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Research Article

Incidence of Blunt Brain and Neck Injury by Blast in Colombian Military Personnel: A Cases Review

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Abstract

General Objective: To describe the incidence of blunt trauma/injury accidents and injuries caused by unconventional weapons in military personnel of the Colombian National Army in a period from 2017-2021.

Specific Objectives: 1. To characterize mortality per year of injuries due to accidents and/or unconventional weapons in the military personnel 2. To describe per year the number of cases attended at the Central Military Hospital of Nueva Granada. 3. To contextualize about blunt Injury and the experience of military engineers of the Colombian National Army in explosive devices.

Methodology: Retrospective systematic review of cases, 704 case histories were reviewed considering clinical and imaging variables for the diagnosis of blunt injury and a descriptive analysis was performed.

Results: The incidence of blunt injury in our study was like that reported at the international level. The study yielded a result of 1.65% incidence, a figure within the international range (0.03 to 4.8%) of reported incidence.

Conclusion: It is important the multi and interdisciplinary management for this pathology, all hospitals, and national clinics, should be prepared for the diagnostic suspicion and approach of Blunt Injury, it is a clinical condition with low incidence but with high impact on morbidity and mortality.

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Keywords: Blunt trauma; Injury; Mortality; Morbidity.

Introduction

Blunt Injury is an intra or extracranial cerebrovascular structural defect that is caused by high-energy non-penetrating trauma [1-3] with an incidence ranging between 0.03% and 4.8% among all cases of blunt force trauma [1]. It is considered as an underdiagnosed pathology with a high impact on mortality [4,5]. Failure to diagnose it can lead to a 50% increase chance of stroke and a 25% increase chance of mortality [3,6].

In a patient diagnosed with blunt injury and who is asymptomatic; the data we have on the possibility of stroke can be compared or divided into two groups, 1. Patients who did not have any type of management and 2. Patients with some type of management where we see that: in patients without treatment, there is a 25% probability of stroke vs management those who have received at least one treatment option, either antiplatelet 8%, anticoagulant 7%, endovascular 5% or with any treatment (3%) [3].

This pathology is frequently described in traffic accidents or falls of heights of more than two or three floors [7] where the mechanism of injury can be found as a direct head trauma of high energy or cervical trauma of hyperflexion, hyperextension and/or rotational; cervical vascular lesions associated with the exercise of chiropractic have also been found [8]; There are the Denver criteria that were extended in 2011 in order to identify the clinical and risk factors associated with blunt injury, this modification managed to increase sensitivity and specificity (97%) and (42%) respectively in the diagnosis [8] these criteria along with those of Memphis can also be used to indicate a radiological screening. [4] it is important to note that the incidence of Blunt Injury increases, if associated injuries occur for example, there is an increase of this to 3-5% if there are skull base fractures, Intra-parenchymal hemorrhages and when there are complex cervical lesions its incidence increases from 25%-30%; the most frequent sequelae is stroke that appear in 41% when there are lesions of the internal carotid artery [9] and 25% when there are lesions of the vertebral arteries [7,10,11] Stroke occurs in the first 3 days by 60% by 85% in the first 7 days of the traumatic event [2,8]. The before mentioned denotes the relevance and importance of being able to make an adequate and timely diagnosis of this pathology, not only because of the impact it can have on mortality, but also the high morbidity that it generates, not being able to make an adequate diagnosis and management; taking this into account, in addition to the trauma mechanisms that can generate this pathology, a retrospective review of cases in military personnel who presented high-energy traumas and the incidence of Blunt Injury in these patients is made.

Blunt injury

This article aims to make a short and punctual review that allows the reader to make a small review of the histopathological anatomy of the arteries and thus be able to contextualize and understand the pathology holistically.

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Remembering the histology of the arteries, if we describe it from the lumen to the outside, we see that it consists of three layers:

1. Intima (innermost layer)
2. Mean
3. adventitia (outermost layer) which give the characteristics of an artery.

It is important to bear in mind that in the route of the carotid and vertebral arteries there are anatomical variants that predispose to their injuries.

As previously noted, Blunt Injury is an Intra or Extracranial cerebrovascular structural defect that is caused by a non-penetrating trauma of high energy, a pathology that represents not only a challenge for its diagnosis, but also for its treatment; the first case that has been reported to be published, was performed by the French surgeon Aristide Verneuil in 1872 in an autopsy.

It has been considered that it is a pathology that has been under-diagnosed mainly for three reasons: 1. For not having clinical suspicion 2. Not to mention before the decade of the 80s with the technological advances in imaging and interventional procedures and 3. The failure to create trauma protocols that took this condition into account. The mechanisms of injury or trauma that allow us to suspect this diagnosis are mainly related to cervical injuries, where the movements of hyperflexion, hyperextension, extreme rotation or the combination of these mechanisms, have a strong association with this pathology (Figure 1).

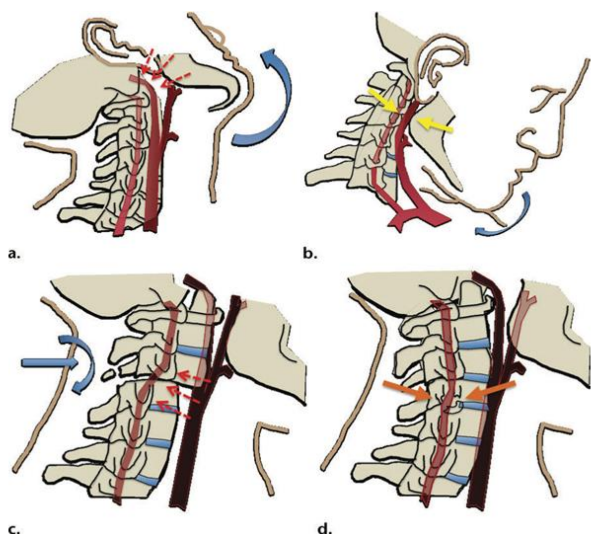

Figure 1: "(a) Longitudinal stretching and/or twisting of the vessel. Illustration depicts hyperex- tension and contralateral rotation, with stretching of the ICA over the C1–C3 transverse processes (red dashed arrows). Blue arrows in a–c = direction of movement. (b) Vessel impingement. Illustration depicts compression of the ICA between the mandible and spine (yellow arrows), which may result from hyperflexión or displaced mandible fracture. Impingement may also result from skull base or cervical spine fracture. Likewise, a blow to the neck or strangulation may directly compress or impinge a vessel against an adjacent structure. (c) Stretching of the vessel. Illustration depicts stretching of the vertebral artery between subluxated or dislocated bone structures (red dashed arrows), which may occur in cases of cervical fracture, dislocation, or ligamentous injury. (d) Direct laceration. Illustration depicts a fracture with direct injury to the vertebral artery by an adjacent bone fragment (orange arrows). This is especially relevant in cases of vertebral transverse foramen or carotid canal fracture" [12].

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In pathophysiology there is a cascade of events that will depend on the intensity and type of trauma (elongation of the vessel and/or direct blow on the intimate), and that in the process of establishing the injury can take several courses; changes at the histopathological level begin with: 1. Intima or middle injury 2. Intimate tear 3. Sub-endothelial collagen exposure 4. Platelet aggregation and thrombus formation 5. Stenosis or occlusion of the vessel or with two possible causal mechanisms 5.1 constant thrombus formation 5.2 there is a dissection between the arterial walls leading to the formation of aneurysm and/or intramural hematoma. If the impact had enough energy to generate an arterial section, the formation of arteriovenous fistulas describe that two mechanisms can be mainly: that they can occur in isolation and/or conjugated and that are: 1 containment of blood by adjacent soft tissues and/or 2 decompression of the adjacent vein; finally, within the pathophysiological mechanisms, it correlates with the genesis of Stroke, two mechanisms that have been the most widely studied 1. Thromboembolics 2. Hemodynamic failure derived from the arterial section [1,5].

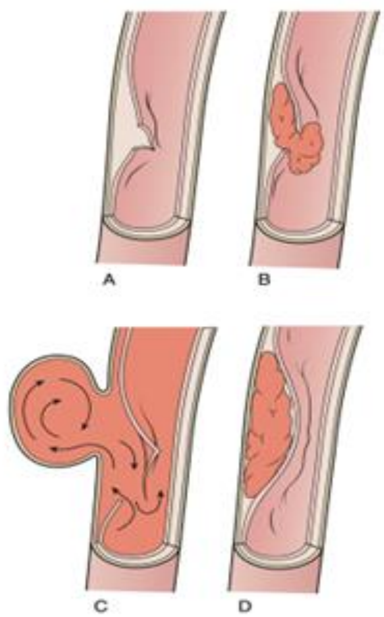

Figure 2: "Patterns of blunt cerebrovascular injury. Common types of injury include intimal tear (A); intimal tear with associated thrombosis (B); dissecting aneurysm formation, resulting from disruption of the internal elastic lamina and bulging of the adventia (C); and intramural hematoma (D)" [1].

Understanding these pathophysiological mechanisms plus other variables correlated with the risk of presenting a Blunt Injury, is that most of the classifications for this traumatic condition have been generated, there is the Denver classification (most used), Boston, Memphis. In practical terms for this article, we will use the Denver classification (Table 1), which is the one that correlates the degree of injury, the imaging findings, and the possibility of Stroke. From Figure 3 to 7 we will show graphically the classifications of the lesion.

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Grade of Injury	Denver Grading System	CTA Findings	Stroke Incidence (%) (CAI/VAI)
I	Irregularity of Vessel Wall Dissection or IMH with <25%, narrowing	No stenotic Luminal Irregularity Intimal Flap or wall Thickening with <25% stenosis	3/6
II	Intraluminal thrombus Dissection or IMH with >25% narrowing	Luminal Hypodensity Intimal flap or wall thickening with >25% stenosis	14/38
III	Pseudoaneurysm	Eccentric contrast-filled outpouching limited by periarterial tissue	26/27
IV	Occlusion	Lack of any intraluminal enhancement Carotid Occlusion: abrupt or tapered Vertebral Occlusion: usually abrupt	59/58
V	Transection	Irregular extravascular collection of contrast, no limited by periarterial tissue. Increases in density on delayed images if obtained	100/100

Table 1: Classification of Denver.

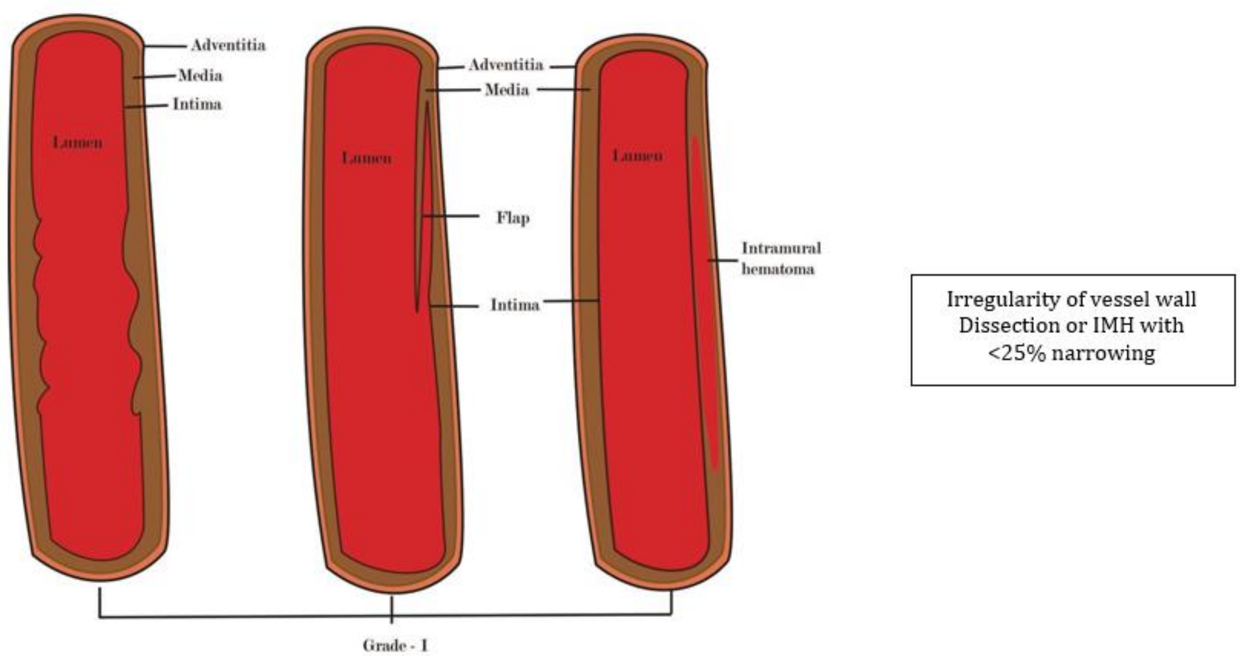

Figure 3: Grade I Arterial Injury [5].

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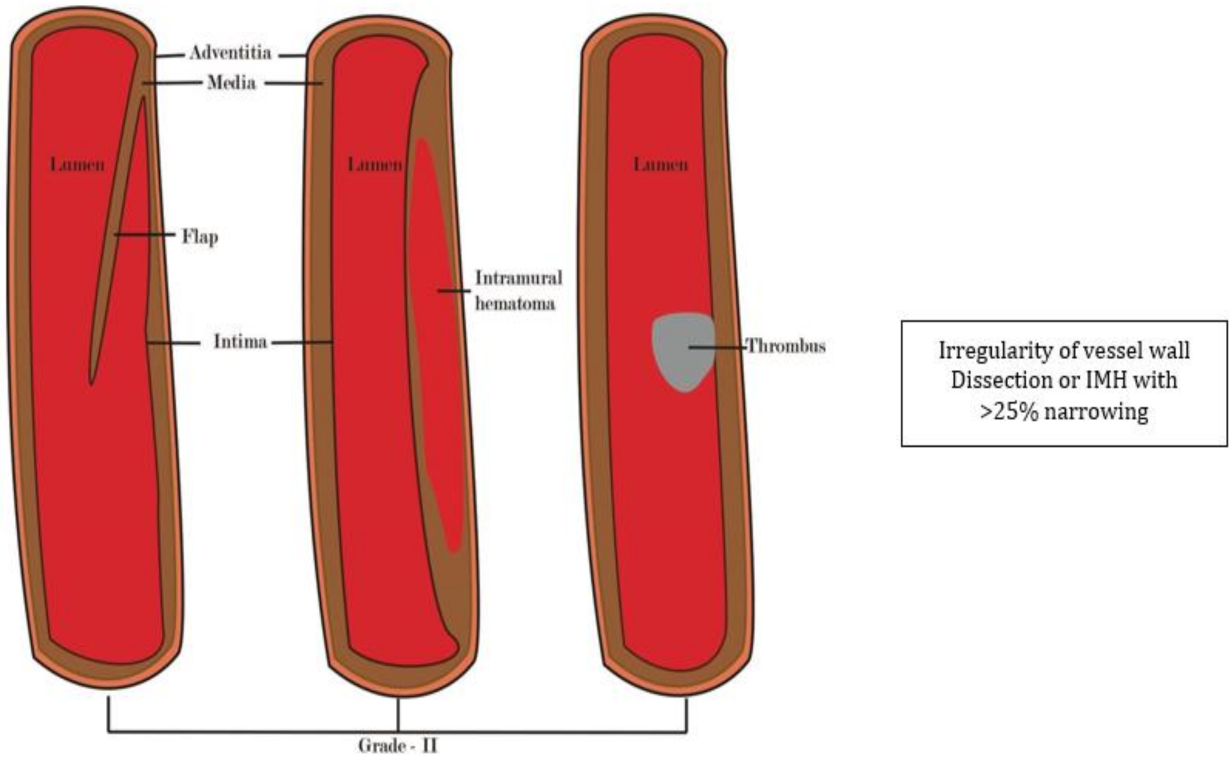

Figure 4: Grade II Arterial Injury [5].

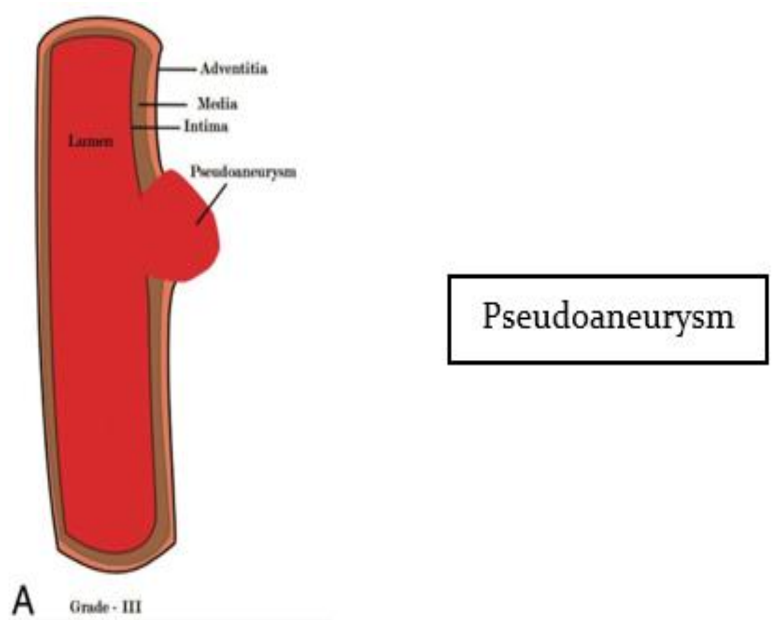

Figure 5: Grade III Arterial Injury [5].

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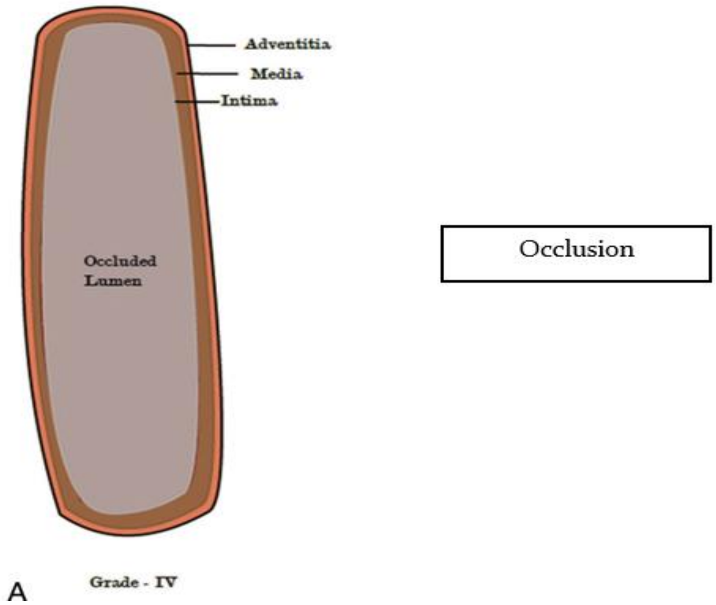

Figure 6: Grade IV Arterial Injury [5].

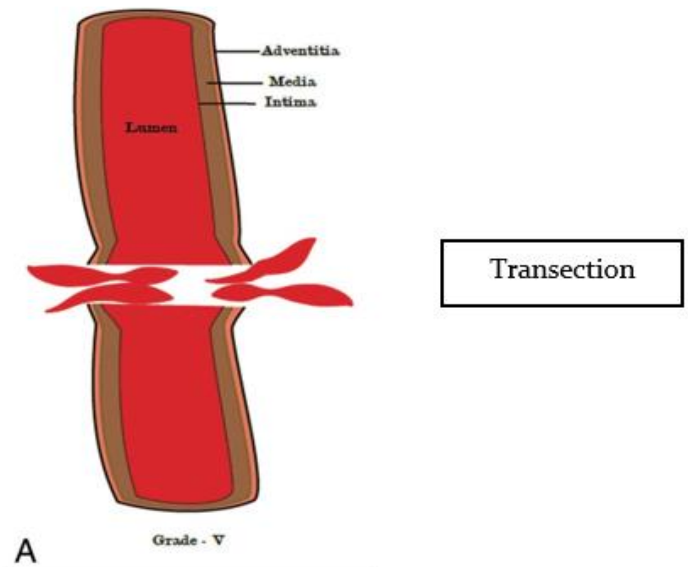

Figure 7: Grade V Arterial Injury [5].

Military contextualization

In the evolution of injuries in military personnel, the understanding and injury capacity of a respective weapon has always played an important role, this has also forced technological advances to be established, and military surgeons to rethink the way to address these injuries, in order to impact on patient mortality [9]. In the United Kingdom, improvised explosive devices (IETs) are the leading cause of death in operational campaigns, and injuries from improvised explosive devices are divided into two:

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assembled and dismantled; referring to the fact that the "mounted" are the injuries suffered by people who are in a vehicle and that the AEI is buried and the "disassembled" are the injuries that occur in the person who is walking [13]. These explosive devices have made exposure to them exclusive traumas of regular and irregular wars; in the war in Afghanistan and Iraq, 75% of head trauma was secondary to EIGs, and 55% of military personnel were exposed to at least two or more explosions. [14,15], in the years 2010-2014, U.S. military personnel presented 250,000 traumatic brain injuries [16] and for example, one study reported that, between 2006 and 2011, 70% of the 43,852 patients evaluated for TBI had a shockwave-related injury. It is important to note that accurate rates of prevalence and incidence of service-related injuries are difficult to determine [17]. In the characterization of the lesions that are caused by explosive devices, there is a taxonomy of these, which place the Blunt Injury as a tertiary lesion, in table 2 the types of lesions that occur in the BLAST and where the Blunt Injury is located are explained.

Blast Injury category	**Description**	**Examples**
Primary	Result from the high pressures, or blast overpressure, created by explosions Blast Overpressure can crush the body and cause internal injuries, primary blast injuries are the category of blast injuries that are unique to the blast or high pressures that occur.	· Blast lung (Pulmonary Barotrauma) Tympanic Membrane rupture a middle ear damage · Globe (eye) rupture · Concussion (mild traumatic brain injury (mTBI) without physical sings of head injury)
Secondary	Result when strong blast wind behind the pressure from propel fragments and debris against the body and cause blunt force and penetrating injuries	· Penetrating ballistic (fragmentation or blunt injuries) · Eye penetration · Closed or open injuries
Tertiary	Result from strong blunt winds and pressure gradients that can accelerated the body and cause the same types of blunt force injury that would occur in a crash car, fall, building collapse	· Bone fractures · Traumatic amputations · Blunt Injuries · Crush injuries · Close or open brain injuries
Quaternary	Result from other explosive products (such as heat and light) and from exposure to toxics substances from fuels, metals and gases that can use burns blindness and inhalation injuries	· Burns (flash, partial and full thickness) · Injury or incapacitation from Inhaled toxic fumes (breathing problems for dust, smoke, or toxics fumes).
Quinary	Refer to the clinical consequences of post-detonation environmental contaminants, including chemical (e.g., sarin) biological (e.g., anthrax) and Radiological (e.g., dirty bombes) substances	· Chemical burns · Radiations exposure · Viral or bacterial infections

Table 2: Taxonomy of BLAST INJURY Injuries [17].

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Tertiary injuries "result from strong gusts of wind and pressure gradients that can accelerate the body and cause the same types of blunt force injuries that would occur in a car accident, a fall, or the collapse of a building" [17].

In Colombia, for a long time, the trauma of war is not only a condition of public health interest, but also a scourge at the national level, which the country has had to face. Given the geographical conditions of our country and the specific characteristics of accidents and the weapons with which military personnel are impacted, in this manuscript we want to contextualize and describe the incidence and prevalence of Blunt Injury in military personnel who have been exposed, an explosive device and/or who have suffered a high energy accident.

The following concept maps provide context:

1. The international classification of explosive ordnance and
2. The study and characterization of military engineering [18] the most used explosives in the attacks against the military in Colombia.

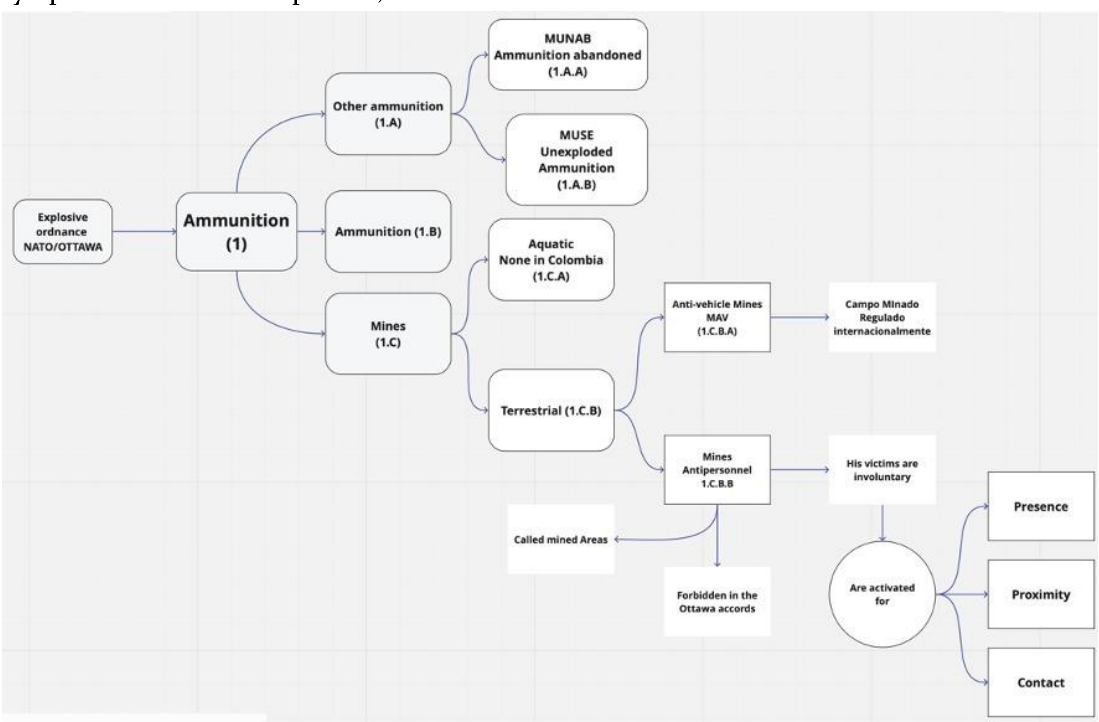

Figure 8: According to the NATO Explosive Ordnance Manual and the Ottawa Treaty, explosive ordnance can be classified in: (1) Munitions (1 A) other munitions, ordnance, (1 A,A) MUNAB abandoned munitions with potential for injury, (1 A,B) MUSE described as munitions that have been considered as "Failed" that are dangerous because they have tried to be activated but this mechanism has failed so they must be destroyed following the explosive handling parameters of the F.F.M.M of Colombia. (1 C) Mines among which special attention are the (1 C,B) Landmines specifically (1 C and B,B) Antipersonnel mines: Described as explosive devices where victims are produced by the action of presence, proximity and contact, therefore their use has PROHIBITION since it does not discriminate their strategic objective, the places demarcated with contamination of the mines will be recognized based on these guidelines as a Mined Zone [18,19].

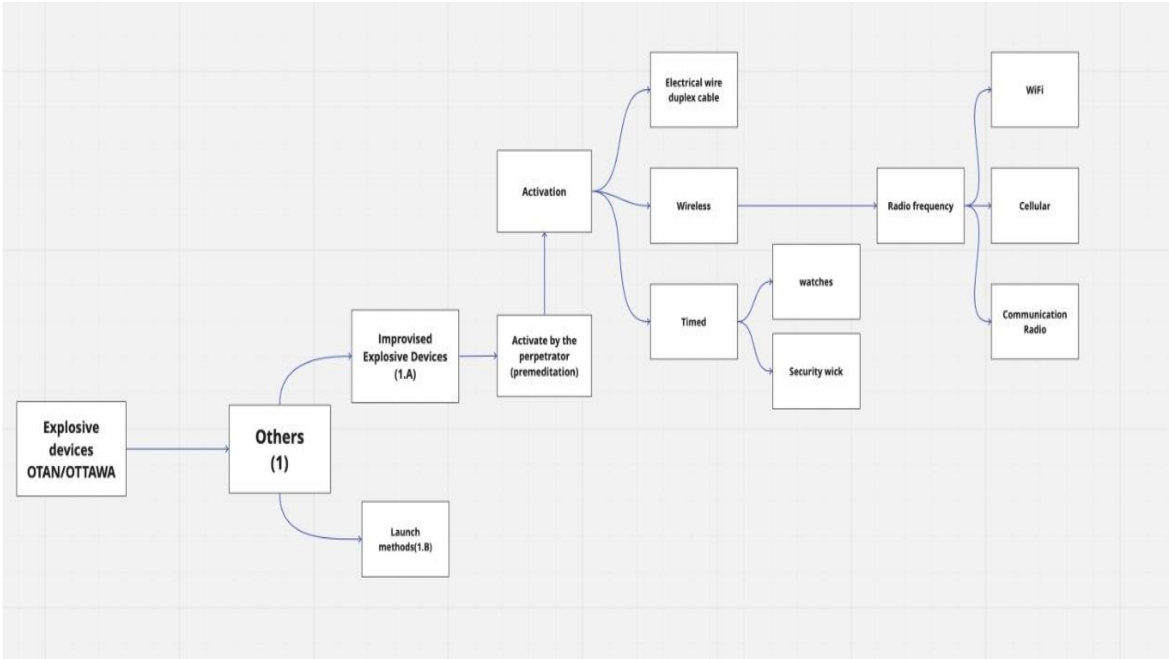

Figure 9: According to the guidelines of NATO and the Ottawa treaty, the second classification includes a paragraph called (1) others, in this category are cataloged the (1 A) improvised explosive devices as all those explosive devices that are controlled or activated by the perpetrator either by electric wire, wirelessly as are radio frequencies such as WiFi, cell phone or communication radios, or by using timers such as safety locks or watches [18-20].

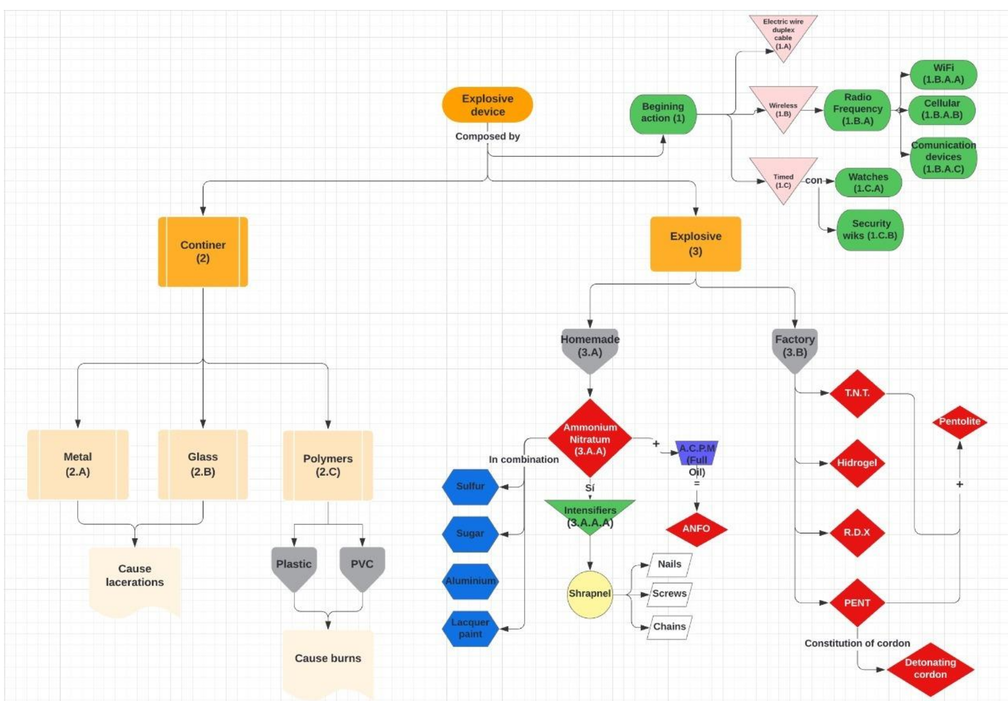

Figure 10: Explosive devices are also described by their composition with three key elements.

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The first described as the (1) activator that is subdivided into activation by (1 A) electrical wire, (1 B) wireless means of (1 B,A) radio frequency such as (1 B,A,A) WiFi, (1 B,A,B) Cellular, (1 B,A,C) communication radios, or (1 C) timers describing (1 C,A) watches, (1 C,B) Safety wicks. Secondly, type of (2) container among which is cataloged the (2 A) metal containers and (2 B) glass that determine or entail lacerations, and (2 C) polymer containers. As a last category, the use of (3) explosives of manufacture (3 A) "Homemade" is evidenced. (3 B) industrial, it should be borne in mind that according to the explosives handling manual of the F.F.M.M of Colombia and the Colombian Military Industry, metric parameters of the substances most commonly found in explosives within the country are given, the measure described in the evaluation of the strength index of an explosive, is the Kilopondium that relates as the impact or the force that is exerted by each kg of mass by the standard gravity or kilogram of weight for each meter of surface, the effects to make them referable exceed the natural limits both in the capacity of volatility and dissociation of particles that this chemical reaction entails; in the particular case the ANFO already described in the previous figure as a homemade mixture of (3 A,A,A) ammonium nitrate and Full oil, has shown that it reaches a reaction force equivalent to a vehicle of 20 tons crashing into a wall at 280 km/h. In addition to this reactive chemical process, we relate that the AEI improvised explosive devices, have elements that arise from the craziest criminal action of organized armed groups where in addition to exploding these devices, they take advantage of the effects of expansion, thermal projection and retraction to include in them shrapnel that can be composed from segments or metal pieces, even biological material such as stools to cause a greater damaging effect [20,19,21].

In a study conducted at the military hospital between 2012-2013, it was found that the order of frequency of injuries associated with facial trauma were respectively as follows: cranioencephalic trauma 45.45%, cervical trauma 18.18%, thoracic 9.091, injuries in upper limbs 18.18 and 0.091% to injuries of lower limbs [22].

For all the above and in order to establish an adequate screenning that allows to identify a pathology (Blunt Injury) with high risk of morbidity and mortality, the motivation of this manuscript arises, and initially it was proposed to characterize the incidence and prevalence of this pathology in military personnel.

Methodology

Databases of military personnel injured by explosive devices. Descriptive observational study, Systematic retrospective review of cases; The 704 case histories were reviewed considering clinical and imaging variables for the diagnosis of Blunt Injury. a descriptive analysis of the sample was performed. Inclusion criteria: all military personnel who have been exposed to waves by explosive devices and/or who have suffered an unconventional high-energy accident. Exclusion criteria: civilian, penetrating injuries to the neck and/or head.

Results

Considering that the main objective of the work is to describe the incidence of Blunt Injury, in the descriptive analysis of the results, we found data of our interest, related to the severity of the trauma and the risk of presenting this pathology in addition to the level of initial care received by military personnel, these results are shown in the following 4 graphs.

The years with the highest number of cases reported were 2019 and 2021 with a mortality rate of 13.9% and 17.6% respectively.

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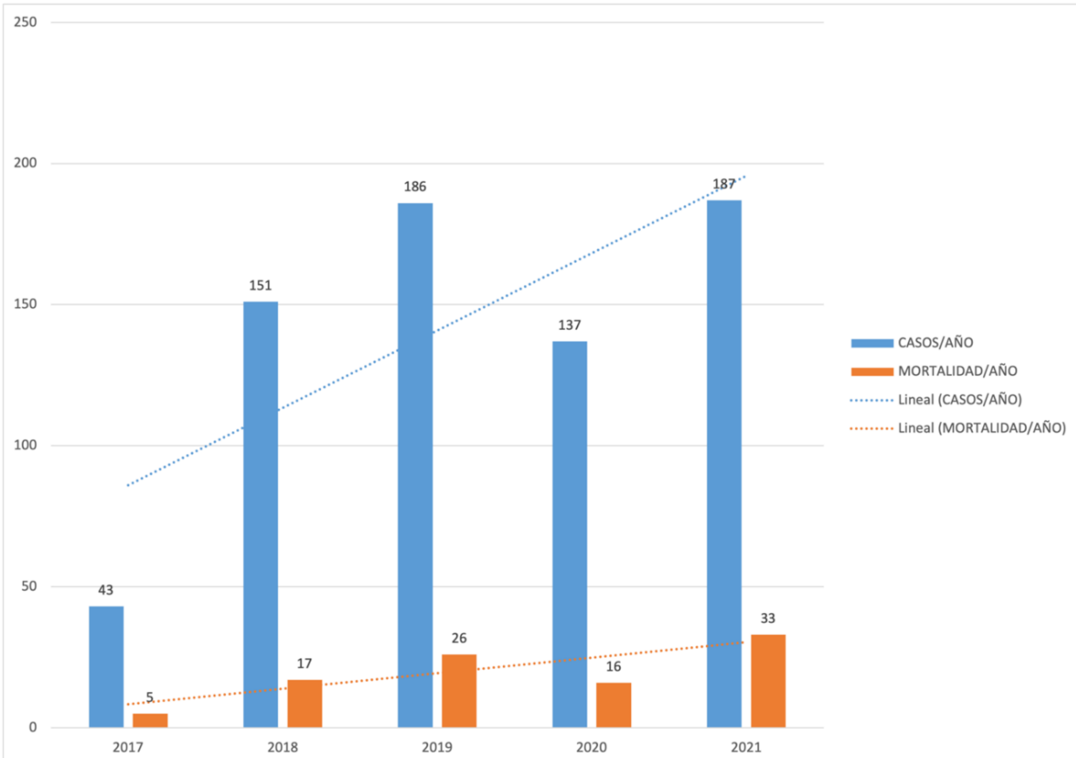
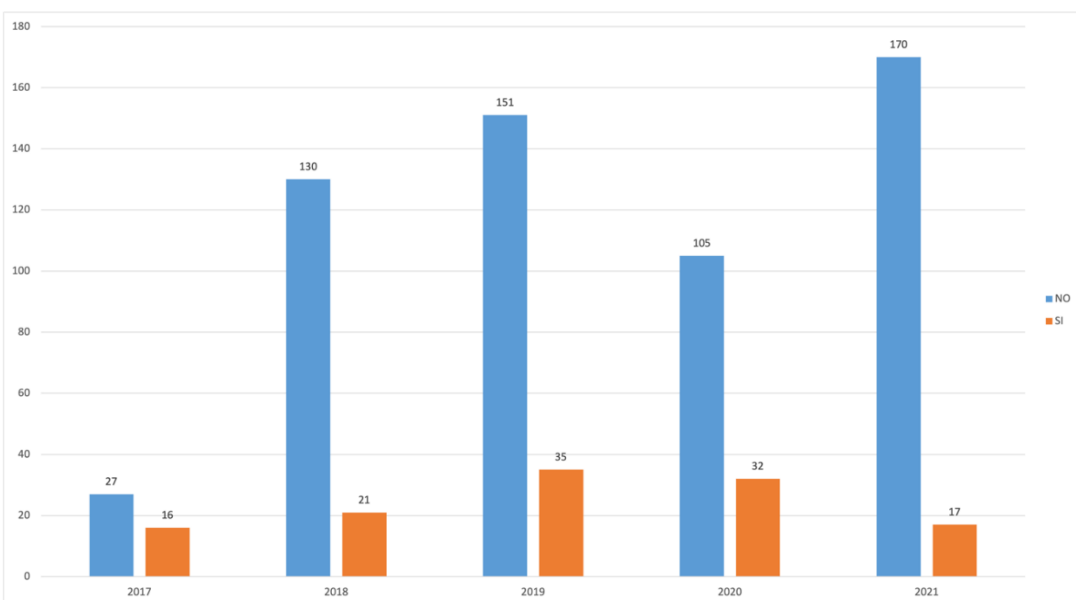
Approximately 20% of the cases were treated at level 4. And 17% of the cases had a high-risk trauma mechanism to generate a blunt injury.

The incidence of blunt injury was 1.65% in the cases studied and in which clinical history and imaging were verified.



Graph 1: Mortality per year due to accidents (Colombia Military Hospital).



Graph 2: Initial Management at Level 4 Center (Colombia Military Hospital) per year.

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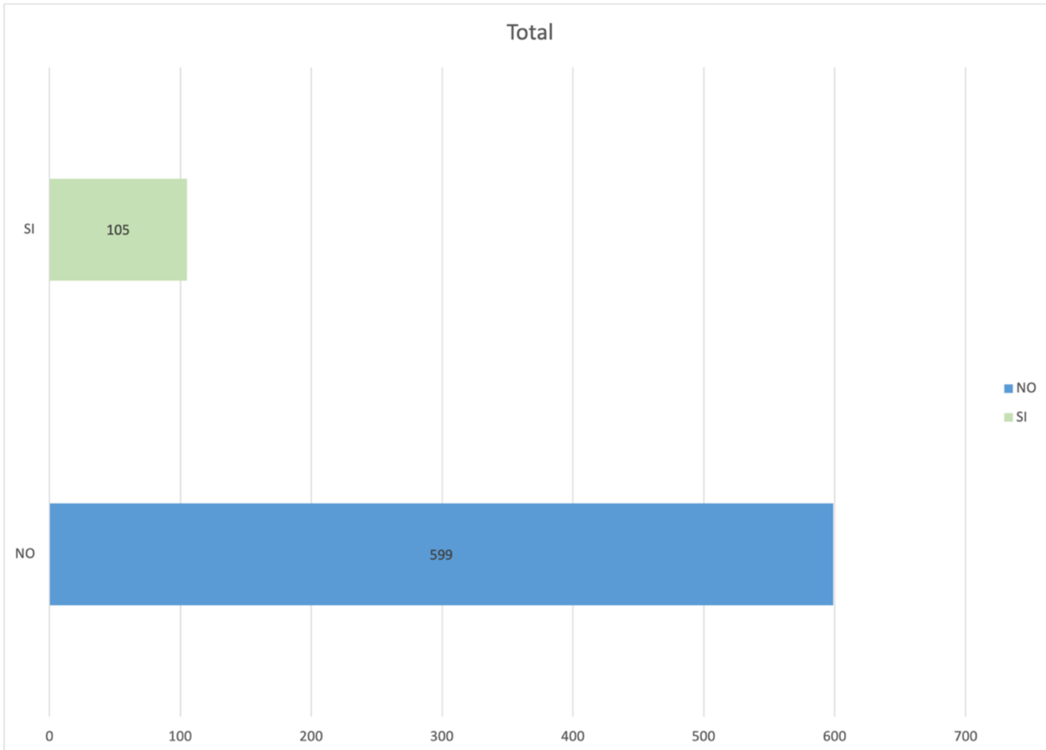
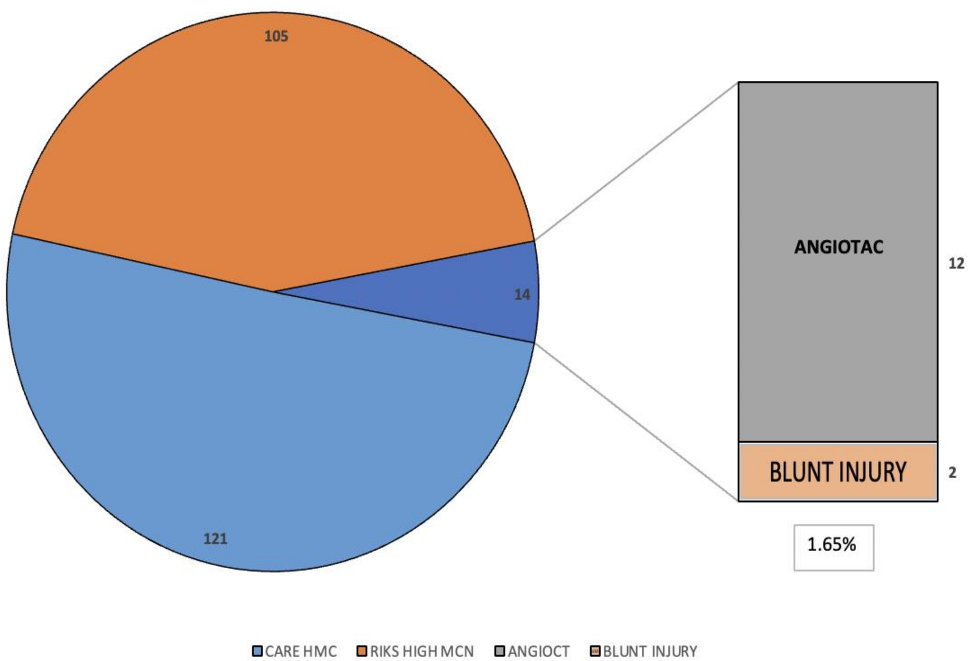


Graph 3: Trauma Mechanism with High Risk for Blunt Injury. (Colombia Military Hospital).



Graph 4: Incidence of Blunt Injury (Colombia Military Hospital).

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Analysis and conclusions

According to our results, the incidence of Blunt Injury is like that of the international literature, this phenomenon of low incidence is surely multifactorial:

1. The definition per se of Blunt Injury
2. The clinical non-suspicion of the Intra or Extracranial cerebrovascular structural defect, given that if an evident lesion is not observed in the neck and/or skull, the appropriate diagnostic aids that allow us to adequately approach this phenomenon can be omitted, another variable that impacts on this point, is not having the information of the mechanism of trauma since patients can regularly arrive under sedation or with alterations of the state of consciousness, which hinders clinical suspicion from the anamnesis
3. Not having the appropriate technological resources, which allow active search for this phenomenon.
4. Finally, and although it is rare; the non-recognition of the image changes presented by the Blunt Injury also has an impact on its incidence.

It is not possible to show which variable has the most relevant role in this; it could even be thought that just as there are anatomical points where these vascular lesions are more frequent, it can also be suggested that there may be anatomical variables that could act as a protective mechanism so that blunt Injury does not occur, but to validate this hypothesis more studies are needed.

As can be evidenced in the results, not all personnel who present high-energy accidents and/or injuries from unconventional weapons are treated initially at the central military hospital, which indicates that for different variables such as the geographical location where the event occurs, the opportunity to transfer to a level 4 and/or the same clinical condition of the patient, our military personnel are treated in Extra-institutional medical centers, so we consider it important to contextualize not only about this phenomenon, but also the mechanisms of trauma and/or injury, to which our military personnel are exposed.

The importance of having an inter and transdisciplinary medical team to reduce the probability of under-registration is one of the most important variables, which would not only give us a better understanding of this phenomenon, but also has a direct impact on the morbidity and mortality that Blunt Injury has.

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