lobe- Contusion Haemorrhage

Table 5: Classification of TBI based on GCS score with corresponding CT findings

			EDH	SDH	SAH	Contusion/Intra-Axial Hemorrhage	Fracture	Scalp injury (hematoma, laceration)	pneumocephalus	midline shift	
TBI groups	**Mild TBI(191)**	Count	5	6	0	12	20	81	0	0	88
	Moderate TBI(50)	Count	19	19	20	23	33	49	3	1	49
	Severe TBI(65)	Count	28	44	45	40	44	65	14	7	65
Total		Count	52	69	65	75	97	194	17	8	202

Positive CT findings was noted in 202 out of total 306 cases (66%). 104(34%) cases had no findings on CT. Maximum proportions of CT findings were noted in the Severe TBI group followed by the moderate TBI group and mild TBI group. {table 5}

Table 6: CT findings with corresponding GCS score

		EDH	SDH	SAH	Contusion/Intra-Axial Hemorrhage	Fracture	scalp injury (hematoma, laceration)	pneumocephalus	midline shift	Total
GCS	3	2	2	1	2	2	2	2	2	2
	4	3	4	5	4	4	5	2	1	5
	5	4	6	10	9	7	10	3	1	11
	6	4	8	7	5	8	10	1	2	10
	7	8	11	6	9	9	14	3	1	14
	8	7	13	16	11	14	23	3	0	23
	9	2	7	7	7	8	12	1	1	12
	10	8	7	7	9	12	16	2	0	16
	11	4	4	4	4	7	10	0	0	10
	12	4	1	2	3	5	8	0	0	8
	13	1	0	0	0	1	3	0	0	3
	14	0	1	0	3	3	15	0	0	15
	15	5	5	0	9	17	66	0	0	73
Total		52	69	65	75	97	194	17	8	202

Total 169 patients had GCS score of 15, out of which 73(43.2%) cases had positive CT findings. Out of them 43 cases had only mild scalp swelling or scalp hematoma. However, it was observed that 30 out of the 169 patients (17.7%) had positive intracranial findings or fracture of the skull. EDH was noted in 5 cases, SDH in 5, contusion hemorrhage in 9 and fracture in 17 cases. It was also observed that midline shift was noted in patients with low GCS score. {table 6}

Table 7: Number of CT findings with corresponding TBI groups based on GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Total No. of findings	0	103	1	0	104
	1	58	1	1	60
	2	24	5	5	34
	3	6	24	11	41
	4	0	11	20	31
	5	0	8	12	20
	6	0	0	11	11
	7	0	0	4	4
	8	0	0	1	1
Total		191	50	65	306

It was observed that two or more than two findings were noted in 142 out of 306 cases (46.4%) and ≥ 3 findings were noted in 108 out of total 306 cases (35.2 %). More than 3 findings were noted in 67 cases. All 67 cases (100%) with more than three findings had low GCS score and were in the moderate or severe TBI group. Out of the 108 cases with 3 or more than 3 findings 102 cases (94.4 %) were in the moderate or severe TBI group. Only 6 cases (5.6%) were in the mild TBI group. {Table 7}

Prevalence and association of various CT findings with the GCS score of the patients

Table 8: Prevalence & association of Contusion/Intra-axial hemorrhage with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Contusion/intra-axial hemorrhage absent/present	Absent	179	27	25	231
	Present	12	23	40	75
Total		191	50	65	306

Spearman rho "ρ" =0.557, p <.001, Spearman rho "ρ" was run to determine the association between contusion/intra-axial hemorrhage and TBI groups amongst 306 participants. There was a moderate, positive correlation between, contusion/intra-axial hemorrhage and TBI groups (GCS) which was statistically significant. (ρ = .557, p < .001). {table 8}

Table 9: Prevalence and association of Extra-axial hemorrhage with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Extra-axial hemorrhage	Absent	180	8	5	193
	Present	11	42	60	113
Total		191	50	65	306

Spearman ρ =.822, p <.001. There was a very strong, positive correlation between, extra-axial hemorrhage and TBI groups (GCS) which was statistically significant. (ρ =.822, p <.001) {table 9}

Table 10: Prevalence and association of Midline shift with GCS

		TBI Classification Based On GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Midline shift	Absent	191	49	58	298
	Present	0	1	7	8
Total		191	50	65	306

Spearman ρ =.244, p <.001. There was a weak, positive correlation between, midline shift and TBI groups (GCS) which was statistically significant. (ρ =.244, p <.001) {table 10}

Table 11: Prevalence and association of ≥3 findings with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Three or more findings	Absent	185	7	6	198
	Present	6	43	59	108
Total		191	50	65	306

Spearman ρ=.851, p<.001. There was a very strong, positive correlation between, three or more findings and TBI groups which was statistically significant. (ρ =.851, p <.001). {table 11}

Table 12: Prevalence and association of fracture with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Fracture	Absent	171	17	21	209
	Present	20	33	44	97
Total		191	50	65	306

Spearman ρ=.575, p<.001

Table 13: Prevalence and association of scalp injury with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Scalp injury(hematoma, laceration)	Absent	110	1	1	112
	Present	81	49	64	194
Total		191	50	65	306

Spearman ρ=.547, p<.001. There was a moderate, positive correlation between fracture, scalp injury and TBI groups which was statistically significant. {Table 12,13}

Table 14: Prevalence and association of Pneumocephalus with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
Pneumocephalus	Absent	191	47	51	289
	Present	0	3	14	17
Total		191	50	65	306

Spearman ρ=.352, p<.001. There was a weak, positive correlation between pneumocephalus and TBI groups which was statistically significant. (Spearman ρ=.352, p<.001) {table 14}

Table 15: Prevalence and association of EDH with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
EDH	Absent	186	31	37	254
	Present	5	19	28	52
Total		191	50	65	306

Spearman ρ=.490, p<.001. There was a moderate, positive correlation between EDH and TBI groups which was statistically significant. (Spearman ρ=.490, p<.001) {table 15}

Table 16: Prevalence and association of SDH with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
SDH	Absent	185	31	21	237
	Present	6	19	44	69
Total		191	50	65	306

Spearman ρ=.632, p<.001. Spearman rho "ρ" was also run to determine the association between SDH and TBI groups amongst 306 participants. There was a strong, positive correlation between SDH and TBI groups which was statistically significant. Spearman ρ=.632, p<.001{table 16}

Table 17: Prevalence and association of SAH with GCS

		TBI classification based on GCS			Total
		Mild TBI	Moderate TBI	Severe TBI	
SAH	A	191	30	20	241
	P	0	20	45	65
Total		191	50	65	306

Spearman ρ=.701, p<.001. Spearman rho "ρ" was also run to determine the association between SAH and TBI groups amongst 306 participants.

There was a strong, positive correlation between SAH and TBI groups which was statistically significant. Spearman ρ=.701, p<.001{table 17}.

Discussion:

The approach to head injury patients had changed significantly in the recent years with the advent of Computed tomography. It was observed that nearly all patients of head injury are subjected to NECT of brain irrespective of the GCS score and clinical findings.

This change in approach was probably due to the increasing case load relative to the manpower and basic infrastructure, to decrease the time of stay of patients in hospital, and increasing number of medicolegal cases. So, the pattern of CT findings on the NECT brain scan of the patients of head injury will help the clinician in further management of the patients. In this study group which comprised of a total number of 306 patients, majority of them were male i.e., 65.7 % and females comprised 34.3 % of the study population. The age at presentation ranged from 5 to 95 years. The mean age was 34.6 ± 15.5 years and the maximum numbers of patients affected belonged to the age group of 21 to 40 years. The most common mode of TBI in our study was Road traffic accident in 156 patients which comprises 51% of our study population, followed by physical assault in 25.2 % (77), self-fall in 22.5 % (69) and other modes of injury in 1.3 % (4) of our total cases.

Table 18: Mode of injury in various studies

Year of study	Study	RTA (%)	Fall (%)	Physical assault (%)
1993	Bharathi et al.	49.1	23.6	23.4
2002	Gururaj G[3]	60	20-25	10
2015	Sah SK et al., [4]	60	20	12
2017	Vignesh RS et al. [5]	65	29	6
2018	Godavarthi RM et al. [6]	42.7	24.8	22.7
2020-21	Present study	51	22.5	25.2

Based on GCS 62.4% the study population in our study was in the mild TBI group and 16.3% patients were in the moderate TBI group and 21.2 % in severe TBI group. These findings are consistent with the study of Sah SK et al. in 2015[4], Godavarthi RM et al. in 2018[6]. {table 18} In the present study positive CT findings was noted in 202 out of total 306 cases i.e., 66% which is close to the findings of Nayebaghayee H et al. in 2016[7] in which 54.5% had abnormal CT findings.

Table 19: Prevalence of CT scan finding in patients of TBI in various studies

Year of study	Study	Extra-axial hemorrhage			Contusion/Intra-axial hemorrhage	Skull Fracture	Midline shift	Pneumocephalus	IVH
		EDH	SDH	SAH					
2008	Gupta PK et al. [8]	30.4	19.4	28.8	46.3	62.0	24.3	12.0	10.7
2014	Chandrapal T et al [9]	20.6	21.7	13.0	57.6	55.4	28.2	6.5	10.8
2016	Jain AK et al [10]	28.6	23.8	4.7	38.0	---	---	---	---
2018	Sivakumar R et al [11]	23	28.5	---	45.8	40.0	13.1	---	---
2018	Godavarthi RM et al [6]	42.2			72.8	70.7	---	---	---
2020-21	Present study	17	22.5	21.2	24.5	31.7	2.6	5.6	---

*All variables are in percentage of total cases. In our study most common intracranial lesion was contusion hemorrhage seen in 24.5% cases followed by SDH in 22.5% cases, SAH in 21.2% cases and EDH in 17%. Skull fracture was noted in 31.7% of cases. Midline shift and pneumocephalus was noted in 2.6% and 5.6% cases respectively.

In our present study a very strong, positive correlation was noted between extra-axial hemorrhages, three or more findings with GCS score (TBI groups). A moderate, positive correlation was noted between contusion/Intra-axial haemorrhage, fracture, scalp injury with GCS score (TBI groups). A weak, positive correlation was noted between pneumocephalus, midline shift with GCS score (TBI groups).

There was a strong, positive correlation between SDH, SAH with GCS score (TBI groups). In 2019 Agrawal B et al., [12] concluded that the presence of multiple lesions and midline shift in NCCT was significantly related to lower GCS score, whereas patients having single lesion had more GCS level. In 2015 Sah SK et al., [4] in their study “Correlation of Computed Tomography findings with Glasgow Coma Scale in patients with acute traumatic brain injury” concluded that the presence of mixed lesions and midline shift regardless of the underlying lesion on CT scan was accompanied by lower GCS.

Farshchian, Nazanin et al. in 2012[13] concluded that more than three positive indications including extra-axial, hematoma, subarachnoid hemorrhage, and hemorrhagic contusion are associated with low GCS scores and moderate or severe TBI.

Based on the results and observations of our study “Computed tomography evaluation of traumatic brain injury with clinical correlation (GCS score)” we conclude that: -NECT brain gives us a vivid picture regarding the pattern of injury with appropriate location and size of lesion.

The NECT brain findings correlated well with the severity of head injury clinically assessed by GCS Score, particularly in patients with more than one finding. Patients of head injury with GCS score of 15 on initial clinical evaluation still remains a diagnostic dilemma in which NECT brain can be used as a tool to clear the doubt regarding further management of the patient.

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