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Original Article

Analysis of the Effect of Time Under Debris as a Mortality Determinant and Injury Patterns in the 2023 Kahramanmaraş Earthquakes

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ABSTRACT

Objective: The current study aimed to analyze injury patterns, explore the correlation between time under debris and patient mortality, and highlight the importance of prompt intervention following the 2023 Kahramanmaraş earthquakes.

Methods: This retrospective study analyzed earthquake-related injuries and ambulance transportation among patients from surrounding provinces. Patient data, including demographics, admission time, duration under debris, province of residence, injury type, presence of crush syndrome, additional injuries, surgical interventions, intensive care unit admission, hospitalization, and discharge, were retrospectively examined.

Results: In this study of 427 patients, with ages ranging from 0 to 91 years and a mean age of 40.9 ± 19.0 years, 89 (20.8%) patients reported being trapped under debris. The overall mortality rate was 1.6%. A total of 328 (76.8%) patients sustained injuries during their escape, with 50 (11.7%) experiencing crush injuries. A total of 25 (5.9%) patients underwent the fasciotomy procedure, whereas 28 (6.6%) patients received hemodialysis treatment. Soft tissue trauma was the primary diagnosis and was often accompanied by an acute kidney injury. The predominant fractures observed were those of the lower extremities, and the time spent under debris has been proven to correlate with increased fasciotomy and death rates.

Conclusion: This study represents a noteworthy contribution to the existing literature by investigating the 2023 Kahramanmaraş earthquakes. The duration of entrapment of victims under debris, as well as the incidence of crush injuries, fasciotomies, and hemodialysis requirements, is a critical determinant of post-earthquake fatality rates.

Keywords: Crush, earthquake, fasciotomy, mortality, time under debris

INTRODUCTION

On February 6, 2023, a powerful earthquake measuring 7.7 on the Richter scale struck the southeastern region of Türkiye, at the epicenter of Kahramanmaraş. Just 9 hours later, the same area was hit by another earthquake with a magnitude of 7.6.[1,2] These back-to-back earthquakes had an impact on a combined total of 11 provinces and an area spanning 110 000 square kilometers, with a length of 350 km.[3] In addition, the World Health Organization (WHO) has categorized the circumstance as a level 3 emergency.[4] The earthquake's impact extended to eleven provinces, including Kahramanmaraş, Hatay, Gaziantep, Osmaniye, Malatya, Adana, Diyarbakır, Şanlıurfa, Adıyaman, and Kilis, as reported by the Turkish Emergency Medicine Association. According to official data, the earthquakes resulted in a death toll of 50 399, with 80 278 individuals sustaining injuries and 6444 buildings collapsing. The direct impact of the event affected approximately 13.5 million individuals in Türkiye, leading to the occurrence of 850 limb amputations. In the second month after the Kahramanmaraş earthquakes, a significant number of 9990 aftershocks were recorded.[4,5]

Due to the seismic event, a significant outcome was the limited operational capacity of the majority of hospitals,

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which were constrained to operate only on their ground floors until the establishment of field hospitals in the ensuing days.[1] Some hospitals were unable to function after the earthquake, while others continued to operate despite being damaged. The ongoing aftershocks prompted a disaster response in 10 provinces, resulting in significant damage and the shutdown of multiple hospitals.[1] The emergency department (ED) of Elazığ Fethi Sekin City Hospital accepted a large number of patients from the surrounding provinces in this disaster, greatly relieving the health system that had become blocked in the region and putting its roughly 1000-bed hospital to the service of the patients affected by the earthquake.

Multiple studies have demonstrated that a majority of earthquake-related injuries consist of fractures in the extremities.[6,7] Earthquake-related injuries commonly result from falling objects or prolonged tissue compression.[8] This underscores the significance of multidisciplinary management involving orthopedic and trauma physicians.[9-11] The primary aim of this investigation was to analyze the fundamental injury patterns that emerged after the Kahramanmaraş earthquakes of 2023. Furthermore, the secondary aim of this study was to investigate the correlation between the length of time spent under debris and patient mortality and to emphasize the significance of prompt intervention in disastrous circumstances such as seismic events.

MATERIAL AND METHODS

The current study retrospectively assessed the casualties of the 2023 Kahramanmaraş earthquake, focusing on the response protocols and patient management at the hospital. The present study was approved by the local institutional Fırat University Non-invasive Research Ethics Committee (date 23.03.2023, approval number: 2023/05-13). Written informed consent was obtained from the patients or a legally authorized representative, and patient information privacy was strictly maintained throughout the research in accordance with the guidelines outlined in the Declaration of Helsinki for the conduct of clinical research. Included in the study were individuals who arrived at or were transported from Malatya, Adıyaman, and Kahramanmaraş to Elazığ Fethi Sekin City Hospital by ambulance, as coordinated by the 112 patient transfer command center. Furthermore, the study also included patients who sustained injuries related to the earthquake within the Elazığ city. Cases not related to the earthquakes were excluded from the analysis. Additionally, patients who were admitted solely due to the psychological impact of the earthquake, without any musculoskeletal injuries, as well as those with isolated head trauma, isolated abdominal trauma, or isolated chest trauma were also excluded. The current study focused exclusively on the analysis of admitted patients with musculoskeletal injuries, excluding those who died at the scene. All patients who reported earthquake-related injuries or were transported by ambulance from the surrounding provinces were assigned the code X34 (earthquake victim). The study's data were collected through a retrospective review of medical records, analyzing patient information such as demographics, time of ED admission, duration of being under debris, province of residence, triage codes, types of injuries, presence of crush syndrome, presence of additional injury (e.g., hemothorax, maxillofacial trauma), need for surgical interventions (e.g., fasciotomy, amputation, dialysis), intensive care unit admission, hospitalization, and discharge. The duration of stay under debris was determined by obtaining information from patients or their family members.

MAIN POINTS

- The purpose of the current research was to examine injury patterns after the 2023 Kahramanmaraş earthquakes, determine whether or not time spent beneath debris is correlated with patient death, and emphasize the significance of timely management.
- This study makes a significant contribution to the current literature by examining the Kahramanmaraş earthquakes that occurred in 2023.
- The primary finding of this study is that the duration of victims being trapped under debris is the most significant determinant of post-earthquake mortality, as well as the need for fasciotomy and hemodialysis.
- Timely intervention, facilitated by the collaboration of rescuers and specialists, has the potential to prevent fatal injuries.

Acute Kidney Injury Definition

Because of the retrospective nature of the present study, traditional standards for identifying acute kidney injury (AKI) were not employed.[12] Sever et al.[13] have established specific criteria for the diagnosis of crush-related acute kidney injury, which require the presence of both a crush injury and impaired values of certain biochemical findings.

Statistics

Descriptive statistics were determined using the mean, standard deviation, median, minimum, maximum value, frequency, and percentage. The Kolmogorov–Smirnov test was employed to examine the dispersion of the variables. The Mann–Whitney *U* test was used to compare the quantitative data. The chi-Square test was employed for the comparison of the qualitative data. Statistical Package for the Social Sciences (SPSS®) Statistics fsoftware, version 28.0 (IBM SPSS Corp.; Armonk, NY, USA).

was used for statistical analyses. Statistical significance was set at $P < .05$.

RESULTS

A total of 427 cases were evaluated, with a mean age of 40.9 ± 19.0 years. In the present study sample, comprising 239 (56.0%) females and 188 (44.0%) males, it was observed that 189 (44.3%) cases sought medical treatment at the ED 24 hours post earthquake. The study findings indicated that 89 (20.8%) patients were trapped under debris. Among these, 42 (9.8%) patients reported entrapment under debris for 6-24 hours. The present investigation included a cohort of 20 (4.7%) individuals who were entrapped beneath the rubble for a duration exceeding 24 hours (Table 1). The study revealed that of the 427 patients, only 1 died in the ED, whereas the remaining 6 patients died during intensive care follow-ups. The overall mortality rate in the current study was 1.6%. According to the data, 328 (76.8%) patients reported sustaining injuries during their escape, whereas 50 (11.7%) experienced crush injuries. A total of 257 (60.2%) patients were admitted outside the province (Table 1). In total, 25 (5.9%) patients underwent fasciotomy, and 1 patient underwent little toe amputation (Figures 1 and 2). Soft tissue trauma was the prevailing diagnosis, with the predominant fractures observed being those of the lower extremities (Table 2).

Patients trapped under debris for a prolonged time, experiencing crush injuries without open wounds, admitted from other cities, undergoing fasciotomy, and receiving hemodialysis had significantly higher mortality rates (Table 3). Fasciotomy frequency increased significantly among younger patients trapped under debris, those with crush injuries, and those from other cities (Table 4).

DISCUSSION

The current study represents 1 of the initial inquiries in the academic literature to examine the damaging impact of the 2023 Kahramanmaraş earthquakes. Furthermore, the primary finding of the current study indicates that the duration of entrapment under debris is the most significant factor influencing post-earthquake fatality rates, the requirement for fasciotomy and hemodialysis, and the number of crush injuries.

In natural catastrophes such as earthquakes, when people are buried for longer periods of time, it is regarded as a miracle when they emerge alive. The "rule of four" claims that a human can endure stuffiness for a maximum of 4 minutes, thirst for a maximum of 4 days, and lack of food for a maximum of 4 weeks, and that the initial 48 hours seem to be the "golden hours," particularly for rescuers.[14]

Table 1. Analysis of the Descriptive Statistics Related to the Study Sample

	Minimum–Maximum	Median	Mean ± SD/n%
Age	0.0-91.0	39.0	40.9 ± 19.0
Gender			
Female			239 ± 56.0%
Male			188 ± 44.0%
Arrival time to the emergency department			
<3 hours			75 ± 17.6%
3-6 hours			59 ± 13.8%
6-24 hours			104 ± 24.4%
>24 hours			189 ± 44.3%
Duration of stay under the debris			
Not from under the debris			338 ± 79.2%
<3 hours			17 ± 4.0%
3-6 hours			10 ± 2.3%
6-24 hours			42 ± 9.8%
>24 hours			20 ± 4.7%
Alive or dead			
Alive			420 ± 98.4%
Dead			7 ± 1.6%
Injury Type			
Crush with open wound			21 ± 4.9%
Crush without open wound			29 ± 6.8%
Injury while escaping			328 ± 76.8%
Psychological trauma			49 ± 11.5%
Place			
From Elazığ			170 ± 39.8%
From other cities			257 ± 60.2%
Decision			
Discharge from the emergency department			304 ± 71.2%
Hospitalization in the relevant clinics			81 ± 19.0%
Admission to the intensive care unit			42 ± 9.8%
Fasciotomy			
No			402 ± 94.1%
Yes			25 ± 5.9%
Amputation			
No			426 ± 99.8%
Yes			1 ± 0.2%
Hemodialysis			
No			399 ± 93.4%
Yes			28 ± 6.6%

Figure 1. A 56-year-old woman came to the emergency department from an external province after being under debris for approximately 28 hours. The patient also had multiple metatarsal fractures, and the image shows the dirty open wound at the time of first presentation to the emergency department.

Figure 2. The patient underwent percutaneous fixation to treat metatarsal fractures, repeated debridement for the open wound, a split-thickness skin graft to address the skin defect, and amputation of the necrosed fifth toe.

A 2021 study revealed that the fatality rate for those who were trapped beneath the debris for more than 24 hours was 96.1%, more than 4 times that of those who were trapped for less than 24 hours (26.1%).[15] The mortality rate of individuals who were trapped during the earthquakes in Italy and Armenia was found to be 100 and 67 times higher, respectively, than that of individuals who were not trapped.[16,17] According to the results of the current study, 20.8% of the patients reported experiencing entrapment under debris. Nearly one-fourth of this proportion got stuck for more than 24 hours. The study revealed a discrepancy with the existing literature, as it reported a mortality rate of 11.1% (2 out of 18 individuals) for those who were trapped in the rubble for over 24 hours and a mortality rate of 10.5% (4 out of 38 individuals) for those who were trapped for a duration of 6-24 hours. We believe that the possible reasons for this are that those who stayed in the rubble for more than 24 hours were most likely to have lost their lives in the region where the earthquake occurred, and that crush injuries with a low chance of survival were not referred to us. There are conflicting beliefs about the relationship between the time spent beneath the rubble and the possibility of renal failure and mortality. Some studies have indicated that the area crushed and the time spent beneath the ground do not correlate with the degree of renal failure and mortality,[18, 19] although other data[20, 21] imply that entrapment time is significant. In the current study, the time spent beneath the debris was associated with an increase in fasciotomy rates, mortality, and the possibility of developing crush-induced acute renal damage.

The number of individuals rescued within the initial hour following an earthquake is dependent on the promptness with which proficient personnel can arrive at the location and the degree of readiness they possess to administer urgent medical aid.[15] The 1999 Marmara earthquake in Türkiye was 7.4 on the Richter scale and killed almost 20,000 people.[22] Nonetheless, there were far fewer nationally accredited search and rescue crews, pieces of technological equipment, and urgent

Table 2. Diagnoses and Additional Diagnoses Made by Specialists on the Research Population

	n	%
Diagnosis		
Soft Tissue Trauma	176	41.2%
Lower limb fracture	81	19.0%
Chest pain	41	9.6%
Crush without compartment syndrome	33	7.7%
Head injury	26	6.1%
Vertebral fracture	26	6.1%
Upper limb fracture	22	5.1%
Anxiety	13	3.0%
Hip fracture	13	3.0%
Compartment syndrome	13	3.0%
Pelvis fracture	10	2.3%
Nasal fracture	2	0.5%
Shoulder dislocation	1	0.2%
Additional Diagnosis		
No	362	84.8%
Yes	65	15.2%
Acute kidney injury	38	8.9%
Maxillofacial trauma	15	3.5%
Hemothorax	5	1.2%
Pneumothorax	5	1.2%
Epidural bleeding	2	0.5%
Intraabdominal injury	2	0.5%
Subarachnoidal hemorrhage	2	0.5%
Subdural bleeding	1	0.2%

Table 3. Differences of Variables Between Survivors and Non-survivors

	Alive	Dead		
	Mean ± SD/n-%	Mean ± SD/n-%	*P*	
Age	40.8 ± 19.0	49.29 ± 20.1	.285	[m]
Gender				
Female	236 ± 56.2%	3 ± 42.9%	.481	X^2
Male	184 ± 43.8%	4 ± 57.1%		
Arrival time to the emergency department				
<3 hours	75 ± 17.9%	0 ± 0.0%	.071	X^2
3-6 hours	59 ± 14.0%	0 ± 0.0%		
6-24 hours	100 ± 23.8%	4 ± 57.1%		
>24 hours	186 ± 44.3%	3 ± 42.9%		
Duration of stay under the debris				
Not from under the debris	337 ± 80.2%	1 ± 14.3%	**.000**	X^2
<3 hours	17 ± 4.0%	0 ± 0.0%		
3-6 hours	10 ± 2.4%	0 ± 0.0%		
6-24 hours	38 ± 9.0%	4 ± 57.1%		
>24 hours	18 ± 4.3%	2 ± 28.6%		
Injury type				
Crush injury with open wound	19 ± 4.5%	2 ± 28.6%	**.000**	X^2
Crush injury without open wound	25 ± 6.0%	4 ± 57.1%		
İnjury while escaping	327 ± 77.9%	1 ± 14.3%		
Psychological trauma	49 ± 11.7%	0 ± 0.0%		
Place				
From Elazığ	170 ± 40.5%	0 ± 0.0%	**.030**	X^2
From other cities	250 ± 59.5%	7 ± 100.0%		
Fasciotomy				
No	399 ± 95.0%	3 ± 42.9%	**.000**	X^2
Yes	21 ± 5.0%	4 ± 57.1%		
Amputation				
No	419 ± 99.8%	7 ± 100.0%	1.000	X^2
Yes	1 ± 0.2%	0 ± 0.0%		
Hemodialysis				
No	398 ± 94.8%	1 ± 14.3%	**.000**	X^2
Yes	22 ± 5.2%	6 ± 85.7%		

X^2Chi-square test.
[m]Mann–Whitney *U* test.

healthcare support available than there are now. Van, Türkiye, experienced a 7.2-magnitude earthquake in 2011, killing 604 people.[23,24] After the Marmara earthquake, national search and rescue teams and emergency medical care services have become more advanced and well-prepared, leading to a dramatic increase in the number of people saved. Van's earthquake zone was less urban; hence, there were fewer high-rises to damage. On the other hand, the Kahramanmaraş earthquake was felt throughout a large area, both urban and rural, severely damaging metropolitan areas and tall structures in around 11 provinces and disrupting emergency aid networks by damaging roads, tunnels, and airports. Several of the epicenters of the quake lost their hospitals, making it impossible to promptly conduct any necessary emergency surgery. It is also impossible to claim that the resources of the ambulance system are not exceeded by the involvement of many patients because of excessive destruction. Approximately 50% of the participants included in the present study were admitted to medical facilities 24 hours after the occurrence of the seismic event. The outcome of the current study

Table 4. The Correlation Between Assessment Data and the Performance of Fasciotomy Surgery

	Fasciotomy, No	Fasciotomy, Yes		
	Mean ± SD/n%	Mean ± SD/n%	*P*	
Age	41.5 ± 19.1	31.8 ± 15.2	**.014**	[m]
Gender				
Female	229 ± 57.0%	10 ± 40.0%	.097	X^2
Male	173 ± 43.0%	15 ± 60.0%		
Arrival time to the emergency department				
<3 hours	75 ± 18.7%	0 ± 0.0%	**.000**	X^2
3-6 hours	59 ± 14.7%	0 ± 0.0%		
6-24 hours	89 ± 22.1%	15 ± 60.0%		
>24 hours	179 ± 44.5%	10 ± 40.0%		
Duration of stay under the debris				
Not from under the debris	338 ± 84.1%	0 ± 0.0%	**.000**	X^2
<3 hours	16 ± 4.0%	1 ± 4.0%		
3-6 hours	10 ± 2.5%	0 ± 0.0%		
6-24 hours	25 ± 6.2%	17 ± 68.0%		
>24 hours	13 ± 3.2%	7 ± 28.0%		
Alive or dead				
Alive	399 ± 99.3%	21 ± 84.0%	**.000**	X^2
Dead	3 ± 0.7%	4 ± 16.0%		
Injury type				
Crush with open wound	7 ± 1.7%	14 ± 56.0%	**.000**	X^2
Crush without open wound	18 ± 4.5%	11 ± 44.0%		
Injury while escaping	328 ± 81.6%	0 ± 0.0%		
Psychological trauma	49 ± 12.2%	0 ± 0.0%		
Place				
From Elazığ	170 ± 42.3%	0 ± 0.0%	**.000**	X^2
From other cities	232 ± 57.7%	25 ± 100.0%		
Amputation				
No	402 ± 100.0%	24 ± 96.0%	.059	X^2
Yes	0 ± 0.0%	1 ± 4.0%		
Hemodialysis				
No	397 ± 98.8%	2 ± 8.0%	**.000**	X^2
Yes	5 ± 1.2%	23 ± 92.0%		

X^2Chi-square test
[m]Mann–Whitney *U*-test.

provides an evident indication of the disruption in the transportation system and the failure to administer the necessary medical treatment to numerous patients in need of urgent intervention.

The overall mortality rate for patients admitted to or referred to our hospital was 1.6%, and the AKI rate was 8.9%. Hatamizadeh et al.[25] conducted a study that revealed that the general mortality rate among individuals affected by the Bam earthquake was 1.9%, whereas the mortality rate for those who developed AKI was 12.7%, which is in line with the current study. Sever et al.[26] conducted a study that found that patients who were admitted to reference hospitals within the first 3 days of a disaster had a higher mortality rate (17.7%) than those who were admitted after this time period (10.0%). This suggests that only individuals with minor injuries were able to survive for 3 days and subsequently reach the hospitals. The present investigation revealed that while no significant association was observed between the time of arrival at the ED and mortality rates ($P = .071$; Table 3), a positive correlation was detected between the duration of entrapment under the rubble and mortality rates ($P = .000$). It is believed that the cause of this phenomenon is due to the fact that certain individuals who had undergone fasciotomy procedures in hospitals located within the earthquake-stricken area were subsequently referred to our ED for the purposes of receiving dialysis treatment and wound monitoring.

Hospitalization data from the 2013 Eastern Marmara earthquake showed that orthopedics and traumatology clinics had the highest percentage of patients (147 of 330).[23] Further research revealed that following the Marmara earthquake, the majority of patients were referred to the orthopedics and traumatology departments, and of the 160 total procedures, 96 were for orthopedic issues.[27] In 234 (51%) of the earthquakes that hit Gujarat, India, the victims mostly suffered from orthopedic ailments.[28] The vast majority of injuries sustained in the Van quake required orthopedic or traumatological care.[23] The study at hand revealed that the majority of the injuries observed were of the soft tissue variety, with lower extremity fractures being the second most frequently occurring injury. Ergen et al.[29] found that a significant number of patients displayed simple soft tissue injuries, including sprains, lacerations, and contusions, in the 2020 Elazıg earthquakes. The study also reported that lower extremity fractures were the most prevalent type of fracture, which is consistent with the findings of the current study. Similar to the current study, the aforementioned study reported that the predominant cause of injury was running in a state of panic. The findings of the current study indicated that a significant proportion of injuries in Elazığ were associated with attempts to escape, while the majority of patients from adjacent provinces presented with crush injuries.

Individuals who become trapped beneath debris in the aftermath of earthquakes may exhibit a diverse array

of injuries, spanning from minor abrasions on different regions of the body to substantial wounds characterized by tissue loss, which can affect the body's muscles, bones, major veins, and nerves. Patients who do not receive proper wound care are at risk of developing life-threatening infections of the wound, wound-related sepsis, and even tissue and limb loss.[30] The current study revealed that the prognosis of crush injuries without open wounds was comparatively more unfavorable than that of crush injuries with open wounds. We believe that this is because the open wounds of crush injuries presented to us were mostly in the form of abrasions and lacerations. The current investigation primarily focused on the monitoring of fasciotomy wounds performed by surgeons. Notably, none of the patients initially presented at our facility with severe wounds.

The current study is an examination of earthquake-affected patients that has to be retrospective in nature; however, multiple restrictions concern the study. First, the present investigation was conducted at a single center, and the number of participants and their distribution were inadequate to provide a precise depiction of the earthquake's entire magnitude. Second, the present study's data were obtained through a cross-sectional approach from the medical records of patients. Third, in the aftermath of the disaster, medical practitioners operated on a rotating schedule within the ED with varying approaches to healthcare delivery. While some physicians discharged mildly affected patients with stringent instructions, other specialists opted to maintain continuous observation of all patients. One of the strengths of the current study is its contribution to the academic literature as one of the few studies investigating the damaging effect of the Kahramanmaraş earthquakes that occurred in 2023. As one of the few studies to do so, this analysis of the correlation between the time spent beneath debris and death and morbidity is another notable strength of the research.

The current study makes a significant scholarly contribution by examining the earthquakes that occurred in Kahramanmaraş in 2023. The length of time that individuals are trapped beneath rubble, along with the occurrence of crush injuries, the need for a fasciotomy, and the requirement for hemodialysis, plays a crucial role in determining the rates of mortality after an earthquake.

Ethics Committee Approval: The study was approved by the local institutional ethical review board of the Fırat University Medical Faculty Ethics Committee (approval date: 23.03.2023, approval number: 2023/05-13).

Informed Consent: Written informed consent was obtained from the patients or a legally authorized representative, who agreed to take part in the study.

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