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Research

Single Center Data of Kahramanmaraş Earthquake: Bakırköy Dr. Sadi Konuk Training and Research Hospital, Nephrology Department Experience

Kahramanmaraş Depreminin Tek Merkez Verileri: Bakırköy Dr. Sadi Konuk Eğitim ve Araştırma Hastanesi Nefroloji Bölümü Deneyimi

 Gamze Ergün Sezer[1], Ahmet Burak Dirim[1], Ecem Güleç[2], Mürvet Yılmaz[1]

[1]University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Nephrology, İstanbul, Türkiye
[2]University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Internal Medicine, İstanbul, Türkiye

ABSTRACT

Objective: The Kahramanmaraş earthquake resulted in great destruction and death. We presented the characteristics of patients with crush syndrome (CS) and acute kidney injury (AKI) brought to our hospital from this region.

Methods: Data of all earthquake victims admitted to our hospital between February 7th, 2023 and February 15th, 2023 were reviewed in this retrospective study. Data of 51 victims over 17 years who were rescued from the rubble were reviewed and the demographic, laboratory, and clinical findings of these patients were investigated. They were evaluated for mortality, AKI, renal replacement therapy (RRT) requirement, and complications, including fasciotomy, amputation, intensive care unit (ICU) hospitalization requirement, microbial growth, antibiotic requirement, and duration of antibiotic treatment days.

Results: Twenty patients (39.22%) required ICU hospitalization, 21 patients (41.18%) had AKI, but 10 of the total patients (19.61%) required RRT, 1 patient (1.9%) died. There was a positive correlation between the time of the patients under the dent and the maximum creatine kinase (CK) level, severity of renal failure, number of hemodialysis sessions, number of albumin and erythrocyte replacements, and length of stay in the ICU. A positive correlation was found between CK and creatinine level, as well as between creatinine level and number of complications.

Conclusion: Patients with CS should be closely followed in terms of their renal survival, and early treatment should be started. Follow-up of these patients requires a multidisciplinary approach with the contribution of surgeons and nephrologists.

Keywords: Rhabdomyolysis, crush syndrome, acute kidney injury

ÖZ

Amaç: Kahramanmaraş depremi büyük bir yıkım ve ölümle sonuçlanmıştır. Bu bölgeden hastanemize getirilen crush sendromu (CS) ve akut böbrek hasarı (ABH) olan hastaların özelliklerini sunmayı amaçladık.

Gereç ve Yöntem: Bu retrospektif çalışmada, hastanemize 7 Şubat 2023 ile 15 Şubat 2023 tarihleri arasında başvuran tüm depremzedelerin verileri incelendi. Enkazdan kurtarılan 17 yaş üstü 51 depremzedenin verileri tarandı. Bu hastaların demografik, laboratuvar ve klinik bulguları incelendi. Hastalar; mortalite, ABH, renal replasman tedavisi (RRT) gereksinimi, fasyotomi, amputasyon, yoğun bakım ünitesi (YBÜ) gereksinimi, mikrobiyal üreme, antibiyotik gereksinimi, antibiyotik verilen gün sayısı gibi komplikasyonlar açısından değerlendirildi.

Bulgular: Yirmi hastada (%39,22) yoğun bakım ihtiyacı, 21 hastada (%41,18) ABH gelişti, ancak 10 hastada (%19,61) RRT gerekti, 1 hasta (%1,9) öldü. Göçük altında geçen süre ile maksimum kreatinin kinaz (CK) düzeyi, girilen hemodiyaliz seans sayısı, albümin ve eritrosit replasman sayısı ve YBÜ yatış günü arasında pozitif korelasyon saptandı. CK ile kreatinin düzeyi arasında ve kreatinin düzeyi ile de komplikasyonların sayısı arasında pozitif korelasyon bulundu.

Sonuç: CS'li hastalar renal sağkalım açısından çok yakından takip edilmeli ve erken tedaviye başlanmalıdır. Aksi takdirde ciddi komplikasyonlar meydana gelebilir.

Anahtar Kelimeler: Rabdomiyoliz, crush sendromu, akut böbrek hasarı

INTRODUCTION

Crush syndrome (CS) is a systemic consequence of rhabdomyolysis caused by prolonged pressure on muscle tissue. Rhabdomyolysis varies from transient hyperkalemia, hypocalcemia, and elevated creatinine phosphokinase (CK) levels to cardiac arrhythmia, hypovolemic shock, and acute kidney injury (AKI) (1,2). The most important cause of CS is earthquakes; it is also the second most common cause of death after the direct effect of trauma in earthquakes (3).

There are various causes of AKI in CS. The direct nephrotoxic effects of heme products, such as myoglobin and urate crystals, cause tubular obstruction, and hypotension and hypoperfusion contribute to acute tubular necrosis (4). Crush-associated AKI manifests as rhabdomyolysis and myoglobinemia, hyperkalemia, hyperphosphatemia, and myoglobinuria. AKI patients who survive and do not become chronically dependent on dialysis have a good prognosis. Even under optimal conditions, the risk of dialysis is approximately 10% (5). The severity of AKI depends on the extent of muscle injury, degree of volume depletion, presence or absence of underlying comorbid conditions, and development of complications such as sepsis (6).

In our country, the 1999 Marmara earthquake, the 2011 Van earthquake, and finally the 2023 Kahramanmaraş earthquake caused thousands of deaths and injuries and showed that Türkiye is an earthquake country (7,8). In the earthquake that occurred in Kahramanmaraş on February 6th, 2023, many surrounding cities were also affected. The hospitals in the region were also damaged, and health services were insufficient. Therefore, earthquake victims were referred to our hospital from the area, but the patients who came to us were in relatively mild clinics. In this study, we investigated the severity of renal failure, the number of hemodialysis sessions, the number of albumin and erythrocyte replacements, and the length of intensive care unit (ICU) stay of patients who were removed from the rubble and admitted to our hospital during the Kahramanmaraş earthquake.

METHODS

Patients and Follow-up

Data of all earthquake victims admitted to our hospital between February 7th, 2023 and February 15th, 2023 were reviewed in this retrospective study (case series). Data of 51 victims over 17 years who were rescued from the rubble were reviewed and the demographic, laboratory, and clinical findings of these patients were investigated.

All procedures performed in studies involving human participants were conducted under the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved by the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (decision no: 2023-08-06, date: 17.04.2023).

Primary and Secondary Outcomes

The primary outcomes were AKI, renal replacement therapy (RRT) requirement, and complications, including fasciotomy, amputation, ICU admission, and length of stay in ICU. The secondary outcome was mortality. In addition, microbial growth, antibiotic requirement, and duration of antibiotic treatment days were evaluated. These data were obtained from the system retrospectively.

Statistical Analysis

SPSS version 25.0 program was used for data analysis. The conformity of the variables to the normal distribution was examined using histogram graphics and the Kolmogorov-Smirnov test. Mean, standard deviation, median, and minimum-maximum (min-max) values were used when presenting descriptive analyses. The Pearson chi-square test was used for comparison between two variables. The Mann-Whitney U test was used to evaluate non-normally distributed (non-parametric) variables between groups. Spearman's correlation test was used in the analysis of the measurement data with each other. Cases with a p-value 0.05 were considered statistically significant.

RESULTS

The mean age of the patients was 45±19 years, 50.98% of patients were male, mean hours under dent was 22.8±28 hours. Twelve of the victims were transferred from Adıyaman (23.53%), 26 from Hatay (50.98%), 8 from Kahramanmaraş (15.69%), and 5 from Malatya (9.8%). Seventeen of the patients had comorbidities including diabetes mellitus, hypertension, hypothyroidism, hyperthyroidism, and chronic heart diseases (33.33%) (Table 1).

At admission, mean serum albumin was 3.58±0.74 g/dL, hemoglobin (Hb) 12.68±3.03 g/dL, CK 15109.8±30313.12 U/L, and creatinine 1.63±1.54 mg/dL. In the follow-up of the patients, the mean of min Hb was 9.83±2.78 g/dL, albumin 2.86±0.8 g/dL, estimated glomerular filtration rate (eGFR) 74.59±46.34 mL/min/1.73 m^2; max creatinine was 2.08±2.39 mg/dL, CK 23412.8±43712 U/L (Table 2).

Twenty patients (39.22%) required ICU care, and the mean length of stay in the ICU was 3.45±8.53 days. Nine patients (17.4%) underwent fasciotomy and 6 patients (11.77%) underwent amputation. Twenty-one patients (41.18%) had

Table 1. Demographic of the patients at admission

		n	%
Gender	Female	25	49.02
	Male	26	50.98
Province in which the patients was under the rubble	Adıyaman	12	23.53
	Hatay	26	50.98
	Kahramanmaraş	8	15.69
	Malatya	5	9.80
Comorbidity		17	33.33

Data were expressed as n (%) for nominal parameters

Table 2. Laboratory data of the patients

	Mean ± SD	Median (min-max)
First Hb (g/dL)	12.68±3.03	12.4 (5.7-20)
First cre (mg/dL)	1.63±1.54	0.9 (0.33-6.12)
First eGFR (mL/min/1.73 m²)	77±43.89	81 (8-138)
First CRP (mg/L)	78±72.21	66 (1-264)
First albumin (g/dL)	3.58±0.74	3.8 (1.9-4.8)
First CK (u/L)	15109.8±30313.12	1493 (31-115,754)
Min Hb (g/dL)	9.83±2.78	9.8 (4.9-16.4)
Min albumin (g/dL)	2.86±0.8	2.9 (1.5-4.6)
Max cre (mg/dL)	2.08±2.39	0.9 (0.33-10.7)
Min eGFR (mL/min/1.73 m²)	74.59±46.34	89 (2-152)
Max CK (u/L)	23412.8±43712.2	2319 (53-236,092)

Data were expressed as median (interquartile range) for quantitative variables.
Hb: Hemoglobin, cre: Creatinine, eGFR: Estimated glomerular filtration rate, CRP: C-reactive protein, CK: Creatinine kinase, SD: Standard deviation, min-max: Minimum-maximum

AKI, but 10 of the total patients (19.61%) required RRT. Four patients (7.8%) were given hyperbaric oxygen therapy and 12 patients (23.53%) had bacterial growth (Table 3). Only 1 patient died (1.9%).

The rate of ICU requirement in patients with renal dysfunction was higher than that in patients without renal dysfunction (p<0.001). The risk of developing AKI was found to be low in the group with normal CK (p<0.001) (Table 4).

In patients with AKI, the length of stay in the ICU, first C-reactive protein, max creatinine level, max CK level, eritrocyte replacement number, albumin replacement number, and duration of antibiotic treatment days were higher than those without AKI (p<0.001, p=0.031, p<0.001, p<0.001, p=0.004, p=0.002, p=0.008, respectively). In the patients with AKI, the first eGFR, min Hb value, min albumin, and min eGFR were lower than those without AKI (p<0.001, p<0.001, p<0.001, p<0.001, respectively) (Table 5).

Table 3. Complications after the earthquake

	n	%
Need for ICU care	20	39.22
Fasciotomy	9	17.64
Amputation	6	11.77
AKI	21	41.18
Hemodialysis requirement	10	19.61
HBO number	4	7.84
Bacterial growth	12	23.53

Data were expressed as n (%) for nominal parameters.
ICU: Intensive care unit, AKI: Acute kidney injury, HBO: Hyperbaric oxygen

Table 4. Comparison of patients with and without renal failure

		Renal failure				p-value
		Yes (n=21)		No (n=30)		
		n	%	n	%	
Gender	Female	11	52.38	14	46.67	0.688
	Male	10	47.62	16	53.33	
ICU requirement	Yes	16	76.19	4	13.33	**<0.001**
CK group	Normal	3	14.29	7	23.33	**<0.001**
	170-1000 (U/L)	0	0.00	4	13.33	
	1000-10,000 (U/L)	2	9.52	16	53.33	
	10,000-50,000 (U/L)	6	28.57	3	10.00	
	50,000-100,000 (U/L)	6	28.57	0	0.00	
	>100,000 (U/L)	4	19.05	0	0.00	
Fasciotomy	Yes	6	28.57	3	10.00	0.087
Amputation	Yes	2	9.52	4	13.33	0.678
RRT requirement	Yes	10	47.62	0	0.00	**<0.001**
HBO therapy	Yes	2	9.52	2	6.67	0.709
Microbial growth	Yes	7	33.33	5	16.67	0.167
Comorbidity	Yes	10	47.62	7	23.33	0.070
Mortality	Yes	0	0.00	1	3.33	0.398

Data were expressed as n (%) for nominal parameters.
ICU: Intensive care unit, CK: Creatinine kinase, RRT: Renal replacement therapy, HBO: Hyperbaric oxygen

Table 5. Comparison of patients with and without renal failure as laboratory data

	Renal failure		p-value
	Yes	No	
	Median (min-max)	Median (min-max)	
Duration under the rubble (hour)	21 (4-56)	10.5 (0.5-168)	0.086
Length of stay in ICU	2 (0-42)	0 (0-10)	**<0.001**
First Hb (g/dL)	12 (6.9-20)	12.55 (5.7-16.4)	0.931
First eGFR (mL/min/1.73 m^2)	28 (8-81)	114.5 (55-138)	**<0.001**
First CRP (mg/L)	84 (3-239)	40 (1-264)	**0.031**
First albumin (g/dL)	3.6 (1.9-4.4)	3.8 (2.1-4.8)	0.139
First CK (u/L)	2829 (31-115,754)	1371 (66-38,480)	0.069
Min Hb (g/dL)	8.2 (4.9-11.6)	11.2 (5.7-16.4)	**<0.001**
Min albumin (g/dL)	2.5 (1.5-3.3)	3.2 (1.8-4.6)	**<0.001**
Max cre (mg/dL)	3.64 (0.46-10.7)	0.7 (0.33-1.17)	**<0.001**
Min eGFR (mL/min/1.73 m^2)	16 (2-124)	111 (42-152)	**<0.001**
Max CK (u/L)	23231 (53-236,092)	1491.5 (66-38,480)	**<0.001**
Erythrocyte replacement number	1 (0-7)	0 (0-6)	**0.004**
Albumin replacement number	0 (0-6)	0 (0-3)	**0.002**
Number of extremities underwent fasciotomy	0 (0-3)	0 (0-1)	0.083
Number of extremities underwent amputation	0 (0-1)	0 (0-2)	0.632
HBO number	0 (0-12)	0 (0-16)	0.774
Antibiotic treatment days	15 (0-53)	2 (0-41)	**0.008**

ICU: Intensive care unit, Hb: Hemoglobin, eGFR: Estimated glomerular filtration rate, CRP: C-reactive protein, CK: Creatinine kinase, cre: Creatinine, HBO: Hyperbaric oxygen, min-max: Minimum-maximum

There was a positive correlation between the time under the dent and the max CK level, number of hemodialysis sessions, length of stay in the ICU, duration of antibiotic treatment days, albumin replacement number, erythrocyte replacement number, first albumin level, min albumin level, and min Hb level (p=0.017, p=0.012, p=0.003, p=0.001, p=0.001, p=0.001, p=0.001, p=0.001, p=0.002 respectively) (Table 6).

Table 6. Correlation of time under the rubble with complications

		Duration under the rubble (hour)
First CK	r	0.203
	p	0.152
Max CK	r	0.332
	p	**0.017**
Total number of HD session	r	0.349
	p	**0.012**
Length of stay in ICU	r	0.404
	p	**0.003**
Duration of antibiotic treatment days	r	0.457
	p	**0.001**
Albumin replacement number	r	0.461
	p	**0.001**
Erythrocyte suspension replacement number	r	0.559
	p	**0.001**
First GFR	r	-0.268
	p	0.057
First cre	r	0.248
	p	0.079
First cre	r	0.181
	p	0.204
First albumin	r	-0.445
	p	**0.001**
First Hb	r	-0.122
	p	0.394
Min albumin	r	-0.588
	p	**0.001**
Min Hb	r	-0.417
	p	**0.002**

Spearman correlation analysis.
CK: Creatinine kinase, HD: Hemodialysis, ICU: Intensive care unit, cre: Creatinine, Hb: Hemoglobin, GFR: Glomerular filtration rate, Max: Maximum, Min: Minimum

DISCUSSION

CS affects almost all organs. It causes not only AKI but also sepsis, acute respiratory distress syndrome, disseminated intravascular coagulation, bleeding, hypovolemic shock, cardiac failure, arrhythmias, electrolyte disturbances, and psychological trauma (6,9,10). In our study, we mainly found AKI and electrolyte disturbance complications of CS.

It was determined that the most important cause of death after direct trauma in the earthquake was CS and related AKI (2,11,12). Fifty-one patients were diagnosed with CS in our hospital; the reason for this low number is that we were far from the earthquake zone and there were transportation difficulties. In addition, patients with better clinical condition who could handle the transport were referred to us.

In our hospital, 21 patients (41.18%) had AKI, but 10 required RRT. After the earthquake in Tangshan, 2-5% of all injured patients had CS (13). After the Kobe earthquake, CS was observed in 13.8 % of the patients who were hospitalized, and AKI developed in half of them (14). In the Marmara earthquake, 43,953 people were injured. Among the hospitalized patients, AKI related to the CS rate was 12%, and the RRT requirement rate was 9% (7). Numerical data on the Kahramanmaraş earthquake have not yet been created. The Disaster and Emergency Management Presidency (AFAD) has announced that there are nearly 50,000 deaths, but there is no clear data on patients with CS and AKI. Those who are admitted to our hospital are only a small part of them.

None of the patients who received RRT remained dependent on hemodialysis, and their renal function improved during follow-up. This may be because, as I mentioned, the patients who were admitted to our hospital were not clinically severe.

In our study, a positive correlation was observed between high CK and creatinine levels. Complications such as the rate of ICU requirement, erythrocyte replacement number, albumin replacement number, and duration of antibiotic treatment days were found more frequently in patients with AKI. Also, as expected, there was a positive correlation between time under the rubble length of stay in the ICU, CK elevation, number of hemodialysis sessions, antibiotic treatment days, albumin replacement number, and erythrocyte replacement number. This was not a surprise because many previous studies have shown that the severity of CS is associated with AKI, hypovolemic and septic shock, and electrolyte imbalance (2,12,15-18).

Early treatment is the most important thing in CS. Aggressive fluid repletion should be initiated before the extrication of entrapped subjects who are prone to develop CS.

Third spacing at the site of muscle injury worsens hypovolemia. Thus, patients with rhabdomyolysis may require massive amounts of fluid to trigger and maintain vigorous diuresis (15,19-23). Electrolyte disturbances are very common in these patients, and the common is hyperkalemia. Therefore, potassium monitoring should be performed carefully and evaluation should be made in terms of RRT in resistant hyperkalemia (6,23,24). In our hospital, kidney functions, electrolyte values, fluid requirement, and RRT requirement of the patients were strictly evaluated, and kidney function disorders improved during follow-up.

The limitations of our study are the small number of patients and the inability to transfer patients with CS who are in severe clinics due to transportation difficulties and distance from the earthquake zone.

CONCLUSION

CS can cause serious morbidity and mortality. Beginning to treat patients with CS quickly and following them closely is essential. Dialysis once a day may not be enough for patients with severe CS; therefore, the nephrologist should take an active role in the follow-up of these patients.

ETHICS

Ethics Committee Approval: This study was approved by the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (decision no: 2023-08-06, date: 17.04.2023).

Informed Consent: Retrospective study.

Authorship Contributions

Concept: G.E.S., M.Y., Design: G.E.S., M.Y., Data Collection or Processing: G.E.S., A.B.D., E.G., Analysis or Interpretation: G.E.S., Literature Search: G.E.S., A.B.D., Writing: G.E.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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REFERENCES

1. He Q, Wang F, Li G, Chen X, Liao C, Zou Y, et al. Crush syndrome and acute kidney injury in the Wenchuan Earthquake. J Trauma 2011;70:1213-7.

2. Sever MS, Vanholder R, Lameire N. Management of crush-related injuries after disasters. N Engl J Med 2006;354:1052-63.

3. Yokota J. Crush syndrome in disaster. JMAJ 2005;48:341-52.

4. Genthon A, Wilcox SR. Crush syndrome: a case report and review of the literature. J Emerg Med 2014;46:313-9.

5. Wald R, Quinn RR, Luo J, Li P, Scales DC, Mamdani MM, et al. Chronic dialysis and death among survivors of acute kidney injury requiring dialysis. JAMA 2009 302:1179-85.

6. Sever MS, Erek E, Vanholder R, Akoglu E, Yavuz M, Ergin H, et al. Clinical findings in the renal victims of a catastrophic disaster: the Marmara earthquake. Nephrol Dial Transplant 2002;17:1942-9.

7. Sever MS, Erek E, Vanholder R, Akoğlu E, Yavuz M, Ergin H, Tekçe M, et al. The Marmara earthquake: epidemiological analysis of the victims with nephrological problems. Kidney Int 2001;60:1114-23.

8. Sever MS, Kazancıoğlu R. Van Depremi'nin Ardından: Yine Yeniden Deprem. Turk Neph Dial Transpl 2012;21:7-9.

9. Shoaf KI, Sareen HR, Nguyen LH, Bourque LB. Injuries as a result of California earthquakes in the past decade. Disasters 1998;22:218-35.

10. Sharma R. Gujarat earthquake causes major mental health problems. BMJ 2002;324:259.

11. Eknoyan G. Acute renal failure in the Armenian earthquake. Ren Fail 1992;14:241-4.

12. Vanholder R, Sever MS, Erek E, Lameire N. Acute renal failure related to the crush syndrome: towards an era of seismo-nephrology? Nephrol Dial Transplant 2000;15:1517-21.

13. Sheng ZY. Medical support in the Tangshan earthquake: a review of the management of mass casualties and certain major injuries. J Trauma 1987;27:1130-5.

14. Oda J, Tanaka H, Yoshioka T, Iwai A, Yamamura H, Ishikawa K, et al. Analysis of 372 patients with Crush syndrome caused by the Hanshin-Awaji earthquake. J Trauma 1997;42:470-5.

15. Better OS. The crush syndrome revisited (1940-1990). Nephron 1990;55:97-103.

16. Gonzalez D. Crush syndrome. Crit Care Med 2005;33(1 Suppl):S34-41.

17. Malinoski DJ, Slater MS, Mullins RJ. Crush injury and rhabdomyolysis. Crit Care Clin 2004;20:171-92.

18. Newton EJ, Love J. Acute complications of extremity trauma. Emerg Med Clin North Am 2007;25:751-61.

19. Zager RA. Rhabdomyolysis and myohemoglobinuric acute renal failure. Kidney Int 1996;49:314-26.

20. Gunal AI, Celiker H, Dogukan A, Ozalp G, Kirciman E, Simsekli H, et al. Early and vigorous fluid resuscitation prevents acute renal failure in the crush victims of catastrophic earthquakes. J Am Soc Nephrol 2004;15:1862-7.

21. Ron D, Taitelman U, Michaelson M, Bar-Joseph G, Bursztein S, Better OS. Prevention of acute renal failure in traumatic rhabdomyolysis. Arch Intern Med 1984;144:277-80.

22. Kazancioğlu R, Korular D, Sever MS, Türkmen A, Aysuna N, Kayacan SM, et al. The outcome of patients presenting with crush syndrome after the Marmara earthquake. Int J Artif Organs 2001;24:17-21.

23. Sever MS, Erek E, Vanholder R, Kantarci G, Yavuz M, Turkmen A, et al. Serum potassium in the crush syndrome victims of the Marmara disaster. Clin Nephrol 2003;59:326-33.

24. Collins AJ, Burzstein S. Renal failure in disasters. Crit Care Clin 1991;7:421-35.