

Never Give Up for Salvaging Extremities: A Case of High-Voltage Electrical Burn

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ABSTRACT

High-voltage electrical injuries pose unique challenges. Here, we report a complicated third-degree bilateral hand and forearm high-voltage burn injury that underwent reconstruction with several free flaps and a pedicled flap to salvage the upper extremity. Maximum efforts to save an extremity and lengthen an amputation stump should be given to patients with high-voltage electric injuries.

KEY WORDS: *Extremity burns, Extremity reconstruction, Free flaps*

INTRODUCTION

Electrical burns are less prevalent than other forms of burn injuries; however, this type of injury is considered one of the most devastating injuries due to its high morbidity and mortality.¹ Electrical injuries in the adult population primarily affect men and are most often work-related.² The classification of electrical burn injuries is typically divided into low-voltage (<1000 volts) and high-voltage (>1000 volts) injuries.² Low-voltage injuries are common in domestic settings in children, whereas adult injuries usually occur at workplaces.³

High-voltage electrical injuries pose unique challenges, and the upper extremities are most frequently affected because they are typically the contact points.⁴ Tissue resistance against electricity decreases with bone, fat, tendon,

skin, muscle, vein, and nerve order.³ Bone warms up to high temperatures and burns surrounding structures like muscles, leading to muscular edema and compartment syndrome in patients with high-voltage electrical injuries.³ Macroscopic and microscopic vascular injuries may occur immediately and are often irreversible.³

Although the initial management of electric injuries consists of fluid-calorie maintenance, debridement of necrotic tissue, and fasciotomies, the reconstruction of soft tissues is highly dependent on the anatomical side and degree of injury.⁴ We report a complicated third-degree bilateral hand and forearm burn injury reconstruction with several free flaps and a pedicled flap to salvage the upper extremity.

CASE REPORT

A 44-year-old otherwise healthy man with a high-voltage electrical burn injury was referred to our burn center. He had contact with high-voltage electrical cable while changing traffic signs at an autobahn. At first physical examination, third-degree burns were observed at the right upper extremity, left hand, and left wrist (Figure 1). Volkmann ischemic contracture was seen at the right upper extremity. Electric exit points were at his right and left foot. On the second day after injury, fasciotomies to the bilateral forearm and hand were performed. Ischemic contracture was released. The demarcation line was seen after 12 days. On day 13, debridement and skin graft were performed to the right and left upper extremity. On day 16, circulation of the right hand had diminished. Cyanotic appearance and brisk capillary refill, which were compatible with venous congestion, were observed. The dorsal network of the right hand was compromised, and thrombectomy and canalization of 2 dorsal veins were performed on day 18. Heparin and alteplase infusions were started. Nevertheless, venous congestion did not resolve, and free follow-through sural venous flap from the right leg was used to deliver venous bypass to the right forearm on day 25. Venous congestion of the right hand was improved after surgery.

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FIGURE 1. First Presentation of the Patient After High-Voltage Electric Burn

On day 31, the left wrist's necrotic tissue at the volar side was debrided, and the ulnar artery and nerve were exposed. Free anterolateral thigh (ALT) flap from the left thigh was elevated and adapted to the left wrist. On day 32, the right hand became ischemic again. To cover the arteries and salvage the right hand, a free ALT flap with vastus lateralis from the right thigh was performed. Nevertheless, the free ALT flap became cyanotic and necrotic due to venous compromise. On day 36, computed tomography (CT) angiography showed total occlusion in radial and ulnar arteries in the mid-forearm level. A vena saphena magna graft from the left leg was anastomosed to left ulnar artery revascularization. On day 37, thrombosis in the vein graft was seen. No further salvage operations were executed after the patient's request. On day 53, the right forearm was amputated. Necrotic tissue at the right olecranon and cubital tissue was debrided. The defect area was reconstructed with a pedicled right latissimus dorsi flap, radial collateral arm flap, and skin graft. There were no complications after this operation. The patient was discharged from the hospital on day 85 (Figure 2).

DISCUSSION

Electrothermal injuries cause progressively devastating damage involving extensive lesions ranging from superficial soft tissue injury to devitalization and devastation to bones, nerves, and vessels.⁵ Most electrical injuries occur in deep tissues and may not be visible on initial clinical

presentation.⁶ Compartment syndrome may develop in an involved extremity secondary to progressive myonecrosis and fluid resuscitation.⁶ Debridement and fasciotomies are cornerstones of initial surgical management in patients with high-voltage electrical injuries.^{6,7} In our patient, we performed fasciotomies on the second day to release pressure in the right and left upper extremities and to prevent progressive tissue necrosis. Despite early compartment release, the right forearm and hand circulation were compromised, and venous congestion occurred.

General indications for free flap coverage arise after deep tissue necrosis and debridement of nonviable tissue with subsequent exposure of tendons, bone, major vessels, and nerves.⁸ The distal forearm and the hands are at especially high risk because they are more likely to be a contact point and have a thin layer of soft tissue, as well as have a concentration of functional structures in a confined space.⁸ Early wound debridement and free tissue transfer can help preserve underlying vital structures and improve the physiological status of patients, thus allowing salvage of limbs that might otherwise have been amputated.⁹ To save the right upper extremities, multiple studies have reported the use of several free flaps.⁸⁻¹¹ In addition, free venous flow through venous flaps has been used in soft tissue reconstruction and vascularization after finger and hand injuries.^{12,13}

In our patient, we performed free flow through sural venous flaps from the left leg to the right forearm to

FIGURE 2. Total Salvage of the Left Upper Extremity and Below Wrist Salvage of the Right Upper Extremity After Several Microsurgical and Pedicled Flap Interventions



Abbreviations: ALT, anterolateral thigh

overcome venous congestion. However, the circulation of the right hand deteriorated after this procedure. The reason behind this might be due to the timing of flap reconstruction. Free flap coverage can be categorized as those that are performed at immediate (<5 days), early (5 to 21 days), intermediate (21 days to 6 weeks), and late (after 6 weeks) stages.¹⁰ Some studies have reported increased complications with early and intermediate flap reconstructions for high-voltage electrical injuries.^{10,11} On day 31 and day 32, we used free ALT flaps to cover the left and right wrist defects in our patient. The ALT flap has also been utilized in hand, forearm, and foot defects in severe high-voltage electric burn injuries.⁵ Our patient's left wrist was successfully reconstructed with a free ALT flap, with no complications seen on the left side.

In our patient, thrombosis, which is a common reason for flap failure in patients with electric burn injuries, at the right radial and ulnar artery was seen in CT angiography, and right forearm amputation was performed. Debridement of all necrotic tissue revealed brachial and olecranon defects at the right arm. A pedicled latissimus dorsi flap was planned to cover the exposed bone and neurovascular structures. The flap survived and resulted in good elbow function. In addition, the patient's amputation stump was reconstructed with the latissimus dorsi myocutaneous flap, and a maximum length of the amputation stump was

obtained. The use of the latissimus dorsi flap in electrical burn injuries has been previously described.¹⁴

Maximum efforts to save extremity and lengthen amputation stump should be given to patients with high-voltage electric injuries.

CONCLUSIONS

High-voltage electrical can progress extensively. To salvage an extremity, multiple microsurgical operations might be needed. Even though a surgical operation can fail, supreme efforts should be given to save the maximum length of an amputation stump, which is essential for future orthoses.

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