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ORIGINAL ARTICLE

The Management of Electrical Burn

Ashok Surybhanji Gajbhiye · Mona M. Meshram · Rekha S. Gajaralwar · Amrish P. Kathod

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Abstract Aim of treatment is to achieve skin cover to prevent infection and to allow early mobilization. Electrical injuries are a relatively uncommon. Adult electrical injuries usually occur as an occupational hazard, whereas children are primarily injured accidently. The spectrum of electrical injury is very broad, ranging from minimal injury to severe multiorgan involvement, with both occult and delayed complications and death. This is a prospective study from Indira Gandhi Government Medical College, Nagpur. A total of 98 patients presenting from June 2002 to September 2011 were included. Patients were treated with surgical excision 31 (31.63 %), fasciotomy 26 (26.53 %), escharotomy 87 (88.78 %), and amputation 12 (12.24 %). In all patients debridement was performed. After follow-up, there was 8.16 % (8 patients) mortality. Minimal mortality may be due to less surface area involved or no visceral injury. Patients survived with morbidity due to amputation. Initial management of electrical burn is imperative to optimize function and minimize long-term scarring. However, further studies are required regarding flap repair and microsurgery to minimize the rate of amputation.

A. S. Gajbhiye (✉) · M. M. Meshram · R. S. Gajaralwar · A. P. Kathod
Department Of General Surgery,
Indira Gandhi Govt. Medical College,
Central Avenue road,
Nagpur -18 Maharashtra, India
e-mail: gsashok72@yahoo.in

A. S. Gajbhiye
e-mail: gsashok1972@gmail.com

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Introduction

Approximately 1,000 deaths per year are due to electrical injuries in the United States, with a mortality rate of 3–5 %. Electrical injuries are estimated to cause approximately 500–1000 deaths per year in the United States [1–5].

In the laparoscopic and robotic era, different types of electrical apparatuses are responsible for accidents. Sometimes this is due to the development of a defect in the insulation and therefore a frayed wire causes a short circuit, but sometimes it is due to faulty construction of assembly. Thus, in some instances it is found that the on–off switch has been incorrectly in the neutral instead of the live wire and therefore the element remains live even when the switch is in the off position. Destruction of human tissue by high-voltage electrical burn is very severe. Visceral injury is possible when the abdominal wall is involved, and early diagnosis and proper treatment of the injury are then very important (Figs. 1 and 2).

Pathophysiology and natural history of electrical injury have been well described. The tissue destruction is often severe and progressive due to vascular injury and prolonged production of thromboxanes induced by the electric current. The involvement of the abdominal wall may result in severe destruction of the wall itself and even the visceral organs. The gall bladder, liver, pancreas, intestine, and colon may all be involved [1, 2, 6].

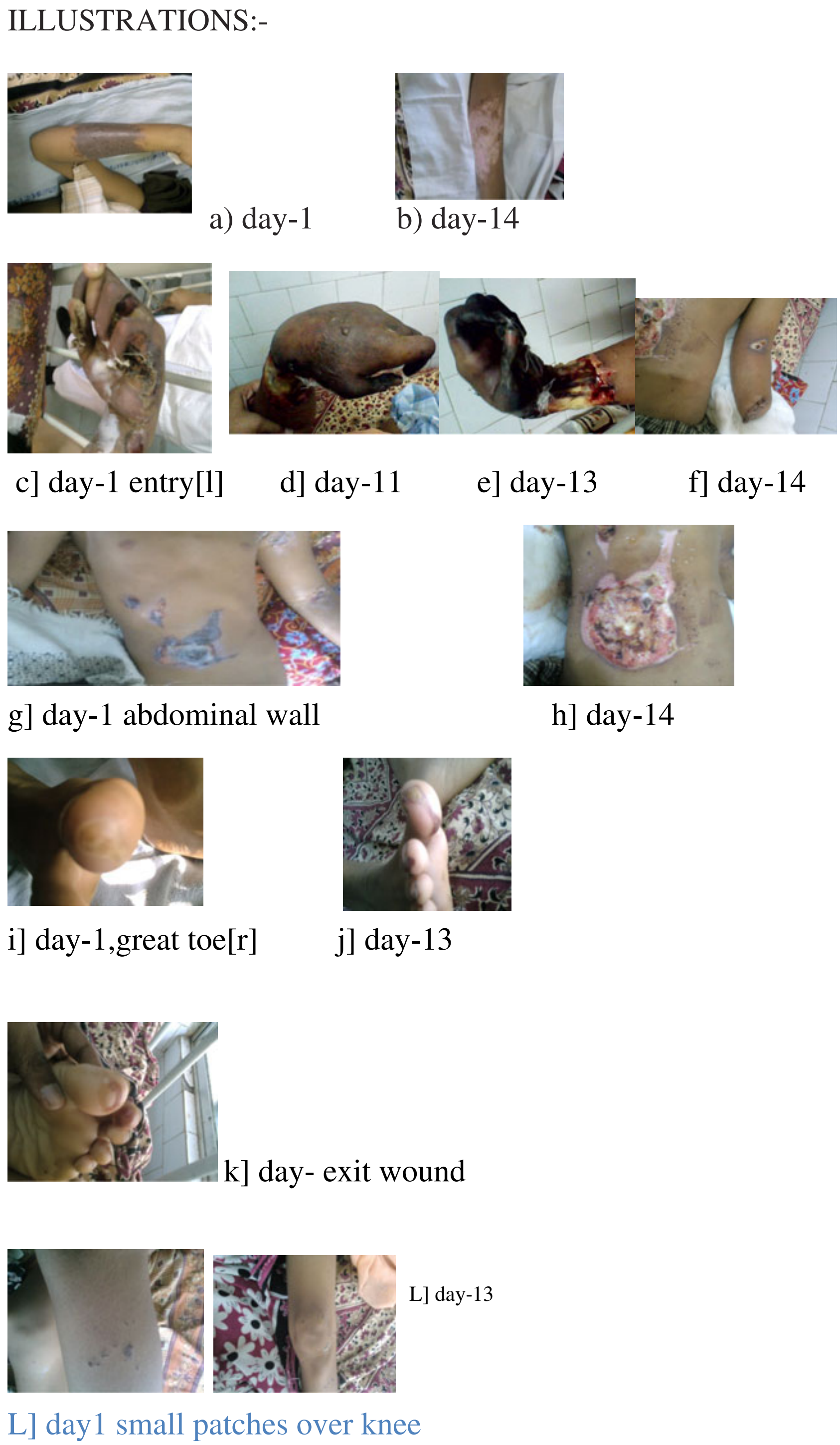


Fig. 1 High-voltage electric burns **a–l**

It is true that high temperature may be produced by the passage of electric current through the tissues, but the natural history of electric burn differs so clearly from that of thermal burn that it is impossible to avoid the conclusion that some specific effect is at least partially responsible for damage. The skin wound of an electrical burn is clearly circumscribed to the area of contact and this skin is dead (Fig. 3). Deep to the skin, the area of injury extends toward the other point of contact with destruction of deeper tissues. Because of their fluid content, main vessels form good

Entry Exit After Excetion

Fig. 2 Low-voltage electric burns

conduction and thrombosis of digital or other main vessels may occur with important consequences.

This article reviews the pathophysiology, clinical features, and treatment of patients with electrical burns. The clinical features and management are discussed and the literature is reviewed.

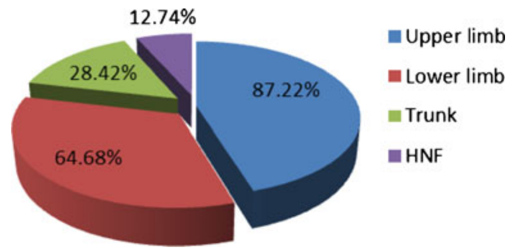
Patients and Methods

This is a prospective study of 98 patients with electrical burn injuries admitted to Indira Gandhi Government Medical College, Nagpur. Of 98 patients, 92 patients were admitted to the burn unit and 6 patients were admitted to the medicine intensive care unit. Those with an electrical injury were included in this study, and burns including scald, chemical, explosive, lightening, and thermal burn were excluded from this study.

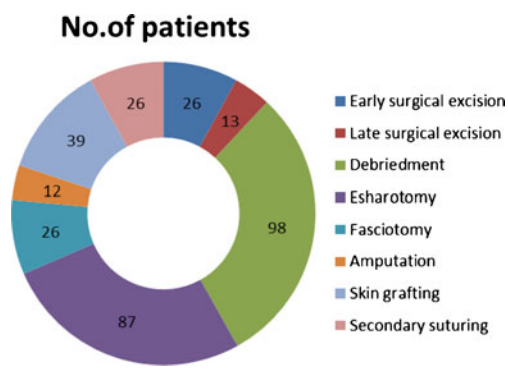
Once the patient is stabilized, the extent and depth of the burn is assessed. Routine laboratory investigation—urine-myoglobinuria, creatine kinase level, a 12-lead electrocardiograph, and cardiac enzyme levels—was done to assess for cardiac arrhythmias and direct cardiac injury. X-ray abdomen standing was performed to detect bowel perforation. Color Doppler examination was done in ischemia.

Results

Bar diagram- location of electrical burn



DOUGHNUT-Surgical treatment of electrical burn



Discussion

A total of 98 patients of electrical burn were included in this study which comprised 63 males (64.29 %) and 35 females (34.3 %). Mean age was 35.5 years in a range of 3–68 years. Maximum 17 patients (17.35 %) were presented in the year 2004 and minimum 2 patients (2.04 %) were present in the year 2002. Electrical injuries exist among the very young children (<6 years) and among young and working-aged adults [1, 7–10]. Patterns of electrical injury vary by age (e.g., low-voltage household exposures among toddlers and

Fig. 3 Different types of electrical burns

1] CONTACT ELECTRIC BURN

2] SUPERFICIAL ELECTRICAL BURN OVER KNEES (FLASH/FERNING) high-voltage exposures among risk-taking adolescents and via occupational exposure). Rates of childhood electrical injury are higher in boys than in girls [6]; 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. No racial susceptibility to electrical burns exists [7, 11–13].

In more severe burn, the separation of the slough may result in the exposure of tendon, joints, or bone, and if these are not protected by viable flap bearing their own blood supply, sloughing of tendons and sequestration of bone and cartilage will follow. In domestic supply accident, although the burn may be deep, the area of deep damage corresponds in lateral extent approximately with the area of skin damage and deep prolongation under intact skin is limited. Occasionally main vessels underlying or close to the burn are seriously damaged and progressive distal thrombosis may result in gangrene of a digit or rarely the distal part of a limb not itself actually burned [14].

In the present study of 89 cases (87.22 %) upper limbs were involved and of 66 cases (66.64 %) lower limbs were involved. The abdominal wall was involved in 5 (4.9 %) patients, but there was no evidence of intestinal perforation. In 67 cases of low-voltage injury, no other part of body was involved, and in 31 cases of high-voltage injury, other parts of body were involved. In 15–20 % patients, total body surface area involvement was observed. The majority (93.88 %) were work-related injuries, most of them (68.37 %) because of low-voltage (<1,000 V), most frequently electrical flash burns (64.68 %). Similar types of findings were observed in other studies [15, 16].

In high-tension injuries, the current may pass through the skin of the hand and up the centre of the arm as it would up the core of a conducting cable, and widespread necrosis of forearm muscles, vessels, and nerves may be present under undamaged skin. The current in these instances often finds its exit through the feet which may suffer comparable damage [17, 18].

Neurological (81.6 %) and psychological (71 %) symptoms were the most common sequelae. The most frequent neurological symptoms were numbness (42 %), weakness (32 %), memory problems (32 %), paraesthesia (24 %), and chronic pain (24 %). The most common psychological symptoms were anxiety (50 %), nightmares (45 %), insomnia (37 %), and flashbacks (37 %) of the event. These findings are comparable with those reported by different authors [3, 6, 16, 19].

In this study, immediate management is directed toward the preservation of life.

(1) Treatment of unconsciousness: In 8 (8.16 %) cases immediate endotracheal intubation with oxygenation was given at once and continued until recovery occurred or unequivocal signs of death were present.

(2) Shock: Surgical shock occurs only in high-tension injuries with extensive tissue damage. In these cases, red cell as well as plasma loss occurs and whole blood transfusion rather than plasma is indicated.

(3) Hot element burn: In this study, 5 (5.10 %) children were suffered from electrical appliance contact burn. They were treated by the conservative method till the slough had separated when thin split-skin graft was applied. In another 3 (3.06 %) cases, when the area of full-thickness loss was circumscribed, the burn was treated by early excision and application of thick split-skin graft or Wolfe graft. And under favorable circumstances, this primary operation may provide a satisfactory definitive repair. Debridement was done in the entire patients. Escharotomy was done in 87 (88.78 %) patients, and early surgical excision was performed in 23 (23.47.%) patients of low-voltage electric burn with split-skin grafting and out of which in 6 (6.12 %) patients, the graft failed to take due to infection. The most common causative organism was pseudomonas. The late surgical excision with grafting was done after 10 days in 8 (8.16 %) patients of high-voltage electrical burn. Amputation was done in 12 (12.24 %) patients of gangrene after development of line of demarcation. Fasciotomy and subsequently secondary suturing due to fasciotomy incision were performed in 26 (26.53 %) patients each.

Muir has suggested that treatment of more extensive burns is often difficult and there is no general agreement as to the best method to adopt. A brief review of the possibilities and arguments is therefore given.

(A) *Early excision and grafting*: The burn is excised down to bleeding and apparently healthy tissue and a free graft is applied. In some instances good results are obtained, but in others the graft fails to take, often tissue thought to be healthy becomes necrotic and not infrequently joints and tendon become exposed.

(B) *Late excision and grafting*: This is advised on the grounds that after 10–14 days it is easier to differentiate between viable and nonviable tissues, that further necrosis will not occur, and that grafts will take more readily. Examination of the records, however, has given no support to this hypothesis, for loss of graft, and further necrosis has occurred even excision has been delayed as long as 21 days.

(C) *Allowing spontaneous separation*: This exceptionally takes 4–6 weeks or more, and during the whole time the danger of infection is present. Even when spontaneous separation has occurred, the granulation is so unhealthy that free grafts will often not take, exposure of tendons or joints still occurs, and repair by flap is often necessary even after the long delay.

(D) *Excision and repair by flap*: Results show that this is a very satisfactory method with few failures and the flaps have taken well and given good cover when used at all periods after burning from the day of injury to the 21st day. This method owes its success to the fact that a flap of skin and fat bearing its own blood supply can resist infection and can protect viable but damage tissue from baneful effect of infection.

Repair by flap has a number of practical disadvantages if distant flaps (e.g., cross arm or abdominal) have to be used. The necessary positioning and immobilization of the hand may interfere with active movements and may take limitation of edema by elevation impossible. Furthermore, the patient will usually have to remain in hospital until the flap is divided. For these reasons, local flaps should be used whenever possible as these will permit immobilization in the position of choice and elevation. Cross-finger flaps are very suitable for burns of the palmer aspect of fingers and thenar flaps may be used for burns of finger pulp. On the dorsum of the hand, rotation or transposed flaps are of value although the limits between safety and necrosis are narrow and the surgeon should not be too ambitious. The palm of the hand presents greater difficulty. The inelasticity of the skin makes true rotation flaps unsuitable and transposed flap should be used with the greatest discretion. For extensive lesions, direct flaps from a distance become necessary. The opposite arm is usually a better site than the abdomen because it frequently allows better positioning of the fingers which very easily become stiff in extension if the hand is fixed to the abdomen.

As a rule every attempt should be made to preserve and repair fingers which promise to retain or regain good function, but if tendon or joints are obviously seriously damaged then early rather than late amputation should be considered. In this connection it should be remembered that it is frequently possible to retain a useful amount of skin of an otherwise useless finger and that this may make an excellent flap for repairs of the palm or adjacent finger. If tendon or joints become exposed during the course of surgical excision or following the failure of a free graft, then repair by flap becomes urgent if these structures are to be saved [14].

Wang has stated that in high-tension injuries destruction of tissues is so extensive that it is often impossible to employ the most desirable methods of local treatment and less reliable methods have to be used. The assessment of the depth and extent of electrical burns may be difficult initially because previously healthy muscles may necrose later on if the nutrient vessel thromboses due to thermal effect induced by the electrical energy. Sometimes visceral injuries are obvious, but often the initial signs and symptoms are very slight due to delayed perforation and the masking effect of the abdominal burn wound.

Initially, to obtain maximal penetration of the burn eschar, the hand is dressed with mafenide cream (Sulfamylon cream) until surgical debridement can be performed. Fasciotomies and escharotomies should be performed within 6–8 h of injury if compartment syndrome is suspected. Clinical signs such as edema, pain with passive motion, and subjective firmness of the compartments are adequate indicators of the need for compartment release. It is essential that all compartments of the hand and potentially the forearm, both dorsal and volar, as well as all digits, Guyon's canal, and the carpal tunnels are released. Serial debridements should then be performed in preparation for definitive reconstruction [14].

This study shows the incidence of complication of hypertropic scar seen in 6.12 % cases, which was managed conservatively. Keloid was seen in 2 (2.04 %) patients, which was managed by steroid (local injection), and contracture was seen in 2 patients, which was released with skin grafting. These findings are comparable with those reported by different authors [16, 19].

Due to the nature of occupational hazards with electricity, electrical injuries represent the fourth leading cause of work-related traumatic death (5–6 % of all workers' deaths) [17]. Morbidity and mortality are largely affected by the particular type of electrical contact involved in each exposure. Overall mortality is estimated to be 3–15 % [1, 11]. There were 8 (8.16 %) cases of mortality. Minimal mortality may be due to less surface area involved or without visceral involvement. Patients survived with morbidity (10.20 %) due to amputation in the present study. This is compared and correlated well with those of different series [1, 11, 16, 17, 19].

Thus, it is concluded that initial management of electrical burn is imperative to optimize function and minimize long-term scarring. However, further studies are required regarding flap repair and microsurgery to minimize the rate of amputation.

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