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Research Article

Neurosurgical Ballistic Injuries in Madagascar

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Received: September 19, 2019 ; **Published:** October 22, 2019

Abstract

Introduction: Ballistic trauma is the consequence of the penetration into the body of a projectile. The aim is to describe the epidemiological and clinical aspects of ballistic trauma in neurosurgery in Madagascar.

Methods: This is a descriptive, retrospective and multicenter study of 38 cases of firearm trauma collected in the neurosurgery departments of Chujra, Cenhosoa and Chu Fianarantsoa.

Results: Ballistic trauma in neurosurgery is still rare in Madagascar. Our study included 38 patients over a period of 5 years. The involvement of the cephalic region predominates in spinal involvement with 24 cases against 14. The sex ratio was 8.5. The wounds were predominantly penetrating, not fatal. Management includes almost systematic antibiotic therapy and broad tetanus coverage. Complementary examinations were focused on imaging including radiography and CT. Surgical treatment was function of the clinic. The most common complications were acute retentions of the urine and chronic headaches. The survival rate of our patients was 97.36%. The Glasgow Coma Scale has been a good indicator of survival, the only patient with a GCS at 7 has died.

Conclusion: The management of a traumatic ballistic in neurosurgery should be evaluated according to clinical and imaging results.

Keywords: *Firearm; Neurosurgery; Wound; Brain Scanner; Trauma*

Introduction

Ballistic trauma is the result of the penetration into the body of a projectile. They are no longer the prerogative of wars.

A French epidemiological study collected 22,000 wounds with firearms and knives over a period of 10 years [1]. Wounds in France represent 5 to 13% of injuries and 1% of all victims treated by SMUR [2,3]. The ratio of knives to firearms varies from country to country. In France, this ratio varies according to the authors from 3/2 to 6/1 [1,3]. In the United States, this ratio is reversed from 2 wounds per gun for a stab wound to 9/1 in North Carolina [4,5]. These traumas occur in half of cases following an attack, in one third of cases by autolysis [6]. The overall mortality of pre-hospital penetrating trauma is 15% (6% by stab and 32% by firearm) [2,3]. In the hospital, it is estimated at 8%, respectively 2% and 16% for knives and firearms [1]. With regard to head injuries by firearms, they remain rare in France. They are mainly due to suicide attempts, less frequently to assaults or hunting accidents [7]. Characterized by the impact of a projectile with high kinetics, it is often serious head injuries with significant morbidity and mortality [8]. In developing countries, gunshot wounds are the third leading cause of vertebromedullary trauma in the civilian population after road accidents and stab wounds. They are also the main cause of spinal trauma with visceral involvement [9,10].

In Madagascar firearm accidents are becoming more and more relevant with the socio-economic decline and the recrudescence of insecurity in direct correlation with the political crises that have occurred in the country [12].

Aim of the Study

Our work aims to study the epidemiological and clinical aspects of ballistic trauma in neurosurgery.

Methods

This is a retrospective descriptive and multicenter observational study, conducted over a period of 5 years (January 2013-December 2017) in the neurosurgery departments of the Joseph Ravoahangy Andrianavalona University Hospital, CH Soavinandriana and the Fianarantsoa University Hospital.

Our work concerns neurosurgery admissions for ballistic injuries during our study period.

Included in the study: patients with cranio-cerebral and/or vertebromedullary injuries by firearms, operated or not, admitted to neurosurgery services with medical records.

We studied the epidemiological-demographic variables, location and type of lesions, clinical manifestations, imaging data, therapeutic aspect and evolution.

Data analysis was done on software: Microsoft Word and Excel 2016, Epi info 7.2.2.6.

Results

During the study period, 38 patients were selected from 76 cases of ballistic injuries recorded in the three neurosurgical departments. The average age of our patients was 31 years old with extremes of 6 years to 65 years. Of a total of 38 patients, 34 were men or 89.47% and 4 were women or 10.52%; for a sex ratio H/F = 8.5.

Of our 38 cases, 25 were due to acts of banditry (65.78%), 12 cases were secondary to aggression (31.57%) and one case was due to attempted autolysis (2.63%). Note that banditry is particularly prevalent in rural Madagascar. It is an act of plunder organized band called "dahalo", whose main victims are the farmers-breeders.

Of the 38 patients, 24 had skull trauma (63%) and 14 spine (27%). Table 1 and 2 show the precise topographies of these lesions.

Seat	Number (out of 24)	Percentage
Frontal	9	37,5%
Frontoparietal	1	4,16%
Parietal-temporal	1	4,16%
Parietal	2	8,33%
Temporo-occipital	1	4,16%
Temporal	6	25%
Occipitital	3	12,5%
Parietal-occipital	1	4,16%

Table 1: *Distribution of lesions in the skull.*

Seat	Number (of 14)	Percentage
Cervical	6	42,86%
Cervicothoracic	1	7,14%
Thoracic	3	21,43%
Thoracolumbar	3	21,43%
Lumbar	1	7,14%

Table 2: *Distribution of lesions in the spine.*

According to the lesion, of the wounds found, 2 were transfixing (5.26%), 2 were tangential and 34 were penetrating (89.47%). All tangential wounds and 3 penetrating wounds in the skull were associated with 20.83% of cranial trauma fractures. Four spinal wounds located at the level Cervical were unstable at 28.57% of the spinal lesions. All transfixing wounds and 2 penetrating wounds in the skull were associated with loss of brain substance. Two patients had a state of cardiovascular failure at entry (5.26%). Five patients had a hyperthermia state of 13.15%, 2 of which were associated with sepsis. The rest of the patients had a stable condition. Of the 24 traumatized skulls in our series, we found a Glasgow score between 13 - 15 in 19 patients (79.1%), a GCS between 10 - 12 in 4 patients (16.6%), and a GCS equal to 7 in one patient (4.16%).

An abnormality of the photomotor reflexes was found in 3 patients (12.5%), including one patient with anisocoria who died as a result of cerebral involvement (Table 3).

Pupils	Name	Percentage
Reactive	21	87,5%
Anisocories	1	4,16%
Myosis series	2	8,33%

Table 3: *Photomotor reflexes in traumatized skull.*

There were 3 patients with sensory deficits such as paresthesia (12.5%), 3 patients with hemiparesis (8.33%) and single-sided motor deficits (4.16%); and 3 patients with sensorimotor deficits such as hemiplegia (8.33%) and tetraplegia (4.16%).

In the 14 spinal trauma patients, 6 patients (42.85%) had sensory and motor deficits such as hemiparesis or hemiplegia with hyperesthesia or paresthesia. One patient presented with quadriplegia and another presented isolated paresthesia.

Deficits paresis and hemiplegia are found in patients with thoracic and lumbar spine. Quadriplegia is a patient with C5 trauma with cervical fracture.

After evaluation by Frankel score (Table 4), only one out of 14 patients presented a grade B (7.14%). This patient suffered a fracture at C5. In the other cases, 4 patients presented a grade C (28.57%), 3 patients presented a grade D (21.43%) and 6 patients presented a grade E (42.86%).

Score of Frankel	Names (14 case)	Percentage (%)
Grade A	0	0
Grade B	1	7,14
Grade C	4	28,57
Grade D	3	21,43
Grade E	6	42,86

Table 4: *Evaluation of Frankel's score in traumatized spine.*

Ballistic injuries were associated with other lesions: 6 cases of maxillofacial trauma (15.78%), 4 cases of thoracic trauma (10.52%), 4 cases of limb trauma (10.52%), 2 cases of abdominal trauma (5.26%) and one case of ophthalmic trauma (2.63%).

The results of the imaging examinations: x-ray images showed images of loss of bone continuity: 5 fractures involved (20.83% of head trauma), 5 vertebral fractures (35.71% of spinal trauma) and 2 fractures bones of the face (8.33% of cranial trauma).

The CT scan made it possible to specify certain lesions: at the level of the skull: intracerebral œdemato-haemorrhagic contusion, intra-parenchymal hematoma, ORL-O fracture (mandibular fracture, facial fracture with involvement of all the orbital walls), at the level of the spine: C5 posterior arch fracture, C3 joint fracture, presence of intracanal debris.

Of the 38 patients, 10 patients (26.31%) underwent surgery and 3 patients were pared (7.89%), four patients with spinal trauma associated with instability and/or signs of deficiency benefited from laminectomy (28.57%), four patients with good general condition benefited from a projectile extraction (10.52%), three patients with embarrassed fractures benefited from recovery of embarrassment (12.5%), 5%) and a patient with cerebral involvement by ventricular flood and intraparenchymal hematoma benefited from an external ventricular bypass (4.16%).

Sequelae encountered in our study, in the traumatized spine: chronic retentions of the urines 5 (35.71%), a disorder stepping type (7.14%) and neuropathic pain members in one patient (7.14%).

In traumatic brain injury: chronic headache 4 (16.66%), bilateral blindness (4.16%), chronic headache associated with a language disorder (4.16%) and monoplegia (4, 16%).

Discussion

Globally, in 2016, approximately 251,000 people died from firearm injuries [12]. In Madagascar, the percentage of homicides committed with a firearm is estimated at 39% in 2011 [13]. In 2010, the United Nations Office on Drugs and Crime (UNODC) calculated the death rate from firearms on a statistical basis from 108 countries (covering just over 50% of overall killings in the world). The results show that about 199,000 homicides out of the estimated 468,000 in 2010 were committed by firearms, or 42% [14]. In 2016, the World Health Organization or WHO gives a homicide rate of 0.9 per 100 000 inhabitants in France, 6 per 100 000 inhabitants in the United States and 27 per 100 000 inhabitants in Brazil [15].

Several studies report that ballistic injuries in neurosurgery mainly concern young adults with an average age of 20 to 35 years [16-18]. The study of 49 cases of in-hospital balloon trauma at the University of Alberta and Royal Alexandra Hospital reports an average age of 30 years [19]. Our results are consistent with those of the literature. Whatever the trauma, the majority of victims often seem to be in the middle age group [11]. This situation could be explained by the fact that young people are more exposed to the factors responsible for the rise in crime.

Ballistic traumas in neurosurgery affect, with a large predominance, men. A study in relation to spinal disorders found an impairment in 236 men against 16 women, a sex ratio of 14.7 [18]. Another study of cranial involvement reported 639 cases in men compared to 55 cases in women, a sex ratio of 11.6 [16].

According to Statistics Canada data on hospitalization for 1993 and 1994, 25% of firearm injuries requiring acute care are inflicted by the victims themselves, for example in the case of attempted suicide. About 43% of injuries are classified as accidents and 22% are caused by others. In almost 9% of cases, the case is not established, and the remaining 1.7% is the result of police intervention [20]. In Canada, over the past 25 years, there has been an average of 1,300 firearm-related deaths each year. Of the 1,125 firearm deaths that occurred in 1995, about 80.1%, or 911, were classified as suicides; there were 145 homicides, or 12.4%; and finally 49 unintentional deaths, which is 4.3% of the total [20]. In Nigeria, the majority of injuries (75%) result from attacks involving activities such as armed robberies, sectarian rivalries, community clashes and terrorist raids. Stray bullets were the cause in 9.6% of cases and attempted suicide in 1.9% of cases [21-22]. The trend of suicidal acts by firearms remains low in the African region.

The frequency of head and neck wounds by penetrating trauma in civilian practice is highly variable. It depends on studies, types of weapons and other criteria. For example, in the Paris region, a study of 304 firearm wounds found 45% of head and neck damage [1]. In the United States, the number of people injured by firearm injuries was 110,215 in 2008. Of all the traumatic brain injuries secondary to traumatic brain injury, 35% are due to gunshot wounds in the head [30]. For spinal injuries 17% are related to firearms [23]. Headquarters of lesions in the skull in frequency order are: frontal (38%), temporal (28%), parietal (12.5%), fronto-parietal (9.3%), occipital (6.2%), fronto-temporal (3.1%), parieto-occipital (3.1%). Most of the spinal involvement is in the dorsal region at 66%, followed by the lumbar region at 17%, and the least affected is the cervical region at 6%.

In a study carried out at the emergency unit of the Loreto Mare Hospital in Naples conducted on 23 traumatized head injuries, 22 wounds were penetrating, tangential and no transfixing. Other authors state that less than 40% of non-lethal head injuries are tangential. In fact, a retrospective study conducted at the University of the Southern California Medical Center between October 1993 and May 1996 reported 420 patients with gunshot wounds to the head, of which 154 patients (36.7%) had tangential wounds]. On the other hand, in most spinal lesions, the wound is transfixing, and only small fragments (in total < 50% of the projectile) remain in the spinal canal. Secondly, there are cases in which the projectile is housed inside the canal, comprising 20.4% of cases [25-26]. In the literature, two cases of bullet lodged in the spinal canal without damage to bone structures of the spine have been reported. In both cases, the lesion was in the thoracic region [27,28].

In the literature, the Glasgow score is a major predictor of prognosis. Patients with a Glasgow score of less than 8 have a poor prognosis. From 1988 to 2002 data from 16 brain-injured patients treated at Taichung Veterans General Hospital were reviewed retrospectively. Of the 7 patients with a Glasgow Coma Scale (GCS) score of more than 8, all survived with satisfactory results. Of the 9 patients with a GCS score below 8, eight had poor results (5 deaths and 3 in persistent vegetative state) [29]. Tangential wounds are almost always favorable, but penetrating and penetrating wounds represent a high risk factor for mortality. In this same series, the satisfactory outcome rate was significantly higher in 7 patients with limited brain injury, as determined by CT, than in 8 patients with extensive brain injury (86% versus 25%) [29].

Other than GCS, pupil reactivity is also a prognostic factor. Multiple studies report results with increased mortality rates associated with pupillary abnormalities. The absence of a pupillary response is correlated with an unfavorable result. In 96% to 100% of patients who died from gunshot wounds in the head, a unilateral dilated pupil or a fixed median pupil was found. In patients with bilateral reactive pupils, the recovered mortality rate is 23.5% [29,30]. Another study found a mortality rate of 80% in patients with dilated bilateral dilated pupils versus only 1.5% of good results [31,32].

Some studies show that the localization of the lesion determines the deficit, so that cervical lesions lead to complete neurological deficits in 70% of cases [33,34]. On the other hand, lesions of the spinal cord of the ponytail and lumbosacral level are incomplete in 70% of the cases [35,36]. Gunshot wounds in the spinal area are generally stable [37]. If a bullet breaks the pedicle or facet during the crossing in the lumbar region, it can cause acute or chronic instability [38]. However, the cervical and lumbar vertebrae are more prone to biomechanical instability [39].

According to the authors, during thoraco-vertebral ballistic wounds, cerebromedullar lesions are found in 5 to 16% of cases depending on the series [40-42]. A retrospective study at Northern Nigerian Teaching found a maxillofacial and cranial association of firearm wounds. A descriptive retrospective study of 128 patients with traumatic spinal cord injuries hospitalized between 1992 and 2012 in Algiers gave the following results: the vertebral level is thoracic (57%) with hemopneumothorax (34%), and lumbar (40%) with trauma abdominals (37%); the other associated lesions were osseous in 21 patients, and peripheral neurological in 5 patients [43]. Another 5-case study reported that visceral-involvement firearm-related cerebromedullar injuries accounted for 2.22% of all spinal injuries and 27.77% of spinal injuries by firearms [44].

The main objectives of imaging are to determine the trajectory of the projectile (s), to assess which tissue has been injured, to estimate the severity of the injury and to determine what additional studies are needed [45,46]. Digital radiography and computed tomography play a vital role in the evaluation of gunshot wounds. When the clinic allows it, magnetic resonance imaging is also a valuable imaging modality for the evaluation of these injuries [47].

Surgical management of cranio-cerebral wounds by bullet is controversial. Some neurosurgeons favor a surgical approach consisting of minimal local debridement while preserving the brain tissue as much as possible. Other neurosurgeons are more aggressive and attempt to remove all reasonably accessible bone and metal fragments [48]. In theory, intracranial bones and metal fragments that are not removed could be associated with a higher infection rate, but in other patients there was no correlation between the presence of preserved fragments and the development of intracranial infection or epilepsy [49]. Tsuei., *et al.* [29] have suggested an algorithm for penetrating bullet brain injury in which the decision whether or not to proceed with surgery is made based on GCS and pupillary responsiveness. Patients with GCS 3 to 5 after resuscitation, who have reactive pupils and are not hypotensive should receive a CT scan [50]. Surgical procedures include mainly irrigation, devitalized tissue debridement and removal of mass-effect hematomas, depressed bones and accessible bullet fragments. In the absence of a significant mass effect, surgical debridement of the projectile trajectory is not recommended [51].

The use of surgery for spinal disorders presents very little interest and many risks of complication in the case of complete or incomplete cervicothoracic deficits, whereas a neurological deficit at the lumbar level requires surgery [52]. For Lin, surgery is not indicated when the neurological deficit is incomplete. According to a study by Meyer [37], spinal wounds by firearm only require surgery in 4.3% of cases.

The objective of surgery is not the extraction of the projectile, it is indicated in the following cases [37,53]: severe instability, progressive secondary post-traumatic kyphosis, ductal obstruction, secondary aggravation of a neurological deficit, projectile migration. For Yashon [54], emergency surgical decompression with a laminectomy with trimming, extraction of intracanal bone and metal fragments and dural closure are the best attitude at the lumbar level. Extraction of the projectile and bone and metal fragments would promote motor recovery when the lesion sits below L1 [54]. Decompression or extraction of the projectile when it leads to a canal obstruction with trimming improves motor recovery when the lesion is located in the lumbar region and the deficit is incomplete [54].

Sequelae and complications at the cranial level, infection [55], cranio-cerebral wounds are associated with a high risk of early secondary epilepsy (10%) or delayed (40%) [56], complications vascular: aneurysm, the peak of occurrence of this complication is between 10 and 20 days after the trauma [57]. In addition to the infectious complications, the spinal location of the lesions increases the complications of decubitus and the occurrence of depressive syndromes [43].

Conclusion

The peculiarity of ballistic traumas in Madagascar is related to its main origin: the flight of zebu by the "dahalo". Affections predominate in the male gender, in the regions. The main cranial location is frontal whereas it is cervical in the spinal lesions. The initial clinic is evaluated from the GCS with a satisfactory survival rate for GCS ≥ 10. The clinic is polymorphic with signs deficient for both cranial and spinal disorders. Complications were noted at the cephalic and spinal level. The examinations received were limited to X-ray and CT because there was essentially no financial means. The medical treatment was mainly aimed at prevention and for analgesic purposes. The surgical measures were oriented according to the clinic. The survival rate of patients admitted to neurosurgery was 97.36%. Despite therapeutic measures, 36.83% of our patients had sequelae. The admission rate of ballistic victims in neurosurgery does not reflect the reality in terms of incidence. Health care infrastructure (hospitals, roads, evacuation services, etc.) is still insufficient given the growth of victims of firearm trauma. Insecurity also remains a hot topic. The strengthening of care at the pre-hospital level, the standardization of care as well as the improvement of technical platforms (imaging service) and social benefits (social security, life insurance) are recommended to allow optimal patient management.

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