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ORIGINAL ARTICLE

Role of routine repeat computed tomography of brain in patients with mild and moderate traumatic brain injury: A prospective study

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ABSTRACT

Background: Computed tomography (CT) has become the primary investigative modality for traumatic brain injury (TBI) and there are established guidelines for the initial CT (CT-1). There are no specific guidelines for scheduling repeat CT in TBI. This study was carried out to compare the usefulness of unscheduled repeat CT (UCT-2) with scheduled repeat CT (SCT-2) in the presence or absence of neurological deterioration and to identify risk factors associated with radiological worsening (RW).

Methods: This prospective study comprised admitted patients with mild and moderate TBI between February and May, 2014 and all patients were subjected to repeat CT brain. Patients with penetrating brain injuries and surgical conditions after CT-1, and age <5 years were excluded. Positive yield after the second CT (SCT-2 and UCT-2) leading to modification of management were compared between the two groups.

Results: In this study, 214 patients (214/222) underwent SCT-2 and 8 underwent UCT-2 (8/222). Surgery was required in 2 (0.9%) from the first group and 7 (87.5%) in the latter. UCT-2 was more likely to show RW warranting surgery as compared to SCT-2 ($P < 0.05$). In the SCT-2 group, CT-1 had been done within 2 h after trauma in 30 patients and 8 (8/30; 26.7%) showed RW and; after 2 h in the remaining 184 (184/214) with RW seen in 23 (23/184; 12.5%). RW was more common when the CT-1 was within 2 h from trauma ($P < 0.05$). In our study, the age of the patient and admission Glasgow Coma Scores did not significantly affect the findings in repeat CT.

Conclusion: Repeating CT brain is costly besides needing significant logistical support to shift an injured and often unstable patient. SCT-2 is more likely to show RW when CT-1 is done within 2 h after trauma. UCT-2 is more likely to show RW and findings warranting surgery as compared to SCT-2. Hence, a repeat CT may be preferred only in the presence of clinical worsening and when CT-1 is done within 2 h after trauma.

Key words: Repeat computed tomography, scheduled versus unscheduled, traumatic brain injury

Introduction

Computed tomography (CT) has become the primary investigative modality for traumatic brain injury (TBI) and there are established guidelines for the initial CT (CT-1). Repeat CT Brain (CT-2) is a very important diagnostic tool in the management of head injury to detect the progression of lesion and change in management thereafter. However, there are no standard guidelines on scheduling CT-2. There are reports supporting CT-2 on clinical deterioration[1-3] while there are other reports supporting it routinely.[4-6] This study was carried out to establish the significance of unscheduled repeat CT brain (UCT-2) and scheduled repeat CT brain (SCT-2) done in

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the presence or absence of clinical deterioration respectively and to identify the risk factors associated with radiological worsening (RW) on CT-2 and their comparative influence on management and outcome.

Methods

This prospective observational study was carried out at a tertiary level Government funded teaching hospital over 4 months from February to May 2014. All patients with mild and moderate TBI (as classified by Glasgow coma scale) due to blunt trauma were included in the study. These patients underwent CT-2 after admission and were followed up until discharge. Patients with age <5 years; penetrating brain injury; operative lesion in the first CT brain (CT-1) were excluded from the study.

CT-2 was SCT-2, whenever CT-1 had been done within 6 h after trauma even if the patient did not have any clinical deterioration. SCT-2 was done within 24 h after trauma if CT-1 showed significant hemorrhagic lesions; between 24 and 48 h after trauma if CT-1 showed minimal findings; and before discharge if CT-1 did not show significant finding. The characterization of the lesions for SCT-2 was decided by the treating neurosurgeon.

CT-2 was UCT-2, whenever there was clinical deterioration due to drop in Glasgow Coma Scores (GCS), worsening headache, repeated vomiting, bradycardia, pupillary asymmetry or onset of new neurological deficits; irrespective of the timing of CT-1.

Findings on all the CT scans were recorded by the treating neurosurgeon in consultation with the radiologist. The CT-2 was compared with CT-1 and the findings recorded as RW when there was an increase in the size of the lesion, increased edema or increased midline shift. The impact of CT-2 on change management by way of operative intervention or institution of changes in medical management was studied. When there was a significant hematoma or midline shift, surgery was considered, and craniotomy for evacuation of hematoma or decompression was performed accordingly. Changes in medical management comprised institution of anti-edema measures or supported mechanical ventilation. The course and outcome of all the patients included in the study were assessed. Factors such as; age, sex, time from injury to CT-1, GCS on admission, and type of lesions seen on CT-1; were studied with regard to RW in the repeat CT.

Results

The study included 222 patients for whom SCT-2 was done in 214 (96.4%) and UCT-2 was done in 8 (3.6%). There were 177 (79.8%) males and 45 (20.2%) females. The mean age of the study population was 36 years with a range of 6–90 years [Table 1].

All the patients underwent CT-2 and 30 underwent second repeat CT (CT-3). From the total group, nine underwent neurosurgical intervention after CT-2 (9/222; 4.05%). In our study, three patients with moderate TBI (3/61) died in the hospital; 2 with surgical management and 1 with medical management, giving a mortality rate of 4.9% for moderate TBI. There were no deaths in patients with mild TBI.

The positive findings in CT-1 showed subdural hematoma alone in 34.7% ($n = 77$), SAH alone in 34.2% ($n = 76$), contusions alone in 32% ($n = 72$), EDH alone in 22.9% ($n = 51$) and mixed lesion (i.e. combination of any of the lesions) in 33% ($n = 74$). Other lesions like intraventricular hemorrhage, pnuemocephalus were seen in 27% ($n = 60$) patient.

RW was seen in 39 (17.6%) out of 222 patients while the remaining 183 (82.4%) patients had either similar findings or resolving changes in CT-2. CT-2 showed RW in 18% of males (32/177) and 15.5% of females (7/45) and there was no statistically significant difference between males and females showing RW on repeat CT ($P = 0.69$). In our study, the age of the patient also did not significantly affect the findings in repeat CT.

CT-1 was normal in 8 patients (8/214) and their CT-2 did not show RW. Table 2 shows the change seen with various traumatic intracranial lesions in CT-2. Contusions were the most common lesions to show RW in CT-2, while perilesional edema increased in almost half of the patients without any change in the primary lesion *per se*.

Table 3 shows the changes seen between the first CT-2 and CT-3, which shows that contusions were the most common lesions that increased in CT-3, while cerebral edema decreased in the majority of patients.

Table 1: Age wise distribution

Age (years)	Number of patients with RW (%)	Number of patients without RW (%)	Total (%)
<20	08 (18.18)	36 (81.81)	44 (19.81)
21–30	13 (21.66)	47 (78.33)	60 (27.02)
31–40	05 (12.50)	35 (87.50)	40 (18.01)
41–50	04 (17.39)	19 (82.61)	23 (10.36)
51–60	05 (20)	20 (80)	25 (11.26)
>61	04 (13.33)	26 (86.66)	30 (13.51)
Total	39	183	222

RW – Radiological worsening

Table 2: Change in lesion between CT-1 and CT-2*

Lesion	Same (%)	Increased (%)	Decreased (%)
EDH	38 (74)	7 (14)	6 (12)
SDH	60 (78)	6 (8)	11 (14)
Contusions	32 (44)	18 (25)	22 (31)
Cerebral edema with same size lesion	04 (19)	12 (57)	05 (24)

*One CT may have more than one lesion. CT – Computed tomography; EDH – Epidural hematoma; SDH – Subdural hematoma

The role of time elapsed between trauma and CT-1 as a determinant for RW in SCT-2 was studied [Table 4]. Among the, 214 patients in SCT-2 group, CT-1 had been done within 2 h from trauma in 30 (30/214) of whom 8 (8/30; 26.7%) showed RW. CT-1 had been done after 2 h in the remaining 184 (184/214) and RW was seen in 23 (23/184, 12.5%). Hence, RW was more common when the CT-1 was done within 2 h from trauma as compared to CT-1 done more than 2 h after trauma; and was significant (26.7% vs 12.5%; $P = 0.04$).

From the entire group, nine patients (9/222; 4.05%) underwent surgical intervention after CT-2; two patients (2/214; 0.9%) from SCT-2 group and seven patients (7/8; 87.5%) from UCT-2 group. Hence, UCT-2 done after clinical deterioration was more likely to show RW warranting surgery as compared to SCT-2 ($P < 0.05$). Among the nine operated patients, seven were discharged, and two from the UCT-2 group died. Among SCT-2 group comprising 214 patients (214/222) 11 (5.14%) required a change in the line of management; two underwent surgery, and nine were administered anti-edema measures.

The impact of the severity of mild TBI on the CT-2 findings was studied [Table 5]. Out of 161 patients (161/222) with mild TBI, 159 patients underwent SCT-2 of whom 19 (12%) showed RW and seven needed a change in management (7/159; 4.4%) with one requiring surgery (1/159; 0.6%). Two patients underwent UCT-2 and both (100%) showed RW and one patient underwent surgery. None of the patients with mild TBI died in this study.

The impact of severity of moderate TBI on CT-2 findings was studied [Table 6]. Out of 61 (61/222) patients with moderate TBI, 55 patients underwent SCT-2 and 12 (12/55; 22%) had RW and change in management was necessary in three patients (3/55; 5.5%) and 1 (1.8%) patient underwent surgical intervention. Among six patients who underwent UCT-2, all (6/6; 100%) showed RW and surgery were necessary in all. Although patients with moderate TBI (12/55, 22%) were more likely to show RW on SCT-2 than mild TBI (19/159, 12%), the results were not statistically significant ($P > 0.05$).

Discussion

Many studies have been published regarding the significance of CT-2 in identifying the progression of the lesion as well as its impact on management[1,7-10] but few studies have compared the significance of scheduled (routine) versus unscheduled repeat CT[7,8] Scheduled repeat CT for all admitted TBI patients is not only costly but also demands significant logistics for shifting a critical and often restless patient. Besides it also entails risks of radiation exposure such as cataract[11] and cancer.[12] In addition, repeat CT Brain was done for all admitted patients, hence the role of CT-2 in TBI is more evident in this study and excludes selection bias.

In our study, we have tried to place in correct perspective, the role of SCT-2 for mild and moderate TBI when there was no clinical deterioration. We have also attempted to characterize the role of other factors such as sex and age of the patient, time to CT-1after trauma, and the nature of lesions seen in CT-1; as determinants of the likelihood of finding RW in the repeat CT. We have also tried to find the impact of SCT-2 in determining

Table 3: Change in lesion between CT-2 and CT-3*

Lesion	Same (%)	Increased (%)	Decreased (%)
EDH	06 (75)	01 (12.5)	01 (12.5)
SDH	08 (61)	00	05 (39)
Contusions	06 (40)	06 (40)	03 (20)
Cerebral edema with same size lesion	03 (27)	01 (9)	07 (64)

*One CT may have more than one lesion. CT – Computed tomography; EDH – Epidural hematoma; SDH – Subdural hematoma

Table 4: Time of injury and its relation to radiological worsening on computed tomography-2

Duration between time of injury to CT-1	Number of patients with RW after SCT-2 (%)	Number of patients without RW after SCT-2 (%)	Total
<2 h	08 (26.7)	22 (73.3)	30
2–4 h	14 (13.46)	90 (86.54)	104
4–6 h	06 (12.5)	42 (87.5)	48
>6 h	03 (9.3)	29 (90.7)	32
Total	31	183	214

CT – Computed tomography; RW – Radiological worsening; SCT – Scheduled repeat computed tomography

Table 5: Mild traumatic brain injury and change in management after computed tomography-2

Patients with mild TBI	Patients required surgical management (%)	Patients required medical management (%)	Change in management after CT-2 (surgical and medical) (%)
Patients underwent SCT-2=159	01 (0.6)	06 (3.77)	07 (4.4)
Patients underwent UCT-2=02	02 (100)	00	02 (1.2)
Total=161	03 (1.8)	06 (3.72)	09 (5.55)

TBI – Traumatic brain injury; CT – Computed tomography; SCT – Scheduled repeat computed tomography; UCT – Unscheduled repeat computed tomography

Table 6: Moderate traumatic brain injury and change in management after computed tomography-2

Patients with moderate TBI	Patients required surgical management (%)	Patients required medical management (%)	Change in management (surgical and medical) (%)
Patients underwent SCT-2=55	01 (1.81)	02 (3.6)	03 (5.45)
Patients underwent UCT-2=06	05 (83.33)	01 (16.66)	06 (100)
Total=61	06 (9.8)	03 (4.9)	09 (14.75)

SCT – Scheduled repeat computed tomography; UCT – Unscheduled repeat computed tomography; TBI – Traumatic brain injury

the need for surgery and change in the line of management. This is probably one of the largest recent prospective studies as either most of the published studies are retrospective[1,13-15] or prospective studies with smaller populations.[8,16,17]

In our study, none of the patients with normal CT brain (8/222) on CT-1 showed RW in CT-2 when there was no clinical worsening. RW in the CT-2 was seen in 17.5% of 222 patients while the remaining 82.5% patients had no change. In our study, the sex or age of the patient did not significantly affect the findings in repeat CT.

Contusions were the most common lesions to show RW in CT-2 while perilesional edema increased in almost half of the patients without any change in the primary lesion *per se* RW was significantly more common when the CT-1 was done within 2 h from trauma as compared to CT-1 done more than 2 h after trauma. Similar observations have been made by Oertel *et al*.[16] Though patients with moderate TBI were more likely to show RW on SCT-2 than mild TBI patients, the results were not statistically significant. UCT-2 done after clinical deterioration was more likely to show RW warranting surgery as compared to SCT-2 done routinely. In our study, the mortality was 4.9% and 0% respectively for moderate and mild TBI.

A meta-analysis by Wang *et al*.[18] showed worsening on CT-2 in 38% and Brown *et al*.[8] showed in 35% of patients. Our study had RW in 17.5% patients that may be explained because other studies included all patients irrespective of GCS. Neurosurgical intervention subsequent to repeat CT varied from 1.5% to 24% in various studies,[8,10,19] while in our study, it was 4%. In a study by Brown *et al*.[8] among mild TBI group, none of the patients with SCT-2 and 33% patients with UCT-2 needed medical/surgical intervention. In our study 4.4% and 100% needed medical/surgical intervention after SCT-2 and UCT-2, respectively. Both the patients who underwent UCT-2 required surgical intervention.

Clinical deterioration before CT-2 was a major determinant for need for surgery. No patient with mild TBI and only two patients with moderate TBI needed surgery after SCT-2 in our study. In comparison, two patients with mild TBI, and 5 patients with moderate TBI underwent surgery after UCT-2; Management required to be changed after SCT-2, in 4.4% of mild TBI patients and 4.9% of moderate TBI patients. Hence, CT-2 after clinical deterioration is more likely to show RW necessitating management change, especially in mild TBI. SCT-2 did not contribute significantly to management change. Similar findings have been observed in other studies.[7,8,19]

Conclusion

In patients with mild TBI and normal CT-1, RW was not seen in CT-2. Clinical deterioration is the key determinant for detecting RW and consequent management change in CT-2. However, if the first CT is done within 2 h after trauma, a scheduled CT is warranted subsequent to admission as then there is a higher possibility of RW.

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Conflicts of interest

There are no conflicts of interest.

References

1. Lee TT, Aldana PR, Kirton OC, Green BA. Follow-up computerized tomography (CT) scans in moderate and severe head injuries: Correlation with Glasgow Coma Scores (GCS), and complication rate. Acta Neurochir (Wien) 1997;139:1042-7.
2. Stippler M, Smith C, McLean AR, Carlson A, Morley S, Murray-Krezan C, *et al*. Utility of routine follow-up head CT scanning after mild traumatic brain injury: A systematic review of the literature. Emerg Med J 2012;29:528-32.
3. Almenawer SA, Bogza I, Yarascavitch B, Sne N, Farrokhyar F, Murty N, *et al*. The value of scheduled repeat cranial computed tomography after mild head injury: Single-center series and meta-analysis. Neurosurgery 2013;72:56-62.
4. Alahmadi H, Vachhrajani S, Cusimano MD. The natural history of brain contusion: An analysis of radiological and clinical progression. J Neurosurg 2010;112:1139-45.
5. Chang EF, Meeker M, Holland MC. Acute traumatic intraparenchymal hemorrhage: Risk factors for progression in the early post-injury period. Neurosurgery 2006;58:647-56.
6. White CL, Griffith S, Caron JL. Early progression of traumatic cerebral contusions: Characterization and risk factors. J Trauma 2009;67:508-14.
7. Kaups KL, Davis JW, Parks SN. Routinely repeated computed tomography after blunt head trauma: Does it benefit patients? J Trauma 2004;56:475-80.
8. Brown CV, Weng J, Oh D, Salim A, Kasotakis G, Demetriades D, *et al*. Does routine serial computed tomography of the head influence management of traumatic brain injury? A prospective evaluation. J Trauma 2004;57:939-43.
9. Kobayashi S, Nakazawa S, Otsuka T. Clinical value of serial computed tomography with severe head injury. Surg Neurol 1983;20:25-9.
10. Lobato RD, Gomez PA, Alday R, Rivas JJ, Dominguez J, Cabrera A, *et al*. Sequential computerized tomography changes and related final outcome in severe head injury patients. Acta Neurochir (Wien) 1997;139:385-91.
11. Lund E, Halaburt H. Irradiation dose to the lens of the eye during CT of the head. Neuroradiology 1982;22:181-4.
12. Ron E. Cancer risks from medical radiation. Health Phys 2003;85:47-59.
13. Servadei F, Nanni A, Nasi MT, Zappi D, Vergoni G, Giuliani G, *et al*. Evolving brain lesions in the first 12 hours after head injury: Analysis of 37 comatose patients. Neurosurgery 1995;37:899-906.
14. Sifri ZC, Livingston DH, Lavery RF, Homnick AT, Mosenthal AC, Mohr AM, *et al*. Value of repeat cranial computed axial tomography scanning in patients with minimal head injury. Am J Surg 2004;187:338-42.
15. Stein SC, Spettell C, Young G, Ross SE. Delayed and progressive brain injury in closed-head trauma: Radiological demonstration. Neurosurgery 1993;32:25-30.
16. Oertel M, Kelly DF, McArthur D, Boscardin WJ, Glenn TC, Lee JH, *et al*. Progressive hemorrhage after head trauma: Predictors and consequences of the evolving injury. J Neurosurg 2002;96:109-16.
17. Fainardi E, Chieregato A, Antonelli V, Fagioli L, Servadei F. Time course of CT evolution in traumatic subarachnoid haemorrhage: A study of 141 patients. Acta Neurochir (Wien) 2004;146:257-63.
18. Wang MC, Linnau KF, Tirschwell DL, Hollingworth W. Utility of repeat head computed tomography after blunt head trauma: A systematic review. J Trauma 2006;61:226-33.
19. Figg RE, Burry TS, Vander Kolk WE. Clinical efficacy of serial computed tomographic scanning in severe closed head injury patients. J Trauma 2003;55:1061-4.