Signa Vitae

ORIGINAL RESEARCH

Patients rescued from rubble after the 2023 Kahramanmaraş earthquake

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Abstract

Background: This study examines the conditions and laboratory results of patients who were rescued from the rubble and brought to the emergency department following the earthquake centered in Kahramanmaraş on 06 February 2023. The aim is to serve as a resource for healthcare professionals in future disasters, helping to enhance preparedness and reduce loss of life. **Methods**: This study was designed as a retrospective descriptive study. Demographic data, clinical conditions, and laboratory results of patients rescued from the rubble were retrieved from the hospital's automation system. Statistical analyses were performed using SPSS Windows version 23.0. A total of 92 patients rescued alive from the rubble were included in the study. **Results**: The mean duration of entrapment beneath the rubble was 3.5 ± 2.19 days. The most significant complications observed were crush syndrome in 35.9% of patients, the need for dialysis in 17.4% and emergency blood transfusion in 7.6%. Of the patients monitored in the study, 26.1% died, 23.9% required intensive care admission, 50% were treated as inpatients and 23.9% were discharged on the same day. **Conclusions**: Our findings suggest that proper management of patients rescued from rubble, with particular attention to the risk of crush syndrome and acute kidney failure, is crucial for improving outcomes.

Keywords

Earthquake; Emergency medicine; Rubble; Kahramanmaraş

1. Introduction

Injuries sustained during earthquakes, particularly those resulting from prolonged entrapment under debris, can lead to significant limb loss and mortality, posing major challenges for humanity [1]. Common injuries among patients trapped under rubble in earthquakes include: "Head and Neck Injuries, Spinal Injuries, Blunt and Penetrating Thoracic Injuries, Abdominal Injuries, Limb Fractures, Compartment Syndromes, Crush Injuries, Acute Kidney Failure, Hypothermia and Hemorrhages".

The primary causes of mortality in earthquakes are typically severe organ trauma in the head, thorax and abdomen, hematomas, hemorrhages, asphyxia due to dust inhalation, chest compression, hypovolemic shock, hypothermia and crush syndrome. A recent study of the 2023 Turkey-Syria earthquake underscores that these factors, particularly the systemic complications following crush syndrome, play a critical role in patient outcomes [2, 3]. Individuals with only limb trauma can survive longer under rubble. However, they are at high risk for compartment syndrome and infections, which may necessitate fasciotomy or amputation [4, 5]. All patients with mild or severe muscle trauma who remain trapped under debris are at risk of developing crush syndrome and acute kidney failure. Therefore, the first 6–8 hours,

known as the golden hours, are critical [1, 5].

The two major earthquakes centered in Kahramanmaraş on 06 February 2023, caused massive destruction in the affected cities and resulted in the deaths of over 50,000 people [6]. This study examines the conditions and laboratory results of patients rescued from the rubble and brought to the emergency department following the 06 February 2023 Kahramanmaraş earthquake. The aim is to provide a resource for healthcare professionals in future disasters, aiding in better preparedness and prevention of loss of life.

2. Materials and methods

This study was designed as a retrospective descriptive study. Patients who were rescued alive from the rubble following the earthquake and brought to the emergency department of Kahramanmaraş Sütçü Imam University Faculty of Medicine Hospital for treatment were included in the study. Demographic data, clinical and laboratory data related to the disease, type of admission, presence of crush syndrome, and need for dialysis were retrieved from the hospital's automation system. All laboratory tests were performed using blood samples collected upon admission to the emergency department. The scan revealed 99 earthquake victims who had been trapped under

the rubble. Seven patients were excluded due to incomplete data, leaving 92 individuals included in the study.

The normality of the data distribution was assessed using the Kolmogorov-Smirnov test, and the data were found to be normally distributed. The independent *t*-test was used for the comparison of normally distributed features between two independent groups, while one-way analysis of variance (ANOVA) was used for comparisons among more than two groups. Correlation between variables was examined using Spearman's *rho* coefficient. Descriptive statistics for numerical variables were presented as mean $\pm$ standard deviation, minimum and maximum values, while categorical variables were presented as counts and percentages. Statistical analyses were performed using SPSS version 15 (Statistical Package for Social Sciences, version 15, SPSS Inc., Chicago, IL, USA), with $p < 0.05$ considered statistically significant.

3. Results

The demographic characteristics of the patients rescued from the rubble included in the study were examined. A total of 92 patients were included in the study. The average age of the participants was 46.40 ± 19.36 years, and the mean duration of entrapment under the rubble was 3.5 ± 2.19 days. Of the participants, 52.2% were women (n = 48) and 47.8% were men (n = 44) (Table 1).

The number of female and male disaster victims recovered from the rubble was similar (Table 1). A significant difference was found when comparing the Mean Platelet Volume (MPV) values of the patients according to gender ($p = 0.036$). MPV for women was 10.62 ± 1.06 fL, which was higher than that for men. A significant difference was also found between the phosphorus levels of male and female patients ($p = 0.003$), with women having a higher phosphorus level of 7.99 ± 3.54 mg/dL. Another notable result was the significant difference found between the mean urea values and gender; although there is no statistical difference when comparing the Blood Urea Nitrogen (BUN) levels provided by the laboratory, a significant difference is observed when the BUN measurement is converted to urea concentration. The mean urea for women was higher than that of men (165.18 ± 108.30 mg/dL *vs.* 127.62 ± 59.08 mg/dL). Calcium values were below normal, with no difference between males and females (8.28 ± 0.88 mg/dL for men and 8.07 ± 1.31 mg/dL for women) (Table 1). The distribution of laboratory values according to gender and the details of the test results are provided in Table 1. When examining the relationship between the development of crush syndrome and the number of days survived under the rubble, a significant difference was found between the number of days spent under the rubble and the occurrence of crush syndrome ($p < 0.001$). It was observed that the number of days spent under the rubble for patients who developed crush syndrome was 1.78, which was lower than those who did not develop the syndrome. It was found that individuals who did not develop crush syndrome remained under the rubble for a longer period. Additionally, when comparing the crush syndrome status with White Blood Cells (WBC) counts ($p = 0.008$), a significant difference was found between the development of crush syndrome and WBC averages. The mean WBC was higher in

TABLE 1. Comparison of laboratory values by gender.

Gender	N	Mean	Standard deviation	*p*
Duration of stay in the rubble (d)				
Man	44	3.72	2.39	0.345
Woman	48	3.29	1.99	
White Blood Cells (10^9/L)				
Man	48	19.47	8.94	0.825
Woman	44	19.85	7.44	
Neutrophil Count (10^9/L)				
Man	48	17.35	10.62	0.465
Woman	44	19.39	15.72	
Platelet Count (10^9/L)				
Man	48	270.20	129.73	0.768
Woman	44	277.50	103.52	
Immature Granulocyte Count (10^9/L)				
Man	48	0.18	0.25	0.522
Woman	44	0.22	0.36	
Sodium (mmol/L)				
Man	48	144.37	11.92	0.534
Woman	44	141.93	24.06	
Potassium (mmol/L)				
Man	48	7.61	9.55	0.868
Woman	44	8.00	12.74	
Calcium (mg/dL)				
Man	48	8.28	0.88	0.353
Woman	44	8.07	1.31	
Phosphorus (mg/dL)				
Man	48	5.91	2.91	0.003
Woman	44	7.99	3.54	
Power of Hydrogen (pH)				
Man	48	7.27	0.08	0.441
Woman	44	7.25	0.08	
Lactate (mmol/L)				
Man	48	5.25	2.50	0.582
Woman	44	5.00	1.78	
Blood Urea Nitrogen (BUN) (mg/dL)				
Man	48	59.33	27.47	0.053
Woman	44	76.79	52.58	
Creatinine (mg/dL)				
Man	48	2.16	1.36	0.736
Woman	44	2.26	1.40	

Independent t-test. The comparison of average laboratory values by gender is shown.

those who developed crush syndrome compared to those who did not. Another laboratory finding that showed a significant difference was the percentage of neutrophils, with the mean neutrophil percentage being higher in those who developed crush syndrome than in those who did not. Furthermore, significant differences were found between Mean Corpuscular Volume (MCV), sodium, phosphorus, and pH values and the development of crush syndrome. The mean values of these laboratory parameters were higher in patients who developed crush syndrome. Similarly, a significant difference was found between mean creatinine levels and the development of crush syndrome, with the mean creatinine being higher in those who developed the syndrome ($p < 0.001$). However, it was noteworthy that the mean levels of urea and BUN were higher in earthquake survivors who did not develop crush syndrome. Details of participants' average laboratory values and crush syndrome status are provided in Table 2.

Evaluating the prognosis of the patients, 17.4% (n = 16) required dialysis, 35.9% (n = 33) developed crush syndrome and 7.6% (n = 7) received blood transfusions. It was determined that 26.1% (n = 24) of the participants died (exitus), 26.1% (n = 24) were admitted to the intensive care unit, 23.9% (n = 22) were admitted to the hospital ward and 23.9% (n = 22) were discharged (Table 3). As a result of comparing the patients' conditions with the average laboratory values, a significant difference was found between the patient condition and phosphorus levels ($p = 0.003$). It was observed that the group with the highest average phosphorus levels consisted of patients admitted to the intensive care unit. Additionally, a significant difference was detected between lactate levels and patient condition ($p = 0.040$). Significant differences were also found between patient condition and the average values of urea, BUN and creatinine, with these levels being higher in patients admitted to the intensive care unit ($p = 0.016$ for BUN, $p < 0.001$ for creatinine). No significant difference was found between the values of other laboratory values and the number of days spent under the rubble concerning patient condition. It was even observed that the average number of days spent under the rubble was 4.5 for patients admitted to the ward, 3.29 for deceased patients and 3.00 for discharged patients (Table 3).

A Spearman correlation analysis between the duration of entrapment and laboratory measurements revealed several statistically significant relationships. Positive correlations were observed with sodium ($rho = 0.551$, $p < 0.0001$), pH ($rho = 0.328$, $p = 0.0001$) and BUN ($rho = 0.311$, $p = 0.0003$). Negative correlations were found with neutrophil count ($rho = -0.443$, $p < 0.0001$), WBC ($rho = -0.353$, $p = 0.0001$) and lactate ($rho = -0.351$, $p = 0.0001$). These findings suggest a time-dependent pattern in laboratory parameters, with inflammatory markers decreasing and pH values increasing over time (Table 4).

4. Discussion

This study examines the demographic data, injury types and laboratory results of patients rescued from the rubble during the 06 February 2023 Kahramanmaraş earthquake, evaluating the impact of these factors on patient prognosis. The findings provide a better understanding of the primary health issues faced

TABLE 2. Comparison of laboratory values based on the presence of crush syndrome.

Crush Syndrome	N	Mean	Standard deviation	p
Duration of stay in the rubble (d)				
Yes	33	1.78	1.05	<0.001
No	59	4.45	2.08	
White Blood Cells (10^9/L)				
Yes	33	22.68	8.04	0.008
No	59	17.96	7.88	
Neutrophil Count (10^9/L)				
Yes	33	19.01	6.90	0.713
No	59	17.94	15.80	
Platelet Count (10^9/L)				
Yes	33	271.18	98.97	0.879
No	59	275.10	127.25	
Immature Granulocyte Count (10^9/L)				
Yes	33	0.17	0.12	0.395
No	59	0.22	0.37	
Sodium (mmol/L)				
Yes	33	135.00	27.21	0.001
No	59	147.79	8.82	
Potassium (mmol/L)				
Yes	33	7.43	10.02	0.814
No	59	8.00	11.78	
Calcium (mg/dL)				
Yes	33	7.99	1.05	0.225
No	59	8.29	1.13	
Phosphorus (mg/dL)				
Yes	33	8.23	3.49	0.004
No	59	6.17	3.09	
Power of Hydrogen (pH)				
Yes	33	7.22	0.09	0.001
No	59	7.28	0.08	
Lactate (mmol/L)				
Yes	33	5.67	2.12	0.078
No	59	4.83	2.17	
Blood Urea Nitrogen (BUN) (mg/dL)				
Yes	33	54.36	28.37	0.022
No	59	75.13	46.69	
Creatinine (mg/dL)				
Yes	33	2.93	1.65	<0.001
No	59	1.80	1.00	

Independent t-test. The comparison of average laboratory values based on the presence of crush syndrome is shown.

T A B L E 3. Comparison of the laboratory values of patients based on their clinical conditions.

	Exitus (n = 24) (mean ± SD)	Service Admission (n = 22) (mean ± SD)	Intensive Care Admission (n = 24) (mean ± SD)	Discharged (n = 22) (mean ± SD)	Total (n = 92) (mean ± SD)	p
Days Trapped Under Rubble	3.29 ± 2.59	4.50 ± 2.04	3.25 ± 2.38	3.00 ± 1.30	3.50 ± 2.19	0.099
White Blood Cell (10^9/L)	17.29 ± 8.02	19.31 ± 6.59	23.06 ± 7.87	18.86 ± 9.50	19.65 ± 8.22	0.093
Neutrophil Count (10^9/L)	14.00 ± 7.30	18.22 ± 14.73	19.56 ± 6.71	21.81 ± 20.06	18.33 ± 13.27	0.235
Platelet Count (10^9/L)	249.62 ± 100.69	296.36 ± 106.94	289.91 ± 134.22	259.59 ± 125.24	273.69 ± 117.34	0.462
Lymphocyte Count (10^9/L)	1.74 ± 1.43	2.05 ± 2.10	1.79 ± 1.84	1.51 ± 1.29	1.77 ± 1.68	0.771
Hemoglobin (g/dL)	13.45 ± 3.76	15.60 ± 2.70	15.10 ± 2.69	14.57 ± 3.05	14.66 ± 3.15	0.112
Immature Granulocyte Count (10^9/L)	0.13 ± 0.09	0.25 ± 0.49	0.19 ± 0.11	0.26 ± 0.36	0.20 ± 0.31	0.488
Sodium (mmol/L)	135.84 ± 31.00	147.50 ± 9.58	145.91 ± 14.19	144.00 ± 7.37	143.20 ± 18.67	0.141
Potassium (mmol/L)	7.64 ± 11.87	10.29 ± 13.74	8.27 ± 12.74	4.96 ± 0.83	7.80 ± 11.13	0.467
Calcium (mg/dL)	7.86 ± 1.38	8.58 ± 0.99	8.15 ± 1.04	8.17 ± 0.89	8.18 ± 1.11	0.189
Phosphorus (mg/dL)	6.75 ± 3.50	6.10 ± 2.92	8.96 ± 3.33	5.65 ± 2.82	6.91 ± 3.37	0.003
Power of Hydrogen (pH)	7.25 ± 0.09	7.29 ± 0.05	7.24 ± 0.06	7.26 ± 0.11	7.26 ± 0.09	0.191
Lactate (mmol/L)	5.68 ± 1.74	4.02 ± 1.62	5.22 ± 1.89	5.56 ± 2.97	5.13 ± 2.18	0.040
Blood Urea Nitrogen (BUN) (mg/dL)	61.62 ± 37.52	60.36 ± 33.95	90.79 ± 55.35	56.40 ± 28.14	67.68 ± 42.11	0.016
Creatinine (mg/dL)	2.48 ± 1.45	1.66 ± 1.28	3.11 ± 1.33	1.47 ± 0.62	2.21 ± 1.37	<0.001

One-way ANOVA test. The comparison of the laboratory values according to the clinical conditions of the patients is shown. SD: standard deviation.

T A B L E 4. Significant correlations between duration of entrapment and laboratory measurements.

Parameter	Spearman's *rho* value	*p* value	n	Correlation strength
Sodium (mmol/L)	+0.551	<0.0001	92	Strong
Neutrophil Count (10^9/L)	−0.443	<0.0001	80	Moderate
White Blood Cell (10^9/L)	−0.353	0.0001	81	Moderate
Power of Hydrogen (pH)	+0.328	0.0001	92	Moderate
Blood Urea Nitrogen (BUN) (mg/dL)	+0.311	0.0003	92	Moderate
Lactate (mmol/L)	−0.351	0.0001	92	Moderate
Potassium (mmol/L)	−0.248	0.0017	92	Weak

by patients trapped under rubble and the medical interventions used to address these issues.

Sever *et al.*'s [7] study following the 1999 Marmara earthquake reported that most patients were trapped under debris for 5–8 hours, with 97% of victims rescued by the 48th hour. In our study, the average duration of entrapment was found to be 3.5 ± 2.19 days. Although the duration under the rubble in our study was different from the duration in the Marmara earthquake, this disparity aligns with findings from other earthquakes, where the average maximum time to rescue was approximately 6.8 days (median = 5.75 days). During the 2024 Noto Peninsula earthquake, a 93-year-old woman

survived after being trapped under rubble for over five days, highlighting the potential for prolonged survival in such disasters [8, 9].

Crush syndrome is a systemic condition resulting from tissue damage by various mechanisms, affecting all organs and systems, and potentially leading to mortality if untreated. It is known to frequently occur due to compression of the lower extremities. Crush syndrome is the second most common cause of death after direct trauma in disasters [10], with a prevalence of around 25% in previous studies [11]. Bulut *et al.*'s [12] study after the 1999 Marmara earthquake found that 54.5% of patients diagnosed with crush syndrome required hemodialysis, with a mortality rate of approximately 21%. Similarly, our findings indicate that crush syndrome is a common complication (33 patients, 35.9%) and that the need for dialysis is high (16 patients, 17.9%). Given that 26.1% of the patients included in the study died and 26.1% required intensive care, it is evident that the earthquake significantly affected morbidity and mortality rates. Thus, it is crucial to recognize the severe health problems caused by crush syndrome and the necessity for prompt and effective intervention.

In crush injuries, components such as myoglobin, phosphorus, potassium and lactic acid accumulated in the muscles enter the systemic circulation due to a mechanism associated with reperfusion injury, leading to crush syndrome. If not treated appropriately in the early stage, this syndrome can cause acute kidney failure due to the direct toxic effect of myoglobin released from the muscles on the renal tubules and decreased renal blood flow due to hypovolemia. Hemodialysis may be required in these patients [13]. Notably, higher creatinine levels in patients with crush syndrome indicate more significant impairment of their renal functions.

When examining the relationships between patients' clinical conditions and laboratory values as presented in Table 3, we observed several significant results. Patients admitted to the intensive care unit exhibited the highest phosphorus levels (8.96 $\pm$ 3.33 mg/dL, $p = 0.003$) compared to other groups, suggesting more severe muscle damage in these critically ill patients. Similarly, intensive care patients had markedly elevated creatinine values (3.11 $\pm$ 1.33 mg/dL, $p < 0.001$), indicating more significant renal impairment compared to discharged patients (1.47 $\pm$ 0.62 mg/dL) and those admitted to hospital wards (1.66 $\pm$ 1.28 mg/dL).

The BUN levels followed a similar pattern, with intensive care patients showing the highest values (90.79 $\pm$ 55.35 mg/dL, $p = 0.016$), followed by deceased patients (61.62 $\pm$ 37.52 mg/dL). Interestingly, deceased patients demonstrated the highest lactate levels (5.68 $\pm$ 1.74 mmol/L, $p = 0.040$) compared to hospital ward-admitted patients (4.02 $\pm$ 1.62 mmol/L), highlighting the association between elevated lactate and mortality. These findings collectively suggest that severe metabolic derangements and end-organ damage, particularly renal dysfunction, were most prominent in patients requiring intensive care.

Regarding pH values, although intensive care patients had slightly lower levels (7.24 $\pm$ 0.06) compared to hospital ward-admitted patients (7.29 $\pm$ 0.05), this difference did not reach statistical significance ($p = 0.191$). This indicates that while metabolic acidosis was present in many patients, it did not

consistently correlate with clinical severity in the same manner as other laboratory parameters [14].

Interestingly in our study we also observed some differences in certain laboratory findings between female and male patients. Our study found a significantly higher MPV in female patients compared to males (10.62 $\pm$ 1.06 fL, $p = 0.036$). This gender difference in MPV likely relates to hormonal factors affecting platelet activation during traumatic stress. Previous studies have demonstrated that MPV indicates platelet activation, with higher values showing increased reactivity [15]. Research has shown that females exhibit different platelet reactivity profiles compared to males, potentially due to estrogen's effects [16]. This may explain the elevated MPV values in our female earthquake victims, suggesting a more pronounced platelet response to tissue damage during entrapment. Female patients showed significantly higher phosphorus levels compared to males (7.99 $\pm$ 3.54 *vs.* 5.91 $\pm$ 2.91 mg/dL, $p = 0.003$). In rhabdomyolysis, which commonly occurs in crush injuries, damaged skeletal muscle releases phosphate into the bloodstream. The severity of hyperphosphatemia often correlates with muscle damage extent [17]. This gender discrepancy might be explained by women's different body composition and potentially greater vulnerability to certain crush injury patterns. Female patients had higher urea levels (165.18 $\pm$ 108.30 mg/dL) compared to males (127.62 $\pm$ 59.08 mg/dL), suggesting more severe renal impairment. However, this finding contrasts with previous literature, which generally reports similar or lower BUN levels in females compared to males during acute kidney injury events [18]. Our findings indicate that in disaster settings, other factors such as differential access to immediate care, baseline nutritional status, or physiological water distribution may override these protective mechanisms. This discrepancy highlights the need for disaster-specific renal injury research that considers gender as an important variable rather than applying general acute kidney injury models to earthquake victims.

Interestingly, patients who developed crush syndrome spent less time trapped under rubble (1.78 days) compared to those who did not (4.45 days, $p < 0.001$). A study by Oda *et al.* [19] supports our observation as it demonstrates that patients with higher CK (Creatinine Kinase) levels spent less time in entrapment compared to those with lower CK levels. This counter-intuitive finding may be explained by survival bias-patients with severe compression injuries develop crush syndrome rapidly, while those who might develop very severe crush syndrome after prolonged entrapment may not survive long enough to be included in our study. However, this finding should be demonstrated in further studies.

Our correlation analysis revealed significant associations between entrapment duration and various laboratory parameters. Positive correlations were observed with sodium, pH, lymphocyte percentage and BUN. Negative correlations were found with neutrophil count, WBC and lactate. These time-dependent patterns suggest a complex physiological response to prolonged entrapment. The decreasing inflammatory markers (WBC, neutrophil count) over time may indicate an exhaustion of the inflammatory response in longer entrapment periods. Conversely, the positive correlation between entrapment duration and pH values suggests a gradual adapta-

tion of acid-base balance over time. The increasing sodium, urea and BUN levels with longer entrapment duration point to progressive dehydration and deteriorating renal function, typical complications in crush injuries [17, 20]. These findings provide valuable insights into the pathophysiological changes occurring during prolonged entrapment and may guide clinical management of earthquake victims in future disasters.

There are some limitations in our study. The most important of these is the low number of patients due to the inadequacy of the hospital patient registration system and the density of patients in the first three days of the earthquake. Again, due to this inadequacy of the system, there are patients whose laboratory results we cannot access because we work manually. We hope that such a disaster will never occur again, but in subsequent studies, more patients with reliable records can be reached.

5. Conclusions

In conclusion, this retrospective study provides critical, real-world data from the 2023 Kahramanmaraş earthquake, highlighting the profound clinical challenges faced by patients rescued from the rubble. Our analysis of 92 survivors confirms that crush syndrome (35.9%) and subsequent acute kidney failure requiring dialysis (17.4%) are the most significant life-threatening complications, emphasizing the crucial need for pre-hospital and emergency department protocols focused on aggressive fluid resuscitation and timely renal support. Additionally, our results highlight that gender differences may significantly influence laboratory parameters and clinical manifestations in earthquake victims, suggesting that gender-specific approaches could be beneficial in the assessment and treatment of these patients.

AVAILABILITY OF DATA AND MATERIALS

All data and materials related to this study are available upon reasonable request.

AUTHOR CONTRIBUTIONS

The authors contributed to this work as follows: AİK, MSG, EK—designed the research study. ÖFK, MP, HH, MAG, MA—performed the research. HH, EK, MSG—analyzed the data. AİK, MSG, EK, GSG, MK—wrote the manuscript. All authors have reviewed and approved the final version of the manuscript and take responsibility for its content and accuracy.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval for the study was obtained from the Ethics Committee for Clinical Research at Kahramanmaraş Sütçü Imam University Faculty of Medicine on 20 June 2023, under decision number 04 of session number 2023/07. Informed consent was obtained from all patients or their legal guardians before their inclusion in the study. Our study complies with the ethical rules of the Declaration of Helsinki of 1975.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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