OPEN

PRS GLOBAL OPEN

CASE REPORT

Burns

Treating Hand High-voltage Electrical Burn by Combination of Radial Artery Perforator Flap, Artificial Dermis, and Vacuum Sealing Drainage

Yibin Guo, MD*
Xiaofei Liu, BM*
Liping Chen, MD†*

Summary: Severe high-voltage electrical burns (HVEBs) to the hand can result in significant injuries, requiring early use of skin flaps or grafts for reconstruction to optimize hand function recovery. However, there is currently a lack of consensus on strategies to improve aesthetics and hand function. We reported a case of severe HVEB on the left hand that was successfully treated by a radial artery perforator flap assisted by artificial dermis (AD) and vacuum sealing drainage (VSD). In phase I, necrotic tissue was removed through debridement while preserving parabiotic tissue. The left thumb was fixed with a Kirschner wire, and the wound was covered with AD and VSD. After 2 weeks, phase II repair surgery was performed using a radial artery perforator flap to cover the wound surface. At 2 weeks after surgery, the skin flap showed good tension and no blood circulation disorders or blister formation. At 12 months after surgery, the flap had not shrunk, and its texture and color closely resembled the surrounding normal tissues. The flap also demonstrated resistance to friction, and there was nearly normal wrist joint mobility. The use of a radial artery perforator flap assisted by AD and VSD provides a simple and effective reconstruction method that preserves important vessels in the forearm, minimizes damage to local cutaneous nerves, and eliminates the need for vascular anastomosis. Therefore, this technique offers advantages in terms of aesthetics and functional improvement for severe HVEBs to the hand, although it has been rarely reported before. *(Plast Reconstr Surg Glob Open 2023; 11:e5397; doi: 10.1097/GOX.0000000000005397; Published online 16 November 2023.)*

Although electrical burns account for 3%–5% of all burns, severe high-voltage electrical burns can result in significant injuries to deep tissues, with amputation rates ranging from 24% to 49%.[1] It is crucial to identify effective methods for wound closure and subsequent reconstruction to promote the recovery of hand function. However, accurately determining the extent of injury can be challenging upon initial assessment due to the potential association of ongoing capillary thrombosis and myonecrosis in HVEB cases. Consequently, there is ongoing debate regarding the suitability of using radical debridement followed by immediate flap coverage.[2] Here, we present a successful case of severe tissue defects, particularly with tendon and bone exposure wounds in the hand caused by HVEB. These defects were treated with a combination of artificial dermis (AD) and vacuum sealing drainage (VSD), followed by a radial artery perforator flap, which has been rarely reported before.

*From the *Department of Burns and Plastic Surgery, the 909th Hospital, School of Medicine, Xiamen University, Zhangzhou city, Fujian Province, China; and †Department of Urology, the Eighth Medical Center, Chinese PLA General Hospital, Beijing, China.*

Received for publication July 3, 2023; accepted September 26, 2023.

DOI: 10.1097/GOX.0000000000005397

CASE PRESENTATION

A 55-year-old female patient experienced a 10-kV HVEB on her left hand on October 31, 2021. The entrance and exit electrical burn wounds were located on the radial side of the left hand and abdomen, respectively. The burned area accounted for 1% of the patient's total body surface area. The wound on the radial side measured 9 cm × 5 cm, and showed scab formation, exposure of the metacarpophalangeal joint of the thumb, rupture of the joint capsule, and local superficial carbonization on the dorsal side of the proximal phalanx of the thumb (Fig. 1A). Limited movement of the metacarpophalangeal

Disclosure statements are at the end of this article, following the correspondence information.

joint, interphalangeal joint, and metacarpal wrist joint of the left thumb resulted in an inability to grasp objects.

The patient's general condition was satisfactory, with stable vital signs. The electrocardiogram, blood, and urine routine tests revealed no abnormalities. However, both creatine kinase and creatine kinase isozyme levels significantly increased. The patient underwent two-stage surgery. Phase I debridement was performed on the third day after HVEB, and we observed necrosis of the extensor pollicis brevis and partial necrosis of abductor pollicis tendon (3-cm defect appeared after debridement). We carefully removed the necrotic tissue, including the thin layer (thickness: 1–2 mm) of carbonized necrosis from the proximal phalanx of the thumb, and the cortical blood supply was found to be adequate. Kirschner wires were used to stabilize the thumb and were removed 3 weeks after surgery. AD (Lando, Landobiom, China) was applied to cover the wound, which was then closed using VSD. The upper layer of the Lando AD is a medical silicone rubber layer of a semipermeable membrane nature, and the lower layer is a cross-linked degradable wet collagen sponge layer.

Phase II surgery was performed 2 weeks later. The rotational point of the flap was set at the exit point of the radial artery perforator, 2 cm above the styloid process of the left

Fig. 1. Treatment of patient with severe high-voltage electric burn on the hand by combination of radial artery perforator flap, artificial dermis, and vacuum sealing drainage. A, On the third day after burn, a rupture of the capsule of the left thumb metacarpophalangeal joint, partial necrosis of the thenar muscles, exposure and partial loss of the left extensor tendon of the thumb, and carbonization of some finger bones. B, Phase II surgery involved the design of a radial artery perforator flap. C, Flap harvesting was performed, and the flap was subsequently transferred to cover the wound on the hand. D, At 12 months after surgery, the flap showed no shrinkage, and its texture and color closely resembled the surrounding normal tissues.

radius, with the radial artery as the axis (Fig. 1B). A retrograde skin flap, measuring 12 cm × 6 cm was dissected from the deep fascia with a 3-cm pedicle, and was then rotated 180 degrees to cover the wound (Fig. 1C). Doppler vascular detection was used to determine the surface projection line of the radial artery and the exit point of the perforator, ensuring that the flap remained on the axis. Tensionless sutures were applied, and a drainage tube was inserted beneath the flap, which was removed on the second postoperative day. A thin skin graft from the left thigh was used to repair the donor site. Piperacillin/tazobactam sodium was used for perioperative anti-infection in both phase I and phase II surgery.

At 12 months after surgery, the flap showed good appearance and elasticity, and its texture and color closely resembled the surrounding normal tissues (Fig. 1D). The flap demonstrated resistance to friction, and the mobility of the wrist joint remained almost normal. At 19 months after surgery, the patient experienced no pain in the left hand and was able to grasp objects. The skin flap had a static two-point discrimination of approximately 5 mm. The thumb metacarpophalangeal joint exhibited a range of motion of 0–60 degrees for extension and flexion, whereas the interphalangeal joint had a range of motion of 0–75 degrees. The activity of the metacarpal and wrist joints seemed to be normal.

DISCUSSION

Soft tissue defects in the hand and wrist present challenges for hand surgeons. The radial artery perforator flap offers a potential solution by providing many of the advantages of the radial forearm flap while minimizing its drawbacks: for example, the necessity to compromise the radial artery, color, and bulk disparities between the flap and recipient tissues, and the appearance of the donor site.[3,4] It can be used to cover moderate-sized soft tissue defects (~8 cm × 18 cm) in the hands and forearm.

The primary advantages of AD included its simplicity and its immediate and plentiful availability. In this case, the combined use of AD and VSD helped close the open wound, fully drain necrotic tissue, reduce local edema and infection, facilitate the formation of new granulation tissue on exposed bone and tendon, and promote endothelial cell differentiation and vascular regeneration.[5,6] Consequently, the combined use of AD and VSD may provide a favorable tissue bed for subsequent flap transplantation, and reduce the occurrence of tendon adhesion and the formation of fibrosis and scar,[7] which is beneficial for the sliding of tendon tissue after skin flap coverage.[8]

Because this patient had open joint injuries with capsule rupture, there is a risk of persistent joint effusion and difficulty in wound closure. In such instances, well-vascularized flaps with strong antimicrobial capabilities are necessary for effective wound closure.[9] After the application of AD combined with VSD, a moderate, although not fully sufficient, vascularized collagen layer formed on the wound 2 weeks after surgery. At this time, the use of a radial artery perforator flap, with its abundant blood supply and ease of dissection, can effectively seal the wound and enhance the survival of the flap.[10]

CONCLUSIONS

The use of radial artery perforator flaps, assisted by AD and VSD, has been proven to be effective in managing complex hand injuries caused by high-voltage electrical burns. This approach preserves vital tissues, maximizes functional recovery of the hand, and reduces the occurrence of complications. The implementation of a radial artery perforator flap enables us to avoid compromising important vessels in the forearm, decreases damage to local cutaneous nerves, and eliminates the need for vascular anastomosis, thus contributing to the simplicity, safety, and reliability of this approach.

Liping Chen, MD
Department of Urology, the Eighth Medical Center
Chinese PLA General Hospital
No. 17th, Heishanhu Road, Haidian District
Bejing, China
E-mail: paradiselily@163.com

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Ding H, Huang M, Li D, et al. Epidemiology of electrical burns: a 10-year retrospective analysis of 376 cases at a burn centre in South China. *J Int Med Res.* 2020;48:300060519891325.
2. Karimi H, Akhoondinasab MR, Kazem-Zadeh J, et al. Comparison of the results of early flap coverage with late flap coverage in high-voltage electrical injury. *J Burn Care Res.* 2017;38:e568–e573.
3. Ho, AM, Chang, J. Radial artery perforator flap. *J Hand Surg Am.* 2010;35:308–311.
4. Page R, Chang J. Reconstruction of hand soft-tissue defects: alternatives to the radial forearm fasciocutaneous flap. *J Hand Surg Am.* 2006;31:847–856.
5. Wang W, Zhang L, Sun L, et al. Biocompatibility and immunotoxicology of the preclinical implantation of a collagen-based artificial dermal regeneration matrix. *Biomed Environ Sci.* 2018;31:829–842.
6. Yuan K, Zhao B, Cooper T, et al. The management of degloving injuries of the limb with full thickness skin grafting using vacuum sealing drainage or traditional compression dressing: a comparative cohort study. *J Orthop Sci.* 2019;24:881–887.
7. Lv Z, Wang Q, Jia R, et al. Pelnac artificial dermis assisted by VSD for treatment of complex wound with bone/tendon exposed at the foot and ankle, a prospective study. *J Invest Surg.* 2020;33:636–641.
8. Hsu KF, Chiu YL, Chiao HY, et al. Negative-pressure wound therapy combined with artificial dermis (Terudermis) followed by split-thickness skin graft might be an effective treatment option for wounds exposing tendon and bone: A retrospective observation study. *Medicine (Baltim).* 2021;100:e25395.
9. Bullocks J, Naik B, Lee E, et al. Flow-through flaps: a review of current knowledge and a novel classification system. *Microsurgery* 2006;26:439–449.
10. Song YH, Li S, Lin DM, et al. [Clinical research of vacuum sealing drainage combined with artificial dermis for the treatment of ankle and foot soft tissue defects]. *Zhongguo Gu Shang.* 2016;29:761–763.