Indian Internet Journal of Forensic Medicine & Toxicology
Vol. 10, No. 3 July-September 2012, 64-70
DOI : 10.5958/j.0974-4487.10.3.021

Original Article

A Comparative Evaluation of CT Scan Findings and Autopsy Findings in Fatal Head Injury Cases

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ABSTRACT

A study titled 'A comparative evaluation of computed tomography (CT) scan findings and autopsy findings in fatal head injury cases' was carried out in the Department of Forensic Medicine, M.S. Ramaiah Medical College, Bangalore, from October 2009 to March 2011 over a period of 18 months to correlate autopsy findings with CT scan findings in fatal head injury cases. All fatal cases of head injury subjected for post-mortem examination, where ante-mortem CT scan reports were available, were taken up for study. Post-mortem examination of each case was carried out and various types of head injuries were recorded and photographed and the respective CT scan reports were collected. Further, a comparative evaluation of post-mortem findings with that of the CT scan reports was analysed. Of the 270 cases of head injury, 44 (16 %) were hospitalised and a CT scan-head was done. In 37 cases (84%), skull fractures were observed at autopsy, whereas in only 20 cases (45%) the same was commented upon in the CT scan. Basal fractures were more under reported than the vault in the CT scan. Most common type of fractures missed in the CT scan was solitary fissured fracture followed by comminuted fracture. Fractures involving middle cranial fossa were missed more often than other fossae in CT scan. Among intracranial haemorrhages, subarachnoid haemorrhage was missed more frequently than others.

Key words: CT scan; autopsy; head injury; skull fractures; intracranial haemorrhage; traumatic brain injury.

INTRODUCTION

'Head injury' as defined by the National Advisory Neurological Diseases and Stroke Council is a morbid state, resulting from gross or subtle structural changes in the scalp, skull and/or the contents of the skull, produced by the mechanical forces[1]. It is also defined as 'any injury that causes lesion or functional damage of cranium, meninges and brain'[2]. The early diagnosis of structural damage and initiation of appropriate treatment is of utmost importance in saving the life of patients with head injury[1].

Computed tomography (CT) scan is commonly used as an initial diagnostic tool to look for various kinds of lesions in cases of head injury. The CT scanning is said to reveal promptly, accurately and non-invasively the intracranial and parenchymal abnormalities in acute cranio-cerebral trauma that were previously recognised only at autopsy, therefore, the CT scan (head) is indispensable in the diagnosis of the various traumatic lesion and their management, it also carries prognostic value[3].

In many patients, CT scan may look normal, yet the patient may have a poor Glasgow Coma Scale. When such fatal cases are subjected to post-mortem examination, various new lesions are observed, which were undetected in a CT scan. So at times, some disparity is observed between CT scan findings and autopsy findings. Some lesions are appreciated during post-mortem examination, but may have gone undetected or missed by a CT scan and *vice versa*[4].

Autopsies provide confirmation, clarification and correction of ante-mortem clinical diagnoses, and as a consequence an 'opportunity for clinicians to enhance their medical knowledge and diagnostic skill and apply this to all patients under their care'[5]. The purpose of this study was to correlate the CT scan and autopsy findings in cases

of fatal head injury. This study highlights potential pitfalls of newer technology with enhanced resolution and the continued value of the autopsy in serving as a 'gold standard' for validating newer and emerging technology.

AIMS AND OBJECTIVES

(a) To correlate autopsy findings with CT scan findings in fatal head injury cases.

(b) To identify the lesions caused by head injury, which are most likely to be missed or may remain undetected by CT scan examination but are appreciated at autopsy or *vice versa*.

MATERIALS AND METHODS

All fatal head injury cases subjected for medico-legal autopsy to the Department of Forensic Medicine, M.S. Ramaiah Medical College, where prior CT scan-head was done, were taken up for study over a period of 18 months. Further a comparative evaluation of post-mortem findings of the head injuries with that of the CT scan report were analysed.

Inclusion Criteria

Fatal head injury cases with ante-mortem CT scan-head reports were included in the study. By the retrospective record analysis of the autopsy registry of cases fulfilling the inclusion criteria, 35 cases were eligible. Keeping this, an attempt was made to include 32 cases (after 10% loss). However, a total of 44 cases fulfilled the criteria and were taken up in the study prospectively.

Exclusion Criteria

Cases where surgical intervention had led to a gross discrepancy between the CT scan findings and autopsy findings were excluded.

Prior ethical clearance was obtained.

RESULTS AND DISCUSSION

Deaths due to head injury constituted 270 (22 %) of the total autopsies (1,260) conducted during the study period. Out of these, in 44 (16%) of the cases the individuals were hospitalised and a CT scan-head had been done.

Table 1: Age and sex distribution of the cases

Age group (years)	No. of cases (%)	Male	Female
0–19	04 (9.5)	3	1
20–39	19 (43)	17	2
40–59	13 (29.5)	11	2
60–69	06 (13.5)	2	4
>70	02 (4.5)	2	0
Total	44 (100)	35 (79.5 %)	9 (20.5%)

The vulnerable age group was those in the 20–39 years followed by age group of 40–59 years as in any other study. The obvious reason being that they from the work group, and hence, prone to road traffic accident, falls, assaults, which are one of the major cause for head injuries.

In all, 35 cases (79.5%) were males and constitutes more than three-fourth of cases, as they are more into the outdoor activities, such as driving vehicles, working outdoors, posing them risk due to accidents, whereas females succumbed mainly to either accidental falls at their residence or due to road traffic injury (RTA) they being pillion riders without head gear.

Kelly C. Bordignon and Walter Oleschko Arruda observed in their study that highest frequency of head trauma occurred in the 21–30 years (25.1%) age group, followed by the age groups 11–20 years (21.6%) and 31–40 years (17.5%). In all, 1306 (67.3%) patients were male and 654 (32.7%) were female (sex ratio M:F=2:1)[2].

Table 2: Trauma mechanisms

Mechanism of trauma	No. of cases	Percentage (%)
Road traffic injury	39	88.6
Fall	5	11.4
Total	44	100

In all, 39 cases (88.6%) were due to RTA injury and remaining 11.4% (5 cases) were due to fall. Surprisingly, there were no cases due to other forms of violence such as assault.

Similar observation was made by Gururaj and Sastry Kolluri, where RTA constituted 62%, fall constituted 22% and assault constituted 10%[3].

Table 3: Distribution of cases according to time interval between CT scan and death

Time interval between CT scan and death	No. of cases	Percentage (%)
<12 h	10	22.8
12–24 h	8	18.2
1–2 days	3	6.8
2–7 days	17	38.6
>7 days	6	13.6
Total	44	100

The relation between time of CT scan and death is significant in our study as the findings by the radiologists and that of the autopsy would significantly vary depending upon the survival period, as there may be some pathophysiological changes or healing that may bring about a change. This has to be borne in mind while comparing the findings.

Table 4: Scalp injury

Total no. of cases	Scalp injury at autopsy	Scalp injury commented in CT scan report
44	39	6

(*33 scalp injuries were either missed or not commented upon)

Of the 44 cases, scalp injuries were noted in 39 cases at autopsy (Fig No. 1 b), whereas CT scan reported scalp injury in only 6 cases (Fig No. 1 a). This disparity (39–6=33) can be attributed to the very simple reason that the scalp injury being very much evident to the naked eye/clinical examination or because the injury could have been minimal and less significant as compared to the injury to the calvaria and its contents. Thus, the chance of under reporting by the radiologist is very high.

In a study done by Mohammad Zafar Equabal *et al*., scalp swelling or haematoma was observed in 86.3% of the cases and the CT scan concurred in all cases. It was also the most common CT scan finding[6].

Table 5: Skull fractures

Total no. of cases	Detected at autopsy	CT scan report
44	37	20

(*17 cases which had fractures were missed)

Of the 44 cases, in 37 cases skull fractures were observed at autopsy (Fig No. 2 a) but in only 20 cases the same

PHOTOGRAPHS HIGHLIGHTING THE FINDINGS IN CT SCAN WHEN COMPARED WITH AUTOPSY

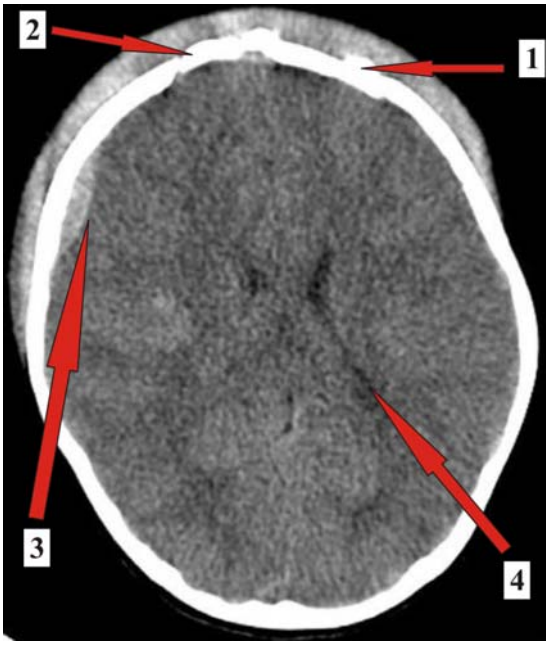

Figure 1(a): CT scan showing various lesions viz - diffuse hyperdense scalp swelling (1), bifrontal fracture (2), right frontal extradural hematoma (3) and brain oedema (4).

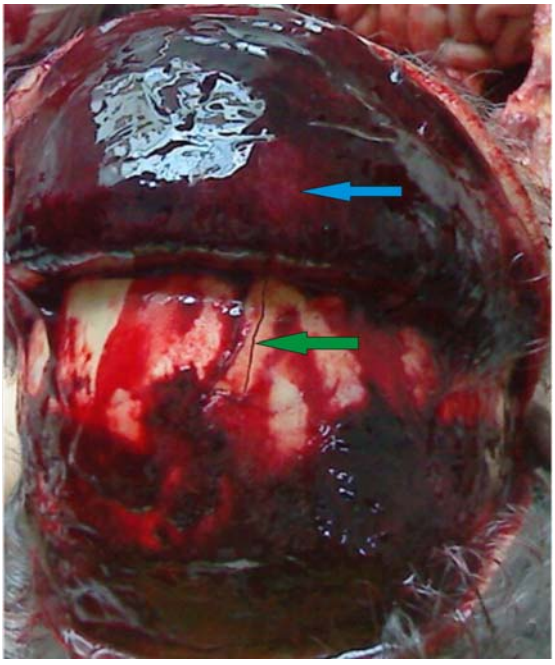

Figure 1(b): Diffuse scalp extravasation (blue arrow) over fronto parietal region with fissured fracture (black arrow), which was not reported in CT scan.

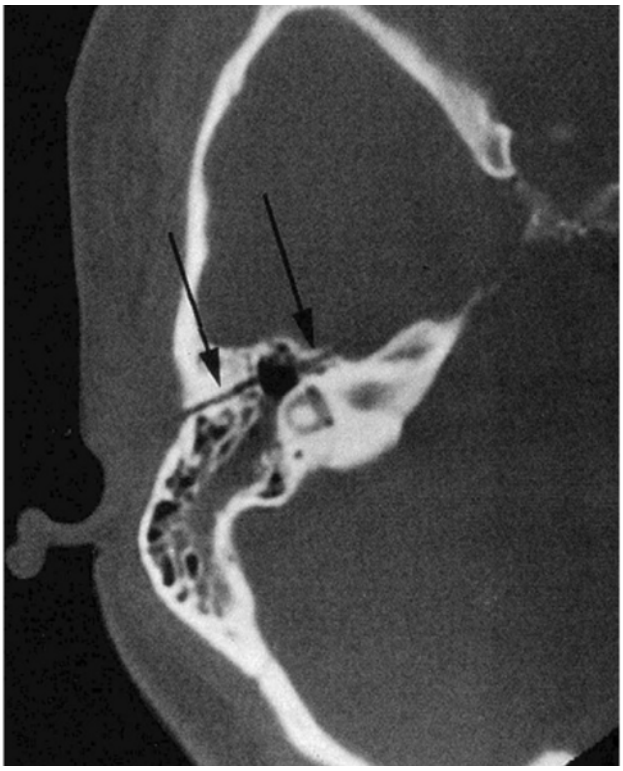

Figure 2(a): CT scan showing longitudinal temporal bone fracture

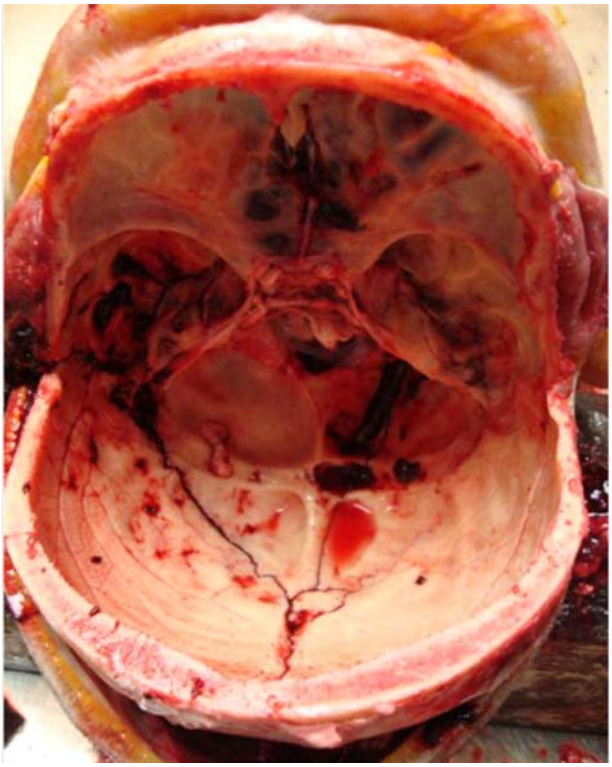

Figure 2(b): Similar lesion observed at autopsy over of base of skull involving left middle and posterior cranial fossae (occiput and petrous temporal bone). Fracture occiput was missed by CT scan in this case.

was commented upon in the CT scan (Fig No. 2 b). A disparity of (37–20) 17 cases was observed.

Sharma and Murari in their study observed that among skull fractures, 76.3% of them were diagnosed in both CT scan and autopsy; whereas 23.7% of them remained undiagnosed by CT scan[4].

Table 6: Anatomical location of skull fractures

Location	Autopsy		CT Scan		Missed
	No.	Percentage (%)	No.	Percentage (%)	No.
Vault	5	13.5	7	35	***+2 NIL**
Base	17	46	9	45	**8 (47)**
Both	15	40.5	4	20	**9 (53)**
Total	37	100	20	100	**17 (100)**

***Two fissure fractures noted at CT scan are those which had comminuted fractures along with fissured fractures of the base of skull, which were not commented in the CT report.

None of the fractures of the vault alone were missed in CT, as the vault being smooth any fractures involving it are easy to be picked up by CT, whereas eight cases (47%) of exclusive basal fractures were missed and nine cases (53%) involving both base and vault were missed in the CT scan. This is due to the various fossae and crevices at the floor or the fracture being too small to have been picked up by CT scan as there are very high chances where in only the outer table or the inner table is involved. Skull fractures are readily identified on the bone windows of CT scan, but small non-displaced linear skull fractures may be missed on CT scan and further the CT scan has low sensitivity for basilar skull fractures. The clinical examination is still more reliable than CT scan in the detection of basilar skull fractures.

Ashis Pathak *et al*. observed that both vault and the basal fractures are also likely to be missed when they are undisplaced and even a bone window image would be unable to detect them[7].

Christina Jacobsen *et al*. have stressed the involvement of middle cranial fossa in 80% of the cases with fractures, which in their study was an area where fracture diagnosis was difficult[8].

Table 7: Type of fractures

Type	Autopsy No. (%)	CT scan No. (%)	Missed No. (%)
Depressed	1 (2.7)	1 (5)	NIL
Fissure	27 (73)	16 (80)	11 (64)
Comminuted	4 (10.8)	1 (5)	3 (18)
Depressed andcomminuted	1 (2.7)	NIL	1 (6)
Fissure andcomminuted	4 (10.8)	2 (10)	2 (12)
Total	37 (100)	20 (100)	17 (100)

Most commonly missed fractures in CT scan were fissured fractures located over vault/base followed by comminuted fracture (five cases). In two cases, where in there were both fissured and comminuted located over the base were missed.

Mukesh K Goyal *et al*. in their study have observed that 77 cases (65%) had linear fractures and 13 cases (11%) had depressed fractures, whereas CT scan was able to pick up 65 cases (55%) and 19 cases (16%), respectively[9].

Table 8: Fossae involved in basal fractures

Fossae	Autopsy (32)		CT Scan (13)		Missed (19)
	No.	Percentage (%)	No.	Percentage (%)	No.
ACF	8	25	3	23	5 (62.5%)
MCF	11	34.5	6	46.2	5 (45.5%)
PCF	7	21.9	2	15.4	5 (71%)
ACF and MCF	3	3.1	1	7.7	2 (33%)
ACF and PCF	1	6.2	NIL	NIL	1 (100%)
MCF and PCF	2	9.3	1	7.7	1 (50%)
Total	32	100	13	100	19 (40%)

ACF: anterior cranial fossa; MCF: middle cranial fossa; PCF: posterior cranial fossa.

Fractures of MCF alone were missed in 45.5% of the cases in CT scan, whereas in 62.5% of the cases fractures of ACF alone were missed and in 71% of the cases fractures of PCF alone were missed. Over all, MCF fractures were missed in 8 (50%) of 16 cases.

In a similar study, Christina Jacobsen *et al*. observed that 13 of 34 cases of middle cranial fossa fractures were detected by CT scan followed by anterior cranial fossa where 11 of 21 cases were detected and in posterior cranial fossa no fractures went undetected by CT scan. But in a second reading of the same film 25 of 34 cases of middle cranial fossa fractures were detected by CT scan followed by anterior cranial fossa where 12 of 21 cases were detected[8].

Table 9: Intracranial haemorrhage

Type	Autopsy	CT scan	Missed
SDH	37	30	7 (19%)
SAH	41	21	20 (48%)
EDH	4	3	1 (25%)
ICH	7	5	2 (28%)

EDH: extradural haemorrhage; ICH: intracerebral haemorrhage; SAH: subarachnoid haemorrhage; SDH: subdural haemorrhage.

In CT scan, subdural haemorrhage (SDH) was missed in 7 cases (19%), subarachnoid haemorrhage (SAH) was missed in 20 cases (48%), intracerebral haemorrhage (ICH) was missed in 2 cases (28%) and extradural haemorrhage (EDH) was missed in 1 case (25%) (Fig No. 3 a & Fig No. 3 b). Sharma and Murari in their study

Figure 3(a): CT scan showing extradural haemorrhage (crescent shaped hyper dense) over right temporal region.

Figure 3(b): Extradural haemorrhage (blue arrow) over left temporo-occipital region missed by CT scan in this case.

have observed that among EDHs, 66.7% were diagnosed in both CT scan and autopsy; whereas 33.3% of them remained undiagnosed by CT scan. The SDHs were diagnosed in both CT scan and autopsy and no mismatch was diagnosed. Among SAH, 64.3% were diagnosed in both CT scan and autopsy, whereas 35.7% of them remained undiagnosed by CT scan. Among ICHs, 70% were diagnosed in both CT scan and autopsy, whereas 30% remained undiagnosed by CT scan[4].

Early CT can fail to diagnose small epidural (EDH), which can either expand or re-bleed later, causing neurological deterioration. Obtaining the CT scan too early, a common problem especially in inner-city hospitals, and not repeating the same after requisite time could lead to the discrepancy in the findings at autopsy and CT scan. A small subdural (SDH) may only appear as increased density of the tentorium as the subdural blood tracks along it. CT scan may fail to recognise this iso-dense SDH and the age of the bleed further decreases the chance of detection. CT scan detects over 90% of SAH within 24 h (corollary is that 10% are missed). It may become negative after 3 days with change in blood density.

Table 10: Traumatic brain injury

Type	Autopsy	CT scan	Missed
Contusion	31	19	12 (38%)
Laceration	1	NIL	1 (100%)
Cerebral oedema	29	23	6 (20%)

Cortical contusions were observed in 31 cases, whereas in CT scan contusions were observed in 19 cases only. A disparity of 12 (38%) is observed. CT scan failed to pick up a solitary laceration and 23 (20%) of the 29 cases of cerebral oedema. Interplay of pathophysiological changes, healing, therapeutic intervention and most importantly the timing of the CT scan would certainly contribute for this disparity. This has to be borne in mind while comparing the findings. Non-haemorrhagic contusions are often not visualised on initial CT scan, but will tend to show mild oedema or haemorrhagic conversion over 24–48 h. The contusions and laceration of the inferior aspects of the temporal and frontal lobes are not readily visualised in CT scan because of beam hardening artefact, which is a well-documented limitation of the CT scan procedure.

Parenchymal injuries along with small hematomas or vault fractures near the bone have a chance to be missed in a CT. Apart from primary changes, delayed (secondary) changes in the brain in the form of infarction, hemorrhage and diffuse swelling also lead to changing pattern of lesion in the CT scan done at different intervals. Non-visualisation of lesions in CT scan in fatal cases can be due to a too early imaging done in critically ill patients. Lawrence Jacobs observed an overall accuracy of 86.2% of CT scan in correctly identifying pathology of the brain[10].

CONCLUSION

- Of the 270 cases of head injury, only 44 (16 %) were hospitalised and subjected to CT scan-head. In all, 79.5% were males commonly between 20–39 years age group.
- 39 Cases (88.6%) were due to RTA and 5 cases (11.4%) due to fall and none due to assault.

- On comparison of autopsy and CT findings disparity was observed thus: scalp 33cases and skull fractures 17 cases.
- Eight cases of exclusive basal fractures and nine cases involving both base and vault and also eight cases of MCF fractures were missed.
- Of the haemorrhages, SDH were missed in 7 cases, SAH in 20 cases, ICH in 2 cases and EDH in 1 case in the CT scan.
- Contusions were not detected in 12 cases more so of the inferofrontal and inferotemporal lobes
- Cerebral oedema was not detected in 6 (20%) of the 29 cases.

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