CASE REPORT

CASE REPORT OF A HIGH VOLTAGE ELECTRICAL INJURY AND REVIEW OF THE INDICATIONS FOR EARLY FASCIOTOMY IN LIMB SALVAGE OF AN ELECTRICALLY INJURED LIMB

INDICATIONS DES APONÉVROTOMIES PRÉCOCES POUR SAUVETAGE DE MEMBRE EN CAS DE BRÛLURE ÉLECTRIQUE PAR HAUT VOLTAGE: À PROPOS D'UN CAS

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SUMMARY. Electrical injuries make up a relatively small portion of burn injuries. Safety measures in place on domestic electricity supply have reduced the occurrence of high voltage electrical injuries. We present the case of a young man who sustained a high voltage electrical injury on all four limbs. Early fasciotomy was performed on both his hands and forearms. Despite early compartment release, the left upper limb deteriorated and required amputation. In this article we discuss the indications, outcomes and complications of early fasciotomy.

Keywords: high voltage, electrical injury, early fasciotomy, limb salvage

RÉSUMÉ. *Les atteintes électrothermiques représentent une faible proportion des brûlures. Les brûlures par haut voltage à domicile ont vu leur incidence diminuer grâce aux protections automatiques. Nous présentons le cas d'un jeune homme ayant subi des brûlures par haut voltage au niveau des 4 membres. Des aponévrotomies ont été réalisées précocement au niveau des avant bras et des mains. Malgré la prise en charge rapide du syndrome compartimental, le membre supérieur gauche a dû être amputé. Nous discutons ici des indications, des complications et de l'intérêt des aponévrotomies précoces.*

Mots-clés*: brûlure électrothermique, haut voltage, aponévrotomie précoce, sauvetage de membre*

Introduction

Contact electrical burns are more severe than other forms of contact burn injury. They lead to an array of complications that involve multiple systems, including cardiac arrhythmias and rhabdomyolysis.[1] In contrast to the medical complications, soft tissue injuries are devastating and surgically demanding.[1] The surgical treatments practiced are escharotomy or fasciotomy, excisional debridement and limb amputation. Early fasciotomy was traditionally employed to treat compartment syndrome caused by deep muscle necrosis and tissue edema. Despite early fasciotomy as a limb-saving measure, there are still cases of limb amputation being reported.[2,3] This article describes a case of high voltage electrical injury to the bilateral upper limbs in which early fasciotomy was performed. Despite best medical efforts, an upper limb could not be salvaged and ended up being amputated. The role and indication of an early fasciotomy for electrical burn injury is also discussed.

Case presentation

A 28-year-old man sustained electrical burn injuries during an attempt to chase a bird, which landed on a high voltage cable (11,000 V), using a metal pole. During the incident he was wearing rubber slippers, and he arrived in the emergency department one hour after the time of injury. On initial examination, he had multiple full thickness burn wounds over the bilateral forearms, palms, left upper back, scalp and both lower limbs (*Figs. 1 and 2*), with approximately 25% total body surface area burnt. The entry points of the electrical arc were at

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Fig. 1 - Pictures depict both hands in fixed palmar flexed posture following electrical burn. On the left, full thickness wounds on the palm with passive extension.

both palms and exit points were at the toes (*Figs. 1 and 2*). Both his forearms and hands were tense, swollen and flexed at the wrist (*Fig. 1)*. Capillary refilling time at fingertips was normal, sensations to touch and pressure were decreased and active movement was limited. He had myoglobinuria with 300cc dark red urine on presentation. Early wound care was taken care of with liquid paraffin-based dressing. Blood results revealed severe rhabdomyolysis (creatine kinase level = 42670 U/L) and acute kidney injury (134.6 μmol/L). Troponin 'I' was normal and an electrocardiogram showed sinus tachycardia, which ruled out cardiac injuries.

An emergency fasciotomy was performed over both the forearms and hands within 2 hours of injury. He completed the 24hour parkland regimen and was maintained on forced alkaline diuresis for 3 days due to rhabdomyolysis. Urine output was maintained at more than 1cc/kg/hour and he had clear urine 12 hours after injury with a reduction of creatine kinase (CK) level from 42670 U/L to 4638 U/L after 5 days. He underwent multiple debridements every 3 to 4 days from day 3 of his injuries. Mobility assessment revealed that his right hand and wrist were severely impaired, with an active left hand extension of only 10 degrees at the metacarpopharyngeal joint and wrist joint. Elbow movements were normal. The debrided wounds over all four limbs developed infection and tissue cultures grew Methicillin resistant Staphylococcus Aureus, which was treated with intravenous Tazocin for 2 weeks. He eventually required a below right elbow trans-radius amputation due to non-functioning limb and non-viable tissue (*Fig. 2*). As a tissue coverage measure, split skin grafting was performed on the remaining healthy granulating wound bed of the lower limbs, scalp and upper back. The split skin graft was epithelized after a 4-week stay in hospital, and the patient was subsequently transferred to a rehabilitation unit to continue rigorous rehabilitation and physiotherapy.

Fig. 2 - Pictures of all 4 limbs before and after amputations.

Discussion

Electrical burns have an inherently different mechanism and distribution of tissue injury to thermal burns. While the majority of injuries following a thermal burn are clinically ap-

parent, a large portion of electrical injury occurs in deep tissues and may not be visible on initial clinical presentation.[3] Within 48 hours of injury, a compartment syndrome may develop in an involved extremity secondary to progressive myonecrosis as well as to fluid resuscitation. If not addressed promptly, increased interstitial pressure results in decreased perfusion of otherwise uninjured tissues, resulting in irreversible damage necessitating amputation.[3] Standard management of severe extremity electrical injury includes early surgical exploration, fasciotomy and debridement within 24 hours of injury. In fact, early fasciotomy is a marker of electrical burn injury severity.[3]

Early fasciotomy is defined as fasciotomy performed during a patient's first trip to the operating room.[4,5] It is warranted in patients with a high voltage electrical injury that is complicated by compartment syndrome of the affected body compartments. Rates of 10 to 50 percent of early fasciotomies performed within 24 hours for compartment release have been reported, and these have reduced the rates of limb amputations.[3,6-8]

However, immediate fasciotomy and decompression of muscle compartments of injured limbs is still controversial. Although some advocate this aggressive procedure to reduce the possibility of amputation, the approach may increase the number of surgical interventions required and lead to soft tissue desiccation by exposing viable tissue.[9] According to Mann et al., the ideal time to determine the extent of muscle injury is 3-5 days after electrical injury. They presented an algorithm for selective decompression to prevent subsequent morbidity[2,9] and reported that progressive neurologic deterioration (motor or sensory) of the extremity, severe pain in the extremity and loss of arterial Doppler signal indicating cessation of perfusion are strong indications for a fasciotomy.[2] When presented with a fixed neurological deficit, irreversible nerve damage should be considered as fasciotomy may not improve the outcome of restoring limb function.[2] Late signs of vascular and neurological compromise may also have a poorer outcome in limb salvage. Measurements of intra-compartmental tissue pressure using a needle, catheter or fibreoptic transducer may objectively indicate for an early fasciotomy when the pressure rises to more than 30mmHg.[10] Pressure measurement, however, is not reliable for all patients with electrical injury of the extremities because edema does not always occur in patients with normal superficial but damaged deep muscles.[9] Other non-invasive methods to assist in the diagnosis of compartment syndrome include ultrasonic device (measures submicrometric displacement of fascia caused by volume expansion), near-infrared spectroscopy (tracking of variations in the oxygenation of muscle tissue) and laser doppler flowmetry.[10,11] However, there are no studies to validate the accuracy of these non-invasive devices in diagnosing compartment syndrome.[10]

Early fasciotomy releases the pressure within a compartment under tension and restores adequate perfusion to viable tissues, which prevents tissue necrosis. In marginally injured tissues seen in the zone of stasis surrounding the necrotic burn zones, early fasciotomy improves tissue perfusion and prevents further necrosis of burn tissue. The drawback of this procedure is that it exposes the tissues to dessication and wound infections.[2] In a relatively recent study, early fasciotomy was associated with a significantly increased number of ICU days, ventilator days, hospital days, and total number of surgical procedures when compared to patients who did not have early fasciotomy. Since it was associated with increased injury severity, early fasciotomy was also associated with a significant increase in amputation.[3] Nevertheless, the possibility of inadequate decompression following fasciotomy leading to amputation must not be overlooked.[9]

In a case of pre-existing irreversible tissue injury, early fasciotomy will not reverse tissue necrosis with compartment release. This is exemplified by our patient, who eventually had to undergo amputation of his upper limb despite having an early fasciotomy. He was subsequently subjected to multiple wound debridements, which eventually led to loss of function of his hands. Early fasciotomy is recognized as an early measure to prevent amputation. But within this group there is a subset of patients with extensive irreversible high voltage electrical tissue injuries who may not benefit from early fasciotomy, which may even be detrimental. The question arises in the identification of this subset of patients with irreversible extensive tissue damage in whom fasciotomy and extensive wound debridement may expose them to the dangers of infection and sepsis.

Rather than attempting limb preservation with early fasciotomy and sequential debridement for every patient with severe high voltage electrical burn, assessment of tissue viability should be undertaken as soon as possible. Parameters that correlate with extent of muscle damage are valuable for predicting the need for limb amputation. Technetium-99m stannous pyrophosphate (99mTc-PYP) scintigram and ultrasonography are advocated to assess the area of muscle necrosis and morphological change in blood vessels. However, these methods should not be relied upon as the sole evidence to indicate that limb amputation is justified.[9]

It has been proposed that elevated muscle enzymes can be used to determine extent of muscle damage in electrical burn patients. Creatine kinase (CK) is readily detected in the circulation and is presumed to reflect significant muscle injury. However, it has a limited prognostic value in predicting the risk of limb amputation. CK has three isoforms – MM, MB and BB – with a wide distribution in tissues such as skeletal muscle, cardiac muscle, liver, erythrocytes, brain and smooth muscle. Total CK elevation does not reflect the real extent of skeletal muscle injury. Although 99% of total CK in skeletal muscle is CK-MM and CK-MB has a myocardial origin and is a predictor of myocardial injury, skeletal muscle injury may release large amounts of CK-MB. A serum creatine kinase-isoenzyme MB (CK-MB) level of above 80 ng/ml is unlikely to be released from sub-clinical myocardial injury. It has been demonstrated to indicate severe skeletal muscle injury that would not benefit from early fasciotomy. In fact, it is indicative of a high risk of limb amputation with high specificity (84%) and sensitivity (77%). Findings suggest that day 1-CK-MB level is a prognostic predictor of the clinical outcome of injured limbs.[9] In patients without major limb injury, levels decrease rapidly thereafter; in contrast, levels of CK and CK-MB decrease slightly in patients who subsequently require a major amputation.[9]

To avoid tissue dessication, subsequent wound sepsis and a protracted hospital course in patients requiring early fasciotomy, secondary wound closure is advocated on the third or fourth day with concurrent intra-compartmental pressure monitoring. Alternatives other than skin grafting for wound closure include intra-cutaneous skin sutures, skin stretching with mechanical closing devices, dynamic skin sutures, vacuum-assisted closure, and shoelace suturing techniques.

Conclusion

Early fasciotomy is warranted as a pre-emptive step that reduces intra-compartmental pressure and restores perfusion to viable tissues. Selective fasciotomy performed by most surgeons based primarily on clinical findings of compartment syndrome such as neurovascular compromise and increased compartment pressure is generally accepted. However, immediate fasciotomy does not necessarily result in limb salvage.[9] In view of the aggressive nature of the procedure, it is probably wise to carefully select those patients who would benefit from early fasciotomy and those in whom early amputation might be more beneficial. Although initial serum CK-MB level has been reported to be highly indicative of amputation in high-voltage electrically injured patients, the utility of a single factor to predict amputation should be viewed with caution. MRI is probably a useful tool for early detection of deep muscle necrosis.[9] On the other hand, prevention of tissue dessication with early wound closure is vital to prevent infection and wound sepsis in patients requiring fasciotomy.

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