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Invited Review

Orthopedic surgery in disaster

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ABSTRACT

Orthopedic injuries are a common occurrence in disasters. In the aftermath of a disaster, there may be a large number of patients with orthopedic injuries, and the health-care system may be overwhelmed. This review hopes to provide a review of modern concepts in disaster orthopedics.

Introduction

Disasters such as earthquakes, floods, and explosions result in significant casualties if not managed properly. Conditions may be limited, making it even impossible for outside crews trying to help. An earthquake of a magnitude 7.8 occurred in the southern and central regions of Turkey, along with the northern and western areas of Syria on February 6, 2023. In Turkey, 50 783 people died, 297 people went missing, and 107 204 people were injured. Millions of people and buildings were affected, with about 345 000 apartments destroyed. The greatest concentration of patients occurred within the initial 24 hours.[1] The predominant injuries resulting from high-energy trauma were soft tissue injuries and fractures.[2] Surgeries included internal fixation, upper/lower extremity fasciotomy, amputation, and soft tissue debridement.[3] Children accounted for 16.2% of affected individuals. Injuries of the lower extremities made up 59.07% of musculoskeletal injuries, with other injuries including the upper limb (21.9%), pelvis (12.7%), and spinal cord (6.25%).[4] Following the earthquake, there was a notable shift in presentation patterns at outpatient clinics for orthopedics and traumatology. The number of patients from other areas and trauma-related diagnoses increased, while unnecessary outpatient visits decreased.[5] Multiple hospitals in the adjacent regions treated a multitude of victims.[6] While one would hope that more lessons were learned from the previous devastating earthquake in 1999, including safer building development, this article will focus on the orthopedic care of patients during disasters. Orthopedic surgery emerged as the most commonly required, followed by neurosurgery, plastic surgery, general surgery, and dental surgery in the aftermath of an earthquake.[7] Relevant literature was reviewed to identify studies on disaster management with a focus on orthopedic surgery. The objective was to underscore the essential lessons learned, which can be implemented in future disaster response practices.

Disaster staging

The same sequence of stages may be used for disasters: hyperacute (immediately following the event), acute (within 48 hours), subacute (within 2 weeks), chronic (following 2 weeks), and rehabilitation and recovery stages.[8] The duration of each stage may be variable depending on the type of disaster, as anticipated disasters such as hurricanes may permit early evacuation, thus shortening the subacute phase, while earthquakes will have a different timeline. As a general guideline, the non-chronic stages typically occur within the initial 2 weeks, while the chronic stages can extend for years.[8]

In the 1980s, the National Disaster Medical System was established in the United States as a collaborative effort between the private and public sectors. Its purpose was to offer medical care to the victims of significant disasters.[9] Functions encompass rescue and initial aid, casualty clearing (involving triage and medical stabilization), emergent surgical treatment, medical staging (sorting and providing temporary care for stabilized casualties at transfer points in the evacuation system), and final care (delivering the necessary remaining medical treatment).[9]

The hyperacute phase involves rescue efforts usually carried out by individuals present at the scene of the disaster. The acute phase includes triage, which classifies patients into 4 main categories: immediate (requiring urgent lifesaving or limb-preserving interventions), delayed (until the subacute phase), expectant (extensive time and resources are needed but can be deferred), and deceased. The subacute phase shifts the surgical care focus toward optimizing outcomes.

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This phase is marked by soft tissue coverage and fracture care for orthopedics.

Two chronic stages include rehabilitation and recovery (also referred to as the humanitarian stage). Rehabilitation involves infection control and the mobilization of the injured. This stage partially overlaps with the recovery stage, which, from an orthopedic standpoint, includes supportive devices such as prosthetics, braces, splints, and crutches, among others. Additionally, the recovery stage encompasses medications as well as the provision of food and water.

Injuries and treatments

Open and closed fractures, wound infections, and cranial trauma emerge as the most prevalent injuries in the aftermath of mass casualty events. The primary surgical interventions typically involve wound debridement, orthopedic trauma care, and, in some cases, amputation. Given the large patient volume and polytrauma, "damage control" orthopedics is often utilized. This concept involves the use of temporizing devices, like external fixators, for early fracture stabilization during the initial resuscitation phase. This approach defers the additional stresses associated with open surgery or even intramedullary nail osteosynthesis until the patient is stabilized. After resuscitation, patients are subsequently brought back to the operating room for definitive fracture fixation.[10]

Closed fractures may be addressed through closed reduction and splint application, but open fractures often necessitate debridement and stabilization using external fixation. Soft tissue management options encompass primary closure, open wound treatment, or the application of negative pressure wound dressings. In certain cases, amputation might be considered as a lifesaving measure for infected open fractures or limb injuries that cannot be salvaged.

Advanced trauma life support protocol should be used for the management of patients' airway, breathing, and circulation. Extremity injuries should be attended to afterward.[11] Prior to wound management, appropriate resuscitation along with the administration of adequate antibiotics and tetanus toxoid are crucial.

Crush injuries are frequently observed after earthquakes.[12] Compartment syndrome may develop following fractures in the upper or lower extremities. Due to the potential unavailability of essential equipment for measuring compartment pressure, surgeons may need to depend on clinical examination. In situations where serial examinations are not feasible, the surgeon might opt for early fasciotomy. The primary concern in these cases is the potential heightened risk of infection in a contaminated environment with insufficient soft tissue coverage. However, the authors think that the risks of missed compartment syndrome may be acutely more devastating than the risk of infection in these cases.[11] In cases of crush syndrome, delayed fasciotomy is not advisable. Amputation proves to be a lifesaving measure, particularly in cases of severe lower extremity injuries.[13]

Amputation during natural disasters, particularly earthquakes, is a common, intricate, and debated topic. The most effective approach to amputation often involves staging, especially when there is a delayed presentation. This approach includes successive debridement and delayed wound closure to reduce the risk of infection and sepsis. Amputation is typically considered a last option and is employed when necessary to help with the extraction of victims when their limbs are trapped under debris.[11]

External fixation will continue to be essential for the early stabilization of extremity fractures. The construct should facilitate the independent implantation of pins or a group of pins into the main bone fragments. After pin insertion, the reduction of bone fragments is carried out. In situations where an urgent and rapid procedure is necessary, a basic alignment may be achieved initially and further refined during a subsequent surgical intervention. Once a satisfactory reduction is achieved, stable fixation should be easily attainable. Postoperative care involves daily cleaning of pin tracts and applying light sterile dressings during the initial days.[14]

Pediatric orthopedic care

Children are especially vulnerable in disaster situations due to a variety of factors. Immature motor and communication skills, reliance on adults for essential needs, and limited judgement compromise their basic survival skills. They are more likely than adults to receive a higher triage level and demonstrate an unrecorded severity of illness, emphasizing the communication difficulties in caring for the pediatric population.[8]

Anatomical and physiological distinctions further heighten children's vulnerability to various forms of trauma. Their decreased skin thickness and fat reserve, as well as increased skeletal flexibility compared to adults, lower their resiliency to trauma and other environmental stresses. Their lower blood volume increases their susceptibility toward negative effects of hemorrhage or other fluid losses, such as vomiting and diarrhea. Additionally, their underdeveloped immune systems and faster metabolism increase their susceptibility to infections. A higher ratio of body surface area to mass leads to faster temperature loss, greater absorption of toxins, and a heightened risk of hypothermia. Lastly, orthopedic injuries frequently involve damage to physes, requiring specialized care.[8]

Organization

Coordinating a prompt and efficient response among individuals and agencies in the aftermath of a local disaster presents a considerable challenge. Nonetheless, this challenge can be alleviated by instituting a preestablished and flexible chain of command crafted to evaluate, communicate, and coordinate all facets of disaster response. The United States has implemented the National Incident Management System (aka NIMS), which describes a systematic approach to incident management.[15] This includes incident command and coordination as well as the management of resources and information. It comprises a set of guidelines for all dangers, incidents, and threats in all mission domains (prevention, protection, mitigation, response, and recovery). It contains fundamental principles for information management and communications as well as standard resource management practices that facilitate cooperation across several agencies or jurisdictions.

The Incident Command System (ICS) was developed as a standardized approach to the command, control, and coordination of on-scene incident management, offering a unified hierarchy for the effective collaboration of personnel from multiple organizations. Incident Command System outlines an organizational framework that integrates and oversees a spectrum of processes, people, facilities, equipment, and communications. Every incident can benefit from using ICS to develop and sustain the skills necessary for efficient coordination of efforts. All governmental levels, as well as several nongovernmental organizations and businesses in the private sector, employ ICS. Incident Command System is cross-disciplinary in nature and facilitates smooth collaboration between various organizations in terms of incident management. This system consists of 5 main functional departments (Command, Operations, Planning, Logistics, and Finance/Administration) that are manned according to the needs of the particular situation.

The Hospital ICS (HICS) was created to apply the same structure and guiding principles to the hospital environment, building on the success of the ICS.[16] Similar to the ICS, HICS serves as an organizational framework (not a concrete plan) guiding hospital operations during emergencies. It incorporates 5 primary management sections, along with hospital-specific units under section chiefs. For example, pediatric orthopedic services would be part of the Surgical Service Unit, led by a surgical service leader reporting to the medical care director and operations chief. Each role on the organizational chart has specific responsibilities and well-defined reporting channels. The modular design of HICS allows hospitals to activate only the components necessary for a specific emergency. Prior to an incident, it is crucial to establish systems for triage and patient transfer, involving local public health services, emergency management agencies, and health-care delivery services. Within a hospital, the triage system should adhere to the principle of providing the minimal acceptable level of care. Designated triage officers should prioritize patients and maintain a continuous, unidirectional flow of casualties. However, this approach may not be feasible for international events where the local infrastructure is entirely devastated, leading all events to fall under the ICS framework. In addition to essential patient care equipment, considerations must be made for additional needs, including decontamination equipment, tools for crowd management, local water purification systems, reliable communication and power generation solutions, and personnel identification methods. To expedite triage, diagnostic testing can be facilitated through portable battery-powered equipment such as ultrasound devices, handheld blood analyzers, and handheld pulse oximeters.[17]

Furthermore, incorporating a method for recordkeeping during an unexpected influx of patients is integral to the preparation phase. While computers and digital devices are optimal for data collection and management, power availability can restrict the extent of their functionality. Despite having the same limitations, the use of digital photography for patient identification and injury documentation remains valuable. It is preferable to adapt existing recordkeeping systems rather than introducing new ones. The most straightforward method of recordkeeping includes labeling casts or bandages with the dates of dressing changes and the upcoming treatment. Regardless of the chosen documentation method, some form of medical recordkeeping is essential to prevent redundant efforts, ensure timely and accurate medication administration, monitor patient progress or deterioration, and facilitate the smooth transition of patient care amid the rapid turnover of volunteer responders.[18,19]

Obtaining timely imaging has been recognized as a challenge. Even with the necessity of adding more radiology and computed tomographic scan technicians, the substantial demand could still result in delays in diagnosis. Early decisions must be made to prioritize necessary imaging and minimize unnecessary orders. Bedside imaging can be considered to avoid tying up personnel in the radiology department and to streamline the imaging process. Initial plain film radiographs may involve single anterior–posterior shots for a rapid diagnosis of evident fractures, followed by a complete imaging series in subsequent days. Patients undergoing surgery may undergo more comprehensive fluoroscopic imaging in the operating room.[20]

Coordination of help from outside

In times of disaster, there is usually national and international support. It is important to have a plan to coordinate these efforts to achieve maximum relief. While the support teams can be prepared for a multitude of local problems, the following can be hindering, as described by the senior author during relief efforts following the Haiti earthquake: the extent and severity of human devastation, with over 200 000 injuries; a deficient medical infrastructure; inadequate support from both the government and the medical community; a lack of coordination and logistical organization on the ground with no clear leadership; an absence of security presence at the hospital; and difficulties in facilitating the timely replacement of supplies and relief teams by air or ground transport. These factors made sustained and effective efforts impossible and unsustainable.[21] Thus, it is crucial to have a disaster plan, including the coordination of relief efforts from outside.

After the Haiti earthquake, it was crucial to identify the core requirements for the success of a surgeon volunteer program. Volunteer responders needed to have education in the principles of disaster management and a solid understanding of the fundamentals of orthopedic practice in challenging environments, taking into account cultural and ethical considerations. Additionally, volunteers should be provided with protection for liability, health, and disability expenses. Implementing a precertification and credentialing process would enable civilian orthopedic surgeons to provide temporary surgical services for the government during periods of crisis. For instance, the United States Navy sought the assistance of the Orthopedic Trauma Association (OTA) to have OTA members perform surgeries on board the naval ship Comfort while it was in the harbor of Port-au-Prince in January 2010. Furthermore, 3 types of orthopedic volunteer responders were identified: Responders classified as types I and II would be assigned for prompt deployment, with the option to serve as general orthopedists or trauma experts. When the crisis winds down and the reconstruction phase begins, type III responders will be ready to go. Individuals interested in becoming volunteer responders can readily explore various disaster management programs. Surgeons with previous training and experience in challenging environments can also streamline their certification process with the assistance of established policies and procedures.

These volunteers may comprise physicians with a military service background and individuals who have experience working abroad with non-governmental organizations such as Médecins Sans Frontières (MSF) and the International Medical Corps.[22] The collaboration between the Société Internationale de Chirurgie Orthopédique et de Traumatologie (SICOT) orthopedic surgeons and MSF began in 2006, following the mobilization of SICOT surgeons after the earthquake in Muzafarad in 2005. This collaboration facilitated the participation of orthopedic surgeons in MSF missions through volunteering.[23] Enhancing the training of civilian responders in comprehensive disaster education, establishing a database containing already credentialed and certified medical specialists, implementing a communication bridge, and fostering agreements between military and civilian medical/surgical groups before major catastrophic events are potential measures to enhance disaster preparedness.[18]

Training

In 1997 and 2009, Germany underwent civil protection reforms with the implementation of a new federal act. The Federal Government supported disaster relief efforts in individual states with approximately 9000 vehicles and allocated a budget for training. Emergency physicians are required to complete an 80-hour course in emergency medicine, emphasizing an interdisciplinary approach. Participation in rescue missions is permitted for emergency physicians only after gaining basic experience in emergency medicine and completing a minimum 18-month postgraduate training period. Senior emergency physicians undergo an extra 40 hours of both theoretical and practical training following a minimum of 3 years of experience in rescue services. Specialized training courses for disaster preparedness are provided by different institutions and organizations, catering to both medical and nonmedical personnel.[24]

Health systems and their affiliated care facilities need to undergo training to effectively manage victims of disasters, as the severity of injuries in life-threatening situations presents a specific challenge for hospitals and their personnel providing initial care. The Terror and Disaster Surgical Care (TDSC®) course was developed by the German Trauma Society and the German Armed Forces and was initiated in 2016.[25]

The TDSC principles involve categorization, prioritization, arrangement, and realization. Categorization encompasses the triage of patients by the leading doctor, followed by prioritization by the central operative coordinator for determining the indication and timing of operative treatment. Subsequently, only essential diagnostics are arranged, and the final operative plan is realized.[26]

The role of patient triage during mass disaster management is critical and ensures the proper allocation of resources. An analysis of unannounced hospital disaster training at Berlin hospitals showed triage issues, including relevant over- and undertriage. This led to the development of a triage algorithm for the clinical setting in Berlin. After presentation and discussion in the circle of representatives for clinical disaster protection, this algorithm was made mandatory in 2015. The triage category allocation was significantly improved in all relevant aspects after implementation, with a significant reduction of over- and undertriaging in 15 unheralded mass disaster drills with 556 actors in 2016-2017.[27] This underlines the importance of algorithms and disaster drills.

The emergence of the European Union as a major player in disaster response highlights the need for not only financial support but also the establishment of a unified approach and governance structure for disaster response. The DITAC (Disaster Training Curriculum) project examined the gaps in existing responder training methods and examined the features and content needed for a new standardized European course in disaster management and emergency response. Consensus, training, and education across different units may lead to the establishment of minimum standards and assessment metrics. The training initiative will focus on a situation-based training approach.[28]

Advanced technology

Disaster mobile health technology shows promise in resource-poor and chaotic settings, offering the potential to enhance patient care during disasters. The use of technologies like iChart has demonstrated improvements in patient tracking, particularly for vulnerable populations, as well as enhancements in patient care, especially in orthopedics and pediatrics. Additionally, facilities management benefited from accurate census data, and interfacility transfers were streamlined. Providers carrying handheld devices after the Haiti earthquake facilitated patient tracking. iChart, in an 8-week trial, showcased its ability to improve provider triage through real-time, standardized, and searchable registration processes.[29]

Virtual reality technology, an emerging technology widely adopted in recent years, holds potential applications in various aspects of disaster medicine. Its suitability spans education, professional training, knowledge dissemination, and psychotherapy, making it a versatile tool in the field.[30]

Aftermath

In the aftermath of a disaster, there may be significant damage to hospitals in the area, making it impossible to provide even basic, non-disaster-related health care to the local people, as evidenced after Hurricane Katrina in New Orleans in 2005.[31] It may take years for these hospitals to reopen. Disaster plans should include distribution of patients to surrounding hospitals, keeping in mind the capacity of each of them, to prevent overload elsewhere.

The personnel of these hospitals need to be transferred to other hospitals to increase help in functioning centers. After Hurricane Katrina, the chairman of Tulane University was able to temporarily relocate 24 residents and 6 interns to different educational programs around the country.[31]

Conclusion

We are consistently under the threat of both natural and man-made disasters. The key to an effective response lies in ongoing rehearsals, established communication pathways, and the seamless integration of orthopedic surgery's response within the hospital's incident command structure. This collaborative approach is crucial for a well-coordinated and efficient team response in the face of emergencies.

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References

1. Gök M, Melik MA, Doğan B, Durukan P. Türkiye-Suriye deprem merkezinden afet sonrası hastane kriz yönetimi. *Ulus Travma Acil Cerrahi Derg.* 2023;29(7): 792-797. [CrossRef]
2. Kulakoğlu B, Uzunay Z, Pota K, Varhan N, Fırat MG. Evaluation of musculoskeletal injuries after the 2023 Kahramanmaras earthquake: a local hospital experience. *Jt Dis Relat Surg.* 2023;34(2):509-515. [CrossRef]
3. Akkaya M, Öktem U, Tolunay T, et al. An overview of the orthopedic patient profile in the first five days following February 6th, 2023 Kahramanmaras earthquake: a single-center experience in the earthquake zone. *Jt Dis Relat Surg.* 2023;34(2):503-508. [CrossRef]
4. Özdemir G, Karlıdağ T, Bingöl O, et al. Systematic triage and treatment of earthquake victims: our experience in a tertiary hospital after the 2023 Kahramanmaras earthquake. *Jt Dis Relat Surg.* 2023;34(2):480-487. [CrossRef]
5. Asfuroğlu ZM, Gümüşoğlu E. Changes in patient admission patterns at orthopedics and traumatology outpatient clinics before and after the earthquakes on 6 February 2023 in Turkey. *J Orthop Surg Res.* 2023;18(1):494. [CrossRef]
6. Gürü S, Zaman S, Karamercan MA. Emergency response and clinical insights from a non-epicenter hospital during the 2023 Turkey-Syria earthquake: a retrospective analysis. *Med Sci Monit.* 2023;29:e941226. [CrossRef]
7. Kanchan KC, Thapa RK, Khadka S, Paudel D. A study of surgical cases during earthquake disaster in A medical college. *JNMA J Nepal Med Assoc.* 2019; 57(215):20-24. [CrossRef]
8. Kelly DM, Heyworth BE, Kruse RW, et al. Current state of pediatric orthopaedic disaster response. *J Pediatr Orthop.* 2014;34(3):231-238. [CrossRef]
9. Brandt EN, Mayer WN, Mason JO, Brown DE, Mahoney LE. Designing a national disaster medical system. *Public Health Rep.* 1985;100(5):455-461.
10. Scalea TM, Boswell SA, Scott JD, Mitchell KA, Kramer ME, Pollak AN. External fixation as a bridge to intramedullary nailing for patients with multiple injuries and with femur fractures: damage control orthopedics. *J Orthop Trauma.* 2004;18(suppl):S2-S12. [CrossRef]
11. Wolfson N. Amputations in natural disasters and mass casualties: staged approach. *Int Orthop.* 2012;36(10):1983-1988. [CrossRef]

12. Gonzalez D. Crush syndrome. *Crit Care Med*. 2005;33(1)(suppl):S34-S41. [CrossRef]
13. Kundakci B, Mirioglu A, Tekin M, et al.. 6 February 2023, orthopedic experience in Kahramanmaraş earthquake and surgical decision in patients with crush syndrome. *J Orthop Surg Res* 2023;18(1):537. [CrossRef]
14. Hinsenkamp M. SICOT contribution to natural disaster assistance: the external fixator. *Int Orthop*. 2014;38(8):1549-1550. [CrossRef]
15. National Incident Management System (NIMS). In: *Foundations of Homeland Security*. Hoboken, NJ: John Wiley & Sons, Inc.; 2011:279-281. [CrossRef]
16. Backer H. Hospital incident command system. www.emsa.ca.gov/media/default/HICS/HICS_Guidebook_2014_11.pdf; 2014.
17. Born CT, Monchik KO, Hayda RA, Bosse MJ, Pollak AN. Essentials of disaster management: the role of the orthopaedic surgeon. *Instr Course Lect*. 2011;60(January):3-14.
18. Born CT, Cullison TR, Dean JA, et al. Partnered disaster preparedness: lessons learned from international events. *J Am Acad Orthop Surg*. 2011;19(suppl 1):S44-S48. [CrossRef]
19. Born C, Mamczak C, Pagenkopf E, et al. Disaster management response guidelines for departments of orthopaedic surgery. *JBJS Rev*. 2016;4(1):1-8. [CrossRef]
20. Harper K, Rehman S. Orthopedic disaster management in the 2015 Amtrak derailment. *J Trauma Acute Care Surg*. 2016;80(6):1032-1038. [CrossRef]
21. Lorich DG, Jeffcoat DM, MacIntyre NR, Chan DB, Helfet DL. The 2010 Haiti earthquake: lessons learned? *Tech Hand Up Extrem Surg*. 2010;14(2):64-68. [CrossRef]
22. Pollak AN, Born CT, Kamal RN, Adashi EY. Updates on disaster preparedness and progress in disaster relief. *J Am Acad Orthop Surg*. 2012;20(suppl 1):S54-S58. [CrossRef]
23. Hinsenkamp M. SICOT contribution to natural disaster assistance: the prerequisite. *Int Orthop*. 2015;39(10):1885-1886. [CrossRef]
24. Fischer P, Wafaisade A, Bail H, Domres B, Kabir K, Braun T. Civil protection and disaster medicine in Germany today. *Langenbecks Arch Surg*. 2011;396(4):523-528. [CrossRef]
25. Achatz G, Bieler D, Franke A, Friemert B, and the Deployment, Disaster and Tactical Surgery Working Group of the German Trauma Society. Terror preparedness as a service of general interest: the Terror and Disaster Surgical Care (TDSC®)-course. *Eur J Trauma Emerg Surg*. 2020;46(4):671-672. [CrossRef]
26. Franke A, Bieler D, Paffrath T, et al. ATLS® and TDSC®: how it fits together: a treatment concept for mass casualty and terrorist-related mass casualty situations, life-threatening and special scenarios. *Unfall*. 2020;123(6):453-463. [CrossRef]
27. Kleber C, Solarek A. Cwojdzinski D. Der Berliner Krankenhaus-Sichtungsalgorithmus für den Massenanfall von Verletzten. *Unfall*. 2020;123(3):187-198. [CrossRef]
28. Khorram-Manesh A, Ashkenazi M, Djalali A, et al. Education in disaster management and emergencies: defining a new European course. *Disaster Med Public Health Prep*. 2015;9(3):245-255. [CrossRef]
29. Callaway DW, Peabody CR, Hoffman A, et al. Disaster mobile health technology: lessons from Haiti. *Prehosp Disaster Med*. 2012;27(2):148-152. [CrossRef]
30. Duan YY, Zhang JY, Xie M, Feng XB, Xu S, Ye ZW. Application of virtual reality technology in disaster medicine. *Curr Med Sci*. 2019;39(5):690-694. [CrossRef]
31. Rodriguéz RP. Catastrophic disaster. *Foot Ankle Int* Rodriguéz RP, Richardson EG, eds. 2006;27(5):315-316. [CrossRef]