Article published online: 2022-09-14

Original Article

Cerebral Contusion: An Investigation of Etiology, Risk Factors, Related Diagnoses, and the Surgical Management at a Major Government Hospital in Cambodia

Abstract

Introduction: Cerebral contusions are a common type of injury among the Cambodian population, mostly due to road traffic accidents. This article aims to assess various aspects around brain contusion focusing on the condition at admission, residing province, mechanism and time of injury, age and sex distribution with differing helmet wearing, and alcohol consumption patterns. Hospitalization-related data such as treatment and outcome were analyzed. **Methods:** This was a retrospective analysis of 406 cases who have been admitted during the period between May 2013 and May 2016. **Results:** Two hundred and ninety-five (75.51%) of the patients came from rural areas, 312 (76.84%) were male (mean age 31.17 ± 12.90 years for males and 38.5 ± 16.29 years for females). The average hospital stay amounted to 10.51 ± 6.67 days. One hundred and eight two cases (52.29%) happened between 4.00 and 11.00 p.m. Three hundred and nineteen (79%) of the injured patients were motorcycle drivers and 18% pedestrians. Male patients had an alcohol involvement in 135 (49.45%) (females in 5 [6.25%]) cases and 26 (10%) wore a helmet (females in 5 [6.25%]). Surgery was performed in 82 cases, specifically craniotomy and craniectomy +/− elevation of a depressed skull fracture. Two hundred and ninety-six (73.09%) patients showed related second diagnosis, mostly subdural hematoma in 96 (32.43%) and epidural hematoma in 63 (21.28%) cases. Fifty patients (13.16%) had a Glasgow Coma Scale of 3–8. 92 (24.21%) of 9–12 and 238 (62.63%) of 13–15 on admission. Most of the patients were discharged with an improved status 324 (91.52%) according to the Glasgow Outcome Scale 4 or 5. **Conclusion:** The severity and resulting neurologic impairment of cerebral contusions show the importance of more in-depth research and prevention programs.

Keywords: *Brain contusion, Cambodia, cerebral contusion, global health, motorcycle*

Louise Vera Hilmer, Kee Bum Park[1], Iv Vycheth[2], Michael Wirsching

Department for Global Health, Albert-Ludwigs-University Freiburg, Freiburg, Germany, [1]Department of Global Health, Social Medicine, Harvard Medical School, Boston, Massachusetts, USA, [2]Department of Neurosurgery, Cambodia Neurosurgical Support Project, Preah Kossamak Hospital, University of Health Sciences, Phnom Penh 12157, Cambodia

Address for correspondence:
Louise Vera Hilmer,
Albert Ludwigs Universität Freiburg, Sundgauallee 26, 79110 Freiburg, Germany.
E-mail: vhilmer@gmx.net

Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_342_16

Quick Response Code:

Introduction

By definition, a cerebral contusion is a type of injury that leads to a bruise of the brain tissue.[1]

Road traffic accidents are a major cause of cerebral contusions worldwide but especially in developing and emerging countries.[2-4]

With most of the admitted patients, it concerns motorcycle users as on the one hand, motorcycles are major means of transportation in Cambodia, and on the other hand, motorcycle-related accidents often affect the head due to a missing car body, way of fall, and deficient helmet usage.

According to the WHO in 2009, approximately 12.1/100,000 people die from road traffic accidents annually and 63% of the injured had been riders or passengers of motorcycles.[5] Above all, in 2013, reported statistics about distribution of road traffic deaths by type of road user shows an increased rate of 70.4% that concerned drivers or passengers of motorized 2–3 wheelers, which was even more than in any other of the specified 140 developing, emerging, and industrial countries.[6] This study aimed to investigate various aspects of patients that had been admitted to a major government hospital in Phnom Penh, such as residing province, age distribution in males and females, time of injury, mechanism, days of hospitalization, Glasgow Coma Scale (GCS) at admission, and the outcome at the end of the hospital stay.

We further analyzed the associated secondary diagnosis.

Population-based data are rarely being collected and still lacking, especially

How to cite this article: Hilmer LV, Park KB, Vycheth I, Wirsching M. Cerebral contusion: An investigation of etiology, risk factors, related diagnoses, and the surgical management at a major government hospital in Cambodia. Asian J Neurosurg 2018;13:23-30.

comprehensive data with all aspects that lead to the hospital stay and the associated consequences.

This study embodies the first one which focuses on cerebral contusion as a common type of injury after road traffic accidents and a major cause of admissions to the concerned hospital.

Therefore, data were collected over a time frame of 3 years, starting from May 2013 to May 2016.

Methods

Patient consent and institutional approval

We obtained patient informed consent before collecting data from each patient.

Ethical approval for this study (Cambodian Neurosurgical Support Project, Neurosurgery at Preah Kossamak Hospital, Version N°1) was provided by the National Committee for Health Research, National Institute of Public Health, Phnom Penh, Cambodia, on August 21, 2015.

Study design and general data

This study is a retrospective study with data of both admitted and elective patients, collected during the period between May 2013 and May 2016, filtered by cerebral contusions.

During this period, 2140 patients had been registered, 406 patients with the leading diagnosis cerebral contusion, 312 being male, and 94 female. Male had an average age of 31.17 years and females of 38.5 years. In 274 cases, the accident happened between 4 and 11 p.m. and patients stayed in the hospital for 10.5 days on average. Three hundred and nineteen of the injured patients were motorcycle drivers or passengers, 72 pedestrians, 5 had been bicycle as well as 5 had been car, and 2 had been tuk-tuk drivers. For analyzing the helmet status, only motorcycle users were considered.

Intervals with the lengths of 3–4 h such as 11.01 p.m.–3.00 a.m., 3.01 a.m.–6.00 a.m., 06.01 a.m.–9.00 a.m., 9.01 a.m.–12.00 a.m., 12.01 p.m.–02.00 p.m., 02.01 p.m.–04.00 p.m., 04.01 p.m.–07.00 p.m., and 07.01 p.m.–11.00 p.m. were used to investigate the time of injury.

The performed procedure was recorded, and for the condition on admission, the GCS was assessed, categorized into the following intervals: 3–8 (50 patients), 9–12 (92 patients), and 13–15 (238) patients. For the condition at discharge, it resorted to the Glasgow Outcome Scale (GOS) such as:

Glasgow outcome scale	
Grade	**Explanation**
Death	Severe injury or death without recovery of consciousness
Persistent vegetative state	Severe damage with prolonged state of unresponsiveness and a lack of higher mental functions
Severe disability	Severe injury with permanent need for help with daily living
Moderate disability	No need for assistance in everyday life, employment is possible but may require special equipment
Low disability	Light damage with minor neurological and psychological deficits

Indications for operations and eventual discrepancies from the strategies in the first-world countries were investigated by interviewing senior neurosurgeons.

Although there is a lack of international guidelines, it is suggested to monitor the intracranial pressure (ICP) in a patient with or without a GCS lower than 8, whereas an ICP <25 mmHg and cerebral perfusion of higher than 70 mmHg should be preserved by hemodynamic support, sedation, external ventricular drainage of cerebrospinal fluid, mannitol, and hyperventilation or hypothermia.[7,8] Data were obtained from patients' medical records and a prospectively collected patient database.

Statistical analysis

Data were analyzed using Excel 2016 (version 15.22) for Mac.

Mean values ± standard deviation were used for data with normal distribution and median values ± interquartile range for nonparametric data. To compare variables, Student's *t*-test was performed. $P < 0.05$ was considered statistically significant. Furthermore, to measure the association between exposure and outcome, odds ratio (OR) was calculated to compare relative odds. To approach the relationship between one dependent and more explanatory variables, linear regression was conducted. If aspects were not comparable, the count and percentage were pointed out.

Results

Residing province

Ninety-eight patients (24.94%) were residents from urban areas, 96 out of them from Phnom Penh, while 295 (75.51%) were from rural areas, mostly from provinces around Phnom Penh such as Kampong Speu (89 patients, 22.64%), Kandal (42 patients, 10.69%), Takeo (30 patients, 7.63%), and Kampong Cham (36 patients, 9.16%) [Figure 1].

Percentage distribution in male and females related to the age

Three hundred and twelve patients were male (76.84%) and 94 (23.15%) female. The mean age of male patients came to 31.17 years (±12.90, $P < 0.05$), the oldest being 88 years and the youngest 14 years. For females, the mean age amounted to 38.5 years (±16.29, $P < 0.05$), the oldest being 75 and the youngest 17 years [Figure 2a].

Days of hospitalization

Three patients stayed 0 day (0.81%), 36 patients 1–2 days (9.76%), 56 patients 3–5 days (15.18%), 109 patients 6–10 days (29.54%), and 165 over 10 days (44.71%). Patients stayed 10.51 days (±6.67) on average [Figure 2b].

Time of injury

As mentioned above, intervals to estimate a correlation between the occurrence and the time of injury were used. It turned out that 182 cases (52.29%) happened between 4.00 p.m. and 11.00 p.m. In fact, 23 injuries occurred at night time between 11.01 p.m. and 03.00 a.m., 13 cases between 03.01 a.m. and 6.00 a.m., 29 cases between 06.01 a.m. and 09.00 a.m., 39 cases between 09.01 a.m. and 12.00 a.m., 29 cases between 12.01 a.m. and 02.00 p.m., 33 cases between 02.01 p.m. and 04.00 p.m., 89 cases between 04.01 p.m. and 07.00 p.m., and 93 cases between 07.01 p.m. and 11.00 p.m. The percentage distribution is shown in Figure 3a.

Linear regression showed a weak but likely positive correlation between the variables with $R^2 = 0.70$.

Mechanism of injury

Locomotion of the injured

Three hundred and nineteen of the patients were motorcycle drivers, 5 car drivers, 2 tuk-tuk drivers, 72 pedestrians, and 5 bicycle drivers. The percentage distribution is shown in Figure 3b.

Pedestrians

Twenty-five patients (34.72%) were victims of assault, 26 patients (36.11%) suffered damage due to a fall in traffic due to stumbling, 7 slipped (9.72%), and 14 (19.45%) were victims of a traffic accident in terms of collision with a vehicle.

Assault

Twenty-five (89.29%) of the pedestrians and three motorcycle drivers (10.71%) were victims of assault.

Alcohol involvement

For male patients, in 135 (49.45%) out of 273 cases, alcohol consumption mattered. For female, this was the case in 5 (6.25%) out of 80 (OR - 15.65:1; 95% confidence interval [CI] - 6.15–39.84).

Helmet status

For male patients, 26 (10%) out of 232, and for females, 4 (5.40%) out of 70 wore a helmet at the time of injury (OR - 0.51; 95% CI - 0.17–1.51).

Performed procedure

Surgery was performed in 82 cases. These included craniotomy in 43 (52.44%), craniectomy in 33 (40.24%) cases, and elevation of a depressed skull fracture in 6 (7.32%) cases. In 19 cases, cranioplasty was performed to replace the bone flap from previous craniectomy. Final indications for operation were cerebral contusion in the first line in 43 cases (56.58%), epidural hematoma in 23 (30.26%), and subdural hematoma in 10 (13.16%) cases. In six cases, data were missing.

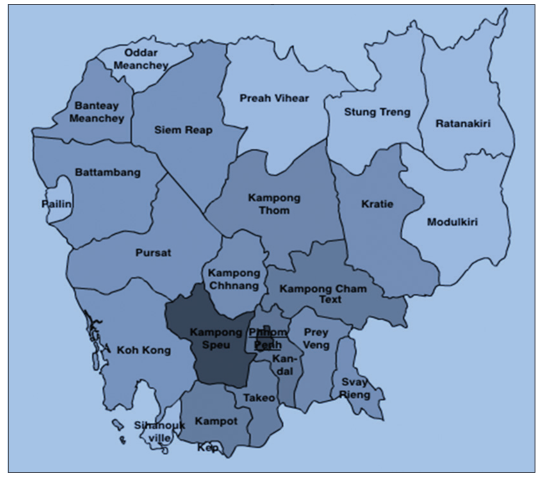

Figure 1: Heatmap showing frequency of provenance of patients in Cambodia

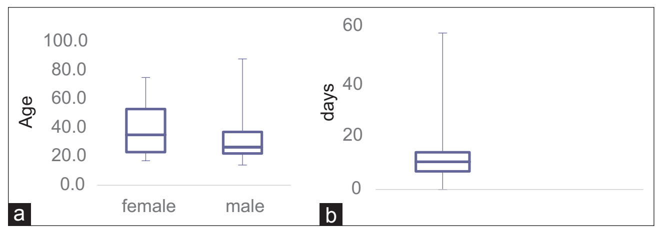

Figure 2: (a) Boxplot showing age distribution in males and females. (b) Boxplot showing distribution of hospitalization days

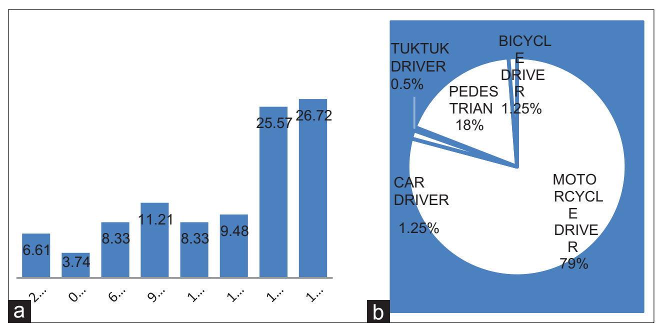

Figure 3: (a) Percentage of incidences depending on the daytime of injury. (b) Locomotion of the injured (percentage distribution)

Secondary diagnosis

We analyzed which diagnoses apart from the main diagnosis cerebral contusion occurred. These may be directly linked to the contusion itself or be separate from it. 296 (73.09%) patients had a second, 138 (34.07%) had an additional third, and 52 (12.84%) out of 405 had an additional fourth diagnosis.

Specification

As for secondary diagnoses, the following occurred: hydrocephalus, pneumocephalus, cephalohematoma, diffuse axonal injury, intracerebral hemorrhage, subarachnoid hemorrhage, subdural hematoma, epidural hematoma, skull fracture, facial fracture, and sinus fracture as well as other diagnoses with a smaller case number. Severe secondary diagnoses, such as epidural hematoma, subdural hematoma, intracerebral hemorrhage, and subarachnoid hemorrhage were pointed out concerning their occurrence in secondary diagnoses, but there was no significance to find ($P > 0.05$) [Table 1].

Condition on registration day

To estimate the condition at admission, respectively, registration for elective patients, the GCS was used. Fifty patients (13.16%) had a GCS of 3–8, 92 (24.21%) of 9–12, and 238 (62.63%) of 13–15.

Related secondary diagnosis to Glasgow Coma Scale

The following chart (count) and diagram (percentage distribution) show how secondary diagnoses were distributed according to the GCS at admission [Table 2 and Figure 4].

Condition at discharge

Three hundred and twenty-four (91.52%) of the patients were discharged with an improved condition, 14 (3.95%) with an unchanged condition, 4 (1.13%) with a worse condition, and 12 (3.39%) died in the hospital. The GOS was also assessed [Figure 5].

Discussion

Traumatic brain injuries (TBIs) are known as a major medical problem and leading factor of mortality among both children and adolescents as well as older adults.[5,9]

From 2009 until 2013, in which the latest data of the WHO had been released, Cambodia remained as a leading country with road traffic-related deaths and injuries although there was a helmet law established in 2009.[5,6] Fortunately, since January 1, 2016, the Cambodian Police has introduced stricter enforcement.

Due to an increasing motorcycle usage worldwide, helmet wearing patterns that give indications of being inconsequent and risky as well as drunk driving, road traffic accidents

Table 1: Specification of secondary diagnoses with respect to their presence as a second, third, or fourth diagnosis

Secondary diagnosis	Second diagnosis count (%)	Third diagnosis count (%)	Fourth diagnosis count (%)
Sinus fracture	6 (2.03)	5 (3.62)	4 (7.69)
Facial fracture	16 (5.41)	18 (13.04)	6 (11.54)
Skull fracture	50 (16.89)	36 (26.1)	12 (23.08)
Epidural hematoma	63 (21.28)	11 (7.97)	3 (5.77)
Subdural hematoma	96 (32.43)	17 (12.32)	3 (5.77)
Subarachnoid hemorrhage	43 (14.53)	18 (13.04)	1 (1.92)
Intracerebral hemorrhage	7 (2.36)	3 (2.17)	0
Axonal injury	1 (0.34)	0	1 (1.92)
Cephalohematoma	4 (1.35)	12 (8.7)	4 (7.69)
Pneumocephalus	3 (1.01)	7 (5.07)	5 (9.62)
Hydrocephalus	2 (0.68)	0	1 (1.92)
Others	5 (1.69)	11 (7.97)	12 (23.08)

Table 2: Count of incidences with regard to secondary diagnoses

Diagnosis	GCS		
	3-8	9-12	13-15
Epidural hematoma	16	16	25
Subdural hematoma	15	16	44
Subarachnoid hemorrhage	4	13	23
Skull fracture	1	19	40
Facial fracture	3	6	12
None	7	11	23
Other	4	11	70

GCS – Glasgow Coma Scale

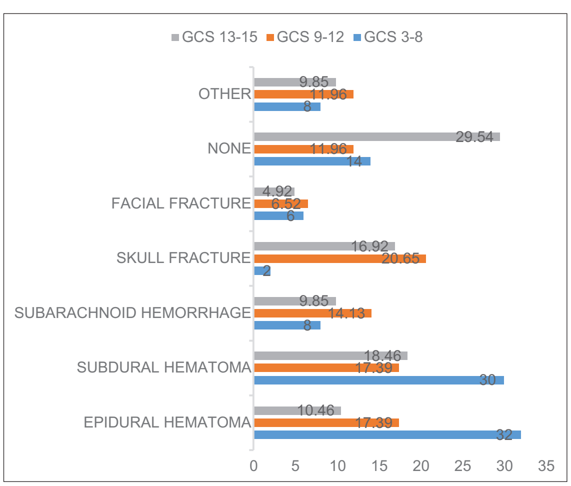

Figure 4: Specified diagnosis related to the Glasgow Coma Scale (%)

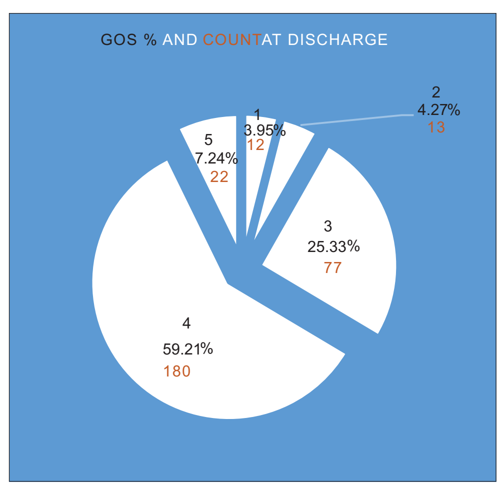

Figure 5: Percentage distribution and count concerning the Glasgow Outcome Scale at discharge

became apparent as a major cause of head injuries and by association cerebral contusions, both in our study such as in other studies.[5,10,11]

In other studies conducted all over the world such as the United States,[12,13] Taiwan,[2] Brazil, Nigeria, India, and Pakistan[4,10] or New Caledonia,[3] the average age of injured due to motorcycle accidents amounted to 25–30 years, whereas our study showed an average of 31.17 years for males and 38.5 for females, which is not less tragic as Cambodians often start families early and therefore already have many children in that age group, with the result of not being able to afford hospitalization costs.

Like in other studies that showed the main sex that is affected by road traffic accidents is males,[10,12,13] 76.84% of the injured in our study turned out to be male most likely due to the fact that males are mostly drivers and tend to riskier and drunk driving in general. In fact, another research group claimed male gender is an independent risk factor for TBIs.[10]

Furthermore, 10.5 hospitalization days on average is indicative for brain contusions being severe injuries in Cambodia. Thereby, it must be considered that Cambodians often do not consult a doctor as long as there is no serious problem that they cannot handle by themselves as they fear the costs on the one hand and as there is a widespread distrust toward conventional medicine on the other hand.

Not negligible, pedestrians (18% of the patients) are also vulnerable. Pedestrians can be injured in traffic easily and can be victims of assault or take a fall. However, the focus of our investigation lies on motorcyclists and their behavior in road transport as they make up 79% of our concerned patients and only an inconsiderable part is constituted by cyclists due to careful and slower driving, and the fact that there are only few and tuk-tuk or car drivers as they have a less exposed position in their vehicles. Similar relations were found in studies conducted in Taiwan.[2,14]

Subsequently, it is obvious that most of the accidents happen in the late afternoon from 4.00 p.m. and 11.00 p.m., with 52.29% mostly due to the rush hour between 4.00 p.m. and 7.00 p.m., a decrease of concentration after finishing work, alcohol involvement in the after work hours, and increasing darkness in the evening hours.

Another study found that the incidence of injuries in El Paso, Colorado, was significantly associated with a day time between 8.00 p.m. and 8.00 a.m.[13] The difference may be due to other incidences of motorcycle usage as well as riding the motorcycle after 11 p.m. is known to be unsafe in Cambodia.

Moreover, alcohol involvement played a significant role with 49.45% in males, whereas females were less likely to drive under the influence of alcohol with 6.25%. This is explainable by cultural issues whereby women drink none or just small amounts of alcohol and men rather tend to meet in the evenings for having dinner accompanied with some alcoholic beverages. Another study ascertained that alcohol consumption is a leading factor in causing severe accidents due to delayed reaction time as well as riskier and faster driving and applied up to 50% of the male patients.[15] For females, it concerned around 20% in that study. The higher percentage as compared to our study is explainable by the fact that alcohol consumption in females is much more common in the Western world. Interestingly, a study conducted in Pakistan with a predominantly Muslim population showed that alcohol intoxication rarely occurs and therefore rarely causes traffic accidents.[4]

By contrast, the helmet usage patterns are different. Only 10% of the male and 5.40% of the female patients stated to have worn a helmet at the time of injury although there is a helmet law and since the beginning of 2016 a stricter enforcement by the police. Another study conducted in 2011 revealed that the helmet usage among all interviewed drivers in Cambodia – not only patients like in our study – remains low at 43% at daytime.[5]

A Taiwanese study reported in 1997 that only 3% of the injured in Taiwan were wearing helmets, whereas in 2007, a paper was published by the same main author showing that the general helmet usage rate increased considerably over 10 years since 1991 from 15% to over 80%.[2,14]

The better compliance in men might be due to cosmetic aspects that are not as important for them as for women.

Similar findings but for pillion riders are shown.[10]

In countries with mandatory helmet use and strict enforcement, the average helmet usage in riders amounts to 90% and above.[16] Hence, it is important to assess how this behavior is changing and will modify after the police started to better apply administrative penalties.

Decompressive craniectomy was suggested as an important therapeutic option for patients with acute severe TBI at risk to develop severe brain edema,[9] which was the case in 33 (40.24%) of our patients who required surgery. Both of the studies mentioned below asserted that 19% of patients with brain contusions required a surgical intervention in general.[17,18] In our study, this applied to 82 patients (20.19% of all patients). 92.68% of them received decompressive surgery in the form of craniotomy or craniectomy and only 7.32% elevation of a depressed skull fracture as a secondary diagnosis.

In severe cases, decompressive surgery is known as the only lifesaving option to prevent death from intracranial hypertension even though it might be associated with severe risks such as brain abscess or postoperative infection and its effect on the postoperative outcome is still not properly evidence based according to two studies who found out that this kind of surgery allowed 25% out of forty critical ill patients to attain social rehabilitation at 1 year.[7,9] It has also been claimed that there is no consensus for operations in general and that for or against surgery must be referred to individual decision-making rules.[19] Such was also published by other studies.[8,20,21]

Indeed, as other evidence-based therapeutic interventions such as hypothermia therapy due to lack of technical capabilities and external ventricular drainage due to high risk of infection cannot be performed, the range of surgical indication is much wider than in industrial countries.

For the surgical indication clinical and vital signs were assessed such as a GCS of or below 8, absence of pupillary reflexes and signs of cerebral herniation like nausea, vomiting or abnormal posturing; correlated with signs shown by computed tomography like hematoma, brain swelling or a midline deviation of over 5 mm. Furthermore, age and the mechanism of injury were considered. The decision to proceed with surgical intervention was based on clinical examination as the actual severity did not always correlate with the results shown by computed tomography, a strategy also pursued in the first-world countries.[20,22]

A recent study realized in the United States points out that patients who undergo surgery have worse outcomes as well as higher infection rates, especially – highly significant – at an age above 60 years.[23]

Nonetheless, despite all well-considered procedures that are being performed and rigorous prophylactic as well as postoperative antibiotic usage, doctors in our hospital report high postoperative infection rates what makes future decisions for or against operation more difficult.

Epidural as well as subdural hematoma played a significant role in our study as they have been the main indication for surgery in 30.26% and 13.16%, respectively. Due to the fact that 73.09% of the patients had an additional second and even 34.07% an additional third diagnosis, it is necessary to specify.

For secondary diagnosis, the following mattered: hydrocephalus, pneumocephalus, cephalohematoma, diffuse axonal injury, intracerebral hemorrhage, subarachnoid hemorrhage, subdural hematoma, epidural hematoma, skull fracture, facial fracture, and sinus fracture. Although there was no sufficient statistical significance to find, it is important to point out that the case numbers of subdural (32.43% of all second diagnosis) as well as epidural (21.28%) hematoma and subarachnoid hemorrhage (14.53%) decreased from being a second to being a fourth diagnosis whereas diagnoses such as skull and facial fracture or others were rather observed as a third or fourth diagnosis in serious injuries with more than two diagnoses apart from the main diagnosis "cerebral contusion." For facial fractures, the intensity and location of the collision were of great significance for the severity and position of the facial bone fracture and therefore its impact as an or on a TBI.[24] Therefore, it seems to be necessary to do some more research on this topic in the future to examine the exact location of the facial fracture.

Diagnoses apart from the named above were of minor importance due to a small case number. These findings indicate that cerebral contusions mostly occurred together with accompanying injuries around the location of the cerebral contusion itself such as subdural and epidural hematoma or subarachnoid hemorrhage as these are known to be major complications of severe TBIs.[20]

The fact that cerebral contusions tend to progress in up to 60% reported other studies who stated that a secondary progression can lead to the diagnoses named above or declared as "secondary diagnoses" in our study shows the importance of analyzing coexisting injuries in the future regarding the distinction between the secondary diagnosis being due to progression of the cerebral contusion or developing separately.[5,9,17,25] It has been published that progression of subdural hematoma and brain contusions is a serious problem.[26] In fact, the literature review and our findings show that often not only the actual injury but also their later progression to or coexistence with secondary diagnosis in the days after incident is a main problem.

Finally, we found out that 13.16% suffered a severe, 24.21% a moderate, and 62.63% mild brain injury according to Kraus *et al*.'s triad of categorization.[27] To better evaluate these findings, we compared them to other studies like one conducted in Pakistan with 30% of the patients having severe, 23% moderate, and 46% mild brain trauma,[17] or[18] 61% of the patients having mild brain trauma and[14] as well as[27] who reported over 70% of the patients having mild brain trauma (both also included in-hospital deaths). Furthermore, we found out epidural (32% of all patients with severe head trauma) as well as subdural (30%) hematoma was rather associated with a worse GCS of or lower than 8, whereas the highest percentage of the patients with moderate head trauma was found for skull fracture in 20.65%, and the highest percentage of patients with mild head trauma was found without a secondary diagnosis. This is obvious as subdural and epidural are known as the ones with the most severe outcomes among TBIs.[26]

In our study, only 7.24% of the patients were discharged with a good recovery (GOS of 5) and 59.21% with a GOS of 4 according to a moderate disability. Surprisingly, this differed from other studies.[14] This study compared its results from Taipei City and Hualien County in Taiwan with results from another study conducted in Hualien, respectively, Taipei, one in San Diego County[27] of the United States, and finally, Trondelag in Norway, whose patients had a good recovery (GOS 5) in mostly over 85% apart from Hualien County itself with 67%. Another study had similar findings.[18]

Chiefly, this might imply that the GOS in our hospital was assessed directly after discharge and not as a follow-up GOS after 3 or 4 month like in other studies as most of the patients do not come again, and second, these findings undermine our assumption that the admissions to our department were exceptional severe cases by a majority due to reasons mentioned above. Anyhow, our findings show that 91.52% were discharged with an improved condition, 3.95% with an unchanged, and only 3.39% died, which showed that the treatment had been effective in most of the cases.

This study was subject to several limitations. First, there was not every aspect recorded for each of the 406 patients, and so, the total numbers for each issue differed as always declared.

An additional limitation is given since it is a retrospective study with a limited number of patients and a wide range of aspects around cerebral contusions without a deep focus on one, but what can also be regarded as an advantage as our aim was to give an overview and to highlight the major causes of cerebral contusions in the hospital concerned. Another study highlighted the problem that crash severity as well as crash speed in traffic is due to its difficulty rarely assessed.[16]

Based on that, several studies as well as ours proceed on the assumption that all accidents had a similar impact.

We did not exclude patients from our statistical analysis and hence reviewed the diagnosis as realistic as possible.

Finally, it is not possible to conclude aspects such as all-cause mortality since most of the deaths due to road traffic accidents happen on site and are never being recorded. This applies to alcohol consumption or helmet usage, as well as the information was gathered by interviewing and not by standardized testing.

Despite all its limitations, our study states like several studies conducted before the impact of road traffic accident as a major cause of cerebral contusions and mortality in general.

Conclusion

The incidence among the Cambodian population, especially in young adults, the rate of severe cases and the predominant number of outcomes with moderate disability and resulting significant level of neurologic impairment, the number of average hospital days, the related diagnoses that tend to develop and to worsen the condition in the days after the incident even in mild injuries,[27] and the requirement of surgery in with all its consequences in several cases suggest cerebral contusions in the field of TBIs as an important global health problem on which more research should be done with regard to an investigation of prehospital deaths, helmet quality, and preferably standardized testing of wearing compliance.

Better information and education of young children about the importance of behaving carefully in traffic and wearing helmets of proper quality as well as enlighten adults are the major concerns in the future even though law enforcement is a step forward.

Acknowledgements

Special thanks to Raksmey Hong who participated in the data collection thoroughly.

Financial support and sponsorship

This work was supported by the Cambodia Neurosurgical Support Project, the Korean American Medical Association, and Gertrud Scheuermann-Hilmer.

Conflicts of interest

There are no conflicts of interest.

References

1. Hardman JM, Manoukian A. Pathology of head trauma. Neuroimaging Clin N Am 2002;12:175-87, vii.
2. Chiu WT, Huang SJ, Tsai SH, Lin JW, Tsai MD, Lin TJ, *et al.* The impact of time, legislation, and geography on the epidemiology of traumatic brain injury. J Clin Neurosci 2007;14:930-5.
3. Guerrier G, Morisse E, Barguil Y, Gervolino S, Lhote E. Severe traumatic brain injuries from motor vehicle-related events in New Caledonia: Epidemiology, outcome and public health consequences. Aust N Z J Public Health 2015;39:188-91.
4. Umerani MS, Abbas A, Sharif S. Traumatic brain injuries: Experience from a tertiary care centre in Pakistan. Turk Neurosurg 2014;24:19-24.
5. GHO. New York City (NY): World Health Organization. Reported Distribution of Road Traffic Deaths by Type of Road User – Data by Country; c2000, 2013. Available from: http://www.apps.who.int/gho/data/node.main.A998?lang=en/. [Last cited on 2016 Jul 20].
6. Albanèse J, Leone M, Alliez JR, Kaya JM, Antonini F, Alliez B, *et al.* Decompressive craniectomy for severe traumatic brain injury: Evaluation of the effects at one year. Crit Care Med 2003;31:2535-8.
7. Timofeev I, Kirkpatrick PJ, Corteen E, Hiler M, Czosnyka M, Menon DK, *et al.* Decompressive craniectomy in traumatic brain injury: Outcome following protocol-driven therapy. Acta Neurochir Suppl 2006;96:11-6.
8. Bachani AM, Tran NT, Sann S, Ballesteros MF, Gnim C, Ou A, *et al.* Helmet use among motorcyclists in Cambodia: A survey of use, knowledge, attitudes, and practices. Traffic Inj Prev 2012;13 Suppl 1:31-6.
9. Haddad SH, Arabi YM. Critical care management of severe traumatic brain injury in adults. Scand J Trauma Resusc Emerg Med 2012;20:12.
10. Ahmed I, Islam T, Ali G, Nawaz MM. Pillion riders' cloth related injuries and helmet wearing patterns: A study of Lahore, Pakistan. Int J Inj Contr Saf Promot 2016;23:388-94.
11. Bachulis BL, Sangster W, Gorrell GW, Long WB. Patterns of injury in helmeted and nonhelmeted motorcyclists. Am J Surg 1988;155:708-11.
12. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002-2006. Atlanta (GA): National Center for Injury Prevention and Control;

c2000. Available from: https://www.cdc.gov/traumaticbraininjury/pdf/blue_book.pdf. [Last cited on 2016 Aug 01].

13. Gabella B, Reiner KL, Hoffman RE, Cook M, Stallones L. Relationship of helmet use and head injuries among motorcycle crash victims in El Paso County, Colorado, 1989-1990. Accid Anal Prev 1995;27:363-9.
14. Chiu WT, Hung CC, Le LS, Lin LS, Shih CJ, Laporte RE. Head injury in urban and rural populations in a developing country. J Clin Neurosci 1997;4:469-72.
15. Harr ME, Heskestad B, Ingebrigtsen T, Romner B, Rønning P, Helseth E. Alcohol consumption, blood alcohol concentration level and guideline compliance in hospital referred patients with minimal, mild and moderate head injuries. Scand J Trauma Resusc Emerg Med 2011;19:25.
16. Lin MR, Kraus JF. Methodological issues in motorcycle injury epidemiology. Accid Anal Prev 2008;40:1653-60.
17. Alahmadi H, Vachhrajani S, Cusimano MD. The natural history of brain contusion: An analysis of radiological and clinical progression. J Neurosurg 2010;112:1139-45.
18. Zhaofeng L, Bing L, Peng Q, Jiyao J. Surgical treatment of traumatic bifrontal contusions: When and how? World Neurosurg 2016;93:261-9.
19. Kawamata T, Katayama Y. Surgical management of early massive edema caused by cerebral contusion in head trauma patients. Acta Neurochir Suppl 2006;96:3-6.
20. Alvis-Miranda H, Castellar-Leones SM, Moscote-Salazar LR. Decompressive craniectomy and traumatic brain injury: A review. Bull Emerg Trauma 2013;1:60-8.
21. Finfer SR, Cohen J. Severe traumatic brain injury. Resuscitation 2001;48:77-90.
22. Bullock R, Chesnut RM, Clifton G, Ghajar J, Marion DW, Narayan RK, *et al.* Guidelines for the management of severe head injury. Brain Trauma Foundation. Eur J Emerg Med 1996;3:109-27.
23. Tierney KJ, Nayak NV, Prestigiacomo CJ, Sifri ZC. Neurosurgical intervention in patients with mild traumatic brain injury and its effect on neurological outcomes. J Neurosurg 2016;124:538-45.
24. Tse KM, Tan LB, Lee SJ, Lim SP, Lee HP. Investigation of the relationship between facial injuries and traumatic brain injuries using a realistic subject-specific finite element head model. Accid Anal Prev 2015;79:13-32.
25. Kurland D, Hong C, Aarabi B, Gerzanich V, Simard JM. Hemorrhagic progression of a contusion after traumatic brain injury: A review. J Neurotrauma 2012;29:19-31.
26. Godoy DA, Rubiano A, Rabinstein AA, Bullock R, Sahuquillo J. Moderate traumatic brain injury: The grey zone of neurotrauma. Neurocrit Care 2016;25:306-19.
27. Kraus JF, Black MA, Hessol N, Ley P, Rokaw W, Sullivan C, *et al.* The incidence of acute brain injury and serious impairment in a defined population. Am J Epidemiol 1984;119:186-201.