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After the Earthquakes with Epicenter in Kahramanmaraş on February 6, 2023; Crush Syndrome

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Research Article

ABSTRACT

Objective: One of the vital problems after earthquakes that caused many deaths and injuries is crush syndrome due to traumatic muscle damage. The aim of this study was to determine the clinical course of patients with crush syndrome and identify factors that may be associated with crush syndrome.

Methods: After the two earthquakes of 7.7 and 7.6 magnitude affecting 11 provinces with the epicentre in Kahramanmaraş on 6 February 2023, 319 patients over the age of 18 were admitted to our hospital between 6-14 February. 87 of 319 patients received inpatient follow-up and treatment. The age, gender, duration of stay in the rubble, province of residence, operation performed, duration of hospital stay, amount of fluid given in the first 24 hours, amount of urine output in the first 24 hours, body trauma sites, some laboratory parameters at the time of admission and during follow-up were retrospectively evaluated from the hospital records of all 43 patients diagnosed with crush syndrome among the inpatients between 6-28 February.

Results: The age of the patients was 39±19.6 years, duration of stay under the cave-in(hours) 22.74±36.32, duration of hospitalization(days) 7.26±5.42, amount of fluid given in the first 24 hours(ml) 4954.18±3142, amount of urine output in the first 24 hours(ml) 2646.42±2262.65, admission creatinine(mg/dl) 1.59±2.25, admission creatine kinase(CK)(U/L) 11716.37±18520. 44.2% of the patients were female, 72.1% came from Kahramanmaraş province, 46.5% underwent surgical intervention, 67.4% had an admission CK above 1000 u/l, 14% received hemodialysis treatment and 51.2% had a duration of hospitalization longer than 21 days.
The effect of other parameters on the duration of hospitalization and the time to reach the reference range of CK and correlation with laboratory parameters were analysed.

Conclusion: As a result, it is thought that the parameters affecting the time to reach the CK reference range and the duration of hospitalization can be used to calculate and reduce the duration of hospitalization in prospective crush syndrome cases.

Keywords: Crush Syndrome, Earthquake, Traumatic Rhabdomyalysis

6 Şubat Kahramanmaraş Merkezli Depremler Sonrası Crush Sendromu

Araştırma Makalesi

ÖZET

Amaç: Çok sayıda ölüm ve yaralanmaya neden olan depremler sonrasında hayati sorunlardan biri de travmatik kas hasarına bağlı meydana gelen crush(ezilme) sendromudur. Bu çalışmada crush sendromu gelişmiş hastaların klinik seyirlerini ve crush sendromu ile ilişkili olabilecek faktörleri saptanması amaçlandı.

Yöntem: 6 Şubat 2023 tarihinde 11 ilde etkili olan Kahramanmaraş merkezli 7.7 ve 7.6 büyüklüğündeki iki depremin ardından 6-14 Şubat tarihleri arasında hastanemize 18 yaş üstü 319 hasta başvurdu. 319 hastanın 87'i yatarak takip ve tedavi aldı. Yatarak tedavi alan hastalardan Crush sendromu tanısı alan 43 hastanın tamamının 6-28 Şubat arasındaki hastane kayıtlarından yaşı, cinsiyeti, geldiği ili, enkazda kalış süresi, yapılan operasyon, hastanede yatış süresi, ilk 24 saate verilen mayii miktarı, ilk 24 saat idrar çıkımı miktarı, travma yerleri, hastaneye başvuru esnasında ve takibindeki bazı laboratuvar parametreleri geriye dönük değerlendirildi.

Bulgular: Hastaların yaşı 39±19.6 yıl, enkazda kalış süresi(saat) 22,74±36.32, hastane yatış süresi(gün) 7,26±5,42, ilk 24 saatte aldığı mayi(ml) 4954,18±3142, ilk 24 saat idrar miktarı(ml) 2646,42±2262,65, başvuru kreatinin(mg/dl) 1,59±2,25, başvuru kreatin kinaz(u/l) 11716,37±18520 olarak saptandı.
Hastaların %44,2'i kadın, %72,1'i Kahramanmaraş ilinden gelmiş, %46,5'una cerrahi müdahale yapılmış, %67,4'ünün başvuru CK 1000 u/l'nin üzerinde, %14'üne hemodiyaliz tedavisi uygulanmış, %46,5'inde CK referans aralığına gelme süresi 7 günden kısa, %51,2'inde yatış süresi 21 günden uzun saptandı.
Yatış gün süresi, CK referans aralığına gelme süresi üzerine diğer parametrelerin etkisi ve laboratuvar parametreleri ile korelasyonu analiz edildi.

Sonuç: Sonuç olarak CK referans aralığına gelme süresini ve hastanede yatış süresini ön görmede süreye etkili parametreler değerlendirilerek ileriye dönük crush sendromu olgularında hastanede yatış süresini hesaplamada ve azaltmada kullanılabileceği düşünülmektedir.

Anahtar Kelimeler: Crush Sendromu, Deprem, Travmatik Rabdomiyaliz

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Introduction

On February 6, 2023, at 04:17 and 13:24 in Turkiye time, two major earthquakes with epicentres in Pazarcık (Kahramanmaraş) and Elbistan (Kahramanmaraş), with magnitudes of 7.7 and 7.6, respectively, affected 11 provinces (Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, Şanlıurfa).

Earthquakes have caused great destruction in settlements for centuries. It is a natural disaster that affects public health to a great extent and in a multi-layered way due to both the deaths and injuries it causes. Crush syndrome, which occurs due to traumatic muscle damage that is vital after an earthquake, is an issue that should be emphasised sensitively.

Crush syndrome was first reported by Seigo in 1923 with his study on three soldiers who lost their lives during World War I. In 1941, it was defined in a study conducted by Bywaters on those who died after the aerial bombardment of London by the Germans.[1]

Crush syndrome is a systemic disease characterized by the release of cellular contents (uric acid, phosphate, potassium, etc.) into the bloodstream due to muscle damage resulting from the crushing of muscle-rich body regions. It can lead to acute kidney injury and multiple organ dysfunction.[2]

The aim of this study was to determine the clinical course of patients with crush syndrome who were hospitalised in our hospital after the earthquakes centred in Pazarcık (Kahramanmaraş) and Elbistan (Kahramanmaraş) and to determine the factors that may be related to crush syndrome.

Materials and Methods

All patients aged 18 years and above who were admitted to our hospital between February 6 and February 14, from the earthquake zone and hospitalised with the diagnosis of crush syndrome were included in the study. The age, gender, city where the earthquake occurred, duration of stay in the rubble, amount of parenteral fluid given in the first 24 hours after extraction from the rubble, amount of urine in the first 24 hours, trauma sites, surgical interventions if performed, and length of hospital stay of the patients who were hospitalized due to crush syndrome, laboratory parameters (blood urea nitrogen (BUN), creatinine, albumin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatine kinase (CK), lactate dehydrogenase (LDH), potassium, phosphorus, sodium, calcium, C-reactive protein (CRP), white blood cell (WBC), hemoglobin, platelets) during admission and follow-up were recorded.

Clinical course, the requirement for dialysis, and any interventions such as fasciotomy, if any, were recorded from the patient files. The creatine kinase (CK) levels of all patients were divided into 5 groups (170-500; 500-1000; 1000-5000; 5000-10000; >10000), and factors associated with CK levels exceeding 5000 were investigated. Patients were also grouped according to the length of hospital stay (1-7 days, 8-14, 14-21 and >21 days) and factors that may be associated with prolonged hospitalization were determined.

The data obtained from our statistical method study is loaded into the SPSS 22.0 program and in the evaluation of the data, when the parametric test assumptions are fulfilled (Shapiro-Wilk), when comparing the measurements obtained from the same individuals at different times, variance analysis in repeated measurements, the least significant difference method to find the measurement groups that make a difference as a result of the analysis, Pearson-Spearman correlation coefficient was found to determine the relationship between the variables, and the Chi Square test was applied to evaluate the data obtaied by counting. Our data were stated in the tables as arithmetic mean, standard deviation, number of individuals and percentage, and the error level was accepted as 0.05.

Results

A total of 319 patients, including 174 female, were admitted to the hospital between February 6 and February 14 2023. While 13 of the 319 patients refused treatment and left the emergency department, 218 patients were treated as outpatients and discharged with recovery, 1 patient died right after he came to the emergency department and the remaining 87 patients were hospitalized and treated. It was found that 43 of 87 those patients had a diagnosis of crush syndrome.

Of the 43 patients diagnosed with crush syndrome, 19 were female. Clinical characteristics and laboratory parameters of patients with crush syndrome are shown in Table 1 and Table 2. The majority of the patients (72.1%) were from Kahramanmaraş province. 88.4% of the patients were followed up in the clinics. Fasciotomy and amputation were performed on 16.3% and 9.3% of the patients, respectively, and no surgical intervention was required in 53.5% of the patients. When the trauma sites of the patients were classified as head, chest, lower extremity, upper extremity and abdomen, 55.8% had 1 site injury, 23.3% had 2 site injuries and 20.9% had 3 site injuries. It was found that 39.5% of the patients stayed in the rubble for 2-6 hours. When admission CK levels were analysed, 27.9% of the patients had CK levels above 10.000 U/L. In 46.5% of the patients, CK reached the reference range in less than 7 days. The total amount of fluid (oral and intravenous) given to the patients in the first 24 hours was between 5000-10.000 ml in 34,9% of the patients. The amount of urine excreted in the first 24 hours was between 500-3500 ml in 55.8% of the patients and less than 500 ml in 16.3%. Hemodialysis treatment was applied to 14% of the patients.

Table 1. Clinical Characteristics and Laboratory Parameters of Patients with Crush Syndrome

		n	%
Gender	Male	24	55.8
	Female	19	44.2
Province	Adıyaman	3	7.0
	Gaziantep	1	2.3
	Hatay	3	7.0
	Kahramanmaraş	31	72.1
	Malatya	5	11.6
Place of hospitalization	Clinic	38	88.4
	Intensive Care Unit	5	11.6
Surgical intervention	None	23	53.5
	Amputation	4	9.3
	Fasciotomy	7	16.3
	Fracture operation	4	9.3
	Tube Thoracostomy	3	7.0
	Other	2	4.7
Number of trauma sites	1	24	55.8
	2	10	23.3
	3	9	20.9
CK level on admission (U/L)	170-500	4	9.3
	500-1000	10	23.3
	1000-5000	9	20.9
	5000-10000	8	18.6
	+10000	12	27.9
Time to reach CK Reference Range (days)	1-7	20	46.5
	8-14	7	16.3
	15-21	8	18.6
The first 24 hours of fluid taken (ml)	0-2500	12	27.9
	2500-5000	12	27.9
	5000-10000	15	34.9
	>10000	4	9.3
The first 24 hours of urine excreted (ml)	0-500	7	16.3
	500-3500	24	55.8
	3500-10000	12	27.9
Hemodialysis	Performed	6	14.0
	Not performed	37	86.0
Duration of stay in the rubble (hours)	0-1	8	18.6
	2-6	17	39.5
	7-24	10	23.3
	+24	8	18.6
Duration of hospitalization (days)	1-7	11	25.6
	8-14	6	14.0
	15-21	2	4.7
	>21	22	51.2

The minimum, maximum, mean and standard deviation values of the patients' age, duration of stay in the rubble, the amount of fluid taken in the first 24 hours, the amount of urine excreted in the first 24 hours, the time to reach the CK reference range, the duration of hospitalization, and the admission laboratory parameters are given in detail in Table 2

Table 2. Clinical and Laboratory Parameters on Admission and Their Quantitative Results

	n	Min	Max	Mean	SD	Reference Values
Age	43	18	97	39.09	19.66	
Duration of stay in the rubble (hours)	40	0	120	22.74	36.32	
The first 24 hours of fluid taken (ml)	43	750	10600	4954.18	3142.61	
The first 24 hours of urine excreted (ml)	43	0	9600	2646.62	2262.65	
Time to reach CK Reference Range (days)	35	1	21	8.71	5.98	
Duration of hospitalization (days)	19	1	20	7.26	5.42	
BUN (mg/dl)	43	3.90	109.90	27.56	23.36	6-20
Creatinine (mg/dl)	43	0.29	11.01	1.59	2.25	0.7-1.2
Albumin (mg/dl)	7	23.20	35.70	28.37	4.89	35-52
ALT (u/l)	43	14	673	120.51	140.12	0-41
AST (u/l)	43	21	1661	221.09	322.38	0-40
CK (u/l)	43	274	90000	11716.37	18520.60	0-190
LDH (u/l)	40	209	4159	673.75	696.80	135-225
Potassium (mmol/l)	43	2.95	6.50	4.33	0.78	3.5-5.1
Phosphorus (mg/dl)	38	1.42	7.93	3.72	1.85	2.5-4.5
Magnessium (mg/dl)	5	1.68	2.18	1.97	0.20	1.6-2.6
Sodium (mmol/l)	43	127	149	138.76	4.67	136-145
Calcium (mg/dl)	43	6.19	10.17	8.28	0.96	8.6-10.2
CRP (mg/l)	32	0.63	349.94	96.33	91.01	0-5
WBC (10^9/L)	43	5.89	69.25	13.48	9.94	4-10.5
Hemoglobin (g/dl)	43	7.30	18.10	11.55	2.17	13.5-18
Platelets (10^9/L)	43	94	366	215.97	60.75	150-450

Table 3. Comparison of Duration of Hospitalization (days) with Other Parameters

		1-7 days n(%)	8-14 days n(%)	15-21 days n(%)	>21 days n(%)	p
Province	Adıyaman	3(100)	0(0)	0(0)	0(0)	
	Gaziantep	0(0)	0(0)	0(0)	1(100)	
	Hatay	2(66.7)	1(33.3)	0(0)	0(0)	0.020*
	Kahramanmaraş	4(13.8)	5(17.2)	1(3.4)	19(65.5)	
	Malatya	2(40)	0(0)	1(20)	2(40)	
CK on admission (U/L)	170-500	4(100)	0(0)	0(0)	0(0)	
	500-1000	2(25)	2(25)	0(0)	4(50)	
	1000-5000	2(22.2)	3(33.3)	1(11.1)	3(33.3)	<0.01*
	5000-10000	3(37.5)	1(12.5)	0(0)	4(50)	
	+10000	0(0)	0(0)	1(8.3)	11(91.7)	
Number of trauma sites	1	10(41.7)	2(8.3)	0(0)	12(50)	
	2	0(0)	1(10)	1(10)	8(80)	<0.01*
	3	1(14.3)	3(42.9)	1(14.3)	2(28.6)	
Surgical intervention	None	8(34.8)	5(21.7)	1(4.3)	9(39.1)	
	Amputation	0(0)	1(25)	0(0)	3(75)	
	Fasciotomy	0(0)	0(0)	0(0)	7(100)	
	Fractur operation	1(25)	0(0)	1(25)	2(50)	0.104
	Tube Thoracostomy	0(0)	0(0)	0(0)	1(100)	
	Other	2(100)	0(0)	0(0)	0(0)	
Duration of stay in the rubble (hours)	0-1	4(50)	0(0)	1(12.5)	3(37.5)	
	2-6	6(40)	1(6.7)	0(0)	8(53.3)	0.082
	7-24	0(0)	3(30)	1(10)	6(60)	
	+24	1(12.5)	2(25)	0(0)	5(62.5)	
The first 24 hours of fluid taken (ml)	0-2500	3(25)	2(16.7)	0(0)	7(58.3)	
	2500-5000	3(25)	1(8.3)	1(8.3)	7(58.3)	0.382
	5000-10000	2(15.4)	2(15.4)	1(7.7)	8(61.5)	
	>10000	3(75)	1(25)	0(0)	0(0)	
The first 24 hours of urine excreted (ml)	0-500	0(0)	2(28.6)	0(0)	5(71.4)	
	500-3500	7(30.4)	3(13)	2(8.7)	11(47.8)	0.514
	3500-10000	4(36.4)	1(9.1)	0(0)	6(54.5)	
Time to reach CK Reference Range (days)	1-7	7(38.9)	3(16.7)	1(5.6)	7(38.9)	
	8-14	1(14.3)	1(14.3)	0(0)	5(71.4)	0.139
	15-21	0(0)	0(0)	1(12.5)	7(87.5)	

Regarding the duration of hospitalization, 25.6% of the patients were hospitalized between 1-7 days, 14% between 8-14 days, 4.7% between 15-21 days, while the majority (51.2%) were hospitalized for more than 21 days and 2 patients were exited during this period. While 19 of 29 patients from Kahramanmaraş province were hospitalized for more than 21 days, all 3 patients from Adıyaman province and 2 of 3 patients from Hatay province were hospitalized for less than 7 days. Of the 12 patients with a CK level of 10,000 U/L and above measured at the time of admission, 11 had a hospitalization period of more than 21 days, while all 4 patients with a CK level between 170-500 U/L had a hospitalization period of less than 7 days. Half of 24 patients with one trauma site were hospitalized for more than 21 days and 10 for less than 7 days; 8 of 10 patients with 2 trauma sites were hospitalized for more than 21 days; 2 of 7 patients with 3 trauma sites were hospitalized for more than 21 days and 3 for 8-14 days. All 7 patients who underwent fasciotomy and 3 of 4 patients who underwent amputation were hospitalized for more than 21 days and there was no significant difference between surgical intervention and length of hospitalization. There was no significant difference between the amount of fluid (oral and intravenous) taken in the first 24 hours and the amount of urine excreted in the first 24 hours and the length of hospitalization. There was no significant difference between the time required for the CK level to decrease to the normal reference range and the duration of hospitalization. Detailed analysis is shown in Table 3.

Patients were divided into two groups according to the CK levels at the time of admission. 23 patients had CK levels <5000 U/L and the remaining 20 patients had CK levels >5000 U/L at admission (Table 4). There was no significant difference between the CK levels of the patients on admission and the province of origin (p=0.473), number of trauma sites (p=0.708), place of hospitalization (p=0.755), length of stay in the rubble (p=0.159), first 24 hours of fluid intake (p=0.7), and first 24 hours of urine volume (p=0.56). When compared with surgical intervention, CK levels were below 5000 U/L in 16 of 23 patients who had no surgery, above 5000 U/L in 3 of 4 patients who underwent amputation, and above 5000 U/L in all 7 patients who underwent fasciotomy and was statistically significant (p<0.01*). 17 of 20 patients with a CK reference range of less than 7 days had a CK level below 5000 U/L, 5 of 7 patients with a range of 8-14 days had a CK level above 5000 U/L, and all 8 patients with a range of 15-21 days had a CK level above 5000 U/L, which was statistically significant (p<0.01*). All 6 patients who underwent hemodialysis had admission CK levels above 5000 U/L and 27 of 37 patients who did not have hemodialysis had admission CK levels below 5000 U/L, which were statistically significant (p<0.01*).

Table 4. Comparison of CK Levels at Hospital Admission with Other Parameters

		<5000 U/L	>5000 U/L	p
		n(%)	n(%)	
Province	Adıyaman	3(100)	0(0)	
	Gaziantep	0(0)	1(100)	
	Hatay	2(66.7)	1(33.3)	0.473
	Kahramanmaraş	15(48.4)	16(51.6)	
	Malatya	3(60)	2(40)	
Number of trauma sites	1	12(50)	12(50)	
	2	5(50)	5(50)	0.708
	3	6(66.7)	3(33.3)	
Place of hospitalization	Clinic	20(52.6)	18(47.4)	0.755
	Intensive Care Unit	3(60)	2(40)	
Surgical intervention	None	16(69.6)	7(30.4)	
	Amputation	1(25)	3(75)	
	Fasciotom	0(0)	7(100)	<0.01*
	Fractur operation	2(50)	2(50)	
	Tube Thoracostomy	3(100)	0(0)	
	Other	1(50)	1(50)	
Duration of stay in the rubble (hours)	0-1	7(87.5)	1(12.5)	
	2-6	9(52.9)	8(47.1)	0.159
	7-24	4(40)	6(60)	
	>24	3(37.5)	5(62.5)	
The first 24 hours of fluid taken (ml)	0-2500	5(41.7)	7(58.3)	
	2500-5000	8(66.7)	4(33.3)	0.70
	5000-10000	8(53.3)	7(46.7)	
	>10000	2(50)	2(50)	
The first 24 hours of urine excreted (ml)	0-500	1(14.3)	6(85.7)	
	500-3500	16(66.7)	8(33.3)	0.56
	3500-10000	6(50)	6(50)	
Time to reach CK Reference Range (days)	1-7	17(85)	3(15)	
	8-14	2(28.6)	5(71.4)	<0.01*
	15-21	0(0)	8(100)	
Hemodialysis	Performed	0(0)	6(100)	<0.01*
	Not performed	23(62.2)	14(37.8	

In the analysis of 21-day laboratory data, when CK level was compared with surgical intervention, it was found that 75% of the patients who did not undergo surgery and all of the patients who underwent tube thoracostomy reached the reference range in 1-7 days, 66.7% of the patients who underwent fasciotomy and all of the patients who underwent amputation reached the reference range in 15-21 days and a statistically significant difference was found (p<0.01*).

No significant difference was found between the time to reach the CK reference range and the number of trauma sites (p=0.904), place of hospitalization (p=0.801), province of origin (p=0.472), gender (p=0.082), length of stay in the rubble (p=0.144), hemodialysis treatment (p=0.076), fluid intake in the first 24 hours (p=0.758), and urine output in the first 24 hours (p=0.150).

When urine output was compared with the amount of fluid taken in the first 24 hours, 33% of patients who received less than 2500 ml of fluid had urine output below 500 ml, 15.8% of patients who received more than 5000 ml of fluid had urine output below 500 ml, 47.4% of patients who received more than 5000 ml of fluid had urine output above 3500 ml and a statistically significant difference was found (p<0.01*).

There was no statistically significant difference in urine output in the first 24 hours between patients admitted to the intensive care unit and patients admitted to the clinic (p=0.825). We did not find any statistically significant difference between urine output in the first 24 hours and length of stay in the rubble (p=0.502).

There was no statistically significant difference between the duration of stay in the rubble and the province of origin of the patients (p=0,195).

Of 38 patients admitted to the clinic, 60.5% had single site injuries and 60% of 5 patients admitted to the intensive care unit had 3 site injuries and a statistically significant difference was found (p=0.045*) There was no statistically significant difference between the number of trauma sites and the length of stay in the rubble (p=0.798)

Hemodialysis treatment was given to 5 of 7 patients with urine output below 500 ml and one of 24 patients with urine output between 500 ml and 3500 ml in the first 24 hours, and hemodialysis treatment was not given to any of the 12 patients with urine output above 3500 ml, and a statistically significant difference was found (p<0.01*).

Surgical intervention was not performed in 57.9% of the patients admitted to the clinic and 20% of the patients admitted to the intensive care unit and a statistically significant difference was found (p=0.22*).

4.2% of patients with single site injuries, 10% of patients with 2 site injuries, 33.3% of patients with 3 site injuries were hospitalized in intensive care unit and a statistically significant difference was found (p=0.042*).

There was no statistically significant difference between surgical intervention and number of trauma sites (p=0.55).

The duration of hospital stay and sodium level (r=-.640; p=0-.03), hemoglobin level (r=-.466; p=.044), and

time to reach CK reference range (r=.653; p= ,011) was found to be correlated. A correlation was found between the duration of stay in the rubble and ALT (r=.423; p=.007), AST (r=.473; p=.002), CK (r=.468; p=.002), phosphorus (r=-.464 ; p=.005), calcium (r=-.532; p<0.001), WBC (r=.407; p=.007), first 24 hours urine amount (r=-.392; p=.009) time to reach the CK reference range (r=.394; p=.019) and those who underwent fasciotomy (r=.343 p=.03).

BUN (r=.394; p=.019) ALT (r=.683; p<.001), AST (r=.835; p<.001), CK (r=.847) with time to reach CK reference range ; p<.01), LDH (r=.719; <.001), potassium (r=-.386; p=.022), sodium (r=-.353; p=0-.038), calcium (r=-.674; p<0.001) and WBC (r=.334; p=.05) were correlated. The amount of urine excreted in the first 24 hours and BUN (r=-.392; p=.009), creatine (r=-.445; p=.003), ALT (r=-.372; p=.014), CK (r=-.308; p=.044) levels were found to be correlated. Hemodialysis patients and BUN (r=.685; p<.01), ALT (r=.594; p<.01), AST(r=.549; p<.01), CK (r=.657; p<.01), creatine (r=.71; p<.01), LDH (r=597; p<.01), phosphorus (r=807; p<.01), sodium (r=-.445 ; p=0.03), WBC (r=.407; p=.007), amount of urine output in the first 24 hours (r=-.467; p<.01), time to reach CK reference range (r=.358 ; p=.044) were also correlated.

Discussion

Earthquakes can cause mass mortality and morbidity. Turkey is located on the Mediterranean Alp-Himalayan seismic belt, which is one of the most active seismic belts in the world.[3] Therefore, many earthquakes have occurred in our country from past to present, which have caused many deaths and injuries. In our study, it was aimed to understand whether there is a relationship between crush syndrome, which is one of the most important problems after the earthquake, and certain parameters and to contribute to the medical literature.

In the two earthquakes that occurred on the same day, both centered in Kahramanmaraş, harsh climatic conditions and transportation problems made search and rescue activities challenging. The duration of patients' stay in the rubble was higher in our study (22.7+-36.3 hours) than in Marmara (11.7 ± 14.3 hours), Kobe (9 ± 13 hours) and Erzincan (9 ± 5 hours).[4,5] Michaelson suggested that the pressure applied to the muscles must last longer than four hours for crush syndrome to develop, it is also known that crush syndrome also develop in patients who were immediately rescued from the rubble.[6]

One of the expected risk factors for crush syndrome is the duration of stay under rubble. In our study, higher ALT, AST, CK, phosphorus, WBC levels and lower calcium levels were found in patients with longer duration of stay under rubble. Sagheb et al. found that the requirement for hemodialysis increased as the duration of stay under rubble increased in their study conducted after the Bam earthquake, and Sever et al. found that those who stayed under rubble for a shorter time the requirement of hemodialysis increased compared to those who stayed under rubble for a longer time in their study conducted after the Marmara earthquake.[5,7] In our study, no

significant difference was found between hemodialysis and duration of stay under rubble.

The mean CK level was 11.716±18.520 (274-90000) U/L. The mean CK level at admission was lower than the Marmara earthquake (58.205 U/L) and Kobe earthquake (66.504 U/L) and higher than the Wenchuan earthquake (5260 U/L) and Iran earthquake (2975 U/L).[8–11]

CK levels above 5000 U/L were found in all 7 patients who underwent fasciotomy, suggesting that it is related to the severity of muscle destruction. A direct correlation between the severity of muscle destruction and CK level is an expected finding.[12]

In our study, as in the study of Sever et al. after the Marmara earthquake, a positive correlation was found between the time under rubble and fasciotomy.[13] Our study supports the hypothesis of Sever et al. that patients with extremity trauma (compared to those with thorax, abdomen and head trauma) may survive longer under rubble, but since their injuries were not treated in the early period, they are at a higher risk of experiencing a more severe compartment syndrome and requiring fasciotomy and amputation.[13]

Duman et al. thought that early fasciotomy would have favorable results on mortality and morbidity.[14] Bulut et al., on the other hand, found deep surgical site infections in 33% of patients who underwent fasciotomy and believed that to broad the indication for fasciotomy increases the mortality.[15]

20 (46.5%) of 43 patients underwent surgical intervention and fasciotomy was performed in 7 (16.5%). This rate was found to be very low compared to the study by Sever et al. which reported that 50.5% of patients underwent fasciotomy in 639 patients and similar to the study by Oda et al. which reported that 13.1% of patients underwent fasciotomy in 372 patients.[16,17]

As in many studies, Michaelson recommends the initiation of fluid replacement under rubble to prevent acute kidney injury and crush syndrome.[6] Early and extensive fluid replacement was also shown to be effective in the Roodbar, Marmara and Kobe earthquake studies.[11,16,18] Patients receiving appropriate fluid therapy had less prolonged acute kidney injury and less requirement for hemodialysis.[7]

There was no significant difference between the amount of fluid given in the first 24 hours, the duration of hospitalization, time to reach the CK reference range and hemodialysis treatment. This was attributed to fluid replacement before hospitalization. Our center was far from the earthquake zone and it took a long time to transfer the patients. We think that fluid replacement during this period, that is, during the time the patients were under rubble and during their transfer to our center, was adequate. We believe that after adequate hydration is performed under the rubble and immediately afterwards and the patient is rendered normovolemic, it is not beneficial to give high amounts of fluid in the follow-up.

In our study, a statistically significant difference was found between the amount of fluid taken in the first 24 hours and urine output. This difference is thought to be a result of more controlled fluid administration in patients with low urine output in the first 24 hours.

Similar to the study of Sever et al., urine volume was lower and BUN, creatinine, phosphorus, LDH, potassium, CK levels were higher in patients on hemodialysis.[13] Unlike the study of Sever et al., the correlation between platelets, albumin, WBC and hemodialysis was not found in our study.[13]

In the Marmara earthquake and Taiwan earthquake it was suggested that there was a correlation between high CK levels at admission and hemodialysis and that it determined the need for hemodialysis.[8,19] The finding of CK levels above 5000 U/L in total of 6 patients (100%) who underwent hemodialysis supports this study.

As in the study by Zhang et al., lower serum sodium levels were found in patients on hemodialysis.[20] It is thought that sodium levels on admission may be used to predict the prognosis of crush syndrome.

Although hyponatremia has many causes, hypotonic hyponatremia is the most common type and is caused by non-osmotic secretion of vasopressin. Especially severe pain and fear experienced by patients trapped under rubble stimulate the secretion of vasopressin. Disruption of the functional integrity of the muscles and fluid losses into the interstitial space cause a decline in intravascular volume and consequently stimulate the secretion of vasopressin.[2,20] Westermann et al. reported that vasopressin was significantly elevated in patients with multiple injuries.[21]

The duration of hospitalization and the time to reach the CK reference range were found to be longer in patients with lower sodium levels on admission. Similar to the study of Zhang et al., low sodium levels are thought to be associated with poor prognosis.[20] In our study, more than half of the patients were hospitalized for more than 21 days. No study was found in the literature regarding the duration of hospitalization in crush syndrome. Patients with lower sodium and hemoglobin levels on admission had longer hospitalization. Anemia and hyponatremia are thought to be effective on the prognosis of the disease.

Decline of CK to the reference range is a signal that rhabdomyolysis is not persisting. There was no significant difference between patients who underwent hemodialysis and those who did not. The association of fasciotomy with the time to reach the reference range of CK is thought to be a result of more severe muscle damage in patients who underwent fasciotomy. There was a positive correlation with BUN, ALT, AST, CK, LDH, WBC, potassium and a negative correlation with sodium and calcium at admission. The correlation between the time to reach the CK reference range and the duration of hospitalization suggests that evaluation of these parameters during hospitalization may shorten the hospitalization period of patients and prevent complications that may be encountered due to prolonged hospitalization.

Our institution was distant from the earthquake zone and therefore the transfer of the patients required a long time. We believe that the fluid replacement therapy started under the

collapse was successfully continued during the transfer. A great deal of progress had already been recorded in this sense until the patients arrived at our center. After the earthquakes, many patients had been transferred to different provinces, especially closer to the earthquake region. The limitations of our study include the inability to work with a larger number of patients due to the low number of patients presenting to our center and the limited assessment of the registration and effectiveness of patients' initial fluid resuscitation treatments during the debris and transfer phases.

Conclusion

Our study revealed that patients with high CK levels required more surgical intervention and hemodialysis. In addition, hospital stay was prolonged in these patients. In crush syndrome, which is always a potential health problem for our country, which is located in the earthquake zone, the time and practices from the rapid detection of patients and safe vascular line placement under the collapse in coordination with search and rescue teams to transfer and close follow-up and treatment in the hospital are of crucial importance.

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