Relation between Serum Pro-Brain Natriuretic Peptide, Myoglobin, CK Levels and Morbidity and Mortality in High Voltage Electrical Injuries

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Abstract

Objective In our study, in addition to evaluating the relation between Pro-Brain natriuretic peptide (Pro-BNP), myoglobin and creatinine kinase (CK) levels and morbidity and mortality, we aimed at identifying the demographic characteristics of patients admitted to emergency service after exposure to high electrical voltage.

Methods In this prospective study, 48 emergency service patients exposed to high electric voltage were included; 19 healthy individuals were included as the control group. Their blood samples and electrocardiographies (ECG) were taken at the time of recourse upon their written approval. Demographic data and laboratory data were checked and compared among the patient group. We investigated the correlation between inpatients that had special clinical manifestations (escaratomy, fasciotomy, exitus, myoglobulinuria, third-degree burn, arrhythmia and etc.) and serum Pro-BNP, myoglobin and CK levels.

Results When serum Pro-BNP, myoglobulin and CK levels were compared for the special clinical manifestations; the pro-BNP levels were statistically significantly higher in patients who had arrhythmia than in those without arrhythmia, and significantly higher in patients who died than in those who healed (respectively $p=0.002$ and $p=0.007$). In contrast, serum CK and myoglobin levels were not statistically significant. The serum CK and myoglobin levels were statistically significantly higher in patients who had third-degree burn than the others ($p<0.001$).

Conclusion Serum pro-BNP level is a marker that can be used for mortality and morbidity with patients exposed to high voltage electrical injuries.

Key words: brain natriuretic peptid, myoglobin, morbidity, mortality, high voltage electrical injury

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Introduction

Electrical current causes complex, unprecedented and unpredictable injuries (1). The term “high voltage” is often used for that over 1,000 volts. Yet evidence is available that seriousness and mortality risk in injuries increase as voltage increases over 600 volts. Electrical burns can be examined in a wide range of injuries starting from simple ones not requiring treatment to injuries causing loss of an extremity and even mortality. Serious tissue damage and mortality is

caused by high voltage among all types of electrical burns (2).

Myoglobin, a 17,800 Dalton protein molecule consisting of 153 amino acids, is present only in heart and skeletal muscular tissue (3). Detectable myoglobin in the serum can be derived from either the cardiac muscle or the skeletal muscular system, or both. Physiologically, myoglobin is only detectable in low concentrations in serum or urine (4). Myoglobin serum level has been found to increase after extended muscular activity or even more after muscular injury (5-8).

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B-type natriuretic peptide (brain natriuretic peptide) is a neuro-hormone in the structure of peptide secreted from cardiac ventricles in response to volume and pressure load. In recent studies, it was reported that the pro-BNP level measured in plasma plays an important role in cardiovascular diseases, especially in the diagnosis and treatment of cardiac failure and acute coronary syndrome (9). If electric current courses through the heart, the efficiency of the heart will be affected and render worse cardiac pathology. The primary effect of electric current is on the cardiac conduction system and directly to myocardial cells. This effect can cause little necrosis at the myocardium and results in stress at ventricles and atriums (10). Ventricles are base sources for plasma BNP. Myocyte tension due to electric current provokes BNP release.

In the present study, in addition to evaluating the relation between serum Pro-BNP, myoglobin and creatinine kinase (CK) levels and morbidity and mortality, we aimed at identifying the demographic characteristics of patients admitted to emergency service after exposure to high electrical voltage.

Materials and Methods

Patients

After receiving approval from the Chairmanship of the Board of Ethics of the Faculty of Medicine of Dicle University, 48 emergency service patients exposed to high electric voltage and who best fit the criteria of acceptance were included in this prospective study. As a control group, 19 volunteers healthy individuals who consented to be in the study were included in our study.

Patients who did not agree to be included in the study and also those with a history of comorbid disease (acute coronary syndrome, chronic ischemic heart disease, valvular heart disease, hypertension and cardio-myopathy, chronic heart failure, chronic pneumonia, etc.) which might effect pro-BNP and myoglobin levels were excluded from the study. Patients and/or their relatives were informed of the study. Their blood samples and electrocardiographies (ECG) were taken at the time of recourse upon their written approval. Blood samples taken were immediately transferred to the laboratory under appropriate conditions and test results were included in the study without delay. Pro-BNP concentrations were determined using a chemiluminescent immunoassay method (Immulite 2500; Siemens Medical Solutions, Holliston, MA, USA, with a reference level of 20-110 pg/mL). Myoglobin concentrations were also determined using a chemiluminescent immunoassay method (Immulite 2500; Siemens, with a reference level of 0-70 ng/mL) and CK concentrations were determined using a chemiluminescent immunoassay method (Architect C 8000, Abbott, USA, reference interval 0-190 U/L).

In this study, their age, sex, vital findings, test findings (entry and exit of power localizations, burn degree, burn percentages due to Wallace's rule of nines), full blood tests,

biochemistry, pro-BNP, CK and myoglobin levels, ECG findings, therapy applied (medical, escharotomy, fasciotomy) and their results were transferred into a form prepared by the researchers. Demographic and laboratory data were checked and compared among patient group individuals. We decided to investigate the correlation between inpatients that had special clinical manifestations (escharotomy, fasciotomy, exitus, myoglobulinuria, third-degree burn, arrhythmia and etc.) and serum Pro-BNP, myoglobin and CK levels.

Statistical analysis

Statistical analysis was carried out using chi-square test for categorical variables and Mann-Whitney U test for permanent variables. For the statistical analysis, $p < 0.05$ was accepted as reasonable. Results were given as mean $\pm$ SD or median; interquartile range.

Results

Patients had a mean age of 22.33 ± 12.21 years and 43 (89.5%) of the patients were male, only 5 (10.5%) were female. The control group had a mean age of 24.89 ± 7.81 and 11 (57.8%) were male and 8 (42.2%) of the control group were female. There was no statistically significant difference between patient and control groups with respect to age and sex. The average admission time to hospital was 4.63 ± 3.87 hours. The average length of stay in the hospital was 6.54 ± 5.44 days. Table 1 shows the demographic characteristics of our patients.

In the patient group, electric current entry wounds are located mostly in the upper left extremity 62.5% ($n=30$), 58.3% ($n=28$) upper right extremity, 4.1% ($n=2$) lower right extremity and 6.25% ($n=3$) on the body. Exit wounds were located in upper left extremity in 4.1% ($n=2$) of our patients, in the lower right extremity in 54.1% ($n=26$) and in lower left extremity in 45.8% ($n=22$); 4.1% ($n=2$) of patients suffered from first-degree burns, 83.3% ($n=40$) second-degree burns and 60.4% ($n=29$) third-degree burns. The average systolic/diastolic blood pressure of patients was $114.3 \pm 12.3/72.0 \pm 8.4$ mmHg and the average systolic/diastolic blood pressure of controls was $110.8 \pm 8.5/71.3 \pm 7.8$ mmHg. There was no statistically significant difference between patient and control groups with respect to systolic/diastolic blood pressure. The average heart rate of patients was 90.7 ± 14.5 /min and the average heart rate of controls was 82.3 ± 10.5 /min. There was statistically significant difference between patient and control groups with respect to heart rate ($p=0.012$); 56.3% ($n=27$) patients had sinus tachycardia and, 29.1% ($n=14$) had normal sinus rhythm; 7 patients had arrhythmia; 2 of them suffered from atrial fibrillation and 5 of them had ventricular premature systole. 93.75% ($n=45$) of patients were discharged with healing and 6.25% ($n=3$) of patients died (Table 1).

Laboratory values

Comparison of patients with respect to laboratory values

Table 1. Demographic Data for Our Patients

Characteristic	n
Sex	
Male	43
Female	5
Admission time (hours; mean±SD)	4.63±3.87
Age (years; mean±SD)	22.33±12.21
Electricity Entry Wound	
Upper Left Extremity	30
Upper Right Extremity	28
Body	3
Lower Right Extremity	2
Electricity Exit Wound	
Lower Right Extremity	26
Lower Left Extremity	22
Upper Left Extremity	2
Burn Degree	
Second-degree Burn	40
Third-degree Burn	29
Total Burn Surface Area (%; mean±SD)	13.42±13.23
Level of consciousness	
Alert	44
Stuporous	3
Coma	1
ECG Findings	
Sinus Tachycardia	27
Normal Sinus Rhythm	14
Arrhythmia	7
Length of stay in the hospital (days; mean±SD)	6.54±5.44
Result	
Healed	45
Exitus	3

is given in Table 2. Comparison of Pro-BNP, myoglobin and CK levels due to special clinical manifestation of electrical burn among patients is given in Table 3.

Of our patients, 23% (n=11) underwent escharotomy and 16.7% (n=8) underwent fasciotomy. In 50% (n=24), myoglobulinuria was positive, in 14.6% (n=7) had arrhythmia, 60.4% (n=29) had third-degree burns and 6.25% (n=3) of patients died. When serum Pro-BNP, myoglobin and CK levels were compared for these special clinical manifestations; the pro-BNP levels were statistically significantly higher in patients who had arrhythmia than those without arrhythmia, and significantly higher in patients who died than in those who were healed (respectively $p=0.002$ and $p=0.007$). In contrast, serum CK and myoglobin levels were not statistically significant (Table 3). When serum Pro-BNP, CK-MB and TPI levels were compared in patients who had arrhythmia or not, the pro-BNP levels were statistically significantly higher in patients who had arrhythmia than in those without arrhythmia ($p=0.002$). But serum CK-MB and TPI levels were not statistically significant ($p=0.785$ and $p=0.632$, respectively). The serum CK and myoglobin levels

were statistically significantly higher in patients who had third-degree burn than in the other burn patients ($p<0.001$) (Table 3).

Discussion

Electrical injuries can be defined as occupational trauma (11). The true incidence of electrical accidents is not known. Although the frequency of non-serious electrical shocks is not known, approximately over 17,000 victims are admitted in emergency services in the United States (USA) annually (12). In US 0.8-1% of accidental deaths are caused by electrical injuries (2, 11).

High voltage electrical injuries often occur in the upper extremities. Since hands are used when working, playing, climbing or holding any object, the upper extremities are exposed to electrical current in a rate as high as 70-80% (11). Generally entry is an upper extremity and exit is a lower extremity (13). In recent studies (14), the typical current pathway is from upper through lower extremity (15). Similarly, in the present study the entry was generally located in the upper extremities and the exit was located in lower extremities.

Electrical injuries may cause various abnormalities from dysrhythmias to myocardial infarct. Cardiac abnormality incidences following electrical injury were found between 15% and 54% in different series (16-18). Most of these studies are high voltage injury studies (18). Sinus tachycardia, premature atrial contractions, premature ventricular contractions, supraventricular tachycardia, arterial fibrillation, first and second degree AV blocks were observed in more than 30% high voltage electrical injuries (2). In 56.3% of our patients sinus tachycardia and in 14.6% arrhythmia was observed. Pro-BNP level was higher in patients with cardiac transmission failure than in those who did not develop cardiac transmission failure, and this value was statistically significant.

The muscle necrosis in electrical injuries is related to massive myoglobulinuria due to large amounts of myoglobin that is usually seen in similar crush type injuries (11). If at the same time, dehydration is also present, this causes injury by gathering in kidneys leading to acute renal failure (11). Although the myoglobin incidence changes between 14-42% after electrical injury, it can rise to 75-100% due to exposure to high voltage (19). In 50% of our cases myoglobulinuria was present. Rosen et al, in their study, indicated that myoglobulinuria can be used in pre-identifying, dismissing those of frivolous risk, and separating high risk patients with myoglobulinuria who need urgent treatment. In the same study myoglobulinuria was seen to be a marker for morbidity (19). Also in the present study, Pro-BNP, myoglobin and CK levels were found to be higher in patients who have myoglobulinuria when compared to those who do not have myoglobulinuria. This was found to be statistically significant. Pro-BNP, myoglobin and CK also can be used as a marker for morbidity.

Table 2. Median Values of Biochemical Parameters for Patient and Control Groups

	Control Group n=19	Patient Group n=48	p value
WBC (K/UL;Median(Interquartile range))	10500(7490-12600)	17000(14650-21425)	<0.001
ALT (U/L;Median(Interquartile range))	12.83(9.60-22.00)	63.50(22.62-194.75)	<0.001
AST (U/L;Median(Interquartile range))	17.05(13.30-21.90)	93.22(38.82-329.90)	<0.001
Glucose (mg/dL;Median(Interquartile range))	98.00(82.9-104.5)	125.50(109-162.7)	<0.001
CK (U/L;Median(Interquartile range))	134.00(50-345)	2759.50(712-12803)	<0.001
CKMB (U/L;Median(Interquartile range))	23.00(12-31)	115.00(49.5-233.8)	<0.001
Troponin I (ng/mL;Median(Interquartile range))	0.10(0.1-0.24)	0.53(0.26-0.98)	<0.001
Pro-BNP (pg/mL;Median(Interquartile range))	37.20(22.5-72.8)	236.55(135.8-508.8)	<0.001
Myoglobin (ng/mL; Median(Interquartile range))	59.0(45.0-69.0)	922.0(472.2-1166.0)	<0.001

Table 3. Median Pro-BNP, Myoglobin and CK Levels in Special Clinical Manifestations

	n	Pro-BNP (pg/mL;Median (Interquartile range))	p	Myoglobin (ng/mL; Median (Interquartile range))	p	CK (U/L;Median (Interquartile range))	p
Escaratomy							
Present	11	871(306-1400)	< 0.001	971(971-1287)	0.013	12777(1919-20000)	0.054
Absent	37	174(98-312)		560 (430-1126)		1530 (525-8641)	
Fasciotomy							
Present	8	923(179-1445)	0.032	948(572-1276)	0.406	10845(1089-2000)	0.306
Absent	40	221(119-379)		843(458-1166)		2759(578-11034)	
Exitus							
Present	3	1472(1400-1545)	0.007	1326(926-1326)	0.053	20000(1690-20000)	0.143
Absent	45	229(129-411)		768(458-1135)		2727(586-12167)	
Myoglobulinuria							
Present	24	349(184-970)	0.003	1126(966-1275)	< 0.001	12794(2743-20000)	< 0.001
Absent	24	167(80-251)		485(382-548)		1128(301-2550)	
Third-degree Burn							
Present	29	290(154-758)	0.242	512(370-560)	< 0.001	9463(1804-20000)	< 0.001
Absent	19	160(84-357)		1067(724-1248)		1043(238-2573)	
Arrhythmia							
Present	7	654(500-1003)	0.002	1142(918-1276)	0.074	2792(570-15510)	0.819
Absent	41	208(113-312)		680(444-1126)		2727(822-12167)	

High voltage injuries are devastating injuries with constant high compartment syndrome. Vascular compression and thrombosis may cause secondary ischemic necrosis which may result in both upper and lower extremity amputation (20). Although it was not statistically significant that early fasciotomy saves organs in patients having 40% less than total body burn after high voltage burn, it should be emphasized that early muscle compartment decompression within 4-6 hours provided great value in preventing tendency towards muscular necrosis (21). Measured pro-BNP levels of patients treated with escharotomy or fasciotomy were found to be higher than non-treated patients. This result was also statistically significant. Therefore, it can be used as a marker for morbidity with high pro-BNP level.

The most frequent reason for mortality related to electric injuries is cardiac. While low voltage injuries cause ventricular fibrillation, temporary ventricular asystole can be formed due to high power alternating current and direct cur-

rent (2). Mortality rates differ between 2-15% in different series (15). In the study carried out by Ferreiro et al, they found that mortality rate directly related to the presence of secondary cranial injury due to respiratory and trauma was 12% in patients with 90% burns (15). In the present study, the mortality rate was found to be 6.25%. These deaths were reported to be due to sepsis which developed in the burn unit. The pro-BNP levels of these cases were significantly high.

Limitations

Our study is based on a single department and patient numbers may be considered as inadequate for this research. Blood pro BNP, myoglobin and CK levels were not evaluated on subsequent days. Multicenter studies with many more electric injured patients must be planned.

Conclusion

Pro-BNP value was high in high voltage electrical injury patients in whom cardiac transmission failure and myoglobulinuria improved, as compared with those who underwent fasciotomy and escharotomy and those with exitus. Consequently, pro-BNP value can be considered a marker that can be used for mortality and morbidity in patients exposed to high voltage electrical injuries.

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