ORIGINAL ARTICLE

Diagnostic Accuracy of the 2019 Traumatic Brain Injury Guideline for Risk Stratification in Predicting Abnormal CT Brain Findings in a Community Hospital Setting

Chanapa Sinthuwong, M.D.[1], Tharathorn Durongbhandhu, M.D.[2]

[1]Phanom Sarakham Hospital, [2]Chonburi Hospital

Received: *March 10, 2026* **Revised:** *April 10, 2026* **Accepted:** *April 28, 2026*

ABSTRACT

BACKGROUND: Traumatic brain injury (TBI) is a common presentation in emergency departments. Selective use of computed tomography (CT) of the brain is crucial, particularly in resource-limited community hospitals. The 2019 Thai TBI Clinical Practice Guideline recommends CT indications based on risk stratification. However, its real-world diagnostic performance remains uncertain.

OBJECTIVE: To evaluate the diagnostic accuracy of the 2019 Thai TBI Clinical Practice Guideline for risk stratification in predicting abnormal CT brain findings among TBI patients in a community hospital.

METHODS: A retrospective study was conducted at Phanom Sarakham Hospital, Thailand, from January to June 2025. Patients aged≥15 years with blunt head trauma who underwent CT brain were classified into five CPG-based categories. Radiologist interpretations served as the reference standard. Proportions of abnormal CT findings, likelihood ratios, and area under the receiver operating characteristic curve (AUROC) were calculated.

RESULTS: Among 276 patients, 95 (34.4%) had abnormal CT findings. Abnormal CT rates increased with severity: 0% (mild low-risk), 33.3% (mild moderate-risk), 28.8% (mild high-risk), 69.3% (moderate TBI), and 90.0% (severe TBI). Positive likelihood ratios ranged from 1.1 to 17.2, while the overall AUROC was 0.61.

CONCLUSIONS: The 2019 Thai TBI Clinical Practice Guideline for risk stratification demonstrates a clear severity-dependent increase in abnormal CT findings but only modest diagnostic accuracy. Low-risk patients were safely identified. However, CT yield among mild TBI—particularly moderate-risk—was relatively low. Further refinement and prospective validation in community hospital settings are warranted.

KEYWORDS: brain injuries, traumatic, tomography, x-ray computed, sensitivity and specificity, practice guidelines, hospitals, community

Thaiclinicaltrials.org number, TCTR20260321008

INTRODUCTION

Traumatic brain injury (TBI) is a major global health issue causing significant morbidity and mortality.[1] The early detection of intracranial injury using computed tomography (CT) is essential[2], but routine CT in TBI patients—especially those with mild cases—may lead to overuse, increased costs, radiation exposure, and resource strain, particularly in community hospitals.[3]

Clinical decision rules such as the Canadian CT Head Rule, the New Orleans Criteria, and others have been developed to guide appropriate CT use.[4,5] In Thailand, the 2019 Thai TBI Clinical Practice Guideline stratifies patients into low-, moderate-, and high-risk groups and recommends CT for moderate- and high-risk patients, while low-risk (mild) TBI may be managed without imaging.[6]

Despite its importance, real-world evidence on the diagnostic performance of the 2019 Thai TBI Clinical Practice Guideline remains limited. Therefore, this retrospective study aimed to evaluate the accuracy of the 2019 Thai TBI Clinical Practice Guideline for risk stratification in predicting abnormal brain CT findings among TBI patients at a Thai community hospital.[7-10]

This retrospective study also aimed to evaluate the diagnostic performance of the 2019 Thai TBI Clinical Practice Guideline in predicting abnormal CT brain findings among traumatic brain injury patients in a community hospital.

METHODS

This retrospective observational study evaluated the diagnostic performance of the 2019 Thai TBI Clinical Practice Guideline in predicting abnormal CT brain findings among patients with traumatic brain injury at Phanom Sarakham Hospital, Chachoengsao, Thailand. Medical records from January 1 to June 30, 2025 were reviewed. Patients aged 15 years and older who presented with blunt head trauma and underwent non-contrast CT brain imaging during the same visit were included. Only cases with complete documentation of clinical variables required for the 2019 Thai TBI Clinical Practice Guideline for risk stratification—such as the Glasgow Coma Scale (GCS) score, neurological symptoms, mechanism of injury, and anticoagulant use—were analyzed. Patients with penetrating injuries, incomplete records, missing CT interpretations, or repeat visits for the same injury episode were excluded.

All patients were classified into one of five categories according to the 2019 Thai TBI Clinical Practice Guideline: mild TBI (low, moderate, and high risk), moderate TBI (GCS 9–12), and severe TBI (GCS 3–8). Mild TBI with low risk referred to patients with a GCS of 15 and no symptoms or risk factors. Mild TBI with moderate risk included those with a GCS of 13–14 or GCS 15 with at least one concerning feature such as headache, vomiting, loss of consciousness, amnesia, intoxication, risk of bleeding tendency (antiplatelet use or bleeding disorder) or dangerous mechanism (fall>0.9 m (3 ft), significant head impact, motorcycle accidents, traffic accidents--patient ejection, death of another passenger, vehicle rollover, or pedestrian struck by a vehicle). Mild TBI with high risk comprised patients with more serious features, including persistent vomiting, signs of skull or basal skull fracture, severe headache, focal neurological deficits, post-traumatic seizure, delayed return of GCS to 15, age≥65 years with loss of consciousness or amnesia, or anticoagulation use.

The reference standard was the official radiologist interpretation of CT brain imaging, categorized as normal or abnormal. Abnormal findings included intracranial hemorrhage, skull fracture, cerebral contusion, subdural or epidural hematoma,

subarachnoid hemorrhage, or cerebral edema. Sample size calculation (expected AUROC 0.65, α=0.05, power 90%, estimated abnormal CT prevalence 30%) required at least 250 patients; a total of 276 were included. Data were extracted from electronic medical records. Descriptive statistics were used to summarize baseline characteristics, and comparisons between normal and abnormal CT groups were performed using chi-square or Fisher's exact tests for categorical variables and independent t-tests, or Mann–Whitney U tests for continuous variables. Diagnostic performance was assessed by calculating the proportion of abnormal CT findings within each risk category, along with sensitivity, specificity, positive likelihood ratios, and the area under the receiver operating characteristic curve (AUROC) with 95% confidence intervals using STATA version 17.

This study was approved by the local Institutional Ethics Committee (reference number PH_CCO_REC 012/2569), and the requirement for informed consent was waived due to the retrospective nature of the study.

RESULTS

A total of 276 patients with traumatic brain injury were analyzed. Of these, 95 patients (34.4%) had abnormal CT brain findings, while 181 (65.6%) had normal results.

For the baseline demographic characteristics (Table 1), the proportion of males was similar in the abnormal and normal CT groups (69.5% vs. 60.8%, p=0.19). The mean age was 46.2±19.7 years in the abnormal CT group and 60.0±21.0 years in the normal CT group (p=0.07). Time of emergency department presentation (morning, afternoon, night) was comparable between groups. Initial vital signs, including systolic and diastolic blood pressure and heart rate, showed no significant differences.

Head injury severity categories were found to be significantly associated with CT findings (p<0.001). No patients in the mild TBI–low risk group had abnormal CT results. Abnormal findings were observed in 33.3% of patients in the mild TBI–moderate risk group and 28.8% of those in the mild TBI–high risk group. The proportion increased markedly in more severe categories, with 69.3% in the moderate TBI group and 90.0% in the severe TBI group demonstrating abnormal CT findings. GCS scores differed significantly between groups (p<0.001), with a higher proportion of patients with GCS 9–12 and 3–8 in the abnormal CT group. Abnormal pupil examination was also more common in the abnormal CT group (10.5% vs. 1.1%, p=0.001).

Patient disposition varied significantly (p<0.001). Among patients with abnormal CT findings, 10.5% were admitted, 87.4% were referred, and 2.1% were discharged. In contrast, among those with normal CT results, 65.2% were admitted, 8.3% were referred, and 26.5% were discharged.

Table 1 Baseline Demographic and Clinical Characteristics

	abnormal CT (n=95)	normal CT (n=181)	*p*-value
Sex, n (%)			
- Male	66 (69.5)	110 (60.8)	0.19
- Female	29 (30.5)	71 (39.2)	
Age (years, Mean±SD)	46.2±19.7	60.0±21.0	0.07

Table 1 Baseline Demographic and Clinical Characteristics (continue)

	abnormal CT (n=95)	normal CT (n=181)	*p*-value
Shift, n (%)			
- Morning	33 (34.7)	61 (33.7)	0.61
- Afternoon	40 (42.1)	86 (47.5)	
- Night	22 (23.2)	34 (18.8)	
Head injury severity, n (%)			
- Mild_low risk	0 (0.0)	16 (8.8)	<0.001
- Mild_moderate risk	64 (67.4)	128 (70.7)	
- Mild_high risk	13 (13.7)	32 (17.7)	
- Moderate	9 (9.5)	4 (2.2)	
- Severe	9 (9.5)	1 (0.6)	
Initial systolic blood pressure (mmHg, Mean±SD)	137.6±30.6	137.4±25.7	0.93
Initial diastolic blood pressure (mmHg, Mean±SD)	80.9±18.1	81.2±15.2	0.93
Initial heart rate (beats per minute, Mean±SD)	88.9±19.2	91.1±17.9	0.35
Initial Glasgow coma scale, n (%)			
- 13-15	77 (81.0)	176 (97.2)	<0.001
- 9-12	9 (9.5)	4 (2.2)	
- 3-8	9 (9.5)	1 (0.6)	
Amnesia, n (%)	39 (41.1)	65 (35.9)	0.43
Altered mental status, n (%)	7 (7.4)	12 (6.6)	0.81
Abnormal pupils, n (%)	10 (10.5)	2 (1.1)	0.001
Discharge status, n (%)			
- Admit	10 (10.5)	118 (65.2)	<0.001
- Refer	83 (87.4)	15 (8.3)	
- Discharge	2 (2.1)	48 (26.5)	

Regarding the diagnostic performance analysis (Table 2), the proportion of abnormal CT findings increased across severity categories, ranging from 0% in mild–low risk to 90.0% in severe TBI. Positive likelihood ratios were 1.1 for mild–moderate risk, 1.6 for mild–high risk, 6.9 for moderate TBI, and 17.2 for severe TBI. The overall discriminative ability of the risk stratification system demonstrated an area under the ROC curve (AUROC) of 0.61 (Figure 1).

Table 2 Diagnostic Performance of TBI Severity Categories for Predicting Abnormal CT Brain Findings

TBI severity	abnormal CT	normal CT	Risk (%)	LR+ (95% CI)
Mild head injury (low risk)	0	16	0	
Mild head injury (moderate risk)	64	128	33.3	1.1 (0.93-1.30)
Mild head injury (high risk)	13	32	28.8	1.6 (0.88-2.90)
Moderate head injury	9	4	69.3	6.9 (2.18-21.80)
Severe head injury	9	1	90.0	17.2 (2.21-133.60)

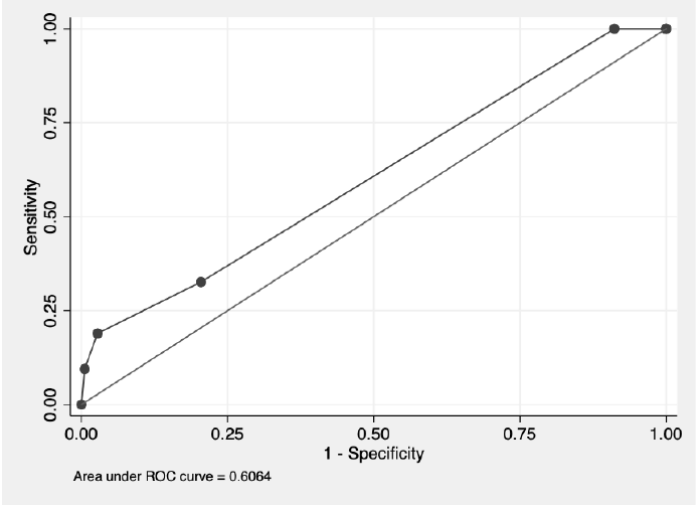


Figure 1 Receiver Operating Characteristic (ROC) Curve of TBI Risk Stratification for Predicting Abnormal CT Brain Findings

DISCUSSION

In this study, the diagnostic performance of the 2019 Thai TBI Clinical Practice Guideline for predicting abnormal CT brain findings was evaluated among TBI patients in a community hospital. A clear stepwise increase was observed in abnormal CT detection across the five risk categories, ranging from 0% in mild TBI–low risk to nearly 90% in severe TBI. This progressive risk gradient is consistent with international evidence demonstrating that worsening neurological status and the presence of high-risk features are strongly associated with a higher likelihood of intracranial injury.[1, 12-13]

Although the 2019 Thai TBI Clinical Practice Guideline for risk stratification identified patients at higher risk of abnormal CT findings, its overall discriminatory performance was modest, with an AUROC of 0.61. This accuracy is comparable to some international decision rules but lower than that reported in large multicenter studies of the Canadian CT Head Rule and the New Orleans Criteria, which generally demonstrate AUROCs between 0.70 and 0.85.[2,6,11] Several factors may account for this difference. Community hospitals may face variability in documentation quality, timing of presentation, and heterogeneity of symptoms, all of which can reduce

the guideline performance. Additionally, the mild TBI categories—particularly the moderate-risk group—likely include a mix of truly low-risk patients and those undergoing high rates of CT utilization, leading to increased false-positive results and reduced overall discrimination.[3]

The absence of abnormal CT findings in the mild low-risk group supports the safety of withholding CT in this population, consistent with recommendations for Thai and international guidelines.[6, 14] However, a considerable proportion of patients in the mild moderate-risk group underwent CT despite a relatively low positive yield, reflecting patterns reported in other studies that demonstrate overuse of CT in low-to-intermediate risk mild TBI.[13] This trend raises concerns regarding resource utilization in community hospitals, where limited CT availability and radiology personnel mean that unnecessary imaging may contribute to increased workload and healthcare costs.

The high specificity and strong positive likelihood ratios observed in the moderate and severe TBI groups reinforce the role of CT as an essential diagnostic tool for these patients. These findings are consistent with global standards recommending immediate neuroimaging for individuals with a GCS≤12 or signs of skull fracture or focal neurological deficit.[16] Nevertheless, the relatively low sensitivity observed in these categories underscores that CT should complement—rather than replace—careful clinical evaluation and structured risk assessment.

The modest ability of the guideline to distinguish between abnormal and normal CT findings suggests that further refinement—particularly within the mild TBI categories—may be warranted. Incorporating more objective risk markers, such as validated clinical decision tools, structured symptom assessments, or emerging blood biomarkers, may improve predictive accuracy, as suggested by recent evidence.[17] Future research integrating these approaches into local practice could help optimize CT utilization while maintaining patient safety.

The 2019 Thai TBI Clinical Practice Guideline can serve as a practical tool to guide CT utilization in community hospital settings, particularly in terms of safely identifying low-risk patients who may not require imaging. However, the relatively low diagnostic yield in mild to moderate-risk patients suggests potential overuse of CT, highlighting the need for careful clinical judgment and possible refinement of the risk criteria to improve efficiency.

This study has several limitations. First, its retrospective design may introduce information bias due to incomplete clinical documentation. Second, the single-center setting may limit generalizability to other healthcare environments. Third, the inclusion of only patients who underwent CT imaging may introduce selection bias and affect the estimation of diagnostic performance. Finally, small sample sizes in certain subgroups may limit the precision of the results.

Overall, the 2019 Thai TBI Clinical Practice Guideline for risk stratification showed a clear stepwise increase in abnormal CT findings across severity levels but demonstrated only modest overall diagnostic accuracy. While low-risk patients were safely identified, CT use in mild TBI remained frequent with relatively low yield. These results underscore the need to refine mild-risk criteria and conduct further prospective studies to promote more efficient, evidence-based CT utilization in community hospital settings.

CONFLICTS OF INTEREST: None

FUNDING: None

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ORIGINAL ARTICLE

ความแม่นยำของการคัดแยกความเสี่ยงตามแนวทางเวชปฏิบัติกรณีสมองบาดเจ็บ พ.ศ. 2562 ในการทำนายความผิดปกติของเอกซเรย์คอมพิวเตอร์สมองในโรงพยาบาลชุมชน

ชนภา สินธุวงษ์, พ.บ.[1], ธราธร ดุรงค์พันธุ์, พ.บ.[2]
[1]โรงพยาบาลพนมสารคาม, [2]โรงพยาบาลชลบุรี

บทคัดย่อ

ที่มาของปัญหา: การบาดเจ็บที่สมองจากอุบัติเหตุ (TBI) เป็นภาวะที่พบบ่อยในแผนกอุบัติเหตุฉุกเฉิน การใช้เอกซเรย์คอมพิวเตอร์สมอง (CT brain) อย่างเหมาะสมมีความสำคัญ โดยเฉพาะในโรงพยาบาลชุมชนที่มีทรัพยากรจำกัด แนวทางเวชปฏิบัติกรณีสมองบาดเจ็บ พ.ศ. 2562 แนะนำการส่งตรวจ CT ตามระดับความเสี่ยง แต่ประสิทธิภาพเชิงวินิจฉัยในทางปฏิบัติยังไม่ชัดเจน

วัตถุประสงค์: เพื่อประเมินความแม่นยำเชิงวินิจฉัยของการแบ่งระดับความเสี่ยงตามแนวทางเวชปฏิบัติกรณีสมองบาดเจ็บ พ.ศ. 2562 ในการทำนายความผิดปกติจาก CT brain

วิธีการศึกษา: การศึกษาย้อนหลัง ณ โรงพยาบาลพนมสารคาม ระหว่างเดือนมกราคม–มิถุนายน 2568 ผู้ป่วยอายุ ≥15 ปี ที่มีการบาดเจ็บศีรษะแบบแรงกระแทกและได้รับการตรวจ CT brain ถูกจัดกลุ่มตามเกณฑ์แนวทางเวชปฏิบัติกรณีสมองบาดเจ็บ 5 ระดับ ใช้ผลอ่านภาพโดยรังสีแพทย์เป็นมาตรฐานอ้างอิง คำนวณสัดส่วนความผิดปกติ likelihood ratio และ AUROC

ผลการศึกษา: จากผู้ป่วย 276 ราย พบความผิดปกติ 95 ราย (ร้อยละ 34.4) อัตราการพบความผิดปกติเพิ่มขึ้นตามระดับความรุนแรง ได้แก่ ร้อยละ 0, 33.3, 28.8, 69.3 และ 90.0 ตามลำดับ ค่า positive likelihood ratio อยู่ระหว่าง 1.1–17.2 และค่า AUROC เท่ากับ 0.61

สรุป: แนวทางเวชปฏิบัติกรณีสมองบาดเจ็บ พ.ศ. 2562 มีความสัมพันธ์กับการพบความผิดปกติจาก CT ตามระดับความรุนแรง แต่มีความแม่นยำเชิงวินิจฉัยระดับปานกลาง กลุ่มเสี่ยงต่ำคัดกรองได้ดี อย่างไรก็ตาม ผลตอบแทนการตรวจในผู้ป่วยบาดเจ็บเล็กน้อยค่อนข้างต่ำ ควรมีการศึกษายืนยันแบบไปข้างหน้าเพิ่มเติม

คำสำคัญ: การบาดเจ็บที่สมองจากอุบัติเหตุ, เอกซเรย์คอมพิวเตอร์สมอง, ความแม่นยำเชิงวินิจฉัย, แนวทางเวชปฏิบัติ, โรงพยาบาลชุมชน