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Characteristics of Blunt Cerebrovascular Injury in Khon Kaen Hospital: A Descriptive Study

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Abstract

Background: Evidence on blunt cerebrovascular injury (BCVI) remains limited. This study aimed to describe the characteristics of BCVI in a tertiary care referral hospital and trauma center in northeastern Thailand.

Methods: This retrospective descriptive study was conducted in the trauma ward and trauma intensive care unit (TICU) at Khon Kaen Hospital from 2020 to 2025. The eligible criteria were the patients sustained blunt trauma and were diagnosed BCVI by computed tomography of 4 vessels of the neck (CTA neck). Baseline data were recorded, including injury characteristics, clinical signs symptoms, and risk factors following standard screening criteria including Denver and Memphis group. Potential endpoints including mortality and in-hospital stroke were also collected.

Results: A total of 14 patients were included in this study. Most were male 71.4%. The mean age was 47.9 ± 17.5 years. The mean injury severity score (ISS) was 18.9 ± 7.0 . The potential parameters for BCVI were severe TBI with GCS < 6 (28.6%) and stroke as a primary presentation (28.6%). Relevant CT findings suggestive of BCVI were cervical spine fracture (42.9%) and complex skull fracture, respectively (28.6%). Most of the patients were presented with total occlusion (grade 4) BCVI with prevalence of 42.9%. The locations of BCVI were equal between common carotid and vertebral arteries. There were 3 (21.4%) patients with in-hospital stroke and 28.6% in-hospital mortality. Median hospital cost was 96,884.5 [45,090.5, 268,775.5] baht.

Conclusion: BCVI was prevalent in tertiary care referral hospital and trauma center. Serious in-hospital complications especially stroke and death were not uncommon. The best way to prevent complications is early detection with high index of suspicious.

Keywords: multiple trauma, blunt cerebrovascular injury, traumatic brain injury

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ลักษณะของการบาดเจ็บหลอดเลือดสมองชนิดแรงกระแทก ณ โรงพยาบาลขอนแก่น: การศึกษาเชิงพรรณนา

ธิตี ธิตักดีสกุล

กลุ่มงานศัลยกรรม โรงพยาบาลขอนแก่น จังหวัดขอนแก่น ประเทศไทย

ABSTRACT

บทนำ: หลักฐานเชิงประจักษ์เกี่ยวกับการบาดเจ็บที่หลอดเลือดส่วนคอยังมีอยู่จำกัด การศึกษานี้เป็นการศึกษาเพื่ออธิบายลักษณะทางคลินิกของการบาดเจ็บที่หลอดเลือดส่วนคอที่พบในโรงพยาบาลระดับตติยภูมิในภาคตะวันออกเฉียงเหนือในประเทศไทย

วิธีการ: การศึกษาย้อนหลังเชิงพรรณนา เก็บข้อมูลจากหอผู้ป่วยและหอผู้ป่วยหนักศัลยกรรมอุบัติเหตุ โรงพยาบาลขอนแก่น ระหว่างพ.ศ. 2563 ถึง พ.ศ. 2568 เหนี่ยวการคัดเลือกได้แก่ผู้ป่วยทุกรายที่ได้รับบาดเจ็บจากกลไกการบาดเจ็บแบบจากแรงกระแทกไม่มีคม (blunt mechanism of injury) และได้รับการวินิจฉัยว่ามีบาดเจ็บที่หลอดเลือดส่วนคอจากเอกซเรย์คอมพิวเตอร์หลอดเลือดคอ ข้อมูลพื้นฐานที่ได้รับการบันทึก ได้แก่ ลักษณะการบาดเจ็บ อาการ อาการแสดง และปัจจัยเสี่ยงที่ทำให้เกิดการบาดเจ็บตามเกณฑ์การคัดกรองจากกลุ่มเดนเวอร์และเมมฟิส ผลการศึกษา ได้แก่ อัตราการตายและการเกิดสมองขาดเลือดในโรงพยาบาล

ผลการศึกษา: ผู้บาดเจ็บทั้งหมด 14 ราย ได้รับการคัดเลือกให้เข้าการศึกษา ร้อยละ 71.4 เป็นเพศชาย อายุเฉลี่ย 47.9 ± 17.5 ปี ค่าเฉลี่ยความรุนแรงของการบาดเจ็บเท่ากับ 18.9 ± 7.0 ปัจจัยเสี่ยงที่ทำให้เกิดการบาดเจ็บของหลอดเลือดส่วนคอได้แก่การบาดเจ็บที่ศีรษะรุนแรงที่มีคะแนนระดับความรู้สึกตัวน้อยกว่า 6 และภาวะสมองขาดเลือดซึ่งเป็นอาการแสดงแรก (ร้อยละ 28.6 ทั้งสองภาวะ) ลักษณะทางเอกซเรย์คอมพิวเตอร์ที่พบและสนับสนุนภาวะการบาดเจ็บของหลอดเลือดสมองส่วนคอ ได้แก่ กระดูกต้นคอหัก (ร้อยละ 42.9) และกะโหลกศีรษะแตกแบบซับซ้อน (ร้อยละ 28.6) ผู้บาดเจ็บหลอดเลือดคอส่วนใหญ่มีความรุนแรงระดับ 4 (ร้อยละ 42.9) โดยมีการพบที่หลอดเลือดคอโรติคและหลอดเลือดกระดูกสันหลังในจำนวนเท่ากัน มีผู้บาดเจ็บร้อยละ 21.4 เกิดภาวะสมองขาดเลือดหลังเกิดภาวะบาดเจ็บต่อหลอดเลือดแดงส่วนคอ และร้อยละ 28.6 เสียชีวิต ค่ามัธยฐานของค่าใช้จ่ายในผู้บาดเจ็บแต่ละราย เท่ากับ 96,884.5 [45,090.5, 268,775.5] บาท

สรุป: ภาวะหลอดเลือดส่วนคอบาดเจ็บพบได้บ่อยในโรงพยาบาลระดับตติยภูมิที่เป็นศูนย์อุบัติเหตุ ภาวะแทรกซ้อนที่รุนแรง ได้แก่ สมองขาดเลือดและเสียชีวิต วิธีป้องกันที่ดีที่สุดคือการตรวจพบให้ทันเวลาที่โดยอาศัยความสงสัยจากเกณฑ์มาตรฐาน

คำสำคัญ: การบาดเจ็บหลายระบบ, การบาดเจ็บที่หลอดเลือดที่ไปเลี้ยงสมอง, การบาดเจ็บทางสมอง

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Introduction

Blunt cerebrovascular injury (BCVI), defined as injury to carotid and vertebral arteries, represents a serious consequence of blunt trauma¹. Historically, BCVI was considered rare, largely because it was difficult to detect with earlier diagnostic methods. With increased availability of high-resolution vascular imaging, particularly computed tomography angiography (CTA), BCVI has been recognized more frequently.

High-energy mechanisms, especially motor vehicle collisions, are among the most common causes of blunt trauma. In many settings, motor-cycle crashes account for a substantial proportion of these injuries². BCVI is thought to occur through several pathophysiologic mechanisms, including direct vessel injury associated with cervical spine fractures, as well as stretching and intimal disruption related to rapid deceleration and hyperextension-rotation of the neck^{3, 4}. Commonly associated injuries include traumatic brain injury (TBI)⁵ and cervical spine trauma⁴ and BCVI may also occur in older adults with pre-existing cervical degenerative disease⁶.

BCVI encompasses a spectrum of injury severity. Lower-grade injuries (grade I-IV) typically involve intimal injury or thrombosis, which can lead to post-injury ischemic stroke. In contrast, grade V injuries represent transection or free rupture and may present with life-threatening hemorrhage⁷. Importantly, untreated BCVI is associated with post-traumatic stroke⁸ and increased in-hospital mortality⁹, underscoring the need for timely recognition and management.

To facilitate early diagnosis, multiple screening tools have been developed to identify patients who warrant vascular imaging. These criteria incorporate clinical signs and symptoms suggestive of

cerebrovascular injury (e.g., focal neurologic deficits, coma unexplained by head CT findings) and mechanism- or injury-pattern risk factors, particularly specific cervical spine, skull base, and facial fractures. Widely used framework include Denver¹⁰ Memphis¹¹, and Canadian CT rule¹². Standard management primarily involves antithrombotic therapy, either antiplatelet or anticoagulant⁷, which has been associated with reduced stroke risk in observational studies. However, BCVI remain under-recognized in routine trauma care. Contributing factors include a low index of suspicion and competing clinical priorities in multiple trauma, as well as concern about hemorrhagic complications when antithrombotic therapy is considered in patients with concomitant injuries, especially intracranial hemorrhage. Although BCVI may not be immediately life-threatening in the acute phase, it can result in severe neurologic sequelae and death if missed.

This study aimed to describe the characteristics of BCVI in a tertiary referral hospital and trauma center in northeastern Thailand, including mechanisms of injury, injury severity and patterns, associated injuries, risk factors aligned with universal screening criteria, and clinical outcomes in a resource-limited setting.

Materials and Methods

This retrospective descriptive study was conducted in the trauma ward and trauma intensive care unit (TICU) at Khon Kaen Hospital, a tertiary referral hospital and trauma center in northeastern Thailand. Data were extracted from the hospital's electronic medical records (EMRs) between 1 October 2020 and 30 September 2025. Patients were eligible if they sustained blunt trauma, either intentional or unintentional, and had BCVI confirmed

on CTA of the cervical vessels (neck CTA). BCVI diagnosis was based on four-vessel neck CTA, defined as CTA assessment of the bilateral carotid arteries and bilateral vertebral arteries. Patients were excluded if BCVI or trauma diagnoses were incorrectly assigned according to the International Classification of Diseases, Tenth Revision (ICD-10). Specifically, ICD-10 miscoding was verified by chart review, including review of clinician documentation and radiology reports, and cases with discordant coding and clinical/imaging evidence were excluded.

Baseline characteristics included sex, age, mechanism/cause of injury, admission Glasgow Coma Scale (GCS) score, and associated injuries. Injury severity and physiologic status were summarized using standard trauma indices: Injury Severity Score (ISS), Revised Trauma Score (RTS), and the Trauma and Injury Severity Score (TRISS) probability of survival.

Clinical features relevant to BCVI were abstracted from trauma assessments, progress notes, and radiology reports. These included presenting signs and symptoms, imaging findings, and risk factors aligned with established BCVI screening frameworks, particularly the Memphis and Denver criteria.

The Memphis screening protocol, developed in the 1990s, identified clinical factors associated with mortality and neurologic impairment, including shock on admission, age, major neurologic deficit at diagnosis, overall injury severity, and associated brain injury. The Denver screening criteria (first proposed in 1996) were used to categorize potential indicators for BCVI into:

1. Signs and symptoms suggestive of BCVI: arterial hemorrhage from the neck/nose/mouth, cervical bruit, expanding cervical hematoma, focal

neurologic deficit, neurologic findings incongruent with head CT results, and ischemic stroke identified on subsequent brain imaging.

2. Risk factors for BCVI (high-energy mechanism with characteristic injury patterns):

- Le Fort II or III facial fractures
- Cervical spine fracture patterns (subluxation; fractures extending into the transverse foramen; fractures involving C1–C3)
- Basilar skull fracture with carotid canal involvement
- Petrous temporal bone fracture
- Diffuse axonal injury with GCS < 6
- Near-hanging with anoxic brain injury

3. Neurologic severity, including low GCS, was additionally recorded given its association with severe head injury and the possibility of occult vascular injury.

BCVI characteristics were recorded from imaging reports, including injured vessel(s), laterality, anatomical location, and injury grade/severity using standard grading where applicable. Study endpoints included in-hospital stroke, in-hospital mortality, and total hospital cost (Thai baht) during the index admission.

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Khon Kaen Hospital (or the affiliated ethics committee). Given the retrospective design and use of routinely collected clinical data, the requirement for informed consent was waived by the IRB. Data were handled confidentially and analyzed in accordance with applicable ethical standards.

Categorical variables are presented as frequencies and percentages and were compared using exact tests when appropriate (given small sample sizes). Continuous variables are presented as mean $\pm$ standard deviation for normally distributed data

and compared using independent-samples t-tests. Non-normally distributed continuous variables are reported as median [interquartile range]. Statistical uncertainty is reported using two-sided 95% confidence intervals. A p-value < 0.05 was considered statistically significant. All analyses were performed using Stata version 18 (StataCorp LLC, College Station, TX, USA).

Results

A total of 14 patients were included to this study. 71.4% were male. Mean age was 47.9±17.5 years. Most common cause of injury was motorcycle accident (64.3%). Median GCS was considered as moderate TBI (9 [6, 15]). Most serious body

region injured was head and neck injury with median AIS 4.5 [3, 5], followed by chest (3 [2, 3]) and extremities (3 [2, 3]). Mean initial SBP on hospital admission was 121.4±46.4 mmHg. Mean ISS was 18.9±7.0. Median RTS was 3.3 [0, 7.8]. Median TRISS probability of survival was 0.54 [0.00, 0.98]. All were shown in **Table 1**.

The potential parameters for BCVI were severe TBI with GCS < 6 (28.6%) and stroke as a primary presentation (28.6%), followed by focal neurologic deficit inconsistent with prior CT brain (14.3%). Near hanging with anoxic brain injury and expanding cervical hematoma were observed at 7.1%. There was no patient with seat belt abrasion with significant symptoms nor carotid bruit.

Table 1. Patient characteristics

Patient characteristics, n (%)	n =14
Sex	
Male	10 (71.4)
Female	4 (28.6)
Age, years (mean±SD)	47.9±17.5
Causes of injury, n (%)	
Motorcycle accident	9 (64.3)
Others	6 (35.7)
Glasgow Coma Scale [median, IQR]	9 [6, 15]
Eye response	4 [1, 4]
Verbal response	1.5 [1, 5]
Best motor response	6 [4, 6]
Associated injury severity according to AIS [median, IQR]	
Head and neck	4.5 [3, 5]
Face	2 [2, 2]

Table 1. Patient characteristics (Cont.)

Patient characteristics, n (%)	n =14
Chest	3 [2, 3]
Abdomen	-
Extremities and pelvic girdles	3 [2, 3]
Skin	1 [1, 1]
Initial SBP on admission, mmHg (mean±SD)	121.4±46.4
ISS (mean±SD)	18.9±7.0
RTS [median, IQR]	3.3 [0, 7.8]
TRISS probability of survival [median, IQR]	0.54 [0.00, 0.98]

SD = standard deviation; AIS = abbreviated injury scale; IQR = interquartile range; SBP = systolic blood pressure; mmHg = millimeter mercury; ISS = injury severity score; RTS = revised trauma score; TRISS = trauma injury severity score

Table 2. Potential signs and symptoms of BCVI

Signs and symptoms, n (%)	n =14
Severe TBI with GCS < 6	4 (28.6)
Near hanging with anoxic brain injury	1 (7.1)
Seat belt abrasion with significant symptoms	0 (0)
Expanding cervical hematoma	1 (7.1)
Focal neurologic deficit inconsistent with CT brain	2 (14.3)
Carotid bruit	0 (0)
Stroke	4 (28.6)

BCVI = blunt cerebrovascular injury; TBI = traumatic brain injury; GCS = Glasgow coma scale; CT = computed tomography

Table 3. Relevant CT findings suggestive of BCVI

Injury characteristics, n (%)	n =14
Base of skull fracture	
Carotid canal involvement	2 (14.3)
Petrous bone involvement	2 (14.3)
Cervical spine fracture	6 (42.9)
LeFort II fracture	0 (0)
LeFort III fracture	2 (14.3)

Table 3. Relevant CT findings suggestive of BCVI (Cont.)

Injury characteristics, n (%)	n =14
Mandible fracture	3 (21.4)
Complex skull fracture	4 (28.6)

CT = computed tomography; BCVI = blunt cerebrovascular injury

Relevant CT findings suggestive of BCVI were cervical spine fracture (42.9%) and complex skull fracture (28.6%), respectively. Mandible and Lefort III fractures, and base of skull fractures were also observed. There was no patient with LeFort II fracture.

Most of the patients were presented with total occlusion (grade 4) BCVI with prevalence of 42.9%, followed by grade 2 (35.7%). Others were shown in

Table 4.

Table 4. BCVI severity according to Biffi et al¹³ but the management of these lesions remains controversial. The authors previously proposed a grading system for BCVI, with grade-specific management guidelines. The authors have noted that a significant number of injuries evolve within 7 to 10 days, warranting alterations in therapy.

Methods

A prospective database of a regional trauma center's experience with BCVI has been maintained since 1990. A policy of arteriographic screening for BCVI based on injury mechanism (e.g., cervical hyperextension.)

BCVI characteristics grading, n (%)	n =14
1	1 (7.1)
2	5 (35.7)
3	1 (7.1)
4	6 (42.9)
5	1 (7.1)

BCVI = blunt cerebrovascular injury

Table 5. Location of BCVI

Location, n (%)	n =14
Common carotid artery	7 (50.0)
Vertebral artery	7 (50.0)

BCVI = blunt cerebrovascular injury

The locations of BCVI were equal between common carotid and vertebral arteries as shown in **Table 5.**

There were 3 (21.4%) patients with in-hospital stroke and 28.6% in-hospital mortality. Median hospital cost was 96,884.5 [45,090.5, 268,775.5] bahts.

All patients received aspirin 81 mg oral daily after traumatic bleeding was stabilized. No post-discharged ischemic stroke was detected.

Table 6. Endpoints and complications

Endpoints and complications, n (%)	n =14
In-hospital stroke	3 (21.4)
In-hospital mortality	2 (28.6)
Total hospital cost, baht [median, IQR]	96,844.5 [45,090.5, 268,775.5]

The latest patient who suffered from BCVI had panfacial fractures as the principle diagnosis. Other associated injuries were diffuse axonal injury, hemothorax, and multiple cervical spinous process fractures. He had grade II of right VA injury. The lesion extended from V1 to V2 segment of cervical vertebrae of 4 to 6. He also had right internal maxillary artery pseudoaneurysm, or grade III BCVI. Pseudoaneurysm was managed by cerebral angiogram with polyvinyl alcohol embolization to prevent delayed ruptured. The patient was discharged with aspirin 81 mg oral daily for up to 1 year. No posttraumatic ischemic stroke was detected.

Discussion

BCVI is infrequently diagnosed among trauma patients despite its potentially catastrophic sequelae¹⁴. Prior studies have reported a BCVI prevalence of approximately 1.6%, although estimates vary depending on case mix and screening intensity⁴. In practice, screening criteria may be underutilized even in patients who exhibit compatible signs, symptoms, or risk factors¹⁵. In our center, only 14 patients were identified over a 5-year period which likely reflects limited awareness and inconsistent application of screening and diagnostic pathways. Clinicians often prioritize more immediate life-threatening conditions in multiple trauma, and BCVI may be overlooked, particularly when initially asymptomatic. Another important

barrier is management complexity. Standard treatment for BCVI involves antithrombotic therapy. However, this is often challenging in trauma patients who have ongoing hemorrhage or a high risk of bleeding, particularly in the setting of concomitant intracranial injury. Even when BCVI is diagnosed, initiation of antithrombotic therapy may be delayed until bleeding stabilizes, which can limit the potential benefit of early detection. These real-world constraints may contribute to the persistent under recognition and under-treatment.

Several reports suggest BCVI is more common than previously appreciated¹⁶, especially when systematic screening is implemented and neck CTA is readily available. Therefore, broader adoption of universal screening criteria and improved access to the neck CTA should be considered at the institutional policy levels. Nevertheless, the optimal scope of CTA screening remains debated¹⁷. Some studies have noted that liberal CTA use is increasingly discussed because a substantial proportion of BCVI cases may still be missed even when standardized criteria are applied, raising concerns about reliance on criteria alone and highlighting the need for context-specific strategies.

In our study, the most common clinical presentations were sTBI and stroke. The most frequent risk factors based on universal screening criteria were cervical spine injury and complex

skull fractures. These clinical and radiological patterns should prompt a high index of suspicion in our population, particularly in patients with severe blunt trauma involving head and neck. Injury patterns can provide critical clues and may support targeted investigation when resources are limited.

Notably, stroke was also a frequent initial presentation in our center, emphasizing how early the consequences of BCVI can occur¹⁸ We observed that BCVI-related stroke was more often present at admission the developing later during hospitalization, underscoring the importance of early recognition and timely diagnostic evaluation. Even when BCVI is identified early, patients with intracranial trauma often require close monitoring for hemorrhage progression for at least several days before antithrombotic therapy can be safely initiated¹⁹. Although prior studies have not consistently demonstrated an association between antithrombotic therapies a delayed intracranial hemorrhage, cautious patient selection and structured monitoring remain essential in clinical practice.

Interestingly, our institute found grade IV BCVI as the most common BCVI finding, followed by grade II. This affected follow-up strategy²⁰. Local protocol on timing to re-imaging might be different according to nature of disease. Most of the patients suffered from BCVI in our institute were total occlusion which could be resolved up to 30 days. Therefore, local guideline could be routine imaging at 30 days²¹. Other findings were consistent with previous literatures^{22,23}.

This study aimed to explore injury features in the pediatric population with BCVIs and compare the clinical manifestations, diagnosis, and

treatment of pediatric and adult BCVIs. Methods: A retrospective data analysis of BCVI patients was conducted using the PROspective Observational Vascular Injury Treatment. However, several limitations should be acknowledged. First, this was a descriptive study without a comparator group; therefore, we could not evaluate associations between specific risk factors, imaging findings, management strategies, and outcomes. Second, the retrospective design introduces potential selection and information bias, and some clinically relevant variables may not have been consistently documented. In particular, we lacked data on how treating physicians selected patients for neck CTA and how management decisions (including timing and choice of antithrombotic therapy) were made. Future studies should employ stronger analytic designs and, ideally, prospective data collection through a BCVI registry to better define incidence, optimize screening strategies, and evaluate treatment feasibility and outcomes in our local context.

Conclusions

BCVI is an important injury in patients with blunt polytrauma, particularly among those with severe trauma and concomitant head and neck injuries. Serious in-hospital complications, especially ischemic stroke and death, were not uncommon, likely reflecting the disease's severity and the high proportion of occlusive lesions. Early recognition through systematic screening and a high index of suspicion is essential to enable timely management and reduce preventable complications.

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