Computed Tomography Profile and its Utilization in Head Injury Patients in Emergency Department: A Prospective Observational Study

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Abstract

**Context:** Based on Glasgow Coma Scale (GCS), head injury can be classified as minor (GCS 13–15), moderate (GCS 9–12), and severe (GCS 3–8). There is a lot of controversy in the use of computed tomography (CT) in head injury patients. **Aims:** This study was intended to estimate the rate of CT positivity in head injury patients and to define the criteria for doing CT in head injury patients. **Settings and Design:** This was a prospective observational study in the emergency department (ED) over a 12-month period. Subjects and Methods: Study involved all head injury patients attending ED. Risk factors studied were a loss of consciousness (LOC), vomiting, seizures, ear bleed, nosebleed, external injuries, and alcohol intoxication. **Statistical Analysis Used:** Comparison of CT positivity with the patient’s demographics and clinical characteristics was carried out using Chi-square. **Results:** A total of 1782 patients were included in this study. Overall CT positivity was 50.9%. In minor head injury (MHI), CT positivity rate was 38%. The study showed significant association of CT positivity with five variables: LOC >5 min, vomiting, seizures, ear bleed, and nosebleed. **Conclusions:** From the study, we recommend following: CT is indicated in all patients with moderate and severe head injury (GCS ≤12). Low threshold for taking CT is advisable in elderly and alcohol-intoxicated patients. In MHI, CT is indicated if any one of the following risk factors are present: LOC >5 min, history of vomiting, history of seizures, history of ear bleed, and history of nosebleed.

**Keywords:** Computed tomography, emergency department, Glasgow Coma scale, head injury

**INTRODUCTION**

Head injuries result in considerable mortality and morbidity among young and productive people of our society.[1] Based on Glasgow Coma Scale (GCS), head injury can be classified as minor, moderate, and severe injury.[2] Minor head injury (MHI) constitutes around 70%–90% of all head injuries.[3] Computed tomography (CT) is the choice of investigation in head injury.[4,5] There is a lot of controversy in the use of CT, especially in MHI.[6,7] This study was intended to estimate the rate of CT positivity and to define the criteria for doing head CT in our patient population with special emphasis on MHI.

**SUBJECTS AND METHODS**

This was a prospective observational study in the Department of Emergency Medicine and Trauma, in collaboration with the Department of Neurosurgery, over a 12-month period. The study involved all head injury patients attending our emergency department (ED). All study subjects and their caregivers had to sign a written informed consent form to be included in our study.

**Inclusion criteria**

All head injury patients attending ED during the index year are included.

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Exclusion criteria
Those with no clear history of trauma as the primary event and neurologic deficit that could not be explained by head trauma are excluded.

A complete clinical history of the patient, which includes age, gender, time of injury, time elapsed after an injury to arrival at the hospital, etc., was collected in a prestructured pro forma. The type of trauma was further classified into road traffic accidents (RTA), falls, assaults, and others. Symptoms including loss of consciousness (LOC), vomiting, posttraumatic seizures, and alcohol consumption were entered. The risk indicators were defined as follows: LOC is defined as documented LOC following head injury. Vomiting is defined as any emesis after a head injury occurrence. Seizure is defined as a witnessed convulsion after the traumatic event. The physical evidence of trauma was defined as any external injury, such as contusions/bruise, abrasions, lacerations, deformities, sutured wounds, and signs of facial or vault fracture. Alcohol intoxication was determined based on the history obtained from the patient or a witness and suggestive features such as slurred speech or breath smell of alcohol and on physical examination.

This was followed by general physical examination and detailed central nervous system examination. Clinical examination including pulse rate, blood pressure on arrival, O2 saturation (SpO2), and GCS was documented. The severity of head injury was classified as per GCS. The patients were classified into three groups depending on the GCS: Group 1: GCS 13–15 (MHI); Group 2: GCS 9–12 (moderate head injury); and Group 3: GCS ≤8 (severe head injury). After initial resuscitation and stabilization, patients were shifted for noncontrast CT scan Brain. All patients underwent imaging on the same CT scanner machine with the same technique. CT findings were noted and entered into pro forma. Different CT findings noted during the study were: skull fractures, contusions, diffuse axonal injury, extradural hematoma, subdural hematoma, subarachnoid hemorrhage, intracerebral hematoma, and pneumocephalus.

Statistical analysis
The data were collected and compiled in Microsoft Excel package. The distribution of categorical data such as gender, mode of presentation and injury, type of vehicle, type of fall, clinical characteristics, type of head injury, and CT profile was expressed as frequency and percentage. The distribution of continuous data such as age, time interval, duration of LOC, vital parameters, SpO2, and GCS was expressed as mean with standard deviation or median with range. The comparison of CT profile with patients’ sociodemographic characteristics and clinical characteristics were carried out using Chi-square test. The level of risk for CT positivity was estimated using Odds Ratio along with its 95% confidence interval. All statistical analysis was carried out using SPSS software, version 19.0 (International Business Machines Corporation, Armonk, New York, United States) at 5% level of significance.

Results
A total of 1782 patients underwent CT for head injury. Baseline characteristics are shown in Table 1. Mean age of study participants was 36.2 ± 17. Minimum age of head injury patient attended to our ED was 4 months to maximum age of 88 years. Time elapsed between the head injury to arrival to our ED varied from 10 min to >1 month. Duration of LOC following head injury varied from 5 min to 16 h. Among RTA, two wheeler users (70%) were most common victims, followed by pedestrians (16%), bicycle users (4.5%), four wheeler users (4.4%), auto rickshaw users (2.4%), and heavy vehicle users (2.1%). Among two-wheeler users, riders were more (82.6%) compared to pillion riders (17.4%). Helmet usage was <1% among 819 two-wheeler riders. History of alcohol consumption was present in 594 (33.3%) head injury patients. More than 90% injuries were isolated head injuries and <10% patients had associated other system injuries.

CT positivity for overall study population and separately for minor, moderate, and severe head injury is given in Table 2.

The distribution of different CT findings shows that fractures (61.7%) were most common followed by brain contusion (32.9%), subdural hemorrhage (20.8%), subarachnoid hemorrhage (15.1%), extradural hemorrhage (14.4%), and subdural hematoma, subarachnoid hemorrhage, intracerebral hematoma, and pneumocephalus.

Table 1: Baseline characteristics of study participants (n = 1782)

| Baseline characteristics | n (%) |
|--------------------------|-------|
| Age (years)              |       |
| <12                      | 113 (6.3) |
| 13-20                    | 166 (9.3) |
| 21-40                    | 884 (49.6) |
| 41-60                    | 468 (26.3) |
| >60                      | 151 (8.5) |
| Gender                   |       |
| Male                     | 1447 (81.6) |
| Female                   | 335 (18.4) |
| Referred cases           |       |
| Yes                      | 1557 (87.4) |
| No                       | 225 (12.6) |
| Mode of injury           |       |
| RTA                      | 1404 (78.8) |
| Assault                  | 173 (9.7) |
| Fall                     | 170 (9.5) |
| Other mode of injury     | 35 (2) |
| Clinical features        |       |
| Loss of consciousness following head injury | 1155 (64.8) |
| History of vomiting      | 470 (26.4) |
| History of seizures      | 91 (5.1) |
| External injury          | 1500 (84.2) |
| History of ear bleeding  | 182 (10.2) |
| History of nose bleeding | 170 (9.5) |
| Type of head injury      |       |
| Mild                     | 1341 (75.3) |
| Moderate                 | 199 (11.2) |
| Severe                   | 242 (13.6) |

RTA: Road traffic accident
pneumocephalus (9.9%), and diffuse axonal injury (4.3%). The associations of CT positivity in relation to sociodemographic variables are given in Table 3.

The association of CT positivity in relation to clinical characteristics is given in Table 4.

### Table 2: CT positivity of Study participants (n=1782)

| CT positive | Frequency (%) |
|-------------|---------------|
| Yes         | 907 (50.9)    |
| No          | 875 (49.1)    |

### Table 3: Association of sociodemographic variables with computed tomography positivity

| Variables            | CT positive | Total          | Statistical significance (P) |
|----------------------|-------------|----------------|------------------------------|
| Gender               |             |                |                              |
| Male                 | 773 (53.4)  | 1447           | 0.000*                       |
| Female               | 134 (46.6)  | 335            |                              |
| Age (years)          |             |                |                              |
| <12                  | 53 (46.9)   | 113            | 0.002*                       |
| 13-20                | 83 (50)     | 166            |                              |
| 20-40                | 419 (47.4)  | 884            |                              |
| 40-60                | 257 (54.9)  | 468            |                              |
| >60                  | 95 (62.9)   | 151            |                              |
| Mode of injury       |             |                |                              |
| RTA                  | 737 (52.5)  | 1404           | 0.000*                       |
| Fall                 | 100 (58.8)  | 170            |                              |
| Assault              | 50 (28.9)   | 173            |                              |
| Others               | 20 (57.1)   | 35             |                              |
| Among RTA            |             |                |                              |
| Pedestrian           | 124 (55.4)  | 224            | 0.001*                       |
| Bicycle              | 34 (54.0)   | 63             |                              |
| Two wheeler          | 536 (54.1)  | 991            |                              |
| Four wheeler         | 18 (29.1)   | 62             |                              |
| Auto rickshaw        | 12 (35.3)   | 34             |                              |
| Heavy vehicles       | 13 (43.3)   | 30             |                              |
| Among two wheeler    |             |                |                              |
| Rider                | 446 (54.5)  | 819            | 0.610                        |
| Pillion rider        | 90 (52.3)   | 172            |                              |
| Among fall victims   |             |                |                              |
| At ground level      | 43 (64.2)   | 67             | 0.252                        |
| From height          | 57 (55.3)   | 103            |                              |
| History of alcohol   |             |                |                              |
| Yes                  | 495 (83.3)  | 594            | 0.000*                       |
| No                   | 412 (34.7)  | 1188           |                              |

CT: Computed tomography, GCS: Glasgow Coma Scale

### Discussion

Head injury is defined as impairment in brain function as a result of mechanical force.[8] The dysfunction can be temporary or permanent, and may or may not result in underlying structural changes in the brain. Head injuries are a major public health problem worldwide. A limited amount of neurological damage occurs at the time of impact (primary injury). Damage progresses during the ensuring minutes, hours, and days (secondary injury).[9] Early and appropriate management of head injury is essential for survival of these patients.[10,11] Choice of investigation for head injury patients is CT, as it is quick, widely available and precise in the detection of skull fractures and intracranial bleeds.[4,5] It is superior to plain radiographs.[12] It is more cost-effective and quick compared to MRI (Magnetic Resonance Imaging).[13] Missed intracranial injury may lead to permanent brain damage, disability, and even death.[14,15]

Based on GCS, head injury is classified as minor (GCS 13–15), moderate (GCS 9–12), and severe (GCS 3–8).[16] There is a lot of controversy in the use of CT in head trauma, especially in MHI. Different guidelines are followed in different parts of the world for taking CT.[6,7]

1782 patients, who satisfied inclusion criteria, during the index year, were included in this study. Out of these, 1447 were males (81.6%). The most common mechanism was RTA (78.8%), followed by assault (9.7%), fall (9.5%), and other modes of injury (2%). These findings are consistent with the findings of India[17] and abroad.[11] Among RTA victims, two wheeler users were commonly affected (70.6%), followed by pedestrian (16%), bicycle users (4.5%), four wheeler users (4.4%), auto rickshaw users (2.4%), and heavy vehicle users (2.1%). Alcohol consumption was present in 33.3% patients. The most common clinical presentation was external injury over scalp and face (84.2%), followed by a history of LOC (64.8%), history of vomiting (26.4%), history of ear-bleed (10.2%), history of nosebleed (9.1%), and history of seizures (5.1%). MHI was the most common (75.3%). This is consistent with findings of Gururaj, who reported minor head is more common (70%), followed by severe (16%) and moderate head injury (14%).[17]
Table 4: Association of clinical characteristics with computed tomography positivity

| Variables                  | CT positive     | Total       | Statistical significance (P) |
|----------------------------|-----------------|-------------|------------------------------|
|                            | Yes (%)         | No (%)      |                              |
| LOC > 5 min                | 612 (80)        | 153 (20)    | 765                          | 0.000*                        |
| LOC < 5 min                | 96 (24.6)       | 294 (75.4)  | 390                          |                               |
| History of vomiting        | 349 (74.2)      | 121 (25.7)  | 470                          | 0.000*                        |
| No history of vomiting     | 558 (42.5)      | 754 (57.5)  | 1312                         |                               |
| History of seizure         | 88 (96.7)       | 3 (3.2)     | 91                           | 0.000*                        |
| No history of seizure      | 819 (48.5)      | 872 (51.5)  | 1691                         |                               |
| External injury            | 760 (50.6)      | 740 (49.4)  | 1500                         | 0.653                         |
| No external injury         | 147 (52.1)      | 135 (47.9)  | 282                          |                               |
| Ear bleed                  | 147 (80.8)      | 37 (19.2)   | 182                          | 0.000*                        |
| No ear bleed               | 762 (47.6)      | 838 (52.4)  | 1600                         |                               |
| Nose bleed                 | 119 (69.2)      | 51 (30.8)   | 170                          | 0.000*                        |
| No nose bleed              | 788 (58.9)      | 824 (41.1)  | 1612                         |                               |
| Mild head injury           | 510 (38)        | 813 (62)    | 1341                         | 0.000*                        |
| Moderate head injury       | 162 (81.4)      | 37 (18.6)   | 199                          |                               |
| Severe head injury         | 235 (97.1)      | 7 (2.9)     | 242                          |                               |

LOC: Loss of consciousness, CT: Computed tomography, *P value < 0.05 is taken as statistically significant

Overall rate of CT positivity in our study was 50.9%, which is more compared to study conducted by Chen et al., in Taiwan, who reported mean CT positivity as 29.1%.[18] Dunning et al., who did a meta-analysis of 16 different studies, reported a wide range of CT positivity 1.3%–36%.[19] Schynoll et al. reported CT positivity of 33% in his study.[20] CT positivity was found to be high in elderly age group (>60 years) compared to adults and young age group with P < 0.05. This is consistent with findings of Schynoll et al.,[20] who reported a high prevalence of intracranial injury among elderly age group (>60 years) and suggested a low threshold for obtaining CT on an elderly head injury patient. Strong association was found between CT positivity and history of alcohol consumption at the time of injury with P < 0.05. CT positivity was found to be 9 times higher in patients who had a history of alcohol consumption at the time of injury, compared to those who did not give a history of alcohol consumption during injury. This finding is consistent with findings of Schynoll et al.,[20] who reported CT positivity to be 5 times more in patients with alcohol intoxication at the time of injury compared to those who were not under the influence of alcohol at the time of injury. Strong association was found between CT positivity and severity of head injury based on GCS score with P < 0.05. CT positivity is higher in severe head injury (GCS ≤ 8) with odds ratio [OR] = 54.702 (95% CI: 25.88–116.943) and in moderate head injury (GCS 9–12) with OR = 7.668 (95% CI: 3.336–17.624), compared to MHI (GCS 13–15) as reference group. This is consistent with findings of Schynoll et al.,[20] who reported strong association of abnormal CT findings with patients with GCS <15. Strong association was found between CT positivity and LOC of more than 5 min following head injury. CT positivity was found to be 12 times higher in patients LOC more than 5 min, compared to those with LOC <5 min (OR = 12.250, 95% CI: 9.016–16.382). This finding is consistent with Schynoll et al.,[20] who reported CT positivity is more in patients with LOC >4 min, compared to those with LOC <4 min. We found strong association of overall CT positivity and variables such as history of vomiting, history of seizures, history of ear bleed, and history nosebleed. CT positivity was 3 times in patients with history of vomiting following head injury compared to those with no history of vomiting (OR = 3.897, 95% CI: 3.084–4.925). CT positivity is 31 times more in patients with history of seizures following head injury compared to those without history of seizures (OR = 31.232, 95% CI: 9.843–99.096). CT positivity is 4 times more in patients with a history of ear-bleed following head injury compared to those with no history of ear-bleed (OR = 4.310, 95% CI: 2.965–6.265). CT positivity is 2 times more in patients nose bleed compared to those without nose bleed (OR = 2.440, 95% CI: 1.733–3.436). We could not found any recent articles on association of overall CT positivity with a history of vomiting, seizures, ear bleed, and nosebleed following head injury.

Table 5: Odds ratio and confidence interval of study variables with computed tomography positivity

| Variables                  | OR   | CI               |
|----------------------------|------|-----------------|
|                            | Lower limit | Upper limit |
| Female                     | Reference group |
| Male                       | 1.720 | 1.351–2.191 |
| Assault                    | Reference group |
| RTA                        | 2.718 | 1.925–3.838 |
| Fall                       | 3.514 | 2.244–5.504 |
| No history of alcohol      | Reference group |
| History of alcohol         | 7.640 | 7.359–12.052 |
| LOC <5 min                 | Reference group |
| LOC >5 min                 | 12.250 | 9.160–16.382 |
| No vomiting                | Reference group |
| History of vomiting        | 3.897 | 3.084–4.925 |
| No seizures                | Reference group |
| History of seizures        | 31.232 | 9.843–99.096 |
| No ear bleed               | Reference group |
| History of ear bleed       | 4.310 | 2.965–6.265 |
| No nose bleed              | Reference group |
| History of nose bleed      | 2.440 | 1.733–3.436 |
| Mild head injury           | Reference group |
| Moderate head injury       | 7.668 | 3.336–17.624 |
| Severe head injury         | 54.702 | 25.588–116.943 |

OR: Odds ratio, CI: Confidence interval, LOC: Loss of consciousness, RTA: Road traffic accident
formulating recommendations for CT in MHI. MHI constitutes majority (>70%) of head injury population. These patients have a small but important risk of serious intracranial injury that requires early identification and neurosurgical treatment. Management involves a potential trade-off between under-investigation, which risks missed the opportunity to provide early effective treatment for intracranial injury, and over-investigation, which risks unnecessary radiation exposures and associated health hazards. This problem can be minimized by considering patients clinical variables. In this study, 38% of MHI patients had positive findings on CT. The incidence of positive CT scans in patients with MHI (GCS 13–15) ranges from 4% to 83%.[21–25] This wide variability in the incidence of positive CT scans in MHI is due to the retrospective nature of some studies as well as due to the selection bias involved in choosing patients for CT and the definition of what constitutes a “positive CT scan.” Our study represents a much more representative sample of patients with MHI because it was a prospective study and there was no selection bias; no historical or clinical criteria were used to select patients for CT scanning. The high incidence of positive CTs in our patient population may be due to our definition of positive CT which includes any acute injury to the brain and cranium. We believe this definition of “positive CT” is appropriate because even lesions that do not require surgical intervention such as linear fractures, contusions, cerebral edema, and pneumocephalus can contribute to significant long-term morbidity suffered by the patient and/or of medicolegal importance.

**Predictors of positive computed tomography in minor head injury**

Our study found strong association of CT positivity with five variables: LOC >5 min, vomiting, seizures, ear bleed, and nasal bleed. LOC following head injury was found to be strongly associated with CT positivity in our study. LOC in MHI has been analyzed extensively as a predictor of CT abnormality in various studies. Haydel et al., Saadat et al., and Sharif-Alhoseini et al.[26–28] reported strong association of CT positivity and LOC following MHI. Gomez et al. found the converse result.[29] Our study found a significant association of CT positivity with vomiting following head injury. Vomiting as a predictor of CT positivity was studied by Sharif-Alhoseini et al.[29] and found similar association as in our study. We found strong association of CT positivity with seizures following head injury. Post-traumatic seizures as a predictor of CT positivity was studied by Haydel et al.,[29] and found similar association of CT positivity as in our study. Ear bleed was found to be significantly associated with CT positivity in our study in MHI population. This is consistent with findings of Munivenkatappa et al.,[30] who studied predictors of CT positivity in pediatric population (age >12 years). Nasal bleed was found to be significantly associated with CT positivity in our study. This is consistent with findings of Munivenkatappa et al.,[30] who studied predictors of CT positivity in pediatric population (age >12 years).

Use of these clinical predictors in MHI can reduce the number of unnecessary CT scans by up to 62%, potentially leading to a large reduction in unnecessary radiation exposure and associated economic burden to hospital and patients. Prospective studies using these criteria may be useful to confirm these findings.

**Conclusions**

This study showed significant association of overall CT positivity with patients sociodemographic and clinical factors such as: male gender, elderly age group (>60 years), history of alcohol consumption, LOC >5 min, history of vomiting, history of seizures, evidence of ear bleed, evidence of nosebleed, and GCS ≤12 (mild and Severe head injury). From the results of this study, we recommend following indications for doing CT in head injury patients: (1) CT is indicated in all patients with moderate and severe head injury (GCS ≤12). (2) Low threshold for taking CT is advisable in elderly

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**Table 6: Association of study variables with computed tomography positivity in minor head injury (Glasgow Coma Scale 13-15)**

| Variables                  | CT positive | Total | Statistical significance (P) |
|----------------------------|-------------|-------|------------------------------|
|                            | Yes (%)     | No (%)|                               |
| Male                       | 430 (40.2)  | 639 (59.8) | 1069 | 0.01*                      |
| Female                     | 80 (29.4)   | 192 (70.6) | 272  |                           |
| Age (years)                |             |       |                               |
| >12                        | 28 (32.9)   | 57 (67.1) | 85   | 0.485                      |
| 13-20                      | 52 (40.0)   | 78 (60.0) | 130  |                           |
| 21-40                      | 254 (36.5)  | 441 (63.5) | 695  |                           |
| 41-60                      | 134 (40.2)  | 199 (59.8) | 333  |                           |
| >60                        | 42 (42.9)   | 56 (57.1) | 98   |                           |
| History of alcohol         |             |       |                               |
| No history of alcohol      | 454 (38.0)  | 742 (62.0) | 1196 |                           |
| LOC >5 min                 | 294 (67.9)  | 139 (32.1) | 433  | 0.000*                     |
| LOC <5 min                 | 60 (17.5)   | 283 (82.5) | 343  |                           |
| History of vomiting        | 195 (63.5)  | 112 (36.5) | 307  | 0.000*                     |
| No history of vomiting     |             |       |                               |
| History of seizures        | 315 (30.5)  | 719 (69.5) | 1034 |                           |
| History of seizures        | 25 (89.3)   | 3 (10.7)   | 28   | 0.000*                     |
| No history of seizures     | 485 (36.9)  | 828 (63.1) | 1313 |                           |
| Ear bleed                  | 69 (66.3)   | 35 (33.7)   | 104  | 0.000*                     |
| No ear bleed               | 441 (35.7)  | 796 (64.3) | 1237 |                           |
| Nose bleed                 | 80 (62.5)   | 48 (37.5)   | 128  | 0.000*                     |
| No nose bleed              | 430 (35.4)  | 783 (64.6) | 1213 |                           |
| External injury            | 433 (38.1)  | 702 (61.9) | 1135 | 0.834                      |
| No external injury         | 77 (37.4)   | 129 (62.6) | 206  |                           |

CT: Computed tomography, LOC: Loss of consciousness, *P value <0.05 is taken as statistically significant
patients and alcohol intoxicated patients, irrespective of GCS. (3) In MHI (GCS 13–15), CT is indicated if any one of the following risk factors is present, namely, LOC >5 min, history of vomiting, history of seizures, history of ear bleed, and history of nose bleed.

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Conflicts of interest
There are no conflicts of interest.

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