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Review article

The role of the orthopaedic surgeon in natural disasters

El papel del cirujano ortopédico en los desastres naturales

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ABSTRACT

A natural disaster is a phenomenon causing significant human, material, economic, and environmental losses, exceeding the capacity of the affected community or country to respond with its own resources. These events progress through phases: hyperacute, acute, subacute, chronic, and rehabilitation/recovery. Orthopedic surgeons play a vital role in each phase, from initial rescue to long-term rehabilitation.

In the acute phase, their responsibilities include triaging and managing injuries such as fractures (commonly in the lower limbs), wound infections, and crush injuries. Effective treatment is crucial to minimizing morbidity and mortality. Coordination between emergency medical teams (EMTs) and local authorities is essential for an efficient response, while poor organization can hinder relief efforts.

Orthopedic surgeons must adapt to limited resources, respect cultural contexts, and address socio-economic realities. Their role is increasingly critical due to the rising frequency of natural disasters linked to climate change, emphasizing the need for preparation and collaboration.

Palabras clave:
Traumatología
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RESUMEN

Un desastre natural es un fenómeno que provoca pérdidas humanas, materiales, económicas y ambientales, excediendo la capacidad de la comunidad o del país afectado para enfrentarlo con sus propios recursos. Estos eventos se desarrollan en fases: hiperaguda, aguda, subaguda, crónica y rehabilitación. En todas ellas los cirujanos ortopédicos desempeñan un papel esencial, desde el rescate inicial hasta la recuperación a largo plazo.

En la fase aguda, su función incluye clasificar y tratar lesiones como fracturas (especialmente en extremidades inferiores), infecciones de heridas y lesiones por aplastamiento. La adecuada gestión de estas patologías reduce la morbimortalidad en emergencias. La coordinación entre equipos médicos internacionales (EMT) y autoridades locales es crucial para una respuesta efectiva.

Los cirujanos ortopédicos deben adaptarse a los recursos disponibles y respetar las particularidades socioculturales. Su importancia crecerá ante el aumento de desastres naturales vinculados al cambio climático.

Introduction

Natural disasters are defined as natural processes that occur in ecosystems, which can result in instability within the social and economic systems, as well as an imbalance between supply and demand for social resources. A typology of disasters may be established according to their origin and characteristics, which may be divided into six categories: geological, meteorological, environmental pollution, fire, marine, and biological.[1]

The World Health Organization understands disaster as a phenomenon involving a "serious disruption of the functioning of a community or society causing human, material, economic or environmental losses that exceed the ability of the affected community or society to cope with its own resources", necessitating a request at the national or international level for external assistance.[2]

The average number of natural disasters worldwide has increased from about 30 per year in the 1950s to more than 400 since 2000. Approximately 800 million people currently live in areas prone to earth-

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quakes or at high risk of severe tropical cyclones. At present, research on natural disasters in today's society shows the characteristics of large varieties, high frequencies, wide coverage and high intensity.[3]

These disasters have increasingly become one of the most challenging problems facing humanity.

Disaster management is becoming increasingly critical today as global climate change increases the severity and impact of natural disasters.[4] The field of traumatology is of particular importance in the context of natural disasters. In situations where the ratio of injured to deceased is higher, victims are more likely to present with traumatic injuries. Earthquakes, in particular, result in a significant number of casualties, with the majority of injuries affecting the limbs. These injuries often require the expertise of orthopaedic surgeons among other professionals.[5]

Purpose

Conduct a literature review in order to update 'the role of orthopaedic surgeons in natural disasters'.

Stages in natural disasters

The performance of international aid in natural disasters depends on the time of arrival and the previous situation in the host country. Natural disasters can follow the same stages as other disasters: hyperacute (immediately after the event), acute (within 48 h), subacute (within 2 weeks), chronic (after 2 weeks) and rehabilitation and recovery.

Depending on the type of disaster, the length of each phase varies. For example, hurricanes allow for early evacuation, shortening the subacute phase, while earthquakes follow a different timeline. Non-chronic phases generally occur within 2 weeks, while chronic phases can last years.[6]

The hyperacute phase

Involves rescue operations, which are typically conducted by individuals present at the scene of the disaster. During the hyperacute phase, emergency responders prioritise search and rescue operations, providing immediate medical care and ensuring the safety of those affected.

The acute phase

Triage (from the French "triage") is a crucial method in emergency and disaster medicine. Its purpose is to select and classify patients according to priorities of care, giving priority to the possibility of survival and taking into account therapeutic needs and available resources. In triage situations, orthopaedic surgeons must make difficult decisions under pressure, balancing the needs of multiple patients with limited resources. They must be able to quickly assess the severity of injuries, determine the likelihood of survival, and prioritise care accordingly. Their expertise and experience are critical to ensuring that resources are allocated appropriately to meet needs.

The triage classifies patients into 4 main categories: immediate (*red*), patients with critical injury, that require minimal treatment time and resources, and after being treated have good prognosis for survival or require urgent lifesaving or limb-preserving interventions; delayed (*yellow*) patients, those with substantial injury for whom the provision of care can be delayed without risk of significant subsequent morbidity, until the subacute phase; expectant minimal, *nonurgent* (*green*), patients also known as walking wounded, with injuries that can wait for treatment. Example: sprains, abrasions, lacerations, small bones fractures, etc. These injuries require a significant amount of time and resources, but they can be postponed until a more convenient time; and deceased (black), patients with injuries so severe that probability of survival is minimal. For example, cases of patients with severe head injuries and third-degree burns covering 95% of the body.[7]

In the acute stage, the focus shifts towards providing temporary shelter, food, water, and medical care to those affected by the disaster.

The subacute phase

This phase (less than two weeks) shifts the surgical care focus toward optimising outcomes. This phase is marked by soft tissue coverage and fracture care for orthopaedics. In the subacute stage, efforts are made to assess the full extent of the damage caused by the disaster and develop long-term recovery plans.

The chronic phase

Two chronic stages are distinguished: rehabilitation and recovery (also referred to as the humanitarian stage). Rehabilitation involves infection control and the mobilisation of the injured. This stage partially overlaps with the recovery stage, which, from an orthopaedic standpoint, includes supportive devices such as prosthetics, braces, splints, and crutches, as well as medications and the provision of food and water. The chronic stage is characterised by ongoing efforts to rebuild and restore the affected area to its pre-disaster state. This may involve repairing or rebuilding damaged buildings, replacing infrastructure, and addressing any environmental hazards caused by the disaster. In the final stage of rehabilitation and recovery, long-term efforts are made to assist communities affected by the disaster in their recovery and to build resilience for the future. This may include mental health support, economic development programs, and community rebuilding initiatives.

Organisation and coordination of international support

In the aftermath of a natural disaster, the initial response is primarily provided by local residents and rescue efforts. Subsequently, national emergency services, such as the military or national medical teams, are typically dispatched to the affected area. The initial 72 h following a natural disaster are of paramount importance in terms of emergency response. During this time frame, effective management can significantly impact the outcomes of the disaster response efforts in the later stages.

If local and national responses to address the emergency are insufficient and demand for assistance, the international community may offer various forms of support, including the deployment of emergency medical teams (EMTs) defined by the World Health Organization (WHO) as "groups of health professionals and supporting staff outside their country of origin, aiming to provide health care specifically to disaster affected populations".[8]

EMTs include interdisciplinary personnel, and are designed to be self-reliant, mobile, flexible and modular.[9]

The composition and number of members of the EMTs, divided into three types: EMT-1, EMT-2 and EMT-3, are determined according to the nature of the needs and services to be provided in the affected area. All teams are made up of physicians, nurses and logisticians.

Type 1 EMTs provide outpatient emergency care. They may consist of mobile or fixed units.

Type 2 EMTs provide emergency inpatient surgical care. This includes damage control, trauma, general and orthopaedic surgery and basic anaesthesia. They must have inpatient beds, appropriate sterilisation equipment, laboratory and blood transfusion facilities.

Type 3 EMTs provide inpatient referral care. It must be able to provide type 2 care in conjunction with other subspecialty services and intensive care unit (ICU) beds. In the context of international aid, it is of the utmost importance to consider the country to which the aid is being sent and the demographic characteristics. For example, children are particularly vulnerable during natural disasters, for reasons such as their dependence on adults for basic needs, which is exacerbated by the loss of parents during natural disasters, greater difficulty in communicating, or the risk of serious growth disorders because of their injuries.[6]

Each country has its own specific needs, cultural context, traditions and socio-economic context, which must be considered when designing aid programmes. By focusing on the country to which international aid is sent, we can ensure that the aid is effective and reaches the people who need it. Furthermore, it is important to consider the potential for cultural conflict or misunderstanding if local realities are not considered.

In essence, the country to which international aid is sent is of paramount importance to guarantee its efficacy, adaptability and long-term sustainability. It is of the utmost importance to collaborate with local authorities and civil society organisations to achieve a positive and lasting impact on recipient communities. It has been highlighted that poor coordination represents a significant barrier to the effective implementation of emergency medical teams (EMTs) during disaster response efforts.[10] Factors such as inefficient utilisation of EMTs and resources, inadequate communication with government entities and regional headquarters, lack of independence in terms of transportation and utilities, and minimal interaction among different EMTs have all been identified as hindrances to efficient implementation. The 2010 Haiti earthquake is an example of the challenges that can arise from a lack of coordination. Despite the presence of many EMTs, the relief effort was hampered by missed opportunities due to poor coordination. This highlights the critical importance of addressing coordination challenges to enhance the effectiveness of EMT operations during disaster response.[11]

The role of orthopaedic surgeons in natural disasters

The incidence of musculoskeletal injuries in the context of natural disasters, such as earthquakes or tsunamis, varies considerably. In the case of earthquakes, the injury/death ratio is 4/1, whereas in other disasters, such as tsunamis or landslides, the ratio is reversed.

In disaster situations, it is of the utmost importance to adhere to the general principles of trauma care, which include rapid triage, transport, early stabilisation and definitive management.

In an emergency or disaster situation, the orthopaedic surgeons are often on the front lines, assessing and treating patients in critical condition. They use their expertise to quickly assess injuries, prioritise treatment, and make decisions about which patients require immediate care.

In addition, they work closely with other health professionals, such as emergency physicians, nurses, other surgeons and rescue teams, to ensure a coordinated and effective response in caring for those affected by traumatic events.

The predominant musculoskeletal injuries in these situations are open and closed fractures, wound infections and crush injuries, with almost 65% reported to be lower limb fractures. Crushed injuries to the extremities are common in earthquakes and are estimated to affect between 3 and 20% of those injured.[5] Based on the studies reviewed, the most common orthopaedic surgical interventions for earthquake victims are fracture fixation (31–61.7% of surgical cases), wound debridement (13.9–43.3%), external fixation with reported rates varying from $<2\%$ to $>30\%$ depending on the timing of arrival of surgical teams, fasciotomy for compartment syndrome with up to 47% of surgical cases in some studies, and amputation with rates ranging from 0.4% to 11%.[12,13]

In disaster situations, early damage control for the patient is critical and the use of external fixators is essential. External fixators offer significant advantages over internal fixation in situations where medical facilities may lack adequate resources and staff and are faced with large numbers of patients with multiple traumatic injuries and fractures. These benefits stem from their cost efficiency, ability to reduce operative time and adaptability for use by healthcare professionals with different levels of expertise.[14]

However, extremity damage should be treated after the patient's airway, breathing and circulation have been managed in accordance with the Advanced Trauma Life Support (ATLS) protocol.

Also, depending on the nature of the event, the orthopaedic surgeon may be called upon to play a critical role in the prompt diagnosis of pathologies such as the crush syndrome, which require a quick diagnosis and referral to an intensive care unit for lifesaving measures.

It is very important for the clinician in the field to distinguish between a crush injury, a crush syndrome and a compartment syndrome so that they can be treated accordingly.

Crush syndrome, also known as traumatic rhabdomyolysis, is a medical condition characterised by severe muscle damage resulting from prolonged pressure on a muscle group. This can occur when a person's body is trapped or compressed for an extended period, such as in a collapsed building or a car accident. As a result of the muscle damage, large amounts of toxic by-products are released into the bloodstream, leading to potentially life-threatening complications such as kidney failure and shock.[15,16]

Crush syndrome can develop within 1 h in a severe crush situation, although it typically takes 4–6 h of compression for systemic manifestations to become evident. In the early stages, there may be subtle local clues to the condition. As the injury progresses, noticeable vascular compromise may occur, leading to ischemic changes in the affected muscles, resulting in rhabdomyolysis and eventual muscle cell death. Symptoms may include significant swelling, skin discoloration, pain with movement, tingling or numbness, and weakness. Treatment for crush syndrome usually involves rapid rehydration, pain management, monitoring for complications and may require dialysis.

Key blood markers that indicate the need for dialysis include: elevated creatine phosphokinase (CPK) levels, often over 5 times the upper limit of normal or >1000 IU/L, hyperkalemia from the release of potassium from damaged muscle cells, hypocalcemia, metabolic acidosis and/or oliguric/anuric acute kidney insufficiency (AKI). Aggressive IV fluid resuscitation is crucial to maintain urine output, with a target of 1–3 mL/kg/h up to 300 mL/h. With prompt treatment, most patients regain normal kidney function within 60 days.[17,18]

On the other hand, compartment syndrome is a potential complication of crush injuries in which there is a sudden increase in pressure within a muscle compartment due to accumulation of fluid and blood. This can result in tissue damage, ischemia and necrosis if the pressure is not relieved through emergency fasciotomy. Compartment syndrome occurs when tissue pressure in a confined space is increased to the point where circulation and tissular function in that space are compromised. Treating acute compartment syndrome injuries with fasciotomy for up to 6 h can reverse ischaemic changes and relieve compartment pressure, resulting in satisfactory outcomes. In summary, timely treatment of acute compartment syndrome with fasciotomy can prevent serious complications and improve the patient's prognosis.

It is important to understand that the approach to addressing crush syndrome differs from the treatment of acute compartment syndrome. While fasciotomy is commonly used to relieve pressure in acute compartment syndrome, its role in managing crush syndrome is more debated and not as straightforward. The decision to perform a fasciotomy in cases of crush syndrome varies among healthcare professionals based on factors such as the extent of tissue damage, presence of systemic issues, and the overall health status of the patient. Some physicians suggest that if a fasciotomy is performed promptly after the crush injury, there is a potential for reversing the tissue damage. If a fracture is present, stabilisation of the limb by means of a splint or external fixation is recommended. High rates of infection are associated with open reduction and fixation techniques that convert closed fractures into open fractures.

Amputation should be considered for crush injuries, regardless of fracture, along with renal and cardiorespiratory compromise and sepsis. However, advancements in fracture stabilisation methods and vascular techniques have made limb salvage a more viable option in recent years. Various scoring systems have been developed over time to aid in the decision-making process between limb salvage and amputation, but none have demonstrated consistent usefulness.[19,20]

Factors such as technique, culture, facilities and surgical skills should all play an important role in the decision-making process when an amputation is being considered. Considering the evidence to date, a staged approach to amputation should be adopted wherever possible to minimise the risk of local and systemic infection. As amputation in the field is an evolving medical skill that will inevitably grow with the increasing frequency of disasters, education about its purpose, techniques, planning and approach should be of paramount importance to all orthopaedic surgeons. International collaboration and the availability and sharing of information will further assist us in developing a more objective approach to some of the most difficult and life-changing human decisions.[20]

Not least, in developing countries, the management of orthopaedic surgical implants during natural disasters poses a significant challenge, given the overwhelming demand and reliance on imported medical equipment, which can be difficult to obtain in sufficient quantities during emergencies. One possible solution would be to use locally sourced materials to manufacture these implants. Local manufacturing not only helps to address the immediate health crisis, but also stimulates the national economy by reducing dependence on imports and promoting local industrial development. However, to ensure efficacy and acceptance by surgeons, this approach requires that locally manufactured biomedical products meet international safety and quality standards.[21,22]

In summary, it is essential for trauma physicians to adapt to the resources available in the affected country during natural disasters. This includes using available surgical material and medical equipment efficiently, as well as adjusting to local protocols and procedures to ensure effective and safe medical care. Adaptability and flexibility are key to providing the best possible care in emergency situations.

Professional training

Triage training is essential during mass disaster management to avoid over- or under-diagnosis and to facilitate the arrival of resources where they are needed.[23]

The collection of data and the monitoring of patients can be greatly aided using artificial intelligence and advanced technology. This will help to analyse and adapt the response to natural disasters.

Virtual reality plays an important role in educating and training professionals, as well as participating in global initiatives and projects facilitated by digital platforms.[6]

International assistance in natural disasters must be of high quality, and organisation and fluid communication between the countries and organisations involved are essential to provide real help and not a burden in difficult moments that exceed the capacity of the country to cope with the situation.

To this purpose, orthopaedic surgeons must be trained before departure, with particular emphasis on respect for the culture of the country to be helped and an understanding of the real needs that will be encountered on arrival. Their help is just as valuable when an EMT-2 with surgical capacity is needed for major and minor surgery as when an EMT-1 is needed because the assisted country needs a temporary centre to deal with minor pathologies.

The role of the traumatologist in natural disasters could be compared to that of the musician in an orchestra, where it is as important for the director to conduct highly qualified professionals with precision as it is for them to be flexible enough to play the instrument with the right intensity at the right moment or the right silence at the right time.

Conclusions

Overall, orthopaedic surgeons are essential members of the healthcare team, playing a crucial role in the care and treatment of patients with traumatic injuries. Their expertise in orthopaedic surgery, collaboration with other healthcare professionals, and dedication to optimising patient outcomes make them essential members of the healthcare team in addressing traumatic injuries.

Due to the effects of climate change, orthopaedic surgeons may be faced with an increased number of casualties from natural disasters. Learning more about the management and profile of these injuries may be a future challenge for orthopaedic and trauma surgeons.

Conflict of interest

The authors declare no conflict of interest.

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