Bu J Med Vol.13 No.1 January – April 2026

นิพนธ์ต้นฉบับ (Original article)

ความผิดปกติจากภาพเอกเรย์คอมพิวเตอร์สมอง ภาวะแทรกซ้อน และผลการรักษาในผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อย

ภาคภูมิ บำรุงราชภักดี (พ.บ.) และ ปองทิพย์ อุ่นประเสริฐ (พ.บ.)

ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยบูรพา จังหวัดชลบุรี ประเทศไทย

บทคัดย่อ

ความเป็นมา การบาดเจ็บที่สมองเป็นสาเหตุสำคัญของการเสียชีวิตและทุพพลภาพในประเทศไทย โดยอุบัติเหตุจากรถจักรยานยนต์เป็นปัจจัยหลัก

วัตถุประสงค์ ศึกษาลักษณะทางคลินิก อุบัติการณ์ ความผิดปกติจากเอกซเรย์คอมพิวเตอร์สมอง ภาวะแทรกซ้อน และผลลัพธ์ของผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อย

วัสดุและวิธีการ ศึกษาแบบย้อนหลังในผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อยที่ได้รับการเอกซเรย์คอมพิวเตอร์สมองโดยรวบรวมและวิเคราะห์ข้อมูลด้านประชากรศาสตร์ กลไกของการบาดเจ็บ ผลการตรวจเอกซเรย์คอมพิวเตอร์สมองผลลัพธ์ทางคลินิก และภาวะแทรกซ้อน เพื่อตรวจหาปัจจัยเสี่ยงที่ทำให้มีความผิดปกติจากเอกซเรย์คอมพิวเตอร์สมองในผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อย ตามแนวทาง Canadian CT head rule ร่วมกับ New Orleans Criteria

ผลการศึกษา ผู้ป่วยทั้งหมด 665 ราย ตรวจพบความผิดปกติจากเอกซเรย์คอมพิวเตอร์สมองร้อยละ 15.80 โดยพบ ภาวะเลือดออกใต้เยื่อหุ้มสมองชั้นอะแร็กนอยด์มากที่สุดร้อยละ 46.70 รองลงมาคือภาวะเลือดออกใต้เยื่อหุ้มสมองดูรา ร้อยละ 33.30 ปัจจัยเสี่ยงที่สัมพันธ์อย่างมีนัยสำคัญกับความผิดปกติจากเอกซเรย์คอมพิวเตอร์สมอง ได้แก่ อุบัติเหตุรถจักรยานยนต์ (p = 0.0002), การพลัดตกหกล้ม (p = 0.0002), การหมดสติ (p = 0.00003), ภาวะความจำเสื่อมชั่วคราว (p < 0.00001), และคะแนน Glasgow Coma Scale (GCS) ที่ต่ำ (p < 0.00001) มีผู้ป่วย 3 ราย (ร้อยละ 0.45) ต้องเข้ารับการผ่าตัดทางศัลยกรรมประสาท โดยทั้งหมดเป็นชายวัยหนุ่มที่ประสบอุบัติเหตุจากรถจักรยานยนต์และมีภาวะมึนเมา อัตราผลการรักษาที่ดีอยู่ที่ร้อยละ 99.85 มีผู้เสียชีวิตเพียง 1 ราย (ร้อยละ 0.15) ซึ่งเกิดจากการบาดเจ็บที่ช่องท้องและทรวงอกร่วมกับความดันโลหิตตก

สรุป การศึกษานี้แสดงให้เห็นปัจจัยเสี่ยงที่สำคัญต่อความผิดปกติของสมองในผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อยและเน้นย้ำถึงความสำคัญของเกณฑ์การตรวจเอกซเรย์คอมพิวเตอร์สมองที่เหมาะสม มาตรการป้องกัน และการดูแลรักษาที่รวดเร็ว จำเป็นต้องมีการวิจัยเพิ่มเติมเพื่อประเมินผลลัพธ์ระยะยาว และพัฒนาแนวทางการดูแลผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อยให้มีประสิทธิภาพยิ่งขึ้น

คำสำคัญ เอกซเรย์คอมพิวเตอร์สมอง การตรวจเอกซเรย์คอมพิวเตอร์สมอง บาดเจ็บที่สมองระดับเล็กน้อย ความผิดปกติจากเอกซเรย์คอมพิวเตอร์สมอง ความผิดปกติจากการตรวจเอกซเรย์คอมพิวเตอร์สมอง ผลการรักษาผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อย

นิพนธ์ที่รับผิดชอบ ภาคภูมิ บำรุงราชภักดี
ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยบูรพา
จังหวัดชลบุรี ประเทศไทย
E-mail: pakpume_b@yahoo.com

Cranial computed tomography abnormalities, complications and therapeutic outcomes in mild traumatic brain injury patients

Pakpume Bumrungrachpukdee (M.D.) and Pongtrip Unprasert (M.D.)

Department of Surgery, Faculty of Medicine, Burapha University, Chonburi, Thailand

Abstract

Background: Traumatic brain injury (TBI) is a major cause of death and disability in Thailand, primarily due to motorcycle accidents.

Objectives: This study examines the characteristics, incidence, cranial CT abnormalities, complications, and outcomes of mild TBI (mTBI) patients

Materials and Methods: This retrospective cross-sectional study analyzed mTBI patients treated at Burapha University Hospital from June 2020 to August 2021. Data on patient demographics, injury mechanisms, cranial CT findings, outcomes, and complications were collected and analyzed. The study aimed to determine the incidence of cranial CT abnormalities, clinical outcomes, and risk factors for cranial CT abnormality in mTBI patients with Canadian CT head rule combined with New Orleans Criteria.

Results: Analyzed 665 mTBI patients. Cranial CT abnormalities were found in 15.80% of patients, with subarachnoid hemorrhage (46.70%) and subdural hematoma (33.30%) being the most common findings. Risk factors significantly associated with abnormal cranial CT included motorcycle accidents ($p = 0.0002$), falls ($p = 0.0002$), loss of consciousness ($p = 0.00003$), amnesia ($p < 0.00001$), and lower GCS scores ($p < 0.00001$). Three patients (0.45%) required neurosurgical intervention, all of whom were young males involved in motorcycle accidents with alcohol intoxication. The overall favorable outcome rate was 99.85%, with only one mortality (0.15%) due to associated thoracoabdominal injuries with hypotension.

Conclusion: This study highlights key risk factors for intracranial abnormalities in mTBI patients and underscores the importance of targeted cranial CT criteria, preventive measures, and timely management of associated injuries. Further research is needed to explore long-term outcomes and optimize management strategies for mTBI patients.

Keywords: Cranial computed tomography, CT brain scan, mild traumatic brain injury, cranial CT abnormalities, CT brain abnormality, clinical outcomes of mild traumatic brain injury patients.

Corresponding author: Pakpume Bumrungrachpukdee
Department of Surgery, Faculty of Medicine,
Burapha University, Chonburi, Thailand
E-mail: pakpume_b@yahoo.com

Received: March 17, 2025 Revised: December 1, 2025 Accepted: December 23, 2025

การอ้างอิง

ภาคภูมิ บำรุงราชภักดี และ ปองทิพย์ อุ่นประเสริฐ. ความผิดปกติจากภาพเอกเรย์คอมพิวเตอร์สมอง ภาวะแทรกซ้อน และผลการรักษาในผู้ป่วยบาดเจ็บที่สมองระดับเล็กน้อย. บูรพาเวชสาร. 2568; 13(1): 1-14.

Citation

Bumrungrachpukdee P and Unprasert P. Cranial computed tomography abnormalities, complications and therapeutic outcomes in mild traumatic brain injury patients. Bu J Med. 2025; 13(1): 1-14.

Introduction

Traumatic brain injury (TBI) is a major global public health problem, representing one of the leading causes of death and disability among all trauma-related conditions. It is defined as a disruption of normal brain function or the presence of brain pathology caused by an external mechanical force. This disruption may manifest as a decreased level of consciousness, anterograde or retrograde amnesia, neurological deficit, or changes in mental status. Evidence of brain pathology can be confirmed through direct observation, neuroimaging, or histopathological examination. According to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), TBI is recorded under codes S00-S09 (Injuries to the head)[1,2].

Globally, TBI imposes a substantial burden on healthcare systems and societies, especially in low- and middle-income countries where road traffic accidents are the predominant cause. The World Health Organization (WHO) estimates that TBI contributes significantly to years of life lost due to disability and premature death.

In Thailand, TBI is a leading cause of death and disability among noncommunicable diseases, with traffic accidents being the most common cause. National data report approximately 15,000 deaths per year (21-23.77 per 100,000 population)[3,4]. Notably, almost 80% of traffic accident-related TBIs result from motorcycle crashes, with an estimated 60,000 new cases annually, a rate of 100 per 100,000 population, representing 42.53-43.37% of all motorcycle-related injuries.

The epidemiology of TBI in Thailand mirrors that of other developing nations, where the majority of victims are young adult males, approximately three times more frequent than females, with the highest incidence among individuals aged 15-34 years[4,5]. Head injury accounts for 29.60% of all severe injuries from motorcycle accidents and rises to 50% among non-helmet users. The majority of TBIs are mild (86.10%), followed by severe (8.80%) and moderate (5.10%) injuries. Helmet use significantly reduces severity: severe TBI occurs in only 3.04% of helmeted riders, compared to 7.10% of non-helmeted riders[6]. These statistics emphasize the critical role of preventive measures, such as helmet compliance, and standard of care in reducing the burden of TBI.

Although road traffic accidents remain the major cause, falls also contribute substantially to TBI cases, particularly among the elderly and children. Falls are the most frequent mechanism of head injury among non-traffic causes, representing 26.85% of all fall-related injuries, and are associated with the highest mortality rate (62.77%) and an injury-related mortality of 8.23%[7]. These findings demonstrate that TBI is not limited to young, active populations but also affects vulnerable groups, highlighting its broad social and healthcare impact.

TBI severity is commonly classified based on the Glasgow Coma Scale (GCS),

where mild TBI corresponds to scores of 13-15, moderate TBI to 9-12, and severe TBI to 3-8[8]. Among these, mild traumatic brain injury (mTBI) constitutes more than 80% of all TBI cases[3-6]. Despite being considered "mild," mTBI still requires careful assessment to detect potential intracranial injuries that may not initially present with severe symptoms but can lead to delayed complications. The primary diagnostic tool for evaluating mTBI is cranial computed tomography (CT), which aids in ruling out intracranial bleeding or skull fractures.

At Burapha University Hospital, the standard of care for mTBI patients follows the Canadian CT Head Rule (CCHR)[9] [High risk; one of following: GCS<15 after 2 hours, open or depressed skull fracture, sign of base of skull fracture, vomiting ≥ 2 times or age ≥ 65 years. Moderate risk; one of following: amnesia before impact ≥ 30 minutes, dangerous mechanism (pedestrian, ejected from motor vehicle, fall from ≥ 3 feet or 5 stairs)] to determine CT indications, categorizing patients into high- and moderate-risk groups based on clinical features. For those who do not meet CCHR criteria but still present with concerning symptoms, the New Orleans Criteria (NOC)[10] (one of following: headache, vomiting, age ≥ 60 years, alcohol or intoxication, amnesia, visible injury above clavicle or seizure) are additionally applied to enhance detection sensitivity of screening, ensuring coverage of patients with subtle or hidden risks. This modification also aimed to adapt the clinical decision-making process to the injury patterns commonly observed in Thailand, where motorcycle-related trauma is highly prevalent. Patients not undergoing immediate cranial CT are admitted for 24-hour neurological observation to monitor for deterioration or complications.

The authors conducted a study to investigate the characteristics, incidence, cranial CT abnormalities, complications, and clinical outcomes of mTBI patients treated at Burapha University Hospital between June 27th, 2020, and August 1st, 2021. Since the mechanism of injury in Thailand, predominantly motorcycle accidents differs from the leading cause of mTBI in Western countries (commonly falls)[11,12], this study aims to provide localized epidemiological data that reflect Thailand's unique circumstances. The findings will contribute to better clinical decision-making, improve diagnostic protocols, and strengthen public health strategies aimed at reducing the burden of TBI nationwide.

Material and Method

A retrospective cross-sectional study, population comprised all patients with mTBI who presented to Burapha University Hospital, a tertiary trauma center, between 27th June 2020 and 1st August 2021 (400 days). The study sample included all mTBI patients within this period who underwent cranial CT.

Inclusion criteria:

1. All the patient who was diagnosis head injury (ICD-10: S00-S09)[2] at all age,

race, and sex at Burapha University Hospital between 27th June 2020 to 1st August 2021.

2. mTBI which Glasgow Coma Scale (GCS)[13] = 13-15.

3. Obtained cranial CT and recorded in Burapha University Hospital's database.

4. Provided electronic medical record in Burapha University Hospital's database.

Exclusion criteria:

1. Inadequate medical record or

2. Incomplete or unavailable cranial CT data in Burapha University Hospital's database.

The authors collect patients' data and cranial CT results from Burapha University Hospital's database in diagnosis of head injury ICD-10: S00-S09 in case record form included the general data (sex, age, anticoagulant or antiplatelet usage, thrombocytopenia, coagulopathy and other bleeding disorder, and neurocognitive disorder)

TBI data: mechanism of injury, Glasgow Coma Scale score, history of loss of consciousness, amnesia, vomiting, headache, seizure and other neurological abnormality, external cranial wound, intoxication, helmet protection, associated extracranial injury.

Cranial CT abnormality data are categorized as skull fracture, base of skull fracture, epidural hematoma, subdural hematoma, subarachnoid hematoma, brain contusion, intracerebral hematoma, intraventricular hemorrhage, and brain herniation by the radiologist's reports and reviewed by the authors.

The patient with coagulopathy (underlying condition, anticoagulant and/or antiplatelet usage) will be corrected in all case with intracranial hemorrhage (ICH) on cranial CT.

Outcome data: duration of follow up, Glasgow Outcome Scale (GOS) Score after treatment, 5 = good recovery: return to normal occupation and social life, 4 = moderate disability: able to take care themselves at home, public transport but cannot return to normal occupation and social life, 3 = severe disability: conscious but needs assistance for some daily activities every day, 2 = vegetative state: unresponsive and speechless, 1 = dead[14]. The author categorized GOS 4 and 5 as favorable outcome and GOS 1- 3 as unfavorable outcome.

Complication data: headache, dizziness and vertigo, neurological abnormality, electrolyte abnormality, newly diagnosed seizure, infection, delayed or missed diagnosis, mortality.

Collect all raw data from case record form, check for correctness and record in Microsoft Excel program. Descriptive statistics: frequency, percentage, mean, standard deviation, t-test, and One-way ANOVA. Analytical statistics analysis Chi-square and Fisher exact test, Odds ratio and 95% confidence interval with Program R for Macintosh.

Results

Six hundred and sixty-five mTBI patients with cranial CT were enrolled in the present study. The demographic characteristics between normal cranial CT group and abnormal cranial CT group are summarized in table 1. There were 391 males and 274 females (a ratio of 1.4:1), age ranging from 1 month to 98 years (mean 44.7 years), the peak age range was 15-59 years (59.20%). The usage of antiplatelet and/or anticoagulant was 38 patients (5.70%).

Table 1 Demographic characteristics of the mTBI patients comparison between normal cranial CT group (n = 560) and abnormal cranial CT group (n = 105)

Demographic characteristic	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
Gender				0.87
Male	391	330(84.40)	61(15.60)	
Female	274	230(83.90)	44(16.10)	
Age				
< 15 years	36	32(88.90)	4(11.10)	0.43
15-59 years	394	316(80.20)	78(19.80)	< 0.001
≥ 60 years	235	212(90.20)	23(9.80)	0.002
Antiplatelet/anticoagulant use				
No	627	526(83.90)	101(16.10)	0.36
Antiplatelet	26	24(92.30)	2(7.70)	0.23
Anticoagulant	11	9(81.80)	2(18.20)	0.83
Antiplatelet+ anticoagulant	1	1(100)	0	1(F)

The most common mechanism of injury was motorcycle accident (40.90%) then simple fall (28.10%), and syncope/near syncope related mTBI (8.70%) (table 2). Overall intoxication was 28.30% and in motorcycle accident group was 51.50% (140 from 272 patients), car accident group was 34.60% (9 from 26 patients).

Table 2 Mechanism of injuries of the mTBI patients comparison between normal cranial CT group (n =560) and abnormal cranial CT group (n = 105)

Mechanism of injury	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
Motorcycle	272	212(77.90)	60(22.10)	< 0.001
Car	26	22(84.60)	4(15.40)	0.95
Pedestrian	19	14(73.70)	5(26.30)	0.20
Bike	9	7(77.80)	2(22.20)	0.59
Simple fall	187	173(92.50)	14(7.50)	< 0.001
Fall from height < 6 meters	30	23(76.70)	7(23.30)	0.25
Fall from height ≥ 6 meters	3	3(100)	0	1(F)
Syncope/near syncope	58	54(93.10)	4(6.90)	0.05
Seizure/epilepsy	10	9(90)	1(10)	0.61
Body assault	28	24(85.70)	4(14.30)	0.82
Extreme sport	11	7(63.60)	4(36.40)	0.06
Hit solid object	9	9(100)	0	0.37(F)
Electrical shock	3	3(100)	0	1(F)

The history of loss of consciousness was 44.20% and amnesia was 39.50%. Headache at presentation was 14%, all vomiting was 6.20%, the presence of cranial wound was 92.90% (table 3).

Table 3 Clinical symptoms and signs of the mTBI patients comparison between normal cranial CT group (n =560) and abnormal cranial CT group (n = 105)

Clinical symptom and sign	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
Intoxication				0.08
No	477	409(85.70)	68(14.30)	
Yes	188	151(80.30)	37(19.70)	
Loss of consciousness				< 0.001
No	371	332(89.50)	39(10.50)	
Yes	294	228(77.60)	66(22.40)	
Amnesia				< 0.001
No	402	360(89.60)	42(10.40)	
Yes	263	200(76)	63(24)	

Table 3 Clinical symptoms and signs of the mTBI patients comparison between normal cranial CT group (n =560) and abnormal cranial CT group (n = 105) **(Part 2)**

Clinical symptom and sign	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
Headache				0.92
No	572	482(84.30)	90(15.70)	
Yes	93	78(83.90)	15(16.10)	
Vomiting				
No	624	527(84.50)	97(15.50)	0.50
1 time	19	16(84.20)	3(15.80)	1
2 times	12	9(75)	3(25)	0.38
≥ 3 times	10	8(80)	2(20)	0.71
Cranial wound				0.56
No	47	41(87.20)	6(12.80)	
Yes	618	519(84)	99(16)	

The GCS score 15 was the most common (91.90%), GCS score 14 was 5.70% and GCS score 13 was 2.40% (table 4). Most common associated injury was extremity injury (overall 91 patients, 13.70%) then maxillofacial injury (overall 72 patients, 10.80%) (table 5).

Table 4 Glasgow Coma Scale (GCS) of the mTBI patients comparison between normal cranial CT group (n = 560) and abnormal cranial CT group (n = 105)

Glasgow Coma Scale	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
15	611	531(86.90)	80(13.10)	< 0.001
14	38	26(68.40)	12(31.60)	0.006
13	16	3(18.70)	13(81.30)	< 0.001

Table 5 Associated injuries of the mTBI patients comparison between normal cranial CT group (n = 560) and abnormal cranial CT group (n = 105)

Associated injury	Total n=665	Normal cranial CT n=560(%)	Abnormal cranial CT n=105(%)	*p*-value (F=Fisher Exact Test)
No	483	421(87.20)	62(12.80)	< 0.001
Maxillofacial	59	41(69.50)	18(30.50)	0.001
Cervical spine	10	10(100)	0	0.38(F)
Thoracoabdominal	15	10(66.70)	5(33.30)	0.06
Extremity	73	62(84.90)	11(15.10)	0.86
Maxillofacial + cervical spine	3	1(33.30)	2(66.70)	0.02
Maxillofacial + thoracoabdominal	2	0	2(100)	0.02(F)
Maxillofacial + extremity	8	6(75)	2(25)	0.47
Cervical spine + thoracoabdominal	2	1(50)	1(50)	0.18
Cervical spine + extremity	2	1(50)	1(50)	0.18
Thoracoabdominal + extremity	8	7(87.50)	1(12.50)	0.80

Cranial CT abnormalities

Cranial CT abnormalities were found in 105 mTBI patients (15.80%). The most common lesion was subarachnoid hemorrhage (49 patients, 46.70%) then acute subdural hematoma (35 patients, 33.30%), cranial vault skull fracture (32 patients, 30.50%), brain contusion (20 patients, 19%), base of skull fracture (19 patients, 18.10%) and acute epidural hematoma (16 patients, 15.20%). Eleven from thirty-two cranial vault skull fracture patients associated with acute epidural hematoma (34.40%).

Patients aged 60 years and older were more likely to have normal cranial CT (90.20%) (p = 0.002). Motorcycle accidents (p < 0.001) and simple falls (p < 0.001) were more common mechanisms of injury in the abnormal cranial CT group. Additionally, loss of consciousness (p < 0.001) and amnesia (p < 0.001) were more frequent in patients with abnormal cranial CT.

Patients with abnormal cranial CT had lower Glasgow Coma Scale (GCS) scores (p < 0.00001), with a notable proportion of patients having GCS scores of 13 (81.30%). Furthermore, associated injuries were more common in patients with abnormal cranial CT, particularly maxillofacial injuries (p = 0.001) and combinations of maxillofacial with cervical spine injuries (p = 0.02) and thoracoabdominal injuries (p = 0.02 F).

In contrast, no significant differences were observed between the two groups in

terms of gender, antiplatelet/anticoagulant use, other mechanisms of injury, intoxication, headache, vomiting, cranial wound, and other associated injuries.

These findings highlight the importance of considering age, mechanism of injury, loss of consciousness, amnesia, GCS scores and associated injuries when evaluating mTBI patients with abnormal cranial CT.

Seventy-nine patients were performed following cranial CT within 24 hours after initial cranial CT with intracranial hemorrhage, without neurological deterioration, none of the patients needed neurological intervention for significant expansion of hematoma.

Outcomes

The overall favorable outcome was 99.85% (664 patients). The mortality in 1 patient (0.15%) presented with car accident. The cranial CT revealed a small amount of subarachnoid hemorrhage. The cause of dead due to thoracoabdominal injury with severe hypotension, but the patient's relatives refused aggressive treatment due to advanced age (96 years) and according to the patient's will before the accident.

Three neurological surgeries were needed in 3 patients (0.45%) after immediate cranial CT. All were males age between 21-30 years, presented with motorcycle accident and alcohol intoxicated. GCS score was 13, 13 and 14 at presentation. The diagnoses were acute subdural hematoma, brain contusion and acute epidural hematoma. All patients have favorable outcome (GOS 5) after discharge.

The authors corrected all coagulopathy, the usage of antiplatelet corrected with platelet transfusion and/or anticoagulant corrected with fresh frozen plasma transfusion in all case with intracranial hemorrhage on cranial CT (4 patients), all favorable outcome (GOS 5) without any complication from the transfusions.

Discussion

Mild traumatic brain injury (mTBI) is a significant public health concern, accounting for a substantial proportion of emergency department visits. This study aimed to characterize the demographics, injury mechanisms, clinical presentations, and outcomes of patients with mTBI who underwent cranial CT.

The present study found that patients aged 60 years and older were more likely to have normal cranial CT (90.20%) (p = 0.002). This finding appears to contradict the Canadian CT Head Rule guideline, which recommends cranial CT for patients aged 65 years and older, and the New Orleans Criteria, which suggest cranial CT for patients aged 60 years and older.

However, it is essential to consider the context and population of the present study. Our findings may suggest that, in our cohort, patients aged 60 years and older with mTBI may have a lower likelihood of significant intracranial injuries. This could be attributed to various factors, such as differences in

injury mechanisms, comorbidities, or other underlying health conditions.

Nonetheless, it is crucial to emphasize that our findings do not necessarily imply that cranial CT can be omitted in patients aged 60 years and older. Rather, our results highlight the need for careful consideration of individual patient factors, such as clinical presentation, injury mechanism, and medical history, when deciding whether to perform a cranial CT.

Future studies are warranted to further investigate the optimal imaging strategies for patients with mTBI, particularly in older adults. By refining our understanding of the relationships between age, injury severity, and imaging findings, we can work towards developing more targeted and effective diagnostic protocols.

The study's findings highlight the importance of considering the mechanisms of injury and clinical presentations when evaluating patients with mTBI. Motorcycle accidents were the most common mechanism of injury, accounting for 40.90% of cases. This underscores the need for targeted prevention strategies, such as helmet use and impaired driving prevention programs.

The study also found that cranial CT abnormalities were present in 15.80% of patients that higher incidence than the previous studies was found 8% in Stiell et al., Canadian CT Head Rule Study 2001[9] and 6.90% in Haydel et al. New Orleans Criteria 2000[10] may be from the high incidence of motorcycle injury in the patients of the present study that has incidence up to 22.10% cranial CT abnormalities. This highlights the importance of routine cranial CT in evaluating patients with mTBI in Thai population, particularly those with a history of motorcycle accident, loss of consciousness or amnesia.

The study's outcomes were generally favorable, with 99.85% of patients having a good outcome (GOS 5). However, one patient died due to thoracoabdominal injury and severe hypotension, highlighting the importance of prompt recognition and management of associated injuries.

The study's findings also highlight the importance of correcting coagulopathy in patients with mTBI and intracranial hemorrhage. The authors' use of platelet transfusion and/or fresh frozen plasma transfusion resulted in favorable outcomes (GOS 5) without any complications.

Comorbidities and medications significantly influence the management and treatment of patients with mTBI. Specifically, pre-existing conditions or chronic medications that compromise blood coagulation can increase the risk of ICH and result in poor clinical outcomes[15]. Conversely, routine repetition of cranial CT in patients with initially normal findings is unnecessary and wasteful[16]. Furthermore, discontinuation of essential medications following diagnosis of intracranial hemorrhage may exacerbate underlying conditions.

Patients presenting with ICH on initial cranial CT who demonstrate stable or

improved neurological status pose a clinical dilemma regarding the necessity of routine follow-up cranial CT within 24 hours. While the benefits of repeat imaging in this context are unclear, it may be justified in select cases to monitor impending surgical lesions or provide psychological reassurance to patients and their families prior to discharge, particularly in cases of smaller ICH.

However, prompt neurological surgical intervention remains the critical factor determining survival and favorable outcomes in patients with emergency surgical lesions. Timely recognition and management of these lesions are essential to prevent further neurological deterioration and optimize patient outcomes.

Limitations

This study has several limitations. Firstly, the study's sample size was relatively small, which may limit the generalizability of the findings. Secondly, the study's follow-up period was relatively short, which may not capture long-term outcomes in patients with mTBI. Finally, the study's findings may be influenced by selection bias, as the study only included patients who underwent cranial CT.

Conclusion

In conclusion, this study provides valuable insights into the demographics, injury mechanisms, clinical presentations, and outcomes of patients with mTBI who underwent cranial CT. The study's findings underscore the importance of individualized patient assessment, considering factors such as age, injury mechanism, and clinical presentation, when evaluating patients with mTBI. While patients aged 60 years and older were more likely to have normal cranial CT, this finding should not be interpreted as a justification for omitting cranial CT in this age group. The study's findings highlight the importance of targeted prevention strategies, routine cranial CT, and prompt recognition and management of associated injuries. Further research is needed to better understand the long-term outcomes and optimal management strategies for patients with mTBI.

References

1. Menon DK, Schwab K, Wright DW, Maas AI. Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil. 2010; 91: 1637-40.
2. World Health Organization. ICD-10: International Statistical Classification of Diseases and Related Health Problems Tenth Revision. Version: 2016. 2016.
3. Division of injury prevention, Bureau of non-communicable diseases, Department of disease control, Ministry of public health, Thailand. Road traffic mortality and mortality rate per 100 000 population in Thailand 2014-2016. 2017. (in Thai)
4. Division of injury prevention, Bureau of non-communicable diseases, Department of disease control, Ministry of public health, Thailand. Road traffic accident in Thailand 2016. 2017. (in Thai)

5. Division of injury prevention, Bureau of non-Communicable diseases, Department of disease control, Ministry of public health, Thailand. Head injury study report in injured and deceased patients from motorcycle accidents–inpatients in Thailand 2009-2011. 2012. (in Thai)
6. Dissemination academic section, Division of epidemiology, Bureau of non-communicable diseases, Department of disease control, Ministry of public health, Thailand. Severe injuries related to motorcycle accident in Thailand, 2012. Weekly Epidemiological Surveillance Report (WESR). 2013; 44: 481-4. (in Thai)
7. Division of epidemiology, Bureau of non-communicable diseases, Department of disease control, Ministry of public health, Thailand. Severe injuries from falls. Summary of the 2015 Disease Surveillance Report. 2016. (in Thai)
8. Carroll LJ, Cassidy JD, Holm L, Kraus J, Coronado VG, WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury Methodological issues and research recommendations for mild traumatic brain injury: the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004; 43: 113–25.
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. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000; 343: 100–5.
11. Peeters W, van den Brande R, Polinder S, Brazinova A, Steyerberg EW, Lingsma HF, et al. Epidemiology of traumatic brain injury in Europe. Acta Neurochir (Wien). 2015; 157: 1683-96.
12. Peterson AB, Xu L, Daugherty J, Breiding MJ. Surveillance report of traumatic brain injury-related emergency department visits, hospitalizations, and deaths—United States, 2014 [Internet]. Atlanta (GA): Centers for Disease Control and Prevention (US); 2019 [accessed Nov 20, 2025]. 23 p. Available from: https://www.cdc.gov/traumaticbraininjury/pdf/TBI-Surveillance-Report-FINAL_508.pdf
13. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974; 2: 81–4.
14. Jennett B, Bond M. Assessment of outcome after severe brain damage. Lancet 1975; 305: 480-4.
15. Prexl O, Bruckbauer M, Voelckel W, Grottke O, Ponschab M, Maegele M, Schöchl H. The impact of direct oral anticoagulants in traumatic brain injury patients greater than 60-years-old. Scand J Trauma Resusc Emerg Med. 2018; 26: 20.
16. Campiglio L, Bianchi F, Cattalini C, Belvedere D, Rosci CE, Casellato CL, et al. Mild brain injury and anticoagulants: Less is enough. Neurol Clin Pract. 2017; 7: 296-305.