© J ORTHOP TRAUMA SURG REL RES
14(3) 2019
Research Paper

Epidemiology of orthopaedic injuries at the local hospital following earthquake in Palu, Indonesia, 2018

YOGI PRABOWO (1), ACHMAD FAUZI KAMAL (1), WILDAN LATIEF (1), DIDI SAPUTRA RAMANG (1), VINO DANIEL (1), LIES DINA LIASTUTI (2), TRIMARTANI (2)

(1) Department of Orthopaedics and Traumatology, Faculty of Medicine, Universitas Indonesia, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia
(2) Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia

Address for correspondence:
Dr. Didi Saputra Ramang, Department of Orthopaedics and Traumatology, Faculty of Medicine, Universitas Indonesia, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia
dsramang@gmail.com

Statistics

Figures	00
Tables	04
References	18

Received: 03.12.2019
Accepted: 20.12.2019
Published: 27.12.2019

Abstract

Background: The earthquake in Palu was a very tragic event that claimed many lives. Orthopaedic surgeons have a key role in identifying and managing earthquake victims related to musculoskeletal injuries. In this review, the authors present an epidemiology study of orthopaedic injuries among victims of the 2018 Palu earthquake in Indonesia admitted to a local hospital.

Methods: This was a retrospective study involving trauma patients admitted to a local hospital (SIS Al Jufrie Hospital) in 23 days following the earthquake on September 28, 2018.

Results: Of 137 trauma cases, 121 (88%) were orthopaedic in nature. Of these 121 cases, soft tissue injury (66.9%) and fractures (25.6%) were the most common orthopaedic injuries. The fractures included fractures of the tibia/fibula (n=8), femur (n=8), ankle/foot (n=3), radius/ulnar (n=5), humerus (n=5), and hand (n=1). The most common procedure performed was debridement (n=13), followed by open reduction and internal fixation (n=10), closed reduction (cast and sling) (n=5), external fixation (n=1), and amputation (n=1). Of 30 fractures, 4 fractures were classified as open fractures.

Conclusions: Most of the trauma patients admitted to the local hospital in Palu following the Palu earthquake sustained orthopaedic injuries. The most common injury types are soft tissue injury and fracture, especially at the femur and tibia fibula. The most commonly performed orthopaedic procedure is debridement. The results of this study may help orthopedists and teams for planning and optimizing the treatment of earthquake victims in the future.

Keywords: earthquake, Palu, fracture, soft tissue injury, debridement

INTRODUCTION

Since 2000, earthquakes have caused more than 800,000 deaths and even more injuries worldwide [1]. Indonesia has faced frequent and severe earthquakes because the country lies along the boundaries of three tectonic plates with many active cracks on the earth's surface. The Eurasian Plate surrounding much of the country is moving East and North, and the Pacific Plate to the country's East is moving south and west. As these two plates meet, the India-Australian plate moves north, hitting violently with its northern neighbors. This plate boundary generates very large earthquakes and sustained volcanic activity. The provinces most at risk of severe earthquakes include Sumatera, Java, Bali, Nusa Tenggara, Maluku, Sulawesi, and Papua [2].

On Friday, September 28, 2018, a massive 7.4 SR earthquake occurred at 5:00 p.m. in Palu, Central Sulawesi, followed by tsunami and liquefaction afterward. The earthquake, liquefaction, and tsunami destroyed the city and caused big losses with 2,100 people dead, 4,612 people seriously injured, 78,994 people becoming refugees, and 68,451 houses damaged [3,4].

The epicenter of the earthquake was located 26 km North of Donggala regency, and 80 km northwest of Palu city. This earthquake was felt in Donggala Regency, Palu City, Parigi Moutong Regency, Sigi Regency, Poso Regency, Tolitoli Regency, Mamuju Regency, and even reached Samarinda City, Balikpapan City, and Makassar City. The earthquake also provoked a tsunami up to 5 meters high in Palu City [5].

A study by Syifa et al. aimed to assess the damage by obtaining pre- and post-earthquake satellite images which are then processed to generate a damage map. The coastal areas incurred heavy damage because of the tsunami. Meanwhile, liquefaction triggered by the earthquake caused large inland mudflows that caused severe damage in the densely populated urban areas in three villages, namely Petobo, Balaroa, and the largest Sidera Jono Oge. Based on the report from the National Board for Disaster Management of Indonesia (Badan Nasional Penanggulangan Bencana/BNPB), the total liquefaction area was 390.82 ha, including 2976 houses. The total damaged area based on two different analysis methods were 8,814,600 m² or 881.46 ha and 7,974,000 m² or 797.4 ha, respectively [5].

Dr. Cipto Mangunkusumo Hospital, Jakarta deployed a team to set up service for outpatient, inpatient, and surgical facilities in SIS-Al Jufrie Hospital, one of the general hospitals located in Palu.

DATA AND METHODOLOGY

This was a retrospective study involving all trauma patients admitted to SIS Al Jufrie Hospital in Palu in 23 days following the first earthquake on September 28, 2018. Medical Team consists of orthopaedic surgeon, anesthesiologist, pediatrician, obstetrician, psychiatric, internist, general surgeon, nurse, pharmacist, sanitation worker, surveillance team, radiographer, laboratory worker. At the site, the team firstly coordinated with the Central National Crisis Team and Health Agency of Central Sulawesi to record and identifies victims and potential risks that could possibly be occurred. In the first week, the hospital service still used a field hospital because of subsequent earthquakes. Entering the second week, hospital service then could utilize the ward. In the first week, daily hospital service was still dominated by surgery procedures. In the second and third week, not only did the hospital conduct surgery procedure but also labor procedure and curative.

RESULTS

A total of 137 patients were admitted with traumatic injury, 72 of them (52.6%) were males and 65 females (47.4%). Most of the trauma patients were in the 4th decade of life. From these 137 trauma cases, 121 (88.3%) were classified as orthopaedic injuries. The breakdown is presented in Table 1. From 121 orthopaedic patients, soft tissue injury and fracture were the most common types of orthopaedic injuries,

Table 1. Classification of 137 injuries admitted to the hospital

No. of injuries				
Orthopaedic (88.3%)	Non orthopaedic (11.7%)			
	Head	Thoracic	Abdominal	Burn Injury
121	5 (3.6%)	5 (3.6%)	1 (0.7%)	5 (3.6%)

Table 2. Types of orthopaedic injuries (n=121) admitted to the hospital

No. of injuries			
Fracture	Dislocation	Soft tissue injury	Compartment syndrome
31 (25.6%)	7 (5.8%)	81 (66.9%)	2 (1.7%)

Table 3. Anatomic location of 31 fractures admitted to the hospital

Upper extremity (n=11, 35.5%)			Lower extremity (n=20, 64.5%)			
Humerus	Radius/ Ulna	Wrist/ Hand	Femur	Tibia/ Fibula	Ankle/ Foot	Patella
5 (16.2%)	5 (16.2%)	1 (3.2%)	8 (25.8%)	8 (25.8%)	3 (9.6%)	1 (3.2%)

Table 4. Types of initial treatment for treating orthopaedic injuries at the hospital.

Debridement	Debridement +external fixation	Open reduction +Internal fixation	Closed reduction (Gips and Sling)	Amputation
13 (43.3%)	1 (3.3%)	10 (33.3%)	5 (16.7%)	1 (3.3%)

with a percentage of 66.9% and 25.6% respectively. The breakdown is presented in Table 2. Fracture more commonly involves lower extremity than upper extremity (64.5% vs 35.5%). From all total fractures, femur and tibial fractures account for 51.6% cases. The breakdown is given in Table 3. Regarding orthopaedic procedures, 30 procedures were performed with the following frequencies: 13 debridements, 10 open reduction and internal fixations, 5 closed reductions (cast and sling), 1 external fixation, and 1 amputation. The breakdown is given in Table 4. The number of patients who had open and closed fractures was 4 (12.9%) and 27 (87.01%), respectively.

DISCUSSION

Earthquakes are the most destructive of natural disasters because they always occur suddenly, causing enormous destructive and heavy casualties as well as triggering many complex social problems. Dealing with casualties in settings of disaster is one of the challenging topics in trauma management. Types of injury related to the earthquake are influenced by some factors:

1. The host as an individual

2. The agent as the energy transferred from the quake

3. The environment as the buildings and infrastructures where humans are situated [6]

Liquefaction of the soil was the primary cause of injuries to the victims in the Palu earthquake. Soil liquefaction has been observed worldwide during recent major earthquakes, inducing effects responsible for much of the damage [7]. Buildings on liquefied soils may sink or tilt, and pipelines are displaced or float to the surface. All of the above phenomena may lead to significant damages [8]. The last listed major earthquakes which have been followed by severe liquefaction effects are the 1964 Alaska earthquake of 9.2 Magnitude (Mw), the 1964 Niigata earthquake of 7.5 Mw in Japan, and the 2011 Christchurch earthquake of 6.3 Mw in New Zealand [8].

Due to the large numbers of victims, better epidemiological knowledge of the injury types caused by earthquakes will be very important in improving disaster relief. Generally, the most common type of earthquake injury is musculoskeletal system injury, which has been proven in many previous reports [1,9,10]. Similarly, our data show that from all trauma cases, 88% were orthopaedic and 12% were non orthopaedic cases. Our data are also similar to the data reported in a

review on earthquake injuries in developing countries by McKenzie et al. In this review, it is reported that based on 6 articles that reported 1549 injuries, 87% of patients were orthopaedic and 13% of patients were nonorthopaedic [1]. As for the anatomical location of the injury, based on a study by Missair et al. that reviewed 15 major earthquakes between 1980 to 2010, the predominant injury pattern in an earthquake was injury of the extremities (upper and lower limb injury), with a calculated incidence of 29% to 98% per report. In studies comparing upper versus lower extremity injury, lower limb involvement invariably exceeds the upper limb in more than 90% of these studies [11]. Except when combined with other vital organ injuries, most musculoskeletal system injuries are treated by an orthopaedic surgeon. Therefore, orthopedists often play an important role in disaster relief [9].

Most of the types of orthopaedic injuries sustained in an earthquake are fractures and soft tissue injuries [1,6,12]. As a comparison to another earthquake in Indonesia, Sudaryo et al. did a study on the 7.6 SR earthquake that hit Padang City, West Sumatra Province, Indonesia in 2009. It was reported that soft tissue injury (bruise and lacerations) and fracture accounted for 67.6% and 27.9% of all 184 cases, respectively. These percentages are similar to our results, where soft tissue injury and fracture accounted for 66.6% and 25.6% of all cases, respectively [13]. Another epidemiologic study of the Padang earthquake done by Pang et al. showed that from 255 orthopaedic patients who underwent surgery, 60.7% had major soft tissue injury [14]. On the contrary, based on a review by McKenzie et al., from 1365 orthopaedic injuries compiled from 4 different studies on an earthquake, 65% of victims had fractures and only 20.3% had major soft tissue injury [1]. Our result also contrasts with another study on an earthquake in Nepal where from 1083 trauma patients, 58% had fractures and only 20% had soft tissue injuries [15]. There might be many factors that can influence our result, such as in Palu, most of the affected area on the coast, the type of earthquake followed by a tsunami that causing soft tissue injuries rather than fractures. The other factor is the different types of buildings' height and construction. In Nepal's earthquake most of the buildings located on the hills with the construction of buildings more than two floors, while buildings located in Palu along the coast.

Among fractures cases, our study shows that the proportion of lower extremity fractures is higher than upper extremity fractures (64.5% *vs* 35.4%). Together, tibia and fibula are involved in 51.6% of all fractures. Our data are similar to several other studies reporting that most of the fracture cases in earthquakes involve lower extremities, especially tibia and femur. This necessitates the orthopaedic surgeons to bring twice as many femoral and tibial implants to the disaster area.

In contrast to other similar studies, in our study, the number of tibial fractures is the same with femoral fractures, while most studies show that tibial fractures are much more common than femoral fractures in the setting of an earthquake [1,12,14]. On the contrary, two studies done by Tahsamebi et al. on an Iranian earthquake and by Blumberg et al. on the Haiti earthquake revealed that femoral fractures are more common than tibial fractures [10,16]. A study from Tahsamebi et al. on the 2005 Iran earthquake reported that when an earthquake happens in the early morning, it will more likely cause fractures in proximal region because most victims are asleep [10]. A study by Guner et al. on an earthquake in Turkey reported that because the earthquake occurred in the evening, the distal bones were more commonly involved [17]. The Palu earthquake occurred in the evening. Most of the earthquake victims were injured because of the falling debris or while trying to escape from falling debris.

When treating earthquake victims, characterizations of fracture as open *vs* closed is also an important consideration since it might influence the initial treatment and fixation technique, therefore also affecting the response planning. Open fractures commonly result from extremity injuries associated with natural disasters and combat from high-energy trauma [18]. Based on the previous study by MacKenzie et al., open fractures are common after earthquakes. In their study, 22% of fractures were open. Meanwhile, in our study, the percentage of open fractures was 12.9% [1].

In our study, the most common procedure to treat the injuries was debridement (43%), which was more common than ORIF (33.3%). This is similar to the result of the review by Mckenzie et al., reporting that out of 1260 procedures recorded from various earthquakes in developing countries, debridement was the most common procedure given to the patient (33%), while ORIF only accounted for 24% of the procedures [1]. A study by Pang et al. that analyzed the procedure of orthopaedic treatment for victims in the previous Padang earthquake in Indonesia also showed a similar result. In the Padang earthquake, the most common treatment was debridement (59%). It was more common than ORIF (20.6%) [14]. The reason why debridement is the most common procedure in our study is because of the high percentage of soft tissue injuries including laceration and bruise. We only performed one external fixation, probably because we only had a few open fracture cases. The higher rate of ORIF compared to external fixation found in our study is an interesting finding because in the immediate aftermath of a massive earthquake, it is often unrealistic to pursue definitive internal fixation, and Damage-Control Orthopedics (DCO), including external fixation and/or amputation when necessary, may be the approach of choice until definitive fixation is possible. However, the ratio of external fixation to ORIF may depend largely on when the response team arrives at the earthquake location. The later they arrive, the possibility for them to perform ORIF is better [1].

CONCLUSION

Most of the trauma patients admitted to a local hospital following the Palu earthquake suffer orthopaedic injuries. The most common injury types are soft tissue injury and fracture with predominant on the femur and tibia fibula site. The most commonly performed orthopaedic procedure is debridement. The results of this study may help orthopaedic surgeon and teams in planning and optimizing the treatment of earthquake victims for the future. Although every earthquake has its own uniqueness, coordinated management and planning will improve outcomes whenever an earthquake happens.

ACKNOWLEDGMENT

This research is supported by Lies Dina Liastuti, MD, MHA (Chief Executive of Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia, Trimartani, MD, MHA, PhD Director of Human Resource and Education, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia, and Prof. Ari Fahrial Syam, MD, PhD (Dean of Faculty of Medicine, Universitas Indonesia).

CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

References:

1. *MacKenzie J.S., Banskota B., Sirisreetreerux N., et al.: A review of the epidemiology and treatment of orthopaedic injuries after earthquakes in developing countries. World J Emerg Surg. 2017;12:9.*
2. *Indonesia disaster management handbook. Center for excellence in disaster management and humanitarian assistance. 2015.*
3. *Situation update no. 5 M 7.4 earthquake and tsunami Sulawesi, Indonesia. The AHA Centre, ASEAN Coordinating Centre for Humanitarian Assistance on disaster management. 2018;14.*
4. *Situation update no. 5 M 7.4 earthquake and tsunami Sulawesi, Indonesia. The AHA Centre, ASEAN Coordinating Centre for Humanitarian Assistance on disaster management. 2018;23.*

5. *Syifa M., Kadavi P.R., Lee C.W.: An artifical intelligence application for post-earthquake damage mapping in Palu, Central Sulawesi, Indonesia. Sensors. 2019;19:542.*

6. *Ramirez M., Peek-Asa C.: Epidemiology of traumatic injuries from earthquakes. Epidemiol Rev. 2005;27:47-55.*

7. *Forcellini D., Tarantino A.M.: Assessment of stone columns as a mitigation technique of liquefaction-induced effects during Italian earthquakes (May 2012). TSWJ. 2014:216-278.*

8. *Clément C., Toussaint R., Stojanova M., et al.: Sinking during earthquakes: Critical acceleration criteria control drained soil liquefaction. Phys Rev E. 2018;97:022905.*

9. *Chen X., Yang T., Li J.: Profile and management of musculoskeletal injuries associated with the Lushan earthquake in 2013. Disaster Med Public Health Prep. 2018;12:408-410.*

10. *Tahmasebi M.N., Kiani K., Mazlouman S.J., et al.: Musculoskeletal injuries associated with earthquake: a report of injuries of Iran's December 26, 2003 Bam earthquake casualties managed in tertiary referral centers. Injury. 2005;36:27-23.*

11. *Missair A., Pretto E.A., Visan A., et al.: A matter of life or limb? A review of traumatic injury patterns and anesthesia techniques for disaster relief after major earthquakes. Anesth Analg. 2013;117:934-941.*

12. *Yasin M.A., Malik S.A., Nasreen G., et al.: Experience with mass casualties in a subcontinent earthquake. Ulus Travma Acil Cerrahi Derg. 2009;15:487-492.*

13. *Sudaryo M.K., Besral, Endarti A.T., et al. Injury, disability and quality of life after the 2009 earthquake in Padang, Indonesia: a prospective cohort study of adult survivors. Glob Health Action. 2012;5:1-11.*

14. *Pang H.N., Lim W., Chua W.C.: Management of musculoskeletal injuries after the 2009 western Sumatra earthquake. J Orthop Surg. 2011;19:3-7.*

15. *Giri S., Risnes K., Uleberg O., et al.: Impact of 2015 earthquakes on a local hospital in Nepal: A prospective hospital-based study. PLoS One. 2018;13:e0192076.*

16. *Blumberg N., Lebel E., Merin O., et al.: Skeletal injuries sustained during the Haiti earthquake of 2010: a radiographic analysis of the casualties admitted to the Israel defense forces field hospital. Eur J Trauma Emerg Surg. 2013;39:117-122.*

17. *Guner S., Guner S.I., Isik Y., et al. Review of Van earthquakes form an orthopaedic perspective: a multicentre retrospective study. Int Orthop. 2013;37:119-124.*

18. *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;38:1563-1568.*