www.surgicalneurologyint.com

ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, NYU Winthrop Hospital, Mineola, NY, USA.

SNI: Trauma

Editor
Iype Cherian, MD
Bharatpur College of Medical Sciences; Chitwan, Nepal

SNI
Open Access

Original Article

Clinical indicators for traumatic intracranial findings in mild traumatic brain injury patients

Tanat Vaniyapong[1], Jayanthon Patumanond[2], Sanguansin Ratanalert[3], Kriengsak Limpastan[1]

Departments of Surgery, Faculty of Medicine, [1]Chiang Mai University, Chiang Mai, [3]Prince of Songkla University, Songkhla, [2]Clinical Epidemiology Unit and Clinical Research Center, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand.

E-mail: *Tanat Vaniyapong - tanat.v@cmu.ac.th; Jayanthon Patumanond - jpatumanond@gmail.com; Sanguansin Ratanalert - sanguansin.r@psu.ac.th; Kriengsak Limpastan - kriengsak@neurosurgerycmu.com

***Corresponding author:**
Tanat Vaniyapong,
Department of Surgery, Faculty of Medicine, Chiang Mai University, 110 Intawarorote Road, Tumbon Sripoom, Amphoe Mueang Chiang Mai, Chiang Mai 50200, Thailand.

tanat.v@cmu.ac.th

Received : 26 September 18
Accepted : 06 February 19
Published : 24 April 19

DOI
10.25259/SNI-101-2019

Quick Response Code:

ABSTRACT

Background: Mild traumatic brain injury (MTBI), accounting for 80% of traumatic brain injury, is one of the most common conditions seen in emergency departments. Clinical parameters to predict intracranial lesions vary among guidelines. This study intended to find clinical parameters that can predict traumatic intracranial lesions in the setting of a middle-income country.

Methods: Data from mild head injury patients admitted to the emergency department from two large hospitals in Chiang Mai, Thailand, were prospectively collected from 2013 to 2014. The primary outcome was identifying clinically-important traumatic brain injury (ciTBI), and the secondary outcome was the neurosurgical procedure performed. Ten clinical findings and six predicting factors were analyzed using univariable and multivariable analysis.

Results: Among 1164 patients, ciTBI was identified in 244 cases (21.0%). The neurosurgical operation was performed in 57 cases (4.9%). Multivariable analysis showed factors for ciTBI were a diffuse headache, neurological deficits, signs of skull base fracture, Glasgow Coma Scale Score <13–14 after 2 h of observation, wound at the scalp, palpable skull fracture, dangerous mechanism, and vomiting 2 times or more. Loss of consciousness, amnesia, intoxication, and age were not predictors for ciTBI.

Conclusion: We found eight indicators to associate with ciTBI after MTBI which can be used to develop further clinical guidelines for computed tomography scans.

Keywords: Brain computed tomography scan, mild head injury, mild traumatic brain injury, predicting factors, traumatic brain injury

INTRODUCTION

Traumatic brain injury (TBI) is one of the world's significant health-care problems. The incidence is increasing in proportion to the increasing number of motor vehicles, especially in developing countries. Over 1.2 million people die each year in traffic accidents, and 20–50 million suffer nonfatal injuries.[11] Among the deaths, 70–80% are the result of TBI.

Mild TBI (MTBI), accounting for 80% of TBI, is one of the most common conditions seen in the emergency departments. Despite the low incidence of intracranial injuries, serious intracranial injury can occur and may lead to morbidity or mortality. Early detection of intracranial injury by brain computed tomography (CT) is the mainstay of the investigation. Mandatory CT scans in MTBI unnecessarily waste money and time due to low yield. Moreover, it may increase brain cancer incidence by 1 in 5000–1 by 10,000 for a single head CT scan in young adults.[6] Selective CT scans are reasonably appropriate, especially in the developing world. Many guidelines have been developed, but clinical predictors for intracranial injury vary among guidelines across the world due to their inclusion criteria.

Canadian CT head rules (CCHR) and new Orleans criteria (NOC) have commonly been used to predict intracranial bleeding and have been externally validated[2-7] but, their uses are limited by inclusion criteria which include only patients with a history of unconsciousness or amnesia and exclude patients with many conditions such as coagulopathy, seizures, or depressed skull fractures. This study intended to find out the clinical predictors for intracranial bleeding in MTBI with more generalizability and represent developing country's MTBI mechanisms. These countries have a higher proportion of motor vehicle accidents, especially motorcycle accidents more than other mechanisms which have a higher force than falling which is the most common mechanism in western countries.

METHODS

The study included MTBI patients at the Emergency Department of Maharaj Nakorn Chiang Mai Hospital and Nakornping Hospital, the trauma centers in Chiang Mai, Thailand, from December 1, 2013, to January 31, 2016. The inclusion criteria were patients with a history of blunt head trauma age ≥16 years and Glasgow coma scale (GCS) 13–14 or GCS 15 with one of the following sign/symptoms: headache, vomiting, loss of consciousness (LOC), amnesia, diffuse headache, sign of skull base fracture, skull fracture palpable, coagulopathy, drug of alcoholic intoxication, previous neurosurgical procedure, and posttraumatic seizure. Exclusion criteria were injuries >24 h old and uncertain history of trauma.

Patients eligible for inclusion criteria were interviewed and managed according to local guidelines for MTBI. Patients in whom ER doctors decided to perform CT scans would proceed to CT scan and be treated as usual. Patients that ER doctors decided to admit for observation were observed for at least 24 h. Patients who were in stable condition with no sign of intracranial lesion (such as headache, nausea, and vomiting) were discharged from hospital after 24 h. If admitted patients had the suspected signs, he/she were sent for a CT scan and managed as indicated. No additional CT scan was required than usual in this study. Retrospective review of the CT scan reports given by neuroradiologists were done.

After discharge, all patients had an appointment at day 7 for follow-up and had a structured questionnaire. Patients who could not go to work due to any neurological symptoms were scheduled for CT scanning. Patients who could not come to follow-up were interviewed by phone from our team to evaluate their symptoms.

Clinical predictors

Ten clinical findings and six predicting factors were collected in this study. Clinical findings included LOC regardless of timing, posttraumatic amnesia, vomiting, GCS <15 after a 2-h observation, neurodeficit, sign of skull base fracture, palpable skull fracture, diffuse headache, wound at face, and wound at scalp. Predicting factors included age, gender, history of antithrombotic medication (history of taking anticoagulant or other coagulopathy not including aspirin), dangerous mechanism (which is defined as riding a motorcycle or bicycle without wearing a helmet, thrown from a car, fall from more than 1-m height, and pedestrian hit by motor vehicle), drug or alcoholic intoxicated, previous neurosurgery, and posttraumatic seizure.

Outcomes

Primary outcomes were reported as clinically-important TBI (ciTBI) defined as any intracranial traumatic finding by CT scan including intracranial hemorrhage, brain edema, and depressed skull fracture but not including linear skull fracture. The secondary outcomes were neurosurgical procedures including craniotomy or craniectomy, intracranial pressure monitoring, external ventricular drainage, and elevation of skull fracture.

Statistical analysis

The association between outcomes and predicting factors was tested by Fisher's exact test for proportional parameters and Student's *t*-test and Mann–Whitney *U*-test for continuous data with a significance level at 0.05. Generalized linear model regression was used for multivariable analysis. We included all variables that had a $P \leq 0.05$ for analysis and used backward stepwise method with a $P > 0.05$ for variable removal. Calculations were performed with STATA software version 14.0.

RESULTS

There were 1164 patients for analysis. Most were male (70.5%) with a median age of 34 (15–98). The most common mechanism was traffic accident (63.4%) followed by falling (26.0%) [Table 1].

CT scan was done at ER in 458 cases. After admission, 23 patients who did not undergo CT at ER had symptoms and need CT. At 7 days follow-up period, additional 6 patients who did not undergo CT at ER and admission period had symptoms and need CT scan. Hence, overall CT scan was done in 487 cases (41.8%) [Figure 1].

Patients who underwent CT scan had more clinical findings and predicting factors than patients who did not undergo CT scan [Table 2].

A total of 244 cases (20.9%) were found to have ciTBIs. 233 cases (95.5%) were identified by CT at ER while 11 cases (4.5%) were identified subsequently during admission and the 7th day follow-up period. Most ciTBIs were subdural hematomas (36.9%) followed by subarachnoid hemorrhage (20.9%). Neurosurgical procedures were required in 57 cases (4.9%). The most common procedure was craniotomy in 51 cases (89.5%) followed by elevation of skull fracture in five cases (8.8%) and one burr hole (0.1%) [Table 3].

By univariable analysis, eight predicting factors for intracranial findings were found. Those are posttraumatic amnesia, two episodes or more of vomiting, GCS 13–14 after 2 h, neurological deficits, sign of skull base fracture, palpable skull fracture, diffuse headache, wound at scalp, age >60 years, and dangerous mechanism [Table 4].

Table 1: Baseline characteristics of patients.

Characters	Traumatic intracranial findings		
	Present (*n*=244)	Absent (*n*=920)	*P*
Median age (range), year	33 (15–98)	36.5 (18–88)	0.13
Male, *n* (%)	171 (22.4)	597 (18.3)	0.11
Mechanism of injury, *n* (%)			0.13
Traffic	169 (69.3)	568 (61.7)	
Falling	50 (20.5)	253 (27.5)	
Assaults	23 (9.4)	90 (9.8)	
Others	2 (1.0)	9 (0.8)	

Primary outcome

After the multivariable analysis was done, eight predicting factors were found to be an association with ciTBI. Those were diffuse headache, which had highest risk ratio at 3.3 (95%, CI 2.52–4.31), neurological deficits, sign of skull base fracture, GCS < 13–14 after 2-h observation, wound at scalp, palpable skull fracture, dangerous mechanism, and vomiting 2 times or more [Table 5].

Secondary outcome

Predicting factors for the neurosurgical procedure were analyzed and after multivariable analysis, five predicting factors were found to be significantly associated with the neurosurgical procedure. Those were a diffuse headache, which had highest risk ratio (RR) at 10.04 (95%, CI 4.76–21.17), GCS 13–14 after 2 h, neurodeficit, sign of skull base fracture, and palpable skull fracture [Table 5].

DISCUSSION

In MTBI patients, identification of the patients who need a CT scan is important. Unnecessary CT scans waste time and resources. Moreover, this exposure to radiation may induce brain tumors in the future.[6] Identifying clinical predictors to predict intracranial lesions are necessary to screen the patients before CT scan. However, predicting factors for intracranial injury in MTBI vary between studies and guidelines. One of the reasons

Table 2: Baseline characteristics of the patients who underwent CT and not underwent CT.

Characters	Not CT (*n*=677)	CT (*n*=487)	*P*
Median age (range), year	32 (22–61)	36 (24–53)	0.57
Male, *n* (%)	427 (63.1)	337 (69.2)	0.03
Mechanism of injury, *n* (%)			0.005
Traffic	401 (59.2)	337 (69.0)	
Falling	200 (20.5)	103 (21.1)	
Assaults	70 (10.3)	43 (8.8)	
Others	6 (0.9)	5 (1.0)	
Clinical findings			
Loss of consciousness	418 (61.7%)	324 (66.5%)	0.096
Post-traumatic amnesia	375 (55.4%)	286 (58.7%)	0.28
Vomiting ≥2	29 (4.3%)	64 (13.1%)	<0.001
GCS 13–14 after 2 h	12 (1.8%)	66 (13.6%)	<0.001
Neurodeficit	1 (0.1%)	7 (1.4%)	0.011
Sign of skull base fracture	6 (0.9%)	75 (15.4%)	<0.001
Palpable skull fracture	2 (0.3%)	38 (7.8%)	<0.001
Diffuse headache	104 (15.4%)	273 (56.1%)	<0.001
Wound at face	371 (54.8%)	303 (62.2%)	0.012
Wound at scalp	280 (41.4%)	340 (69.8%)	<0.001
Risk factors			
Age >60 years	179 (26.4%)	83 (17.0%)	<0.001
Coagulopathy	130 (19.2%)	42 (8.6%)	<0.001
Dangerous mechanism of injury	40 (5.9%)	52 (10.7%)	0.004
Drug or alcoholic intoxicated	264 (39.0%)	181 (37.2%)	0.54
Previous neurosurgery	3 (0.4%)	5 (1.0%)	0.29
Posttraumatic seizure	18 (2.7%)	32 (6.6%)	0.002

CT: Computed tomography, GCS: Glasgow coma scale

is that the inclusion criteria of each study are different. Our study's inclusion criteria included GCS 13–14 or GCS 15 plus any predicting factors. Our study's inclusion criteria were wider and more generalized than NOC which included only patients with GCS 15 plus LOC and CCHR which included only GCS 13–15 patients but with LOC or posttraumatic amnesia and excluded patients with coagulopathy, seizure, and skull fracture. Our study's inclusion is closer to the Netherland's CHIP (CT in Head Injury Patients) study.[8] The mechanism of injury of our datasets is different from western studies. Most of our cases are traffic injuries and >85% of traffic injury are motorcycle accidents. This may partly explain the difference in predictors found from other studies.

On univariable analysis, we found that significant predicting factors were posttraumatic amnesia, vomiting, GCS 13–14 after 2 h, neurodeficit, signs of skull base fracture, palpable skull fracture, diffuse headache, wound at scalp, age >60 years, dangerous mechanism, drug, or alcohol intoxication. However, when the multivariable analysis was performed, only neurological deficits, headache, sign of skull base fracture, palpable skull fracture, GCS 13–14 after 2 h, wound at scalp, dangerous mechanism, and drug or alcohol intoxication were significant predictors.

Table 3: Characteristic of intracranial finding from CT and surgical treatment.

Characters	*n* (%)
ciTBI found on CT scan (*n*=244, 21.0%)	
Subdural hematoma	90 (36.9)
Subarachnoid hemorrhage	51 (20.9)
Epidural hematoma	50 (20.5)
Intracerebral hematoma	42 (17.2)
Depressed skull fracture	11 (4.5)
Operation (*n*=57, 4.9%)	
Craniotomy/craniectomy	51 (4.4)
Elevate fracture skull	5 (0.4)
Burr hole	1 (0.1)

ciTBI: Clinically-important traumatic brain injury, CT: Computed tomography

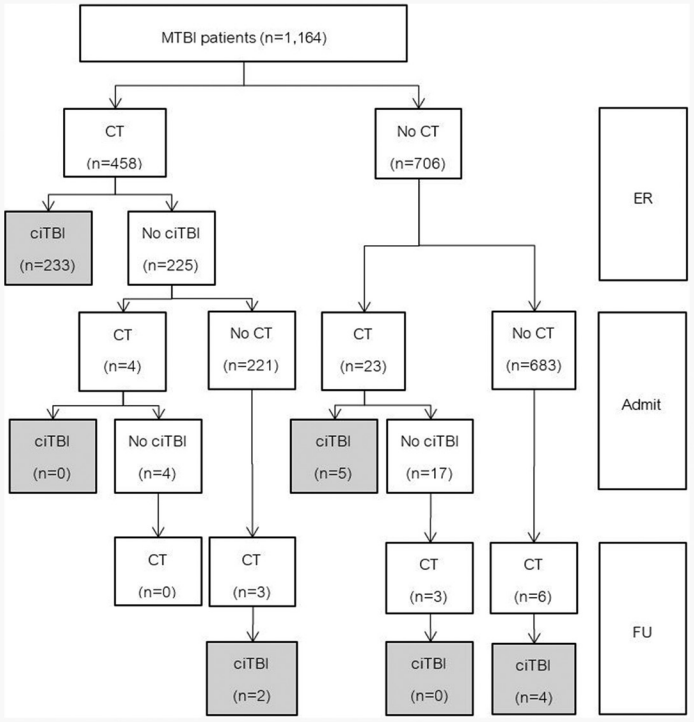

Figure 1: Study flow.

Table 4: Univariable risk parameters for presence of ciTBI.

Risk parameters	−CT (*n*=920)	+CT (*n*=244)	RR	95%, CI	*P* value
Clinical findings					
Loss of consciousness	581 (63)	161 (66)	1.10	0.87, 1.40	0.41
Posttraumatic amnesia	508 (55)	153 (63)	1.28	1.56, 2.72	0.04
Vomiting ≥2	56 (6.1)	37 (15)	2.06	1.21, 2.11	<0.01
GCS 13–14 after 2 h	33 (4)	45 (18)	3.14	2.50, 3.95	<0.01
Neurodeficit	2 (0.2)	6 (3)	3.45	2.78, 4.27	<0.01
Sign of skull base fracture	31 (3)	50 (20)	3.57	2.88, 4.43	<0.001
Palpable skull fracture	17 (2)	23 (9)	2.92	2.19, 3.91	<0.001
Diffuse headache	206 (22)	171 (70)	4.89	3.82, 6.25	<.001
Wound at face	503 (58)	144 (59)	1.04	0.83, 1.31	0.69
Wound at scalp	430 (47)	190 (78)	3.09	2.33, 4.08	<0.001
Risk factors					
Age >60 years	222 (24)	42 (17)	0.699	0.51, 0.97	0.03
History of antithrombotic medication (excluding ASA)	53 (6)	12 (5)	0.75	0.52, 1.48	0.61
Dangerous mechanism of injury	58 (6)	34 (14)	1.89	1.41, 2.54	<0.001
Drug or alcoholic intoxicated	326 (35)	73 (30)	0.82	0.64, 1.05	0.11
Previous neurosurgery	7 (0.8)	1 (0.4)	0.59	0.09, 3.73	0.56
Posttraumatic seizure	35 (4)	15 (6)	1.46	0.94, 2.26	0.11

GCS: Glasgow coma scale, ASA: Acetylsalicylic acid, ciTBI: Clinically-important traumatic brain injury

Table 5: Multivariable risk parameters for ciTBI and neurosurgical procedure.

Risk parameters	RR	95%, CI	*P*
For ciTBI			
Diffuse headache	3.30	2.52, 4.31	<0.001
Neurodeficit	2.25	1.41, 3.59	0.001
Sign of skull base fracture	1.99	1.58, 2.49	<0.001
GCS 13–14 after 2 h	1.93	1.51, 2.46	<0.001
Wound at scalp	1.90	1.45, 2.50	<0.001
Palpable skull fracture	1.89	1.38, 2.59	<0.001
Dangerous mechanism	1.41	1.11, 1.79	0.005
Vomit 2 times or more	1.39	1.04, 1.86	0.026
For neurosurgical procedure			
Diffuse headache	10.04	4.76, 21.17	<0.001
Neurodeficit	7.29	4.18, 12.73	<0.001
Palpable skull fracture	2.79	1.37, 5.67	0.005
Sign of skull base fracture	2.14	1.16, 3.95	0.015
GCS 13–14 after 2 h	1.9	1.02, 3.55	0.044

GCS: Glasgow coma scale, ciTBI: Clinically-important traumatic brain injury, CI: Confidence interval

LOC alone in this study is not found to be the predictor of ciTBI, but in some studies such as the CHIP study it is a minor criterion while in CCHR and NOC, LOC is inclusion criteria itself, so LOC alone is considered a low possibility to be related to intracranial lesion. Amnesia, history of antithrombotic medication (excluding acetylsalicylic acid), previous surgery, alcohol intoxication, and seizure are predictors in some studies but not found significantly related to an intracranial lesion in our study.[2,8-9] Interestingly, a study from Middle Eastern countries found alcoholic consumption to be very low incidence, so they did not evaluate this factor.[10] Dangerous mechanism definition in most studies is pedestrians struck by motor vehicles, ejection from motor vehicle, fall from height >1 m.[8-5] Other may include high speed (64 km/h), auto-deformity, rollover of vehicle, long extrication time, and intrusion to passenger compartment >30 cm.[10] Our study uses the first three conditions which are easy to obtain information from witnesses. Age alone is not the independent predicting factor as in other studies. Vomiting two episodes or more is a significant predictor as in other studies.[9,4]

Our study had some limitations. First, the CT rate is 40% and the rest "no ciTBI" patients are dependent on history taking which were scheduled on the 7th day after injury. However, we believe that if the patients have no or minor symptoms on the 7th day, they should not have a significant injury. CCHR study also has CT rate at 32.2%.[9] Second, there was some missing data that we could not obtain from patients and had to impute as "have" that risk factor (as in clinical practice). These imputations are < 5% which need to be mentioned.

Further analysis to create prediction rules to predict intracranial bleeding and guidelines for MTBI model from this data is to be done in the future.

CONCLUSION

We found an association between eight predicting factors for intracranial injury and MTBI. Those were a diffuse headache, neurological deficit, sign of skull base fracture, GCS <13–14 after 2 h observation, wound at scalp, palpable skull fracture, dangerous mechanism, and vomiting 2 times or more.

Financial support and sponsorship

Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM, et al. Indications for computed tomography in patients with minor head injury. N Engl J Med 2000;343:100-5.
2. Haydel MJ. The canadian CT head rule. Lancet 2001;358:1013-4.
3. National Clinical Guideline Centre (UK). *Head* Injury: Triage, Assessment, Investigation and Early Management of Head Injury in Children, Young People and Adults. Partial Update of NICE CG56. London: NICE (UK); 2014. Available from: http://www.nice.org.uk/guideance/cg176. [Last accessed on 2014 Jan 22; Last cited on 2017 Sep 15].
4. Nee PA, *Hadf*ield JM, Yates DW, Faragher EB. Significance of vomiting after head injury. J Neurol Neurosurg Psychiatry 1999;66:470-3.
5. Scottish Intercollegiate Guidelines Netwo*rk. Ea*rly Management of Patients with a Head Injury. Edinburgh: Scottish Intercollegiate Guidelines Network; 2009.
6. Smith-Bindman R, Lipson J, Marcus R, Kim KP, Mahesh M, Gould R, et al. Radiation dose associated with common c*omputed* tomography examinations and the associated lifetime attributable risk of cancer. Arch Intern Med 2009;169:2078-86.
7. Smits M, Dippel DW, de Haan GG, Dekker HM, Vos PE, Kool DR, et al. External validation of the canadian CT head rule and the new orleans criteria for CT scanning in patients with minor head injury. JAMA 2005;294:1519-25.
8. Smits M, Dippel DW, Steyerberg EW, de Haan GG, Dekker HM, Vos PE, et al. Predicting intracranial traumatic findings on computed tomography in patients with minor head injury: The CHIP prediction rule. Ann Intern Med 2007;146:397-405.
9. Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, et al. The canadian CT head rule for patients with minor head injury. Lancet 2001;357:1391-6.
10. Vos PE, Battistin L, Birbamer G, Gerstenbrand F, Potapov A, Pr*evec T*, et al. EFNS guideline on mild traumatic brain injury: Report of an EFNS task force. Eur J Neurol 2002;9:207-19.
11. World Health Organization. Global Status Rep*ort on* Road Safety: Time for Action. Geneva; 2009. Available from: http://www.whqlibdoc.who.int/publications/2009/9789241563840_eng.pdf. [Last cited on 2012 Apr 15].

How to cite this article: Vaniyapong T, Patumanond J, Ratanalert S, Limpastan K. Clinical indicators for traumatic intracranial findings in mild traumatic brain injury patients. Surg Neurol Int 2019:10:64.