



# Characteristics of Pediatric Intensive Care Patients Following the 2020 İzmir Earthquake

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## ABSTRACT

**Aim:** Unforeseeable disasters such as earthquakes can lead to significant catastrophes. Early and effective treatment methods are life-saving in reducing post-earthquake mortality and morbidity. The aim of this study was to evaluate the treatment and outcomes of patients with crush injuries in the İzmir earthquake.

**Materials and Methods:** Eight patients, 2 male, and 6 female were admitted to the intensive care unit. The medical records of these 8 crush injury patients were retrospectively reviewed.

**Results:** Eight children rescued from rubble were admitted to the pediatric intensive care unit, and one of them died. The median age of the patients was 148.5 (range, 35 to 210) months and the median PRISM score was 4 (interquartile range 0-31). The median duration of being trapped under the rubble was 23 (range: 4 to 92) hours.

**Conclusion:** Crush syndrome is a life-threatening event. The authors believe that early transportation and immediate intensive care therapy would have improved survival rates.

**Keywords:** İzmir earthquake, Crush syndrome, acute kidney failure

## Introduction

Unforeseeable disasters such as earthquakes can lead to significant catastrophes. Early and effective treatment methods are life-saving in reducing post-earthquake mortality and morbidity. Immediately after earthquakes, the direct impact of trauma may result with disaster victims' deaths, while others may die under the rubble later, depending on the degree and location of their injuries, or be rescued and admitted to hospital. The first and crucial clinical findings in patients after earthquakes emerge at

the disaster site. However, due to the chaos in the rubble area, there is limited comprehensive information about the type and characteristics of these findings in the literature. Therefore, knowledge about injuries and clinical findings in disaster areas is reached based on the clinical symptoms determined in hospital admissions (1,2). The most common complications observed after earthquakes include Crush syndrome, traumatic rhabdomyolysis, tissue injuries, multiple fractures, compartment syndrome developing after tissue damage, and acute kidney failure (3). The most

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affected areas are the lower extremities (74%), followed by the upper extremities (10%), and other body parts (9%) (3,4). Crush syndrome and traumatic rhabdomyolysis occur due to severe muscle injuries. The main mechanism of rhabdomyolysis is the stretching of the muscle sarcolemma under pressure. Increased permeability of the sarcolemma leads to the entry of sodium, calcium, and water into cells, activating proteolytic enzymes which cause membrane destruction. Elevated levels of potassium, phosphate, myoglobin, creatine kinase (CK), lactate dehydrogenase, aspartate aminotransferase, alanine aminotransferase and uric acid in the blood can lead to toxic and life-threatening complications (3). The effect of hypovolemia, combined with the activation of the renin-angiotensin and sympathetic nervous systems, exacerbates renal perfusion disorders. Simultaneously, increased myoglobin obstructs renal tubules, disrupting renal perfusion. Myoglobin reduction in the tubules releases free iron, catalyzing the formation of free radicals, further increasing ischemic damage. Acute tubular necrosis and acute kidney failure subsequently develop (3,4). Myoglobinuria obstructs renal tubules, leading to acute tubular necrosis and, consequently, acute renal failure in these patients (3-5). Hyperkalemia, hyperphosphatemia, hypocalcemia, myoglobinuria, and metabolic acidosis can occur within hours in this group of patients. Therefore, prompt initiation of appropriate fluid resuscitation is crucial (3,4). Compartment syndrome disrupts tissue circulation due to increased intra-tissue pressure caused by trauma or edema. Impaired blood supply leads to ischemia and edema, and without early intervention, tissue necrosis develops. Metabolic acidosis and myoglobinuria resulting from muscle tissue breakdown lead to kidney failure. Early recognition of compartment development in tissue areas and performing fasciotomy can prevent tissue losses (4,5). Electrolyte imbalances are widespread among crush victims of earthquakes. The aim of this study was to evaluate the changes in sodium, calcium, and phosphorus ions, renal function tests, and muscle enzymes in pediatric patients rescued from under rubble and admitted to the pediatric intensive care unit due to crush syndrome after the 2020 Izmir earthquake.

## Materials and Methods

Patients rescued from the rubble after the Izmir earthquake on October 30<sup>th</sup>, 2020, and followed up in our pediatric intensive care unit were retrospectively reviewed. The patients' demographic information (age and gender), methods of presentation to the emergency department after the earthquake (outpatient/ambulance service), requested

laboratory and imaging tests, administered treatments, consultations requested, and intensive care outcomes were analyzed. Cases resulting in acute kidney failure due to ischemia in crushed muscles and released products were defined as "crush syndrome". The condition of elevated serum muscle enzymes due to muscle necrosis and the release of intracellular muscle components was defined as "rhabdomyolysis". Cases with increased compartment intra-pressure requiring fasciotomy due to reduced tissue perfusion were defined as "acute compartment syndrome" (6-8).

## Statistical Analysis

The Statistical Package for the Social Sciences version 22.0 package program was used for data analysis. Numbers and percentages are specified as descriptive statistical data (mean, standard deviation, minimum, maximum, median). Minimum and maximum values are specified as categorical variables, and mean values are given for numerical variables.

## Results

On Friday, October 30<sup>th</sup>, 2020, at 14:51 local time, a severe shallow earthquake with a magnitude of Mw 6.6 occurred with its epicenter in the Aegean Sea (Seferihisar). This earthquake caused casualties and property losses, particularly in the districts of Bayraklı, Bornova, Buca, Kemalpaşa, and Menderes in Izmir, due to strong ground shaking and building damage (9). The earthquake resulted in the deaths of 116 people and injuries to hundreds. Eight children rescued from under rubble were admitted to the pediatric intensive care unit, and one of them died. Out of the 8 patients, 2 were male, and 6 were female. The median age of the patients was 148.5 (range: 35 to 210) months and the median PRISM score was 4 (Interquartile range 0-31). The median duration of being trapped under the rubble was 23 (range: 4 to 92) hours, the median length of stay in the intensive care unit was 28 (range: 20 to 160) hours and the median hospitalization duration was 97 (range: 12 to 528) hours. The first patient rescued after 4 hours had severe head trauma and passed away at the 30<sup>th</sup> hour of hospitalization. The demographic characteristics of the patients are presented in Table I.

Upon initial admission, complete blood counts, kidney and liver function tests, blood gases, and urine analyses were performed for all patients. As they had been trapped under the rubble for an extended period, fluid resuscitation with normal saline was administered at the disaster site, and no cases of hypoglycemia were observed. Fluid volume was adjusted for all patients based on age, weight, severity

**Table I.** Demographic characteristics of the patients

Patients (n)	Male/ Female	Duration under the wash (hours)	Stay in the intensive care unit (hours)	Hospitalization duration (hours)	PRISM score	Expected death rate (%)	Injured limb	Result
1	F	92	54	47	6	2.8	-	Discharged
2	M	11	160	528	14	13.2	Left and right lower extremities	Discharged
3	F	58	24	84	0	0.8	Left and right lower extremities	Discharged
4	F	4	30	30	31	83.7	Head	Ex
5	F	16	96	456	2	1.3	Left and right lower extremities	Discharged
6	F	65	26	110	2	1.3	Head	Discharged
7	F	23	20	264	0	0.8	Left lower extremities	Discharged
8	M	23	22	12	6	2.8	Left lower extremities	Discharged

of trauma, urine output, and physical examination findings, and sodium bicarbonate (30-50 mEq/L) in 0.45% NaCl with 5% dextrose (1/2 NS) was administered. Two patients underwent fasciotomy due to compartment syndrome. One of them was an 11-year-old male patient rescued 160 hours after the earthquake. Due to crush syndrome and compartment syndrome in the bilateral lower extremities, fasciotomy procedures were performed on both thighs and calves, superficial and deep posterior compartments were released. This closely monitored patient with crush syndrome and rhabdomyolysis had the highest CK level of 301.997 U/L, myoglobin level of 42.275 ng/mL, and creatinine level of 1.07 mg/dL. Mannitol at a dose of 0.5 g/kg was administered to increase urine output. The patient did not develop kidney failure and did not require dialysis. The fasciotomies performed for compartment syndrome were closed on the fifth day. The other patient was a 16-year-old female who was rescued from the rubble 96 hours after the earthquake. Fasciotomies were performed on both calves with two incisions each due to injuries in the lower extremities. A drop foot developed on the right-side during follow-up, and physical therapy was initiated. The fasciotomies were closed on the fourth day. A 17-year-old female patient was rescued from the rubble in the fourth hour after the earthquake. She was intubated, had a Glasgow Coma scale score of 3, and bilateral fixed dilated pupils. Despite aggressive treatment, the patient died at the 30<sup>th</sup> hour of hospitalization. Except for the patient who

died, 7 patients did not require respiratory support. None of our patients in the pediatric intensive care unit developed kidney failure, electrolyte imbalances (hyperphosphatemia, hyperkalemia), or required dialysis. The intensive care admission and discharge kidney function test results and CK values of the patients are presented in Table II.

## Discussion

Between 1998-2023, earthquakes caused nearly 850,000 deaths globally, more than half of all deaths related to natural disasters. More than 130 million people were affected by earthquakes during this time period, meaning they were injured, made homeless, displaced or evacuated during the emergency phase of the disaster. It takes years to eliminate the physical, psychological and economic effects which occur after an earthquake.

At 14:51 on October 30<sup>th</sup>, a magnitude 6.6 earthquakes in Izmir caused 116 deaths. The relatively low number of collapsed buildings during the earthquake and the rapid rescue efforts resulted in less development of kidney failure in the patients.

The locations and types of injuries observed after earthquakes vary depending on the countries' building characteristics. Following the 2005 Pakistan earthquake, superficial injuries such as lacerations and contusions were common, followed by orthopedic extremity injuries, head injuries, and chest injuries (5). In the 2011 Van earthquake, 95% of the disaster victims presented to the hospital with

**Table II.** Laboratory parameters of our patients

Patient	Hospital admission day				Before discharged			
	Urea (mg/dL)	Creatinine (mg/dL)	Creatine kinase (U/L)	Myoglobin (ng/mL)	Urea (mg/dL)	Creatinine (mg/dL)	Creatine kinase (U/L)	Myoglobin (ng/mL)
1	57	0.43	755	26	20	0.2	183	<21
2	40	1.07	43.597	30.000	47	0.33	301.000	8.344
3	37	0.57	1.781	41	17	0.55	364	<21
4	24	1.12	557	6.349	36	1.25	9.282	5.544
5	24	0.73	2.841	6.281	12	0.34	3.406	158
6	59	0.42	383	107	16	0.28	312	<21
7	34	0.70	14.034	1.393	17	0.47	10.590	218
8	52	0.61	10.917	2.464	15	0.4	9.730	278

soft tissue injuries (6). During the Marmara earthquake, the most affected area in the group of patients with crush syndrome was the extremities, with the lower extremities being more traumatized. The lower extremities contain larger muscle groups, leading to more rhabdomyolysis and a higher incidence of acute kidney injury. In the Marmara earthquake, 17,480 people died, and 43,950 were injured. Among 5,302 hospitalized patients diagnosed with crush syndrome and rhabdomyolysis, 639 had acute kidney failure, and 477 of them received dialysis. Crush syndrome resulting from upper extremity injuries generally had a milder course (10).

The İzmir earthquake had a magnitude of 6.6 and lasted approximately 16 seconds. The earthquake was felt throughout Western Anatolia, especially in the provinces of İzmir, Muğla, and Aydın. According to the Disaster and Emergency Management Authority, 116 people died, and 1,034 were injured (4). Many buildings collapsed or suffered severe damage in the Bayraklı and Bornova districts of İzmir, where the highest number of casualties and injuries occurred. Since our hospital is located in this region, all pediatric patients were admitted to the intensive care unit. Most of the presenting patients had non-life-threatening injuries. The relatively low number of pediatric patients trapped under the rubble was due to the earthquake occurring during daytime hours. The earthquake happened during regular working hours, with all clinics in our hospital working at full capacity, leading to a lower number of pediatric patients in need of immediate medical attention, and most of them had non-life-threatening injuries. Therefore, there were no issues in providing initial intervention procedures.

Among our patient population, 2 patients underwent fasciotomy procedures, and one of them was diagnosed Crush syndrome and received medical treatment. Crush syndrome is a systemic condition which arises as a result of trauma-induced rhabdomyolysis, leading to numerous medical and surgical complications. After earthquakes, there is a risk of crush syndrome and acute kidney failure in all patients with mild or severe muscle injuries. To prevent this, adequate hydration and the administration of alkaline fluids are essential. In our intensive care unit, which treated the most severe crush syndrome patients, none of our patients developed kidney failure or required dialysis. The use of mannitol to prevent acute kidney damage in crush injuries is controversial. It may or may not be beneficial in patients with traumatic rhabdomyolysis, or it may have the potential to cause harm. If the patient's urine output is sufficient (20 mL/h), mannitol can be administered. Studies have shown that in non-oliguric patients with traumatic rhabdomyolysis, close monitoring can prevent acute tubular necrosis and subsequent renal injury. In addition, mannitol may be useful in reducing edema in muscles and treating compartment syndrome (11,12).

#### Study Limitations

The retrospective nature and limited number of patients are the limitations of this study.

#### Conclusion

In conclusion, in earthquakes where the number of collapsed buildings and affected people is low, it is seen that patients are easier to manage both in the earthquake zone and in hospitals. With the 2023 Turkey-Syria earthquake, we,

unfortunately, experienced how devastating and terrible the consequences the opposite situations can cause. Although mortality and morbidity rates can be reduced with good planning and organization, it should always be a priority to take long-term measures to reduce mortality in natural disasters which we cannot prevent.

### Ethics

**Ethics Committee Approval:** Ethical approval was obtained from the Ege University Faculty of Medicine Medical Research Ethics Committee (approval no: 21-4T/52, date: 07.04.2021).

**Informed Consent:** Retrospective study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: E.E.T., P.Y.Ö., G.K., İ.E., B.K., Concept: E.E.T., B.K., Design: P.Y.Ö., Data Collections or Processing: G.K., Analysis or Interpretation: İ.E., Literature Search: E.E.T., İ.E., Writing: E.E.T.

**Conflict of Interest:** None of authors have any conflicts of interest to report.

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