REVIEW / DERLEME
DOI: 10.26650/IUITFD.1255192
İst Tıp Fak Derg 2023 / J Ist Faculty Med 2023

TRIAGE AND MANAGEMENT OF MUSCULOSKELETAL INJURIES DURING EARTHQUAKE

DEPREM DURUMUNDA KAS-İSKELET YARALANMALARININ TRİYAJ VE YÖNETİMİ

Serkan BAYRAM[1], Gökhan POLAT[1]

[1]Istanbul University, Istanbul Faculty of Medicine, Department of Orthopedics and Traumatology, Istanbul, Turkiye

ORCID IDs of the authors: S.B. 0000-0001-7651-1200; G.P. 0000-0002-5162-6842

Cite this article as: Bayram S, Polat G. Triage and management of musculoskeletal injuries during earthquake. J Ist Faculty Med 2023;86(2):180-184. doi: 10.26650/IUITFD.1255192

ABSTRACT

The harm of earthquakes can be decreased with operative catastrophe planning and successful emergency assistance. First aid and triage organization are essential for the medical care of those trapped under the rubble after the earthquake. Every injury seen in orthopedics and traumatology practice can be observed with being under the rubble; these can be in a spectrum ranging from simple muscle crush to pelvis fracture with vascular injury. The main function of the orthopedist is to perform a quick diagnosis and accurate treatment to save the life and extremities. The first step in the management of limb and axial skeletal injuries is accurate immobilization of the injured region, such as a cervical collar for the cervical spinal segment. Maintaining a safe airway and large-bore intravenous access for hemodynamic stabilization are also priorities in traumatized patients. Surgical procedures related to orthopedics and traumatology can be classified as follows; emergency care, emergency surgeries, delayed surgeries, and planned surgeries. While performing all these surgical procedures, a multidisciplinary approach should be applied to monitor and treat the patient's general condition.

Keywords: Disaster, trauma, crush injury, amputation, extremity salvage

ÖZET

Etkin afet planlaması ve başarılı acil durum yardımı ile depremin zararı azaltılabilir. Deprem sonrası enkaz altında kalanların tıbbi bakımı için ilk yardım ve triyaj organizasyonu şarttır. Ortopedi ve travmatoloji pratiğinde görülen her yaralanma enkaz altında kalındığında da gözlemlenebilir, bunlar basit kas ezilmesinden damar yaralanmalı pelvis kırığına kadar uzanan bir yelpazede olabilir. Ortopedistin temel işlevi, hızlı teşhis ve doğru tedaviyi yaparak hayatı ve uzuvları kurtarmaktır. Ekstremite ve aksiyal iskelet yaralanmalarının yönetiminde ilk adım yaralı bölgenin doğru şekilde immobilizasyonudur; servikal spinal segment için boyunluk gibi. Güvenli bir hava yolunun sürdürülmesi ve hemodinamik stabilizasyon için geniş çaplı intravenöz erişim de travma geçirmiş hastaların yönetiminin önceliğidir. Ortopedi ve travmatoloji ile ilgili olarak cerrahi işlemler şu şekilde sınıflandırılabilir; acil bakım, acil ameliyatlar, gecikmiş ameliyatlar ve planlı ameliyatlar. Tüm bu cerrahi işlemler yapılırken hastanın genel durumunun takibi ve tedavisi için multidisipliner bir yaklaşım uygulanmalıdır..

Anahtar Kelimeler: Afet, travma, ezilme yaralanması, amputasyon, ekstremite kurtarma

Corresponding author/İletişim kurulacak yazar: Serkan BAYRAM – dr.serkanbayram89@gmail.com

Submitted/Başvuru: 22.02.2023 • **Revision Requested/Revizyon Talebi:** 07.03.2023 •
Last Revision Received/Son Revizyon: 08.03.2023 • **Accepted/Kabul:** 09.03.2023 • **Published Online/Online Yayın:** 27.03.2023

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

INTRODUCTION

Earthquakes have caused major morbidity and mortality in earthquake-prone countries worldwide (1). When we investigated the past decade, we encountered a series of dire earthquakes in Turkiye [(Muradiye/Van (1976); Gölcük/Kocaeli (1999) and Pazarcık/Kahramanmaraş (2023)]. Numerous researchers have estimated that the next earthquake is likely to happen in Istanbul, Turkiye's most populous city (2). Turkiye has suffered a recent devastating earthquake, therefore revisiting the literature and reviewing the practical approach may be useful for clinicians. Because an earthquake is a natural disaster, it is impossible to predict and prevent it with current technology. Nonetheless, the harm of earthquakes can be decreased with operative catastrophe planning and successful emergency assistance (3, 4). It is a major challenge for medical systems, especially when destruction is massive in large-scale earthquakes. One of the ways to overcome this challenge is to examine the practices made at the time of previous disasters together with their missing and faulty aspects (5, 6). For this reason, comprehensive evaluations should be made about the causes, characteristics, and treatment of injuries after each earthquake disaster.

Triage of patients

First aid and triage organization are essential for the medical care of those trapped under the rubble after an earthquake. The first step after an earthquake is the rescue of those who are under the rubble. Rescued patients should be transported quickly to safe areas for further management. Kuwagata et al. reported an analysis of the Hanshin-Awaji earthquake, which included 2702 traumatized patients (7). In that population, one-third of the patients were treated in hospitals surrounding the area and had a mortality rate of 3%. The remaining patients were treated in the hospitals affected by the earthquake and faced a higher mortality rate of 8%. Patients should be evaluated by general surgeons, orthopedists, anesthesiologists, and internal medicine physicians as soon as they reach the health center. Orthopedic surgeons play a central role in the care provided to the patients trapped under the rubble because injuries in which patients have survived are mostly orthopedic. Kanchan et al. investigated an epidemiological outcome after the Nepal earthquake in 2015 (8). In that study, they reported on a series of 238 patients, the majority of which were related to orthopedic surgical procedures (77.7%).

Surgical procedures related to orthopedics and traumatology can be classified as follows; emergency care, emergency surgeries, delayed surgeries, and planned surgeries. This surgical treatment algorithm's success relies on the accuracy of indication, timing, and orderly practice. In the Pakistan earthquake in 2005, there were 40,000 traumatized patients, including 55% major injuries, 60% limb injuries, 20% cavity injuries, 2% spinal injuries, and 1% head injuries (9). Oda et al. reported 372 cases of crush syndrome, which can be partitioned into the lower extremities (74%), followed by the upper extremities (10%), and the trunk (9%) (10). Every injury seen in orthopedics and traumatology practice can be observed with being under the rubble; these can be in a spectrum ranging from simple muscle crush to pelvis fracture with vascular injury. The main function of the orthopedist is to perform a quick diagnosis and accurate treatment to save the life and extremities.

Management of orthopedic injury

Crush injuries, and bone and soft-tissue trauma are the most important injuries which can be seen after an earthquake. The first step in the management of limb and axial skeletal injuries is accurate immobilization of the injured region, such as a cervical collar for the cervical spinal segment. Maintaining a safe airway and large-bore intravenous access for hemodynamic stabilization are also priorities in traumatized patients.

1. Emergency care: The primary intervention is to control the bleeding caused by penetrating injuries and to provide hemodynamic stabilization. If there is minor bleeding, applying direct pressure on the wound by using clean gauze will be sufficient to control it. If there is major bleeding, the patient should be stabilized immediately with a multidisciplinary approach and vascular surgeons. Another emergency care resulting in trauma is an uncontrollable hemorrhagic pelvic fracture, a major cause of patient mortality (11). Managing this life-threatening situation is difficult and requires aggressive methods. Hemodynamic stabilization with blood transfusion and crystalloid solution via large-bore intravenous cannula is an effective protocol for improving hypovolemic shock. The use of other supportive care measures, such as external fixations, angiography and embolization, and pelvic packing to stop or reduce bleeding may also be effective (12, 13).

2. Emergency surgery: Fasciotomy is one of the most critical emergency surgeries due to crush injuries after an earthquake, followed by open fracture debridement, amputation, simple suturing, and external fixation (14). Crush injury of a limb typically comprises closed crushes suffered by victims due to prolonged immobilization under the rubble. In a patient with compartment syndrome after a crush injury, it should be considered that crush syndrome may develop which requires early diagnosis and a therapeutical approach. The decision for both medical and surgical treatment should be made quickly. Most patients who developed compartment syndrome have pain (especially by passive extension of the joint), loss of motor function, missing arterial pulse and capillary filling, pares-

thesia, and parlor. It should be remembered that compartment syndrome will not develop after every crush injury. It has been reported that 15% of patients with crush injuries develop compartment syndrome (15). However, fasciotomy following clinical suspicion gives us the best chance to optimally save the extremities and is a critical factor in managing crush syndrome (16). Fasciotomy provides the maintenance of circulation and prevents the necrosis of muscles. There is still controversy regarding the proper timing of fasciotomy to avoid irreversible ischemic changes. The ischemic necrosis of muscles can become permanent in 8 hours (16). However, this procedure holds the risk of fluid loss from the wound, and the risk of the infections (Figures 1, 2). In one study, Michaelson emphasized that the fasciotomy procedure should not be performed and conservative treatment should be chosen in patients with crush injuries (17). Another study suggested that patients suffering closed crush injuries that are treated with late fasciotomy (≥24 hours) faced worse outcomes than conservatively treated ones (18). Fasciotomy areas require frequent inspection to check for signs of vascular deterioration, inadequate fasciotomy, or emerging infection.



Figure 1: A 16-year-old boy who was trapped under the rubble in the Kahramanmaraş earthquake. Fasciotomy was performed on both cruris for the prevention of necrosis of muscles. The left distal crus developed necrosis and amputation was performed below the knee.

- Amputation: Acute renal failure and cardiac arrhythmias may develop due to myoglobinuria and hyperkalemia after necrosis of large muscle masses in crushed patients after an earthquake. In earthquake victims who develop these clinical conditions despite preventive treatments such as medical treatment and fasciotomy, limb amputation may be required (19). Amputation of a limb with or without circulation but with tissue continui-



Figure 2: A 15-year-old patient who was trapped under the rubble in the Kahramanmaraş earthquake developed necrosis and infection after fasciotomy.

Table 1: Mangled Extremity Severity Score.

	Points
Age, year	
>30	0
30 – 50	1
>50	2
Shock	
Systolic blood pressure >90mmHg	0
Transient hypotension	1
Persistent hypotension	2
Limb ischemia	
Pulse reduced or absent, perfusion normal	1*
Pulseless; diminished capillary refill, paresthesias	2*
Cool, paralyzed, numb, no sensation	3*
Tissue injury	
Low-energy (simple fracture, stab wounds)	1
Medium-energy (open or chain fractures, dislocation)	2
High-energy (crush injury)	3
Very high-energy (high contamination and extensive)	4

*double the score if ischemia duration >6 hours
A score of 6 or less is associated with 100% limb salvage rate.
A score of 7 or more is associated with 100% amputation rate.



Figure 3: A 17-year-old boy who was trapped under rubble in the Kahramanmaraş earthquake for a long time (more than 24 hours). Amputation above the knee was performed on this patient.

ty is a crucial decision for orthopedics and traumatology specialists, patients, and their relatives (20). It is helpful to use specific scoring systems, Mangled Extremity Severity Score (MESS) (Table-1) (21) and Injury Severity Score (ISS), when making the difficult decision to preserve with conservative treatments, fasciotomy, and debridement or amputation of the crushed limb. If the extremity circulation is insufficient and necrosis is increasing despite protective procedures such as fasciotomy, amputation should be performed without delay (Figure 3). In the Van earthquake, amputation was performed in one-third of the patients who underwent fasciotomy due to complications such as sepsis during the follow-up, and one-third died despite all efforts (22). Since the general condition of these patients can suddenly deteriorate, surgical procedures should be determined meticulously.

- Debridement: It is a priority to intervene in patients with soft tissue injuries, especially with open fractures. According to Kanchan et al., open reduction and internal fixation were the most routinely performed surgeries, followed by debridement in 238 cases (61.7% and 13.9%, respectively) (8).

3. Planned surgery: The above-mentioned surgical procedures can be performed under emergency conditions, perhaps in non-sterile environments. In patients with a crush injury with a bone fracture, a temporary external fixator can be applied to the injury condition (damage control orthopedics). Improving the physiological state is also an essential strategy of orthopedics damage control. Damage control orthopedics can delimitate the primary trauma, prevent further detriment and reduce morbidity and mortality (23). Patients with crush injuries and suitable soft tissue conditions can be included in planned surgeries and performed at the appropriate time. Finally, appropriate surgical management of spinal fractures and traumatic spinal cord injury, which carry high morbidity and mortality rates is also essential.

CONCLUSION

Although technology has advanced substantially, the essential skill of orthopedic surgeons in triaging many crushed patients to manage the available resources remains a critical issue. The most crucial intervention point is evaluating those people trapped under the rubble after an earthquake. Patients should be triaged according to the priority order from saving lives to simple debridement. While performing all these surgical procedures, a multidisciplinary approach should be applied to monitor and treat the patient's general condition.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- S.B., G.P.; Drafting Manuscript- S.B.; Critical Revision of Manuscript- G.P.; Final Approval and Accountability- S.B., G.P.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Ellidokuz H, Ucku R, Aydin UY, Ellidokuz E. Risk factors for death and injuries in earthquake: cross-sectional study from Afyon, Turkey. Croat Med J 2005;46(4):613.
2. Boğaziçi University, Kandilli Observatory and Earthquake Research and Institute, Regional Earthquake-Tsunami Monitoring Center [Boğaziçi Üniversitesi, Kandilli Rasathanesi ve Deprem Araştırma Enstitüsü, Bölgesel Deprem-Tsunami İzleme ve Değerlendirme Merkezi]. Büyük depremler. http://www.koeri.boun.edu.tr/sismo/2/deprem-bilgileri/buyuk-depremler/
3. Noji EK. The public health consequences of disasters. Prehosp Disaster Med 2000;15(14):21-31. [CrossRef]
4. Bulut M, Fedakar R, Akkose S, Akgoz S, Ozguc H, Tokyay R. Medical experience of a university hospital in Turkey after the 1999 Marmara earthquake. Emerg Med J 2005;22(7):494-8. [CrossRef]
5. Peek-Asa C, Kraus JF, Bourque LB, Vimalachandra D, Yu J, Abrams J. Fatal and hospitalized injuries resulting from the 1994 Northridge earthquake. Int J Epidemiol 1998;27(3):459-65. [CrossRef]
6. West JG, Murdock MA, Baldwin LC, Whalen E. A method for evaluating field triage criteria. J Trauma 1986;26(7):655-9. [CrossRef]
7. Kuwagata Y, Oda J, Tanaka H, Iwai A, Matsuoka T, Takaoka M, et al. Analysis of 2,702 traumatized patients in the 1995 Hanshin-Awaji earthquake. J Trauma 1997;43(3):427-32. [CrossRef]
8. K C K, 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):20-4. [CrossRef]

9. Laverick S, Kazmi S, Ahktar S, Raja J, Perera S, Bokhari A, et al. Asian earthquake: report from the first volunteer British hospital team in Pakistan. Emerg Med J 2007;24(8):543-6. [CrossRef]
10. Oda J, Tanaka H, Yoshioka T, Iwai A, Yamamura H, Ishikawa K, et al. Analysis of 372 patients with Crush Syndrome caused by the Hanshin-Awaji earthquake. J Trauma 1997;42(3):470-6. [CrossRef]
11. Hussami M, Grabherr S, Meuli RA, Schmidt S. Severe pelvic injury: Vascular lesions detected by ante- and post-mortem contrast medium-enhanced CT and associations with pelvic fractures. Int J Legal Med 2017;131(3):731-8. [CrossRef]
12. Burlew CC, Moore EE, Stahel PF, Geddes AE, Wagenaar AE, Pieracci FM, et al. Preperitoneal pelvic packing reduces mortality in patients with life-threatening hemorrhage due to unstable pelvic fractures. J Trauma Acute Care Surg 2017;82(2):233-42. [CrossRef]
13. Vaidya R, Waldron J, Scott A, and Nasr K. Angiography and embolization in the management of bleeding pelvic fractures. J Am Acad Orthop Surg 2018;26(4):e68-76. [CrossRef]
14. Bortolin M, Morelli I, Voskanyan A, Joyce NR, Ciottone GR. Earthquake-related orthopedic injuries in adult population: a systematic review. Prehosp Disaster Med 2017;32(2):201-8. [CrossRef]
15. Mubarak SJ, Owen CA, Hargens AR, Geretto LP, Akeson WH. Acute compartment syndromes: diagnosis and treatment with the aid of the wick catheter. J Bone Joint Surg Am 1978;60(8):1091-5. [CrossRef]
16. Guo J, Yin Y, Jin L, Zhang R, Hou Z, Zhang Y. Acute compartment syndrome: Cause, diagnosis, and new viewpoint. Medicine (Baltimore) 2019;98(27):e16260. [CrossRef]
17. Rajagopalan S. Crush injuries and the Crush Syndrome. Med J Armed Forces India 2010;66(4):317-20. [CrossRef]
18. Dover M, Memon AR, Marafi H, Kelly G, Quinlan JF. Factors associated with persistent sequelae after fasciotomy for acute compartment syndrome. J Orthop Surg (Hong Kong) 2012;20(3):312-5. [CrossRef]
19. Wolfson N. Amputations in natural disasters and mass casualties: staged approach. Int Orthop 2012;36(10):1983-8. [CrossRef]
20. Herard P, Boillot F. Amputation in emergency situations: indications, techniques and Médecins Sans Frontières France's experience in Haiti. Int Orthop 2012;36(10):1979-81. [CrossRef]
21. Johansen K, Daines M, Howey T, Helfet D, Hansen ST Jr. Objective criteria accurately predict amputation following lower extremity trauma. J Trauma 1990;30(5):568-672. [CrossRef]
22. Görmeli G, Görmeli CA, Güner S, Ceylan MF, Dursun R. The clinical profile of musculoskeletal injuries associated with the 2011 Van earthquake in Turkey. Eklem Hastalik Cerrahisi 2012;23(2):68-71.
23. Awais S, Saeed A, Ch A. Use of external fixators for damage-control orthopaedics in natural disasters like the 2005 Pakistan earthquake. Int Orthop 2014;38(8):1563-8. [CrossRef]