



Acute electrical injury: A systematic review

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ABSTRACT

Objective: To review low-voltage, high-voltage and lightning electrical burns in adults and children, identify novel areas that are not recognized and improve treatments results and outcome.

Methods: An extensive literature search on electrical burn injuries was performed using Ovid Medline, PubMed and Embase databases from 1976 to 2016. Studies related to electrical injury in the adult and children (< 15 years of age) population were included in our study. Fifty-one research papers and review articles were identified and included in this study.

Results: Total occurrence of electrical injury among burn injuries ranged from 3.5% to 15.0%. Most of them were low voltage (73%) and one fourth were high voltage and percentage of lightning injuries were very low around 2%–4% of total cases of electrical injury. Mortality is somehow higher among high voltage electrical injuries and lightning. Most of complications of them were morbid in kidney, heart, extremities (including amputations) and nervous systems. Long-term psychological problems were reported with greater incidence rates in high-voltage injuries. Psychological and posttraumatic stress disorders were also reported. Mortality rates from electrical injuries were 2.6% in low voltage and 5.2% in high voltage.

Conclusions: High-voltage injury leads to greater morbidity and mortality than low-voltage one. Lightning has mortality of about 32%, higher rates of complications and specialty long-term complications. Strict multi-specialty treatment and rehabilitations are required for proper treatment of electrical injuries.

1. Introduction

Electrical injuries, though uncommon, are among severe burn injuries and have multiple organ involvement. Multi-specialty treatment group is needed in order to have good and reasonable results[1-5].

Several complications and sequel have been reported after electrical injury[6-10]. These should be in the mind of attending physicians to prevent and treat the special complications that may happen for the patients. Kidney, heart, nervous system, musculoskeletal system, eyes and ears are among the organs that may be affected during the process of injury[11-16].

In this report, we systemically surveyed all articles about

electrical injury during last 40 years and some of the important guidelines will be provided for the physicians who treat electrical injury patients.

2. Materials and methods

Three search engines, Ovid Medline, PubMed and Embase databases from 1976 to 2016 were used by searching the following key terms: electrical injury, electrical burn, high voltage, low voltage, lightning, adults, children, electrical injury complication, electrical injury sequel, mortality, morbidity and amputation.

All relevant papers were chosen and their data were used for the present systemic review manuscript. This systematic review article has been written on the base of these researches.

3. Results

We found 247 papers and some of them were not relevant.

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After omission of some of them, 51 papers were selected for the systemic review article.

All of the 51 papers were studies which met the inclusion criteria. Different sources of electrical injury and different classifications were reviewed.

The rate and percentage of low voltage injury was 73%. High voltage was 25% and lightening was about 2%–4% of all electrical injury[4,17].

Mortality was higher in lightening and high voltage groups. Morbidity was higher in high voltage group comparing with morbidity in low voltage group[18-20]. Cardiac electrical injury and dysrhythmia were higher in low voltage group[4,6,21]. Cardio-respiratory arrest was higher in lightening group. Most of electrical injury was reported out of home and in workplace. Although in children below 6 years old it is reported in home and low voltage, in adolescence it is reported during summer, during leisure activities and out of the home, in open areas. Electrical injury has been reported mostly in spring and summer with wet body either due to working and sweating or due to heavy rain[22-26]. Lightening is reported mostly in summer and heavy rain, near a tree or tall structure or in open space, when having a metallic object in hand or near the bare body and in 15% cases multiple victims are affected[17,20,27-30].

High-voltage injury is defined as more than 1 000 volts and low voltage is defined as less than 1 000 volts, mostly between 220–360 volts[4,8,17,22]. Lightening is more than 200 000 to 300 000 volts and in a small percentage of one second[18,19,31,32].

Direct electricity has been reported to have higher burn injuries specially in extremities[4,5,7,8]. High-voltage injury has more extremities and muscle injuries, but low-voltage injuries cause more cardiac dysrhythmia, although both can be seen in both injuries[2,11,13,19,21].

Factors that determine the severity of injury include voltage, amperage, duration of injury, path of injury in the body, resistance of the body, type of current (direct or indirect) and individual characteristics[4,20].

The basic fundamentals for treatment of these injuries are basic trauma resuscitation, decompression and debridement, early definitive closure[10,33-37] and treatment of special parts of body like hand and elbow, splinting, rehabilitation[38-43] and neurological and psychological support[44-50].

4. Discussion

Electrical injuries have many adverse effects and have several direct, immediate and long-term or indirect sequels. In process of treatment and caring for electrical injuries, several important guidelines are recommended.

First, the electricity should be discontinued (safety of the medical personnel). Second, the patient should be removed from the site of injury. Third, as a severe trauma patient, he should be cared and treated. Airway, breathing, circulation and diagnosis are important and cannot be emphasized further[1-4].

If there is cardio-respiratory arrest, this should be attended first then removing the clothes and evaluation of the burn injury will be done[4,21-23].

Sites of electrical injury (input and output sites) are obvious as they are a 3rd or 4th degree burns with complete necrosis of the skin and sometimes necrosis of the tissues below the skin such as fascias, nerves, muscles, tendons, vessels and bones. Normally surface of these areas are very small and not more than 1% of total body surface area. But in the path of the current, most of the deep muscles and sometimes even superficial muscles have been burnt due to extreme heat that are produced with high resistance of the bones and voltage of the current. The heat produced is directly related to resistance of that part of body and second exponential of voltage. So in high-voltage injuries, we have much more extensive muscle injuries and burns[4,17]. Necrosis of muscles will have two consequences: release of myoglobin that may produce renal shutdown, and severe edema in the compartments that will result in compartment syndrome and require escharotomy and fasciotomy.

Electrical injury will have injury to conduction system of heart and will produce arrhythmias from the first seconds of the injury, so cardiac monitoring and electrocardiograph are very important in this regard and any arrhythmias should be treated promptly.

Contractions of the muscles due to electricity would have produced fractures in the bone especially in the cervical vertebral bones and long bones of the body such as humerus and femur.

Necrosis of the muscles in the closed compartments of the extremities is a good place for anaerobic bacteria and anaerobic infections such as clostridia which are frequently seen with these necrosis. These infections should be prevented by parenteral intravenous injection anaerobic antibiotics and early debridement of the site, to open the site to the air and have an aerobic environment[4,8,17,22].

Skin necrosis in the sites of adherence should be evaluated and in 24–48 h should be debrided. And debridement will follow every 48 h until a good and alive tissue is encountered. After that, early coverage of the wounds are recommended by most of the authors. Only in some special areas, late treatments are recommended such as lips, tongue, orbital sockets and penis. In these areas, conservative treatments are recommended.

In lightening group, cardio-respiratory arrest would be seen frequently and long term resuscitation and cardio-pulmonary resuscitation are recommended (sometimes more than 1 h), as

most of these patients will recover from the arrest[18,19,31,32].

Lightening are in different types such as ribbon lightening, flash lightening, and bolt lightening, and so on. And one of the main pathognomonic sign of this injury is Lichtenstein figure or Lichtenstein tree that can be seen over the patient's skin[18,19,31]. In these cases, internal organ burn is not present and most of the burns are from 1st and 2nd degree.

Some of the complications after electrical injuries are renal failure, cardiac arrest, arrhythmias, bone fracture, wound infections, muscle infections, amputation, long bone fracture, numbness, unconsciousness, internal bleeding, internal organ perforations, and acalculous cholecystitis[10,33-37]. And long-term complications are cataract, transverse myelitis, amyotrophic lateral sclerosis, post-traumatic stress disorder, depression and psychological and neurological disorders[41-47].

5. Conclusion

Electrical injuries are uncommon, but the complications are severe. Mortality, morbidity and amputation rates are higher among high-voltage and lightening injuries.

Lightening, though very rare, has a high mortality rate and high rate of complications.

Conflict of interest statement

The authors report no conflict of interest.

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