CONDUCTS IN HAND TRAUMA BY EXPLOSIVE DEVICE: LITERATURE REVIEW

https://doi.org/10.56238/sevened2024.037-062

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ABSTRACT

Multiple hand trauma from explosive devices is a public health problem. Thus, this article presents a literature review with the objective of identifying practices in the treatment of these lesions. The search was conducted in the MEDLINE database, using specific terms related to explosion injuries, covering the last 10 years. We selected 5 studies that met the inclusion criteria, such as focusing on hand injuries and detailing treatment approaches. The selection was made based on methodological quality and clinical relevance. The studies revealed a high incidence of amputations and fractures. In addition, they highlighted the need for pharmacological and surgical interventions, with an emphasis on pain relief and infection prevention. A significant gap was also observed in the training of health professionals to deal with traumas of this nature, evidencing the need for specialized training. Despite the contributions, the review revealed the scarcity of robust research on the topic, indicating the need for more studies exploring different therapeutic approaches and rehabilitation protocols.

Keywords: Multiple trauma. Orthopedics. Bombs (explosive devices).

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INTRODUCTION

The history of trauma is intertwined with the history of humanity itself and despite being a source of suffering and death, trauma has contributed to the genetic incorporation of efficient hemodynamic, endocrine and metabolic characteristics that favor human survival (Birolini, 2012). This evolutionary history also reflects the importance that trauma has presented over time until modern medicine. That said, the literature defines trauma as any injury caused by the transfer of physical energies, such as kinetics, heat, cold, electricity, among others (Abib & Perfeito, 2012).

According to the SBCM-Brazilian Society of Hand Surgery [202-], the inappropriate use of explosive and pyrotechnic devices can cause burns of different degrees, fractures, respiratory damage, injuries to soft tissues and internal organs, and even amputations, especially of fingers and hands, in addition to blood loss that can lead to shock. Other frequent damages include burns and hearing and visual deficits. According to Merck Sharp & Dohme (MSD), there are five main mechanisms of blast injury:

Table 1. Mechanisms of explosion injury

Kind	Mechanism	Typical lesions
Primary	Impact of supersonic shock wave on the body. It preferentially reaches hollow or air-filled structures.	Bartaraoma Pulmonar Tympanic membrane rupture Middle ear damage Rupture of the eyeball Mild head trauma
Secondary	Impact of debris from the explosion on the body	Penetrating or Closed Injuries Eye penetration (overt or hidden)
Tertiary	Impact of the body thrown by the explosion on environmental surfaces or fragments	Traumatic fractures and amputations Closed and open brain injury
Quaternary	Independent processes of primary, secondary, or tertiary blast injury (e.g., burns, toxic inhalation, crush injury from entrapment under rubble, aggravation of health problems)	Burns Traumatic crush injuries with rhabdomyolysis and compartment syndrome Respiratory tract injury from inhaled toxicants Asthma, angina, or myocardial infarction triggered by the event
Quinaria	Injuries resulting from toxic materials absorbed into the body from the explosion and the post-detonation environment (e.g., radiological, biological substances)	Radiation burns or acute radiation sickness

MSD, 2023

Complex hand injuries are characterized by trauma that affects two or more functional structural systems, such as soft tissues, muscles, tendons, bone, vascular, and nerve structures. Classifying them is essential to guide clinical management. Thus, although proposed by Entin in 1964, the classificationof hand injuries is still used in current clinical practice and divides them into curable, reconstructible, salvageable, and non-salvageable.

Although traumatic injuries that exclusively affect the musculoskeletal system rarelydetermine the risk of death to the patient, they can cause important functional losses (Barroso & Barreto Filho, 2016).

These incidents are a challenge for health management (WHO, 2012). According to Gandra (2023), a reporter for Agência Brasil, a Brazilian public news agency, the Unified Health System (SUS) recorded 1,548 hospitalizations for fireworks injuries between 2019 and 2023, which corresponds to one hospitalization per day. Additionally, the Brazilian Society of Orthopedics and Traumatology (SBOT) brought in 2019 that one in ten people who handle fireworks has one of the upper limbs amputated.

The creation of protocols in the pre- and intra-hospital phases ensures that the trauma patient receives excellent care (Stefanelli, 2012). Victims should be referred to hospitals based on the severity of the injuries, the need for immediate surgery, or the presence of pre-existing conditions that complicate care. The ideal hospital may not be the closest to the accident site, but it should be the one that offers the best care conditions (Stefanelli, 2012).

This situation requires a broad approach, since these injuries affect the individual's activities of daily living. In this sense, with the advancement of pharmacological, surgical and rehabilitation techniques, this literature review aims to carry out an investigation in the literature to synthesize information that offers a comprehensive and up-to-date view on the medical treatment of hand trauma caused by explosives.

METHODOLOGY

This is a literature review carried out between June and July 2024, using the MEDLINE database, where searches containing the single term "*blast injuries*" were consulted, restricting the search to studies published in the last 10 years. The initial search brought 1443 articles and after screening, which used as criteria: treating a hand injury and/or establishing care conduct in explosive trauma, 5 (five) studies were selected, of which 3 (three) were in English, 1 (one) in German and 1 (one) in Dutch, no articles were found in Portuguese.

The phases of this research were organized as follows: first, the appropriate descriptors were determined; Then, in a sequential manner, the search strategy was elaborated, the databases were chosen, the most relevant titles were selected, and the texts were read completely. Finally, these stages culminated in the elaboration of the text.

According to item III of Resolution No. 510/2016, due to the use of secondary data in the public domain, it was not necessary to submit the project to a Research Ethics Committee.

RESULTS

Table 2 presents the results of the research, organizing the studies according to the year of publication and the objective. This framework was chosen for its ability to provide a comparative view of the selected studies

Table 2. Studies listed according to the year and objective of the research

Author, year	**Methodology**	**Results**
Staruch *et al*, 2017	Reassessed hand injuries sustained by improvised explosive devices on 380 service members serving in Afghanistan between 2006 and 2013	In all, 484 injuries were identified on the hands of 380 service members. The analysis of the 103 patients who suffered metacarpal injuries, phalanges or digital amputation revealed that the middle and ring fingers are the most commonly injured. Amputation of the ring finger is strongly associated with injuries to the adjacent fingers and simultaneous amputations of the middle, ring and little fingers is a commonly observed pattern. The proximal phalanges of the middle and ring fingers had a strong correlation for joint fracture.
Westrol *et al*, 2017	Describes the physics of the explosion and pathophysiology of explosive injuries	Understanding the pathophysiology of blast injuries helps healthcare providers in diagnostic and treatment decisions. In addition, in an explosion incident, early identification of the type of explosive can help identify resource needs. While this information may not be immediately available during an incident, a provider can use their knowledge of blast physics and the pathophysiology of injuries to identify patient injury patterns, which may correspond to certain types of explosives.
Más *et al*, 2017	Case series of children with injuries caused by a type of pyrotechnic explosive with a different pattern than previously known.	n=6. All male, five teenagers. The six had severe injuries in the hands with amputation of one or several fingers, determining aesthetic and functional sequelae.
Haerkens *et al*, 2016	Explanation of the mechanisms of explosion and their effects on the human body	Provide 15 tips on the key principles of blast wound treatment
Könneker *et al*, 2016	Case series of patients who suffered severe trauma to the hands and face by detonation of traps and paraphernalia (n = 9, Ø 60 years of age).	All patients with hand trauma (n = 8) had soft tissue injuries. Six of these patients also had fractures or injuries to capsular or tendon structures. Therapies included debridement as well as skin grafts or flaps to cover tissue defects.

DISCUSSION

The descriptive research carried out by Más *et al.* (2017) included patients treated at a pediatric emergency department in Uruguay who had injuries associated with the use of explosive devices between December 2014 and January 2016. Those over 14 years of age were excluded from the study. Based on the cases analyzed, the authors prepared the following table:

Table 3. Presentation, treatment and evolution of clinical cases

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Age (years)	11	12	12	14	12	3
Sex	M	M	M	M	M	M
Origin	Paysandú	Rio Negro	Montevideo	Cannelloni	Montevideo	Montevideo
Mechanism of injury	Bomb explosion	Bomb explosion	Bomb explosion	Bomb explosion	Bomb explosion	Bomb explosion
Affected region	Right hand	Right hand	Right hand	Right hand	Right hand	Left hand
Type of injury	Partial amputation of 1st, 2nd and 3rd phalanges	Partial amputation of the 1st phalanx, injury to the 2nd and 3rd phalanx	Partial amputation of the 3rd phalanx	Partial amputation of 1st, 2nd and 3rd phalanx	Partial amputation of 1st phalanx	Amputation of 2nd, 3rd and 3rd phalanx
Associated injury	Chest and abdomen burns	Ecchymosis on the face, neck and chest	No	No	No	No
Surgery	Yes	Yes	Yes	Yes	Yes	Yes
Analgesics	Cetoprophen, dipirona	Ketoprophen, tramadol	Dipiron, morphine	Morphine	Morphine	Dipiron, morphine
Antibiotics	Cefradine	Clindamycin, Gentamicin	Clindamycin, Gentamicin	Clindamycin, Gentamicin	Clindamycin	Clindamycin
Sequels	3rd phalanx retraction	Pain, deviation of the 2nd phalanx	Aesthetic	Aesthetic	Aesthetic	Aesthetic and functional, PTSD

PTSD = Post-traumatic Stress Disorder

The researchers observed that the circumstances of the accident were identical among the five adolescents (n = 5): they all held an explosive in their right hand and were injured when trying to light it. Consequently, all (n = 6) had traumatic amputations ranging from partial amputations of phalanges to the loss of several fingers and required analgesia, imaging tests to assess the extent of damage, evaluation by a plastic surgeon, and surgical interventions.

Regarding the management studied by Más *et al*, the supporting literature shows that polytrauma patients require rapid evaluation and immediate adoption of life support measures, such as: maintenance of the patent airway, hemorrhage control, and hemodynamic stabilization. Time is decisive in these cases and a systematized approach is recommended that facilitates communication between professionals. In team care, the presence of a leader responsible for maintaining the global view of care is essential, since those who are performing a procedure may lose this perspective and ignore other potentially fatal injuries (Abib, Monteiro & Mella, 2012).

It is crucial to follow an order of priorities that facilitates the identification of life-threatening conditions, known as ABCDE (Abib, Monteiro & Mella, 2012):

A. Airway and cervical spine immobilization;
B. Ventilation;
C. Circulation and hemorrhage control;
D. Neurological dysfunction, neurological status;
E. Exposure and control of the environment, completely undressing the patient and preventing hypothermia.

When receiving the polytrauma patient, a quick general inspection should be carried out and immobilization should be ensured, in addition to checking the level of consciousness, breathing and verbalization. It is also essential to administer supplemental oxygen by mask, usually at 12 L/min for all cases (Abib, Monteiro & Mella, 2012).

At the same time, hemodynamic stability should be assessed by observing the following signs: pallor, level of consciousness, and palpation of pulses. Findings such as cold and clammy skin, sweating, prolonged capillary refill time, and absence of peripheral pulses indicate hypoperfusion. If there is heavy bleeding, pressure should be applied to the site, perform "*wound packing*" – a technique that involves filling the lesion with hemostatic gauze to stop bleeding – or using tourniquets in uncontrollable bleeding of extremities that could not be managed by other means. Cardiac monitoring and non-invasive blood pressure measurement are essential, with special attention to signs of hypotension and tachycardia. In this sense, the calculation of the shock index, obtained by the ratio between heart rate and systolic blood pressure, is a valuable tool to identify occult shock. An index greater than 0.8 or a variation of ≥ 0.1 indicates the presence of occult shock and is associated with a higher risk of death. (Pereira *et al,* 2023).

It is essential to establish two caliber peripheral venous accesses, at least 18G. If this is not feasible, the following should be tried in sequence: intraosseous access, central venous access and, finally, phlebotomy. It is also necessary to collect samples to assess serum hemoglobin and hematocrit levels, INR, blood typing, lactate, and arterial blood gases to check for base deficit, as well as beta-HCG in all women of childbearing age (Pereira *et al*, 2023).

Moderate to severe hemorrhagic shocks and patients who have not reached blood pressure goals even after initial volume expansion indicate the need for blood component transfusion. In severe hemorrhagic shock, it is essential to activate the massive transfusion protocol, which usually consists of the acute administration of a volume greater than one and a half times the patient's volume in less than 24 hours (Pereira *et al*, 2023).

Regarding analgesia, in the study by Más *et al*., it was found that morphine was widely used, since it acts as an agonist of opioid receptors, resulting in significant and rapid analgesia. Ketoprofen was also widely found in the conducts, a finding that corroborates what was exposed by Abib & Perfeito (2012). For the authors, the general principle of treatment is to maintain the regular use of anti-inflammatories and analgesics, and the regimen of use by patient demand should be avoided. Initially, anti-inflammatory analgesics should be used followed by the use of opioids. Safety is offered by drugs using small incremental doses, until the desired analgesia is obtained. Table 4, contained in the researchers' work, shows the analgesia conduct on an increasing scale, followed by its dosage.

Table 4. Anti-inflammatories and analgesics

Drug	Dose venosa usual (mg/kg)	Adverse effect
Dipyrone	20 to 30 every 6 hours	Leucopenia nása
Ketoprofen	1 to 1.5 every 8 hours	Epigastralgia, nephritis, sangramento
Tenoxican	0.5 to 0.4 every 12 hours	Epigastralgia, nephritis, sangramento
Morphine	0.03 to every 4 hours	Respiratory depression, constipation, urinary retention

The explosion leads to the continuity solution and in open lesions there is a greater chance of bacterial contamination that can interrupt the normal healing process (Ohara, 2008). Thus, prophylaxis against infections should be performed with broad-spectrum antibiotics. This approach could be observed in the approaches observed in the study by Más *et al*, in which clindamycin was the most commonly used antibiotic, since it ensures coverage of Gram-positive microorganisms and strict anaerobes, which have a good action on soft tissue infections.

The study conducted by Staruch *et al* (2017) documented 484 hand injuries in 380 service members who were injured on duty in Afghanistan with improvised explosive devices between 2013 and 2016. By specifically analyzing 103 patients who suffered injuries to the metacarpal structures, phalangeal or digital amputations, the researchers found that the third and fourth phalanx were more frequently injured, intensifying the data from the study by Más *et al*. In addition, it was common to observe simultaneous amputations in the third, fourth, and fifth phalanges. The research also revealed that the proximal phalanges of the third and fourth phalanges showed a significant correlation for fractures together. This research contributed to the understanding of injuries caused by explosives.

Westrol *et al* (2016) emphasized the pathophysiology of blast injuries and identified five factors that influence blast wave damage: the initial peak pressure, which determines the severity of the impact; the duration of the overpressure, which affects the extent of tissue damage; the distance from the epicenter of the blast, which determines the intensity of the wave; the reflection of the shock wave, which can amplify the damage indoors and the density of the environment where the explosion occurred, which influences the propagation of the wave.

Könnefer *et al* (2016) reported a series of nine cases of severe trauma to the hands and face as a result of the detonation of booby traps and explosive devices of patients who received primary care in the emergency department of the Faculty of Medicine in Hannover, Germany. During the period 2011 to 2015, the department's staff treated six patients who had hand trauma resulting from gun-like devices, two patients with hand injuries due to booby traps, and one patient who suffered facial injuries as a result of a gas cartridge explosion.

All patients with hand trauma due to explosives had soft tissue injuries, fractures, or injuries to capsular and tendon structures. Surgical treatment included interventions such as debridement, skin grafts, and the use of flaps to cover tissue defects. These therapeutic approaches reaffirm the findings of Más and Staruch, who emphasized in their studies the importance of reconstructive surgical treatment for this type of injury.

According to the literature, the restoration of blood flow is the top priority and circulatory conditions should be assessed through tissue staining. Arterial or venous involvement may result from arterial contusion or occlusion, as well as difficulties in venous return due to congestion (Ohara, 2008).

The debridement technique mentioned by Könnefer is performed to reduce contamination, prevent the development of osteomyelitis, and preserve the viability of injured tissues. Initially, abundant irrigation with saline solution increases the effectiveness of the cleaning process that aims to remove all debris to facilitate the healing of tissues that can be used in future reconstructions. It is also essential to identify the presence of osteoarticular lesions that may go unnoticed, especially dislocations in less visible areas (Ohara, 2008).

The reduction of bone fragments should be performed anatomically with different methods: crossed Kirschner wires, intramedullary fixation, or bayonet interposition techniques in cases of loss of bone segments. After bone stabilization, all available repairs must be performed. In situations of multi-tissue injury or intense contamination, immediate primary suturing of the flexor tendons may be contraindicated. The presence of fractures and associated neurovascular injuries does not necessarily preclude immediate tendon repair, as long as the fracture reduction is anatomically and rigidly fixed. After bone stabilization, it is preferable to perform the necessary sutures (Ohara, 2008).

As for the grafting mentioned by Könnefer, it is clarified by Ohara (2008) who states that grafting is always preferable and that primary amputation is indicated only when there is a total and irreversible loss of blood supply. Parts of the skin of amputated segments that cannot be reimplanted can be used as a source of total skin grafting, removing all subcutaneous cellular tissue. The skin should be closed with simple stitches, which should be placed with a certain "slack" to avoid tension on the wound edges, thus preventing vascular suffering and necrosis of the edges.

Haerkens *et al* (2016) wrote their article in a context marked by the terrorist attacks that took place in Paris and Brussels in 2015, which brought to light the relevance of injuries caused by explosives and brought a view on the need for good preparation for an efficient management of explosion injuries. The author noted that the Netherlands' experience in dealing with bomb-based terrorist attacks was limited, which meant that Dutch health workers were inadequate to deal with such injuries.

After detailing the mechanisms surrounding explosions and the impacts these events have on the human body, Haerkens offered guidance on the main principles of treatment for explosion injuries, such as initial stabilization, hemorrhage control, and evaluation of associated injuries. These guidelines are essential, since effective management of these injuries can mean the difference between life and death, in addition to significantly influencing the long-term recovery of patients. Adopting these guidelines in emergency care protocols is essential to ensure that healthcare workers are well prepared to face the challenges presented by blast injuries.

In addition, the author emphasized the importance of a multidisciplinary approach to ensure that patients receive comprehensive and continuous care. Haerkens' article, therefore, serves as a call for health services to be better prepared to deal with the consequences of incidents involving explosives.

CONCLUSION

The literature on trauma by explosive devices is still limited, which urges the need for more research, especially in Portuguese, to expand knowledge on the subject.

Epidemiological data indicated that men were the main victims, with the right hand being most frequently affected. Treatment of these lesions required a careful approach to analgesia, with morphine and ketoprofen being the most common options, while clindamycin stood out as the prophylactic antibiotic of choice. The importance of surgical referral for lesion repair was also highlighted, given that appropriate intervention significantly influences long-term results.

Understanding the pathophysiology of blast injuries is critical for healthcare professionals to be able to make informed decisions about diagnosis and treatment. In addition, the literature emphasized that safety and training are essential to ensure positive outcomes in the care of victims of explosives. Continuous training of health professionals is essential to improve the response to these emergency situations. That said, knowing the best pharmacological and surgical alternatives and care flows will not only save lives, but also contribute to a more effective recovery of victims.

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