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Epidemiological Analysis of 135 Cases of Severe Traumatic Brain Injury Managed at a Surgical Intensive Care Unit

Aurélien Ndoumbe[1*], Paul Boris Ngoyong Edu[1], Chantal Simeu[2], Samuel Takongmo[3,4]

[1]Faculty of Medicine & Pharmaceutical Sciences, University of Douala, Douala, Cameroon
[2]Service of Anesthesiology & Intensive Care, University Hospital Center of Yaoundé, Yaoundé, Cameroon.
[3]Faculty of Medicine & Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon
[4]Service of Surgery, University Hospital Center of Yaoundé, Yaoundé, Cameroon
Email: *aurelien.ndoumbe@gmail.com, *aurelen@yahoo.fr

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Abstract

This study was a retrospective analysis of the epidemiologic profile of severe traumatic brain injuries managed at the surgical intensive care unit of the University Hospital Center of Yaoundé, Cameroon, between January 2011 and December 2015. All the patients admitted at the surgical intensive care unit for a traumatic brain injury with an initial Glasgow coma scale score ≤ 8 were included. One hundred and thirty-five cases were enrolled. One hundred and fourteen were males and 21 were females. Their mean age was 32.75 years. Forty-four patients were aged between 16 to 30 years. Road traffic accidents represented the first mode of injury with 101 cases and most of the patients were pedestrians hit by a car. Pupils and students were the most involved. Twenty-three patients had additional extracranial injury. On admission, 97 (71.85%) patients had GCS 7-8. A brain CT scan was done for 115 patients. Intracranial and intracerebral hemorrhages were the most frequent radiological findings with 57 cases. The overall mortality was 32.59% with 44 deaths. Thirty-two of the deaths occurred in patients with GCS 7 - 8 on admission. Ninety-one (67.40%) patients survived, 74 (54.81%) had persisting disabilities, while only 17 (12.59%) recovered fully. The following factors had an impact on the outcome: GCS at admission, pupillary anomalies, length of hospital stay, endotracheal intubation and surgery. Severe TBI remains a heavy socio-economic burden worldwide. In Cameroon where the health system is poorly organized, the outcome of individuals who sustained a severe TBI was dismal.

Keywords

Severe Traumatic Brain Injury, Intensive Care, Epidemiology, Outcome, Cameroon

1. Introduction

Traumatic brain injury (TBI) or head trauma is a major public health issue worldwide that affects 10 million people each year with 4.5 million deaths and 90% of the burden affects low and middle income countries. Severe TBI is defined as TBI with initial Glasgow coma scale ≤ 8 after resuscitation. It threatens life on short term and can lead to persisting neurologic disability which puts a heavy socio-economic burden on the entire society, families and individuals [1]-[11]. Severe TBI is the 3rd leading cause of death in industrialized countries and according to the WHO it might become the leading cause of death and disability worldwide by the year 2020 [1] [8]. It is already the leading cause of death in peoples less than 45 years in developed countries. In 2004 in the USA, 1.5 million individuals were admitted in emergency departments for a TBI and 5.3 million were leaving with a permanent disability after a TBI in that country. In Europe, the annual incidence of TBI was estimated at 235 cases for 100,000 inhabitants (range: 91 - 546 cases for 100,000) [5] [6] [7] [8] [10]. In sub-Saharan Africa in the year 2000 in Mali, the annual incidence of patients hospitalized for a TBI was 2000/100,000 cases [12]. Severe TBI is responsible for most of the deaths due to RTA. The reported mortality of severe TBI in Africa is within 21% - 91% [1] [2] [3] [12] [13] [14]. The goal of this study was to report on the epidemiological analysis of severe TBI treated at the surgical ICU of the University Hospital Center (UHC) of Yaoundé, Cameroon. The age, gender, mode of injury, clinical presentation, computed tomography (CT) findings, management procedures and outcome data were retrospectively reviewed.

2. Patients and Methods

An epidemiological analysis of 135 cases of severe TBI managed at the surgical ICU at the University Hospital center of Yaoundé was done. It was a descriptive, transversal and retrospective analysis from the 1st January 2011 to the 31st December 2016 (recruitment period, 01/01/2011 to 31/12/2015; follow up period, 01/01/2011 to 31/12/2016). The age, gender, mode of injury, clinical presentation, computed tomography (CT) findings, management procedures and outcome data were retrospectively reviewed. The study enrolled all cases of head trauma admitted at the SICU for severe TBI. The severity of the TBI was determined by calculating the initial Glasgow coma scale (GCS) score on admission after resuscitation. The Glasgow coma scale (**Table 1**) was determined by the assessment of patients' eye opening (E), verbal (V) and motor (M) responses to command or painful stimulation. The sum of E + V + M was done. If it was ≤ 8, the patients was categorized as "severe TBI" and included in the study no matter his age. If the GCS score was >8, the patient was labeled as "non-severe TBI" and was not included in the study. The adapted GCS was used for patients less than 4 years old (**Table 1**). Non-severe TBI, patients managed outside the SICU or who died on arrival were not included. After admission, the severe TBI patients were followed on a day to day basis with repeated neurologic examinations and thorough

Table 1. The Glasgow coma scale & the Glasgow outcome score.

GLASGOW COMA SCALE [13]		
Eye Opening (E)	**Verbal Response (V)**	**Motor Response (M)**
4 = opens spontaneously	5 = normal conversation	6 = normal, obeys to command
3 = opens to voice	4 = confused, disoriented	5 = localizes pain
2 = opens to pain	3 = incoherent, inappropriate	4 = withdraws from pain
1 = none	2 = incomprehensible	3 = decorticate posturing
	1 = none	2 = decerebrate posturing
		1 = none
Score = *E* + *V* + *M*. *Minimum* = 3. *Maximum* = 15		

GLASGOW OUTCOME SCORE [2]	
Score	**Definition**
1	Dead
2	Permanent vegetative state
3	Severe disability, dependent
4	Moderate disability, independent
5	Good recovery

clinical evaluation focused on hemodynamic, respiratory, infectious and nutritional aspects. Patients were followed until their discharge from the ICU and the hospital for at least 12 months. Patients with neurologic sequelae were followed until the end of the study. The Glasgow outcome score (GOS) [4] (**Table 2**) was the tool used to evaluate neurological outcome and it was determined at the time of discharge from the hospital, after six months and at the last visit for patients with persisting disabilities.

The statistical analysis was done with the software SPSS 20.0 for Windows® [Microsoft, Seattle, USA].The Fisher and the Chi-square tests were used. The statistical significance was set for p value < 0.05.

3. Results

3.1. Sociodemographic Data

One hundred and thirty-five patients were enrolled in the study. One hundred and fourteen (84.44%) were males and 21 (15.55%) were females (SR, 5.42). Their mean age was 32.75 years (median, 31; SD, 17.68; range, 2 - 70 years). One hundred and two patients (75.55%) were aged 45 or less. The patients aged between 16 and 30 years were the most numerous with 44 (32.59%) cases (**Figure 1**). Pupils and students were the socio-professional category most often involved with 42 (31.11%) cases, followed by civil servants with 25% (N = 34).The road traffic accident(RTA) was by far the first mode of injury with 101 cases (74.81%) and most of the patients were pedestrians hit by a car in 44 cases (**Table 2**). The motorcycles were involved in 33% of the RTA. The assaults were the second mechanism of injury with 20 cases.

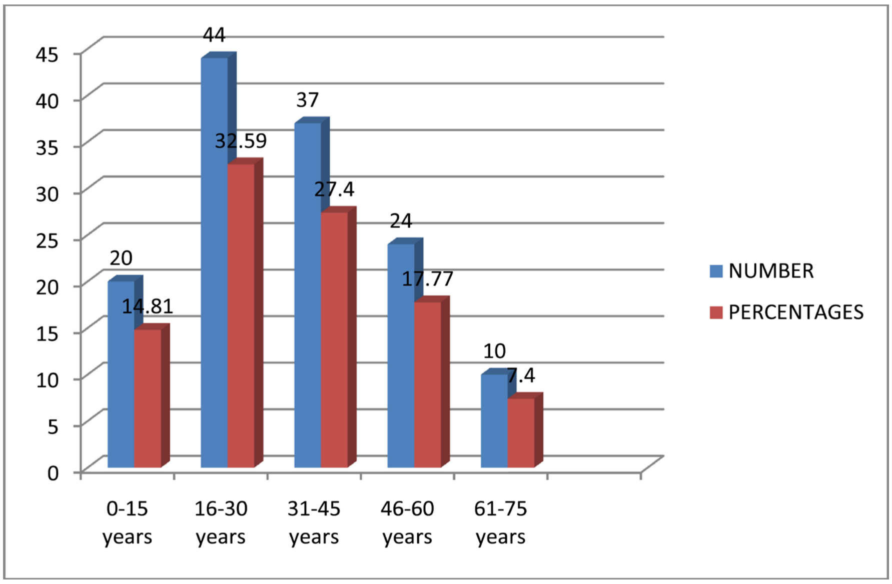
3.2. Clinical Data

At admission, 97 (71.85%) patients had a GCS of 7 or 8 points, 41 (30.37%) had pupillary anomalies. Their mean arterial pressure was <90 mmHg in 47.5% and between 90 - 120 mmHg in 45% of the cases respectively. Twenty-four (17.77%) patients had hemoglobin level < 10 g/dl and 27 (20%) had electrolytes imbalance.

Table 2. Features of the study population.

FEATURES	NUMBER (N)	PERCENTAGES (%)
Number of patients	135	
Gender		
Male	114	84.44
Female	21	15.55
Male: female ratio		5.42: 1
Mode of injury		
Road traffic accidents	101	74.81
Assaults	20	14.81
Falls	03	02.29
Profession		
Pupils/students	42	31.11
Civil servants	34	25
Without employment	17	12.59
Business	10	7.40
GCS scores on admission		
GCS 8	57	42.22
GCS 7	40	29.63
GCS 6	10	07.40
GCS 5	14	10.37
GCS 4	07	05.18
GCS 3	07	05.18
CT findings		
Intracranial/intracerebral hemorrhages	85	62.98
Skull fracture	30	22.22
Pneumocephalus	10	07.40
Isolated cerebral edema	05	03.70
Acute hydrocephalus	03	02.22
Outcome		
Mortality	44	32.59
Survivors	91	67.41
Disability	74	54.81
Full recovery	17	12.59

GCS: Glasgow coma scale; CT: computed tomography.



Mean, 32.75 years; median, 31 years; SD, 17.68. STBI: severe traumatic brain injury. SD: standard deviation.

Figure 1. Age distribution of STBI patients.

Twenty-seven (20%) patients had additional extracranial injury, 4 thoracic injuries and 10 limb fractures (Table 2, clinical profile).

3.3. Radiological Data

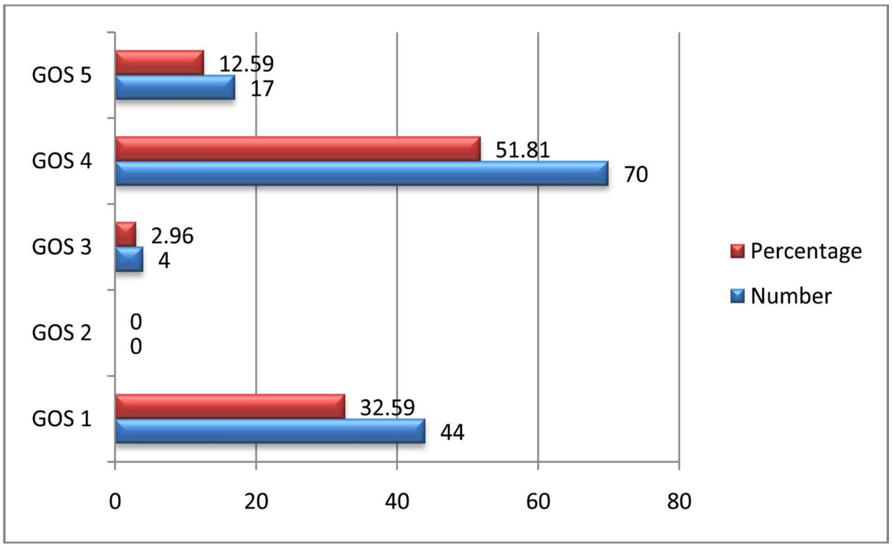
A brain CT scan was done for 115 (85.18%) patients. Intracranial and intracerebral hemorrhages were found in 85 (62.98%) and skull fractures in 30 (22.22%) cases respectively (Table 2, CT findings).

3.4. Management Data

All the patients had empirical and systematic application of some BTF guidelines and recommendations such as: elevation of head over bed at 30˚, nasal oxygenation to maintain oxygen saturation > 92%, maintenance of normal body temperature, and normovolemia by isotonic saline infusion, mannitol osmotherapy, indwelling urinary catheter, nasal gastric tube for precocious enteral nutrition, deep vein thrombosis, stress and decubitus ulcers prevention. Conversely, 65% (N = 88) of the patients were not intubated, though 57.77% (N = 78) were sedated and 31 (23%) had mechanical ventilation. Thirty-four (25%) patients underwent a neurosurgical operation for intracranial, intracerebral hematoma removal; depressed skull fracture or acute hydrocephalus (Table 2). The 27 patients with additional extracranial injuries also had specific management of these injuries.

3.5. Outcome Data

The median follow up period was 42 months (range 12 to 72 months). The overall mortality was 32.59% with 44 deaths (GOS 1). Thirty-two over 44 (72.72%) of the deaths occurred in patients with a GCS 7 - 8 on admission. Thirty-six



GOS 1, dead. GOS 2, permanent vegetative state. GOS 3, severe disability, dependent. GOS 4, moderate disability, but independent. GOS 5, good recovery. STBI: Severe traumatic brain injury.

Figure 2. Outcome of STBI. GOS: Glasgow outcome score.

(81.81%) deaths occurred within the first week of hospitalization. The mortality was higher in patients managed conservatively (77.27% of deaths, N = 34) than in those who were operated (22.73% of deaths, N = 10). Ninety-one (67.41%) patients survived, 74 (54.81%) of them had persisting neurologic disabilities (GOS 3 - 4) while only 17 (12.59%) had a good recovery (GOS 5). The persisting neurologic disabilities were as follows: motor deficits, 43 (31.85%); high mental functions (memory, speech, thought) disturbances, 25 (18.52%); and sphincter disturbances, 6 (04.44%) cases respectively (Figure 2, outcome). The length of hospitalization was ≤7 days in 60% (N = 81) of the cases. The outcome was influenced by the GCS at admission, pupillary anomalies, and the length of hospital stay; endotracheal intubation and surgery.

4. Discussion

Most findings from this series such as age, gender, cause of trauma, were consistent with data from the literature [1]-[6] [11]-[17].

4.1. Age Distribution

The patients' mean age of this series was 32.75 years. Almost 76% of the patients were 45 years or less. The second and third decades were the most involved with 32.59% of the cases. These data are consistent with findings from most authors and reflect the fact that TBI in general and STBI in particular, primarily affect young active populations involved in activities at risk [1]-[6]. It is well established that TBI is the leading cause of death in peoples less than 45 years in developed countries.

4.2. Gender

The male predominance for TBI and STBI is unanimously reported from the literature suggesting that males are more exposed to activities at risk for TBI [1] [2] [4] [5] [11]-[16]. In the present series, males represented 85% of the patients which is similar to that reported by Kinyanjui and Kiwango *et al.*, [1] [2]. Therefore, male gender was a risk factor for sustaining a severe TBI.

4.3. The Cause of STBI

The road traffic accident was the first mechanism of injury and pedestrians were hit by a car most of the time. In Ethiopia, pedestrian accounted for 50% of RTA deaths [3]. Kinyanjui had reported that despite having the lowest rate of car-owner per inhabitant in the world, sub-Saharan Africa faces the highest mortality rates due to RTA per in habitant in the world. This has been labeled "the silent epidemic" [1]. This reflects the fact that in sub-Saharan Africa, cars and roads are generally of poor quality and that driving rules are violated. These findings are obvious in this series where almost 50% of RTA victims were pedestrians hit by cars. Depending on the series, the other modes of injury for severe TBI are falls, assaults, sport and domestic injuries and gunshots in different variations [4] [5] [6] [11] [12] [13] [14] [15].

4.4. The Professions

Pupils and students represented one-third of patients who sustained a STBI in this series. This reflects the fact that most patients were young adults; most of them were pedestrians hit by cars or were motorcycle riders. This is a realistic picture of Cameroon's social demography and is consistent with data reported from other African countries [1] [2] [3].

4.5. Clinical Data

Forty-seven point five percent of the patients had at least one episode of arterial hypotension. This frequency is close to those reported by Chesnut *et al.* and Ouedraogo *et al.* (45.8% and 34.6% respectively) [18] [19] but is quite high compared to the frequency reported by Stochetti [20]. This high occurrence of hypotensive episodes can explain the very low proportion of good outcomes from this series. Arterial hypotension is a well-known factor for poor prognosis in STBI [1] [2] [9] [11].

Seven (5%) patients had at least one episode of arterial hypertension. High levels of arterial pressure can overcome cerebral vascular autoregulation and therefore worsen post-traumatic cerebral edema.

Hypoxemia ($SpO_2 < 90\%$) was present on admission in six (04.44%) patients. This rate was very low compared to the 45% and 57% reported by Chesnut and Stoccheti [18] [20]. The difference is explained by the fact that their series were pre-hospital phase studies. Hypoxemia causes secondary brain insult and is frequently associated with arterial hypotension, grieving the prognosis of STBI patients. Hypoxemia should be promptly corrected whenever noticed [2] [8] [16] [21] [22] [23] [24] [25].

Seventy-two percent of the patients had a GCS score of 7 or 8 at admission, while those with GCS score of 3 - 4 represented only 10%. The low proportion of patients with low GCS scores at admission was probably due to high mortality on the field, therefore these patients did not reach the emergency department or the ICU. According to El-Gindi and Abdel Azeem [3], the documented mortality rates of victims of RTA with TBI in Africa were as follows: 20% - 30% at the site of trauma, 7% - 20% during transportation, and 2% - 10% on hospital admission. We can therefore extrapolate that 29% - 60% of victims of RTA with STBI in Africa might not reach ICUs. In the series from Petroni *et al.* GSC 7 - 8 and 3 - 4 represented 41.9% and 38.5% of the cases respectively [11]. In studies from developed countries, STBI with low GCS (3 - 5) often outnumber those with high GCS (6 - 8) on admission [17] [21] [26]. This discrepancy with our results reflects the fact that STBI patients with low GCS are prone to die before reaching ICU in our setting.

Thirty percent (N = 41) of our patients presented with a pupillary abnormality. The presence of a pupillary anomaly in a STBI patient is a poor prognostic factor and it reported frequency is variable [4] [9] [11] [17].

Twenty percent of the cases of this series had an associated extra cranial injury. The prevalence of extracranial injury in STBI patients could be as high as 77% [4] [9].

Anemia is a deleterious factor for outcome of STBI [9] [21] [22] [23] [27]. For this reason, the hemoglobin level should be maintained above 9 g/dl. In the present series, the hemoglobin level was at some time < 10 g/dl in 37% of the patients.

Hypernatremia is another factor related with poor outcome in STBI and is reported in 16% - 40% of patients and it is associated with increased mortality [9] [28]. Hypernatremia was recorded in 10.52% of the cases in this series. The other electrolytes disturbances noticed were hyperchloremia and hyperkalemia.

4.6. CT Scan Findings

CT scan was done in 85% of the cases of this series. It is not possible to do a CT scan in all patients with STBI because some of them are clinically very unstable and therefore not transportable to the CT scan facility [4], Most findings were intracranial or intracerebral hemorrhages (62.98%) and depressed skull fractures (22.22%). In their study, Oddo *et al.* [21] report that 79% of patients in their series had traumatic SAH or intraventricular hemorrhage on admission CT scan. In the series from Rejeb *et al.* and Petroni *et al.* [9] [11], CT findings were also dominated by intracerebral and intracranial hemorrhages.

4.7. Management

The Brain trauma foundation and other entities have established guidelines for the management of TBI in general and STBI in particular [8] [11] [16] [17] [22]-[27] [29] [30] [31] [32] [33]. The main risk in patients with STBI is the occurrence of intracranial hypertension which develops in more than half of the cases. A refractory intracranial hypertension is responsible for most deaths in STBI. Intracranial pressure monitoring is necessary for managing intracranial hypertension. ICP monitoring is not available in our setting and STBI patients were managed empirically. The presence of an acute mass lesion worsens the prognosis of STBI patients. For patients with such lesions, prompt neurosurgical intervention is mandatory in order to avoid brain herniation. The presence of an acute mass lesion requiring surgical removal is a strong factor for poor outcome in patients with STBI. In this series, 25% of patients had intracranial lesions requiring surgery. But, there was no significant difference in terms of outcome between patients who needed surgery and those who did not. Kinyanjui reports the same percentage of STBI patients managed at ICU and who were operated [1].

In this series, patients were not routinely intubated although more than half were sedated. Tracheal intubation was performed only when a patient showed signs of imminent death. This explains why intubation seemed deleterious to patients in this series. Severe TBI patients although managed at ICUs do not have routine tracheal intubation in most series from sub-Saharan Africa in spite of the recommendations. In this area, the proportion of STBI patients who benefit from intubation is most often lower than one third [13] [15].

All patients of this series had mask oxygenation and this explains why 95.65% had SpO_2 > 90%, though 65% were not intubated. Correcting any hypoxemic episode in the course of STBI improves outcome [8] [16] [21]-[26] [29] [30] [31] [32].

Mechanical ventilation is not systematic but may be required in the management of patients with STBI. In this series, only 35% of the patients had mechanical ventilation. It was always preceded with tracheal intubation and was always performed after neurological deterioration of the patients was observed. The frequency of mechanical ventilation in the management of STBI in sub-Saharan Africa remains very low compared to developed countries (5.3% - 37% vs 96.3%) [13] [15].

4.8. Outcome

The mortality of this series was 32.59% with 44 deaths (GOS 1). Ninety-one (67.41%) patients survived. Seventy-four (54.81%) had permanent neurologic disabilities (GOS 3 - 4) and only 17 (12.59%) recovered fully. The mortality of this series is quite low when it is compared to the mortality reported in other sub-Saharan Africa series for STBI managed at ICUs [1] [2] [13] [15] in which the mortality varies from 54% to 91%. The mortality of the present series was similar to that reported from industrialized countries and this low mortality in our setting can result from empirical application of some guidelines. Only 12.67% (17/135) of the patients recovered fully (GOS 5) and the remainder were disabled at some extent. Kiwango *et al.* reported 63.6% disability prevalence in

STBI in their series [2]. This shows the unanimously admitted poor prognosis related with severe TBI. Although most of the survivors of this series were functionally independent (N = 70; 51.85%), 33.34% showed cognitive or behavioral impairment. In 2013 in Kenya, the prevalence of cognitive impairment in patients who had TBI varies from 32 to 50% depending on the scale used [1]. In long-term, although the majority of patients who sustained a STBI will show good physical recovery with independence in locomotion and basic life skills, most will remain with neuropsychological disabilities such as cognitive and behavioral disorders impeding on social reintegration [34].

On multivariate analysis, the outcome was influenced by the length of hospital stay, pupillary abnormalities and intubation.

5. Conclusion

This study was a retrospective analysis on the epidemiologic profile of patients who sustained a STBI and were managed at the surgical ICU of the UHC of Yaoundé. This service was supposed to be the place where these patients could have the best treatment for their condition in our setting. This series has revealed that in Cameroon, severe TBI patients admitted at ICU are principally young adult males between 16 and 30 years old. Most of them were involved in RTA and were pedestrians hit by a car or were riding motorcycles. Most of them were admitted with high GCS scores 7 - 8, though one third showed pupillary anomalies. Most had intracranial or intracerebral hemorrhages on CT. Their management did not rely on objective application of the recommended guidelines, though some were applied empirically and systematically. The mortality, although significant was quite low for this setting. Nevertheless, the functional outcome was fair in most survivors in terms of motor deficits, memory, cognitive and speech impairments. Therefore, only a few percentages recovered fully.

Conflict of Interest

None.

References

[1] Kinyanjui, B. (2016) Traumatic Brain Injury in Kenya: A Preliminary Review of the Literature. *Sage Open*, 1-7. https://doi.org/10.1177/2158244016638392

[2] Kiwango, G., Msilanga, D., Hocker, M., Gerardo, C., Lester, R., Mvungi, M., *et al.* (2013) Epidemiology of Traumatic Brain Injury Patients at Kilimanjaro Christian Medical Centre, Moshi, Tanzania. *African Journal of Emergency Medicine*, **3**, S4-S10. https://doi.org/10.1016/j.afjem.2013.08.012

[3] El-Gindi, S., Mahdy, M. and Abdel Azeem, A. (2001) Traumatic Brain Injury in Developing Countries. Road War in Africa. *Revista Española de Neuropsicologia*, **3**, 3-11.

[4] Hofman, K., Primack, A., Leusch, G. and Hrynkow, S. (2005) Addressing the Growing Burden of Trauma and Injury in Low-and-Middle-Income Countries. *American Public Health Association*, **95**, 13-17.

https://doi.org/10.2105/AJPH.2004.039354

[5] Bruns Jr., J. and Hauser, W.A. (2003) The Epidemiology of Traumatic Brain Injury: A Review. *Epilepsia*, **44**, 2-10.

[6] Langlois, J.A., Rutland-Brown, W. and Wald, M.M. (2006) The Epidemiology and Impact of Traumatic Brain Injury. A Brief Overview. *The Journal of Head Trauma Rehabilitation*, **21**, 375-378. https://doi.org/10.1097/00001199-200609000-00001

[7] Lingsma, H.F., Roozenbeek, B., Steyerberg, E.W., Murray, G.D. and Maas, A.R. (2010) Early Prognosis in Traumatic Brain Injury: From Prophecies to Predictions. *The Lancet Neurology*, **9**, 543-548. https://doi.org/10.1016/S1474-4422(10)70065-X

[8] Bhat, R., Hudson, K. and Sabzevari, T. (2008) An Evidence-Based Approach to Severe Traumatic Brain Injury. *Emergency Medicine Practice*, **12**, 1-24.

[9] RejebBelfekih, I., Chakroun, O., Chtara, K., Boujelbene, M., Ksibi, H., Chaari, A., *et al.* (2015) Factors Predicting Early Outcome in Patients Admitted at Emergency Department with Severe Head Trauma. *Journal of Acute Disease*, 68-72.

[10] Mathe, J.F., Richard, I. and Rome, J. (2005) Sante publique et traumatismes crâniens graves. Aspects épidémiologiques et financiers, structures et filières de soins. *Annales Françaises d'Anesthésie et de Réanimation*, **24**, 688-694. https://doi.org/10.1016/j.annfar.2005.03.029

[11] Petroni, G., Quaglino, M., Lujan, S., Kovalevski, L., Rondina, C., Videtta, W., *et al.* (2010) Early Prognosis of Traumatic Brain Injury in an Urban Argentinian Trauma Center. *The Journal of Trauma Injury, Infection, and Critical Care*, **68**, 564-570. https://doi.org/10.1097/TA.0b013e3181ce1eed

[12] Coulibaly, Y., Diallo, A., Doumbia, D., Keïta, M. and Keita, M. (2004) Traumatisme crânien a l'hôpital du point G. *Mali Médical*, **3**, 29-30.

[13] Motah, M., Belley Priso, E., Beyiha, G., Ngonde Sende, C., Malongue Nguemgne, C., Verbova, L.N., *et al.* (2008) Prise en charge du traumatisme crânien isolé à l'Hôpital General de Douala. *Pan African Medical Journal*, **8**, 115-120.

[14] Karim, T., Bensalah, N., Rebillard, L. and Vigue, B. (2008) Epidemiologie des traumatismes craniens. *MAPAR*, **1**, 141-150.

[15] SimaZue, A., Benamar, B., Ngaka, D., Mbini, J.C. and Nzoghe, J.J. (1998) Reanimation en milieu africain. Experience du Centre Hospitalier de Libreville. *Medecine d'Afrique Noire*, **45**, 8-9.

[16] Stiefel, M.F., Spiotta, A., Gracias, V.H., Garuffe, A.M., Guillamondegui, O., Maloney-Wilensky, E., *et al.* (2005) Reduced Mortality in Patients with Severe Traumatic Brain Injury Treated with Brain Tissue Oxygen Monitoring. *Journal of Neurosurgery*, **103**, 805-811. https://doi.org/10.3171/jns.2005.103.5.0805

[17] Härtl, R., Gerber, L.M., Ni, Q. and Ghajar, J. (2008) Effect of Early Nutrition on Deaths due to Severe Traumatic Brain Injury. *Journal of Neurosurgery*, **109**, 50-56. https://doi.org/10.3171/JNS/2008/109/7/0050

[18] Chestnut, R.M., Marshall, L.F., Klauber, M.R., Blunt, B.A., Baldwin, N., *et al.* (1993) The Role of Secondary Brain Injury in Determining Outcome from Severe Head Injury. *Journal of Trauma*, **34**, 216-222. https://doi.org/10.1097/00005373-199302000-00006

[19] Ouedraogo, N., Ouandaogo, S., Kaboré, R.A.F. and Rouamba, A. (2010) Traumatisme crânien grave au CHU Souro Sanou de Bobo-Dioulasso. *Reanoxyo*, **26**, 58-61.

[20] Stoccheti, N., Furlan, A. and Volta, F. (1996) Hypoxemia and Arterial Hypotension at the Accident Scene in Head Injury. *Journal of Trauma*, **40**, 764-767.

https://doi.org/10.1097/00005373-199605000-00014

[21] Oddo, M., Levine, J.M., Mackenzie, L., Frangos, S., Feihl, F., Kasner, S.E., *et al.* (2011) Brain Hypoxia Is Associated with Short-Term Outcome after Severe Traumatic Brain Injury Independently of Intracranial Hypertension and Low Cerebral Perfusion Pressure. *Neurosurg*, **69**, 1037-1045.

[22] Bratton, S.L., Chesnut, R.M., Ghajar, J., McConnell Hammond, F.F., Harris, O.A., Hartl, R., *et al.* (2007) Guidelines for the Management of Severe Traumatic Brain Injury. 3rd Edition, *Journal of Neurotrauma*, **24**, S1-S106.

[23] Haddad, S.H. and Arabi, Y.M. (2012) Critical Care Management of Severe Traumatic Brain Injury in Adults. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, **20**, 12. https://doi.org/10.1186/1757-7241-20-12

[24] Ghajar, J. (2000) Traumatic Brain Injury. *The Lancet*, **356**, 923-929. https://doi.org/10.1016/S0140-6736(00)02689-1

[25] Scaife, E.R. and Statler, K.D. (2010) Traumatic Brain Injury: Preferred Methods and Targets for Resuscitation. *Current Opinion in Pediatrics*, **22**, 339-345. https://doi.org/10.1097/MOP.0b013e3283395f2b

[26] Gerber, L.M., Chiu, Y.-L., Carney, N., Härtl, R. and Ghajar, J. (2013) Marked Reduction in Mortality in Patients with Severe Traumatic Brain Injury. *Journal of Neurosurgery*, **119**, 1583-1590. https://doi.org/10.3171/2013.8.JNS13276

[27] Sekhon, M.S., McLean, N., Henderson, W.R., Chittock, D.R. and Griesdale, D.E. (2012) Association of Hemoglobin Concentration and Mortality in Critically Ill Patients with Severe Traumatic Brain Injury. *Critical Care*, **16**, R128. https://doi.org/10.1186/cc11431

[28] Kolmodin, L., Sekhon, M.S., Henderson, W.R., Turgeon, A.F. and Griesdale, D.E.G. (2013) Hypernatremia in Patients with Severe Traumatic Brain Injury: A Systematic Review. *Annals of Intensive Care*, **3**, 35. https://doi.org/10.1186/2110-5820-3-35

[29] Aries, M.J.H., van der Naalt, J., van den Bergh, W.B., van Dijk, M., Elting, J.W.J., Czosnyka, M., *et al.* (2015) Neuromonitoring of Patients with Severe Traumatic Brain Injury at the Bedside. *The Netherlands Journal of Critical Care*, **20**, 6-12.

[30] Bernard, S.A., Nguyen, V., Cameron, P., Masci, K., Fitzgerald, M., Cooper, D.J., *et al.* (2010) Prehospital Rapid Sequence Intubation Improves Functional Outcome for Patients with Severe Traumatic Brain Injury. A Randomized Controlled Trial. *Annals of Surgery*, **252**, 959-965. https://doi.org/10.1097/SLA.0b013e3181efc15f

[31] Dinsmore, J. (2013) Traumatic Brain Injury: An Evidence-Based Review of Management. Continuing Education in Anaesthesia, Critical Care & Pain. https://doi.org/10.1093/bjaceaccp/mkt010

[32] Robertson, C.S. (2001) Management of Cerebral Perfusion Pressure after Traumatic Brain Injury. *Anesthesiology*, **95**, 1513-1517. https://doi.org/10.1097/00000542-200112000-00034

[33] Zeng, T. and Gao, L. (2010) Management of Patients with Severe Traumatic Brain Injury Guided by Intraventricular Intracranial Pressure Monitoring: A Report of 136 Cases. *Chinese Journal of Traumatology*, **13**, 146-151.

[34] De Guise, E., LeBlanc, J., Feyz, M., Meyer, K., Duplantie, J., Thomas, H., *et al.* (2008) Long-Term Outcome after Severe Traumatic Brain Injury: The McGill Interdisciplinary Prospective Study. *The Journal of Head Trauma Rehabilitation*, **23**, 294-303. https://doi.org/10.1097/01.HTR.0000336842.53338.f4

Abbreviations

CT: Computed tomography
BTF: The Brain Trauma Foundation
EDH: Epidural or extradural hematoma
GCS: Glasgow coma scale
GOS: Glasgow outcome score
(S)ICU: (Surgical) intensive care unit
ICP: Intracranial pressure
LOC: Loss of consciousness
SAH: Subarachnoid hemorrhage
TBI: Traumatic brain injury
STBI: Severe traumatic brain injury
UHC: University Hospital Center.