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Original Article

Radiology section

Diagnostic Utility of Conventional Radiography in Head Injury

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ABSTRACT

Background: Head injury is the frequent cause of morbidity and mortality and frequently encountered in emergency department. Radiological examination of the skull is an indispensable part in the management of patients suffering from head trauma.

Aim: To determine the accuracy of X-ray in detecting skull fractures, comparing the same with autopsy and CT evaluation.

Materials and Methods: The medico-legal cases that died of traumatic head injury and brought for autopsy over a period of two years were included in the study. Only those cases were selected who had underwent both X-ray and CT evaluation prior to death.

Results: When compared with autopsy, X-ray missed 19.1% of fractures while 11.9% fractures missed in contrast to CT scan.

Conclusion: Skull X-ray is of little benefit when a CT scan is obtained. It has no added advantage over CT scan. Whenever there is facility of CT scan is available, the patient of head injury should not underwent X-ray as it can only delay the diagnosis of an associated intracranial injury and exposes the already traumatised patient to harmful radiations.

Keywords: CT scan, Fracture, X-ray skull

INTRODUCTION

Head injury is a morbid condition resulting from structural changes in scalp, skull and/or contents of the skull, produced by the mechanical forces [1]. It is frequently encountered in road side accidents, assault, fall from height, sports injury, etc. [2]. Head injury creates substantial demand on health services as it is frequent cause of mortality and disability in young individuals. Nearly one quarter to one third of accidental deaths and two third of trauma related deaths are consequent to head injury [3]. Radiological examination of the skull is an indispensable part in the management of patients suffering from head trauma [4]. There has been revolution in the field of radiology with the invention of CT and MRI. Fracture of skull was first described as an X-ray finding in 1962 and by computed tomography (CT) in 1983 [5]. Presence of fracture skull on X-ray is indicative of more serious intracranial injury that is why skull radiographs are routinely performed [6]. The preliminary evaluation of head injury patients with skull films (X-rays) has been superseded by CT examination of the skull and brain. CT has now become the primary modality for evaluating patients with head trauma [7]. CT is now being recognized as the most critical imaging technique for the management of patients in the acute stage of closed head injuries. Axial non-contrast CT scanning is the gold standard technique [8]. While MRI has proved to be more sensitive than CT scan in the detection cerebral pathology, still CT has upper hand in the management of closed head injury patients in acute stage, which is due to its cost effectiveness [8].

In developing countries, the facility of CT scan is not available at large. In India, the primary health centres and peripheral hospitals still lacks the CT scan facility. They largely depend on the X-ray for primary evaluation of head trauma. Even when, the facility of CT scan is available, X-ray skull still being done in routine in conjugation with CT scan. The study was intended to determine the accuracy of X-ray in detecting skull fractures, comparing the same with autopsy and CT evaluation.

MATERIALS AND METHODS

The present study was conducted in tertiary care institute of northern India. The medico-legal cases that died of traumatic head injury and brought for autopsy over a period of two years (September 2009 to August 2011) were included in the study. Only those cases were selected who had underwent both X-ray and CT evaluation prior to death. Victims with massive destruction of head and who had surgical intervention were excluded from the study.

A detailed examination and dissection of the head as per standard forensic autopsy procedure was carried out. After dissecting the scalp, temporal muscles and denuding the periosteum the fractures on outer table were noted down. The cranium was opened with an oscillating saw by making a circular cut round the cranium, a little above the eyebrow ridges, keeping close to the reflected flaps of scalp. After removal of the skull cap, the dura was cut with scissors along the line of sawing and reflected. Brain was removed and then the dura mater was stripped from the base of the skull to facilitate its examination for the presence of fractures internally over the base of skull [9].

Apart from the preliminary entries, the radiological reports of skull radiographs and CT scan were collected from the hospital records of the deceased. The data collected was tabulated and comparatively evaluated.

STATISTICAL ANALYSIS

SPSS statistical software version 16.0 was applied to analyse the scientific data. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were determined by using 2 by 2 contingency tables for radiological (X-ray and CT) and autopsy, taking autopsy as gold standard and holding CT scan as gold standard while comparing with X-ray.

RESULTS

Forty-two victims of head injury underwent both X-ray and CT evaluation prior to death. Out of 42 X-ray skulls, 20 (47.6%) showed fracture in skull; while during autopsy, fractures were found in 28 (66.7%) subjects indicating that 19.1% fractures were missed on X-ray [Table/Fig-1]. CT showed fractures in 25 cases which signify that only three fracture were missed on CT scan as compared to

Investigation	No. of cases	Fracture	%	% Missed on X-ray
X-ray skull	42	20	47.6	19.1
Autopsy	42	28	66.7	

[Table/Fig-1]: Comparison of fracture skull labelled in radiograph and autopsy (n=42)

Finding	TP	TN	FP	FN	Sn %	Sp %	PPV %	NPV %	Acc %	Kappa	p-value
#	20	14	0	8	71.4	100	100	63.6	80.9	0.625	<0.001

[Table/Fig-2]: Statistical evaluation of [Table/Fig-1]
CT - Computerized tomography, Acc - Accuracy, , FN - False negatives, FP - False positives NPV - Negative predictive value, PPV - Positive predictive value, Sn – Sensitivity, Sp - Specificity, TN - True negatives, TP - True positives, # - Fractures

Investigation	No. of cases	Fracture seen	%	% Missed on X-ray
X-ray skull	42	20	47.6	11.9 %
CT scan	42	25	59.5	

[Table/Fig-3]: Comparison of fractures reported on X-ray and CT scan (n=42)

Finding	TP	TN	FP	FN	Sn %	Sp %	PPV %	NPV %	Acc %	Kappa	p-value
#	20	17	0	5	80	100	100	77.3	88.1	0.764	<0.001

[Table/Fig-4]: Statistical analysis of [Table/Fig-3]

autopsy. The sensitivity of X-ray for fractures was 71.4%, specificity 100% with accuracy of 80.9%. Kappa was 0.625 which shows good agreement with p value of <0.001 which was statistically highly significant [Table/Fig-2].

On comparison of X-ray and CT, 11.9% fractures were missed on X-ray [Table/Fig-3]. The sensitivity of X-ray for fractures was found to be 80% with accuracy of 88.1%. Kappa was 0.764 which shows good agreement with p value of <0.001 which was statistically highly significant [Table/Fig-4].

DISCUSSION

It is not possible to detect every single linear fracture of the vault in routine skull radiographic examination. The delineation of a fracture on radiography depends upon the width and direction of the fracture [10]. The temporal bone fractures usually missed on X-ray [11]. Skull films are also suboptimal in revealing of fractures over base of skull [12]. Though plain X-ray can detect skull fractures, they are outdated now. CT scan with bone window is more accurate in detecting depressed skull fractures and more sensitive than skull radiograph [13]. Pfeifer & Pape reviewed several studies for missed injuries in trauma patients and observed that misinterpreted X-rays (15–34.9%) are main radiological factors contributed to missed diagnosis. Clinical inexperience (26.5%), assessment errors (33.8–60.5%), technical errors are additional contributing factors [14]. Cranial sutures are confused with fractures many a times on X-ray. Vascular marking may also be difficult to distinguish from fractures [11].

Although MRI is having more accuracy in diagnosing cerebral pathology, CT is considered the most critical imaging technique for the management of head-injured patients in the acute stage. CT is recommended even for patients with mild head injury having GCS>12 head injury who have the risk factors in form of either loss of consciousness, amnesia, over 60 years of age, seizure, previous neurosurgery, drinker, bleeder, drug abuse. A repeat CT should be done if the initial CT findings were abnormal but the patient's status has changed within 24 hours after trauma. As the possibility of delayed intracranial haemorrhage cannot be ruled out [8,15]. CT scan also have inherent technical limitations such as beam hardening artefact and partial volume effect which may be responsible for failure to visualize the intracranial lesions. Goyal et al., studied the correlation of CT scan with post-mortem findings of acute head trauma cases. Out of 140 cases taken up for study, 26% of fractures and 8% contusions of brainstem were missed on CT scan when compared with autopsy [16]. Pathak et al., in their study also highlights the fallacies of routine CT scan in detecting lesions close to the bone, e.g. subdural haemorrhage (SDH), subarachnoid haemorrhage (SAH) and basal contusions. Small contusions on the brain stem, cerebral peduncles, corpus callosum or thalamic/hypothalamic areas were also missed in 64% of patients on CT scan. CT scan detected fracture in 13 cases of head injury while it was obvious in 47 cases during autopsy. They observed that the linear fractures at the vault and base of skull are probable to be missed in majority of the cases in routine CT scan and also a normal initial CT scan does not rule out development of delayed intracranial haemorrhage [17]. Yet CT scan is indispensible in evaluation of head trauma patients.

X-ray missed 19.1% of fractures when compared to autopsy, while 11.9% missed when compared to CT scan in our study. It has been observed earlier also by Goel et al., that X-rays detect lesser number of fractures as compared to autopsy findings. Their study concluded that 63.6% of fractured were missed during X-ray when compared with conventional autopsy findings [18]. Thiruppathy et al., also stated that CT has upper hand over plain X-rays in detection of skull fractures [19]. X-ray has lower specificity and accuracy as compared to high-resolution CT scan in delineating skull fractures. The single fracture sensitivity was 71% by conventional CT and 63% by X-ray [20]. Elrahim et al., in their study over 250 patients of head injury concluded that 1.3% linear fracture and 5.1% depressed fracture were missed on X-ray skull. X-ray did not detect single fracture over base of skull which was obvious over CT scan in 12 cases. Plain radiograph was also unable to detect associated intracranial haemorrhages i.e. extradural haemorrhage (EDH), intracerebral haemorrhage, haemorrhagic contusions which were visualized on CT scan [21]. The probability of an intracranial injury increases to fivefold in skull fracture. The meta-analysis by Hofman et al., concluded that plain radiograph is of limited clinical value in analysis of brain injury and its low sensitivity interdict its use [22]. Another study has pointed out that CT scan is more valuable in the evaluation of head injury. Many a times skull fracture is associated with intracerebral haemorrhage which would be improbable to diagnose clinically or by skull radiography alone [23,24].

Yousfani et al., also observed that CT scan had superior performance in precisely assigning the medico legal grade of head injury in contrast to plain X-rays. Out of 100 cases studied by them, X-rays in 21 cases of clinically moderate to severe head injury did not show any injury while CT scans in those cases showed 04 fractures without dislocation, 04 fractures with dislocation, 09 fractures with extradural haemorrhage and 04 fractures of skull with ruptured membranes [25]. A retrospective review of 1845 patients was performed by Masters SJ to evaluate the efficacy of skull films in acute head trauma. The study concluded that skull fracture alone rarely indicates more severe internal head injury. CT scan should be considered as primary diagnostic procedure of choice in cases having features of serious intracranial injury [26]. Increasing use of skull radiography in head injury didn't yield any useful information and only add up the cost of medical care [27]. In an emergency setting numerous criterion like age and vitals of the patient, pupillary reaction, GCS score are noteworthy predictors for outcome in case of head injury. Still CT scan is long established radiological modality to describe the status of head injury patient. It is efficacious in management of head injury patients in golden hours without wasting valuable time [28].

CONCLUSION

The detection of skull fracture on conventional radiograph is an indication of serious intracranial injury. However, the diagnostic value of plain radiography is argued. The limited sensitivity of X-ray in detection of skull fracture makes it unreliable. CT is indispensible in the management of acute head injury patients. Skull radiograph is of little benefit when a CT scan is obtained. It has no added advantage over CT scan. Whenever there is facility of CT scan is available, the patient of head injury should not undergo Skull radiograph as it can only delay the diagnosis of an associated intracranial injury and expose the already traumatised patient to harmful radiations.

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