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Early use of microvascular free tissue transfer in the management of electrical injuries

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ABSTRACT

High-tension electricity can cause devastating injuries which may result in major soft-tissue loss, limb loss and sometimes major threat to life. Deep structures may be exposed and require flap cover, but microvascular flap transfer in electrical burn has a comparatively high-failure rate. This article aims to evaluate the outcome of early reconstruction of such injuries using free tissue transfer. In the course of 3 years (2004–2006), 16 free tissue transfers were performed in 13 cases of electrical injury from 24 h to 3 weeks after trauma. All flaps survived except one. The failure was due to vascular erosion and secondary haemorrhage. There was no incident of vascular occlusion. Thus, if wound debridement is meticulous and microvascular anastomosis is performed well away from the trauma site, free flaps should survive as well in electrical burn cases as in any other.

1. Introduction

In high-tension electrical injuries the passage of current classically produces entry and exit wounds, but the path of the current is often not obvious. Deep tissue destruction may be underestimated during the initial assessment of these cases, and management of the potential multisystem involvement can be challenging [1].

The majority of acute electrical burns undergoing surgical treatment require excision of the eschar and split skin grafting [2]. However, not all local wound conditions can support skin grafts, for example when tendons, nerves, bones and vessels are exposed. Historically such wounds have been managed with regular dressings and eventual eschar separation and granulation, decortication and local flaps [3]. These techniques have frequently resulted in long-term morbidity, infection and sometimes increased mortality due to invasive sepsis.

The benefits of free tissue transfer in the acute stage are early wound coverage, early mobility, preservation of vital structures and function, reduced hospital stay and possible limb salvage. Local flaps are used for cover wherever feasible. Where local flaps are not possible, the choice lies between regional and distant pedicled flaps and free flaps. Free flaps have better and more reliable blood circulation; unfortunately, pedicled flaps often have the worst circulation exactly at the point where they are most needed. Distinct additional advantages of free flaps over regional or distant pedicled flaps include immediate one-stage reconstruction and limb elevation, greater freedom in flap planning and composite reconstruction.

Many of the published studies of the outcome of free tissue transfers in burns focused on secondary reconstruction of electrical burns. Others combined acute burns and late cases, and still others combined thermal and electrical injuries. This study is an attempt to analyse the outcome of free tissue transfer specifically in acute electrical injuries.

2. Materials and methods

Between January 2004 and December 2006, 13 people with acute electrical injuries underwent soft-tissue reconstruction

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involving 16 free tissue transfers. We retrospectively reviewed the records of these individuals to extract data such as age, gender, type of injury, total body surface area involved, indications for free tissue transfer, timing of reconstruction, complications, flap survival and return to work, and also important surgical details, for example, the recipient pedicle and the distance of the site of anastomosis from the actual wound site.

Our policy was to debride the defect as early as possible and achieve closure of wounds with skin graft or with local or free tissue transfer. Indications for free tissue transfer included exposed vital parts such as tendons, bones and neurovascular structures. Timing of such free flap coverage has been classified in three stages: immediate (<5 days), early (within 6–21 days) and late (>21 days) [4].

No patient in this study underwent peripheral angiography. After thorough debridement a flap was selected depending upon local needs, dimensions of the defect and pedicle length needed. The final selection was done after the vessels were dissected out and microscopically examined for quality, diameter and flow to assess suitability for anastomosis. The radial artery in the volar forearm was the most common recipient vessel, selected in eight procedures. All flaps were connected to a single artery and a single vein. Whenever possible we anatomised the artery end to side, i.e. in nine cases. Venous anatomises were always end-to-end. Vein grafts were not used.

The majority ($n = 11$) of the flaps were constructed at the time of initial debridement but, whenever tissue with questionable viability was left behind in the wound, flap cover was performed after an additional debridement. All the procedures were carried out by a team consisting of a consultant and two senior registrars in our department.

3. Results

Sixteen free tissue transfers were performed for 13 patients, of whom 11 were victims of high-voltage (>1000 V) [1] electrical injuries and 2 were injured during domestic incidents. There were 11 males and 2 females, and the average age was 32 years (range 8–64 years). Average body surface area (BSA) involved was 22.4% (range 1–54%). Most of the flaps (thirteen) were for upper limb defects, of which 4 were performed on the day of admission for limb/digit salvage. Eleven flaps were performed within 5 days and five were performed before the end of 3 weeks (Table 1).

The various flaps used for reconstruction were gracilis muscle flap (two), lateral arm flap (four), anterolateral thigh flap (three), vastus lateralis myocutaneous flap (one), temporoparietal facial flap (two), latissimus dorsi muscle flap (three) and one parascapular flap.

One of the flaps (approximately 7%) failed because of secondary haemorrhage following infection at the anastomotic site. This patient had a high-voltage injury involving 54% BSA. He had undergone fasciotomies for upper limbs, a left below-knee amputation and a right forefoot amputation. Exposed neurovascular structures on the volar aspects of the right and left wrists were covered with a gracilis muscle flap and a temporoparietal facial flap on the 3rd and 9th days post-burn, respectively. The delay in covering the defect over the left wrist was probably responsible for flap loss (see Section 4). Three hands (two patients) in this series developed claw deformity due to nerve injury, requiring claw correction. One person needed static correction with gold implant for facial nerve palsy. One person died 3 months postoperatively from infective endocarditis. Mean follow-up period was 20 months (4–44 months). No amputations were performed as a consequence of flap failure.

In one case, an 8-year-old boy had a high-voltage electrical injury (Fig. 1). He presented 12 h after burn with contact burns over the right hand. After initial resuscitation he was taken to surgery. The wound was debrided, and the distal hand was found to have lost vascularity. The radial artery was reconstructed with vein graft, after which good perfusion was observed. The vein was not reconstructed, as the intact skin bridge over dorsum retained some veins for drainage of the distal hand. The defect was covered with free latissimus dorsi muscle flap, which 1 month postoperatively was well settled. Secondary reconstruction was carried out with an ulnar nerve graft to supply the digital nerves to the remaining fingers. Subsequently an anterolateral thigh flap (not part of present series) was used to resurface the same defect, creating a bed for smooth tendon movement after a proposed free functional muscle transfer for finger flexion. Unfortunately the boy never returned for surgery after completing 3 months of follow-up after the second flap.

In another case, a 64-year-old man with high-voltage electrical burns involving 7% body surface area presented 10 days after injury. The burns had already been partly debrided at another hospital, leaving some temporal bone exposed (Fig. 2); burn extended to the middle ear cavity. At redebridement, with the help of an ENT surgeon, all non-viable bone and the incus and malleus were removed. The defect was covered with free anterolateral thigh flap, well settled 3 months postoperatively. This man had facial nerve palsy, and early after the flap cover static correction (gold weight) was carried out to protect the eye. The man will need further corrections to camouflage aesthetic asymmetry.

4. Discussion

High-voltage electrical trauma is fairly common in industrial environments. These devastating injuries involve a spectrum of lesions ranging from soft-tissue and neuromuscular damage to potentially fatal problems such as respiratory arrest following muscle tetany, ventricular fibrillation and cardiac arrest. The problems faced by reconstructive surgeons include varying degrees of cutaneous damage, extensive destruction of deeper tissues, soft-tissue coagulation, rhabdomyolysis and peripheral nerve injuries [5].

The main treatment principles for electrical trauma are well established; decisions taken during the initial stages may significantly influence the patient's future quality of life [6]. After fluid resuscitation, people with these injuries require expert management. Additional soft-tissue loss due to compartment syndrome should be avoided, to minimise neuromuscular sequelae. Further on in the management, tissue reconstructive procedures of varying complexity may