NEUROLOGY

Factors associated with the severity of traumatic brain injury

Ghazwan Lafta[1], Hayder Sbahi[2]

1) Department of Surgery, Faculty of Medicine, University of Al-Ameed, Karbala, Iraq

2) Department of Surgery, Imam Alhasan Hospital, Karbala, Iraq

Abstract

Introduction. Traumatic brain injury (TBI) is a defect in the brain function resulting from the action of external factors. The condition ranges from transient shifts in cellular ionic concentrations to total structural damage; the clinical symptoms can vary from brief confusion to death. The current classification system, based on the Glasgow Coma Scale (GCS), divides TBI into mild (GCS 14 to 15), moderate (GCS 9 to 13), and severe TBI (GCS 3 to 8). The leading causes of head injury in the population can be falls, motor vehicle collisions, blasts, and bullet injuries. The ultimate survival and neurologic outcome of the head trauma patient depend on the extent of TBI occurring at the time of injury. The aim of the study is to assess the factors associated with brain injury and their effect on its severity.

Method. A cross sectional, retrospective study including 469 adult patients with head injury was carried out in the emergency department of Baghdad teaching hospital between 1 October 2016 - 30 October 2017. Data of all the patients were entered and analyzed using the statistical package for social sciences (SPSS) software for Windows, version 24. The significance of correlation was assessed using a Chi-square test. Level of significance was set at ≤ 0.05. Final findings were presented in tables with an explanatory paragraph for each table using the MS. Office (Word 2013) for Windows.

Results. A total number of 469 patients were enrolled in this study with a mean age of 42.6 ± 13.7 years. The vast majority of the patients were males (383/469), which represented 81.7%. The male to female ratio was 4.45 to 1. The distribution of the patients according to their traumatic brain injury was 241 patients (51.4%) with mild, 99 (21.1%) with moderate and 129 (27.5%) with severe TBI. Associated injuries among the studied group were facial injuries in 133 (28.4%), skull fracture in 150 (32%), and thoracolumbar fracture in 51 (10.9%). The associated injuries were more frequent in the extremities - 112/469 (23.9%), combined injuries in 112 (23.9%), chest and abdomen injuries were reported in only 6% and 6.8%, respectively. The causes of injuries in the studied group were road traffic accidents (RTA), the most frequent mechanism - 37.1% of the cases, followed by fall from height (FFH) (23.9%), blast injury (16.8%), bullet injury (13%), while other mechanisms represented only (9.2%). There is a significant association reported with gender, where severe injuries were more frequent among males than females (P=0.014). All associated injuries were significantly associated with severe traumatic brain injury (P<0.05), also bullet injury was significantly associated with severe traumatic brain injury, followed by blast injury (P<0.001). Severe traumatic brain injury was significantly associated with the presence of clinical and radiographic findings (P<0.001).

Conclusion. The severity of TBI is significantly related to the type of the associated injury, mechanism of injury, clinical and radiological findings, and to the male gender, while it is not dependent on the age of the patient.

Keywords: traumatic brain injury, Glasgow Coma Scale, severity

DOI: 10.15386/mpr-2314

Manuscript received: 26.06.2021
Received in revised form: 29.08.2022
Accepted: 20.09.2022

Address for correspondence:
Ghazwan Lafta
ghazwan_altayy@yahoo.com

Introduction

Traumatic brain injury (TBI) is a cerebral function defect due to external stimuli [1]. The pathology ranges from transient shifts in cellular ionic concentrations to a total structural damage, so, the clinical symptoms can vary from brief confusion to coma, severe disability, and / or death. TBI is classified according to the clinical assessment of a patient's conscious level [2,3]. The current classification system, based on the Glasgow Coma Scale (GCS), divides TBI into mild (GCS 14 to 15), moderate (GCS 9 to 13), and severe (GCS 3 to 8) [4]. In the severe type, mortality rate approaches 40%, with most deaths occurring in the first 48 hours after injury [5]. Only less than 10% of patients with severe TBI show good recovery [6,7]. There are at least 1.7 million cases of traumatic brain injury annually, the majority of these cases are mild [8,9]. Eighty percent of TBI patients who present to the emergency room are discharged the same day; while the morbidity and mortality of TBI are high among those with severe TBI (39-74%) especially in old age patients [10,11]. Head injury is the main cause of traumatic mortality in patients younger than 25 years and accounts for nearly one third of all trauma deaths [12,13]. The leading causes of head injury in the civilian population are falls (43.7%) and motor vehicle collisions (MVCs) (21.5%) [14]. TBI caused by explosions is the main type of injury of the wars in Iraq and Afghanistan [15]. The emergency room receives patients with head injuries of different clinical severity caused by different mechanisms. External physical signs do not always accompany TBI [16]. The neurologic outcome of a head injured patient depends on the extent of TBI occurring at the time of injury, alone or in combination with secondary systemic manifestations, such as hypotension and hypoxia, which worsen the outcomes [17].

The aim of the study is to assess the factors associated with brain injury and their effect on its severity.

Methods

A cross sectional, retrospective study including 469 adult patients with head injury was carried out in the emergency department of Baghdad teaching hospital from the first of October 2016 to 30 October 2017. Primary survey had been accomplished for all patients regarding maintaining air way, breathing and circulation with full neurological assessment and exposure, hard collar, I.V. lines, O2, monitoring, analgesia. All patients were subjected to X-rays and CT-Scan of the skull for evaluation of head injury as a routine step in the emergency department, any traumatic brain injury with GCS (15-13) was considered mild head injury, GCS (9–12) as moderate, while head injury with GCS <8 was considered as severe head injury. The primary objectives of trauma management are rapid and accurate assessment of the patient's condition, resuscitation and stabilization and determining whether hospital transfer will be likely. Data of all the patients were entered and analyzed using the statistical package for social sciences (SPSS) software for Windows, version 24. Prior to analysis, all data were checked for possible errors and inconsistency. Descriptive statistics presented as frequencies (no.), proportions (%), mean and standard deviation. Variables were checked for normal distribution and parametric tests were used for analysis and assessment of significance. The significance of correlation was assessed using Chi-square test. Level of significance was set at ≤ 0.05. Final findings were presented in tables with an explanatory paragraph for each table using the MS. Office (Word 2013) for Windows.

Results

A total number of 469 patients were enrolled in this study, age range 19 - 73 years, mean age 42.6 ± 13.7 years. The vast majority of the patients were males (383/469), which represented 81.7%. The male to female ratio was 4.45 to 1 (Table I).

The distribution of the patients according to their traumatic brain injury was: 241 patients (51.4%) with mild, 99 (21.1%) with moderate and 129 (27.5%) with severe TBI. The presentation and findings of the clinical examination of the patients (as shown in Table II) were cervical pain in 72 patients (15.4%), cervical tenderness in 60 patients (12.8%), weakness and paralysis in 98 patients (20.9%), numbness and paresthesia in 94 patients (20%) and hypotension in 48 patients (10.2%). Some findings in a group of patients were difficult to be assessed.

Table I. Distribution of age and gender in the studied group.

Variable		No.	%	No. of males	No. of females
Age (years)	< 40	256	54.6	192	64
	41-64	163	34.8	150	13
	> 65	50	10.7	41	9
	Total	469	100.0	383	86
	Mean ± SD	42.6 ± 13.7	-		
Gender	Male	383	81.7		
	Female	86	18.3		
	Total	469	100.0		

Associated injuries among the studied group were facial injuries in 133 (28.4%), skull fractures in 150 (32%), and thoracolumbar fractures in 51 (10.9%).

The associated injuries were more frequent in the extremities - 112/469 (23.9%), combined injuries in 112 (23.9%); chest and abdomen injuries were reported in only 6% and 6.8%, respectively (Table III).

Table II. Presentations and examination findings of patients (N = 469).

Presentation		No.	%
Cervical pain	*Yes*	72	15.4
	No	243	45.5
	Difficult to assess	154	39.1
	Total	469	100.0
Cervical tenderness	*Yes*	60	12.8
	No	255	48.1
	Difficult to assess	154	39.1
	Total	469	100.0
Focal neurological deficit	*Yes*	98	20.9
	No	348	74.2
	Difficult to assess	23	4.9
	Total	469	100.0
Paresthesia	*Yes*	94	20.0
	No	347	74.0
	Difficult to assess	28	6.0
Hypotension	*Yes*	48	10.2
	No	421	89.8
	Total	469	100.0

Table III. Types of injuries reported among the studied group (N = 469).

Injury		No.	%
Facial injury	*Yes*	133	28.4
	No	336	71.6
	Total	469	100.0
Skull fracture	*Yes*	150	32.0
	No	319	68.0
	Total	469	100.0
Thoracolumbar fracture	*Yes*	51	10.9
	No	418	89.1
	Total	469	100.0
Other injuries	*Chest*	28	6.0
	Abdomen	32	6.8
	Extremity	112	23.9
	Combined	112	23.9
	None	185	39.4
	Total	469	100.0

The causes of injuries among the studied group are as shown in Table IV, road traffic accident was the most frequent mechanism about (37.1%) of the cases, followed by fall from height (23.9%), blast injury (16.8%), bullet injury (13%), while other mechanisms represented only (9.2%).

Table IV. Causes of injuries reported among the studied group (N = 469).

Mechanism of injury	No.	%
Road traffic accident	174	37.1
Fall from height	112	23.9
Blast injury	79	16.8
Bullet injury	61	13.0
Other	43	9.2
Total	469	100.0

Relationship between the severity of traumatic brain injury and other patient variables

Age and gender

No statistically significant association was found between the severity of traumatic brain injury and age, (P>0.05), while a significant association was found with gender, where severe injuries were more frequent among males than females, (P= 0.014) (Table V).

Severity of traumatic brain injury and associated injuries

All associated injuries were significantly associated with severe traumatic brain injury. Patients who had one or more associated injuries were more likely to have severe traumatic brain injury than those who did not (P< 0.05) (Table VI).

Severity of traumatic brain injury and mechanism of injury

Bullet injury was significantly associated with highest percentage of severe traumatic brain injury, followed by blast injury (*P*<0.001) (Table VII).

Relationship between the severity of traumatic brain injury and clinical and radiographic findings

Severe traumatic brain injury was significantly associated with the presence of clinical and radiographic findings, in all comparisons (*P*<0.001) (Table VIII).

Table V. Relationship of severity of traumatic brain injury with age and gender.

		Traumatic brain injury type						*P*
		Mild		Moderate		Severe		
		No.	%	No.	%	No.	%	
Age (year)	< 40	128	53.1%	50	50.5%	78	60.5%	0.547
	41-64	85	35.3%	39	39.4%	39	30.2%	
	>65	28	11.6%	10	10.1%	12	9.3%	
	Total	241	100.0%	99	100.0%	129	100.0%	
Gender	male	205	85.1%	71	71.7%	107	82.9%	**0.014**
	female	36	14.9%	28	28.3%	22	17.1%	
	Total	241	100.0%	99	100.0%	129	100.0%	

Table VI. Relationship between the severity of traumatic brain injury and associated injuries

		Traumatic brain injury type						*Total*	*P*
		Mild		Moderate		Severe			
		No.	%	No.	%	No.	%		
Facial injury	*Yes*	**46**	34.6	**42**	31.6	**45**	33.8	**133**	**< 0.001**
	No	**195**	58.0	**57**	17.0	**84**	25.0	**336**	
Skull fracture	*Yes*	**50**	33.3	**49**	32.7	**51**	34.0	**150**	**< 0.001**
	No	**191**	59.9	**50**	15.7	**78**	24.5	**319**	
Thoracolumbar fracture	*Yes*	**9**	17.6	**21**	41.2	**21**	41.2	**51**	**< 0.001**
	No	**232**	55.5	**78**	18.7	**108**	25.8	**418**	
Cervical injury	*Yes*	**6**	10.2	**24**	40.7	**29**	49.2	**59**	**< 0.001**
	No	**235**	57.3	**75**	18.3	**100**	24.4	**410**	
Other injuries	*Chest*	**19**	67.9	**5**	17.9	**4**	14.3	**28**	**0.001**
	Abdomen	**22**	68.8	**7**	21.9	**3**	9.4	**32**	
	Extremity	**62**	55.4	**26**	23.2	**24**	21.4	**112**	
	Combined	**39**	34.8	**29**	25.9	**44**	**39.3**	**112**	
	None	**99**	53.5	**32**	17.3	**54**	29.2	**185**	

Table VII. Relationship of the severity of traumatic brain injury with the mechanism of injury.

Mechanism of injury	Traumatic brain injury type						Total	
	Mild		Moderate		Severe			
	No.	%	No.	%	No.	%	No.	%
Road traffic accident	**87**	50.0	**44**	25.3	**43**	24.7	**174**	37.1
Bullet injury	**0**	0.0	**27**	44.3	**34**	55.7	**61**	13.0
Blast injury	**38**	48.1	**13**	16.5	**28**	35.4	**79**	16.8
Fall from height	**77**	68.8	**11**	9.8	**24**	21.4	**112**	23.9
Other	**39**	90.7	**4**	9.3	**0**	0.0	**43**	9.2
Total	**241**	100.0%	**99**	100.0%	**129**	100.0%	**469**	100.0

Chi-square test is significant at ***P*<0.001**

Table VIII. Relationship between severity of traumatic brain injury and clinical and radiographic findings (N=469).

		Traumatic brain injury type						*Total*	*P*
		Mild		Moderate		Severe			
		No.	%	No.	%	No.	%		
Cervical pain	*Yes*	**38**	52.8	**34**	47.2	**0**	0.0	**72**	**< 0.001**
	No	**203**	84.1	**40**	15.9	**0**	0.0	**243**	
	Difficult to assess	**0**	0.0	**25**	17.1	**129**	82.9	**154**	
Cervical tenderness	*Yes*	**31**	51.7	**29**	48.3	**0**	0.0	**60**	**< 0.001**
	No	**210**	82.9	**45**	17.1	**0**	0.0	**255**	
	Difficult to assess	**0**	0.0	**25**	17.1	**129**	82.9	**154**	
Weakness + paralysis	*Yes*	**16**	16.3	**26**	26.5	**56**	57.1	**98**	**< 0.001**
	No	**225**	64.7	**73**	21.0	**50**	14.4	**348**	
	Difficult to assess	**0**	0.0	**0**	0.0	**23**	100.0	**23**	
Numbness + paresthesia	*Yes*	**16**	17.0	**25**	26.6	**53**	56.4	**94**	**0.001**
	No	**225**	64.8	**72**	20.7	**50**	14.4	**347**	
	Difficult to assess	**0**	0.0	**2**	7.1	**26**	92.9	**28**	
Hypotension	*Yes*	**0**	0.0	**8**	16.7	**40**	83.3	**48**	**< 0.001**
	No	**241**	57.2	**91**	21.6	**89**	21.1	**421**	
Lateral view X-ray	*Yes*	**6**	28.6	**12**	57.1	**3**	14.3	**21**	**< 0.001**
	No	**235**	52.5	**87**	19.4	**126**	28.1	**448**	
CT scanning	*Yes*	**6**	10.2	**24**	40.7	**29**	49.2	**59**	**< 0.001**
	No	**235**	57.3	**75**	18.3	**100**	24.4	**410**	

Discussion

Four hundred sixty nine patients with traumatic brain injury were received and treated in our cross sectional study which was carried out at the emergency department of Baghdad Teaching Hospital from October 2016 to October 2017.

In our study, a total of (469 patients) were enrolled, ranging from 19 to 73 years, with mean age of 42.6 ± 13.7 years, which is superior to studies of Nazir et al. [18], Nayebaghayee et al. [19], and Eaton et al. [20], with 369, 100 and 280 patients, respectively. Our study reports that the higher number of patients were males (81.7%) with a male to female ratio of (4.45:1): these findings are consistent with trends throughout the literature, with males commonly representing significantly higher percentages of patients suffering traumatic brain injury, spinal injury, fatal injuries, and neurological damage. This result is as close as possible to Nayebaghayee et al. [19], Eaton et al [20], Munivenkatappa et al. [21] and Bruns and Hauser [22] as most of the patients were males (80-85%). According to Bazarian et al. [23], the gender distribution of neuro-trauma is more interesting because they found that 45.1% were females and 54.9% were males.

This variation between our study and the above mentioned studies regarding the distribution of patients according to gender may be due to cultural and social divergence, with different degree of involvement of women in those countries. Our study revealed a significant association between cranio-cervical injuries with gender, where severe injuries were more frequent among males than females. According to Ghobrial et al. [24], females composed 53.18% of patients suffering an isolated spine injury; however, males number exceeded females in cases of isolated traumatic brain injury (64.07%), these discrepancies between genders can be explained by the more violent mechanisms by which males are injured; for example, motor vehicle collisions more frequently involve males.

In our research, mild traumatic brain injury occurred in 241 patients (51.4%), while moderate and severe degrees represented 21.1% and 27.5% respectively. This shows that our results are closer to Bruns and Hauser [22], when they found that mild injuries comprised 80%, while moderate and severe cases represented about 10% for each.

Nayebaghayee et al. [19] reported that 80.5% of cases were mild, 10.5% were moderate, and 9% were severe injuries, while Holly et al. [25] reported that the majority of the patients with moderate and severe traumatic brain injury.

Nazir et al. [18] showed that the majority of head injuries were moderate 271 (73.4%), in addition, Heskestad et al. [26] estimated that the patients with traumatic brain injury of minimal and mild severity represented about 8% of cases.

The mechanism of injury emerged as an important risk factor in cases of TBI in our study. Road traffic accidents were the most frequent mechanism (37.1%), followed by fall from height (23.9%), then blast injury (16.8%) (Table VII). Our study showed that bullet injuries were significantly associated with more severe injuries

(55.7%), which is much higher than other mechanism of injuries.

Heskestad et al. in Norway [26] reported that frequency of head injuries were falls (51%) followed by (21%) RTAs, while Nayebaghayee et al. [19] and Esnault et al. in [27] showed that RTA was the most common mechanism of cranio-cervical injuries followed by FFH (38%), assault (9%), blast (2%), and penetrating injuries (1%). Given the availability of airbags and improved restraint devices in automobiles, this high rate of cervical injuries is hopefully declining.

Nevertheless, war, blast of terrorism and the poorly applied rules of roads and seat belts in our country make these injuries unfortunately increasing.

All associated injuries were significantly associated with severe traumatic brain injury; also the severity of head injury was significantly associated with the occurrence of cervical injury. Hills and Deanne [28] showed that head-injured patients had a significantly higher risk of cervical spine injury (4.5%) than those without head injury (1.1%). Hypotension is significantly associated with the severity of TBI in our study, it can occur due to severe bleeding from the injury site or as a sequel of spinal injury.

Conclusion

The severity of TBI is significantly related to the type of the associated injury, mechanism of injury, clinical and radiological findings, and to the male gender, while it is not dependent on the age of the patient. Strict traffic rules and safety measures should be applied during driving either cars or motor cycles, including wearing helmets, as there is no concern of wearing helmets in our community; this might help minimize as much as possible head injuries due to road traffic accidents. More attention should be paid to the presence of walls around the roves of houses and along the stairs as they cause people falls from these heights.

References

1. Menon DK, Schwab K, Wright DW, Maas AI; Demographics and Clinical Assessment Working Group of the International and Interagency Initiative toward Common Data Elements for Research on Traumatic Brain Injury and Psychological Health. Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil. 2010;91:1637-1640.
2. Tator C, Bray G, Morin D. The CBANCH report--the burden of neurological diseases, disorders, and injuries in Canada. Can J Neurol Sci. 2007;34:268-269.
3. Langlois JA, Rutland-Brown W, Thomas KE. Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths 2002-2006. CDC Publication: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004. Available from: https://www.cdc.gov/TraumaticBrainInjury/
4. Lafta GA, Dolachee AA, Al-Zubaidi AK. Factors affecting outcomes of surgically treated patients with cranial extradural hematoma: A cross-sectional study. J Acute Dis. 2020;9:105-108.
5. Dewall J. The ABCs of TBI. Evidence-based guidelines for adult traumatic brain injury care. JEMS. 2010;35:54-61; quiz 63.
6. Maegele M, Lefering R, Sakowitz O, Kopp MA, Schwab JM, Steudel WI, et al. The Incidence and Management of Moderate to Severe Head Injury. Dtsch Arztebl Int. 2019;116:167-173.
7. Ruet A, Bayen E, Jourdan C, Ghout I, Meaude L, Lalanne A, et al. A Detailed Overview of Long-Term Outcomes in Severe Traumatic Brain Injury Eight Years Post-injury. Front Neurol. 2019;10:120.
8. Andriessen TM, Horn J, Franschman G, van der Naalt J, Haitsma I, Jacobs B, et al. Epidemiology, severity classification, and outcome of moderate and severe traumatic brain injury: a prospective multicenter study. J Neurotrauma. 2011;28:2019-2031.
9. Hukkelhoven CW, Steyerberg EW, Rampen AJ, Farace E, Habbema JD, Marshall LF, et al. Patient age and outcome following severe traumatic brain injury: an analysis of 5600 patients. J Neurosurg. 2003;99:666-673.
10. Dara PK, Parakh M, Choudhary S, Jangid H, Kumari P, Khichar S. Clinico-radiologic Profile of Pediatric Traumatic Brain Injury in Western Rajasthan. J Neurosci Rural Pract. 2018;9:226-231.
11. Kirankumar MR, Satri V, Satyanarayana V, Ramesh Chandra VR, Madhusudan M, Sowjanya J. Demographic profile, clinical features, imaging and outcomes in patients with traumatic brain injury presenting to emergency room. J Clin Sci Res. 2019;8:132-136.
12. Wan-Ting C, Chin-Hsien L, Cheng-Yu L, Cheng-Yu C, Chi-Chun L, Keng-Wei C, et al. Reverse shock index multiplied by Glasgow Coma Scale (rSIG) predicts mortality in severe trauma patients with head injury. Sci Rep. 2020;10:2095.
13. Lafta GA, Dolachee AA, Al-Zubaidi AK, Hoz SS. A death calls from unsafe heights. A study of factors influencing the outcome of surgically treated pediatric head trauma patients in Baghdad. Int J Res Pharm Sci. 2019;10:1997-2001.
14. Greenwald BD, Burnett DM, Miller MA: Congenital and acquired brain injury. 1. Brain injury: Epidemiology and pathophysiology. Arch Phys Med Rehabil. 2003; 84(3 Suppl 1):S3-S7
15. Jaffee MS, Helmick KM, Girard PD, Meyer KS, Dinegar K, George K. Acute clinical care and care coordination for traumatic brain injury within Department of Defense. J Rehabil Res Dev. 2009;46:655-666.
16. Dolachee AA, Lafta GA, Mohammed AN, Al-Zubaidi AK. Factors affecting the outcome in surgically treated civilian penetrating head injury: Case series. International Journal of Research in Pharmaceutical Sciences. 2019; 10:2120-2126. https://doi.org/10.26452/ijrps.v10i3.1437
17. Macciocchi S, Seel RT, Warshowsky A, Thompson N, Barlow K. Co-occurring traumatic brain injury and acute spinal cord injury rehabilitation outcomes. Arch Phys Med Rehabil. 2012;93:1788–1794.

18. Nazir M, Khan SA, Raja RA, Bhatti SN, Ahmed E. Cervical spinal injuries in moderate to severe head injuries, J Ayub Med Coll Abbottabad. 2012;24:100-102.

19. Nayebaghayee H, Afsharian T. Correlation between Glasgow Coma Scale and brain computed tomography-scan findings in head trauma patients. Asian J Neurosurg. 2016;11:46–49.

20. Eaton J, Hanif AB, Grudzaik J, Charles A. Epidemiology, Management, and Functional Outcomes of Traumatic Brain Injury in sub-Saharan Africa. World Neurosurg. 2017;108:650-655.

21. Munivenkatappa A, Agrawal A, Shukla DP, Kumaraswamy D, Devi BI. Traumatic brain injury: Does gender influence outcomes? J Crit Illn Inj Sci. 2016;6:70-73.

22. Burns J Jr, Hauser WA. The epidemoilogy of traumatic brain injury: a review. Epilepsia. 2003; 44:2-10.

23. Bazarian JJ, Blyth B, Mookerjee S, He H, McDermott MP. Sex differences in outcome after mild traumatic brain injury. J Neurotrauma. 2010;27:527–539.

24. Ghobrial GM, Amenta PS, Maltenfort M, Williams KA Jr, Harrop JS, Sharan A, et al: Longitudinal incidence and concurrence rates for traumatic brain injury and spine injury - a twenty year analysis. Clin Neurol Neurosurg. 2014;123:174–180.

25. Holly LT, Kelly DF, Counelis GJ, Blinman T, McArthur DL, Cryer HG. Cervical spine trauma associated with moderate and severe head injury: incidence, risk factors, and injury characteristics. J Neurosurg. 2002;96(3 Suppl):285-291.

26. Heskestad B, Baardsen R, Helseth E, Romner B, Waterloo K, Ingebrigtsen T. Incidence of hospital referred head injuries in Norway: a population based survey from the Stavanger region. Scand J Trauma Resusc Emerg Med. 2009;17:6.

27. Esnault P, Cardinale M, Boret H. Blunt cerebrovascular injuries in severe traumatic brain injury: incidence, risk factors, and evolution. J Neurosurg. 2017;127:16-22.

28. Hills MW, Deane SA. Head injury and facial injury: is there an increased risk of cervical spine injury? J Trauma. 1993;34:549-553, discussion 553-554.