THE ROLE OF MULTISLICE SPIRAL CT IN CASES OF HEAD TRAUMA

Daisy Gupta[1], Bharat Gupta[2], Sohan Singh[3]

[1]Senior Resident, Department of Radiodiagnosis, Government Medical College and Hospital, Amritsar.
[2]Junior Resident, Department of Radiodiagnosis, Government Medical College and Hospital, Amritsar.
[3]Professor and HOD, Department of Radiodiagnosis, Government Medical College and Hospital, Amritsar.

ABSTRACT

Traumatic Brain Injury (TBI) continues to be an enormous public health problem even with modern medicine in the 21st century. Traumatic Brain Injury (TBI) is a common and potentially devastating clinical problem. Proper management of TBI sequelae can significantly alter the clinical course especially within 48 hrs. of the injury. Neuroimaging techniques have become an important part of the diagnostic workup of such patients. In the acute setting, these imaging studies can determine the presence and extent of injury and guide surgical planning and minimally invasive interventions. Neuroimaging also can be important in the chronic therapy of TBI, identifying chronic sequelae, determining prognosis, and guiding rehabilitation. CT advantages for evaluation of the head-injured patient include its sensitivity for demonstrating mass effect, ventricular size and configuration, bone injuries, and acute haemorrhage. CT offers widespread availability, rapidity of scanning, and compatibility with medical devices.

KEYWORDS

TBI (Traumatic Brain Injury), CT, Head Trauma.

HOW TO CITE THIS ARTICLE: Gupta D, Gupta B, Singh S. The role of multislice spiral ct in cases of head trauma. J. Evolution Med. Dent. Sci. 016;5(70):5105-5111, DOI: 10.14260/jemds/2016/1158

INTRODUCTION

Traumatic Brain Injury (TBI) continues to be an enormous public health problem even with modern medicine in the 21st century. Most patients with TBI (75-80%) have mild head injuries and almost 100% of persons with severe head injury and as many as two thirds of those with moderate head injury will be permanently disabled in some fashion and will not return to their premorbid level of function. The impact is even greater when one considers that most severe head injuries occur in adolescents and young adults. While various mechanisms may cause TBI, the most common causes include motor vehicle accidents, falls, assaults, sports-related injuries, and penetrating trauma. The male-to-female ratio for TBI is nearly 2:1 and TBI is much more common in persons younger than 35 years.[1]

Pathoanatomic Classification

A pathoanatomic classification describes the location or anatomical features of the abnormality to be targeted by a treatment and generally falls into the scheme of "where and what" terminology.

1. Scalp includes laceration, abrasion, oedema, ecchymoses, and subgaleal haematoma.
2. Skull fracture.
3. Extra-axial lesions like EDH, SDH, and SAH.
4. Intra-axial lesions like contusions, ICH, IVH, DAI (focal and diffuse) etc.

Each of these entities can be further described by their extent, location, multiplicity, and distribution.

Financial or Other, Competing Interest: None.
Submission 08-03-2016, Peer Review 18-05-2016,
Acceptance 23-05-2016, Published 01-09-2016.
Corresponding Author:
Dr. Bharat Gupta,
Room No. 77, F-Block,
Boys Hostel Medical College Campus,
Circular Road,
Amritsar-143001,
Punjab.
E-mail: bharat_3009@hotmail.com
DOI: 10.14260/jemds/2016/1158

A number of classification schemes of these entities have been used for pathoanatomic description in many acute head injury studies including the Marshall score for CT findings.

Marshall CT Classification of Head Injury.[2]

Diffuse Injury I (No visible pathology)	No visible intracranial pathology seen on CT scan
Diffuse Injury II	Cisterns are present with midline shift 0-5 mm and/or lesion densities present, no high or mixed density lesion >25 cc may include bone fragments and foreign bodies
Diffuse Injury III (Swelling)	Cisterns compressed or absent with midline shift 0-5 mm, no high or mixed density lesion >25 cc
Diffuse Injury IV (Shift)	Midline shift >5 mm, no high or mixed density lesion >25 cc
Evacuated mass lesion	Any lesion surgically evacuated
Non-evacuated mass	High or mixed density lesion >25 cc, not surgically evacuated lesion

TBI CLASSIFICATION (PATHOANATOMIC AND PATHOPHYSIOLOGICAL)[3]

Primary Traumatic Lesions

a. Primary Neuronal Injuries;-Cortical contusions, Diffuse axonal injury, Subcortical grey matter injury, Primary brainstem injury (DAI, direct laceration, pontomedullary tears).
b. Primary Haemorrhage; -Subdural haematoma, Epidural haematoma (Arterial, venous), Intracerebral haematoma, Diffuse haemorrhage (IVH, subarachnoid).
c. Primary Vascular Injuries; -Carotid-cavernous fistula, Arterial pseudoaneurysm, Arterial dissection/ laceration/occlusion, Dural sinus laceration/occlusion.
d. Traumatic Pia-Arachnoid Injuries; -Posttraumatic arachnoid cyst, Subdural hygroma.
e. Cranial Nerve Injuries.

Secondary Traumatic Lesions
Major territorial arterial infarctions, Boundary and terminal zone infarctions, Diffuse hypoxic injury, Diffuse brain swelling/oedema, Pressure necrosis (Due to displacement and herniation), Secondary "delayed" haemorrhage, Secondary brainstem injury (mechanical compression, infarction, etc.) Others (Fat embolism, infection, etc.).

IMAGING TECHNIQUES

Skull Radiographs.[1,4]
Once an important part of the head injury evaluation, skull radiographs have been replaced by CT scans and are rarely used in patients with closed head injury. Skull x-rays are poor predictors of intracranial pathology and should not be performed to evaluate adult TBI. Lack of abnormality on skull films do not exclude major intracranial injury. Patients who are at high risk for acute intracranial injury must be imaged by CT. The scout view that is obtained with all CT exams can be used as "pseudo-skull film." Skull radiographs are occasionally used in the evaluation of penetrating head trauma to help provide a rapid assessment of the degree of foreign body penetration to screen for retained intracranial bullet fragments.

CT Scan.[1,4]
A CT scan is the diagnostic study of choice in the evaluation of TBI because it has a rapid acquisition time, is universally available, is easy to interpret, and is reliable. The standard CT scan for the evaluation of acute head injury is a noncontrast scan that spans from the base of the occiput to the top of the vertex in 5-mm increments. Three data sets are obtained from the primary scan, as follows: (1) bone windows, (2) tissue windows, and (3) subdural windows. These different types of exposure are necessary because of the significant difference in exposure necessary to visualise various intracranial structures. The bone windows allow for a detailed survey of the bony anatomy of the skull and the tissue windows allow for a detailed survey of the brain and its contents. The subdural windows provide better visualisation of intracranial haemorrhage especially those haemorrhages adjacent to the brain (e.g., subdural haematomas).

Advantages and Disadvantages of CT Scanning in the Head Trauma Evaluation.[4]

Advantages	Disadvantages
Non-invasive and rapid	Traumatic vascular lesions maybe missed.
Very sensitive for acute haemorrhage	DAI is likely to be missed.
Defines nature of ICH (i.e., SDH†, SAH‡)	Motion artefact may limit study.
Defines anatomical location of lesion	Posterior fossa lesions are poorly depicted.
Identifies fractures of the cranium	Depressed skull fractures at the vertex (or along the plane of an axial scan) are poorly depicted.
Sensitive to detecting intracranial air	The scanner has a weight limit and a patient maybe too heavy.
Sensitive in identifying foreign objects	A patient may decompensate while in the scanner.

*Intracranial Haemorrhage; †Subdural Haemorrhage; ‡Subarachnoid haemorrhage.

MRI[1,5,6]
MRI has a limited role in the evaluation of acute head injury. Although, MRI provides extraordinary anatomic detail, it is not commonly used to evaluate acute head injuries because of its long acquisition times and the difficulty in obtaining MRIs in persons who are critically ill. However, MRI is used in the subacute setting to evaluate patients with unexplained neurologic deficits. MRI is superior to CT scan for helping identify Diffuse Axonal Injury (DAI) and small intraparenchymal contusions.

MATERIALS AND METHODS

The present study was conducted in Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar, as 400 patients presenting with head trauma selected at random from emergency departments of Guru Nanak Dev Hospital and Shri Guru Teg Bahadur Hospital of Government Medical College, Amritsar, undergone CT scan of head in department. CT scans, a systematic approach and same protocol was used each time. Bone windows were examined for fractures beginning with the cranial vault and then examining the skull base and the facial bones. Soft tissue windows were examined for the presence of (1) extra-axial haematomas (e.g., epidural haematomas, subdural haematomas), (2) intraparenchymal haematomas, or (3) contusions. Next, the brain was surveyed for any evidence of pneumocephalus, hydrocephalus, cerebral oedema, midline shift, or compression of the subarachnoid cisterns at the base of the brain. Finally, the subdural windows were examined for any haemorrhage that which may not have been visualised on the soft tissue windows.

OBSERVATIONS

The epidemiological characteristics of the study population are showed in the following table.

Age Groups (yrs.)	No. of Cases	% age
0-10	43	10.8
11-20	57	14.3
21-30	116	29
31-40	77	19.3
41-50	51	12.8
51-60	36	9.0
>60	20	5.0
Total	**400**	**100**

Table I: Age-Wise Distribution of Cases

The distribution of the Pattern of Lesions on CT scan are as follows

Type of Lesion	No.	%
Total No. of Cases:	**400**	**100**
Total no of cases with no lesion-fracture or intracranial:	65	1.63
1. Total no cases with scalp injury:	290	72.5
2. Total no of cases with fractures:	232	58
3. Total cases with hemosinus	42	10.5%
4. Total cases with opacified mastoid air cells	15	3.75%
5. Total no of cases with pneumocephalus	40	10
6. Total number of primary intracranial lesions (intra-axial and extra-axial)	157	

a. Total no of EDH	46	11.5
b. Total no of SDH	22	5.5
c. Total no of SAH	40	10
d. Total no of haemorrhagic contusions	76	19
e. Total no of non-haemorrhagic contusions	8	2
f. Total no of IVH	12	3
g. Total no of cases with bleeding/effacement of cisterns	18	4.5
h. Total no of cases with bleed in IHF/tentorium	18	4.5
7. Distribution of secondary lesions		
a. Total no of cases with oedema	64	16
b. Total no of cases showing midline shift	24	6
c. Total no of herniations	12	3

Table II: Distribution of Various Lesion (Extra and Intracranial) Detected by CT Examination of Patients Presenting with Head Trauma

Site of Fracture	No.	%	Site of Fracture	No.	%
1. Frontal	78	19.6	Maxilla	26	6.5
2. Parietal	88	22.1	Zygomatic	38	9.5
3. Occipital	37	9.3	Sphenoid	7	1.75
Temporal			Nasal	27	6.75
• Squamous	63	15.8	Ethmoid	11	2.75
• Petrous	64	16.1	Pterygoid	5	1.25
• Combined:	32	8.0	Mandible	2	0.5
Orbit: (One blow out fracture)	49	12.25	Other sites include middle cranial fossa, sella, etc.	2	0.5

Table III: Distribution of Cases of Fracture According to Site

Type of Lesion	No.	% of Fractures	P value	Significance
EDH	42	18.10%	0.000 (x^2=23, df=1)	Highly significant
SDH	18	7.75%	0.02 (x^2=5.4, df=1)	Significant at 5% significance level
SAH	33	14.2	0.001 (x^2=10.9, df=1)	Significant at 1% significance level
Cistern (bleed/ effacement)	15	6.4	0.02 (x^2=4.9, df=1)	Significant at 5% significance level
Bleed in IHF/ tentorium	12	5.1	0.4 (x^2=0.58, df=1)	Not significant
Haemorrhagic contusions	68	29.3%	0.000 (x^2=38.1, df=1)	Highly significant
Non-haemorrhagic contusions	5	2.1%	0.7 (x^2=.06, df=1)	Not significant
Intraventricular haemorrhage	10	4.3%	0.071 (x^2=3.2, df=1)	Not significant
Pneumocep-halus	40	17.2%	0.000 (x^2=32.1, df=1)	Highly significant
Oedema	51	21.9%	0.000 (x^2=14.7, df=1)	Highly significant
Midline shift	21	9.0%	0.003 (x^2=9.1, df=1)	At 1% significance level
Herniations	12	5.1%	0.4 (x^2=4.4, df=1)	Not significant

Table IV: Fractures with Extra- and Intra-axial Lesions with Secondary Changes

RESULTS

Three hundred thirty two patients (83%) were males and 68 patients (17%) were female. (Sex ratio M:F=4.9:1). Age ranged from 8 months to 85 years with mean age 32.06±17.7 years. The highest frequency of head trauma occurred series i.e. 116 (29%) cases were in the age group of 21-30 years followed by 77 (19.3%) cases in age group 31-40 years.

Of 400 patients of head trauma studied using CT scans, scalp injury is the most common finding 290 cases followed by fractures (232) accounting for 58% cases. The most common site of fracture was parietal followed by frontal. Fractures included facial fractures, skull base fractures, vault of skull, both linear and depressed ones. Other CT finding associated with fracture are EDH in 91% cases, SDH in 81.8%, contusions in 89.4%, oedema in 79.6%, SAH in 82.5%, pneumocephalus in 40 (10%) cases, intraventricular haemorrhage in 12, bleeding in cisterns in 6 while effacement of cistern in 12 cases. CT grading according to Marshall's classification, 60% patients belong to grade I, 33.3% are grade II, 2.3 and 3.8 belong respectively to grade III and IV. 15 patients have NEML (Non-evacuated mass lesion).

DISCUSSION

Head injury is a major health problem and a frequent cause of death and disability. In developing countries, the incidence of traumatic brain injury is increasing as traffic increases besides other confounding factors such as industrialisation, falls, and ballistic trauma.[7,8] Radiographic examination of the skull is an essential part of management of head trauma,[9] but its limitations in plain radiographs are now recognised even in diagnosis of skull fractures.[10] CT facilitates a comprehensive diagnosis and permits early and targeted intervention.

In our study, we found that the mean age of our patients is 32±17 year's age with maximum number of patients in the age group of 21-30 years (116-29%) followed by 31-40 years age group with 77 (19.3%) patients. In our series, males were more prevalent than women with head injury. The male:female ratio is 4.9:1 with 83% males to 17% females. Bordignon et al and Lee et al confirmed the similar findings. This is the age group, which is the most active group with maximum number of vehicles being driven by them and also prone to rash driving particularly under the influence of alcohol and drugs.

SCALP INJURY

Total no of cases with scalp injury are 290 (72.5%). Scalp injury is associated with underlying fracture is seen in 191 out of 290 cases (65%). Ghebrehiwet et al found soft tissue swelling associated with fractures in 2.7% of cases. Bordignan et al found fractures in 14.3% cases with soft tissue swelling.[11,12]

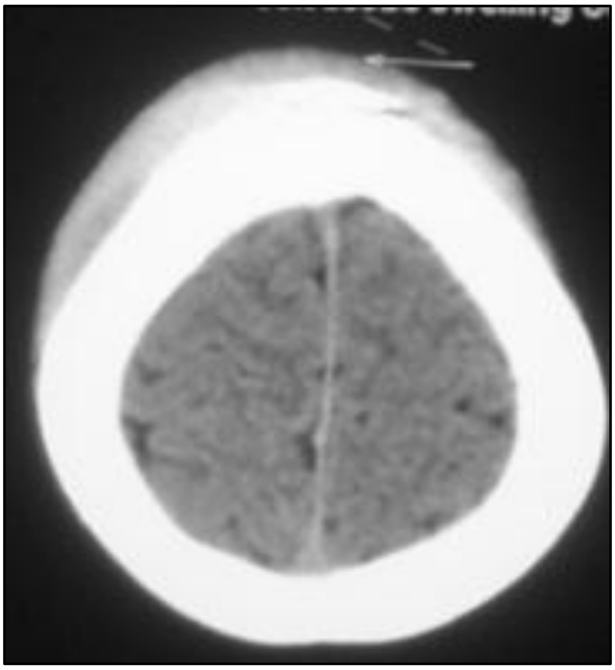
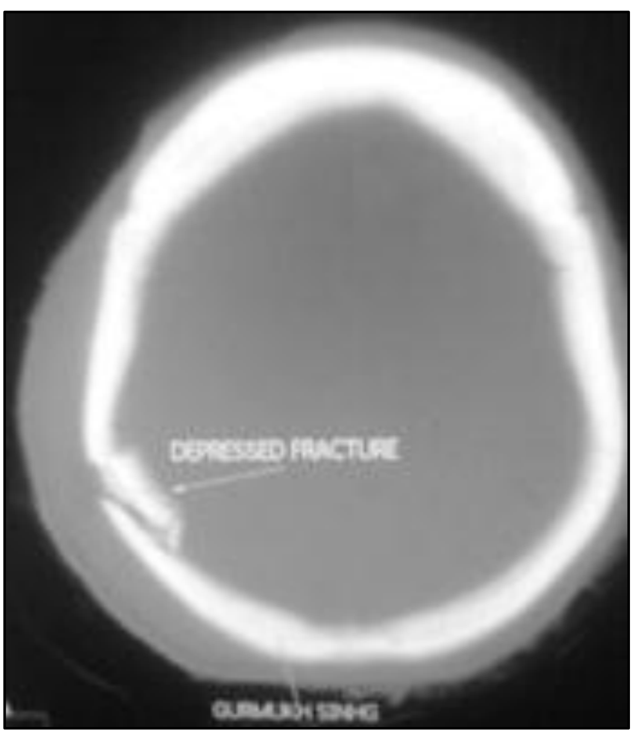


Fig. 1: CT Axial Image showing Soft Tissue Swelling

FRACTURES



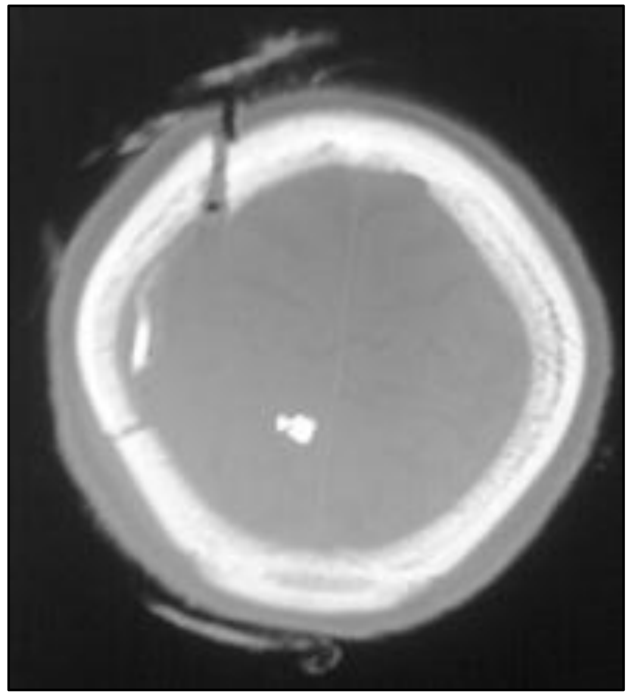


Fig. 2: CT Axial and 3D Reformatted Image showing Fractures

Fractures are seen in 232 patients amounting to 58% of cases in our series. Nagy et al found incidence of fractures in abnormal cases to be 30.7%.[13] The most common site is parietal (22.1%) followed by frontal bones (19.6%). The fractures are usually involving multiple bones in contiguous location particularly the facial bones.

Relation of Various Intracranial Lesions with Presence of Fractures and types of Fracture

In our study, total number of patients with fractures are 232 (58%) with intracranial lesions seen in 129 cases with fractures (55.6%). 168 cases had no fracture, 28 (16.6%) patients had intracranial lesions in such cases. Macpherson et al found in their study that out of 850 patients of fractures, intracranial haematoma was seen in 71% of cases. Intracranial lesions are seen without fractures in 46%. In a study by Lee et al out of 158 (18%) fractures, intracranial lesions were found in 138 (87%) cases. 166 (22%) cases of intracranial lesions were seen in cases without fracture (740-82%). Our study shows EDH is associated with fractures in 91.3% of cases compared to 87% found by Macpherson et al[14] and 83.3% by Stein et al. SDH is associated with fractures in 81.8% in our study while Macpherson gave the incidence as 72% and Stein et al as 50%. Contusions are seen in association with fractures in 89.4% cases in our study. Macpherson calculated the association as 77% and Stein et al 45.07%. Zimmerman et al found fractures in 75% cases of contusions. Our study has found higher incidence of oedema (79.68%) and SAH (82.5%) in relation to fractures as compared to Stein et al who found the incidence to be 39% and 20%, respectively. Our study correlates well with the study done by Macpherson et al and Zimmerman et al.[14,15]

PNEUMOCEPHALUS

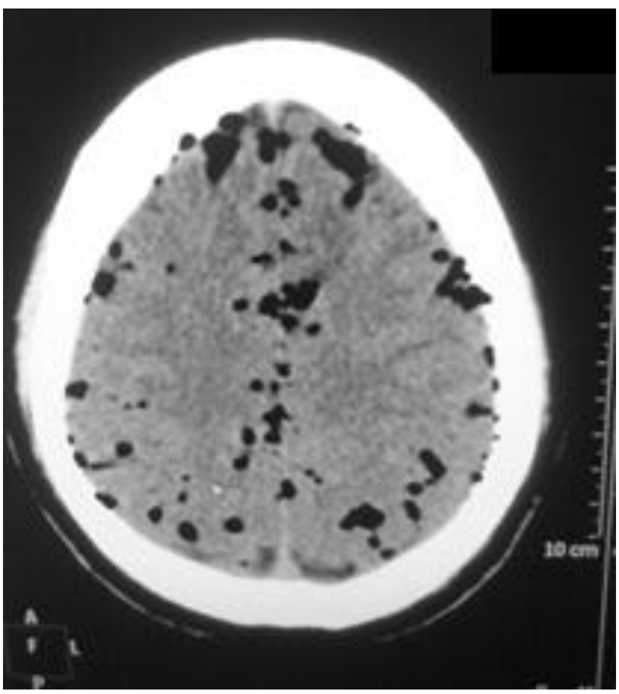


Fig. 3: CT Axial Image showing Extensive Pneumocephalus with Underlying Fracture

Pneumocephalus is seen in 40 (10%) of total cases. Fractures are seen in all the cases of aerocele. Nagy et al[13] found pneumocephalus in 2.6% cases in their series while Bordignon et al[11] and Lee et al[12] detected it in approximately 1.6% cases.

Intracranial Lesions

Total no of patients with intracranial lesions are 157 (39.25%) with total of 278 lesions including EDH, SDH, SAH, Contusions-haemorrhagic and non-haemorrhagic, IVH, oedema, bleeding in cisterns and IHF/tentorium. Ghebrehiwet et al found the incidence as 17.2% in their study, 33.9% by Lee et al, 7.6% by Smits et al, 58.3% by Zimmerman et al. Stein et al calculated the incidence to be 17.2%[16] and Nagy et al as 3.3%. Variability of the incidence in work done by different authors is due the selection of patients, according to the clinical severity of the cases or random sampling or consecutive selection irrespective of clinical status. The incidence of intracranial lesions varies from 3.3% to 58.3% in various studies. Our study has incidence of 41%, which falls within this range.

EXTRADURAL HAEMATOMA

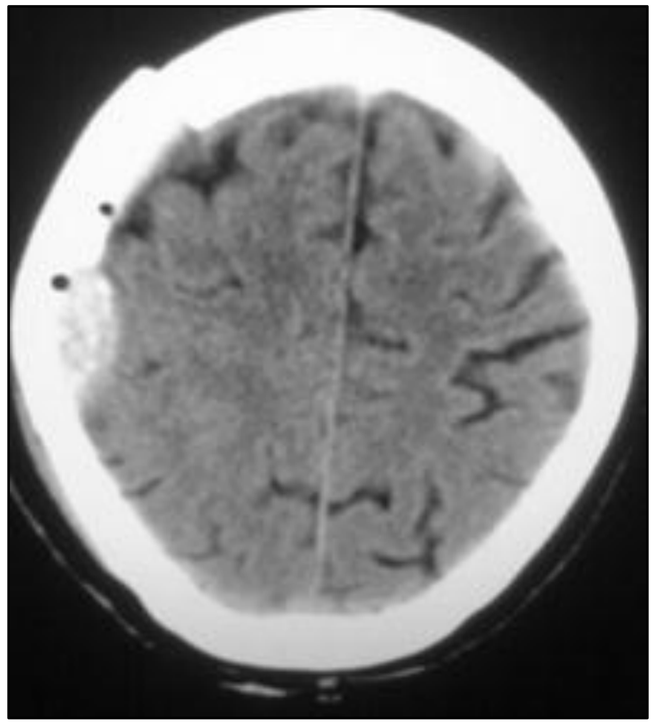


Fig. 4: CT Axial Image showing EDH Underlying the Fracture with Air Pockets

In our study, EDH was found in 46 cases i.e. 11.5% of total patients. Bordignon et al[11] found EDH in 1.4% cases, 3.6% cases by Ghebrehiwet et al[8], 3.2% by Lee et al,[12] 14% by Smits et al,[16] 4.9% by Zimmerman et al[5]. These studies vary in incidence of EDH from 1.4% to 14% by various authors. The most common site of EDH in our study is temporal and frontal. In a study by Toyama et al,[8] the most common site is temporal, frontal followed by occipital region. In our study, also found that EDH is associated with fractures in 42 out of 46 cases accounting for 91.3% cases. Toyama et al[17] and Osborn et al[18] found the similar observations. In our study, we found EDH significantly caused oedema and midline shift with associated mass effects in some cases. This is again in concordance with study done by Zimmerman et al.[5]

Subdural Haematoma

In our study, SDH was seen in 22 cases accounting for 5.5% of total patients SDH is found in 6.4% cases by Bordignon et al,[11] 12.7% of cases by Ghebrehiwet, et al,[8] 9.6% by Lee et al,[12] 28% by Smits et al,[16] 12.5% cases by Zimmerman et al.[5] Yamaura et al[6] found the incidence of SDH varying between 0.8% in mild head injury cases to 23% cases in severe head injury cases. The most common site in our cases is fronto-temporo-parietal region.

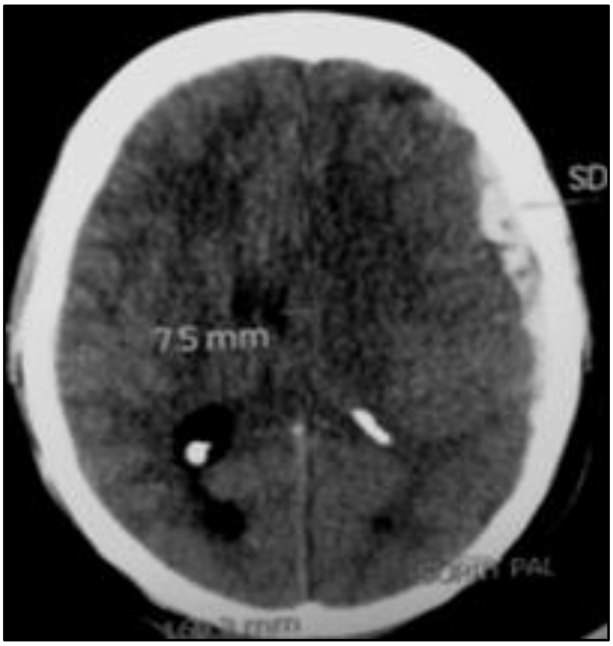


Fig. 5: CT Axial Image showing Small SDH in Left Frontoparietal Convexity with Oedema with Compression of Ipsilateral Ventricles with 7.5 mm Midline Shift

SUBARACHNOID HAEMORRHAGE

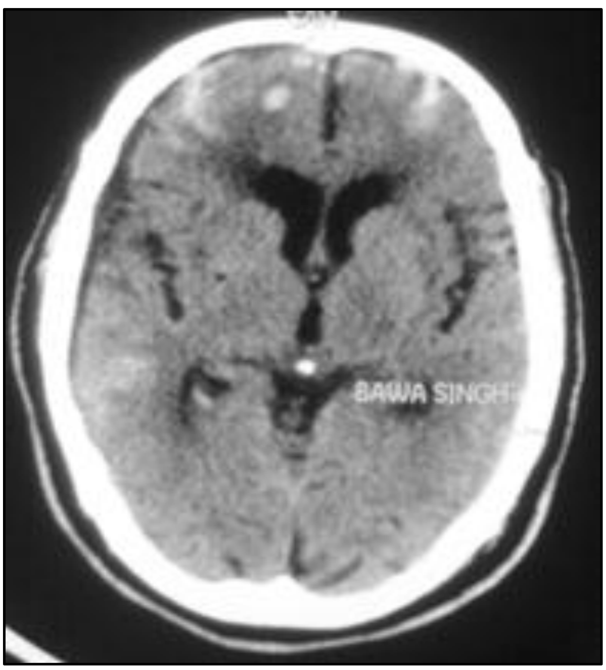


Fig. 6: CT Axial Image showing SAH Frontoparietal Sulci with Haemorrhagic Contusion-Frontal Lobe

In our study, SAH is seen in 40 cases accounting for 10% of total cases, 25.4% of cases with intracranial lesions. Bordignon et al[11] found SAH in 6.6% cases, 1.8% of cases were seen by Ghebrehiwet et al,[8] 2.8% by Lee et al,[12] 35% by Smits et al.[16] Eisenberg et al found incidence of SAH in 39% of severely injured cases. The most common site is frontal followed by parietal and sylvian fissures. Toyama et al[17] found SAH most frequent over convexities followed by fissures and basal cisterns.

CONTUSIONS

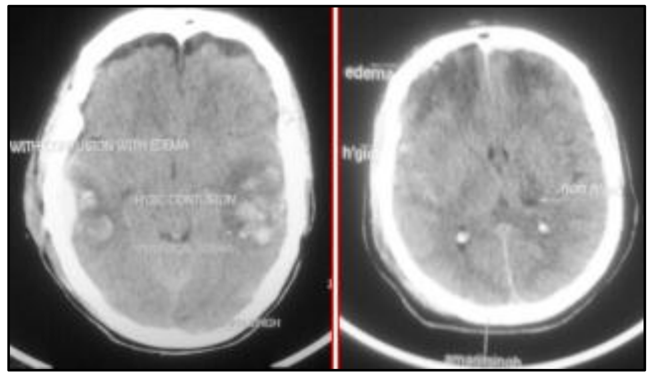


Fig. 7: CT Axial One Images showing B/l Multiple Haemorrhagic Contusions another Image showing Non-Haemorrhagic Contusions

In our study, contusions is seen in 76 cases accounting for 19% of total cases, 48.4% of cases with intracranial lesions. Bordignon et al[11] found contusions in 12.9% of their cases, 16.4% of cases by Ghebrehiwet et al,[8] 13.6% by Lee et al,[12] 49% by Smits et al,[16] 21.3% cases by Zimmerman et al.[5] The most common site is frontal followed by temporal.

In our study, 42% of cases are multiple and 17% are bilateral. Toyama et al[6] has found multiple contusions in 30% cases whereas Zimmerman et al[5] found multiple contusions in 29% cases.

Intraventricular Haemorrhage

In our study, we found that IVH is seen in 12 (3%) cases out of 6% of intracranial lesions and Ghebrehiwet et al[8] found IVH in 9.1% of cases of intracranial haematoma, 1.8% of total cases, whereas Yamaura et al[6] found IVH in 7.4% of cases in severely head injured group. Yamaura et al[10] found haemorrhagic contusions in 7 out of 8 cases of IVH. In our study, haemorrhagic contusions are seen in 8 out of 12 cases of IVH.

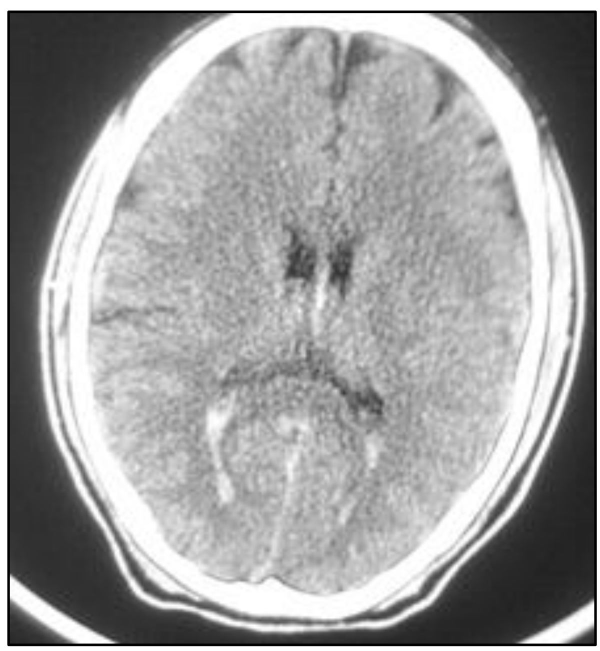


Fig. 8: CT Axial Image showing Intraventricular Haemorrhage

OEDEMA

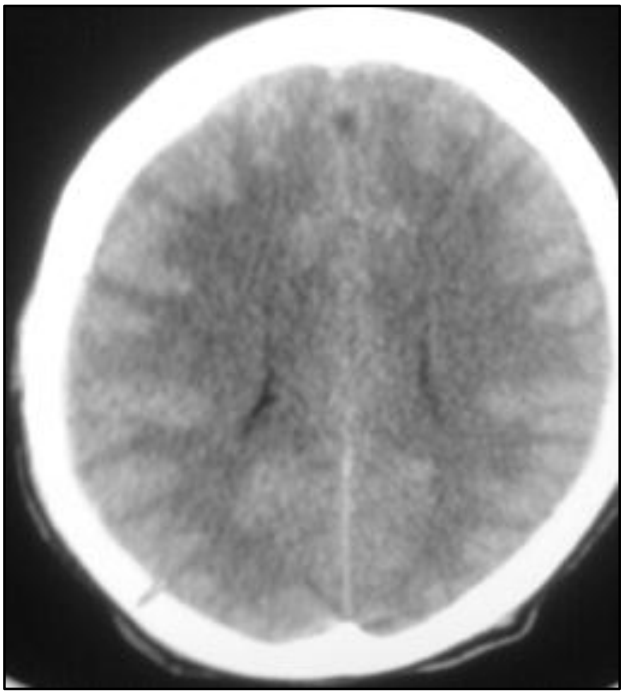


Fig.9: CT Axial Images showing Cerebral Oedema with Obliteration of Sulci and Gyri and Compression of Ventricles

In our study, cerebral oedema is seen in 64 cases accounting for 16% of total cases and 40.76% of total cases with intracranial lesions. Bordignon et al[11] found oedema in 7.5% cases, Nagy et al[13] in 2.6% cases, Zimmerman et al[5] in 16.1% cases. Stein et al[15] found oedema in 5.3% of total cases and 30.9% of cases with intracranial lesions. Our study has 17 cases of oedema with midline shift forming 26.5% of cases of oedema. Eisenberg et al[17] found oedema without midline shift in 39% cases and with midline shift in 16% of total cases.

CONCLUSION

CT scans is helpful in assessing the degree of intracranial injury in predicting outcome and if findings are normal in avoiding unnecessary hospitalisation. It is very sensitive to acute haemorrhage or skull fractures and aids in evaluating intracranial haemorrhage, skull fractures, mass effect and midline shift, obliteration of the basal cisterns, and evidence of herniation (subfalcine, tonsillar, or uncal).

REFERENCES

1. David Crippen. Head trauma: http://emedicine.medscape.com/article/433855. Update 19 April, 2010.
2. Marshall LF, Marshall SB, Klauber MR, et al. A new classification of head injury based on computerised tomography. Journal of Neurosurgery 1991;75(1):S14-20.
3. Gentry LR. Imaging of closed head injury. Radiology 1994;191(1):1-17.
4. Leonardo Rangel-Castilla. Closed head trauma: http://emedicine.medscape.com/article/251834. Update Sept 22, 2009.
5. Zimmerman RA, Bilanuik LT, Gennarelli T, et al. Cranial computed tomography in diagnosis and management of acute head trauma. Am J Roentgenol 1978;131(1):27-34.
6. Toyama Y, Kobayashi T, Nishiyama Y, et al. CT for acute stage of closed head injury. Radiation Medicine 2005;23(5):309-16.
7. Emejulu JK, Ekweogwu C, Nottidge T. The burden of motorcycle-related neurotrauma in South-East Nigeria. J Clin Med Res 2009;1(1):13-7.
8. Ghebrehiwet M, Quan LH, Andebirhan T. The profile of CT scan findings in acute head trauma in Orrota Hospital, Asmara, Eritrea. Journal of Eritrean Medical Association 2009;4(1):5-8.
9. Ohaegbulam SC. The role of emergency radiographic examination of the skull in trauma. Ghana Med J 1977;16:255-7.
10. Nakahara K, Shimizu S, Utsuki S, et al. Linear fractures occult on skull radiographs: a pitfall at radiological screening for mild head injury. J Trauma 2011;70(1): 180-2.
11. Bordignon KC, Arruda WO. CT scan findings in mild head trauma: a series of 2000 patients. Arq Neuro Psiquiatr 2002;60(2-A):204-10.
12. Lee YB, Kwon SJ. A more detailed classification of mild head injury in adults and treatment guidelines. J Korean Neurosurg Soc 2009;46(5):451-8.
13. Nagy KK, Joseph KT, Krosner SM, et al. The utility of head computed tomography after minimal head injury. Journal Trauma 1999;46(2):268-70.
14. Macpherson B, Macpherson P, Jennett B. CT evidence of intracranial contusion and haematoma in relation to presence, site, and type of skull fracture. Clinical Radiology 1990;42(5):321-6.
15. Stein SC, Ross SE. Mild head injury: a plea for routine early CT scanning. Journal Trauma 1992;33(1):11-3.
16. Smits M, Dippel DWJ, Steyerberg EW, et al. Predicting intracranial traumatic findings on computed tomography in patients with minor head injury: the chip prediction rule. Annals of Internal Medicine 2007;146(6):397-405.
17. Eisenberg HM, Gary HE, Aldrich EF, et al. Initial CT findings in 753 patients with severe head injury a report from the NIH traumatic coma data bank. J Neurosurg 1990;73(5):688-98.