CT Scan Findings and Outcomes of Head Injury Patients: A Cross-Sectional Study

Gupta Prashant K[1] Krishna Atul[2] Dwivedi Amit N[3] Gupta Kumkum[4] Bala Madhu[5] Garg Gouri[5] Agarwal Shivani[6]
[1]Department of Radio-diagnosis, Imaging & Interventional Radiology
[2,3]Department of Surgery
[4]Department of Anaesthesiology and Critical Care, NSCB Subharti Medical College, Swami Vivekananda Subharti University, NH-58, Meerut (UP), India

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Correspondence to Prof. Prashant K. Gupta, M.D.

Address: Department of Radio-diagnosis, Imaging & Interventional Radiology, N.S.C.B. Subharti Medical College, Subhartipuram, NH-58, Meerut-250004(U.P.), India

Email: prashantk.gupta@yahoo.com

ABSTRACT

BACKGROUND: Trauma secondary to road traffic accidents (RTA) constitutes a major cause of head injury. Every trauma victim with altered level of consciousness must be evaluated for brain injury. Radiological evaluation has undergone dramatic changes with the advent of computed tomography (CT) as it can precisely define the nature and location of the culprit lesion(s).

METHOD: This cross-sectional study includes 382 patients, admitted to the emergency department of our hospital, from September 2008 to September 2010. We present results of evaluation by CT on the nature and location of the identified lesion(s).

RESULTS: CT scans revealed skull fractures (62.04%), intra-cerebral hematoma (46.33%), epidural hematoma (30.36%), subdural hematoma (19.37%), subarachnoid hematoma (28.79%), diffuse axonal injury, brain swelling and edema (63.35%), midline shift (24.34%), pneumocranium (12.04%) and intra-ventricular hemorrhage (10.73%) in our study. We also found that young males between the ages of 20 and 40 years were predominantly involved with head trauma due to road traffic accidents.

CONCLUSION: CT scan has detected and precisely localized the parenchymal damage of brain and effectively predicted the functional outcome.

Key words: Road Traffic Accident; Head Trauma; Computed Tomography

INTRODUCTION

Polytrauma due to road traffic accidents (RTA) is a leading cause of head injury in teenagers and young adults [1]. Head injuries cause immediate death in 25% of acute trauma victims [2]. More than half of the cases of head trauma are caused by RTA, leading to 70% of all deaths due to brain injury. Amongst the severely injured patients, majority survives with severe disability and few continue to be in a vegetative state. Increasing age is associated with poorer outcome in patients with head injury [3].

Computed tomography (CT) has become the diagnostic modality of choice for head trauma due to its accuracy, reliability, safety, and wide availability [4]. The changes in microcirculation, impaired auto-regulation, cerebral edema, and axonal injury start as soon as head injury occurs and manifest as clinical, biochemical, and radiological changes. Proper therapeutic management of brain injury is based on correct diagnosis and appreciation of the temporal course of the disease process. CT scan detects and precisely localizes the intracranial hematomas, brain contusions, edema and foreign bodies. Because of the widespread availability of CT, there is reduction in arteriography, surgical intervention and skull radiography. The present study was conducted to ascertain CT scan findings in head trauma patients and clinical outcomes with different types of head injuries.

SUBJECTS AND METHODS

This cross-sectional observational study included 382 patients with head injury who were admitted in the emergency department of a multispecialty tertiary care hospital, from September 2008 to September 2010. After approval from the ethics committee and written informed consent, all consecutive patients underwent complete clinical examination and head CT scan. Patients with associated systemic injuries or those who died before performing CT scan were excluded. Most patients had multiple findings on CT scans; therefore, they were grouped on basis of the principal finding on the CT scan.

Cranial Computed Tomography Scan Technique

All patients underwent CT scan from skull base to the vertex and sequential axial slices of 10 mm were obtained and left to the discretion of radiologist further thin sections, if required. Detailed radiological evaluation was done and recorded. Midline shift was determined by measuring the displacement of middle structure of septum pellucidum. The size of mass lesion in cases of extradural hematoma, intracerebral hematoma and contusion were calculated by multiplying the vertical height, length and maximum width. Vertical height was calculated by the number of cuts in which the lesion was present. In cases of subdural hematoma, the maximum thickness of the lesion was taken into consideration. Pneumocranium was assessed by the presence of intracranial air on the CT scan [Figure-1]. Skull fracture was confirmed by skull radiographs. We defined neurocranial injuries as all traumatic findings on CT scans, while intracranial lesions excluded skull fractures. Intra-parenchymal contusions may be hemorrhagic or non-hemorrhagic. Diffuse axonal injury was defined as multiple small focal lesions in cerebrum. Depressed fractures of skull vault were considered to be present when at least one skull bone showed inward displacement, while linear fractures means no displacement of bone fragments[5].

Fractures:

When the outer table of the skull was displaced below the level of the inner table, it was considered as depressed fracture [Figure-2]. An air-fluid level in the paranasal sinuses or in the mastoid cells was viewed secondary to a basilar skull fracture.

Intracerebral Hematoma:

Intracerebral hematomas were homogeneously hyperdense, with sharp margins surrounded by a rim of decreased density. Considerable mass effect was present, depending on the size of the lesion [Figure-3]. Serial CT scan showed a typical pattern of evaluation as blood products were gradually broken down and the hematoma became isodense with brain parenchyma. They exhibited ring-like enhancement from the surrounding capillary proliferation and thus were differentiated from hemorrhagic contusions.

Epidural Hematoma:

The radiological appearance of a typical epidural hematoma was biconvex, lentiform, biventricular, crescentic or irregular and was heterogeneous in attenuation, containing areas of hyperdense blood clot and isodense serum. The brain tissue adjacent to most epidural hematomas was severely flattened and displaced with secondary herniations in few patients [Figure-4].

Subdural Hematoma:

The subdural hematoma was characterized as diffusely overlying the entire cerebral hemisphere. The typical appearance was a hyperdense crescent-shaped extra-axial collection with a convex lateral border and concave medial border overlying the cerebral convexity. Subacute subdural hematomas were nearly isodense with the underlying cerebral cortex. It showed hypodensity either as marginal, central irregular areas or laminar areas, encapsulated with loculated collections of sanguineous or serosanguineous fluid in the subdural space.

Subarachnoid Hematoma:

On CT scan, hyperdensity of acute hemorrhage was visualized in the sulci overlying the cerebral convexities, within the sylvain fissures, basal cisterns, and inter-hemispheric fissure [Figure 5]. The serial CT scans after 1 week appeared normal.

Contusion:

The lesion was characterized as areas of hemorrhagic necrosis with edema and appeared as areas of heterogeneous increased density mixed with areas of decreased or normal density [Figure 6].

Diffuse Axonal (Shear) Injury:

CT scan showed diffuse cerebral swelling, corpus callosal hemorrhage and subarachnoid hematoma. Hemorrhage was present in the area of the third ventricle and hemispheric white matter. The lesions were usually multiple, ranging from 0.5 to 1.5 cm and were oval or elliptical, located in the subcortical white matter of the frontal and temporal lobes, splenium of the corpus callosum, corona radiata, and internal capsule.

Brain Swelling and Edema:

Early CT scan showed compression of the lateral and third ventricles and perimesencephalic cistern. There was an associated increase in density of the white matter from transient hyperemia. The cerebral ventricle appeared small or compressed. Brain exhibited homogenously decreased attenuation with grey-white matter interface.

Patients were evaluated clinically during the course of hospitalization and were routinely re-examined by sequential CT. The CT examinations were evaluated by different consultants. The diagnostic interpretations reported in the present study are the final working diagnoses accepted by the radiologist responsible for this investigative study. The patients who were normal or had minimal deficit were categorized as having good outcome while those with moderate or significant disability or death were categorized as having poor outcome.

RESULTS

The common age group was between 20-50 years (70.9%), and less than 13% were elderly (> 60years) patients. Males had higher incidence of head trauma than females (306 vs. 76) [Table-1].

The highest proportion of skull fractures was found in the frontal region (49%), followed by temporal or temporo-parietal region (33.3%), followed by parieto-occipital region (17.6%). The proportion of pneumocranium in frontal, temporal or temporo-parietal and parieto-occipital regions was 60%, 30% and 10%, respectively.

Epidural hematoma was present in temporo-parietal region in 48.0% patients, 32% in frontal region, and 20% in parieto-occipital region. In about half of the patients, intracerebral hematoma was present in the frontal region. Overall, coup injuries were greater than counter coup injuries at all sites [Table-3].

Age Groups (years)	Male	Female	Total
21-40	207 (67.7%)	63 (82.9%)	270
51-60	54 (17.6%)	11 (14.5 %)	65
>60	45 (14.7%)	02 (2.6 %)	47
Total	306	76	382

Table 1: Age and sex distribution

History of altered sensorium (68.3%) was the most common clinical presentation, followed by vomiting (47.6%), headache (34.2%), nasal/aural discharge (28%), convulsions (9.8%), shock (4.9%), respiratory distress (3.7%), and abdominal distension (2.4%). Long bone or pelvic bone fractures were the most commonly associated injury (13.4%), followed by maxillary or mandibular fracture (11%), chest injury (4.9%), abdominal visceral injury (3.7%), and spinal injury (2.4%).

Cerebral edema was detected in 63.4% of the cases, followed by skull fracture (62%), hemorrhagic contusion (46.3%), and epidural hematoma (30.4%). Acute subdural hematoma was present in 19.4% and subarachnoid hemorrhage was seen in 28.8% patients, midline shift in 24.3% patients, pneumocranium in 12% and intra-ventricular hemorrhage in 10.7% of the patients [Table-2].

Findings	No. of Patients
Cerebral edema	242 (63.4%)
Skull fracture	237 (62%)
Intra-cerebral Hematoma	177 (46.3%)
Epidural Hematoma	116 (30.4%)
Subarachnoid Hematoma	110 (28.8%)
Midline shift	93 (24.3%)
Subdural Hematoma	74 (19.4%)
Pneumocranium	46 (12%)
Intraventricular Hemorrhage	41 (10.7%)

Table 2: CT findings in head injury patients

Site	No. of Patients
Frontal	38 (32%)
Temporo-parietal	55 (48%)
Parieto-occipital	23 (20%)
Total	116 (30.5%)

Table 3: Site of epidural hematoma

Intra-cerebral hematoma was present in frontal regions in majority of the cases (52.5%), followed by temporo-parietal (26%), and parieto-occipital region (21.5%) [Table-4].

Among various CT findings, intraventricular hemorrhage was associated with the highest mortality (77.8%) and epidural hematoma was about one-fourth (24%). The presence of diffuse axonal injury was associated with poor prognosis. The mortality rate associated with pneumocranium was 10.9% [Table-5].

DISCUSSION

The neuroradiology of head trauma has undergone dramatic changes since the advent of computed tomography, which has helped significantly to modify the management of head trauma. Using CT scan, we have confirmed that young males are the most common victim of head injury and a wide variety of CT abnormalities are identified in head trauma victims. We further show that the overall mortality of trauma victims varies based on the underlying type of head injury.

Our results are consistent with previous studies that have shown that the peak incidence of road accident head trauma was seen in the most productive years of life. Bharti *et al* reported that 64% patients sustain head injury in road traffic accidents [6] while Reverdin has reported that 60-70% of head injuries occur in young people [7]. In the present study, 71% of the patients belonged to the 20 to 50 years age group. Most likely the reason is that this age group is maximally involved in driving and hence most susceptible. Hukkelhoven *et al* concluded that age is one of the important factors that affects the outcome after head injury. The outcome is worse with increasing age group [3].

It was found that more males suffered from head trauma as compared to females because of the exposure of males to traffic and outdoor activities than females in India. The male to female ratio was 4:1. Our findings were consistent with Bharti *et al* who reported that males were predominantly involved with head injuries (85%) [6]. In the present study, skull fracture was maximally present in the frontal region (49%), followed by temporo-parietal region (33.3%). Zimmerman stated that epidural hematoma was most common (65%) in temporo-parietal region [4]. Samudrala *et al* stated that epidural hematomas are associated with skull fracture in more than 90% of patients [8]. The epidural hematomas are frequently associated with linear fracture according to Phonprasert[9]. In the present study, the temporo-parietal epidural hematoma was found in 48% and frontal hematoma in 32% of the cases.

hemorrhagic contusions. According to MacPherson and Jennet, the occurrence of cerebral contusion varied from 30% to 40% [11]. The mechanism of contusion production was complex, with lesions occurring at the site of impact (coup) as well as sites remote from the impact (countercoup). In the present study, coup injuries were greater than the countercoup injuries at all sites.

Subdural hematoma occurred in approximately 5% to 22% of patients with severe head injury as reported by Seeling *et al* and was the most lethal of all head injuries as it was commonly associated with concomitant parenchymal brain injuries [12]. In the present study, it was found in 19.37% of the patients.

The incidence of traumatic subarachnoid hemorrhage, reported by different authors, ranged from 12% to 44% [13, 14]. In the present study, it was found in 110 patients (28.8%).

Head injury patients usually have associated systemic injuries that worsen prognosis. In the present study, acute subdural hematoma was associated with mortality in 75% of the cases. Generalized cerebral edema was associated with mortality in 50% patients and epidural hematoma was associated with 24% of the patients. Head injury patients who sustain sub-lethal intracranial damage tend to recover unless certain secondary effects, like cerebral herniation, traumatic ischemia, infarction, diffuse cerebral edema and hypoxic injury, set in that worsen prognosis [15,16].

Wei *et al* stated that the coronal reformations improve the detection of intracranial hemorrhage over axial images alone, especially for lesions which lie in the axial plane immediately adjacent to bony surfaces and should be considered in the routine interpretation of head CT examination for evaluation of head injury victims [17].

Type of Injury	Total No. of patients	Coup Injury	Counter-coup Injury
Frontal	93 (52.5%)	56 (60.2%)	37 (39.8%)
Temporo-parietal	46 (26%)	32 (69.6%)	14 (30.4%)
Parieto-occipital	38 (21.5%)	29 (76.3%)	09 (23.7%)

Table 4: Intracerebral hematoma (n-177) and its relation with the side of impact

According to Hirsh, intracerebral hematoma of frontal and temporal lobe was commonest in head injuries [10]. In the present study, the intracerebral hematoma was found in 177 patients (46.3%). It was 52.5% (n-93) in the frontal region and 26% (n-38) in the temporo-parietal region.

Cortical contusions were the second most common primary traumatic neuronal injury. Initially, the CT scans was subtle or normal. In 20% of the cases, delayed hemorrhages developed in previously appeared non-hemorrhagic low density areas. Intracerebral hematomas were differentiated from

CT scan has evaluated the lesion of head trauma rapidly, precisely and non-invasively. Nature of injury, site, mode and impending herniation was reliably assessed by CT alone. By its ability to accurately differentiate the various forms of gross neuro-pathological lesions, it has led to prompt and effective management. Evidence of parenchymal damage on CT is predictive of poor functional outcome. Other important factors in predicting poor outcome were presence of an intracranial hematoma and increasing age. Serial computed tomography scans aid the diagnosis of subsequent complications. The clinical outcome is also dependent on time of the occurrence of brain lesions. Because of the availability of CT, there is reduction in arteriography and surgical intervention.

CONCLUSION

CT scan has precisely localized the parenchymal damage of the brain of head trauma victims rapidly and non-invasively, for prompt and effective management as patients with head injury deteriorate suddenly. Evidence of parenchymal damage on CT is predictive of poor outcome.

CT findings	No. of Patients	Survived	Expired
Pneumocranium	46	41 (89.1%)	05 (10.9%)
Epidural Hematoma	116	88 (75.9%)	28 ((24%)
Skull fracture	237	165 (69.6%)	72 (30.4%)
Intracerebral Hematoma	177	89 (50.3%)	88 (49.7%)
Cerebral Edema	242	121 (50%)	121 (50 %)
Subdural Hematoma	74	18 (24.3%)	56 (75.7%)
Intraventricular Haemorrhage	41	9 (21.9%)	32 (78%)
Midline shift	93	20 (21.5%)	73 (78.5%)
Subarachnoid Hematoma	110	23 (20.9%)	87 (79%)

Table 5: Outcome related to various CT findings in head injury patients

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