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Electrocardiographic changes of patients who were under the rubble and were admitted to the hospital during Kahramanmaraş Earthquake

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ABSTRACT

Aims: In this study, we aimed to determine the electrocardiographic findings in earthquake victims who were admitted to our hospital after the Kahramanmaraş earthquake.

Methods: We included all patients who applied to Diyarbakır Gazi Yaşargil Training and Research Hospital as earthquake victims in the study. The total number of injured patients removed from the rubble after the earthquake and admitted to our hospital was 321. A total of 139 patients were admitted to our hospital for examination and treatment. Fourty of them have a electrocardiograhphy. Clinical characteristics of the patients were compared according to the presence of crush syndrome. Patients who received further treatment in the intensive care unit (ICU) were compared with patients who did not require intensive care in terms of clinical characteristics. Electrocardiograpghy (ECG) findings were presented in all groups.

Results: Crush syndrome developed in 45% of patients, while 25% developed acute renal failure. As expected, compartment syndrome was more common in patients with crush syndrome (66.7% vs 18.2%, p=0.002). The proportion of patients requiring dialysis treatment was 12.5% (n=5). The proportion of patients who received further treatment in the intensive care unit was 35% (n=14). In terms of ECG characteristics, heart rate was higher in ICU-treated patients (105/min vs 86/min, p<0.001), PR interval was longer in ICU-treated patients (0.2 s vs 0.14 s), QRS complex was shorter in ICU-treated patients (0.05 mm vs 0.077 mm, p=0.021). QT interval was shorter in patients who admitted to intensive care unit (0.33 vs 0.35, p=0.021). In patients with crush syndrome, PR interval was longer (0.17 vs 0.16, p=0.006), QRS width was shorter (0.06 vs 0.072, p=0.021). In addition, the T-amplitude in the ECG was found to be higher in those who developed acute kidney injury compared to those who did not (0.20 vs. 0.10, p=0.018). Again, the T-amplitude was higher in those who required dialysis treatment (0.20 vs. 0.10, p=0.009).

Conclusion: In this study, we demonstrated some possible ECG changes such as PR prolongation and narrow QRS in earthquake victims admitted to our hospital. ECG can be used as a simple but predictive tool to monitor cardiovascular outcomes in earthquake victims.

Keywords: Crush syndrome, electrocardiography, electrocardiographic findings

INTRODUCTION

On February 6, 2023, two earthquakes of magnitude 7.8 Mw (±0.1) and 7.5 Mw occurred at 04:17 and 13:24, nine hours apart, with the epicenter in the Pazarcık and Ekinözü districts of Kahramanmaraş. Many houses were destroyed after the earthquake, so according to official figures, 50,785 people lost their lives and 108,000 citizens were rescued from the rubble with injuries.[1] The people who were trapped under the rubble after the earthquake and survived had to deal with severe organ injuries, bleeding, bruising, crush syndrome and multiple organ failure related to crushing. Those who lived in the area where the earthquake occurred and who were rescued from the rubble, as well as their relatives, faced a huge housing problem and there was a large exodus. The housing and other stressful situations caused by the earthquake and after the earthquake affected people's biopsychosocial situation and caused disturbances.

After the earthquake, an earthquake relief committee was set up for the injured who were rescued from the rubble and taken to the Diyarbakır Gazi Yaşargil Training and Research Hospital. This committee included specialists in cardiology, nephrology, internal medicine, emergency medicine, orthopedics, general surgery, anesthesia and intensive care. Numerous metabolic parameters of the earthquake victims who were admitted to our hospital were examined. The treatment process for the injured hospital patients was based on these metabolic values. ECG monitoring was carried out to monitor the patients who were dehydrated under the rubble,

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transferred to our hospital and admitted as inpatients. An attempt was made to determine the presence of cardiac effects based on the developing parameters in the ECG. We also wanted to investigate the relationship between the changes in the ECG of the patients and the consequences of muscle contusion in the patients, the length of hospitalization of the patients, the need for admission to the intensive care unit, the length of stay of the patients, the results of contusion syndrome, the number of amputations, the duration of infection treatment and mortality.

Victims trapped under rubble during earthquakes are forced to remain in narrow piles of rubble in an oxygen-free environment for a long time. People trapped under the rubble suffer muscle contusions in various parts of the body. As a result of muscle contusions, there may be excessive calcium release from the muscle cell, intense release of oxygen radicals, lipid peroxidation and increased interaction between PMN and endothelium, which can affect and even injure the heart. In addition, the destruction of muscle cells leads to an increase in potassium levels (K+). Hypovolemia occurs because earthquake victims who lie under the rubble for a long time remain hypoxic under the rubble and do not consume food or drink for a long time. The physiopathological condition that results from all these reasons can also lead to problems in the heart muscle. The simplest medical method that can show us doctors the possible pathologies that can develop in the heart muscle is the ECG. The potassium, calcium, hypoxia and hypovolemia environments mentioned above alert us by causing changes in the P wave, QRS wave and T wave on the ECG.[2]

The earthquake itself and the long stay under rubble can also cause changes in the autonomic nervous system of people. The people trapped under the rubble are under severe stress. This affects the heart rate and heart rhythm in different ways via the autonomic nervous system. The autonomic nervous system affects the heart: Due to the different autonomic innervations in people trapped under rubble, stimulation of the sympathetic and parasympathetic nervous systems can have different effects. Stress increases sympathetic tone and subsequently decreases parasympathetic activity, which can trigger supraventricular arrhythmias and also lead to the development of life-threatening ventricular arrhythmias. The increase in certain electrolytes in the blood due to muscle breakdown and asymmetric innervation caused by stress in the autonomic nervous system affects the heart muscle and causes cardiac arrhythmias. Most sudden deaths that occur during and after the earthquake are attributed by clinicians to renal causes. However, there may also be deaths due to sudden cardiac arrhythmias caused by the above-mentioned causes. The ECG may be the easiest method to determine if the heart muscle is affected in patients hospitalized after the earthquake and what negative consequences increased electrolytes may have on the heart.[2-4]

In this study, we aimed to determine the ECG findings in earthquake victims who were admitted to our hospital after the Kahramanmaraş earthquake.

METHODS

The study was carried out with the permission of Gazi Yaşargil Training and Research Hospital Clinical Researches Ethics Committee (Date: 04.08.2023, Decision No: 499). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In the first hours of the earthquake, only patients transferred from Diyarbakır province and its districts were accepted to our hospital. However, in the later hours of the earthquake, the injured people rescued from the rubble in the provinces of Kahramanmaraş, Adıyaman, Hatay, Şanlıurfa, and Gaziantep began to be referred to our hospital, and follow-up and treatment processes were initiated by the earthquake response committee.

We included all patients who applied to Diyarbakır Gazi Yaşargil Training and Research Hospital as earthquake victims in the study. We recorded patients' age, gender, time spent under the rubble, duration of hospitalization, needing for intensive care unit, duration of intensive care unit, laboratory parameters at the time of admission, clinical course. Laboratory parameters (ure, creatinin, potassium, creatinin phosphokinase (CPK), total calcium, phosphate, uric acid, white blood cell (WBC), hemoglobin, neutrophil, lymphocyte, platellet, C-reactive protein (CRP), albumin, pH and bicarbonate), ECG, 24-hour urine volumes, type of trauma (extremity, head, thorax, abdominal, spinal), penetrating injury, need for fasciotomy, need for amputation, presence of compartment syndrome, presence of crush syndrome, presence of acute kidney injury (AKI) and deceased patients were recorded. The total number of injured patients removed from the rubble after the earthquake and admitted to our hospital was 321. 182 of 321 patients were discharged from the emergency department after completing their treatment. A total of 139 patients were admitted to our hospital. Since the ECG recordings of 40 hospitalized patients were available, this number of patients was included in the study. ECG recordings were performed at a speed of 25 mm/s and an amplitude of 10 mm/mV using a Schiller AT 102 G2 12-lead/12-channel ECG machine. All ECGs were scanned at a resolution of 300 DPI and transferred to an electronic storage medium. The images were evaluated using the program "Adobe Photoshop CS2 Version 9.0" with a resolution of 1500 DPI and an accuracy of four milliseconds. Standard measurements such as heart rate (HR), P-wave duration, P-amplitude, PR interval, QRS complex, T-wave duration, T-amplitude, QT interval and QTc interval were performed for all ECGs and the ratios of Tp-e/QT and Tp-e/QTc were measured electrocardiographically. The duration of the P wave was assessed as the duration between the initial deflection and its return junction to the isoelectric baseline. QT interval was calculated as the duration between the onset of the QRS complex and the end of T wave in the isoelectric baseline. QTc was measured using Bazett's formula ($QTc=QT/\sqrt{RR}$). Tp-e interval was evaluated as the duration between the peak and the end of the T wave on isoelectric baseline. PR prolongation is defined as prolongation of the PR interval on an electrocardiogram (ECG) to more than 200 msec. An ST elevation is considered significant if the vertical distance inside the ECG trace and the baseline at a point 0.04 seconds after the J-point is at least 0.1 mV (usually equivalent to 1 mm or 1 small square) in a limb lead or 0.2 mV (2 mm or 2 small squares) in a precordial lead. T-wave inversion is defined as a negative T-wave ≥1 mm deep in two or more adjacent leads, with the exception of leads aVR, III and V1. The patients were divided into groups, e.g. those who developed crush syndrome and those who required intensive care and those who did not, and were compared in terms of their clinical characteristics.

Statistical Analysis

Variables with normal distribution are presented as mean±standard deviation, and variables without normal distribution are presented as median (minimum-maximum). The p value obtained by comparing normally distributed numerical variables with the independent sample t test and the p value obtained by comparing non-normally distributed numerical variables with the Mann-Whitney U test are given. The chi-square test result p is given by giving the percentage rates of categorical variables and taking into account the expected value. The statistical significance level was accepted as p<0.05.

RESULTS

The demographic, clinical and ECG characteristics of the patients are shown in Table 1. The mean and median ages were 29.4 and 27 years, respectively. It was found that 60% of the patients (n=24) were female. The majority of patients (n=34, 85%) were adults. Regarding the type of trauma, extremity trauma was the most common type of trauma (77.5%, n=31 patients). The mean and median hours timing under the rubble were 17.6 hours and 7 hours, respectively. Crush syndrome developed in 45% of patients, while 25% developed acute renal failure. As expected, compartment syndrome was more common in patients with crush syndrome (66.7% vs 18.2%, p=0.002). The proportion of patients requiring dialysis treatment was 12.5% (n=5). The proportion of patients who received further treatment in the intensive care unit was 35% (n=14).

The clinical characteristics of the patients in terms of Crush syndrome are shown in Table 2. As expected, oligo-anuria was higher in patients with crush syndrome (5 vs 0, p=0.013). Regarding the type of trauma, although extremity trauma was found to be more common in patients with crush syndrome (88.9% vs 68.2%, p=0.118), no statistical significance was found. AKI developed in half of patients with crush syndrome (9 vs. 1, p=0.001), and dialysis treatment was required in 27.8% (5 vs. 0, p=0.013) of patients with crush syndrome. Urea levels were higher in patients with crush syndrome (60 mg/dl vs. 40 mg/dl, p=0.001), while no difference was observed for creatinine. Potassium levels were higher in patients with crush syndrome (4.8 mmol/l vs. 4 mmol/l, p=0.006). Uric acid was higher in patients with crush syndrome (5 mg/dl vs. 3.5 mg/dl, p=0.034). CRP was higher in patients with crush syndrome (117 IU/L vs. 36 IU/L, p=0.004). Albumin levels were lower in patients with crush syndrome (21 g/L vs. 31.3 g/L, p<0.001). HCO3 was lower in patients with crush syndrome (19.8 mmol/L vs. 23 mmol/L, p=0.046). Regarding ECG findings, the PR interval was longer (0.17 mm vs. 0.16, p=0.006 and prolonged PR patients' rate 57.1% vs 23.1%, p=0.036), the QRS distance was shorter (0.06 vs. 0.072, p=0.021) and the T wave was shorter (0.142 vs. 0.18, p=0.030) in patients with crush syndrome.

Table 1. Clinical characteristics of patients	
Age, years	29.4+13.5 / 27 (8-66)
Gender, f/m (f%)	24/16 (60%)
Adult, y/n (yes%)	34/6 (85%)
Oligo-anuria, y/n (y%)	5/35 (12.5%)
Abdominal trauma, y/n (y%)	1/39 (2.5%)
Thoracic trauma, y/n (y%)	3/37 (7.5%)
Head trauma, y/n (y%)	3/37 (7.5%)
Extremity trauma, y/n (y%)	31/9 (77.5%)
Spinal trauma, y/n (y%)	3/37 (7.5%)
Penetrating trauma, y/n (y%)	12/28 (30%)
Crush syndrome, y/n (y%)	18/22 (45%)
Acute kidney injury, y/n (y%)	10 (25%)
Dialysis treatment, y/n (y%)	5/35 (12.5%)
Compartment syndrome, y/n (y%)	16/24 (40%)
Fasciotomy, y/n (y%)	10/30 (25%)
ICU admission, y/n (y%)	14/26 (35%)
Amputation, y/n (y%)	4/36 (10%)
Mortality, y/n (y%)	1/39 (2.5%)
Timing under the rubble, hours	17.6±37.7/7 (1-152)
Day of hospitalization	10.3±7.84/7 (2-34)
ICU, days	9.43±7.2/8 (2-28)
Ure, mg/dl	57±52/31 (15-200)
Creatinin, mg/dl	1.23±1.12/0.69 (0.48-4.68)
Potassium, mmol/L	4.4±5.2/4.2 (2.7-6.8)
CPK, U/L	36569±44602 / 21154 (165-190000)
Total calcium, mg/dl	8.1±1.1/8.2 (4.6-10)
Phosphate, mg/dl	3.5±1.5/3.2 (1.8-8.7)
Uric acid, mg/dl	4.3±2.24/3.6 (0.9-10.5)
WBC, $x10^3$/ml	15.7±6.9/14.1 (1.8-33.7)
Hemoglobin, mg/dl	14.1±3.24/13.9 (6.9-22.4)
Neutrophil, $x10^3$/ml	13±6.5/11.7 (1.5-3.1)
Lymphocyte, $x10^3$/ml	1.6±0.8/1.5 (0.2-4)
Platellet, $x10^3$/ml	260±94/247 (65-560)
CRP, IU/L	79±61 / 69 (2-224)
Albumin g/L	27.2±7.1/28 (11-38)
pH	7.37±0.09/7.38 (7.01-7.51)
$HC0_3$, mmol/L	21.7±4.7/22.8 (9-31)

a: Independent sample-t test, b: Pearson Chi-square test, c: Fisher's exact test, d: Mann Whitney-U test, ICU: Intensive care unit, CPK: Creatine phosphokinase, WBC: White blood cell, CRP: C-reactive protein

Table 2. According to crush syndrome patients' clinical characteristics

	Crush Syndrome		p
	No (n=22)	Yes (n=18)	
Age, years	27.5±9.4	31.8±17.3	0.344[a]
Gender, f/m (f%)	15/7 (68.2%)	9/9 (50%)	0.243[b]
Adult, y/n (yes%)	19/3 (86.4%)	15/3 (83.3)	0.565[c]
Timing under the rubble, hours	7 (1-144)	7 (5-152)	0.610[d]
Oligo-anuria, y/n (y%)	0/22 (0%)	5/13 (27.8%)	0.013[c]
Abdominal trauma, y/n (y%)	1/21 (4.5%)	0/18 (0%)	0.550[c]
Thoracic trauma, y/n (y%)	2/20 (1.7%)	1/17 (5.6%)	0.577[c]
Head trauma, y/n (y%)	2/20 (9.1%)	1/17 (5.6%)	0.577[c]
Extremity trauma, y/n (y%)	15/7 (68.2%)	16/20 (88.9%)	0.118[c]
Spinal trauma, y/n (y%)	3/19 (13.6%)	0/18 (0%)	0.156[c]
Penetrating trauma, y/n (y%)	7/15 (31.8%)	5/13 (27.8%)	0.781[b]
Acute kidney injury, y/n (y%)	1/21 (4.5%)	9/9 (50%)	0.001[b]
Dialysis treatment, y/n (y%)	0/22 (0%)	5/13 (27.8%)	0.013[c]
Compartment syndrome, y/n (y%)	4/18 (18.2%)	12/6 (66.7%)	0.002[b]
Fasciotomy, y/n (y%)	3/19 (13.6%)	7/11 (38.9%)	0.071[c]
Ure, mg/dL	28 (18-56)	60 (15-200)	0.001[d]
Creatinin, mg/dL	0.62 (0.48-1.18)	0.77 (0.5-4.63)	0.075[d]
Potassium, mmol/L	4±0.5	4.8±1.1	0.006[a]
CPK, U/L	4380 (165-84594)	41511 (1055-249203)	0.006[d]
Total calcium, mg/dl	8.8 (8-10)	7.5 (4.6-8.3)	<0.001[d]
Phosphate, mg/dl	3.1±0.5	4.1±2.1	0.060[a]
Uric acid, mg/dl	3.5±1.4	5±2.4	0.034[a]
WBC, $x10^3$/ml	14.8±5.4	16.7±8.4	0.391[a]
Hemoglobin, mg/dL	14±2.8	14.3±3.8	0.801[a]
Neutrophil, $x10^3$/ml	12.1±5.4	14.2±7.7	0.321[a]
Lymphocyte, $x10^3$/ml	1.8±0.9	1.4±0.6	0.108[a]
Platellet, $x10^3$/ml	279±97	236±87	0.155[a]
CRP, IU/L	36 (2-164)	117 (10-224)	0.004[d]
Albumin g/L	31.3 (26-38)	21 (11-33)	<0.001[d]
pH	7.39±0.05	7.34±0.13	0.072[a]
HC03, mmol/L	23±3.6	19.8±5.7	0.046[a]
ECG, pulse rate	90±15	96±19	0.201[a]
QT, ms	0.35±0.027	0.34±0.037	0.596[a]
QTc, ms	0.420±0.034	0.428±0.021	0.540[a]
P amplitute, mV	0.1 (0.06-0.94)	0.1 (0.06-0.15)	0.878[d]
P wave, ms	0.08 (0.06-0.12)	0.08 (0.06-0.12)	0.146[d]
PR, sn	0.16 (0.12-0.30)	0.17 (0.1-0.3)	0.006[d]
QRS, ms	0.072 (0.03-0.48)	0.06 (0.04-0.10)	0.021[d]
T amplitute, mV	0.2 (0.08-0.9)	0.12 (0.08-0.3)	0.266[d]
T wave, ms	0.18±0.04	0.142±0.05	0.030[a]
Tpe, ms	0.099±0.024	0.098±0.023	0.962[a]
Tpe/QT	0.28±0.07	0.28±0.06	0.836[a]
Tpe/QTc	0.24±0.06	0.23±0.06	0.988[a]
ST elevation, y/n (y%)	11/11 (50%)	7/11 (38.9%)	0.482[b]
T wave inversion, y/n (y%)	7/15 (31.88%)	4/14 (22.2%)	0.337[c]
PR prolongation, y/n (y%)	8/14 (36.4%)	6/12 (33.3%)	0.842[b]

a: Independent sample-t test b: Pearson Chi-square test c: Fisher's exact test d: Mann Whitney-U test, ICU: Intensive care unit CPK: Creatine Phosphokinase WBC: White blood cell CRP: C-reactive protein

The clinical characteristics of the patients with and without the need for intensive care unit are shown in Table 3.

Table 3. The clinical characteristics of the patients with and without the need for intensive care unit

	ICU admission		p
	No (n=26)	Yes (n=14)	
Age, years	29.9±12.3	28.4±15.9	0.737[a]
Gender, f/m (f%)	17/9 (65.4%)	7/7 (50%)	0.343[b]
Adult, y/n (yes%)	23/3 (88.5%)	11/3 (78.6)	0.346[c]
Timing under the rubble, hours	7 (1-152)	7 (6-144)	0.808[d]
Oligo-anuria, y/n (y%)	2/24 (7.7%)	3/11 (21.4%)	0.222[c]
Abdominal trauma, y/n (y%)	1/25 (3.8%)	0/14 (0%)	0.650[c]
Thoracic trauma, y/n (y%)	1/25 (3.8%)	2/12 (14.3%)	0.276[c]
Head trauma, y/n (y%)	2/24 (7.7%)	1/13 (7.1%)	0.724[c]
Extremity trauma, y/n (y%)	17/9 (65.4%)	14/0 (100%)	0.011[c]
Spinal trauma, y/n (y%)	2/24 (7.7%)	1/13 (7.1%)	0.724[c]
Penetrating trauma, y/n (y%)	9/17 (34.6%)	3/11 (21.4%)	0.311[c]
Crush syndrome, y/n (y%)	8/18 (30.8%)	10/4 (71.4%)	0.014[b]
Acute kidney injury, y/n (y%)	4/22 (15.4%)	6/8 (42.9%)	0.065[c]
Dialysis treatment, y/n (y%)	2/24 (7.7%)	3/11 (21.4%)	0.222[c]
Compartment syndrome, y/n (y%)	5/21 (19.2%)	11/3 (78.6%)	<0.001[b]
Fasciotomy, y/n (y%)	4/22 (15.4%)	6/8 (42.9%)	0.065[c]
Ure, mg/dL	29.5 (15-122)	56 (18-200)	0.023[d]
Creatinin, mg/dL	0.67 (0.48-3.9)	0.67 (0.6-4.63)	0.305[d]
Potassium, mmol/L	4.1±0.5	4.6±1.2	0.047[a]
CPK, U/L	7957 (165-190000)	24679 (470-249203)	0.200[d]
Total calcium, mg/dl	8.7 (5.8-10)	7.9 (4.6-9.1)	0.013[d]
Phosphate, mg/dl	3.1±0.8	4.4±2.1	0.060[a]
Uric acid, mg/dl	3.7 (1.7-10.5)	3.9 (0.9-8.4)	0.738[d]
WBC, x10^3/ml	15.2±5.6	16.6±8.9	0.559[a]
Hemoglobin, mg/dl	14.1±2.3	14.2±4.6	0.963[a]
Neutrophil, x10^3/ml	12.6±5.5	13.9±8.3	0.565[a]
Lymphocyte, x10^3/ml	1.7±0.9	1.4±0.6	0.296[a]
Platellet, x10^3/ml	271±98	238±86	0.296[a]
CRP, IU/L	50 (2-184)	122 (2-224)	0.025[d]
Albumin g/L	30.5 (13-38)	23 (11-32)	0.001[d]
pH	7.38 (7.27-7.51)	7.39 (7.01-7.50)	0.856[d]
HC03, mmol/L	22.6±3.9	20.1±5.8	0.118[a]
Heart pulse rate, per minute	86±13	105±16	<0.001[a]
QT, ms	0.35±0.027	0.33±0.034	0.021[a]
QTc, ms	0.420±0.029	0.432±0.027	0.181[a]
P amplitute, mV	0.1 (0.06-0.94)	0.1 (0.06-0.20)	0.878[d]
P wave, ms	0.08 (0.06-0.12)	0.08 (0.06-0.12)	0.146[d]
PR, ms	0.14 (0.12-0.30)	0.2 (0.1-0.3)	0.006[d]
QRS, ms	0.077 (0.04-0.48)	0.05 (0.03-0.09)	0.021[d]
T amplitute, mV	0.15 (0.08-0.9)	0.15 (0.08-0.5)	0.266[d]
T wave, ms	0.168±0.04	0.143±0.06	0.166[a]
Tpe, ms	0.1 (0.04-0.14)	0.1 (0.06-0.13)	0.946[d]
Tpe/QT	0.28±0.07	0.29±0.05	0.619[a]
Tpe/QTc	0.24±0.06	0.23±0.05	0.602[a]
ST elevation, y/n (y%)	14/11 (56%)	4/7 (36.4%)	0.278[b]
T wave inversion, y/n (y%)	7/18 (28%)	4/7 (36.4%)	0.449[c]
PR prolongation, y/n (y%)	6/20 (23.1%)	8/6 (57.1%)	0.036[c]

a: Independent sample-t test b: Pearson Chi-square test c: Fisher's exact test d: Mann Whitney-U test, ICU: Intensive care unit CPK: Creatine Phosphokinase WBC: White blood cell CRP: C-reactive protein

There were no differences between the groups in terms of age, sex, adult/child, time under debris and presence of oligo-anuria. All patients (n=14) admitted to the ICU (100% vs. 65.4%, p=0.011) had extremity trauma. Crush syndrome was more common in patients treated in the ICU (71.4% vs. 30.8%, p=0.014). Compartment syndrome was more common in patients treated in the intensive care unit (78.6% vs. 19.2%, p<0.001). Urea levels were higher in patients treated in the ICU (56 mg/dl vs. 29.5 mg/dl, p=0.023). Potassium levels were higher in ICU patients (4.6 mmol/l vs 4.1 mmol/l, p=0.047). Calcium levels were lower in ICU patients (7.9 mg/dl vs. 8.7 mg/dl, p=0.013). CRP was higher in ICU patients (1222 IU/L vs. 50 IU/L, p=0.025). Albumin levels were lower in ICU patients (23 g/L vs. 30.5 g/L, p=0.001).

In terms of ECG characteristics, heart rate was higher in ICU-treated patients (105/min vs 86/min, p<0.001), PR interval was longer in ICU-treated patients (0.2 s vs 0.14 s; proportion of patients with long PR was 57.1% vs 23.1% p=0.006), QRS complex was shorter in ICU-treated patients (0.05 mm vs 0.077 mm, p=0.021). QT interval was shorter in patients who admitted to intensive care unit (0.33 vs 0.35, p=0.021). In patients with crush syndrome, PR interval was longer (0.17 vs 0.16, p=0.006), QRS width was shorter (0.006 vs 0.072, p=0.021). In addition, the T-amplitude in the ECG was found to be higher in those who developed AKI compared to those who did not (0.20 vs. 0.10, p=0.018). Again, the T-amplitude was higher in those who required dialysis treatment (0.20 vs. 0.10, p=0.009).

DISCUSSION

In this study, we showed that there were some ECG changes in the patients admitted to our hospital from the victims of the Kahramanmaraş earthquake. We showed that the PR interval was longer and the QRS width was shorter in patients who developed crush syndrome and required further treatment in the intensive care unit. We also showed that the heart rate was higher in patients admitted to the ICU and the T wave was narrower in patients who developed crush syndrome. We were able to show that the T amplitude was longer in patients who developed AKI and in patients who required dialysis treatment.

ECG changes seen in people trapped under rubble may be the result of traumatic rhabdomyolysis, which develops as a result of prolonged pressure on the muscles, tissue hypoxemia, which may develop as a result of fluid and nutrient deprivation, an increased calcium load that develops in the muscle cell after reperfusion following the person's rescue from the rubble, released oxygen radicals and potassium, adverse effects of increased sympathetic activity, an increase in antidiuretic hormone, and cardiac effects of an active renin angiotensin aldosterone system (RAAS).[5,6] Experimental studies have shown that there are numerous ECG changes following decompression that are due to both the direct effect of the trauma on the myocardium and the prolonged muscle injury.[7-9] These changes include increased heart rate, ST segment elevation, ST segment depression, prolonged PR interval, T wave changes, arrhythmias, abnormal Q wave, QT prolongation, wide QRS wave.[7-9]

In people trapped under rubble in earthquakes, adverse effects on the heart may occur as a result of hypovolemia, increased sympathetic activity, many electrolytes released into the blood after muscle injury, free radicals, and triggering of cytokines and various hormonal pathways as a result of immune system activation. The negative effects of the earthquake on the heart and the increase in cardiovascular events persist not only at the time of the earthquake, but also in the months that follow. The number of sudden cardiac deaths in earthquake victims has been shown to increase in earthquake victims.[10] When muscle contusion develops in earthquake victims, many unfavorable clinical outcomes such as fasciotomy, amputation, AKI, and the need for renal replacement therapy occur in these individuals. Therefore, these individuals may need to be hospitalized and some of them may require further treatment in the intensive care unit to monitor these clinical pictures. After the Kahramanmaraş earthquake, many earthquake victims were hospitalized and continued to be treated in the ICU depending on their clinical condition.[11-13] In the study conducted by Sarı et al.[11] on the victims of the Maraş earthquake, 38.3% of hospitalized patients were hospitalized, 17.4% of these patients were admitted to the ICU, 16.9% of hospitalized patients required hemodialysis, and 8.3% of patients died. In a study conducted by Koyuncu et al.[12] on Kahramanmaraş Earthquake victims admitted to Kayseri City Hospital, it was found that 7.4% of patients developed crush syndrome, 2.73% required AKI, 2.23% required hemodialysis, 4% required intensive care, and 1.29% died. In a study of pediatric victims of the Kahramanmaraş Earthquake conducted by Döven et al.[13] it was found that 16% were hospitalized and followed up, 9.1% developed crush syndrome, 1.85% required intensive care, and 1.54% required hemodialysis treatment. There were no deaths in this series. A significant proportion of deaths among earthquake victims can be attributed to cardiovascular causes.

ECG, a simple method for follow-up of hospitalized patients, can be used as a predictive tool for cardiovascular assessment of patients and mortality. Erdem et al.[14] demonstrated that a score obtained from the ECG of ICU patients has the same sensitivity and specificity as the APACHE-II score for non-cardiac mortality. George et al.[15] showed that prolonged QT time was associated with adverse clinical outcomes in adult ICU patients, and Ozdemir et al.[16] showed that the Tpe/QT ratio may be an effective tool for predicting mortality in pediatric ICU patients. In our study, we found that the heart rate was higher, the PR interval was shorter and the QRS was shorter in earthquake victims who were treated in the intensive care unit.

As a result of muscle contusion, patients develop hypocalcemia and hyperkalemia. Pathological ECG findings may be observed due to these electrolyte disturbances. Hypocalcemia may be severe in the first few days after muscle contusion due to the high accumulation of calcium in the muscle cells. In the following days, calcium levels are expected to return to normal due to release from the muscle cells into the plasma. Hypocalcemia prolongs phase 2 of the action potential depending on the rate of change in serum calcium concentration and myocyte calcium channel function.

Prolongation of the QT interval is associated with premature depolarizations and triggered arrhythmias. Although electrocardiographic conduction disturbances are common, severe arrhythmias due to hypocalcemia such as heart block and ventricular arrhythmias are rare. Hyperkalemia may be accompanied by various changes in the electrocardiogram (ECG). A shortened QT interval and high T waves are usually the first findings. As hyperkalemia worsens, the PR interval and QRS duration become progressively longer, the P wave may disappear, and eventually the QRS broadens to a sinus wave pattern. In the complete absence of electrical activity, ventricular arrest occurs with a flat line on the ECG.[17-19] In our study, although total calcium levels were found to be significantly lower in patients who developed crush syndrome and were followed up in the ICU, there was no difference between the groups in terms of QTc. This is probably due to the fact that albumin levels were also significantly lower and ionized calcium levels were similar in patients who developed crush syndrome and continued in the ICU. It is likely that the total calcium values in our study were not adjusted for albumin. The longer PR interval and narrower T wave could be due to hyperkalemia, and we may not have seen prolongation of the QT interval due to hyperkalemia.

Limitations

The limitations of our study are as follows. First, the number of cases was very small. Second, the association between ECG and adverse clinical outcomes could not be investigated. Third, due to the fact that only one ECG was evaluated at the time of hospitalization, it was not possible to detect ECG abnormalities that may develop over time. Finally, the study did not provide information on the physiopathologic process between ECG abnormalities and clinical outcomes in earthquake victims.

CONCLUSION

In this study, we demonstrated some possible ECG changes such as PR prolongation and narrow QRS in earthquake victims admitted to our hospital. ECG can be used as a simple but predictive tool to monitor cardiovascular outcomes in earthquake victims. Further studies in which the ECG is monitored in a larger group of patients and throughout the process could provide more information on this topic.

Hypocalcemia prolongs phase 2 of the action potential, with effects depending on the rate of change in serum calcium concentration and myocyte calcium channel function. Prolongation of the QT interval is associated with early afterdepolarizations and triggered arrhythmias. Although electrocardiographic conduction abnormalities are common, severe arrhythmias due to hypocalcemia, such as heart block and ventricular arrhythmias, are rare. Hyperkalemia can be accompanied by a variety of changes in the electrocardiogram (ECG). High T waves with a shortened QT interval are usually the first finding. As hyperkalemia worsens, the PR interval and QRS duration become progressively longer, the P wave may disappear, and eventually the QRS broadens to a sinus wave pattern. A ventricular arrest with a straight line on the ECG occurs in the complete absence of electrical activity.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Gazi Yaşargil Training and Research Hospital Clinical Researches Ethics Committee (Date: 04.08.2023, Decision No: 499).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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