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ROLE OF SERIAL CT EVALUTION IN HEAD INJURY PATIENTS: A PROSPECTIVE ANALYTICAL STUDY

Neurosurgery

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ABSTRACT

The CT scan plays an important adjunct to define pathology, severity of head injury and is essential in the ongoing management.

MATHODS: A total of 104 cases of traumatic brain injury (TBI) patients who met with inclusion and exclusion criteria were included in the study. Patients were managed, initial CT scan (<12 hours of injury) and serial CT scan (<48 hours of injury) were done. Data was recorded, compared with neurological status and glasgow outcome scale(GOS).

RESULTS: Persistence of symptoms of TBI had significant association with change in Marshall and modified Marshall grading ($p<0.0001$, $p=0.010$). GOS had association with change in CT-Marshall grading but not with change in Modified Marshall. Change in neurological status had significant association with change in Marshall grading ($p<0.0001$).

CONCLUSION: The change in Marshall or Modified Marshall grading together with change in neurological status can improve the accuracy of detection of operative surgical lesions.

KEYWORDS

Traumatic Brain injury (TBI), computed tomography (CT), Glasgow coma scale (GCS), Glasgow outcome scale(GOS)

INTRODUCTION

Traumatic Brain injury (TBI) is a heterogeneous disease with varying clinical and radiological presentation. TBI is associated with significant morbidity and mortality. Head injury forms major bulk of trauma patients in any tertiary care/trauma center. Critical objective of management of TBI is to prevent second insult after primary brain injury. Patients suspected to have TBI are evaluated clinically and subjected to an early CT scan when clinically indicated. Non contrast CT scan remains the imaging modality of choice in acute TBI because of its high sensitivity, specificity and can be done within few seconds.[1] CT scan plays a critical role in decision making in acute TBI. The management involves observation, admission, and monitoring, medical or surgical intervention. [1] The CT scan plays an important adjunct to define pathology, severity of head injury and is essential in the ongoing management. The TBI is a dynamic disease state. Hence, after the primary brain injury has happened, it is important to prevent secondary brain injury. Resuscitation at field, emergency rooms, severity of primary head injury and other associated injuries, age, preinjury health and certain genetic factors can all influence this dynamic disease process.

Can serial CT scan evaluation help to study this dynamic disease process and in ongoing management? There are many research articles, on role of serial CT scan in assessing disease progression in TBI. Repeat CT scan is usually done when there is neurological deterioration. The routine use of serial CT scan in TBI in all patients is not warranted. According to studies there may be few subsets of patients which may benefit from serial CT scan. [2-4] But still no consensus exists on the need of follow up CT especially in minor intracranial hemorrhage in absence of neurological deterioration. The serial CT scan done within 24-48 hours after injury may show new lesions or progression of already existing lesions which may help in altering the line of management. Hence, this study had been done to assess the role of serial CT scan in head injury patients admitted in this hospital.

MATERIALS AND METHODS: Consecutive 104 cases of TBI who had met inclusion and exclusion criteria were included. This study was conducted in Neurosurgery department, Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi between 2015 to 2016. Inclusion criteria: patients who managed on expectant lines after initial CT scan done within 12 hours of injury, age more than 12 years**,** non pregnant female, serial CT evaluation done within 48 hours of injury, minimum gap of 4 hours between two CT scans without neurologic deterioration. Willing to give informed consent in participating the study. Exclusion criteria: The patients who were operated based on initial CT scan or those who expired before repeat CT evaluation, critically ill, hemodynamicaly unstable patients. A complete history and clinical examination was done. Primary Survey of all trauma patients as per ATLS guidelines was performed. All patients had Chest X ray and FAST done. If required other X rays and NCCT of the desired region was also done. For classification of neurological changes, patients were divided into 3 groups based on change in their clinical status– (1.) Improving, (2.) same and (3.)symptomatic or deteriorating.

CT scan classification of TBI was based on Marshall and Modified Marshall (Rotterdam score). Both early and 2nd CT scan was graded based on these scores. The patients were also divided into mild, moderate and severe head injury groups based on admission GCS. Follow up was done to assess GOS at 6 months duration. All information was kept confidential.

STATISTICAL ANALYSIS: Quantitative variables were compared using Unpaired t-test/Mann-Whitney Test between the two groups and ANOVA/Kruskal Wallis test (for non-parametric data) between more than two groups. Qualitative variables were correlated using Chi-Square test /Fisher's exact test. A p value of <0.05 was considered statistically significant. The data was analysed using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS: The study group consisted of 104 subjects who were subjected to sequential CT scans and treatment intervention. Out of total 104 patients, 74 (71.15%) were in Group A (≤40years) and 30 (28.85%) belonged to Group B (>40years). Men constituted more than ¾ of the study group (80.77%) and only 20 (19.23%) were women. In this 83.78% men and 16.12% female belonged to group A and 73.33% men and 26.67% female belonged to group B. Mild trauma patients formed the major bulk (72.12%), followed by moderate 20 (19.23%) and only 9 (8.65%) cases were in severe grade. Out of 104 cases 65.38% patients had RTA, 19.23% had history fall, 14.42% had physical assault and 0.96% seizure and fall. No significant difference exist in distribution of pateints as men and women in 2 age groups.

Severity of head injury based on GCS had no significant difference between 2 age groups (≤40 and >40 years). No significant difference exist between 2 groups for the time interval between injury and first CT scan ($p=0.359$) with mean ±SD, 5.05±2.83hrs in group A and 5.3± 2.28hrs in group B. Subarachnoid hemorrhage (SAH) was seen more commonly with patients in relatively group B (older subgroup). Accounting for 43.33% of patients in group B as compared to 24.32 % in group. No significant difference exist between two groups with

respect to change in neurological status, that means neurological change(deteioraed,improving and same). Change in CT scan Marshall and CT-modified Marshall is independent of age in both groups Aand B (p=0.661, p=0.427 respectively). No significant correlation was seen with change in CT grading (Marshall and Modified Marshall) and severity of head injury (p=0.403,p=0.432)respectively.

Change in management was independent of severity of head injury(p=0.815). Frequency of extra dural hematoma (EDH) had no association with severity of head injury(p=0.770). Frequency of SAH had no association with severity of head injury (p=0.114). Lenght of hospital stay was more with increasing severity of head injurybut not significantly associated(p=0.072).

GOS had statistically significant correlation with severity of head injury. Severe head injury had low GOS as compared to mild and moderate groups(p=0.0001). Sixty five patients neurological status remained same (62.50%), 34 (32.69%) improved and 5 (4.81%) cases deterioted. Change in neurological status was also significantly associated with change in management as well as length of hospital stay (p<0.0001) each. Change in neurological status had significant association with change in Marshall grading (p<0.0001).

Table1 : Change in Neurological status and change in CT-Marshall grading

Change in neurological status	CHANGE IN CT- MARSHALL			Total	P value
	Downgradation	No change	Upgradation		
Symptomatic	1 (20.00%)	1 (20. 00%)	3 (60.00%)	5 (100. 00%)	<0.0 001
Improving	1 (2.94%)	33 (97. 06%)	0 (0.00%)	34 (100. 00%)	
Same	0 (0.00%)	61 (93. 85%)	4 (6.15%)	65 (100. 00%)	
Total	2 (1.92%)	95 (91. 35%)	7 (6.73%)	104 (100. 00%)	

Table 2: Change in Neurological status and change in CT-Modified Marshall grading

Change in neurological status	CHANGE IN CT- MODIFIED MARSHALL			Total	P value
	Downgradation	No change	Upgradation		
Symptomatic	0 (0.00%)	3 (60. 00%)	2 (40. 00%)	5 (100. 00%)	0. 001
Improving	1 (2. 94%)	33 (97. 06%)	0 (0. 00%)	34 (100. 00%)	
Same	2 (3. 08%)	61 (93. 85%)	2 (3. 08%)	65 (100. 00%)	
Total	3 (2.88%)	97 (93.27%)	4 (3.85%)	104 (100. 00%)	

Table 3: Change in CT scan- in neurolgical status , change in CT grading and change in management

Change in neurological status and CT	Change of management		Total	P value
	N0	YES		
Improving and no Upgradation in CT	34 (100.00%)	0 (0.00%)	34 (100.00%)	**<0. 0001**
Same/Symptomatic Neurological with no Upgradation in CT	61 (96.83%)	2 (3.17%)	63 (100.00%)	
Same/symptomatic with CT Upgradation	1 (14.29%)	6 (85.71%)	7 (100.00%)	
Total	96 (92.31%)	8 (7.69%)	104 (100.00%)	

Table 4: Change in CT- Marshall grading and length of Hospital stay

LENGTH OF HOSPITAL STAY(days)	Down gradation	No change	Up gradation	p value
Sample size	2	95	7	**0.001**
Mean ± Stdev	5 ± 0	3.26 ± 1.57	5.14 ± 1.35	
Median	5	3	5	
Min-Max	5-5	1-9	4-8	
Inter quartile Range	5 - 5	2 – 4	4.250 – 5	

Table 5: Change in CT- Modified Marshall grading and length of Hospital stay

LENGTH OF HOSPITAL STAY(days)	Down gradation	No change	Up gradation	P value
Sample size	3	97	4	**<0.0001**
Mean ± SD	3.33 ± 1.53	3.37 ± 1.64	4.75 ± 0.5	
Median	3	3	5	
Min-Max	2-5	1-9	4-5	
Inter quartile Range	2.250 - 4.500	2 – 4	4.500 - 5	

Presence of SAH in initial scan was significantly associated with change in CT marshall grading(p=0.021). Five patients with SAH on initial scan were operated subsequently compared to 3 patients with no SAH. Presence of SAH in Initial CT scan was significantly associated with change of management (p=0.049). Presence of SAH was significantly associated with GOS (p=0.008). Patient with SAH on initial scan had poorer outcome.

Presence of EDH in the initial scan had some association with change of management but not significant. There was no association of presence of EDH with severity of head injury, change in CT grading and GOS. GOS was signficantly associated with severity of head injury, presence of SAH. GOS had association with change in CT-Marshall grading but not with change in Modified Marshall. The late Marshall score had better correlation with GOS in present study.

Table 6: GOS with change in CT-Marshall grading

Gos (Glasgow Outcome Scale)	CHANGE IN CT-Marshall grading			Total	P value
	Downgradation	No change	Upgradation		
1	0 (0.00%)	1 (100.00%)	0 (0.00%)	1 (100.00%)	**0. 0001**
2	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
3	0 (0.00%)	2 (100.00%)	0 (0.00%)	2 (100.00%)	
4	1 (16.67%)	2 (33.33%)	3 (50.00%)	6 (100.00%)	
5	1 (1.05%)	90 (94.74%)	4 (4.21%)	95 (100.00%)	
Total	2 (1.92%)	95(91.35 %)	7 (6.73%)	104 (100.00%)	

Table 7: GOS with change in CT-Modified Marshall grading

Glasgow Outcome Scale (Gos)	CHANGE IN CT- MODIFIED Marshall			N=104	P value
	Downgradation	No change	Upgradation		
1	0 (0.00%)	1 (100.00%)	0 (0.00%)	1 (100. 00%)	**0.788**
2	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0. 00%)	
3	0 (0.00%)	2 100.00%)	0 (0.00%)	2 (100. 00%)	
4	0 (0.00%)	5 (83.33%)	1 (16.67%)	6 (100. 00%)	
5	3 (3.16%)	89 (93.68%)	3 (3.16%)	95 (100. 00%)	
N=104	3 (2.88%)	97 (93.27%)	4 (3.85%)	104 (100. 00%)	

Table 8 : GOS and correlation with Late Marshall score.

		GOS(GLASGOW OUTCOME SCALE)
Initial Marshal grading N=104	Correlation Coefficient	-0.112
	P value	0.2592
Late Marshall grading N=104	Correlation Coefficient	-0.272
	P value	**0.0052**

Initial CT scan was done on an average of 5.12 ± 2.67 hours after head injury. The second CT scan after 23.77 ± 8.04 hours of head injury. The ROC curve plotted for timing of CT scan correlated with change of management or change in CT grading. No signficant association can be derived about timing of CT scan.

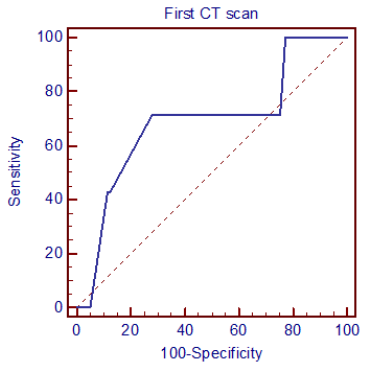


Fig.1: ROC Curve for First CT scan

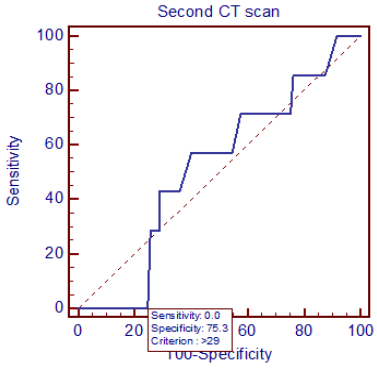
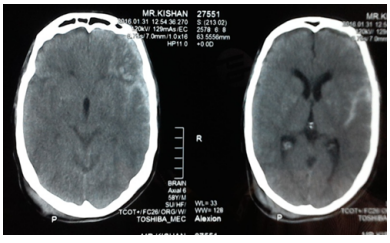
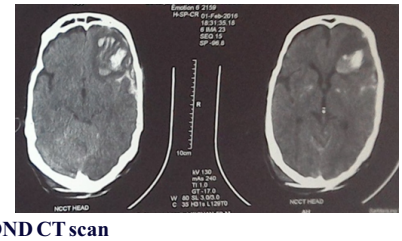


Fig. 2: ROC curve for Second CT scan

1. 59 years old severe head injury patient, first CT done at 3 hours and 2nd CT done after 14 hours with no change in neurological status.

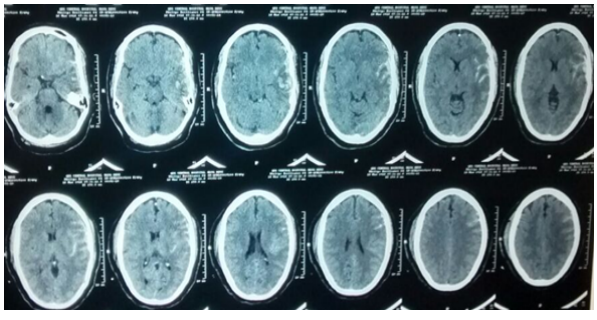


(A) First CT scan

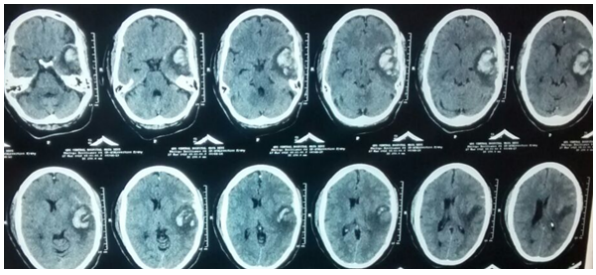


(B) SECOND CT scan

2. 42 years old lady with moderate head injury. First CT done at 3 hours and sequential CT done after 24.5 hours with no change in Neurological status.

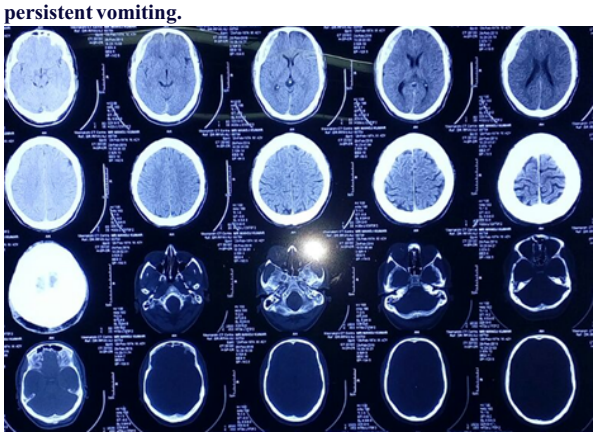


(A) First CT scan

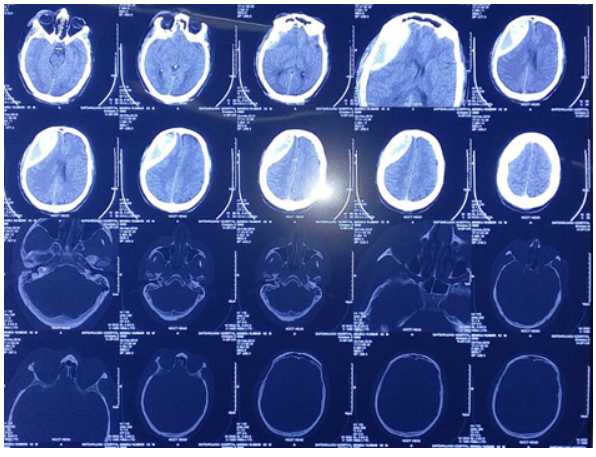


(B) Second CT scan

3. 40 years old gentleman with mild head injury with initial CT scan done at 2 hours and repeat CT done after 12 hours with persistent vomiting.



(A) First CT scan



(B) Second CT scan

DISCUSSION: The present study was conducted to assess the role of serial CT in TBI patients admitted in Neurosurgery department. A total of 410 consecutive non penetrating head injury patients were admitted. Out of which 110 patients were operated based on first CT scan. 92 patients were admitted 12 hours after head injury and other 82 patients in whom 2nd CT could not be done because of early deterioration or were critically ill, hemodynamically unstable or not willing were excluded. A total of 6 patients who had severe polytrauma were also excluded. A total of 120 patients were subjected to serial CT evaluation. Out of 120 patients, 16 patients could not be included due to drop out during follow up and were excluded.

Men constituted more than ¾ of the study group. 84 were men and 20 were women. RTA (Road traffic accident) was most common mode of injury accounting 65.38% of total patients. Among women the most common mode of injury was fall from bike (sitting behind without helmet). About 8.7% patient had associated other systemic injury. Mild trauma patients formed the major bulk in the group constituting 72.12% of total, 20 patients were in moderate group and only 9 in severe. This is comparable to general distribution of patients according to severity of TBI.[1]

The difference between two age groups with respect to demographic factors, change in neurological status, change in CT grading and change in management were not statistically significant. The length of hospital stay and GOS were also not dependent on age groups. SAH is seen more commonly with patients in relatively older subgroup, accounting for 43.33% of patients in group B as compared to 24.32 % in group A. According to Susman M et al, elderly traumatic brain injury patients (>65 years) had a worse mortality and functional outcome than nonelderly patients who present with head injury even though their head injury and overall injuries are seemingly less severe.[5]

Majority of patients 62.5% (65) had the same neurological status before 2nd CT. 55 belonged to mild, 7 belonged to moderate and 3 were in severe head injury groups. Five patients (4.81%) were symptomatic and belonged to mild head injury group, whereas 34 (32.69%) were improving. Sifri Z. C. et al studied abnormal neurologic examination in 24 % of 130 mild head injury patients which was defined as any patient with GCS score less than 15 with neurologic deficits or with symptoms of TBI. Thus they had probably also included patients with no improvement in neurological status. Non uniformity in defining change in neurological status in different studies is probably the reason for this difference.[6]

Change in neurological status was significantly associated with change in CT grading of both Marshall ($p<0.0001$) and modified Marshall systems ($p =0.001$). All 5 symptomatic patients had no change in GCS score but had corresponding change in CT grading. All these 5 patients were operated and thus there is significant association with change in neurological status and change of management ($p <0.0001$). These patients had increased hospital stay. In a study by Smith J. S. et al, 6 (5%) of their patients required operative intervention after 2nd CT scan, but all developed neurological change concurrent with planned follow up CT imaging. Thus they concluded although progressive hemorrhagic injury is common after head injury but delayed interventions in the absence of clinical indicators are uncommon. [2]

Change in CT grading was significantly associated with change of management. Total of 8 patients had change of management. Up gradation in Marshall grading was associated with 6 patients, one patient had down gradation and one had no change. 3 patients had up gradation in Modified Marshall whereas 5 patients had no change. 34 patients who were improving had no CT up-gradation and had no change in management. Out of 63 patients who were either same or symptomatic with no CT up-gradation, 61 had no change of management but 2 patients were operated based on primarily neurological status. Total of 7 patients had CT up-gradation out of which 6 were operated. Out of these 6 patients 5 had prior change in neurological status whereas 1 patient had neurologically same status. The one remaining patient with neurologic same status and CT up gradation was not operated. Thus only 1 patient was operated primarily on up-gradation of CT grading. This was statistically significant ($p<0.0001$). Thus neurological change along with change in CT grading are both together significant for change of management leading to operative intervention. This had been also validated in other studies as well. [7,8]

Even though, no consensus yet exists regarding the need for follow-up head CT in cases of minor intracranial hemorrhage on the initial CT and in the absence of any neurological deterioration or new focal neurological sign and despite some evidence in the literature that follow-up CT should be performed selectively based on such factors as the (1) initial GCS score, (2) severity of initial CT findings, (3) serial clinical examinations, and (4) presence of coagulopathy, in many institutions the follow-up CT is routinely scheduled within several to 48 hours after TBI in the presence of any acute intracranial hemorrhage on the initial CT. [2-4,6-9] Study from Cooper et al, Servadei F. et al and Brown C.V. et al suggested that serial CT scanning may be used to make prognostic assessments in severely head-injured patients and may be of value in increasing the confidence in and accuracy of assessments made on clinical grounds alone. [9-11]

Presence of SAH on initial scan was found to had significant association with change in CT grading, change in management and GOS in our study. Study by Fainardi E.et al with 141 traumatic SAH patients had concluded that early admission CT did not represent the full extent of the post traumatic damage. They also suggested that to identify changes in patients with traumatic SAH, CT scans should be repeated at 12-24 and possibly after 24-48 hours for early detection and evacuation of evolving intracranial lesions. [12]

Presence of SAH had already been proven to affect prognosis and outcome in various studies. The recent Rotterdam modification of Marshall grading had thus included SAH in scoring system. [13] In the present study presence of EDH on initial scan had some association with change of management even though there was no corresponding change in CT grading. In a case series reported by Borovich B. et al, 7 patients developed significant EDH after repeat CT scan done within 24 hours. Out of which 6 were operated, 1 was reabsorbed spontaneously. Only 1 had neurological deterioration, 4 patients remained unchanged and 2 improved before diagnosis.[14]

GOS is signficantly associated with severity of head injury and presence of SAH. It is not dependent on age groups in the present study. GOS had been found to have association with change in CT-Marshall grading but not with change in Modified Marshall grading. The late Marshall score has better correlation with GOS in present study.

In addition to its essential role in early management, the initial noncontract head CT has been demonstrated to have long-term prognostic significance following TBI, across the spectrum from mild to severe. [11,13,15-17] The study by Lobato R. D. et al concluded that CT changes leading to second diagnostic categorization could be detected within first 2 days, a control CT scan performed at this time period seems to be most useful for establishing an accurate prediction of the final outcome than by using initial CT scans.[18] Initial CT scan was done on an average of 5.12 ± 2.67 hours after head injury. The second CT scan after 23.77 ± 8.04 hours. The gap between subsequent scan was an average of 18.5 hours. From the present study no signficant association can be determined about timing of CT scan. Different studies on timing of CT scan could not be correlated due to no fixed or standardized timing for serial CT scans.

Study by Brown CV et al concluded that the timing of repeat CT is unclear at this point and should be based upon clinical judgment as well as identified risk factors for progression of injury.[9] According to Servadei F. et al, in studies comparing series of head-injured patients, correspondence of timing of CT scans is necessary for valid comparison. [11] Eight patients (7.69 %) had change in Management (that is from expectant lines to operative intervention). The study by Smith J. S. et al, had 6 (5%) out of 116 patients operated and study by Oertel M. et al, had 24% rate of surgical intervention after 2nd CT scan. [2,19]

CONCLUSION: In our study we found no relationship between severity of head injury and change in CT grading. The persistence of symptomatology of TBI in mild head injury or no improvement in moderate or severe head injury should prompt for sequential CT evaluation. The change in CT grading either Marshall or Modified Marshall can be used as an objective measure to assess the sequential CT scans. The change in grading together with change in neurological status can improve the accuracy of detection of operative surgical lesions. Late Marshall grading based on subsequent CT scan was found to have better correlation with GOS as compared to admission CT grading. Presence of SAH in initial CT scan in TBI should be followed by close monitoring for neurological change and preferably serial CT evaluation. SAH has also been found to be associated negatively with GOS. No association can be derived for timing of serial CT evaluation based on this study.

LIMITATIONS OF THE STUDY: The sample size of the study was small. Hence, further studies with increased sample size is required to give concrete recommendations.

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CONFLICTS OF INTEREST: There are no conflicts of interest.

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