
Correlation Between Brain Imaging and Glasgow Coma Scale in Traumatic Head Injury in Pediatrics

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Abstract: Objectives: The aim of this work is to study the relationship between the initial GCS and admission brain CT findings and MRI brain findings if indicated in head trauma patients at pediatric age group. Background: Trauma is a leading cause of death in children older than 1 year, with head trauma representing 80% or more of the injuries. In approximately 5% of head trauma cases, patients die at the site of the accident. Head trauma has a high emotional, psychosocial and economic impact because these patients often have comparatively long hospital stays. Methods: This prospective study included 100 patients with head trauma at pediatric age group; the patients were evaluated with respect to their initial GCS and admission brain CT findings and correlated with clinical data. Some patients were further evaluated with MRI of brain when needed. Results: Male to female ratio was 73:27, their ages ranged from 1 day to 18 years with a mean age of 9.1 years. Of the 100 cases included in this study 21 cases were with normal CT examination and 79 were with abnormal imaging findings. 54% of the cases classified as mild TBI, 8% of the cases classified as moderate TBI and 38% of the cases classified as severe TBI. Imaging findings such as subgaleal hematoma, skull fractures, subarachnoid hemorrhage, cerebral contusion, intracerebral hemorrhage, extra-axial blood collection and diffuse cerebral edema were observed in 79% of the patients. Conclusion: Statistical significance was observed between GCS and the imaging findings, the lower the GCS score, the more severe were the TBI and imaging findings. MRI has been shown to be superior to CT in the detection of non-hemorrhagic brain injury and cases of diffuse axonal injury.

Keywords: Head Trauma, CT, GCS, MRI, Pediatric

1. Introduction

Trauma is a leading cause of death in children older than 1 year, with head trauma representing 80% or more of the injuries. In approximately 5% of head trauma cases, patients die at the site of the accident. Head trauma has a high emotional, psychosocial and economic impact because these patients often have comparatively long hospital stays, and 5-10% requires discharge to a long-term care facility. ⁽¹⁾ In addition, the highest rate of injury is among children ages 0-14 and adults age 65 and older ⁽²⁾.

The overall outcome for children with head injuries is better than that for adults with the same injury scores ⁽³⁾. Time to maximum recovery after injury is longer in children (months to years) than in adults (typically about 6 months) ⁽⁴⁾. Patients with multiple organ injuries, including head trauma, generally have a far worse outcome than those with head injury alone ⁽⁵⁾. Long-term complications of head injury are

common in children, and they are related to both primary and secondary injuries ⁽⁶⁾. Outcome assessment based on the Pediatric Glasgow Coma Scale (PGCS) can be used as an early predictor, but this scale has limitations regarding long-term outcome. Mechanism of injury appears to be a significant predictor of clinical and functional outcomes at discharge for equivalently injured patients ⁽⁷⁾.

Computed tomography (CT) of the head remains the most useful imaging study for patients with severe head trauma or unstable multiple organ injury ⁽⁸⁾. Indications for CT scanning in a patient with a head injury include GCS score less than 12, posttraumatic seizures, amnesia, progressive headache, loss of consciousness for longer than 5 minutes, physical signs of basilar skull fracture, repeated vomiting or vomiting for more than 8 hours after injury. ⁽⁹⁾

MRI is useful for estimating the initial mechanism and extent of injury and predicting its outcome in the neurologically stable patient. It is not practical in emergency situations, because the magnetic field limits the use of the

monitors and life-support equipment needed by unstable patients.⁽¹⁰⁾

This study aimed to study the relationship between the initial GCS and admission brain CT findings and MRI brain findings if indicated in head trauma patients at pediatric age group.

2. Material and Methods

This prospective study was done within the period from January 2014 to January 2015 and conducted on 100 patients with head trauma at the pediatric age group, their age ranged from 1 day to 18 years. All patients underwent brain CT examination which was done on "Siemens Somatom spirit dual MDCT" utilizing 120kVp and 150mAS with scanning time of 4.8 seconds and a 512 X 512 matrix. Axial cuts were performed parallel to infra orbito-meatal line with slice thickness of 5mm at the posterior fossa region and 10 mm at the other regions. Angulation of the gantry ranged from -5 to +20 in respect to the infra orbito-meatal line. The images were analyzed at soft tissue window (W: 80 and L: 40) and bone window (W: 1500 and L: 500). All examinations were done with the patient in the supine position. The patients were centralized and fixed as much as possible. All patients were examined without intravenous administration.

MRI study was done for 10 patients whom their initial GCS was suspicious and do not correlate with CT finding and to the cases with severe TBI. The examinations were done by superconducting MR machine 0.5 Tesla. All examinations were done with the patient in the supine position. The patients were centralized and fixed as much as possible. All patients were examined without intravenous administration. MRI scan parameters used were as the following: T1 sequence was recorded with TR 500 ms, TE 15 ms, matrix 256x256, FOV 256x192 mm², duration of the scan was about 8 minutes. T2 sequence was recorded with TR 4000 ms, TE 120 ms, matrix 256x256, FOV 256x192 mm², duration of the scan was about 3 minutes. FLAIR sequence was recorded with TR 5500 ms, TE 120ms, matrix 256x256, FOV 256x192 mm²; duration of the scan was about 2 minutes. Chloral hydrate used as sedative in some cases.

3. Results

This study included 100 patients, 73 males and 27 females. Their age ranged from 1 day to 18 years with the mean age of 9.1 years. The most affected age group is the age group between 15 years and 18 years. The causes of head trauma in this study were 52% due to road traffic accident, 34% due to falling from height and 14% due to violence. The distribution of patients in respect to initial GCS at the time of arrival to hospital were as following: 54% of the cases classified as mild TBI (GCS \geq 13), 8% of the cases classified as moderate TBI (GCS between 9 and 12) and 38% of the cases classified as severe TBI (GCS between 3 and 8). Among the studied patients, 79% had positive CT imaging finding, with 91.1% of them presenting with subgaleal hematoma, 55.6% with

craniofacial fractures, 18.9% with brain contusion, 17.7% with diffuse cerebral edema, and 50.6% with extra-axial blood collection (10.1% epidural hematoma, 20.2% subdural hematoma, 15.1% subarachnoid hemorrhage and 5.2% intraventricular hemorrhage). One or more imaging findings were observed in 67.1% of the patients. These results are shown in table (1). Of 100 cases examined with CT there were 10 cases with discrepancy between their initial GCS and their admission CT finding; these 10 cases were further examined with MRI. The patients have the following MRI findings: 60% presented with subdural hematoma, 50% with brain contusions, 20% with intracerebral hemorrhage and 20% with diffuse axonal injury. The correlation between GCS and MRI findings in these patients shown in table 2.

4. Discussion

In this study, 73% of the patients with TBI were males and only 27% of them were females. Similar statistics were observed in other several epidemiological studies that show obvious male predominance in head trauma accidents.^(11,12,13,14) Such a fact is due to a greater exposure of male individuals to risk factors for TBI such as accidents with motor vehicles and violence.^(15, 16) This study shows that the highest incidence of cases is in the age group between 15 years and 18 years representing about 31% of patients followed by age group between 1 year and 5 years accounting for 29% of patients. In the most of the prior studies, motor vehicle accidents were reported to be the most common cause of trauma.^(12, 13) Some other authors reported that falling from height is the most common trauma cause.⁽¹⁴⁾ In this study, the most common cause of trauma was found to be road traffic accident representing about 52% of all cases whereas falling from height represent about 34% of the cases and 14% of the cases were due to violence. In this study falling from height was found to be the most common cause of trauma in age group below 5 years with about 65% of them. While the most common cause of trauma in age group between 15 and 18 years was found to be road traffic accident with about 80% of this age group, same results were shown in Hidayat SKh.⁽¹⁷⁾ study.

By associating the different types of TBI with the imaging findings in cases of mild TBI, it is observed that of the 54 patients in this category, 21 cases were with normal CT examinations, 33 cases were with abnormal CT findings presented as the following: 33 cases presented with subgaleal hematoma, 17 cases with craniofacial fractures, 3 cases with cerebral contusion, 1 case with subarachnoid hemorrhage, 1 case presented with diffuse cerebral edema and 14 cases out of 33 cases were presented with more than one abnormal imaging findings. In this study MRI was able to detect 2 cases of non-hemorrhagic contusion that was not detected on the initial CT scan.

By analyzing these findings it is found that the most common imaging finding in mild TBI cases is subgaleal hematoma which was found in 61.1% of mild TBI cases (33/54 cases) followed by skull fractures which was found in

31.5 % of mild TBI cases (17/54 cases) and brain contusions found in 5.5% of mild TBI cases (3/54 cases); these results is in agreement with what Bordignon KC, et al⁽¹⁸⁾ reported in their study that the most frequent lesions in mild TBI were

subgaleal hematoma, fractures and brain contusions, while Smits M, et al⁽¹⁹⁾ found in their study that skull fractures is the most common finding in mild TBI patients. Example of mild TBI is shown in figure 1.

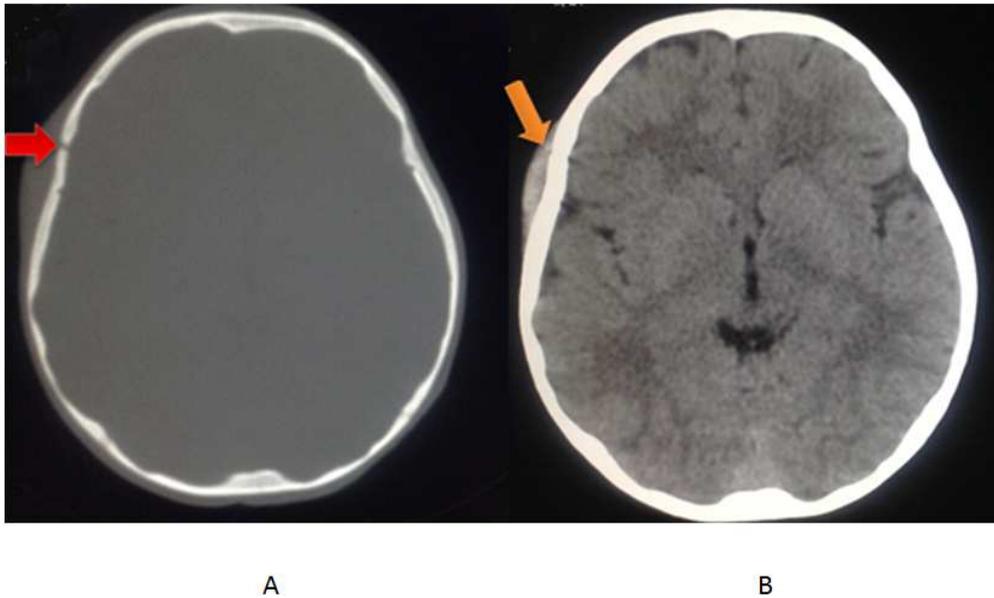


Figure 1. MDCT of the brain axial cut bone window shows a right sided frontal linear fracture (red arrow). (B) MDCT of brain axial cut soft tissue window shows a small right sided subgaleal hematoma (orange arrow) overlying the skull fracture. GCS of this 2 years old male was 14 (mild TBI).

Of the eight patients classified as moderate TBI in this study, 6 patients presented with subgaleal hematoma, 3 with craniofacial fractures (2 depressed and 1 comminuted fractures), 2 with cerebral contusions, 2 with subdural hematoma, 1 with epidural hematoma, 1 with intraventricular hemorrhage, 1 with diffuse cerebral edema and 1 with subarachnoid hemorrhage. In 6 cases out of 8 cases with moderate TBI there were more than one CT findings. In this study MRI was able to detect another large non-hemorrhagic brain contusion that was not shown on the initial CT examination and the patient initial GCS was 9.

By analyzing these findings it is found that the most common CT finding in moderate TBI cases is subgaleal hematoma which was found in 75% cases followed by fractures which found in 37.5% of cases while subdural hematoma found in 25% of cases and brain contusions was found in 25% of cases too. These results are in agreement with study done by MorgadoFL, et al⁽¹¹⁾ which reported that in moderate TBI, the main tomographic findings were subgaleal hematomas, skull fractures and contusions. Example of moderate TBI is shown in figure 2.

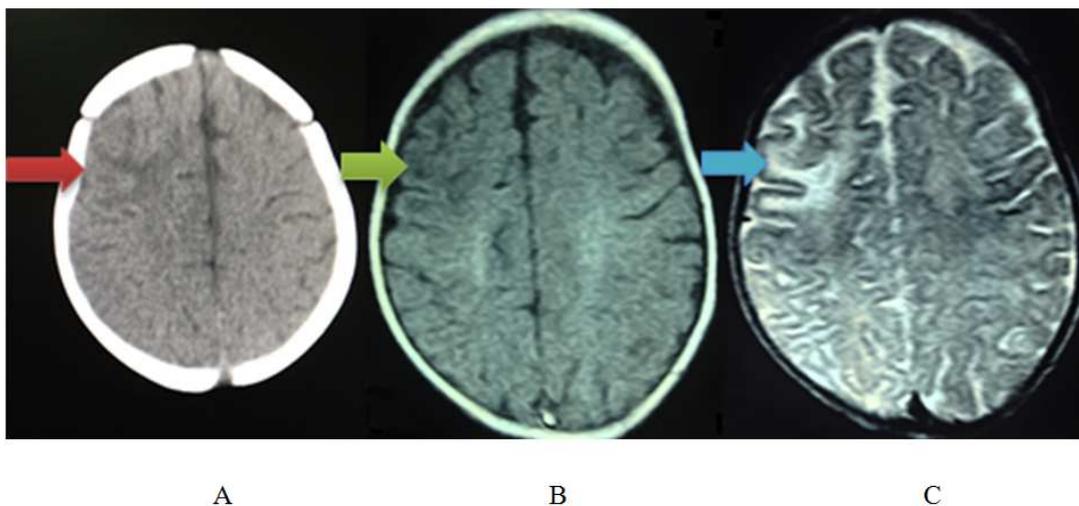


Figure 2. (A) MDCT without contrast axial cut soft tissue window shows subtle area of hypodensity (red arrow) at the right high parietal region. (B) MRI T1WI axial cut shows area of low SI (green arrow) at the same region. (C) MRI T2WI axial cut shows high SI (blue arrow) in the same region suggestive of non-hemorrhagic brain contusion; there was no significant mass effect. The GCS of this young 3 months old female was 9. (moderate TBI).

Of 38 patients classified as severe TBI, 33 cases presented with subgaleal hematoma, 24 craniofacial fractures (14 linear, 9 depressed and 1 comminuted fracture), 10 with cerebral contusions, 10 subarachnoid hemorrhage, 7 with epidural hematoma, 14 with subdural hematoma, 3 cases with intraventricular hemorrhage, 12 cases of diffuse cerebral edema, 8 cases of intracerebral hemorrhage and 5 cases of diffuse axonal injury. Of 38 cases of severe TBI 33 cases presented with more than one CT findings.

Of the 5 cases of diffuse axonal injury 3 cases was suspicious on the initial CT examination but they died before they further examined with MRI, while the other 2 cases were evaluated with MRI which confirm the diagnosis of diffuse axonal injury and detect the actual extent of the injury. By analyzing these findings we found that apart from subgaleal hematoma which found in 86.8% of cases and skull

fractures which were found in 63.1% of cases with severe TBI (24/38 cases), the most common extra-axial finding in severe TBI was subdural hematoma which found in about 36.8% of severe TBI cases (14/38 cases) followed by subarachnoid hemorrhage which found in 26.3% of severe TBI cases (10/38 cases) and epidural hematoma was found in 18.4% of severe TBI cases (7/38 cases) and at the last intraventricular hemorrhage was found in 7.9% of cases (3/38 cases). And the most common intra-axial finding was brain edema which found in about 31.6% % of severe TBI cases (12/38 cases) followed by brain contusions which found in 26.3% of severe TBI cases (10/38 cases) while intracerebral hemorrhage was found in 21.1% of cases (8/38 cases) and DAI was found in 13.1% of cases with severe TBI (5/38 cases). Example of severe TBI is shown in figure 3.

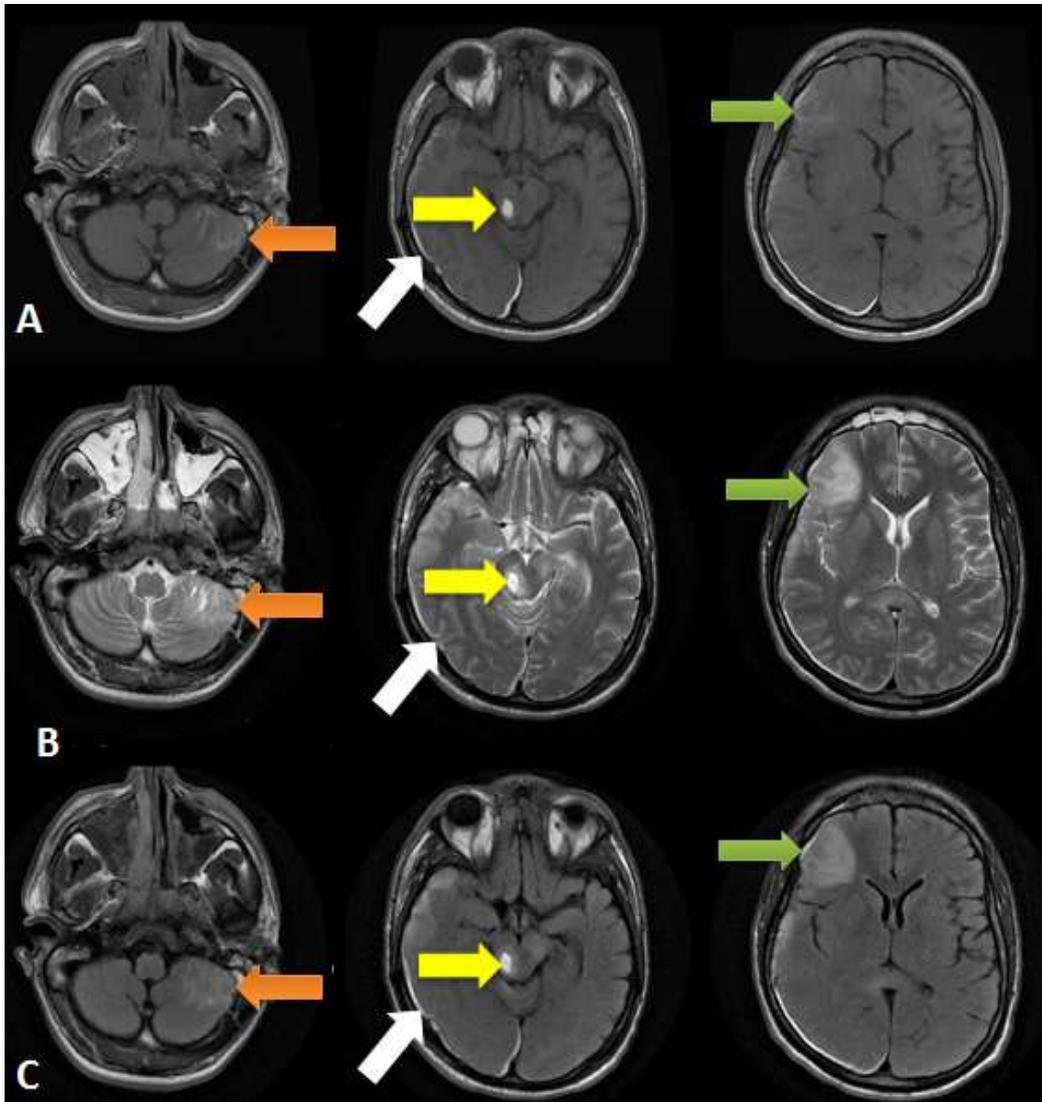


Figure 3. (A) MRI T1WI axial cuts, (B) MRI T2WI axial cuts and (C) MRI FLAIR sequence axial cuts showing foci of hyperintensity on all pulse sequences within the right dorsolateral midbrain (yellow arrows). Also there is area of hyperintensity is seen on all pulse sequences within the lateral aspect of the left cerebellar hemisphere corresponding to subacute hemorrhagic contusion (orange arrows). Thin subdural hematoma (white arrows) is seen overlies the right cerebral hemisphere which displays high signal intensity on all pulse sequences. Areas of T2 and T1 hyperintensity is seen in the right frontal lobe (green arrows) corresponding to subacute hemorrhagic contusion. All these findings are suggestive of grade III diffuse axonal injury. The GCS of this 18 years old male was 8 (severe TBI).

5. Conclusion

In the present study, statistical significance was observed between GCS and the imaging findings. The lower the GCS score, the more severe were the TBI and imaging findings. CT is the modality of choice in the evaluation of acute head injury because it is fast, widely available, highly sensitive to acute blood and can more easily accommodate life-support and monitoring equipment. MRI is indicated for patients with

acute TBI when the neurological findings are unexplained by CT and don't correlate with GCS. MRI has traditionally been less desirable than CT in the acute setting because of the longer examination times, difficulty in managing life support and other monitoring equipment, and inferior demonstration of bone detail. MRI however has been shown to be superior to CT in the detection non-hemorrhagic brain injury and cases of diffuse axonal injury. MRI is also more sensitive to brainstem injury especially with FLAIR sequence.

Table 1. Shows the relation between CT imaging findings and GCS.

Number of the Cases CT features	No. of Mild TBI	No. of Moderate TBI	No. Severe TBI	Total No. of cases	% of total no. of cases	% of cases with abnormal finding
Subgaleal hematoma	33	6	33	72	72	91.1
Fractures	17	3	24	44	44	55.6
Linear fracture	13	0	14	27	27	34.1
Depressed fracture	4	2	9	15	15	18.9
Comminuted fracture	0	1	1	2	2	2.5
Extra axial injury	1	5	34	40	40	50.6
Epidural hematoma	0	1	7	8	8	10.1
Subdural hematoma	0	2	14	16	16	20.2
Subarachnoid Hemorrhage	1	1	10	12	12	15.1
Intraventricular hemorrhage	0	1	3	4	4	5.2
Intra axial injury	3	2	18	23	23	29.1
Contusions	3	2	10	15	15	18.9
Intracerebral Hge	0	0	8	8	8	10.1
Brain edema	1	1	12	14	14	17.7
Pneumocephalus	0	0	11	11	11	13.9
More than one CT finding	14	6	33	53	53	67.1

*owing to multiplicity of findings in the same case the total number of findings exceeds the total number of cases.

Table 2. Shows the relation between MRI imaging findings and GCS.

Number of cases MRI finding	No. of Mild TBI	No. of Moderate TBI	No. Severe TBI	Total No. of cases	% of total no. of MRI examined cases
Subdural Hemorrhage	0	2	4	6	60
Diffuse axonal injury	0	0	2	2	20
Contusion	2	1	2	5	50
Intracerebral hemorrhage	0	0	2	2	20

*owing to multiplicity of findings in the same case the total number of findings exceeds the total number of cases.

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