

Evaluation of Serum Creatinine Phosphokinase Levels and Need of Amputation in Electrical Contact Burns

Pankaj Saini,
Raman Tandon,*
Komal Tripathi

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ABSTRACT

Background: Increased serum creatinine kinase levels in electric burns can be used as a prognostic indicator with regard to the need for limb amputation.

Aim: To assess serum creatine phosphokinase (CPK) levels in electric burns as a prognostic indicator for limb amputation

Patients and methods: In patients admitted with electric burns, serum CPK levels were measured serially from the time of admission for 5 occasions. The change in trends of serum levels of CPK levels was studied, and it was then correlated with amputations among these burn patients.

Results: Most patients belonged to the age group of 16-30 years (40%) and fell in the category of <10% and 11-20% body surface burn (27% each). The highest mean value of CPK levels was on Day 3 - 11639.68 ± 7432.56 U/L. The mean values of CPK were higher in amputated patients. The difference between the two means on all days was significant (p -value<0.05). Pre-gangrenous changes occurred in 35% out of which 33% of patients had to be amputated. Dorsal slit procedure, fasciotomy, and escharotomy were done in 11, 31, and 6% of patients, respectively. The difference in the proportion of patients between the two categories i.e., amputated and non-amputated was statistically significant in which <10% body surface area was affected and 11-20% body surface area was affected (p -value<0.05). In rest all the other classes, the difference was not statistically significant (p -value>0.05).

Conclusion: CPK levels increase in patients with electric burns. The highest mean value was seen on day 3. The mean values of CPK were higher in the patients in which amputation had to be done. Moreover, the difference between the two means on all days i.e., day 1, day 3, day 5, day 7, and day 10 was found to be statistically significant (p -value<0.05).

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Department of Burns, Plastic & Maxillofacial Surgery, Vardhaman Mahavir Medical College & Safdarjung Hospital, New Delhi, Delhi, India

*Correspondence: Raman Tandon, tdandonraman410@gmail.com

Department of Burns, Plastic & Maxillofacial Surgery, Vardhaman Mahavir Medical College & Safdarjung Hospital, New Delhi, Delhi, India

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INTRODUCTION

Electrical burns constitute 3-5% of all burn cases in developed countries whereas in developing countries, this ratio increases up to 21-27% and the mortality rate is reported to be between 3.75 and 58.8%.^{1,2}

The patients coming with electrical burns usually have an occupational history of being electrical workers and construction workers. Electrical burns still constitute a serious health problem in our country, leading to severe complications and socioeconomic deterioration.⁷

PATIENTS AND METHODS

This prospective observational study conducted for 18 months, consisted of 100 patients. The study was carried out after obtaining approval from the institutional ethical committee and obtaining fully informed written consent.

Inclusion criteria

All age groups admitted within 48 hours of electric contact burn injury

Exclusion criteria

Patients with a history of previous cardiac abnormality, crush injuries and other associated trauma. Patients reporting after 48 hours of electric contact burn injury.

STUDY PROCEDURE

Patients fulfilling the inclusion criteria were enrolled in the study. Clinical courses and surgeries were documented. The percentage of burns was calculated by Lund and Browder chart. Measurement of total CPK levels was done by using a CPK reagent kit for serum and plasma. Total CPK serum levels were investigated on 1,3, 5,7, and 10 days after injury.

The sample size was calculated using the formula according to study by Memon *et al.* The sample size required for the study was calculated according to the formula $N = \sigma (Z_{\alpha} + \alpha)^{(1-\beta)} 2 \mu_1 - \mu_0$

N	Sample size =95
$\mu_1 - \mu_0$	Difference between the means (28098-25000)
σ	Standard deviations (10758.64)
α	Confidence limit 0.05,95
β	power of study 0.2, 80%

STATISTICAL ANALYSIS

The data and variables were entered into MS Excel spreadsheet, and SPSS 23.0 was used for the statistical analysis. Measures of central tendency like Mean, Mode, Median, Standard Deviation were given for quantitative data.

The association of serum CPK and amputation was taken out by the Chi-Square and Fisher exact test. A p-value less than 0.05 was considered significant

RESULTS

Out of 100 patients enrolled, 33 patients underwent amputation. Most patients belonged to the age group of 16-30 years (40%), followed by the age group of <15 years (33%) and 31-45 years (19%). Least number of patients were in the age group of 46-60 years (8%). In our study 89% of patients were males and 11% were females.

Most patients fell in the category of <10% and 11-20% body surface burn (27% each), followed by 31-40% (16% patients) and 21-30% (14%). The least number of patients fell in the category of >71% body surface area getting affected (only one patient) followed by 61-70% (3% patients), 41-50% (5% patients) and 51-60% (7% patients).

The highest mean value of CPK levels was calculated on Day 3 i.e., 11639.68 ± 7432.56 U/L, followed by Day 1 and Day 5 with the values of 9780.65 ± 7258.36 U/L and 5186.77 ± 4296.08 U/L, respectively. The lowest mean Creatinine Phosphokinase levels were calculated on Day 10 with a value of 379.53 ± 940.57 U/L (Table 1).

Table 1: Mean values of serum CPK on subsequent days

Day	Mean	SD
Day 1	9780.65 U/L	± 7258.36 U/L
Day 3	11639.68 U/L	± 7432.56 U/L
Day 5	5186.77 U/L	± 4296.08 U/L
Day 7	1666.73 U/L	± 2080.77 U/L
Day 10	379.53 U/L	± 940.57 U/L

On all the occasions when the CPK levels were assessed, the mean values of CPK were higher in the patients in which amputation had to be done. Moreover, the difference between the two means on all days i.e., day 1, day 3, day 5, day 7, and day 10 were found to be statistically significant (p-value < 0.05) (Table 2).

It was observed that pre gangrenous changes occurred in 35% of all patients out of which 33% patients had to be amputated while 2% patients improved. Furthermore, in 31% of the total patients fasciotomy was done, and in 33% patients, pre-gangrenous changes occurred. Dorsal slit procedure was done in 11% patients, whereas in 6% patients, escharotomy was done.

Higher proportion of patients underwent fasciotomy in whom amputation was done (36.36%)

Table 2: Mean values of CPK on subsequent days in amputated and non-amputated patients

Days	Amputated (33)		Non-amputated (67)		p-value
	Mean	SD	Mean	SD	
Day1	16087.33 U/L	± 8612.56 U/L	6674.37 U/L	± 3657.76 U/L	0.000
Day 3	19550.42 U/L	± 6882.75 U/L	7743.34 U/L	± 3632.44 U/L	0.000
Day 5	9164.58 U/L	± 4154.23 U/L	3227.55 U/L	± 2740.26 U/L	0.000
Day 7	3179.97 U/L	± 2666.47 U/L	933.58 U/L	± 1161.35 U/L	0.000
Day 10	765.09 U/L	± 1533.16 U/L	189.63 U/L	± 276.40 U/L	0.000

Table 3: Fasciotomy vs Amputation status

Fasciotomy	Amputated (33)		Non amputated (67)		p-value
	No of patients	Percentage	No of Patients	Percentage	
Present	12	36.36%	19	28.36%	0.416
Absent	21	63.64%	48	71.64%	

than non-amputated patients (28.36%). However, the difference between the two was not statistically significant (p-value>0.05) (Table 3).

In 94.29% of patients in whom pre-gangrenous changes appeared, amputation had to be done, whereas only 2% of patients with pre-gangrenous changes improved without performing amputation. The difference in the proportion of patients between the two was statistically significant (p-value<0.05).

In amputated patients, 6.06% of the patients underwent an additional procedure of dorsal slit and the same percentage of patients underwent escharotomy. Whereas in non-amputated patients, 13.43% of patients underwent dorsal slit procedure and 5.97% of patients underwent escharotomy. In amputated patients, 6.06% of the patients underwent the additional procedure of Dorsal slit and the same percentage of patients underwent Escharotomy. Whereas in non-amputated patients, 13.43% of patients underwent dorsal slit procedure and 5.97% of patients underwent escharotomy. However, the difference in the proportion of patients of both the procedures in between the amputated and non-amputated patients was not statistically significant (p-value>0.05).

In patients in whom amputation was done, the highest proportion of patients was in the age group of 16-30 years (45.45% patients), followed by <15 years (33.33%) and 31-45 years (12.12%). The least number of patients were in the age group of 46-60 years (9.09%). Similarly in non-amputated patients, highest proportion of patients was in the age group of 16-30 years (37.31%), followed by <15 years (32.84%) and 31-45 years (22.39%). The least number of patients were in the age group of 46-60 years (7.46%). However, the difference the proportion of patients between the two categories of patients i.e., amputated and non-amputated was not statistically significant in any of the age groups (p-value>0.05) (Table 4).

Table 5 shows the comparison of proportion of patients based on percentage of body surface area affected in different age groups between the amputated and non-amputated patients.

In amputated patients, most patients were in the category of 11-20% body surface area affected (45.45% patients), followed by 21-30% body surface area (18.18% patients) and <10% body surface area (15.15% patients). Least number of patients fell in the category of 61-70% body surface area and 41-50%

Table 4: Age vs Amputation status

Age	Amputated (33)		Non amputated (67)		p-value
	No of Patients	Percentage (%)	No of Patients	Percentage (%)	
<15 years	11	33.33	22	32.84	0.961
16-30 years	15	45.45	25	37.31	0.435
31-45 years	4	12.12	15	22.39	0.218
46-60 years	3	9.09	5	7.46	0.778

Table 5: Electrical burn (%) vs amputation status

% of body surface area affected	Amputated (33)		Non amputated (67)		p-value
	No of Patients	Percentage (%)	No of Patients	Percentage (%)	
<10%	5	15.15	22	32.84	0.000
11–20%	15	45.45	12	17.91	0.000
21–30%	6	18.18	8	11.94	0.398
31–40%	3	9.09	13	19.40	0.186
41–50%	1	3.03	4	5.97	0.526
51–60%	2	6.06	5	7.46	0.796
61–70%	1	3.03	2	2.99	0.991
>71%	0	0.00	1	1.49	0.481

body surface area (3.03% patients each), followed by 51–60% body surface area (6.06% patients) and 31–40% body surface area affected (9.09% patients). None of the patients fell in the category of >71% body surface area affected.

On the other hand, in non-amputated patients, most patients were in the category of <10% body surface area affected (32.84% patients), followed by 31–40% body surface area (19.40% patients) and 11–20% body surface area (17.91% patients). Least number of patients fell in the category of >71% body surface area (1.49% patients), followed by 61–70% body surface area (2.99% patients) and 41–50% body surface area affected (5.97% patients).

Moreover, the difference between the proportion of patients between the two categories i.e., amputated and non-amputated was statistically significant in two classes only which were <10% body surface area affected and 11–20% body surface area affected (p-value < 0.05). In rest all the other classes, the difference was not statistically significant (p-value > 0.05).

DISCUSSION

Electric burns are a common cause of burns in developing countries. Our study was primarily aimed to find out the relation between the CPK levels and the need for amputation in patients suffering from electrical contact burns.

A total of 100 patients were included in the study. For study purposes, these patients were divided into two groups i.e., patients with amputation and patients without amputation. Similar studies measuring serum CPK serially were done by Memon AR and Kopp j *et al.*^{3,4} The dimensions and the parameters of these two studies

were quite similar to our study and henceforth, considered into the discussion. Tien NG *et al.* conducted a retrospective study consisting of 104 patients (aged from 16 to 83 years old) who suffered from burns due to high voltage and were treated as inpatients at the National Burns Hospital. Patients were divided into two groups, i.e., patients with limb amputations in group A and patients without limb amputations in group B, similar to our study.⁵

In our study, most patients belonged to the age group of 16–30 years (40%), followed by the age group of <15 years (33%) and 31–45 years (19%). Least number of patients were in the age group of 46–60 years (8%). Moreover, in patients in whom amputation was done, highest proportion of patients was in the age group of 16–30 years (45.45% patients). Similarly in non-amputated patients, highest proportion of patients was in the age group of 16–30 years (37.31%). However, the difference in the proportion of patients between the two categories of patients i.e., amputated and non-amputated was not statistically significant in any of the age groups (p-value > 0.05). In our study 89% of patients were males and 11% were females. In the study conducted by Memon AR *et al.*, 82% patients were males and 18% were females.³ The age of patients ranged from 7 to 62 years with mean age of 28 years. In another study conducted by Kopp J *et al.*, the range of age of patients was 10–65 years with an average of 30.2 years.⁴ Males were 83.3%, and 16.7% were females. In Gille J *et al.*'s study, 6.8% patients were aged below 18 years (range 12–17 years).⁶ Most patients were male (94.4%), and the mean age was 37.7 ± 15.5 years. In the study conducted by Tien NG *et al.*, there were 97 males and 7 females, with an average age of 37.1 years (range 16–83 years).⁵

In our study, Serum CPK levels were measured on various days post-electrical burn injury. The highest mean value of CPK levels was calculated on Day 3 i.e., 11639.68 ± 7432.56 U/L, followed by Day 1 and Day 5 with the values of 9780.65 ± 7258.36 U/L and 5186.77 ± 4296.08 U/L, respectively. The lowest mean CPK levels were calculated on Day 10 with a value of 379.53 ± 940.57 U/L. Moreover, on all the occasions when the CPK levels were assessed, the mean values of CPK were higher in the patients in which amputation had to be done. Moreover, the difference between the two means on all days i.e., day 1, day 3, day 5, day 7 and day 10 were found to be statistically significant ($p\text{-value} < 0.05$). Similar results came in the study conducted by Gille J *et al.*, where the statistical significance was proved between CPK levels in the serum and the status of amputation.⁶ In the study conducted by Memon *et al* mean serum CPK level for all the patients, at the time of admission, was 38878 ± 13195.21 U/L.³ Statistically significant difference ($p=0.000$) was observed for those patients who expired during the period of hospital stay, who showed not only initial high levels of serum CPK (mean 48518.07 U/L) but its decline after indicated surgical procedure was not as dramatic as for those who survived. Patients, who survived, were those who responded well to the emergency surgical procedure, and their serum CPK showed remarkable reduction. In the study conducted by Tien NG *et al*, in the group of patients with amputation in group A ($n=20$ patients), the plasma CK (creatinine kinase) index increased to very high levels, from 15.6 to 46.5 times compared with normal CK index.⁵ The CK level increased from the first day of inpatient stay to the 4th day post-operation, an average of 6.5 days. The deeper the burn area, the higher the plasma CK levels. One day after limb amputation surgery, the plasma CK enzyme index was examined and found to have decreased significantly from 52931.21 ± 4200.94 U/l to 733.97 ± 432.01 U/l ($p\text{-value} < 0.05$), following a similar trend with that of our study. In group B-without amputation patients ($n=84$), plasma CK index increased for all groups of burn area, from 5.5 to 22.4 times compared with plasma CK in normal subjects. In all these studies, there was a significant association between serum CPK levels and the need for amputation.

In our study, amputation was done in 33% of patients, whereas in 33% of the total patients, fasciotomy was done and in 31% of patients, pre-gangrenous changes occurred. Moreover, higher proportion of patients underwent fasciotomy in whom amputation was done (36.36%) than non-amputated patients (28.36%). However, the difference between the two was not statistically significant ($p\text{-value} > 0.05$). Furthermore, in 93.94% of patients who were amputated, pre-gangrenous changes occurred, whereas no incidences of pre-gangrenous changes were there in non-amputated patients. The difference in the proportion of patients between the two was statistically significant ($p\text{-value} < 0.05$). The study conducted by Gille *et al.*, found that there was a significant association between fasciotomy as well as pre-gangrenous changes, and amputation.⁶ However in our study, the frequency of the fasciotomy procedure was only slightly higher in amputated patients without any significant statistical difference. In another similar study conducted by Kopp J *et al.*, he found that within the group of 12 amputated patients, fasciotomies had been performed in 8 cases on the day of admission, in one case this was carried out 3 days following injury. In one patient no fasciotomy was performed. In four additional patients immediate fasciotomy following admission was done for the preservation of electrically injured extremities (one arm, three lower legs) in combination with repeated necrosectomies.⁴

In our study, dorsal slit procedure was done in 11% of patients whereas in 6% of patients, escharotomy was done. In amputated patients, 6.06% of the patients underwent an additional procedure of dorsal slit and the same percentage of patients underwent escharotomy. Whereas in non-amputated patients, 13.43% of patients underwent dorsal slit procedure and 5.97% of patients underwent escharotomy. However, the difference in the proportion of patients of both the procedures in between the amputated and non-amputated patients was not statistically significant ($p\text{-value} > 0.05$). In the study conducted by Gille J *et al.* and Saracoglu *et al.*, similar results were obtained when these ancillary procedures were compared in between amputated and non-amputated patients.^{6,7} In the study conducted by Memon *et al.* eighty different surgical procedures were performed in 38 cases, the commonest being

fasciotomy in 26 cases (32.5%), skin grafting in 16 cases (20%), partial limb amputations in 10 cases (12.5%), total limb amputations in 09 cases (11.25%), multiple procedures in 3 cases (3.75%) and revision surgery in 07 cases (8.75%).³ Therefore, it was stated that the greater the serum CPK, the greater was the need for an invasive surgical procedure to save the life of the patient.

In our study, it was found that most patients were in the category of <10% and 11-20% body surface burn (27% each). In amputated patients, most patients were in the category of 11–20% body surface area affected (45.45% patients). The least number of patients fell in the category of 61-70% body surface area and 41-50% body surface area (3.03% patients each). On the other hand, in non-amputated patients, most patients were in the category of <10% body surface area affected (32.84% of patients). The least number of patients fell in the category of >71% body surface area (1.49% patients). Moreover, the difference between the proportion of patients between the two categories i.e., amputated and non-amputated was statistically significant in two classes only which were <10% body surface area affected and 11–20% body surface area affected (p-value<0.05). In rest all the other classes, the difference was not statistically significant (p-value>0.05). In Gille J *et al.* study, it was observed that as the body surface area that was affected due to electrical burn increased, the percentage of patients in whom amputation was done also increased.⁶ In the study conducted by Saracoglu A *et al.* the burn percentage of TBSA was calculated to be $42.5 \pm 23.4\%$ for the deceased patients and $26.5 \pm 19.6\%$ for the rest of the study group (p-value<0.05).⁷ The burn percentage (TBSA, $42.5 \pm 23.4\%$) had a significant influence on the mortality rate (p-value<0.05). For every 1% increase in the burn percentage, the mortality risk increased 1.03 times. In the study conducted by Memon *et al.*, the percentage of burnt area was significantly related to the level of CPK at the time of admission (p-value=0.000), but the likelihood of performing different procedures in relation to body surface area

affected was also not statistically appreciable.³ In another similar study conducted by Kopp J *et al.*, 17 amputations of extremities in 12 out of 37 patients were done (32.4%).^{www} All these patients displayed the highest CPK levels within their groups when compared to those who did not require amputations. The results of Gille J *et al.* study showed a statistically significant association between the TBSA affected in electrical burns and the need for amputation in patients.⁶

CONCLUSIONS

The mean values of CPK were higher in the patients in which amputation had to be done. Moreover, the difference between the two means on all days i.e., day 1, day 3, day 5, day 7 and day 10 was found to be statistically significant (p-value < 0.05).

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