Original Article ISSN (O):2395-2822; ISSN (P):2395-2814

Section: Radiology

Role of Computed Tomography in the Evaluation of Craniocerebral Trauma

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Received: June 2019
Accepted: July 2019

ABSTRACT

Background: The aim of this study was to assess prognostic significance of CT in the outcome of patients of head injury, to evaluate the different traumatic lesions in trauma to the head, correlation between skull fractures and intracranial lesions, and establish that CT has significant role in management of patients with head injury. **Methods:** The present study was carried out on 100 patients of head injury, referred to the Department of Radiodiagnosis, Civil Hospital, Aizawl. Adults from the age of 18 years onwards, patients with a history of road traffic accident, fall or assault and in-patient cases were included. Pediatric cases, penetrating injuries and out-patient cases were excluded. All these patients were clinically assessed and grouped according to the Glasgow Coma Scale before the procedure was conducted. CT findings were reported directly from the monitor and frequency distribution of craniocerebral lesions, types of fractures, association of fractures with various lesions, comparison of skull fractures with conventional radiographs, density pattern and distribution of lesions noted and correlated with mortality. **Results:** Oedema and contusions were the two most commonly encountered lesions. Fractures formed the next major group accounting for 81% of lesions. Linear fractures were seen in 64% patients while depressed fractures were seen in 12% patients. Outcome was poor in patients with midline shift more than 5 mm (45% mortality). **Conclusions:** We concluded that this fast, simple, inexpensive, highly effective and safe imaging modality should be considered the first imaging of choice in acute head injury as it forms the cornerstone for rapid and effective diagnosis.

Keywords: Head injury, Computed Tomography, Craniocerebral Trauma, Glasgow coma scale.

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INTRODUCTION

The apparent seriousness of head injury can be misleading. Head trauma can have transient symptoms, or lead to chronic signs and symptoms. The medical management of acute head trauma can be quite complicated and expensive. As more medical and surgical therapies for head trauma are available, the role of neuroimaging has become more important.[1]

Today it is clearly recognized that trauma can be identified, evaluated and the effects of trauma can be ameliorated and lives saved. The primary goal in treating patients with craniocerebral trauma due to any cause is to preserve the patients life and remaining neurological function. Optimal management of these patients depends on early and correct diagnosis and therefore neuroimaging has a vital role. The advent of CT has been a major breakthrough as it meets these vital requirements. CT also been a principle screening modality for victims of both blunt and traumatic injuries.

CT is the single most informative diagnostic modality in the evaluation of a patient with a head injury. Besides facilitating rapid implementation it can demonstrate significant primary traumatic injuries including extradural, subdural, intacerebral haematomas, subarachnoid and intraventricular hemorrhages, skull fractures, cerebral oedema, contusions and cerebral herniations. The present day scanners due to refined technology can further help in diagnosing diffuse axonal injuries which were never thought before. Contribution of CT is crucial to complete injury assessment and forms the basis of patient management.[2]

Prompt recognition of treatable injuries is critical to reduce mortality and CT of the head is the cornerstone for rapid diagnosis.[3] Follow up assessment using CT is frequently necessary to detect progression and stability of lesions and evidence of delayed complications and sequalae of cerebral injury which can determine whether surgical intervention is necessary.

Not only is exact pictorial depiction of the effect of head trauma possible with 3-D reconstruction, CT

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has also furthered the understanding of pathophysiology of head trauma. Technically superior 3rd and 4th generation scanners have decreased the scan time and lesions of minimally differing attenuation can be imaged.

CT is currently the procedure of choice over MRI because it is faster and more readily available and it more easily accommodates emergency equipment and can easily enable the detection of blood during the acute phase.[4] Inability to use life supporting ferromagnetic equipment, inability to acquire bone details and cost factors further makes MRI inferior to CT in the evaluation of craniocerebral trauma.

This study attempts to assess the utility of CT in the diagnosis, management and prognosis with cerebral trauma.

MATERIALS & METHODS

The present study was carried out in 100 patients of head injury, referred to Civil Hospital, Aizawl, in the Department of Radiodiagnosis during a period from March 2015 to January 2017. All patients were cases that were admitted in the hospital till they were discharged from the hospital. Adults from the age of 18 years onwards, patients with a history of road traffic accident, fall or assault and in-patient cases were included. Pediatric cases, penetrating injuries and out-patient cases were excluded. Almost all these patients were clinically assessed and grouped according to the Glasgow Coma Scale before the procedure was conducted. No preparation was required as only plain study was indicated in these patients. Details were noted down on proforma either immediately before or after the procedure was carried out, depending on the status of the patient. Few of the patients underwent plain radiography of skull before conducting the CT scan.

Equipment Used and Technical Specifications:

Wipro GE Bright Speed Select – 16 Slice. Tube: 6.3MHU. Detector Width: 20mm. Number of Channel: 24. Scan Mode Axial. Scan Time: 12 Seconds. Slice Thickness: 0.625mm kV:120. mA:160.

CT technique:

Proper immobilization and positioning of head was achieved in all patients.

Un co-operative patients were sedated by giving I.V Diazepam (5-20 mg) Axial sections were taken starting from orbitomeatal line to vertex. The obtained images were studied at brain and bone window settings.

Average duration between scan and head injury was 6 to 8 hours.

Surgical confirmation was obtained in 6 cases who were operated for evaluation of depressed fracture fragment, craniotomy and evaluation of haematoma.

Follow UP:

Follow up cases were performed in 3 cases who showed persistent neurological abnormality or deteriorated or failed to improve following surgical intervention.

Statistical Analysis

All the data were collected and converted into percentages wherever necessary. Chi-square test and the Spearman's correlation coefficient were used for comparison of CT findings of different variables and parameters. p value was calculated using MINITAB (USA 13.3) programme.

RESULTS

Table 1: Frequency Distribution of Various Craniocerebral lesions in 100 patients

CT Findings	Number of Patients	Percentage
Fracture	81	81 %
Pneumocephalus	26	26 %
Extradural haemorrhage	16	16 %
Subdural haemorrhage	28	28 %
Intracerebral haemorrhage	8	8 %
Intraventricular haemorrhage	4	4 %
Herniation	17	17 %
Oedema	49	49 %
Contusion	48	48 %
Midline shift	27	27 %

[Table 1] shows Oedema 49% and contusions 48% were the two most commonly encountered lesions. Fractures formed the next major group accounting for 81 % of lesions the commonest parenchymal lesion was contusion apart from oedema. Haematomas were seen in 36 patients. Extradural haemorrhage was seen in 16 patients, subdural haemorrhage was seen in 28% of patients.

Table 2: Types of Fractures and their Distribution

Type of fracture	Number of patients	Percentage
Linear	64	64%
Depressed	12	12%
Linear + Depressed	5	5%

Linear fractures were detected in 64% of patients while depressed fractures were noted in 12% of patients. Both linear and depressed fractures were seen in 5% of the total spectrum [Table 2].

Table 3: Association of fractures with various lesions

Fractures	Number of Patients
Isolated fracture	3
Fracture associated with other lesions	78
Pneumocephalus	26
EDH	15
Contusions	40
SDH	21
Intracerebral haemorrhage	5

Isolated fractures were seen in 3 cases while 78 cases showed associated lesions. The commonest lesion was contusion which was seen in 40 cases. Pneumocephalus accounted for 26 cases [Table 3].

Table 4: Extradural Haemorrhage: Relationship with Overlying Fractures

	Number of Patients	Percentage
EDH with fracture	15	93.75 %
EDH without fracture	1	6.25 %
Total	16	100 %

EDH was associated with overlying fracture in 93.75 % of cases. This is a well-established association.

Table 5: Density pattern of SDH

Density pattern	Number of Patients
Hyperdense	26
Isodense	1
Hypodense	-
Mixed	-
Layering	1

Acute SDH were predominantly hyperdense.

Table 6: Traumatic intracranial Haemorrhage – Location and Associated Lesions

Location	Number
Frontal	5
Temporal	2
Parietal	1
Occipital	0
Associated findings	
Oedema	4
Subarachnoid haemorrhage	1
Intraventricular haemorrhage	1
Extradural hematoma	1
Fracture	5

ICH was seen in 8 % of cases and most commonly found in the frontal region. It is equally associated with subarachnoid and intraventricular haemorrhage.

Table 7: Contusions

Contusions	Number	Percentage
Non-haemorrhagic	8	16.66 %
Haemorrhage	40	83.33 %
Total	48	100 %

Haemorrhagic contusions was seen in 83.3% of cases and non-haemorrhagic in 16.6 % of cases.

Table 8: Types of Lesions and Mortality in Minor Injury

Lesion	GCS			
	13	14	15	Total
Fracture	5	4	13	22
Hematoma				
SDH	1	2	2	5
EDG	0	0	2	2
ICH	0	0	1	1
Oedema	1	2	7	10
Contusion	0	0	15	15
SAH	1	0	0	1
Pneomocephalus	1	0	3	4
Death	1	0	0	1
Number of Patients	5	4	17	26

We had 26 patients with GCS score of 13 – 15. Fractures were noticed in 84.6 % of patients while oedema was seen in 38 % of cases and contusions in 57 %. Haematomas contributed to 30 % of the total number of patients. One patient with a GCS score of 13 died while in the higher scores there was no death which shows that CT can predict the outcome of patients.

Table 9: Outcome on Basis of Glasgow Coma Score

Glasgow Coma Score	Number of Cases	Death	Percentage
<8	47	22	46.8 %
9 – 2	27	0	0 %
13 – 15	26	1	3.8 %

Outcome was poor with GCS score of <8 while recovery was almost the rule with scores between 13–15.

X2 = 31.5 and p < .001 which shows that the relationship is highly significant.

Table 10: GCS – Early and Late Deterioration

GCS	Number of Patients who died	Died in 48 Hours	Died After 48 hours	Recovered
3 – 5	27	8	11	6
6 – 8	20	0	3	15
9 – 12	27	0	0	20
13 - 15	26	0	1	21

Patients with low scores (3 - 5) showed early deterioration as compared to those with higher scores. This could be attribute to the severity of primary injury. Late deterioration was more common than early deterioration in scores of >8 where mortality within 48 hrs was virtually nil and recovery rate was much higher.

Table 11: Midline shift in relation to GCS score in patients with mass lesions

GCS	Midline Shift (in mm)				
	0 - 2	3 - 5	6 - 8	9 - 11	>12
3 – 5	-	-	4	3	5
6 – 8	-	1	1	3	1
9 – 12	-	1	2	1	-
13 - 15	-	4	1	-	-

GCS score was found to be inversely proportional to the midline shift.

Low GCS score was seen in midline shift of > 6 mm. Spearman correlation coefficient P= -0.59 and p < .01 which shows that the relationship is significant.

Table 12: Outcome on the Basis of Midline Shift

Midline Shift	Outcome				
	ND		Death		
< 5 mm	5	5	0	0	-
≥ 5 mm	22	8	22	10	4

Outcome was poor in patients with shifts of > 5 mm (45 % mortality) while recovery was seen in 36 % and 7.6 % cases had neurological deficit.
Comparatively in patients with < 5 mm outcome was extremely good with all patients recovering and no neurological deficit.
Chi-square x2= 6.61 and p < .05 which indicates that the relationship is significant.

Table 13: Outcome on the basis of type of lesion

Type of lesion	Number of Patients	Death	Death (%)
Mass lesions	• 61	• 22	95.65 %
Non Mass Lesions	• 39	• 1	4.34 %
Total Abnormal Scan	• 100	• 23	100 %

Of the total 23 deaths recorded 95 % were due to mass lesion while 4.34 % were due to non mass lesion indicating that outcome was poor in those with mass lesion.
Chi square x2 = 13.2 and p < .001, which shows that the relationship is highly significant.

Table 14: Outcome of Various Hematomas

Hemotomas	Number of Patients	Death	Death (%)
EDH	16	2	12.5 %
SDH	28	9	32.1 %
ICH	8	5	62.5 %

In case of mass lesion 2 out of 16 cases of EDH (12.5 %), 9 out of 28 cases of SDH (32.1 %) and 5 out of 8 of ICH (62.5 %) showed a fatal outcome. Outcome is therefore poorer in IHC and SDH as compared to EDH.
Chi Square x2 = 6.14 and p < .05 which shows that the relationship is significant.

Table 15: Outcome in Patients who required decompression of acute intracranial mass lesion

Location	No. of Cases	Operated Cases	Dead		Recovered	ND
			Total	Post-Operative		
EDH	16	3	2	0	12	2
SDH	28	2	9	1	17	2
ICH	8	0	5	0	2	1

Operative intervention was planned in 6 patients and poor outcome was seen in one patient with SDH. Other factors like systemic insult and polytrauma besides the time lag for the institution of management had to take into consideration that leads to the deterioration.

DISCUSSION

The acute effects and the chronic sequelae of trauma are often severely disabling and the importance of efficient utilization of diagnostic studies and appropriate management of these cases cannot be overemphasized. Computerized tomography allows us to make a specific diagnosis quickly and in a non-invasive manner. The purpose of this study is to discuss the important role of computerized tomography in cases of head trauma with the recent advances.
It is not economically feasible to perform CT in every case of head injury. Criteria defining significant craniocerebral trauma are a definite history of blow to the head, a period of altered consciousness, amnesia and local neurological deficit, etc. Even in such patients CT may be normal. Results from different countries reflect the effects of sampling bias, as there may be different marked variation in the type of patients and severity of head injury. Therefore neurologists usually follow various criteria by which they decide the necessity for performing CT on different patients of head trauma.
The present study include 100 patients with the history of head trauma. CT findings of different lesions were then studied. The various CT appearances of traumatic lesions are as follows:

1) **<u>Acute Cerebral Swelling and Brain Oedema:</u>**
Cerebral oedema occurs in maximum cases of head trauma. It is seen as an area with average density lower than that of surrounding normal tissue (12-24 HU) due to increased water content. Then mechanical trauma, there is loss of vascular integrity with extravasation of plasma preteins into extra cellular space where fluid accumulates rapidly. CT detects this extra cellular fluid as early as 3-5 hours following insult.
We had 49 % of oedema out of a total case of 100 patients which accounted for the highest number of cerebral lesion. [Table 1]

2) **<u>Contusions:</u>**
Focal brain contusions may develop at point of impact or remote from the site. CT shows contusion as heterogeneous lesions (50-70 HU) surrounded by irregularly marginated hypodensity due to oedema and necrosis causing a mottled or salt and pepper lesion in affected area.
A peripheral contusion may present as a rim of slightly higher density than adjacent brain next to the inner skull table, often difficult to differentiate from a small extracerebral collection. A helpful CT sign is that contusion is invariably associated with brain oedema while small extracerebral collection is not. Brain stem contusion can be seen on high-resolution scanners and commonly occur with other lesions. Contrast enhancement is of little use. The contusion evolves into an irregularly marginated hypodense lesion or may normalize completely in 10-14 days.

Out of 48 % cases of contusion in our study, 8 cases (16.66%) were non-haemorrhagic while 40 cases (83.33 %) were haemorrhagic. Most had associated lesions, and 40 cases (83.33 %) had associated fractures. [Table 7]

Associated intracranial haematoma, poor Glasgow coma score and increasing age caused increased in mortality in the patients.[5]

3) **Fractures and Pneumocephalus:**

Fractures are readily detected with CT especially by increasing the window width though fractures, which are parallel to the axial slices, may be missed. pneumocephalus is easily identified on CT, the CT value of air being easily detected.

We had 3 isolated fractures, 64 linear and 12 depressed fractures. 26 had accompanying pneumocephalus. Plain skull radiograph as a primary mode of imaging was done only on 2 cases and both were also confirmed by CT. CT detected fracture in 80% of the cases [Table 1-3]. Thus skull radiograph have little or no role to play in modern day imaging in the presence of CT scan.[6,7]

We had 28 cases of SDH of which 24 showed the typical hyperdense density pattern. SDH seen in other series are one case of isodense pattern and one case of layering. Hyperdense SDH dominated the series. 21 cases (75 %) of SDH are associated with fracture [Table 3 & 5].[8,9]

4) **Extradural Haematoma (EDH):**

On CT they appear as well-localized hyperdense extracerebral lesion with a biconvex / lenticular shape with a sharp marginal which bulges towards parenchyma. 16 cases of EDH were found in this study. Of these 15 patients had associated fracture, which is a well-established observation [Table 4].

5) **Subdural Hematoma (SDH):**

Acute subdural haematoma can occur as a primary injury (most frequent variety) and is due to disruption of bridging cortical veins. This results entirely from inertial and not contact forces. The veins rupture because of sudden change in velocity of the head. These are usually associated with underlying brain damage, like diffuse axonal injury, because the mechanism of these two injuries is similar.

We had 28 cases of SDH of which 26 showed the typical hyperdense density pattern. SDH seen in other series are 5 % and 36 %. Hyperdense SDH dominated the series [Table 5].

6) **Intracerebral Haematoma (ICH):**

These occur commonly in the frontal and temporal lobes; less frequently in parietal and occipital lobes. They are usually superficial and occur immediately following head injury but delayed traumatic intracerebral haematomas can occur from 48 hours to 2 weeks after injury. CT is most reliable diagnostic study to detect traumatic ICH. They appear as homogeneous hyperdense lesions (70-100 HU) with irregular margins surrounded by oedema.

In our series of 100 patients we had 8 cases of intracerebral haematoma. The most frequent site for traumatic ICH are noted to be in the frontal lobe. Frequently accompanying ICH are extracerebral haemorrhages as well as subarachnoid and intraventricular haemorrhages [Table 6]. This correlates with findings by Koo and Laroque.[10]

Secondary Effects:

Because of rise in intracranial pressure, herniation can occur. The herniation can be subfalcine, transtentorial or uncal. Out of 100 patients a total of 17 patients had various herniations in isolation or combination [Table 1].

The role of CT findings in the management of patients was then evaluated.

Patients were classified into those with Minor injury i.e. GCS of 13 – 15

Minor Injury:

Minor head injury defines a subset of closed head injuries ranging from simple scalp laceration or contusions without brain involvement to those incurring a loss of consciousness. All patients with a GCS score of 13 to 15 were included in minor injury.

Before improved diagnostic neuroimaging minor injury was believed to be reversible or transient without persistent sequelae. However, certain morbidity exists despite the relatively benign nature of mild head trauma. With the advent of CT, a number of lesions were detected in this group that were previously neglected.

In our study we had 26 patients of GCS score of 13-15 fractures were noticed in 84.6 % patients while oedema accounted for 38 % and contusions contributed to 57 % lesions. Haematomas were noticed in 30 % of total number of patients (Table 8). Patients with fracture but no neurodeficit could be safely discharged after a period of observation of 48 hours. Among those with detected lesions 6 patients underwent operative intervention (6%). 5 for evacuation of haematomas and 1 for elevation of depressed fractures.

	Patients with Minor Injury	Operative Intervention (%)
Dacey et al (1986),[11]	610	3 %
Nagy (1989),[12]	300	1.5 %
Present study	240	2.9 %

Our findings were a little higher than the above authors but emphasized the utility of CT in management of small but significant number of patients of minor head injury.

1) **AGE:**

Studies carried out in Western countries and India indicate that incidence of head injury has increased steadily with age.

The patients in our series ranged from 18 years to 80years old. But the maximum head injuries occurred in age group 18-50 years (79 %). People above 50 years were 21 %.

This reflects the fact that since adults constitute the major working population they are more prone to road traffic accidents which is a major cause of head injury.

2) **GCS:**

Patients could be placed in 3 categories. Those of scores < 8, score between 9-12, and scores of 13-15. Percentage mortality was then analysed in each group. Those of scores < 8 showed 46.8 % mortality while with scores between 13-15 showed only 3.8 % mortality pointing to favourable outcome in this group [Table 9].

Patients with low scores (3 -5) showed early deterioration. This could be attributable to the severity of primary injury. Late deterioration was noticed in scores > 8, thereby pointing to added factors like systemic insults and polytrauma that lead to increased mortality in this group besides the severity of the primary injury [Table 10].

3) **PRIMARY DIAGNOSIS:**

Of the total 23 death recorded, 22 (95.65 %) were due to mass lesions while 1 (4.34 %) were due to non-mass lesions [Table 13]. Outcome was poor in those with mass lesions.

4) **MASS LESIONS:**

In case of mass lesions, 2 out of 16 cases of EDH (12.5 %), 9 out of 28 cases of SDH (32.1 %) and 5 out of 8 cases of ICH (62.5 %) showed a fatal outcome [Table 14].

The outcome is therefore poor in SDH and ICH as compared to EDH, findings correlated with those of Miller et al.[13]

5) **MIDLINE SHIFT:**

In cases of haematomas, extent of midline shift was recorded and findings were analyzed in light of GCS score and outcome. In present study 27 patients had midline shift.

Outcome was poor in patients with shift more than 5 mm (45 % mortality) while in patients with shift < 5 mm outcome was good with recovery in all cases and no neurological deficit [Table 12].

GCS score was found to be inversely proportional to the midline shift. Low GCS score was seen in midline shift of > 6 mm. Spearman correlation coefficient P= -0.59 and p < .01 which shows that the relationship is significant [Table 11].

6) **OPERATIVE INTERVENTION:**

Operative intervention was planned in a 6 patients of whom poor outcome was noticed in one patient of SDH. This case showed late deterioration (i.e. beyond 48 hours) and had added factors like systemic insult and polytrauma that lead to fatal outcome. Besides this the time lag between the time of injury and institution of management was more, thereby pointing to the importance of early intervention to obtain favourable outcome [Table 15].

CONCLUSION

We concluded that CT along with clinical evaluation and Glasgow Coma score helps in predicting the outcome of patient indicating its prognostic value where midline shift and age also play a major role. CT affected management where patient treatment can be decided upon by characterizing lesions based on type, size and associated midline shift. It is justifiable to conclude that this simple, inexpensive, highly effective and safe imaging modality should be considered the first imaging of choice in acute head injury as it forms the cornerstone for rapid and effective diagnosis.

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How to cite this article: Ralte WL, Hauhnar H, Vanlalhlua C. Role of Computed Tomography in the Evaluation of Craniocerebral Trauma. Ann. Int. Med. Den. Res. 2019; 5(5):RD01-RD06.

Source of Support: Nil, **Conflict of Interest:** None declared