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THE BLAST INJURED: EXPERIENCE OF THE ARMY TRAINING HOSPITALOMAR BONGO ODIMBA

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ABSTRACT

Objectives: To highlight the specificities of blast trauma in our context and analyzetheir management. ***Material and Method:*** Single-center, retrospective study from April 1, 2018 to January 31, 2020. ***Inclusion criteria:*** Patients admitted in emergency for explosion trauma. ***Results:*** 11 patients included. Average age was 37.82 The sex ratio (M/F) was 4.5. The injuries during industrial explosions were the mostnumerous (63.64% n=07). Among the injuries recorded we had (9.09% n=01) primary injuries, (18.18% n=02) secondary injuries, (9.09% n=01) tertiary injuries. The burnwas the quaternary injury, almost systematic, with a predominance of deep 2nd degreeburns. Mortality (45.4%, n=05) was related to respiratory and other complications. The average length of staywas 8.81±12.52 days. ***Conclusion:***The blast-injured patient is a criticallyill patient with multiple trauma. Blast-related injuries should be systematically investigated, as they can lead to secondary respiratory and hemodynamic complications. Burns are the mostcommoninjury in civilian explosions in Gabon. Addressing these factors could improve the prognosis of these severely injured patients.

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INTRODUCTION

An explosion is a physical phenomenon resulting in a significant release of energy in a very short time in the form of high-pressure, high-temperature gas production [1,2]. Explosion injuries constitute a public health problem due to their frequency, severity, and the complexity of their treatment. Explosion-related pathology has never ceased to be a concern for researchers and clinicians. Worldwide, and more specifically in the West, explosions are the result of numerous terrorist attacks. Initially a concern of wars and military medicine, explosions have subsequently developed in both industrial and domestic settings [1]. The most common explosions are mechanical (pressure cooker explosion), electrical (electric arc with sudden heating and air expansion), nuclear, and chemical. The term "blast" is associated with the notion of explosion, an anglicism used in the absence of a French expression to designate the anatomical lesions and the clinical syndrome caused by the exposure of the organism to the effects of a strong explosion. Strictly speaking, "pure" blast concerns primary lesions linked solely to the physical effects of the shockwave, which is a purelystaticover pressure wave. Despite the divergences of authors, usage has led to the acceptance that blast, blast injury, shockwave and blast effect are synonyms [1,2]. In Africa, explosions are more often the result of industrial and domestic accidents. Their frequency could be increased due, on the one hand, to the frequent use of gasstoves and the use of butane gas. This use, carried out by under integrated populations who are sometimesuna ware of the rules and risks, exposes people to explosions. On the other hand, the development of an industrialfabric (boilermaking, gas, etc.) in many Central African countries, particularly Gabon, could see an increase in this type of accident. However, the subject of blast trauma is rarely addressed by African authors. It is therefore difficult to assess the incidence of this serious pathology in tropical environments. In this context, we proposed to conduct a study focusing on blast injuries (trauma), the objective of which was to highlight the specificities of blast trauma in our context and analyze their management.

MATERIALS AND METHODS

This study took place in the intensive care and burn unit of the Omar Bongo Ondimba Army Training Hospital (HIA OBO). Our study is

retrospective and covered a period from April 1, 2015, to January 31, 2020, a total of 56 months. Patients were identified from the intensive care unit's clinical records and hospitalization records. We included all patients admitted as emergency patients who suffered blast trauma, regardless of the cause. Our study did not include blast victims who were not directly admitted to the HIA OBO. For each patient, the following variants were studied using a data collection sheet, and data entry and analysis were performed using EPI INFO version 7 software. Microsoft Office EXCEL 2010 was used to create the graphs. Authorizations were obtained from the Head Physician of the facility, and data confidentiality was respected.

RESULTS

A total of 11 patients were included over a 56-month period. These patients were reportedly traumatized following four explosions. Two occurred at an industrial site (an oil platform in the interior of the country). The other two (2) were domestic, occurring in residential areas. These were airborne explosions; 10 of the 11 patients were victims of an explosion in a closed airspace. Regarding the explosives, we were only able to determine this in two explosions. These involved butane gas for domestic use. The mean age was 37.82 ± 15.99 years. The range was 1 to 58 years. Of the eleven patients included, nine (9) were men and two (02) were women. The sex ratio was 4.5 in favor of men. Ofour eleven (11) patients identified, seven (07) were workers, or 63.6% were explosion victims. Regarding the circumstances of occurrence, industrial explosions predominated (63.64 n=7) followed by domestic accidents. (Table 1).

Table 1. Circumstances of Accident Occurrence

Explosion Location	Incidence (n)	Number of Victims
Industrial Explosion	2	7
Domestic Explosion	2	4
Total	4	11

In blasts, we found a number of anatomicallesions and clinical syndromes consistent with their pathophysiology. In our case series, we reported one blast lesion in one of our patients. This was a basithoracicinfiltrate image on chest X-ray, suggesting a pulmonary contusion, this lesion was associated with a tympanic membrane perforation on otoscopy. Secondary lesions were noted in two cases. These included polycribbling and two cervical wounds from metal structures (probablynails), as shown in Figure 1.

Figure 1. Cervical projection of metal fragments (reference: Our study)

Only one case of tertiary injury was found in the included population ; this was an open ankle fracture. At the quaternary level, a burn was the injury systematically found in all our patients. Its extent and depth varied. The average body surface area burned was 56.4 ± 25%, ranging from 15% to 91%. According to the anatomical distribution of the burns, the most affected areas were the trunk, the upper limbsin 91% of cases, followed by the face and lower limbs in 9 patients, as shown in Table 2. We observed severe burns that all ranged from superficial 2nd degree to 3rd degree (Figure 2). Six (06) of our patients, or 54.5%, were treated after the explosion by witnesses. Five (05) of our patients received secondary medical transport, three (03) received secondary non-medical transport, and the remaining three (03) arrived at our facility on their own.

Table 2. Distribution of burns by anatomical location

Distribution of burns	Number (n)	Percentage (%)
Head	2	18,2
Face	9	81,8
Hands	4	36,4
Trunk	10	90,9
Upperlimbs	10	90,9
Lowerlimbs	9	81,8

We note that two (02) of our patients under went medical imaging (chest X-ray coupled with a body scanner) upon admission to the emergency room. None of our patients under went endoscopy. None of our patients received an ophthalmological assessment. In terms of care, all of our patients received warming, dressings, and multimodal analgesia upon arrival at the hospital. Eight (08) of them, or 72.7%, had received oxygen therapy, five (05) had received antitetanusserum and two (02) had received antibiotic therapy. All patients had been filled according to the Parck land formula. Seven (07) of our patients had under gone surgical stripping and only one (01) benefited from foreign body extraction. We deplored five (5) deaths or 45.4% of the patients, four (04) were evacuated to a better equipped health center outside the country and two (2) survived. (Table 3)

Table 3. Patient Outcomes

Outcome	Number (n)	Percentage (%)
Deceased	5	45,4
Evacuated	4	36,7
Survived	2	18,2
Total	11	100,0

Four (04) of our patients hadinfectious complications, three (03) othershadrespiratory complications and one (01) had a hemodynamic complication. (Figure 3)

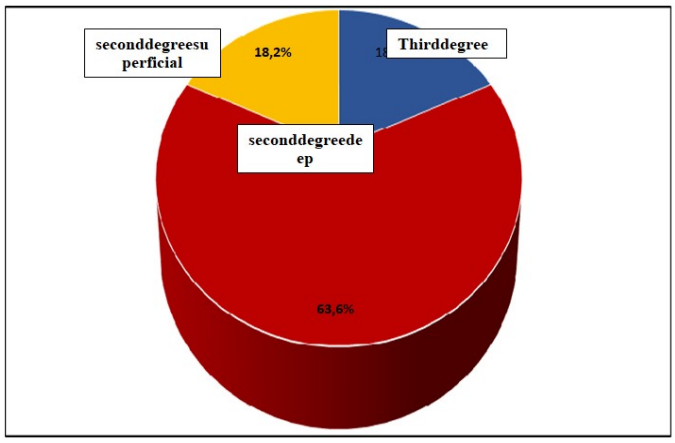

Figure 2. Distribution of patients according to the depth of burns

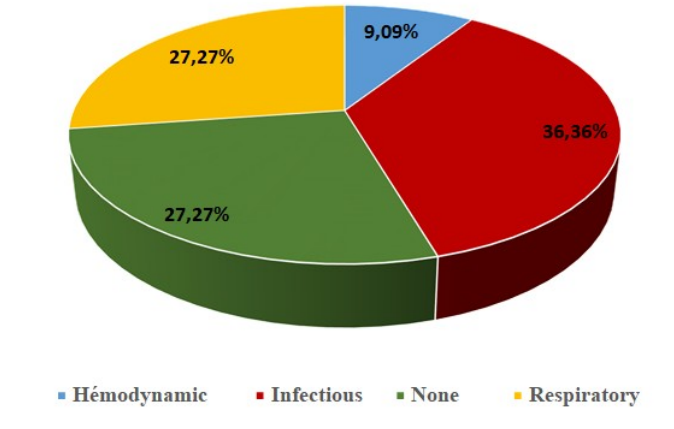

Figure 3. Description of the complications observed

Of the five (5) deaths in our series, two (2) were related to hemodynamic distress, two (2) were related to respiratory distress, and one death was of infectious origin. The average length of stay for our patients was 8.81 ± 12.52 days, with a range from 1 to 45 days.

DISCUSSION

We conducted a retrospective and prospective study that allowed us to analyze the appropriateness of pre hospital and inpatient management of explosions at the Omar BONGO ONDIMBA Army Training Hospital.

Limitations: Our study had several limitations:

- The retrospective component of our study was already the first challenge. Furthermore, the inefficient record archiving system made data collection difficult.
- The small sample size of our series and the single-center nature of the study only allow for a partial analysis of this pathology.

Explosions cause trauma of varying severity, with severity related both to the intensity of the explosion and to the location and distance of the victim from the epicenter. These are complex injuries that can pose management challenges for the practitioner.

Characteristic Explosions and Clinical Implications: The incidence of blast injuries is poorly understood; they are most often the result of armed conflicts, with the use of multiple explosive devices. In the civilian context, these injuries occur in the context of industrial or domestic explosions. Thus, they are airborne explosions [3]. The pathogenic potential of liquid-filled explosions is higher for the same load. Airborne explosions characterize our series, and we observed them in all cases. In our series, the majority of explosions occur in a closed air environment. This type of explosion generates a complex pressure environment, due to an incident and reflected wave. Thus, the blast is very high and more severe, compared to a blast in open air. The source of the explosion that we observe is the most common [1], it is the chemical explosion, it is linked to explosives, most often it is a mixture of gas or vapor in air. In the context of industrial explosion, we were unable to determine the type of gas. For Domestic explosions involved house hold gas (butane++ gas). The explosion, accidental, is induced by a flame, a spark, or heat. This type of explosive generates little over pressure, usually less than 110 kilopascals (Kpa). In addition to this type of explosion, there are explosives themselves, whose use is intentional in the context of attacks or conflicts, of which we did not observe any cases in this study. Before considering the clinical implications, its hould be noted that from a pathophysiological perspective, any explosion in an air borne environment generates three simultaneousphenomena:

- A static over pressure wave;
- A dynamic over pressure wave; and
- A thermal effect.

The static over pressure wave, or shockwave, is the cause of primary injuries or blast injuries. These injuries result from the interaction of the shock wave with the body. The consequences vary with the organcrossed [1], depending on whether it is heterogeneous (hearing system, larynx, lung, digestive tract) or homogeneous (eye, heart, brain). The hearing system is the most sensitive to blast. Lesions are observed from a peak over pressure of 30KPa, and we have noted in the literature that gas explosions generate pressures of approximately 110Kpa. These hearing lesions are of the hemotympanum type or rupture of the eardrum. It constitutes the formal diagnostic criterion of blast. Its diagnosis is easy by otos copy. However, the reliability of the otoscopic examination depends on the expertise of the practitioner first. In fact, the lesions are not limited to the perforation of the eardrum [4], We only performed it in one (01) case. The diagnosis of blast suggest so the rvisceralllesions, which could lead to more caution in the performance and analysis of the lesion assessment. Confirmed blast should lead to a more careful look at possible pulmonary lesions, and lead to more targeted prophylactic or the rapeuticmeasures. Similarly, in the digestive sphere, the presence of blast should raise the possibility of digestive sepsis in the context of uncontrolled infectious syndrome or abdominal pain, suggesting a ruptured holloworgan. At this stage, any examination of a blast victim should clarify the context and type of explosion, and otoscopy should be routine. The lungis the critical target organ; pulmonary injuries are the leading cause of morbidity and mortality. The yappear to be uncommon in patients admitted to the hospital. Any suspicion of a high-intensity blast, for example, should prompt asearch for them. Due to its critical prognostic significance, were commend routine screening for anysuspected blast (otoscopy). This could beassessed by performing a chest CT scan if the patient's condition is compatible withit.

Blast Victims: Epidemiological Aspects: Regarding the injured, the victims are young (youngadults). In our series, the average age of the patients was 37.82 ± 15.99 years, but we found few studies in the literature addressing age. In explosions occurring in a military or non-military context, young subjects are the most exposed due to their predominance in industrial work and military environments. Added to this is a relatively young population in urban African environments. The prevalence of males is the rule; we note a sex ratio of 4.5 in favor of men. These results are consistent with those of BALSSA et al [5] who report 56% to 73% male predominance. This aspect could be explained by the fact that men are the majority in high-risk locations such as combat zones for military personnel and industrial sites. The predominance of domestic explosions leads us to the following observation: all age groups, from early childhood to the elderly, are exposed to this pathology. This makes the versatility of practitioners and services, which take care of them in limited health situations, essential. Accurate assessment of lesions requires knowledge of the pathophysiology of the mechanisms observed during explosions. Thus, we noted primary lesions in only one case, which is easily understandable given the small size of our cohort. Our results are lower than those of MENGYANG YU et al [6], who found 48% primary lesions.

This could be explained by the weakness of the over pressure phenomen on generated by the explosion, as explosions mostlyoccur in open environments, but especially by an underestimation of blast (or static over pressure wave) lesions. The susceptibility of the hearing system to blast should require systematic to scopic examination in every explosion victim, an examination rarely performed in our series. It should be remembered that morbidity and mortality induced by blasts affects various organs: lungs, digestive tract, etc. The presence of a tympaniclesion should systematically lead to a chest CT scan to rule out a pulmonary blast [6]. Secondary injuries are less frequent than those reported in the literature in ourcohort, occurring in only 18.2% of cases, and this involved polycribbling. Our results are lower than those of MENGYANG YU et al., who found 84% secondary injuries. This low incidence of secondary injuries is also observed for tertiary injuries. They were observed in 9.09% of patients in ourseries, compared to 44% for some authors [7]. Burning is the permanent injuryduring explosions in our series. It is found in all our patients. The meanburned surface area of our patients was 56.45 ± 25.05%, with a range of 15% to 91%. These results are higher than those of Matthews et al. [8], who found body surface areas burned at 43.5 ± 20%. This high incidence is due to a chemical explosion, with a gas and air mixture as the explosive. This type of explosion is accompanied by fire and smoke inhalation. This explains the seriousness of these patients who are designated by the initials "BBB": injured, burned, blasted [1]. We note the predominance of deep second-degree burns in our series. Depthis a parameter that plays a greaterrole in functional prognosis than in life prognosis, as the skin's healing capacity and quality depend on depth [9].

Aspects of Management: In our series, management was assessed in two ways: pre hospital management and hospital management. Regarding hospital management, 54.5% of our patients were treated by witnesses to the explosion and the rest by healthcare personnel. The explanation seems to lie in the fact that the Gabonese population

does not yet have the reflex to seek medical services when accidents occur. The second group of people treated pre hospitally received medical care. These were patients with multiple injuries from industrial accidents. Industrial safety regulations should have played a role in enabling the faster provision of medical care in the event of an accident. These results are comparable to the study carried out at ATH OBO by ERIGA in 2017, which found 44.44% of medical evacuations [10]. These results are still superior to other African studies, notably those of OWONO ETOUNDI, where 100% of evacuations were non-medical [11]. Despite the initial low level of medical care, some life saving procedures were performed; nearly half of the burn patients received water cooling within 15 minutes of the accident. At the hospital level, the admission time was three hours for three of our patients. These times are sometimes longer. This result could be explained by the fact that the only burn center in the country is located at the ATH OBO. The patients came from both Libreville and the provinces (Oyem and Port-Gentil), and many of them passed through different health facilities. However, the only facility providing treatment for multiple trauma and severe burns was the ATH. As part of the injury assessment up on admission, we note that only two of our patients under went imaging (chest X-ray, CT scan). Although injury assessment is primarily based on clinical evaluation, blast injuries (contusion, pneumothorax) and mediastinal injuries may be overlooked. These injuries can become secondary complications and be life-threatening [1]. Therapeutically, the management of blast injuries presents few specificities. Our strategies are consistent with those in the literature. All our patients received fluid replacement, warming, dressings, and analgesia upon arrival at the hospital. The initial acute phase after a severe burn is characterized by hemodynamic instability that can lead to tissue hypo perfusion. In our series, fluid replacement was routinely administered according to the Parkland formula. These results are consistent with the study by GUEUGNIAUD [12], which recommends maintaining an infusion rate as regular as possible. All burns are painful, including those causing first- and third-degree injuries. The larger the burned area (multiple nerve endings are involved), the more intense the pain, hence the systematic need to introduce analgesia. Eight (8) patients, or 72% of the patients, had received oxygen therapy. This proportion remains lower than the recommendations of GUEUGNIAUD [12], who advises systematic oxygen therapy by inhalation of high-concentration oxygen in view of the constant oxygen debt and the frequency of possible associated carbon monoxide poisoning. Inhalation of fire smoke considerably worsens the prognosis of these patients [3]. Two patients in the series had received antibiotic therapy. The initial antibiotic therapy is never the less debated. Indeed, if the burn causes rapid and severe immune suppression, super infection of the burns rarely occurs before the end of the first week of treatment [11]. However, the risk of selection of resistant mutant bacteria, which can generate fulminating sepsis in this debilitated terrain, leads to more restraint in the prescription of antimicrobials. In these patients, all antibiotic therapy must bed ocumented and instituted, then reassessed on the basis of an anti biogram. The two patients who received antibiotic therapy in the series only received it for the management of tertiary lesions with a high risk of infection and/or perineal burns.

Outcome: The outcome of our patients depended on the extent of the lesions and the speed of treatment. In the study, the outcome was favorable for one patient and unfavorable for five. We were unable to obtain further information on the outcome of the three patients evacuated to the West. Regarding the prognosis of these patients in the early acute phase, mortality is generally cardiopulmonary in origin. Respiratory complications were acute respiratory distress syndromes, the origin of which could be pulmonaryedema, myocardial contusion, or gasembolism, which raises the question of the progression of pulmonary blasts. This proportion remains lower than the recommendations of GUEUGNIAUD [12], who advises systematic oxygen therapy by inhalation of high-concentration oxygen in view of the constant oxygen debt and the frequency of possible associated carbonmonoxidepoisoning. Inhalation of fire smoke considerably worsens the prognosis of these patients [3]. Two patients in the serieshad received antibiotic therapy. The initial antibiotic therapy is never the less debated. Indeed, if the burn causes rapid and severe immune suppression, super infection of the burnsrare lyoccurs before the end of the first week of treatment [11]. However, the risk of selection of resistant mutant bacteria, which can generate fulminating sepsis in this debilitated terrain, leads to more restraint in the prescription of antimicrobials. In these patients, all antibiotic therapy must be documented and instituted, then reassessed on the basis of an anti biogram. The two patients who received antibiotic therapy in the series only received it for the management of tertiary lesions with a high risk of infection and/or perinea burns.

CONCLUSION

The outcome of our patients depended on the extent of the lesions and the speed of treatment. In the study, the outcome was favorable for one patient and unfavorable for five. We were unable to obtain further information on the outcome of the three patients evacuated to the West. Regarding the prognosis of these patients in the early acute phase, mortality is generally cardiopulmonary in origin. Respiratory complications were acute respiratory is tress syndromes, the origin of which could be pulmonaryedema, myocardial contusion, or gasembolism, which raises the question of the progression of pulmonaryblasts. Although there are still some gray areas regarding the pathophysiology of blast injuries, their resuscitation and surgical management are currently well codified. Many questions regarding blast injuries remainunans wered, and there are many opportunities for experimental and clinical research.

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