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The Epidemiology and Management of Electrical Burns in Kasr El-Eni Hospital between the Years 2010-2015

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ABSTRACT

Background: Electrical burns are classified into low and high voltage burns. The arbitrary cutoff is usually set at 1,000 V.

Aim of the Work: This study attempts to show the prevalence of electrical burns in our burn unit and the epidemiological difference between high and low voltage injuries. It comprises retrospective study including the years 2010-2014 and prospective study of the year 2015.

Patients and Methods: The retrospective study is more of a statistical analysis of number of electrical burn patients and mortality rate, while in the prospective study we were able to follow the patients, treatment process, response and outcome.

Results: In the retrospective section, 1233 burn patients were admitted, 118 were due to electric injury, 21 females, 25 cases of high voltage burns, 93 cases were due to low voltage injury, 44 cases of contact injuries, 83 flash burn patients, 5 cases of amputation and 13 mortality cases. In the prospective section, 277 burn patients were admitted, of which 15 were due to electric injury, 2 females, 10 cases of high voltage burns, 10 cases of low voltage, 14 cases of contact injuries, 1 flash burn patient, 6 cases of amputation and 2 mortality cases. Electric burn injury predominantly involves young males aged 21-40 years. Our study has found a constant incidence of electric burn injuries ranging between 15- 29 cases per year (5.4-10.2% of total burn cases) in the successive years. In 2015, amputation rate was 40%. Since such devastating injuries with high morbidity rate stem from largely avoidable hazards, there is need for adoption of preventive strategies which appear to be the most effective way in controlling health problems related to the electric burn injuries.

Conclusion: Standardization of electrical devices and continuous supervision of workers, proper use the devices, security precautions, restriction of access of unskilled individuals to dangerous electrical instruments, settlement of continuous educational programs for workers and electrician can help to reduce electrical injury incidence and meticulous medical care will help to decrease the mortality and disability rates.

Key Words: *Electric burn – High-voltage burn – Low-voltage burn – Electric burn pathophysiology – Electric burn management.*

INTRODUCTION

Electrical burns are classified into low and high voltage burns. The arbitrary cutoff is usually set at 1,000 V **[1]**.

Electrical injuries are responsible for an estimated 50,000 emergency department treatments per year in the United States alone and account for 4% to 6.5% of all admissions to burn units and for approximately 1000 fatalities per year in the USA **[2]**.

In modern industrialized societies, the majority of severe electrical accidents are suffered by electrical utility employees or construction workers. In other societies, where the infrastructure is less developed and there is more theft of electrical power, the majority of electrical accidents occur to amateurs. Electrical injuries represent the fourth leading cause of work-related traumatic death (5-6% of all workers' deaths) **[3]**.

A bimodal distribution of electrical injuries exists among the very young children (<6y) and among young and working-aged adults. Patterns of electrical injury vary by age (e.g. low-voltage household exposures among toddlers and high-voltage exposures among risk-taking adolescents and via occupational exposure) **[5,6]**.

Rates of childhood electrical injury are higher among boys than girls; the most common electrical injury seen in children less than 4 years of age is the mouth burn that occurs from sucking on a household electrical extension cord. These burns usually represent local arc burns, may involve the orbicularis oris muscle, and are especially worrisome when the commissure is involved because of the likelihood of cosmetic deformity. A significant risk of delayed bleeding from the labial artery

exists when the eschar separates. Damage to developing dentition is reported **[4]**.

Rates of adult injury are significantly higher in men than in women, likely because of occupational predisposition. Most series show more than 80% of electrical injuries occur in men **[4]**.

Electrical injury during pregnancy from low-voltage sources is reported to result in stillbirth. A prospective cohort study of women receiving electric shock in pregnancy suggests that accidental electric shock usually does not pose a major fetal risk. Nevertheless, obstetric consultation or referral is advisable for all pregnant patients reporting electrical injury, regardless of symptoms at the time of presentation. Placental abruption, the most common cause of fetal death after blunt trauma, may result from even minor trauma such as may be associated with electrical injuries. Patients in the latter half of pregnancy should receive fetal monitoring if there has been even minor blunt trauma and be considered high-risk patients for the remainder of their pregnancy. First-trimester patients should be informed of the remote risk of spontaneous abortion and, if no other indications for admission exist, may be discharged with instructions for threatened miscarriage and close obstetric follow-up evaluation **[4]**.

Electrical burns can also be classified into four different types: Direct contact, Indirect contact (Arc), Flame, Flash burns.

Factors Determining Electrical Injury include Type of circuit, Voltage, Amperage, Duration, Pathway of current, Resistance and resistivity of tissues.

There are various pathophysiological changes with electric burns. Vascular damage is greatest in the media. This can lead to delayed hemorrhage when the vessel eventually ruptures. Intimal damage may result in either immediate or delayed thrombosis in addition to vascular occlusion as edema and clots form on the damaged internal surface of the vessel over a period of days **[7,8]**.

Both low- and high-voltage electrical currents can interfere with the conducting system of the heart. Cardiac arrest, either from asystole or ventricular fibrillation is a common presenting condition in electrical accidents. Ventricular fibrillation is the most common cause of death at the scene. Acute myocardial infarction is reported but is relatively rare. Damage to skeletal muscles may produce a rise in the CPK-MB fraction, leading to a wrong diagnosis of myocardial infarction in some settings **[9]**.

Burns in severe electrical accidents often appear as painless, depressed, yellow-gray, punctate areas with central necrosis, or the areas may be mummified. High-voltage current often flows internally and can create massive muscle damage. If contact was brief, however, minimal flow may have occurred and the visible skin damage may represent nearly all of the damage. One should not attempt to predict the amount of underlying tissue damage from the amount of cutaneous involvement. The total body surface area affected by burns in electrical injury averages 10% to 25% **[7,8]**.

Fractures of most of the long bones caused by the trauma associated with electrical injury are reported. Both posterior and anterior shoulder dislocations caused by tetanic spasm of the rotator cuff muscles are also reported, as well as spinal fractures **[10]**.

The head is a common point of contact for high-voltage injuries, and the patient may exhibit burns as well as neurologic damage. Cataracts develop in approximately 6% of cases of high-voltage injuries, especially whenever electrical injury occurs in the vicinity of the head. Although cataracts may be present initially or develop shortly after the accident, they more typically appear months after the injury. Visual acuity and funduscopic examination should be performed at presentation **[11]**.

In high-voltage injuries, transient loss of consciousness may occur. Patients may exhibit confusion, flat affect, and difficulty with short-term memory and concentration. Electrical injury to the central nervous system (CNS) may cause a seizure, either as an isolated event or as part of a new-onset seizure disorder. Delayed neurologic damage may present from days to years after the insult. Specific complications of electric burns include neuromuscular complications as paresis, paralysis, Guillain-Barre syndrome, transverse myelitis or amyotrophic lateral sclerosis. Reflex sympathetic dystrophy (now more commonly known as complex regional pain syndrome), is also seen in these patients and presents with neuropathic pain, edema, and skin changes that may be disabling **[12]**.

A whole spectrum of neuropsychological issues may be present. These range from depression, cognitive dysfunction, memory impairment, attention disturbances, affective problems, anxiety, irritability and poor frustration tolerances, to physically aggressive outbursts. Post-traumatic stress disorder is also more common after electrical burns than after thermal burns **[13]**.

The ultimate goal of rehabilitation after burn injury is reintegration into society, which includes employment. A study in 363 burned adults who were employed at the time of injury demonstrated a mean time off work of 17 weeks. Only 37% returned to the same job, with the same employer, without accommodations in a detailed subgroup analysis. Based on current data, predictors of return to work include the following characteristics TBSA and burn site, Medical factors such as length of hospitalization and psychiatric history, Demographic factors including age, race, marital status, and employment status at the time of injury **[14]**.

Electric burn management entails the various body systems. All high voltage injury victims and low-voltage victims with cardiorespiratory complaints should have an ECG and cardiac isoenzyme eterminations. If any neurologic deterioration occurs after an electrical injury, a CT scan is indicated to assess for intracranial hemorrhage. Wound care follows the recommendations outlined in ABLS. Full thickness contact points are best treated with mefanide acetate ointment (sulfamylon). The excellent eschar penetration of sulfamylon makes this a good treatment option in these deep wounds, Silver sulfadiazine for flash and flame burn areas provides good broad spectrum coverage at low cost with few side effects.

Electrical burns are especially prone to tetanus, and patients should receive tetanus toxoid and tetanus immune globulin on the basis of their immunization history. In general, systemic antibiotics are not used unless culture or biopsy proves infection is present. Patients with heme pigment in the urine should be assumed to have myoglobinuria until the diagnosis can be excluded by more specific testing. Alkalinization of the urine increases the solubility of myoglobin in the urine increasing the rate of clearance. Urine output should be maintained at 1.0 to 1.5ml/kg/hr until all traces of myoglobin have cleared from the urine while the blood is maintained at a pH of at least 7.45 using sodium bicarbonate. Furosemide or mannitol may be used to cause further diuresis. An electrical injury should be treated like a crush injury, rather than a thermal burn, because of the large amount of tissue damage that is often present under normal-appearing skin. Fluids should be administered at a rate sufficient to maintain a urine output of at least 0.5 to 1.0ml/kg/hr in the absence of heme pigment in the urine and 1.0 to 1.5ml/kg/hr in its presence.

Current management of electrical injuries of the extremities favors early and aggressive surgical management, including early fasciotomy, carpal tunnel release, or even amputation of an obviously nonviable extremity. Extremities should be splinted in a functional position to minimize edema and contracture formation. During the first several days of hospitalization, frequent monitoring of the neurovascular status of all extremities is essential. ABA (American Burn Association) guidelines recommend extremity exploration for Progressive neurologic dysfunction, vascular compromise, increased compartment pressure with a pressure greater than 30mmHg is considered significant. Patients not meeting indications for exploration may be debrided on the third to fifth postinjury day. Elevated CK levels have been correlated to the extent of muscle damage and the requirement for surgical intervention. Four compartment fasciotomies of the lower leg and anterior/posterior fasciotomies of the upper extremity done in the operating room under general anesthesia is standard of care. Upper extremity decompression will generally require carpal tunnel release and may in some cases require release of intrinsic muscles of the hand **[10]**.

The one instance when immediate amputation is contemplated is in the setting of mummified and contracted tissue. This occasionally occurs and most commonly involves the upper extremities. Operative debridement can begin on post burn day two or three either as a second look operation following fasciotomy or as the first procedure. All necrotic tissue should be excised while tissue of questionable viability retained and re-evaluated every 2-3 days until wound closure is achieved **[10]**.

Patients who are totally asymptomatic and have a normal physical examination after low-voltage exposure can be reassured and then discharged without performing any ancillary tests. Those patients with cutaneous burns or mild persistent symptoms can be discharged if they have a normal ECG and no urinary heme pigment. The ED physician should provide out-patient referral in the event that current symptoms persist or new symptoms (delayed cataracts, weakness, or paresthesias) develop **[15]**.

Pediatric patients with oral burns may generally be safely discharged if close adult care is assured. In general, these patients require surgical and dental consultation for oral splinting, eventual debridement, and occasionally reconstructive surgery. After appropriate consultation, if hospitalization is not deemed necessary, the child's parents should be warned about the possibility of delayed hemorrhage and receive instructions to apply direct pressure by pinching the bleeding site and to immediately return to the ED **[16]**.

MATERIAL AND METHODS

From January 2010 to December 2014, a retrospective analysis of clinical records was performed for 1233 patients admitted to the Burn Unit in El-Kasr El-Eni University Hospital in Cairo. In this part of the study we found 118 electric burn patients of which we statistically analyzed.

From January 2015 to December of the same year we ran the prospective part of this study and 277 burn patients were admitted during this year of which 15 electric burn cases were documented and followed.

1- *The retrospective study:*

In the retrospective part (2010-2014), information regarding age, sex, TBSA and outcome were collected from the medical records as possible. Many files were missing important information which were not documented, and some files have contradicting information. No pictures were taken nor could progress of the treatment process be analyzed. This part of the study is mainly statistical analysis, as long as no patient could be interviewed or assessed, and files with missing information were excluded from our study due to the insufficient data.

2- *The prospective study:*

In the prospective part of this study, patients with electrical injuries were thoroughly interviewed and examined, of course after resuscitation, and information related to the study were taken including: Age, sex, TBSA, depth of the wound, injury mode, voltage of burn source, work up and pictures of the injured areas upon admission.

Electric burn patients were continuously followed to monitor the progress of treatment process and the patient's response. According to the set point by definition of low voltage burns, burns from electrical sources of <1000 volts were categorized as “Low Voltage burns” and other cases were considered ad “High Voltage burn” cases to compare clinical manifestations and outcome. Escharotomies, amputations, debridement sessions, ICU admission, grafting or flap coverage and other surgical interventions were all recorded and followed-up in the electric burn patients.

This study aims to focus on the prevalence and importance of high and low voltage electrical burns in our burn care unit and the outcome of the treatment plan through the last few years.

Treatment strategy in the prospective study:

Patients with low-voltage injuries were admitted to the general ward directly while patients with high-voltage injuries were admitted to the burn intensive care unit (BICU) for monitoring. Initial management included fluid resuscitation, electrocardiogram, and cardiac monitoring during the first 24h, escharotomy or fasciotomy was performed immediately in case of any potential peripheral circulation jeopardy. Urine analysis was evaluated for myoglobinuria and aggressive fluid resuscitation was performed in the presence of positive test to maintain urine output at 2ml/kg/h.

All necrotic wounds were removed by early excision to minimize the risk of infection. After these treatments, deep dermal thickness and full thickness wounds were covered using simple surgical procedures such as skin grafts or artificial dermis. If there were any exposed structures (e.g. bones, tendons, cartilage, nerves), appropriate flap surgeries were undertaken. Groin and abdominal flaps were the most frequently used coverage methods. Sometimes free flaps, mainly latissimus dorsi flap, were needed to reconstruct wide defects.

RESULTS

1- *The retrospective study:*

Out of 1233 total burn patients count admitted in the retrospective study, 118 patients where due to electric injury. This equals to 9.6% of the total burn patient's count.

Table (1- A): Results of the Retrospective Study (2010-2014).

Year	Total Burns				Electric Burns				
	#	Recovered	Died	Mort%	#	%	Died	Mort%	Elect Mort/All Burn Mort
2010	205	145	60	29.26%	16	7.80	3	2%	5%
2011	284	218	66	23.23%	29	10.20	6	2.10%	9.1%
2012	246	191	55	22.35%	25	10.20	1	0.40%	1.8%
2013	278	247	31	11.15%	28	10.10	2	0.70%	6.5%
2014	220	186	34	15.45%	20	9.10	1	0.50%	2.9%
Sum	1233	987	246	20%	118	9.6	13	11%	5.3%

Table (1-B)

Year	Total Burns			Electric Burns					
	Male	Female	Age 0-20	Female	Male	Age 0-20	Age 21-40	Age 41-60	Age >61
2010	134	71	102	2	14	3	11	1	1
2011	211	73	123	4	25	13	13	2	1
2012	154	92	122	5	20	11	11	3	0
2013	178	100	143	6	22	11	9	8	0
2014	140	80	114	4	16	4	13	3	0
Sum	817	416	604	21	97	42	57	17	2

Year	Elect.B. Min Age	Elect.B. Max Age	Elect.B. Average Age
2010	3	66	27.875
2011	1.6	57	22.124
2012	0.8	60	22.844
2013	1.5	57	26.267
2014	2.5	55	28.425
Total	0.8	66	25.1

Table (1-C)

Year	Mortality #	Amputation #	High Volt #	Low Volt #	Contact Burn #	Flash Burn #
2010	3	0	3	13	4	12
2011	6	1	9	20	9	29
2012	1	2	3	22	7	18
2013	2	1	4	24	12	16
2014	1	1	6	14	12	8
Total	13	5	25	93	44	83

Table (1-D)

Year	Mortality %	Amputation %	High Volt %	Low Volt %	Contact Burn %	Flash Burn %	Average TBSA
2010	18.80%	0%	18.80%	81.20%	25%	75%	22.25%
2011	20.70%	3.40%	31%	69%	31%	69%	30.97%
2012	4%	8%	12%	88%	28%	72%	24.36%
2013	7.10%	3.60%	14.30%	85.70%	42.90%	57.10%	25.14
2014	5%	5%	30%	70%	60%	40%	22.47%
Total	11%	4.2%	21.2%	78.8%	37.3%	62.7%	25.59%

Age, Sex, TBSA, and Distribution:

The average age of patients in the retrospective study was 25 years (range = 0.8-66 years). The average age in the high-voltage group was 17.743 years, while the low-voltage group average age was 26.174. The ratio of males to females was 4.6 males to each female in the whole group. The majority of all electrical burns occurred in patients aged 21-40 years (56 cases) then <20 years old (41 cases).

Average TBSA was 25% in all patients. The average TBSA was greater in the high-voltage group (38.94%) than the low-voltage group (20.16%). The hospital stay average in the high-voltage group was 5.79 days while in low-voltage group was 6.31 days.

Table (2): Age, Sex, TBSA, and Distribution.

Variables	Total, n=118	Low Volt, n=94	High Volt, n=24
Sex (Male to Female)	97:21 (4.6:1)	86:8 (10.75:1)	20:4 (5:1)
Age Average (years)	24.749	26.94	17.74
Range (years)	0.8-66	0.8-65	4-66
	Age distributions		
0-20 years	42 (35.6%)	29 (31%)	13 (54.2%)
21-40 years	58 (49.2%)	50 (53%)	8 (33.3%)
41-60 years	16 (13.6%)	14 (15%)	2 (8.3%)
>60 years	2 (1.7%)	1 (1%)	1 (4.2%)
TBSA	25%	20.16%	38.94%

Type and mode of electrical injury:

Thermal injuries with contact-type electrical burns were documented in 44 cases (37.3%) of electrical burn, 72 out of 94 low voltage cases showed flash burns, and the rest showed contact burn injury. Two cases out of 24 high voltage injuries showed flash burns and the rest were contact injuries. As a proportion, contact injuries were much higher in high voltage accidents while flash injuries were more common in low voltage cases.

Treatment method and amputation:

Out of the 118 patients of total electric burn number, 106 got sterile repeated dressing with Dermazine as the main treatment modality and no surgical intervention were documented to cover the wound. Twelve patients needed surgical reconstruction, either with full thickness, split thickness grafts or flaps to cover the burn wound. Eight cases where due to high-voltage injury and the rest were low voltage. In the low-voltage group no patient underwent an amputation, while in the high-voltage group, 5 out of 24 patients (21%) underwent an amputation, and all were males.

Mortality:

Out of 1233 burn patients admitted in the retrospective study, 246 patients died (20%), and out of the 118 (9.5%) electric burn cases admitted 13 (11%) patients died. One case was due to low voltage injury and 12 where in the high voltage group.

2- *The prospective study:*

In 2015, 15 out of 277 patients were due to electric wound and that equals to 5.4%.

Table (3): Type and mode of electrical injury.

Injury type	Total, n=118	Low Volt, n=94	High Volt, n=24
Flash	74 (62.7%)	72 (76.6%)	2 (8.3%)
Contact	44 (37.3%)	22 (23.4%)	22 (91.7%)

Table (4): Treatment method and amputation.

Treatment	Total, n=118	Low Volt, n=94	High Volt, n=24
Dressing	106 (90%)	90 (95%)	16 (71%)
Surgical	12 (10%)	4 (5%)	8 (29%)
Amputation	5 (4%)	0	5 (21%)

Table (5): Mortality.

Outcome	Total, n=118	Low Volt, n=94	High Volt, n=24
Recovered	105 (89%)	93 (99%)	12 (50%)
Died	13 (11%)	1 (1%)	12 (50%)

Table (6): The prospective study.

Total Burns #				Electric Burns				
#	Recovered	Died	Mort %	#	%	Died	Mort %	Elect Mort/ All Burn Mort
277	234	43	15.5%	15	5.4	2	13.33%	4.65%

Total Burns #			Electric Burns					
Male	Female	Age 0-20	Female	Male	Age 0-20	Age 21-40	Age 41-60	Age >61
180	97	144	2	13	7	7	0	1

Elect.B. Min Age	Elect.B. Max Age	Elect.B. Average Age
3	66	23

Mortality #	Amputation #	High Volt #	Low Volt #	Contact Burn #	Flash Burn #
2	6	10	5	14	1

Mortality %	Amputation %	High Volt %	Low Volt %	Contact Burn %	Flash Burn %	Average TBSA
13.33%	40%	66.7%	33.3%	93.33%	6.66%	19%

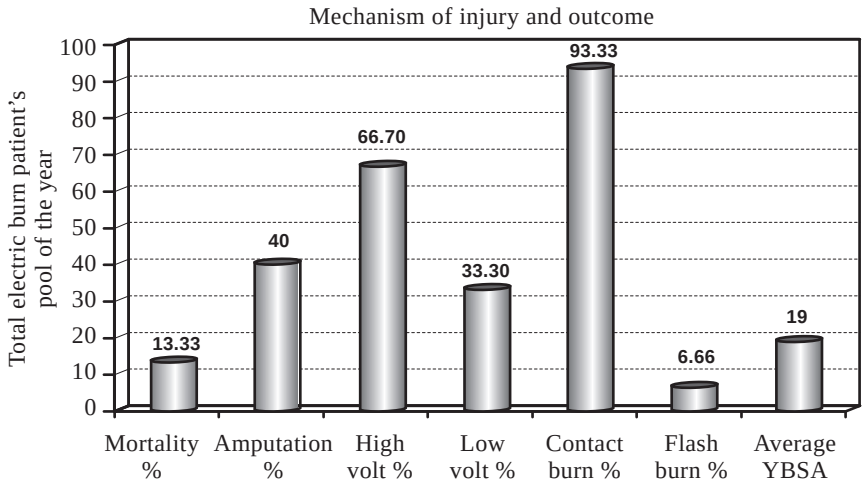

Fig. (1): Mechanism of injury and outcome.

Table (7):

Case	Age	Sex	TBSA	Stay	Voltage	Description
1	3	F	2%	3	Low	Left cheek superficial contact burn
2	13	M	3%	7	Low	Bilateral thumb superficial contact burn
3	5	M	3%	20	Low	Volar & dorsal right hand deep contact burn
4	27	M	3%	10	Low	Left dorsal hand deep contact burn
5	5	F	1%	7	Low	Left hand contact burn
6	35	M	20%	7	High	Upper chest and back superficial flash burn
7	16	M	20%	27	High	Right forehead/left arm deep contact burn
8	27	M	9%	22	High	Left arm circumferential deep contact burn
9	26	M	15%	20	High	Left arm/forearm and right axillary deep contact burn
10	27	M	7%	75	High	Right hand/wrist/knee and left foot deep contact burn
11	26	M	15%	12	High	Bilateral hand/arm deep contact burn
12	22	M	20%	21	High	Left face/shoulder and right big toe deep contact burn
13	8	M	20%	22	High	Left arm/forearm superficial burn, bilateral lower thigh deep contact burn
14	16	M	45%	65	High	High voltage deep contact burn
15	66	M	80%	4	High	Deep burn

Table (8):

Case	ECG	Basic Labs	Culture	X-ray	PT/OT*	Dressing	Debride	Flap Graft	Amput
1	Y	Y	N	N	N	Y	N	N	N
2	Y	Y	N	N	Y	Y	Y	N	N
3	Y	Y	N	Y	Y	Y	Y	Y	N
4	Y	Y	N	Y	Y	Y	Y	N	N
5	Y	Y	N	Y	Y	Y	Y	N	Y
6	Y	Y	N	N	N	Y	N	N	N
7	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	N	Y	Y	Y	Y	Y	N
9	Y	Y	Y	Y	Y	Y	Y	Y	Y
10	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	Y	Y	Y	Y	N	Y	Y	Y	N
13	Y	Y	N	N	Y	Y	Y	Y	N
14	Y	Y	Y	Y	Y	Y	Y	N	Y
15	Y	Y	Y	N	N	Y	Y	N	N

* Physical treatment/Occupational therapy.

Age, Sex, TBSA, and Distribution:

In 2015, 2 female patients were admitted with electric burn and 13 males. Patient's age ranged between 3 and 66 years with average of 21.4 years. The average age in the low-voltage group was 10.6 years and in the high-voltage group was 27.5 years.

Average TBSA was 18%. In the low-voltage group was 2% while in the high-voltage group was 25%. Average stay in the hospital was 21.4 days.

Table (9): Age, Sex, TBSA, and Distribution.

Variables	Total, n=15	Low Volt, n=5	High Volt, n=10
0-20 years	7 (46%)	4 (80%)	3 (30%)
21-40 years	7 (46%)	1 (20%)	6 (60%)
41-60 years	0	0	0
>60 years	1 (8%)	0	1 (10%)
TBSA	18%	2%	25%

Type and mode of electrical injury:

Contact injuries were observed in 14 cases, 5 low voltage cases and 9 high voltage cases. We documented 1 flash injury in a high voltage male patient.

Table (10): Type and mode of electrical injury.

Injury type	Total, n=15	Low Volt, n=5	High Volt, n=10
Flash	1 (7%)	0	1 (10%)
Contact	14 (93%)	5 (100%)	9 (90%)

Treatment method and amputation:

In 2015, 5 (33.33%) patients got sterile repeated dressing with Dermazine as the main treatment method for burn coverage, 8 (53%) patients got surgical intervention to cover their wounds, 5 flaps (1 groin, 2 abdominal flaps and 2 latissimus dorsi flaps) and 4 grafts were done.

Six amputation cases were observed; 1 female with low voltage injury (index) and 5 males in the high voltage group (2 forearms, 2 arms, 1 big toe, 1 index and middle finger).

Table (11): Treatment method and amputation.

Treatment	Total, n=15	Low Volt, n=5	High Volt, n=10
Dressing	5 (33.33%)	3 (60%)	2 (20%)
Surgical	8 (53%)	1 (20%)	7 (70%)
Amputation	6 (40%)	1 (20%)	4 (40%)

Mortality:

Out of the 277 burn patients admitted, 43 (15.5%) patients died. Fifteen (5.4%) electric burn cases were observed and only 2 (13.33%) cases had died and both were males and due to high voltage injury.

Table (12): Mortality.

Outcome	Total, n=15	Low Volt, n=5	High Volt, n=10
Recovered	13 (87%)	5 (100%)	8 (80%)
Died	2 (13%)	0	2 (20%)

Low Voltage Cases:

Fig. (2): A Case of low voltage face electrical burn in a 3 year old female child.

Fig. (3): A Case of bilateral low voltage thumb burn in a 13 year male patient.

High Voltage Cases:

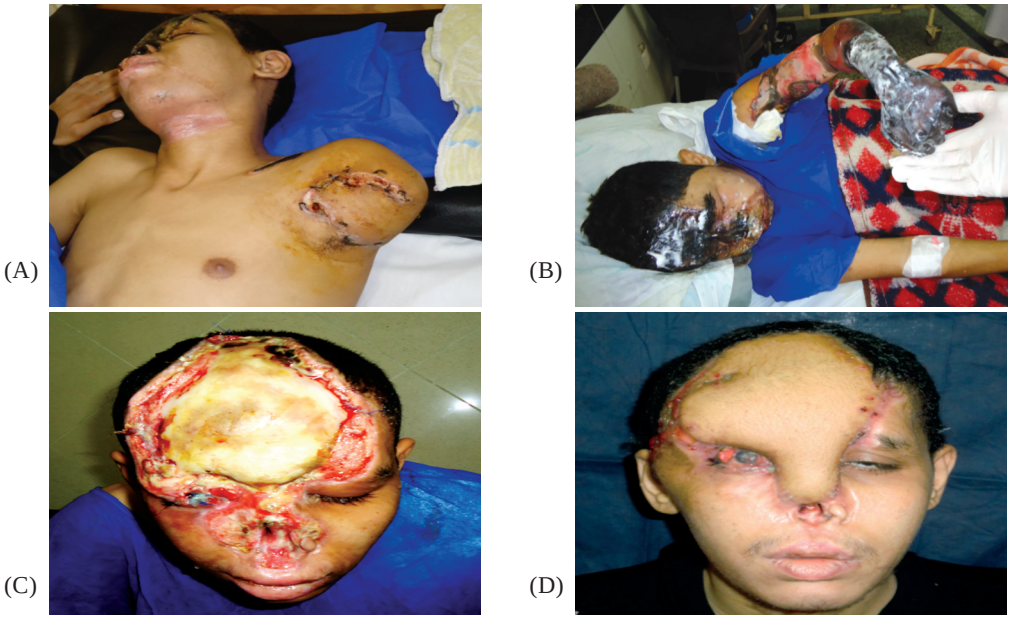

Fig. (4): A case of (A) Face, left arm, forearm and hand high voltage electrical burn in a 16 year old male on presentation, day 1. (B) Post amputation, 2 weeks later. (C) Facial burn preoperative, 1 month. (D) After flap coverage, 4 month.

Fig. (5): A Case of (A) High voltage electric burn in a 27 year old male patient. Right hand and wrist on admission. (B) On admission. Right thigh and knee burns. (C) Left big toe burn before amputation, 1 week.(d) Left big toe amputated, right wrist and knee wound before coverage, day 12. (E) Right wrist wound during operative coverage with abdominal flap. (F) During the operative coverage of the right wrist wound by abdominal flap. (G) End results of the abdominal flap in the wrist, 6 month. (H) Big toe amputated, post operative results. (I) Postoperative results of split thickness skin graft of the right knee wound, left anterior thigh is the donor site (healed).

Mortality Cases:

Fig. (6): A Case of 16 years old male electrical burn patient with TBSA 45%, upper limbs amputated. Patient died, 1 month.

Fig. (7): A Case of (A) Sever flame burn in a 66 year old male, no inlet or exit burn wounds were identified, day 1, died. (B) Sever flame burn in a 66 years old male patient, day 1, died.

Mortality cases in details:

Case 14: A 16 year old male patient who was diagnosed with high voltage contact electric burn of an estimated TBSA 45%, mostly deep burns and associated with multiple limbs fractures. The patient had an inlet electric burn in his arms and feet exit burn with few chest and back deep burns. Right arm below elbow and left above elbow amputations were done with external fixations for both lower limbs. Beside on-bed debridements and daily dressings, no other burn surgical treatments could be delivered to this patient due to the critical situation he had. Eventually the patient died because of septicemia.

Case 15: A 66 year old male patient was admitted in the burn unit in February of 2015 and transferred to the ICU to stay there fo r about three days then passed away. This patient had deep flame burn of an estimated TBSA 80% with no identified inlet or exit electric burns. He could not survive for more than three days and died because of systemic failure due to the severe and extensive deep burn he had. No specific surgical burn treatment was delivered to him besides the dressing due to his critical situation.

Obviously this patient is not an electrical burn patient; most probably it is caused by flame ignited by electric circuit, even though this patient was documented as “Electrical Burn Patient”.

DISCUSSION

Approximately 1000 deaths per year are due to electrical injuries in the United States, with a mortality rate of 3-5% **[2]**.

Electrical injury may be the end result of contact with faulty electrical appliances or machinery or inadvertent contact with household wiring or electrical power lines. Electrical injuries can be characteristically divided into high-voltage and low voltage injuries, using 1000V as the cutoff. High morbidity and mortality has been described in 600V direct current injury associated with railroad "third rail" contact **[17]**.

In Egypt, typical household electricity provides 200-240V for general use and high powered appliances, while industrial, electrical and high-tension power lines can have more than 100,000V.

This study attempted to show the prevalence of electrical burns in our unit and the epidemiological consideration of the difference between high and low voltage injuries. It comprises retrospective study including the years 2010-2014 and prospective study of the year 2015. The retrospective study is more of a statistical analysis of number of electrical patients and mortality rate, while in the prospective study in 2015 we were able to follow the electrical burn patients, treatment process, response and outcome.

In the retrospective section, 1233 burn patients were admitted in our unit, of which 118 were due to electric injury. Out of the 118 electric burn patients in the retrospective section, 21 females, 25 cases of high voltage burns, 93 cases were due to low voltage injury, 44 cases of contact injuries, 83 flash burn patients, 5 cases of amputation and 13 mortality cases.

In the prospective section, 277 burn patients were admitted, of which 15 were due to electric injury. Out of the 15 cases, 2 females, 13 males, 10 cases of high voltage burns, 14 cases of contact injuries, 1 flash burn patient, 6 cases of amputation and 2 mortality cases. Amputation cases were as following: 1 female with low voltage injury (index) and 5 males in the high voltage group (2 forearms, 2 arms, 1 big toe, 1 index and middle finger). Out of the 15 electric burn patients admitted in the year of 2015, 5 patients got sterile repeated dressing with Dermazine as the main treatment method for burn coverage, 8 patients got surgical intervention to cover their wounds: 5 flaps (1 groin, 2 abdominal flaps and 2 latissimus dorsi flaps) and 4 grafts were done.

In our study we found that the most common age group involved was between 21 and 40 years followed by ages younger than 20 years.

In Shahid Motahari Burn Hospital (Tehran, Iran) Dr. Yaser Ghavami and colleges conducted a descriptive cross sectional retrospective study on 682 patients with electrical burn from March 2007 to November 2011. Out of 6315 total burn patients they assessed 682 electrical burn patients (~10.8% of all burn patients); the average age was 29.4 years and 97.8% were males. The most common affected age group was the 21-30 year. The mean burn extent of TBSA was 14.43%. Severe morbidities caused 17 (2.5%) deaths. Amputation was performed in 162 cases (23.75%). High voltage electrical current (more than 1000 V) caused 72% of electrical burns. There was a correlation between voltage and amputation and also between voltage and fasciotomy, but there was no correlation between voltage and mortality **[18]**.

By comparing our study to the Iranian study, we find that we have almost the same incidence rate of electrical burns comparing to total burn number, although they have much higher patient's flow because the center has much bigger capacity. The most common affected age group was the same in both studies, but we have another peak in the group younger than 20 which stands behind the younger average age (25 years comparing to 29) probably because of the early age of which people start working in Egypt comparing to Iran. In Iran they have a higher male/female ratio (44:1) comparing to us (5:1) probably because females are involved in the working field in Egypt much more than the more conservative society in Iran. In another study in Turkey, 95% of their patients were also males **[19]**. In a study conducted in Taiwan, 92.5% of patients with electrical burn were males too **[20]**. We have a higher burn extent (TBSA%) probably because of other burn cases that were documented as “Electrical Burns” though they are not indeed. We have higher mortality rate too mostly due to the higher TBSA cases which have higher mortality rate too. Due to the missing data in the retrospective study, the amputation rate is very low, but in the prospective study is higher comparing to the Iranian study which is due to the fact that our cases were more severe (higher TBSA %). As in our study, most amputations were executed on fingers and upper limb. This is similar to the results of other studies by Sun, Buja and Tarim **[21-23]**. We do share almost the same percentage of high voltage/low injuries.

In South Korea, a retrospective study analyzed the clinical records of 625 electric burn patients admitted to Hangang Sacred Heart Hospital, Department of Plastic Surgery Burn Unit from January 2005 to December 2011. Out of this patient's group, 185 (29.6%) were due to low voltage injury and 440 (70.4%) due to high voltage injury.

This study showed that the mean age of all electrical burn patients was 33.4 years. The ratio of males to females was 13.5. The mean burnt area to the TBSA was 14.0%. The majority of electrical burns in the low-voltage group and high-voltage group occurred in patients under 20 years and in patients aged 40-59 years, respectively **[24]**.

Male proportion was higher in the high-tension group (99.1%) than in the low-tension group (78.9%). The mortality rate of electrical injury varied from 0% to 21.7% in other studies. Mortality rate was not calculated because non-surviving patients were not included in this study.

In the low-voltage group, 29 of 185 patients (15.6%) underwent an amputation while in the high voltage group, 329 of 440 patients (74.7%) underwent an amputation. Low voltage burns accounted for 29.6% of injuries and predominantly involved patients less than 19 years of age. On the other hand, high-voltage burns accounted for 70.4% of all electrical injuries and were observed in patients of working age (i.e. 20-50 years of age).

By comparing our study to the Korean's, they have higher number of electric burn patients included in the study which is due to the higher capacity in the Korean burn center and they covered longer period of time comparing to us. Much higher percentage of high voltage injuries in the Korean study comparing to us. Low-tension injuries comprise 72.8%-76.3% of all electrical injuries which

is very similar to our study. Our study showed that low voltage injuries predominantly involved patients in ages between 21-40 while high voltage injuries predominantly involved patients below 20 years of age. This age distribution is the opposite of the Korean study, probably because of the early exposure of high risk jobs in our country and the lower safety measures. In Korea, steel chopsticks are typically used in daily life; thus, many patients under 20 years of age were included in the low-voltage injury group, which explains the early peak of low voltage burns. Our study and the Korean's showed high male proportion in electrical burn, specially in the high voltage group since the high voltage group was primarily composed of males in the working age and the low voltage group was composed of young children, many of whom were female, on the other hand the burn's TBSA % was higher in the high voltage group comparing to the low voltage group, which is similar to our study, even though we have higher burnt TBSA % comparing to this study due to the lower safety precautions and sever burn cases we admitted **[24]**.

In the Korean study groin and abdominal flaps were the most frequently used coverage methods other than grafts in the high-tension group, which is similar to our study. Sometimes free flaps, mainly latissimus dorsi flap, were needed to reconstruct wide defects which is similar to our study too.

In Civil Hospital Karachi a retrospective hospital based observational study on patients admitted with electric burn injury from January, 2006 to December, 2011. Out of total 371 patients, 336 (90.5%) were males while 35 (9.5%) were females. Total male to female ratio observed was approximately 9:1. Patients ranged in age between 1 to 70 years. The average age of electric burn injury patients was found to be 27.35. The proportion of age-groups most affected by electric burn injury was between 21 and 30 years followed by 11 and 20 years **[25]**.

By comparing this study with ours, we find that they have higher electric burn incidence, otherwise we share almost the same parameters with the Pakistani study.

In Belarus, a survey was conducted from 2008 to 2012 at Gomel regional burn centre. During the four year period, 98 people were hospitalized as a result of an electrical injury. Electrical injury rates at males were much higher than at females. For both males and females, rates of hospitalized electric injury were the highest at the young adults (20-30 years) and children (0-16 years). The main part of burns was full thickness (66%) with involvement of 1-3-10% TBSA, other cases include partial thickness (24%) and superficial (10%) burns. The mean length of stay for cases of electrical injuries was 19 days. The majority of electrical injuries at adults tend to occur within a work environment while electrical injuries at children mostly occur at home. When we compare our study with this study, we find that we both have almost the same incidence rate of electrical burn; we both have close burn TBSA % and age distribution **[26]**.

According to American Burns association repository report 2011, cases of electric burns constituted 4.09% of all burns cases presented to American Burns Association. It accounts for 4% to 6.5% of all admissions to burns units in the United States and for approximately 1000 fatalities per year, with a mortality rate of 3-5% **[2]**. Comparing to the USA, we have close electrical percentage out of total burns, but we got higher mortality rate due to the difference in healthcare system, staff and equipment.

Conclusion:

Electric burns are not common yet dangerous especially direct contact burns. They represent about 7-10% of total burn cases admitted in our hospital. They are classified according to the source voltage into high voltage injuries (more popular between adults due to the high risk of contact with such a voltage because of work) and low voltage injuries (tend to be more common between younger ages and children). Initial management may need ICU or CCU admission for neurological or cardiological life threatening conditions. Wound management includes dressing, debridement and escharotomy when needed. Definitive treatment will be grafts or flaps according to each case. Amputation may be limb salvage in low voltage type or radical in high voltage type. Early physical treatment and rehabilitation measures are core segments in the treatment process and play crucial role in limiting morbidity.

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