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Postoperative outcomes in earthquake victims with orthopedic trauma: a focus on mortality and dialysis needs

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Abstract

Background This study aims to identify the factors associated with postoperative mortality and the need for dialysis in earthquake survivors presenting with isolated orthopedic injuries, with particular emphasis on crush syndrome and its clinical consequences.

Methods This single-center retrospective study included patients who sustained limb or vertebral injuries during the February 6, 2023, earthquake and underwent surgical intervention following transfer from the disaster zone. Exclusion criteria comprised non-earthquake-related injuries, pre-existing chronic renal or liver failure, prior amputations unrelated to the earthquake, concomitant head, thoracic, or abdominal injuries, pregnancy, and cases with incomplete data. Data on injury location, anesthesia technique, surgical procedures, dialysis requirements, and postoperative outcomes were collected. Surgical interventions were classified into four categories: fasciotomy, amputation, debridement, and osteosynthesis. Intergroup comparisons were conducted by Kruskal-Wallis test. The backward stepwise approach for regression model was employed to minimize suppressor effects—where a predictor's significance is contingent on the presence of another variable—and to reduce the risk of type II errors, thereby ensuring the identification of significant predictors. Analyses were performed using Statistical Package for Social Sciences version 20 program.

Results A total of 561 patients were included in this study. Patients had several injuries as follows: upper extremity in 123 patients (19.6%), thigh in 151 (24.1%), calf and foot in 279 (44.6%) and vertebral column in 72 (11.5%). The findings showed that patients with thigh injury had the highest mortality rate, which was 55% ($p=0.012$). A sum of 187 patients (33.3%) were diagnosed as crush syndrome. Dialysis requirement was observed in 25.1% of patients with crush syndrome, highlighting its significant impact on mortality ($p=0.017$). A multivariate linear backward regression analysis showed that hematocrit, platelet count, alanine transaminase, and time to admission were the significant predictors for mortality (ß=-0.113, $p=0.039$; ß=-0.133, $p=0.007$; ß=0.196, $p<0.05$; ß=0.158, $p=0.001$, respectively).

Conclusions It can be concluded that above-knee injuries and the requirement for dialysis are significant predictors of increased mortality. Early diagnosis and timely therapeutic intervention in these patients are critical to improving clinical outcomes. Furthermore, delayed hospital admission is associated with higher mortality rates, highlighting the importance of rapid medical response and efficient triage in disaster scenarios to optimize patient survival.

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Clinical trial number Not applicable.

Keywords Earthquakes, Mortality, Crush syndrome, Renal replacement therapy, Disaster medicine, Orthopedics

Introduction

Disasters cause widespread damage and disruption to the normal operation of society, leading to losses of life and infrastructure [1]. Worldwide, earthquakes are responsible for a high number of fatalities, and proximity to the epicenter has a direct impact on the medical complications profile and response capacity at the time of the earthquake [2].

On February 6, 2023, two massive earthquakes of magnitude 7.8 and 7.7 on the Richter scale occurred at 4:17 and 13:24 local time, with epicenters in Kahramanmaras, Türkiye. Eleven provinces of Türkiye were affected, with direct impacts on around 15 million people. Approximately 300,000 buildings were reported as either collapsed or moderately to severely damaged. The official reported death toll was over 50,000 people, making it the most fatal natural disaster worldwide in 2023.

Survivors of this disaster suffered severe injuries and health problems, including crush syndrome. It is a life-threatening condition following crush injuries (e.g., from earthquakes), occurs when prolonged muscle compression causes cell death, releasing toxic substances like potassium and myoglobin into the bloodstream. This leads to hyperkalemia, myoglobin-induced kidney damage, and hypovolemia due to fluid shifts, resulting in acute kidney injury (AKI). Calcium dysregulation further worsens muscle and kidney damage, creating a dangerous cycle of complications [3]. Moreover, AKI is the other critical complication after earthquakes where earthquake victims are at risk of developing AKI through multiple mechanisms [4]. Approximately 50% of individuals with crush syndrome develop AKI, with half of these patients requiring dialysis. Acute Kidney Injury secondary to crush syndrome in earthquake victims presents a particularly complex and challenging clinical scenario, especially during the initial days following the event [5]. The mortality rate for AKI is estimated to be approximately 40% in which it is the second leading cause of mortality following the direct effects of trauma in disaster settings [6].

After the Kahramanmaras earthquakes, many trauma patients were transferred to our center, which is located about 220 km from the epicenter. Most of these patients underwent limb and spinal surgeries under relevant anesthesia procedures. This study aims to identify the factors associated with postoperative mortality and the need for dialysis in earthquake survivors presenting with isolated orthopedic injuries, with particular emphasis on crush syndrome and its clinical consequences.

Methods

Ethics statement

Before the study, the research protocol was approved by the Mersin University Clinical Research Ethics Committee (approval number: 2024/030, date: January 10, 2024).

Study design

In this single-center, retrospective study, we conducted a records review of the patient database of Mersin City Training and Research Hospital. Patients who were transferred from the earthquake zone after February 6, 2023, had limb or vertebral injuries from being trapped under rubble, and were operated on by orthopedic surgeons were included in the study. Exclusion criteria were: (1) non-earthquake related injuries, (2) history of chronic renal failure or chronic liver failure, (3) history of amputation for any reason before the earthquake, (4) injury to the head, thorax, or abdomen in addition to limb/vertebral injury, (5) pregnancy, and (6) missing data. Demographic data, time to admission, injury site, type of surgical procedure and anesthesia, dialysis requirement, and postoperative mortality were recorded. In addition, the patients' complete blood count values and C-reactive protein (CRP), procalcitonin, ferritin, myoglobin, creatine kinase (CK), troponin I, aspartate aminotransferase, alanine aminotransferase (ALT), gamma-glutamyl transferase, lactate dehydrogenase, total, direct, and indirect bilirubin, urea, uric acid, creatine, blood urea nitrogen, sodium, potassium, calcium, phosphorus, magnesium, fibrinogen, d-dimer, and lactate values were recorded. Operation type was categorized into four main groups: fasciotomy, amputation, debridement and osteosynthesis. Injury sites were also classified into four groups: vertebrae, upper extremity, lower extremity below the knee (calf and foot), and lower extremity above the knee (thigh). Patients could be included in multiple groups according to their orthopedic injuries and surgical procedures. Rates of mortality, dialysis requirement, and crush syndrome were compared among the groups.

Crush syndrome was defined as a crush injury to muscle mass with CK > 1000 U/L at admission and associated systemic symptoms such as electrolyte disturbances and acute renal failure [3]. Crush-related acute kidney injury was defined as crush injury with at least one of the following findings: serum potassium > 6 mEq/L, phosphorus > 8 mg/dL, calcium < 8 mg/dL; oliguria (urine output < 400 mL/day); blood urea nitrogen > 40 mg/dL; serum creatinine > 2 mg/dL; and serum uric acid > 8 mg/dL [7].

Table 1 Demographic and clinical characteristics of the earthquake victims

		Mean ± SD	Min-Max	CI
Age (years)		39.59 ± 21.38	1–93	37.81–41.36
Time to admission (days)		4.22 ± 4.97	0–23	3.80–4.63
		n (%)		
Age group (years)	< 20	138 (24.6)		
	20–40	150 (26.7)		
	40–65	192 (34.2)		
	> 65	81 (14.4)		
Gender	Female	318 (56.7)		
	Male	243 (43.3)		
Injury site	Upper extremity	123 (19.6)		
	Thigh	151 (24.1)		
	Calf and foot	279 (44.6)		
	Vertebra	72 (11.5)		
Operation type	Amputation	57 (10.2)		
	Fasciotomy	145 (25.8)		
	Osteosynthesis	281 (50.1)		
	Debridement	127 (22.6)		
Received dialysis		70 (12.5)		
Status	Non-survivor	18 (3.2)		
	Survivor	543 (96.8)		

SD, standard deviation; CI, confidence interval

Statistical analysis

Normality and variance were evaluated for each variable using the one-sample Kolmogorov-Smirnov test. Quantitative data were expressed as means ± standard deviations, while qualitative data were reported as frequencies and percentages. Intergroup comparisons were conducted using the Mann-Whitney U test. Multivariate analysis was performed using a linear backward stepwise regression model, incorporating all potential predictors. The backward stepwise approach was employed to minimize suppressor effects—where a predictor's significance is contingent on the presence of another variable—and to reduce the risk of type II errors, thereby ensuring the identification of significant predictors. At each step, the variable with the highest p-value exceeding the 0.05 significance threshold was systematically excluded. Receiver operating characteristic (ROC) curve analysis was performed to determine optimal cut-off values for creatine kinase CK and myoglobin, along with their respective sensitivity and specificity, for predicting dialysis requirement. All statistical analyses were conducted using SPSS Statistics version 20.0 (SPSS Inc., Chi., IL), with statistical significance set at $p < 0.05$.

Results

A total of 651 patients were evaluated for the study and 561 patients were included. The demographic data are presented in Table 1. Upper extremity injuries were present in 123 patients (19.6%), thigh injuries in 151 patients (24.1%), calf/foot injuries in 279 patients (44.6%), and vertebral injuries in 72 patients (11.5%). Osteosynthesis was performed in 281 (50.1%), fasciotomy in 145 (25.8%), debridement in 127 (22.6%), and amputation in 57 patients (10.2%). The mortality rate was 3.2% ($n = 18$). Patients with thigh injury had the highest mortality rate, at 55% ($p = 0.012$; Table 2). There was no significant difference in admission time according to mortality ($p = 0.307$).

A total of 70 patients (12.5%) required dialysis. There was no difference in dialysis requirement according to gender or time to admission ($p = 0.490$, $p = 0.072$, respectively; Table 3). Patients who needed dialysis had a significantly higher frequency of calf/foot injury, amputation, and fasciotomy and a significantly lower frequency of

Table 2 Comparison of demographic and clinical parameters according to mortality status

	Status			OR	95% CI
	Non-survivor ($n = 18$)	Survivor ($n = 543$)	*p*		
	Mean ± SD	Mean ± SD			
Age (years)	41.22 ± 21.5	39.53 ± 21.4	0.660[a]		
Time to admission (days)	5.44 ± 5.7	4.18 ± 4.95	0.307[a]		
	n (%)	n (%)			
Amputation	3 (16.7)	54 (9.9)	0.414[c]	1.811	0.508–6.456
Fasciotomy	5 (27.8)	140 (25.8)	0.790[c]	1.107	0.388–3.161
Osteosynthesis	8 (44.4)	273 (50.3)	0.626[b]	0.791	0.308–2.035
Debridement	3 (16.7)	124 (22.8)	0.775[c]	0.676	0.193–2.372
Upper extremity injury	3 (16.7)	120 (22.1)	0.775[c]	0.705	0.201–2.476
Thigh injury	10 (55.6)	141 (26.0)	**0.012[c]***	3.564	1.379–9.208
Calf/foot injury	7 (38.9)	272 (50.1)	0.350[b]	0.634	0.242–1.660
Vertebral injury	3 (16.7)	69 (12.7)	0.716[c]	1.374	0.388–4.868

*$p < 0.05$

[a]Mann-Whitney U test

[b]Chi-square test

[c]Fisher's exact test

Table 3 Comparison of demographic and clinical parameters according to dialysis requirement

		Required dialysis (*n* = 70)	No dialysis (*n* = 491)	*p*	OR	95% CI
		***n* (%)**	***n* (%)**			
Gender	Female	37 (52.9)	281 (57.2)	0.490[b]	1.193	0.722–1.972
	Male	33 (47.1)	210 (42.8)			
		Mean ± SD	**Mean ± SD**			
Time to admission (days)		2.97 ± 3.61	4.39 ± 5.11	0.072[a]		
		n (%)	**n (%)**			
Upper extremity injury		13 (18.6)	110 (22.4)	0.469[b]	0.790	0.417–1.496
Thigh injury		24 (34.3)	127 (25.9)	0.137[b]	1.495	0.877–2.549
Calf/foot injury		44 (62.9)	235 (47.9)	**0.019[b]***	1.844	1.100–3.089
Vertebral injury		5 (7.1)	67 (13.6)	0.128[b]	0.487	0.189–1.253
Amputation		13 (18.6)	44 (9.0)	**0.013[b]***	2.317	1.177–4.561
Fasciotomy		35 (50)	110 (22.4)	**< 0.05[b]***	3.464	2.071–5.793
Osteosynthesis		20 (28.6)	261 (53.2)	**< 0.05[b]***	0.352	0.204–0.610
Debridement		18 (25.7)	109 (22.2)	0.511[b]	1.213	0.681–2.160

*$p < 0.05$

[a]Mann-Whitney U test

[b]Chi-square test

[c]Fisher's exact test

Table 4 Comparison of clinical parameters according to the presence of crush syndrome

	Crush syndrome (*n* = 187)	No crush syndrome (*n* = 332[†])	*P*	OR	95% CI
	***n* (%)**	***n* (%)**			
Required dialysis	47 (25.1)	20 (6.0)	**< 0.05[a*]**	5.237	2.992–9.168
Mortality	7 (3.7)	8 (2.4)	0.384[a]	1.575	0.562–4.414
Upper extremity injury	42 (22.5)	68 (20.5)	0.597[a]	1.125	0.728–1.737
Thigh injury	60 (32.1)	80 (24.1)	**0.049[a*]**	1.488	1.001–2.213
Calf/foot injury	115 (61.5)	146 (44)	**< 0.05[a*]**	2.035	1.412–2.933
Vertebral injury	14 (7.5)	57 (17.2)	**0.002[a*]**	0.390	0.211–0.722
Amputation	18 (17.0)	28 (35.9)	**0.003[a*]**	0.365	0.184–0.726
Fasciotomy	88 (83.0)	50 (64.1)			

[†]Patients who could not be assessed for crush injury were not included in this analysis

*$p < 0.05$

[a]Chi-square test

[b]Fisher's exact test

osteosynthesis ($p = 0.019$, $p = 0.013$, $p < 0.05$, $p < 0.05$, respectively; Table 3).

A total of 187 patients (33.3%) were diagnosed as having crush syndrome, and a quarter of those patients required dialysis. Need for dialysis was more common among patients with crush syndrome than those without (25.1% vs. 6%, $p < 0.05$; Table 4). Thigh and calf/foot injuries were significantly more frequent among patients with crush syndrome, whereas vertebral injuries were less common ($p = 0.049$, $p < 0.05$, $p = 0.002$, respectively; Table 4). Fasciotomy was performed more often than amputation in patients with crush syndrome ($p = 0.003$; Table 4). The proportion of patients needing dialysis was significantly higher among non-survivors than survivors (33.3% vs. 11.8%, $p = 0.017$; Table 5).

Binary logistic regression analysis showed that neither fasciotomy nor amputation had an effect on mortality (ß=0.175, $p = 0.748$; ß=0.629, $p = 0.340$). Multivariate linear backward regression analysis included hemoglobin, hematocrit, red blood cell, white blood cell, neutrophil, and platelet counts, CRP, myoglobin, troponin, ALT, creatinine, creatinine kinase, urea, sodium, potassium, and time to admission. Of these variables, hematocrit, platelet count, ALT concentration, and time to admission emerged as significant predictors of mortality (ß=-0.113, $p = 0.039$; ß=-0.133, $p = 0.007$; ß=0.196, $p < 0.05$; and ß=0.158, $p = 0.001$, respectively). Binary logistic regression analysis with fasciotomy, amputation, osteosynthesis, and debridement revealed that no significant association with mortality (ß=-0.320, $p = 0.729$; ß=0.248, $p = 0.790$; ß=-0.640, $p = 0.526$; ß=-0.782, $p = 0.381$, respectively).

Of the non-surviving patients, 10 (55.6%) had thigh injury, 7 (38.9%) had calf/foot injury, three (16.7%) had

Table 5 Comparison of anesthesia type and dialysis requirement according to mortality status

		Status		*p*	OR	95% CI
		Non-survivor (*n* = 18) *n* (%)	Survivor (*n* = 543) *n* (%)			
Anesthesia	General	11 (61.1)	358 (65.9)	0.672[a]	1.231	0.470–3.229
	Regional	7 (38.9)	185 (34.1)			
Dialysis requirement[†]		6 (8.6)	64 (91.4)	**0.017[b]***	3.742	1.357–10.317

[†]row percentages given, *$p < 0.05$

[a]Chi-square test

[b]Fisher's exact test

vertebral injury, and three (16.7%) had upper extremity injury. Linear regression analysis revealed that CK and myoglobin levels were significant predictors of dialysis requirement (ß=0.187, $p < 0.05$ and ß=0.256, $p < 0.05$, respectively).

In ROC curve analysis to predict mortality, a cut-off value of 997.4 U/L for CK showed a sensitivity of 90.9% and a specificity of 56.2%, with an area under curve (AUC) of 0.681 ($p < 0.05$). The AUC for myoglobin was 0.774, with a cut-off of 5462.5 U/L showing 84.8% sensitivity and 64.9% specificity ($p < 0.05$).

Discussion

This study investigated mortality, dialysis requirements, and crush syndrome in patients undergoing surgery for isolated orthopedic injuries following the 2023 Kahramanmaras earthquake. Higher mortality rates were observed in patients with injuries above the knee and in those requiring dialysis. The need for dialysis was more prevalent among patients with injuries below the knee, as well as those who underwent amputation or fasciotomy, whereas patients treated with osteosynthesis had a lower dialysis requirement. As anticipated, the dialysis requirement was significantly higher in the crush syndrome group compared to those without crush syndrome. Analysis of injury sites revealed that leg injuries (both above and below the knee) were more common in the crush syndrome group, while vertebral injuries were less frequent. Additionally, fasciotomy rates were notably higher in patients diagnosed with crush syndrome.

Earthquakes are a major cause of death and injury in many parts of the world. According to the literature, the lower extremities are most frequently affected in earthquake-related injuries [8–11]. Consistent with this, lower extremity injuries accounted for the majority of isolated orthopedic traumas in this study. Strikingly, the largest proportion of lower extremity traumas in our study were below-the-knee injuries. The present study is one of the few studies in the literature to evaluate injuries above and below the knee separately.

In the surgical management of earthquake-related trauma, anesthesia practices vary across clinics due to differing conditions, resources, and expertise. Missair et al. emphasized that no single anesthesia method is universally ideal for such trauma, with choices depending on clinical circumstances [12]. In this study, 192 patients received regional anesthesia, while 369 underwent general anesthesia. General anesthesia was primarily used for emergency cases involving bleeding, volume deficit, unsuitable coagulation parameters for neuraxial anesthesia, or vertebral injuries. Regional anesthesia was preferred for hemodynamically stable patients with appropriate coagulation parameters and no vertebral injuries or communication barriers.

Most patients transferred to the center presented with bleeding and dehydration. Pre-anesthetic fluid or blood supplementation was administered to prevent hemodynamic instability, though time constraints in post-disaster emergencies often limited such interventions, potentially contributing to the higher prevalence of general anesthesia. Peripheral nerve blocks were performed in only six patients, largely due to the rapid influx of casualties and limited availability of ultrasound devices and personnel skilled in peripheral block techniques. Despite two-thirds of patients receiving general anesthesia, no association was observed between anesthesia type and mortality.

Bulut et al. reported a total mortality rate of 8% among victims of the 1999 Marmara earthquake in their study [13], while this rate was reported by Cagiran et al. as 25.7% in their study of victims of the 2020 Aegean earthquake [14]. We determined a mortality rate of 3.2% among the earthquake victims in the present study. However, this relatively low rate compared to the literature can be attributed to the inclusion of patients with isolated orthopedic and the exclusion of those with head, chest, and abdominal trauma.

Kundakci et al. previously reported that leg injury above the knee was associated with higher mortality rate compared to other types of orthopedic injuries [15]. Likewise, the mortality rate was higher among patients with above-the-knee injuries in this study, indicating that this subset of lower extremity injury has poorer prognosis. Although lower extremity injuries are generally evaluated as having a poor prognosis in the literature, the mortality rate was low among patients with below-the-knee injuries in this study [16–18]. Thus, lower extremity injuries

above and below the knee should be assessed separately in terms of mortality risk, and it can be recommended that expedited treatment and closer monitoring are of crucial in patients with thigh injuries.

Furthermore, Erek et al. noted higher mortality among victims of the 1999 Marmara earthquake who required dialysis [19]. Similarly, dialysis requirement was associated with a higher mortality rate in the present study. Electrolyte imbalances (e.g., hyperkalemia, hypocalcemia) with related arrhythmias and dialysis complications may be associated with increased mortality rates in patients requiring dialysis.

When oliguria, severe metabolic acidosis, or hyperkalemia cannot be managed medically during the perioperative follow-up of earthquake victims, renal replacement therapy may be required. In a study by Sever et al., 12% of patients hospitalized after the 1999 Marmara Earthquake developed renal problems, and renal replacement therapy was administered in 8.9% of cases [20]. In the present study, 12.5% of the patients received renal replacement therapy, and lower extremity injuries were more common than upper extremity injuries among patients requiring dialysis. As the lower extremities have more muscle mass, soft tissue traumas to the lower extremities may be associated with extensive rhabdomyolysis and greater dialysis requirement. While the difference in dialysis necessity was higher only for below-the-knee injuries, thigh injuries were also more prevalent in patients requiring dialysis. These findings highlight the importance of closely monitoring kidney function and promptly assessing the need for renal replacement therapy, especially in patients with lower extremity injuries. In relation, in the context of a large-scale earthquake, dialysis centers could face overwhelming demand, and supplies for dialysis might become inadequate to meet the needs of affected individuals.

Regarding the surgical procedures performed, the rates of dialysis were higher in earthquake victims who underwent amputation and fasciotomy, but lower in patients who underwent osteosynthesis. In other studies about the 2023 Kahmaranmaras earthquake, Koyuncu et al. reported the need for hemodialysis in 55.7% of the fasciotomy group and 54.5% of the amputation group [21], while Atmis et al. observed a higher rate of dialysis in patients with amputation compared to those without [3]. Another study conducted by Sever et al. reported a greater need for dialysis in the fasciotomy group but not in the amputation group in victims of the 1999 Marmara earthquake [20]. During the period between trauma and amputation, myoglobin and potassium continue to enter the systemic circulation from the damaged tissue. In patients with fasciotomy, this may continue throughout the perioperative phase. Thus, it is expected that the need for dialysis will be higher in these two surgical groups. In contrast, the lesser need for dialysis among patients treated with osteosynthesis can be attributed to the less severe muscle and soft tissue damage, as most patients in this group did not require debridement, fasciotomy, or amputation.

In this study, the need for dialysis was higher in the group with crush syndrome than in patients without crush syndrome. The rate of dialysis requirement in patients with crush syndrome was 25.1%. Similar to our findings, Atmis et al. indicated that 23% of patients with crush syndrome needed renal replacement therapy [3]. Medical conditions like hyperkalemia, uremia, and metabolic acidosis are likely factors in the increased need for dialysis in patients with crush syndrome.

One-third of the patients in this study were diagnosed with crush syndrome. The prevalence of crush syndrome was reported as 31% by Atmis et al. and 37% by Koyuncu et al. [3, 21], and Bulut et al. determined this rate to be 33% among victims of the 1999 Marmara earthquake [13]. The similar crush syndrome rates in these studies may be associated with similarity in factors such as climatic conditions, building materials, rescue team capabilities, and the effectiveness of medical assistance. In terms of the relationship between crush syndrome and injury site, we observed a higher rate of crush syndrome in lower extremity injuries, which is also likely related to the higher muscle and soft tissue mass in the lower extremities compared to the upper extremities.

According to surgical procedure, the rate of crush syndrome was higher in patients who underwent fasciotomy. Fasciotomy performed on extremities with necrotic muscle tissue increases reperfusion and metabolic product transfer from necrotic tissue to the systemic circulation, resulting in the development of crush syndrome [22]. Both amputation and fasciotomy procedures are still considered controversial procedures in extremity injuries regarding their timing and effects on complications and mortality [20, 23–25]. A previous study performed in patients with crush injuries from the earthquake in Bam, Iran showed that the group in which fasciotomy was performed had a similar mortality rate as the group in which fasciotomy was not performed [26]. In contrast to the findings of the present study, fasciotomy has been linked to an elevated risk of mortality, largely attributed to the potential for wound infection and sepsis [19]. However, Yalin et al. reported an increased requirement for dialysis in patients who underwent fasciotomy following the Kahramanmaras earthquake, without observing a corresponding rise in mortality rates [27]. Similarly, in our study, although the incidence of crush syndrome and the need for dialysis were higher among patients who underwent fasciotomy, no increase in mortality rates was noted.

Furthermore, studies by Safari et al. and Kundakcı et al. found no association between fasciotomy and mortality in earthquake victims [15, 26]. We posit that the lessons learned from previous earthquake responses in Türkiye have informed our judicious approach to selecting candidates for fasciotomy. Specifically, we suggest that fasciotomy, particularly in well-selected cases such as those with compartment syndrome, does not increase mortality and can be regarded as a viable limb-preserving surgical intervention.

The results of this study also showed that lower hematocrit and platelet values, abnormally high ALT values, and longer time to hospital admission were significant predictors of mortality in earthquake survivors with isolated orthopedic trauma. Patients with earthquake-induced traumas may have anemia and thrombocytopenia due to complications such as massive blood loss and disseminated intravascular coagulation. Moreover, transaminase elevation may be seen in earthquake victims due to rhabdomyolysis after muscle damage. Weibrecht et al. reported that 75% of rhabdomyolysis patients with CK levels of 1000 U/L or higher had elevated ALT levels [28]. The cause of the elevation in ALT, which is a liver-specific aminotransferase, may be liver injury caused by free radicals in the liver formed as a result of the breakdown of myoglobin released from damaged muscle.

In addition, elevated CK and myoglobin levels were identified as predictors of the need for dialysis in this study. High CK and myoglobin levels are expected as a result of severe muscle damage in patients with trauma. The lower CK threshold for predicting dialysis requirement compared to previous studies may be related to the fact that isolated orthopedic traumas were included in this study, while head, chest, and abdominal traumas were excluded [3, 29]. Given that CK and myoglobin levels may continue to increase over time following muscle injury, patients should undergo daily or more frequent monitoring, particularly when there is a high clinical suspicion of impending renal failure. A multidisciplinary approach, including early involvement of nephrologists, is essential to ensure timely consideration of dialysis and implementation of renal protective measures in the management pathway.

Patients with thigh injuries are at elevated risk for developing crush syndrome, exhibiting higher mortality rates compared to injuries at other anatomical sites. Consequently, such patients should be prioritized for orthopaedic surgical intervention during triage. Our findings indicate that the requirement for dialysis is a significant predictor of increased mortality in this population. Early recognition and timely therapeutic intervention are critical to enhancing clinical outcomes. Additionally, delayed hospital admission has been associated with elevated mortality rates. Thus, rapid medical intervention and efficient triage in disaster settings are imperative to improving patient survival.

Limitation

The present study has some limitations. It was a retrospective, single-center study relying on medical records and is inadequate to fully represent the scale of an earthquake affecting 11 provinces. As we included patients with isolated injuries, the sample was relatively small. However, the primary aim of the study was to focus on one type of injury to avoid bias.

Conclusion

This study highlights the critical importance of early and targeted management of earthquake-related orthopedic injuries, particularly above-the-knee injuries, which are associated with higher mortality rates. The need for dialysis, driven by crush syndrome and rhabdomyolysis, is a significant predictor of poor outcomes, emphasizing the importance of early renal support. Elevated CK and myoglobin levels are valuable biomarkers for identifying patients at risk of requiring dialysis. Despite the challenges of post-disaster care, fasciotomy remains a vital limb-saving procedure, although it is associated with an increased risk of crush syndrome. Future research should focus on optimizing resource allocation and treatment protocols in disaster settings to improve outcomes for earthquake victims.

Abbreviations

CRP	C-reactive protein
ALT	Alanine aminotransferase
CK	Creatine kinase
ROC	Receiver operating characteristic
AUC	Area under curve

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Not applicable.

Author contributions

Material preparation and data collection were performed by EHE, MA and IY. Analysis was performed by SD and HO. The first draft of the manuscript was written by BA and EHE, and all the authors commented on the previous versions of the manuscript. All authors have reviewed and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Mersin University Ethics Committee (Approval number: 2024/030). The need for informed consent was waived because of the retrospective design of the study and the use of anonymized personal information.

Consent to participate

Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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