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Microsurgical Flaps for the Treatment of Burn Patients

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ABSTRACT

The treatment of burn patients poses unique challenges, both in the acute and delayed setting. Although partial-thickness skin grafting and, to a lesser extent, local tissue rearrangement form the mainstay of burn wound management, the literature suggests that free tissue transfer can be used successfully in select cases (either in the acute or delayed setting). The most common indication for early free tissue transfer in burn surgery is to salvage an extremity when the injury exposes vital structures (neurovascular bundles, tendons, joint spaces, bones). Most free flap reconstructions are used in the delayed setting, often to release scar contracture and optimize return to function.

KEYWORDS: Microsurgery, burn reconstruction, acute burn coverage, delayed burn management, free tissue transfer, flap failure.

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I. INTRODUCTION

In 1975 Sharzer et al. presented the successful transfer of two free groin flaps for reconstruction of acute burn wounds, and Harii et al. reported 47 free flap procedures for secondary reconstruction of 36 contractured or unstable burn scars in the same year [1].

Severe burns usually involve skin and soft tissue loss and often require extensive wound reconstructions. While most burn wounds are sufficiently reconstructed with partial-thickness skin grafts, some burn wounds present complex defects with deep tissue necrosis and exposed functional structures such as bone, tendon, or nerves after complete eschar removal. Because of their delicate soft tissue layers with structures directly beneath, the hands and feet are often affected and may require free flap coverage in the acute setting, but other areas with thin skin coverage over bony prominences such as the elbow, knee, or tibia are also at risk [1].

II. INDICATIONS

Burn injuries represent a worldwide health problem. Acute and reconstructive burns are a major challenge. Skin grafting has been the main treatment of acute partial and full-thickness burns over the years, allowing large defects to be covered with minimal donor site morbidity [2,3].

In cases where wounds are not amenable to immediate skin grafting, one can opt for the temporary use of innovative technologies, such as skin substitutes or negative pressure dressings, bridging therapy between injury and acute burn reconstruction. These approaches promote the formation of granulation tissue and neovascularization, often allowing subsequent skin grafting via a two-step approach [3].

Severe burns can result in significant soft tissue loss. Consequently, critical structures such as bones, joints, and neurovascular structures may be exposed. In this scenario, vascularized soft tissue transfer is often necessary to achieve durable healing [2].

When skin substitutes and local flaps cannot be considered an option due to the involvement of the tissue surrounding the lesion or are considered inadequate, free flaps may be the only suitable alternative. Free flaps allow the wound to be covered in a single-stage procedure, potentially accelerating the healing process and reducing the risks associated with prolonged hospitalization, such as infections and wound healing problems [1].

Primary microsurgical reconstruction of burn wounds with a devitalized wound bed or exposed functional structures offers a wide variety of different free flaps to provide customized reconstruction of almost all possible defect sites. Due to the fast and stable tissue coverage, early functional training can begin in the first days after surgery to ensure the best possible functional outcome. Therefore, free flap reconstruction should be the first choice for early reconstruction of complex and large defects with exposed bone, nerves, or tendons when local flaps are not available in the acute phase [1].

Severe, circumferential damage to the skin of the extremities with fascial excision of the burn can result in acute post-traumatic lymphedema due to injury and disruption of local lymphatic vessels, and can be addressed with advanced microsurgical solutions, such as composite flaps along with vascularized lymph node flaps [1].

III. TIMING

Studies have shown that a transient hypercoagulability begins 24 to 48 hours after the initial burn injury and peaks at 2 to 3 weeks [2].

The risk of flap failure is higher in free tissue transfer due to anastomosis-related problems (blood flow turbulence, intimal injury, transient hypercoagulopathy), pedicle-related problems (kinking, twisting, and iatrogenic injury), perforator-related problems (spasm and iatrogenic injury), or other surgery-related problems (flap ischemia time and operative time) [2].

Extensive burns cause characteristic shock due to vascular hyperpermeability and consecutive fluid shift in the early phase after trauma. In these cases, fluid resuscitation and sequential debridement with subsequent skin grafting should be performed to achieve a stable circulatory status before microsurgical tissue transfer is planned. In these cases, definitive closure of the defect can be postponed by preserving exposed bone or tendon using negative pressure wound therapy hydrogel dressings [1].

Given the evidence the recommendation would be to delay free flap reconstruction at least 21 days after the burn injury. Other strategies could also be used to minimize the impact of hypercoagulability on flap perfusion. Routinely anticoagulate patients at the time of anastomosis and after surgery. At the time of anastomosis, a bolus of 5000 units of intravenous heparin is administered. Postoperatively, the following protocol is used: intravenous heparin at a rate of 500 units per hour, aspirin 325 mg per rectum at the end of surgery followed by 81 mg daily, use of sequential compression devices while in bed, Bair Hugger and warm room temperature, and early mobilization according to flap location [2].

IV. CHOICE OF FLAP

Fasciocutaneous flaps are ideal for covering tendons and joints, as they are thin and flexible, making them a suitable option for hand and foot reconstruction. They have less donor site morbidity compared to muscle flaps [4].

Whenever a significant three-dimensional defect needs to be covered, muscle flaps provide adequate tissue to fill the dead space. They are also preferentially used in limb reconstructions due to a faster healing rate.The main disadvantage is the possible morbidity of the donor site [4].

The anterolateral thigh flap was first described by Song et al. in 1984. It is used in patients with unburned thighs. It offers tremendous versatility when designed as a composite flap. While it is capable of closing even extensive defects by accepting a skin graft from its donor site, it can be raised with fascia if necessary. In addition, it can be used as a continuous flow flap to reconstruct damaged axial arteries of injured extremities [1].

Free muscle flaps are used in the absence of suitable donor sites, including in patients with severe burns and in donor sites with full-thickness burn wounds. Using free rectus abdominis (Pennington, 1980), vastus lateralis (Ger, 1976) or latissimus dorsi muscle flaps (Tansini, 1896) combined with partial-thickness skin grafts, large-scale defects can be closed in a single-stage procedure and may be especially necessary in acute burn reconstruction [1].

V. OUTCOME

The timing of free flap reconstruction in burn injuries requires special attention, even in the acute setting. Failure rates of flaps performed for acute burn reconstruction compared with those performed for other indications tend to be higher, specifically for surgeries performed during days 5 to 21 postburn. Infection, postsurgical inflammatory changes, and vascular compromise are potential etiologic factors contributing to flap failures during this time period. Free flaps outside this period have a lower failure rate [5].

Cardiovascular instability or airway compromise often preclude free flaps before the fifth day after a burn, in addition, the need for a free flap is not always evident at such early stages [5].

To ensure the best possible outcome in free flap transfer in primary burn reconstruction, recipient vessels should be well chosen and carefully examined, while arteriovenous loops should be used with a low threshold. To avoid hypercoagulability and chronic inflammation, the choice of the optimal timing for free flap reconstruction is of vital importance for successful microsurgical reconstruction of the defect [1].

VI. ACUTE RECONSTRUCTION

Reconstruction after an acute burn is generally classified as acute when performed within 6 weeks of the day of injury [3].

Burns requiring wound coverage are primarily treated with the use of skin grafts, which can cover a large area, especially if they are meshed. Flap reconstruction is rarely required, and the use of free flaps is even rarer [3].

Among the reasons why microsurgical reconstruction is rarely chosen as the primary approach for patients with acute burns is the inherently prolonged nature of surgery, which can be challenging for patients with severe burns who often present with an unstable clinical status due to systemic inflammatory flare. In addition, the postoperative period after a free flap procedure requires meticulous care and strict patient compliance, which can be difficult to achieve in patients with a faltering clinical condition [3, 6].

Flap loss has been reported in the literature in 12-20 % of acute free flap transfers. Of note, most flap failures were observed in patients with high-voltage injuries. This could be due to local damage to the recipient vessels in terms of partial obliteration, intimal damage or subacute inflammation. In cases where there is high-voltage electrical current flow through an extremity, these alterations could be located proximal to the actual defect and may not be easily detectable upon inspection of a recipient vessel during flap transfer [1].

Given that microsurgical reconstruction may be the only alternative in limb salvage situations, further research is needed on strategies to reduce the risk of free flap failure in acute burns [3].

VII. DELAYED RECONSTRUCTION

Free tissue transfer has been used more in the treatment of late burns (i.e. for secondary reconstruction) compared to the acute setting. Indications for late reconstruction fall into two main categories: functional and aesthetic [5].

Early use of free tissue transfer is most used in the treatment of electrical injuries, while its later use is more likely in the treatment of thermal injuries [5].

Release of a scar or contracture is the most common indication for free flap reconstruction that occurs after an acute period. Often, burn contractures cause profound functional deficits when they occur in thin joint spaces, such as in the hand, or in extensive functional areas such as the axilla or anterior neck [5].

Free flap coverage for the release of scars or joint contractures has been consistently shown to produce safe, reproducible, and durable results that improve functional and aesthetic outcomes [5].

Free flap tissue expansion has gained wide acceptance for large, extensive, and complex wounds that often pose many reconstructive challenges. Expansion can be performed before or after microsurgical free tissue transfer; it provides a larger flap that covers a larger body surface area, as well as a thinner flap with improved flexibility. Pré-expanded flaps have many applications in head and neck reconstruction, as this region is often the most affected region in severe burn injuries [5].

VIII. COMPLICATIONS

The risk of flap failure is higher in free tissue transfer due to anastomosis-related problems (blood flow turbulence, intimal injury, transient hypercoagulopathy), pedicle-related problems (kinking, twisting and iatrogenic injury), perforator-related problems (spasm and iatrogenic injury) or other surgery-related problems (flap ischemia time and operative time) [2].

Incomplete debridement, increased risk of infection, and recipient vessel injury are factors that have been noted in the literature as possibly responsible for a higher rate of complications in free tissue transfer during treatment of burn patients. We did not report any cases of infection or sepsis in our group of patients [4].

Proper resuscitation and stabilization of the patient, radical debridement of all devitalized and necrotic tissues, and careful preoperative planning are essential for successful free tissue transfer in burn patients [4].

The importance of meticulous flap control in the postoperative period cannot be overemphasized, especially in the first 72 hours, when vascular problems and hematomas are more frequent [4].

CONCLUSIONS

The use of microsurgical techniques through free flaps in the context of patients with primary and secondary burns is increasing. In well-selected patients, free flaps can reduce the number of surgical procedures necessary to achieve wound closure, and may allow preservation of deep burn areas that could not be saved with other techniques. However, at present there is still little evidence for free flap reconstruction in burn patients. Free flaps are rarely used in acute burns because these patients are often critically ill and this results in a high rate of loss of free flaps.

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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