Clinical Symptoms of Minor Head Trauma and Abnormal Computed Tomography Scan

Mohammadreza Maghsoudi,¹ Mehdi Samadzadeh,² Saghi Maghsoudi,³ Khatereh Isazadehfar,⁴ Tooraj Asadi,¹ and Bita Shahbazzadegan⁵,⁶,*

¹Emergency Department, Tehran University of Medical Sciences, Tehran, IR Iran
²Department of Psychiatry, Ardabil University of Medical Sciences, Ardabil, IR Iran
³Emergency Department, Hamadan University of Medical Sciences, Hamadan, IR Iran
⁴Department of Community and Preventive Medicine, Ardabil University of Medical Sciences, Ardabil, IR Iran
⁵Department of EDO, School of Medicine, Ardabil University of Medical Sciences, Ardabil, IR Iran
⁶Department of Public Health, School of Health, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran
*Corresponding author: Bita Shahbazzadegan, Department of Public Health, School of Health, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran. Tel: +914-4515848, Fax: +45-15510057, E-mail: bitashahbaz2004@yahoo.com

Received 2015 September 22; Revised 2015 October 19; Accepted 2015 November 1

Abstract

Background: Minor head trauma accounts for 70% to 90% of all head traumas. Previous studies stated that minor head trauma were associated with 7% - 20% significant abnormal findings in brain computed tomography (CT)-scans.

Objectives: The aim of this study was to reevaluate clinical criteria of taking brain CT scan in patients who suffered from minor head trauma.

Patients and Methods: We enrolled 680 patients presented to an academic trauma hospital with minor head trauma in a prospective manner. All participants underwent brain CT scan if they met the inclusion criteria and the results of scans were compared with clinical examination finding.

Results: Loss of consciousness (GCS drop or amnesia) was markedly associated with abnormal brain CT scan (P < 0.05). Interestingly, we found 7 patients with normal clinical examination but significant abnormal brain CT scan.

Conclusions: According to the results of our study, we recommend that all patients with minor head trauma underwent brain CT scan in order not to miss any life-threatening head injuries.

Keywords: Craniocerebral Trauma, Clinical Markers, Abnormalities, CT Scan

1. Background

There are almost 0.8 to 1.2 million patients with head injury in United States annually (1, 2), that 70% - 90% of them category as minor head trauma (3). In several studies, it is estimated that intracranial lesions following a brain computed tomography (CT) scan of these patients is as high as 7% - 20% (4-7).

Brain CT scan is extensively used for screening patients with minor head injury although it is often normal (8). About one million patients with head trauma undergo brain CT scan every year (6). Which patient with head trauma should undergo a CT scan is still controversial. At first CT scan was used only for patients with major injuries due to resource limitations, after that by common access to CT scan it also used for patients with minor head trauma, and it was found retrospectively that about 17% - 20% of patients with minor head trauma had pathologic findings in their CT scans (8).

As most of these patients do not require special medical treatments, some physicians do not have tendency to request a brain CT scan for minor head traumas. Unlike them, others believe that in order to reduce dramatic consequences of ignoring brain pathologies, CT scans should be used freely during patient evaluations (9).

Minor head trauma will be diagnosed by history of loss of conciseness (LOC), amnesia and Glasgow coma scale (GCS) 13 to 15. There are some differences in determining minor injury and based on some studies patients with minor head trauma may not have LOC or neurologic changes (10).

Indications and overuse of computed tomography in minor head trauma (11). Comparison of the Canadian CT Head Rule and the New Orleans Criteria in patients with minor head injury (12). A number of clinical decision rules have been developed to identify high-risk patients in the minor head trauma category to predict intracranial pathologies that need CT scan and decrease unnecessary imaging for these patients (13, 14). A 10% decrease in brain CT requests for...
minor head trauma would result in saving $20 million in US (15). It would also lead to saving time and less crowded emergency department (ED) (3,16). While the sensitivities of these algorithms range from 80% to 100%, (2, 14, 17, 18) and their specificities have been suboptimal, emergency physicians tend to use brain CT scan for all the patients not missing any potential finding which is an expensive screening test (8).

2. Objectives
Considering the high number of head trauma cases in our country and taking into account that 80% of them have minor head trauma, we designed a study to evaluate and confirm clinical criteria suggested in previous studies to determine those with minor head trauma that do not need to undergo brain CT scan in ED.

3. Patients and Methods
This cross-sectional study was performed in an urban academic trauma center of Tehran university of medical sciences from April 2010 to April 2011.

In this study, 3 - 65 years old patients with blunt head trauma and GCS ≥ 13 without focal neurologic finding were evaluated. All the patients with minor head trauma underwent brain CT scan as soon as possible during the first two hours after ED arrival without using any special screening rule and pathologic findings were recorded. An expert radiologist reported the findings of the imaging.

Our exclusion criteria consisted patients with other serious injuries, unstable patients and suspicion to malingering. Recorded variables included LOC, GCS, amnesia, age, sex, sign or symptoms of skull base fracture, seizure, nausea and vomiting, headache, skull fracture or signs of skull base fracture can be a predictor of abnormal findings in brain CT scan (Table 1) (Figure 1).

Data analysis showed that 7.9% of patients with GCS = 15 had positive findings in brain CT scan and statistical analysis showed a significant relation with brain CT finding and skull fracture showed the strongest relation (Table 2). As shown in Figure 2, increase in number of clinical findings would significantly increase the probability of having abnormal CT scan (chi-square; Asymp sig. = 0.000). Interestingly, seven patients (2.6%) had no symptom or sign while presenting the ED, but had abnormal CT scan.

Among children aged 3 to 12 years old, patients’ GCS score and presence of skull fracture are statistically related with abnormal brain CT scan findings while in teens and adults, LOC, number of clinical findings prior to performing a brain CT scan, GCS score, amnesia, vomiting, headache, skull fracture or signs of skull base fracture can be a predictor of abnormal findings in brain CT scan (Table 3) (Figure 2).

Of the patients the day after discharge was SDH and LOC, because of taking warfarin and one patient a week after discharge with rebleeding admitted to ICU.

The sensitivity, specificity, positive predictive value and negative predictive value for clinically important brain injury in CT according to the Canadian CT Head Rule (CCHR) were as follows for two age groups: 3-12 years old (87.5%, 43.5%, 15.2%, 96.8%, respectively) and 13 - 65 years old (93.3%, 45.3%, 22.8%, 97.5%, respectively).

![Figure 1. Presence of Abnormal Computed Tomography Scan According to Patients’ Glasgow Coma Scale](image1)

![Figure 2. Presence of Abnormal Computed Tomography Scan According to the Number of Clinical Findings Before Performing Brain CT Scan](image2)
Table 1. Demographic Data of the Participants

| Variables                  | Valuesa |
|----------------------------|---------|
| **Gender**                 |         |
| Male                       | 515 (75.7) |
| Female                     | 165 (24.3) |
| **GCS**                    |         |
| 15                         | 583 (85.7) |
| 14                         | 62 (9.1) |
| 13                         | 35 (5.1) |
| **Mechanism of trauma**    |         |
| CA                         | 239 (35.1) |
| MVA                        | 195 (28.7) |
| FALL                       | 104 (15.3) |
| Pedestrian                 | 83 (12.2) |
| Hard objects blow          | 51 (7.5) |
| Sport                      | 4 (0.6) |
| Syncope                    | 3 (0.4) |
| Other                      | 1 (0.1) |
| **Abnormal CT scan**       |         |
| Skull fracture             | 82 (12.1) |
| Skull base fracture        | 57 (8.4) |

Abbreviations: CA, car to car accident; CT, computed tomography; GCS, Glasgow coma scale; MVA, motorcycle to car or other vehicle accident.

Data are presented as No. (%).

Table 2. Clinical Findings of the Patients With Minor Head Trauma

|                      | Total   | With Abnormal CT scan | Odds   | PVaule |
|----------------------|---------|-----------------------|--------|--------|
| Amnesia              | 149 (21.9) | 41 (27.5)       | 3.22   | .000a  |
| Seizure              | 7 (1.0)   | 3 (42.9)         | 4.62   | .064b  |
| Vomiting             | 162 (23.8) | 38 (23.5)       | 2.38   | .000a  |
| Raccoon Eye          | 23 (3.4)   | 13 (56.5)       | 8.86   | .000a  |
| Otorrhea             | 3 (0.4)    | 0 (0)           | NA     | .630b  |
| Otorragia            | 23 (3.4)   | 16 (9.9)        | 16.25  | .000a  |
| Rhinorrhea           | 1 (0.1)    | 0 (0)           | NA     | .857b  |
| Base of skull fracture | 57 (8.4)  | 30 (52.6)      | 9.21   | .000a  |
| Headache             | 161 (23.7) | 45 (28.0)      | 3.48   | .000a  |
| Loss of consciousness| 161 (23.7) | 39 (24.2)      | 2.54   | .000a  |

Abbreviation: NA, not available.

aChi-square tests.
bFisher’s exact test.
cAny sign or symptom (≥ 1)
### Table 3. Clinical Findings of the Patients With Minor Head Trauma by Age Group

| Variable                | 3 - 12 Years | 13 - 65 Years |
|-------------------------|--------------|---------------|
|                         | CT Scan      |               |
|                         | Normal       | Abnormal      | P     | Normal       | Abnormal      | P     |
| LOC                     |              |               | .032  | .000         |               |       |
| No                      | 59           | 4             |       | 402          | 54            |       |
| Yes                     | 10           | 4             |       | 112          | 35            |       |
| Number of clinical findings |              |               | .030  | .000         |               |       |
| 0                       | 30           | 1             |       | 233          | 6             |       |
| 1                       | 28           | 2             |       | 138          | 14            |       |
| 2                       | 8            | 3             |       | 88           | 19            |       |
| 3                       | 1            | 1             |       | 35           | 21            |       |
| 4                       | 1            | 1             |       | 11           | 13            |       |
| 5                       | 1            | 0             |       | 9            | 16            |       |
| GCS                     |              |               | .000  | .000         |               |       |
| 15                      | 63           | 4             |       | 474          | 42            |       |
| 14                      | 5            | 2             |       | 27           | 28            |       |
| 13                      | 1            | 2             |       | 13           | 19            |       |
| Amnesia                 |              |               | .603  | .000         |               |       |
| No                      | 62           | 7             |       | 413          | 49            |       |
| Yes                     | 7            | 1             |       | 101          | 40            |       |
| Seizure                 |              |               | .896  | .045         |               |       |
| No                      | 68           | 8             |       | 511          | 86            |       |
| Yes                     | 1            | 0             |       | 3            | 3             |       |
| Vomiting                |              |               | .554  | .000         |               |       |
| No                      | 48           | 6             |       | 411          | 53            |       |
| Yes                     | 21           | 2             |       | 103          | 36            |       |
| Headache                |              |               | .551  | .000         |               |       |
| No                      | 63           | 7             |       | 404          | 45            |       |
| Yes                     | 6            | 1             |       | 110          | 44            |       |
| Skull fracture          |              |               | .000  | .000         |               |       |
| No                      | 63           | 2             |       | 489          | 44            |       |
| Yes                     | 6            | 6             |       | 25           | 45            |       |
| Base skull Fx           |              |               | .361  | .000         |               |       |
| No sign                 | 66           | 7             |       | 490          | 60            |       |
| Any sign                | 3            | 1             |       | 24           | 29            |       |

Abbreviations: CT, computed tomography; GCS, Glasgow coma scale; LOC, loss of consciousness.

### 5. Discussion

According to our results on 680 patients with minor head trauma, there were a significant relation between all signs and symptoms (except for seizure) and positive findings of brain CT scan; and increase in number of clinical complaints would increase the risk of presence of cerebral pathologies.

Less than 10% of patients with minor head trauma have positive findings in their brain CT scan and less than 1% would need a neurosurgery intervention (8). There are varieties of choices to manage minor head trauma like performing brain CT scan, brain MRI or close observation of the subjects for few hours. Limited studies reported that patients with initial normal brain CT scan showed intracranial findings during subsequent imaging studies (19). Although many studies suggest that patients with normal neurologic examinations and brain CT scan can surely leave ED (9, 14), findings of recent studies show that we cannot confidently say that there is no cerebral injury in these patients.

Although decision rules such as CCHR are widely validat-
ed and cost-effective for adults, they need further validation for children (20). As seen in our study, LOC, amnesia, vomiting, headache, signs of skull-base fracture, the number of clinical findings prior to performing a brain CT scan are not statistically related to abnormal brain CT scan findings among children aged 3 to 12 years old; these results are somehow challenging with CCHR criteria about signs of basal skull fracture, vomiting and amnesia (21).

Use of CT scans can be limited to children with ongoing specific symptoms and/or focal neurological signs. The implementation of guidelines in the management of head injuries in children could have a substantial effect on clinical practice and health-care costs (22).

Lots of studies have examined accompaniment of clinical findings to probability of positive brain CT scan in patients with minor head trauma but none of them had 100% sensitivity. Adjusting our data to identify clinically important brain injury using the CCHR rule showed that CCHR rules had 87.5% sensitivity and 43.5% specificity for 3 - 12 year-old patients, while these were 93.3% and 45.3% for 13-65 year-old patients, respectively. These results are similar to other studies which ranged 80% to 100% for sensitivity and 39% to 50% for specificity in general population (2, 14, 17, 18).

In previous studies, clinical findings such as headache (13), nausea and vomiting (13, 14), amnesia (23, 24) and seizure (14, 25) had positive relation with abnormal brain CT scan among patients with minor head trauma which is comparable to our results, except for seizure. In a study on 448 patients, 92% of those who had positive brain CT scan were found based on findings such as soft tissue injury, evidence of skull base fracture, abnormal neurologic examinations and age over 60 years old (26). In the study conducted on 373 patients, 90% of the subjects with positive brain CT scan were found based on findings such as alcohol abuse, abnormal neurologic examination and amnesia (24). As abnormal brain CT scan had been related to headache, vomiting, LOC or amnesia and alcohol intoxication, it is suggested that patient with any of these indicators must be considered a high-risk minor head trauma (27). However, in our study, 2.8% of the patients had abnormal CT scan without having any sign or symptom. Some researchers believe that it worth ignoring some patients with minor head trauma who had positive findings in brain CT without neurosurgical intervention for performing selective brain CT scan (13). On average, about 37% of the patients with MHT referring to the EDs had no indication of CT and approximately 86.5% of CT results were normal. Improving this situation can result in a significant saving in health care costs (11).

However, others believe that because of susceptibility of potential morbidity, no risk is acceptable (28).

In view of the results of this study, we believe that considering probability of unwanted consequences of ignored patients with positive brain CT scan, a method with 100% sensitivity should be administered.

We recommend revising the clinical criteria for using brain CT scan among patients with minor head trauma to reduce the risk of ignoring positive finding.

Acknowledgments

We would like to express our special thanks to all the hospital personnel for their help and support.

Footnote

Authors’ Contribution: Study concept and design: Mohammadreza Maghsoudi and Tooraj Asadi; analysis and interpretation of data: Saghie Maghsoudi, and Tooraj Asadi; drafting of the manuscript: Mehdi Samadzadeh; critical revision of the manuscript for important intellectual content: Bita Shahbazzadegan, Mehdi Samadzadeh and Mohammadreza Maghsoudi; statistical analysis: Saghie Maghsoudi and Khatereh Isazadehfar.

References

1. Cassidy JD, Carroll LJ, Peloso PM, Borg J, von Holst H, Holm I, et al. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004;43 Suppl:28-60. [PubMed: 15083676]
2. Stiell IG, Wells GA, Vandermeer K, Clement C, Lesiuk H, Laupacis A, et al. The Canadian CT Head Rule for patients with minor head injury. Lancet. 2001;357(9266):1391-6. doi: 10.1016/S0140-6736(01)06456-X. [PubMed: 11356436]
3. Rosengren D, Rothwell S, Brown AF, Chu K. The application of North American CT scan criteria to an Australian population with minor head injury. Emerg Med Australas. 2004;16(3):195-200. doi: 10.1111/j.1742-6723.2004.00561.x. [PubMed: 15228461]
4. Bordignon KC, Arruda WO. CT scan findings in mild head trauma: a series of 2,000 patients. Arq Neuropsiquiatr. 2002;60(2-3):204-9. [PubMed: 12068346]
5. Holmes JF, Hendey GW, Oman JA, Norton VC, Lazarenko G, Ross SE, et al. Epidemiology of blunt head injury victims undergoing ED cranial computed tomographic scanning. Am J Emerg Med. 2006;24(2):167-73. doi: 10.1016/j.ajem.2005.08.009. [PubMed: 16490565]
6. Mower WR, Hoffman JR, Herbert M, Wolfson AB, Pollack JR, CV, Zucker MI, et al. Developing a decision instrument to guide computed tomographic imaging of blunt head injury patients. J Trauma. 2005;59(4):954-9. [PubMed: 16374287]
7. Stiell IG, Lesiuk H, Wells GA, Coyle D, McKnight RD, Brison R, et al. Canadian CT head rule study for patients with minor head injury: methodology for phase II (validation and economic analysis). Ann Emerg Med. 2001;38(3):317-22. doi: 10.1067/men.2001.116795. [PubMed: 11524653]
8. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DelBleeux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000;343:2190-5. doi:10.1056/NEJM200007133430204. [PubMed: 10891951]
9. Shackford SR, Wald SL, Ross SE, Cogbill TH, Hoyt DB, Morris JA, et al. The clinical utility of computed tomographic scanning and neurologic examination in the management of patients with minor head injuries. J Trauma. 1992;33(3):3385-94. [PubMed: 1404507]
10. Saadat S, Ghodsi SM, Naeni KH, Firouznia K, Hosseini M, Kadhodaie HR, et al. Prediction of intracranial computed tomography findings in patients with minor head injury by using logistic regression. J Neurol. 2009;256(4):588-94. doi: 10.3717/2009.2.JNS08099. [PubMed: 19284234]
11. Zargar Balaye Jame S, Majdzadeh R, Sari AA, Rashidian A, Arab M, Rahmani H. Indications and Overuse of Computed Tomography in Minor Head Trauma. Iran Red Crescent Med J. 2012;14(6).
12. Stiell IG, Clement CM, Rowe BH, Schull MJ, Brison R, Cass D, et al. Comparison of the Canadian CT Head Rule and the New Orleans Criteria in patients with minor head injury. JAMA. 2005;294(12):1511-8. doi: 10.1001/jama.2004.16189364

Maghsoudi M et al.
13. Miller EC, Holmes JF, Derlet RW. Utilizing clinical factors to reduce head CT scan ordering for minor head trauma patients. *J Emerg Med.* 1997;13(4):453-7. doi: 10.1016/s0736-4679(97)00071-4. [PubMed: 9279694]

14. Nagy KK, Joseph KT, Kroner SM, Roberts RR, Leslie CL, Dufty K, et al. The utility of head computed tomography after minimal head injury. *J Trauma.* 1999;46(2):268-70. [PubMed: 10029012]

15. Haydel MJ. Clinical decision instruments for CT scanning in minor head injury. *JAMA.* 2005;294(12):1551-3. doi: 10.1001/jama.294.12.1551. [PubMed: 16189370]

16. Sinha M, Kennedy CS, Ramundo ML. Artificial neural network predicts CT scan abnormalities in pediatric patients with closed head injury. *J Trauma.* 2001;50(2):308-12. [PubMed: 11242297]

17. Harris A, Williams D, Jain N, Locke A. Management of minor head injuries according to NICE guidelines and changes in the number of patients requiring computerised tomography imaging in a district general hospital: a retrospective study. *Int J Clin Pract.* 2006;60(9):1120-2. doi: 10.1111/j.1742-1241.2006.00106.x. [PubMed: 16939555]

18. Miller EC, Derlet RW, Kinser D. Minor Head Trauma: Is Computed Tomography Always Necessary? *Ann Emerg Med.* 1996;27(3):290-4. doi: 10.1016/s0196-0644(96)70226-5. [PubMed: 8599485]

19. Taheri PA, Karamanoukian H, Gibbons K, Waldman N, Doerr RJ, Hoover EL. Can patients with minor head injuries be safely discharged home? *Arch Surg.* 1993;128(3):289-92. [PubMed: 8442684]

20. Pandor A, Goodacre S, Harnan S, Holmes M, Pickering A, FitzGerald P, et al. Diagnostic management strategies for adults and children with minor head injury: a systematic review and an economic evaluation. *Health Technol Assess.* 2011;15(27):1-202. doi: 10.3310/hta55270. [PubMed: 21806873]

21. Ro YS, Shin SD, Holmes JF, Song KJ, Park JO, Cho JS, et al. Comparison of clinical performance of cranial computed tomography rules in patients with minor head injury: a multicenter prospective study. *Acad Emerg Med.* 2011;18(6):597-604. doi: 10.1111/j.1533-2727.2011.01094.x. [PubMed: 21676057]

22. Ng SM, Toh EM, Sherrington CA. Clinical predictors of abnormal computed tomography scans in paediatric head injury. *J Paediatr Child Health.* 2002;38(4):388-92. [PubMed: 12174002]

23. Duus BR, Boesen T, Kruse KV, Nielsen KB. Prognostic signs in the evaluation of patients with minor head injury. *Br J Surg.* 1993;80(8):988-91. [PubMed: 8402098]

24. Reimus WR, Wippold FJ, Erickson KK. Practical selection criteria for noncontrast cranial computed tomography in patients with head trauma. *Ann Emerg Med.* 1993;22(7):1148-55. doi: 10.1016/s0196-0644(05)80981-3. [PubMed: 8517566]

25. Lee ST, Lui TN. Early seizures after mild closed head injury. *J Neurol Neurosurg Psychiatry.* 1992;56(3):415-9. doi: 10.1136/jnnp.56.3.415. [PubMed: 1738023]

26. Borczuk P. Predictors of Intracranial Injury in Patients With Mild Head Trauma. *Ann Emerg Med.* 1995;25(6):731-6. doi: 10.1016/s0196-0644(95)70199-0. [PubMed: 7755912]

27. Sharif-Alhoseini M, Khodadadi H, Chardoli M, Rahimi-Movaghar V. Indications for brain computed tomography scan after minor head injury. *J Emerg Trauma Shock.* 2011;4(4):472-6. doi: 10.4103/0974-2700.86651. [PubMed: 22097470]

28. Stein SC, Ross SE. Mild head injury: a plea for routine early CT scanning. *J Trauma.* 1992;33(1):31-3. [PubMed: 1615094]