PAEDIATRIC ELECTRICAL BURN INJURIES: EXPERIENCE FROM A TERTIARY CARE BURNS UNIT IN NORTH INDIA

BRÛLURES ÉLECTRIQUES PÉDIATRIQUES: L'EXPÉRIENCE D'UN CTB RÉFÉRENT EN INDE SEPTENTRIONALE

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SUMMARY. Electrical burn injuries in the paediatric age group constitute a small proportion of all burn cases and cause significant morbidity and long-term psychosocial impact. The objective of this study was to evaluate various aspects of electrical burn injuries in the paediatric age group in our region. A retrospective review was done of all paediatric electrical burns admitted to a tertiary care burns unit over a period of 12 months (January 2016 to December 2016). There were 77 cases of electrical burns under the age of 16 years. High voltage burns predominated and older age groups were more frequently affected. Male:female ratio was 4.1:1. Amputations were required in 18 (23%), skin grafting in 52 (67%) and flap cover in 29 (37%) patients. There were unfavourable outcomes in 32% patients with a mortality rate of 7.8%. Significant association was found between unfavourable outcomes and high voltage burn injuries and length of hospital stay. The impact of electrical burn injuries is substantial and can be reduced by simple preventive measures such as educating parents, improving health infrastructure and adherence to safety regulations.

Keywords: paediatric, electrical, burn, prevention

RÉSUMÉ. *Les atteintes électriques représentent une petite partie des brûlures de l'enfant, mais sont responsables d'une morbidité et de séquelles psycho-sociales importantes. L'objectif de cette étude était d'évaluer les divers aspect de cette pathologie dans notre région. Une revue des dossiers des patients admis pour cette raison dans notre service en 2016 a été réalisée. Soixante dix sept patients de moins de 16 ans ont été hospitalisés pour brûlure électrique. Le groupe à risque était celui le plus âgé, et l'atteinte par haut voltage prédominait. Les sex ratio était de 4,1/1. Des amputations ont été nécessaires 18 fois (23% des cas), des greffes 52 fois (67%) et des lambeaux 29 fois (37%). L'était de santé à la sortie était considéré comme dégradé chez 32% des patients, la mortalité était de 7,8%. L'état de santé obérré à la sortie corrélait avec le haut voltage et la durée de séjour. Les conséquences des accidents éléctriques sont majeures alors que des mesures simples de prévention comme l'éducation, l'observation des règles de sécurité et l'amélioration des structures de santé pourraient les limiter.*

Mots-clés: *brûlure électrique, enfant, prévention*

Introduction

Electrical burn injuries (EBIs) constitute a small fraction of total admissions to any burns unit with a reported incidence of about 5-7% of all burns.[1] These injuries are most commonly accidental and occupational.[2] EBIs are the most disastrous when compared to other forms of burns involving the same surface area.

Electrical burns in the paediatric age group are different in etiology to those in adults, and present a unique challenge regarding management. A child is unwary, impulsive and inherently curious by nature, and may suffer uncommon and more severe forms of electrical burn injuries. In a developing country such as ours, a recent increase in accessibility to electricity in remote areas coupled with a lack of safety awareness among the public has compounded the problem.

The devastating sequelae in paediatric burn survivors through adulthood are well known.[3] There is a lack of comprehensive preventive measures and paucity of articles that specifically focus on paediatric electrical burn injuries. This led us to conduct a study to evaluate the various aspects of EBIs in the paediatric age group in our region and provide data to help investigate and formulate more effective preventive measures.

Materials and methods

Medical records were retrospectively reviewed for all patients under the age of 16 years who were admitted to the Burns Unit of the Department of Burns and Plastic Surgery in our institute for evaluation and management of electrical burn injuries over a period of 12 months (January 2016 to December 2016). The district of Jaipur has a population of over 6 million. Our Burns Unit, functioning from 1988, is a tertiary care referral centre, the largest in Rajasthan, and caters for not only Jaipur but also for neighbouring districts in the state and other states as well.

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Details of demographic data, mode of injury including voltage and time interval from injury to presentation, body regions involved, associated injuries, investigations, length of hospital stay, details of surgical procedures and outcome were collected. Data were collected by the authors from the burns proforma. Parents or guardians were contacted by phone whenever required information was not available.

Injuries were classified into low voltage (<1000V) and high voltage (>1000V). Outcome was categorized as favourable or unfavourable ('grievous injury resulting in permanent disability', 'amputation' or 'death').

The qualitative data were expressed in proportion and percentages and the quantitative data expressed as mean and standard deviations. The difference in proportion was analysed by Chi-square test and the difference in means by student *t*-test. Statistical analyses were done using SPSS software for Windows Version 23.0 (Armonk, NY). A *p*-value of <0.05 was considered to be significant.

Results

Demographic data

There were 1672 admissions to the Burns Unit in the year 2016. A total of 375 patients had suffered electrical burn injuries (EBIs) of which 77 were in the paediatric age group.

The youngest patient was aged 3 years and the oldest was aged 16 years. (mean = 11.52±4.1 years). Incidence of high voltage EBIs increased with increasing age (*Table I*). Boys (*n*=62; 80.5%) were more commonly injured than girls (*n*=15; 19.5%) with an overall male:female ratio of 4.1:1. This ratio was comparable in all age groups irrespective of voltage of injury. Patients largely belonged to rural areas (*n*=56; 72.7%) rather than urban areas (*n*=21; 27.3%).

Mode of injury

There were 15 (19.5%) low voltage (LV) burns and 62 (80.5%) high voltage (HV) burns. High voltage burns were more common in older age groups compared to low voltage burns ($p<0.01$). Low voltage electrical burn injuries were almost always due to household mishaps while high voltage burn injuries mostly occurred outdoors (*Table I*).

The time interval between injury and presentation ranged from 2 to 12 hours with a mean of 5.35±2.6 hours. This time interval was significantly greater in patients from rural areas ($p<0.05$).

Table I - Type of voltage, mode of injury and age

Voltage	Mode of injury	Age (in years)				Total
		0-4	5-8	9-12	13-16	
Low voltage	Biting electric wire	3	1	0	0	4
	Contact with low-voltage wire or electrical appliance	2	1	0	4	7
	Placing object in wall socket	0	2	1	1	4
High voltage	Contact while playing in field	1	4	7	10	22
	Contact on house roof	0	4	5	4	13
	Contact on balcony	0	1	3	4	8
	Contact while climbing tree	0	0	3	7	10
	Contact while flying kite	0	0	1	5	6
	Falling live wire while walking or in a vehicle	1	0	2	0	3
Total		7	13	22	35	77

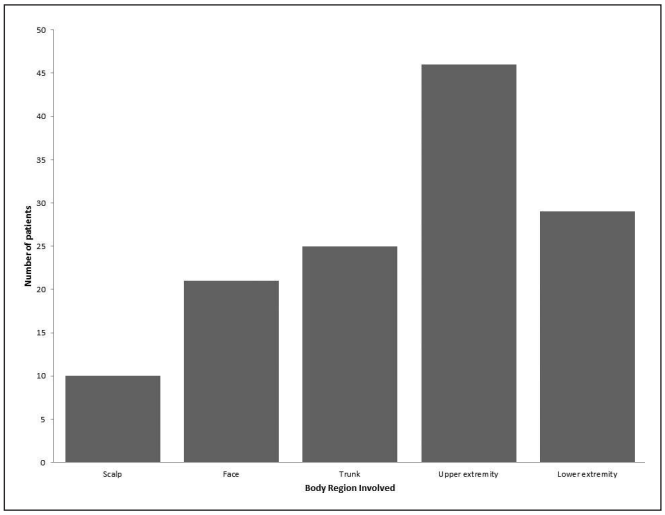

Fig. 1 - Summary of body regions involved.

Body region involved

Upper extremity was most frequently involved followed by lower extremity, trunk, face and scalp (*Fig. 1*). Involvement of multiple regions was almost the norm in HV injuries (60/62), but less common in LV injuries (5/15).

Associated injuries

Seven patients (9.1%) had concomitant injuries. Three patients had closed head injury - two were managed conservatively and one underwent drainage of extradural hematoma. One patient had a mandibular fracture managed by intermaxillary fixation. One patient had a fractured humerus and one had a compound calcaneal fracture; both were managed with help from the Department of Orthopaedics. One patient who suffered contact burns over his face and scalp had irreversible loss of vision in the right eye.

Investigations

Electrocardiograms (ECG) were performed for all patients on admission and were found to be abnormal in seven cases - five patients had sinus tachycardia and two had ectopic beats; all cases settled spontaneously over 24 hours without specific intervention. Creatine phosphokinase (CPK) test was ordered for 55 patients of whom 29 had elevated levels. CPK was ordered more frequently for patients with high voltage burns (54/62 vs. 1/15). Myoglobinuria was noted in six patients with high voltage burn injuries.

Length of hospital stay

The length of hospital stay ranged from 1 to 67 days. Mean hospital stay was significantly longer in patients with high voltage injuries (24.4±11.7 days) than in those with low voltage injuries (6.1±5.7 days) ($p<0.01$).

Surgical procedures

Escharotomies were required in 14 cases with circumferential burns to the extremities. Twenty-five patients underwent fasciotomies – 18 in the upper extremities, 2 in the lower extremities and 5 in both. All patients who required fasciotomy had suffered high voltage burns. Fasciotomies were performed early (within 24 hours of injury) for 17 patients. Subsequent rate of amputations was higher in those with late fasciotomies,

but this difference was not significant (p=0.73).

Broadly categorized, the various surgical procedures were amputation, split-skin grafting and flap cover. Dressings and minor procedures in the form of local debridement or primary repair were required for almost all patients and were not assessed separately.

Split skin grafting (n=52), alone or combined with other procedures, was the most frequently performed surgery. A graft take of more than 95% was recorded in forty-one patients (79%), nine patients required supplementation of graft, while two patients recovered with dressings alone.

Flap cover was required in 29 patients (*Table II*); three patients required multiple flaps. Thirteen local flaps and nineteen distant flaps were performed. Free flaps were employed in seven patients - four latissumus dorsi muscle flaps (2 for scalp defects, 2 for lower extremity defects), two radial artery forearm flaps for defects involving the mouth and nose, and one anterolateral thigh flap for a heel defect. The planning and timing of free flaps were individualized and tailored to each patient. All the flaps healed well, barring one groin flap in which there was suture dehiscence and required revision.

A total of 18 patients underwent amputations. Eleven patients had amputations of multiple regions. A summary is depicted in *Table III*.

Table II - Summary of reconstructive flap surgeries

Type of flap	Number of patients
Local	
Paramedian forehead flap	2
Latissimus dorsi flap	2
Local transposition flap	9
Distant	
Groin flap	8
Cross-leg flap	4
Latissimus dorsi free flap	4
Radial artery forearm free flap	2
Anterolateral thigh free flap	1

Table III - Summary of amputations performed

Amputated structure	Number of patients
Fingers	9
Toes	7
Upper extremity, below elbow	6
Upper extremity, above elbow	2
Lower extremity, below knee	4
Lower extremity, above knee	1

Outcome

Unfavourable outcomes were encountered in 25 patients (32.5%): six patients (7.8%) succumbed to their burn injuries (*Table IV*), eighteen patients (23.4%) had amputations and one patient (1.3%) had complete loss of vision in the right eye. Renal insufficiency was not observed in any patient.

High voltage injuries (p=0.01) and longer hospital stay (p=0.02) significantly correlated with unfavourable outcome, whereas gender (p=0.85) and time interval (p=0.15) did not affect outcome.

Discussion

Resistance offered by various tissues to the flow of electricity differs, with bone being the most resistant. Hence, muscles and neurovascular structures face the major brunt of damage.[4] Severity also depends on the voltage, type of current, wetness of the skin and duration of exposure, among other factors. The extent of injury is not always evident superficially, and even a benign-looking burn can cause grave complications. The risk of deep tissue injury is compounded in children owing to different surface area to volume ratios and lower overall fat content.[5]

Electrical burns in the paediatric age group constitute from 2% to as high as 10% of all burn admissions both in India and across the world, according to different studies.[6,7,8] Such burns accounted for 4.6% of admissions in this study, up from 1% in 1990.[9] Furthermore, high voltage EBIs accounted for over 80% of them. Increase in population, early referrals, accessibility of electricity and rapid industrialization over the years may have a role to play in this increased incidence.

Boys and older age groups were seen to be most frequently affected - a trend that is similar to other studies.[6,10,11] This can be attributed to increased outdoor activity thereby exposing them to high tension power lines. Kite flying, a common and popular sport especially in rural areas, is an interesting mode of injury that has been previously reported.[12] Another unusual mode that affected 3 children was a high-tension wire falling on them while they were walking or in a vehicle.

Patients from rural areas had a significantly longer time interval before presentation. Ridiculous first aid measures like application of ink, toothpaste, cow dung, turmeric powder, honey and other homemade remedies are, surprisingly, not rare even today.[8] Ignorance and illiteracy coupled with lack of expertise and poor health infrastructure are major concerns in rural and remote areas.

All patients with abnormal ECGs recovered spontaneously, and elevated CPK levels did not significantly correlate to unfavourable outcome. These findings are consistent with other studies.[1,13,14]

Table IV - Summary of mortality

Patient No.	Age / Sex	POR (Urban/Rural)	Time interval from injury to presentation (in hours)	Length of hospitalization	Volt (High / Low)	Body regions involved	ECG	CPK	Myoglobinuria
20	12 / Male	Rural	11	1	High	F,T,U,L	A	Elevated	Present
31	10 / Female	Rural	5	3	High	F,T,U,L	A	Elevated	Present
59	14 / Male	Urban	2	2	High	S,F,T,U,L	N	Elevated	Absent
62	15 / Male	Rural	6	10	High	T,U,L	N	Normal	Absent
69	9 / Male	Urban	3	1	High	T,U,L	N	Elevated	Present
75	15 / Male	Rural	6	1	High	S,F,T	N	Normal	Absent

*POR = place of residence; Body regions involved: S = Scalp, F = Face, T = Trunk, U = Upper extremity, L = Lower extremity; ECG: N = Normal, A = Abnormal

Alternating current produces muscular contraction and relaxation with each cycle, which may lead to associated injuries. We observed such injuries in about 9% of patients. Early interventions, when required, have shown better outcome.[15,16]

EBIs are responsible for a high number of major extremity amputations, resulting in lifelong disability in young individuals.[17] Surgical management of electrical trauma, especially in the paediatric patient, continues to be a major challenge.[18] Traditionally, the reconstructive ladder advocated a step-wise approach for surgical defects, moving up the rungs from the simplest to more complex procedures. However, patients with electrical burn defects may require a more individualistic approach to moving up the ladder. More than half the patients in our study required major surgery in the form of amputations and immediate reconstruction.

Various series report EBI-related mortality ranging from 1 to 17%.[6,19-21] We noted an overall mortality rate of just under 8% of patients, all of whom had suffered high voltage EBIs. It is important to note that a large number of these patients belong to rural areas. Pre-existing diseases and malnutrition may frequently be encountered in such children. As a result thereof, these children have a reduced ability to compensate for the physiological stress inherent in such injuries.[22]

A primary limitation of the study was the population base, due to the virtue of being a tertiary care referral centre for burn injuries. Minor electrical injuries that did not require referral may have been missed, as were those that were immediately fatal. The study may over-represent patients with serious high voltage injuries while at the same time under-represent low voltage burns. The criteria for admission in EBIs are not uniform in the literature; nevertheless, admission is almost always indicated in high voltage burn injuries.[23,24] On the other hand, recommendations for admissions for low voltage burns have gradually evolved from mandatory admission to a more selective approach.[10,14]

The old adage 'an ounce of prevention is worth a pound of cure' can be aptly applied here. Lethality of faulty placement of power lines can be prevented by simple measures, from identifying trees that contain power lines to regulating the location of power lines with respect to physical structures.[21] Rules have been laid out under the Indian Electricity Act 2003, and should be strictly adhered to.[25] Parents should be educated about safety and hazard-prevention. It is equally important to train doctors and other health personnel in the peripheries to deal with such injuries. Prompt referral and an effective transport infrastructure are crucial. National programs can be made sustainable and more effective by using data from studies such as ours to develop targeted community-based prevention, as evident in literature.[26-28]

Conclusion

Electrical burn injuries are a preventable danger, more so in the paediatric age group. The long-term physical and psychological stress is profound. The importance of burn prevention by educating parents about safety measures, improving health infrastructure, a dedicated national program for burns and adherence to safety regulations with respect to placement and maintenance of power lines cannot be over-emphasized.

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