Salvaging length for below-knee-level amputations after burn injury using muscle flaps, negative pressure wound therapy with instillation, and allograft skin

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Introduction

We describe a case of severe flame burns to the bilateral lower extremities following a motor vehicle accident, which required bilateral split gastrocnemius and soleus flaps to obtain coverage of the below-knee-amputation stumps. Knowledge of the blood supply and location of the pedicles of these muscles is critical to their successful rotation in this context. The importance of allografts and negative pressure wound therapy prior to autografting is also emphasised. Limited access to allografts remains a considerable barrier for the South African reconstructive surgeon when trying to obtain successful wound coverage in burns and complex wounds.

Case study

A 39 year-old man sustained a closed head injury, a right acetabular fracture and full-thickness burns to his legs during a motor vehicle accident. He was extricated from the motor vehicle after it was engulfed in flames. He was intubated on the scene, and transported to the emergency department of the hospital. After initial fluid resuscitation and stabilisation, bilateral escharotomies were performed for the deep leg and foot burns bilaterally. Neurosurgical service personnel inserted intracranial pressure-monitoring devices. Mechanical ventilatory support and inotropic agents were initiated to maintain adequate cerebral perfusion pressure.

On day 3 (delayed owing to the recommendation of the neurosurgical team), the full-thickness eschar was excised fascially, and some of the anterior compartment debrided in the right leg, under general anaesthetic, and Biobrane® (Smith and Nephew, UK) was placed. Biobrane® was selected, rather than allograft, to reduce the duration of anaesthesia. On return to the operating room on day 5, the Biobrane® was found not to be adherent to the residual fascia, and extensive necrosis of the tibial cortex, ankles and feet, as well as in the lateral and anterior muscle compartments, necessitated below-knee amputations. The patient manifested features of sepsis. Inotropic support was still necessary at this stage.

The burns involved the cortices of the patellae and remaining subcutaneous portion of the tibial bones. The knee joints were exposed bilaterally. These cortices were burred to bleeding tissue. Both the proximal gastrocnemius and soleus muscles were predominantly viable. The soleus muscles were used to cover the distal end of the tibia and fibula, and the bipennate gastrocnemius was divided longitudinally and transposed to cover the patella, knee and proximal tibia (an area of 200 $cm^2$and 180 cm^2 on the right and left, respectively). Adequate length and tension-free coverage was obtained by dissecting the gastrocnemius muscles to their dominant pedicles, and by transverse scoring of the fascial layers.

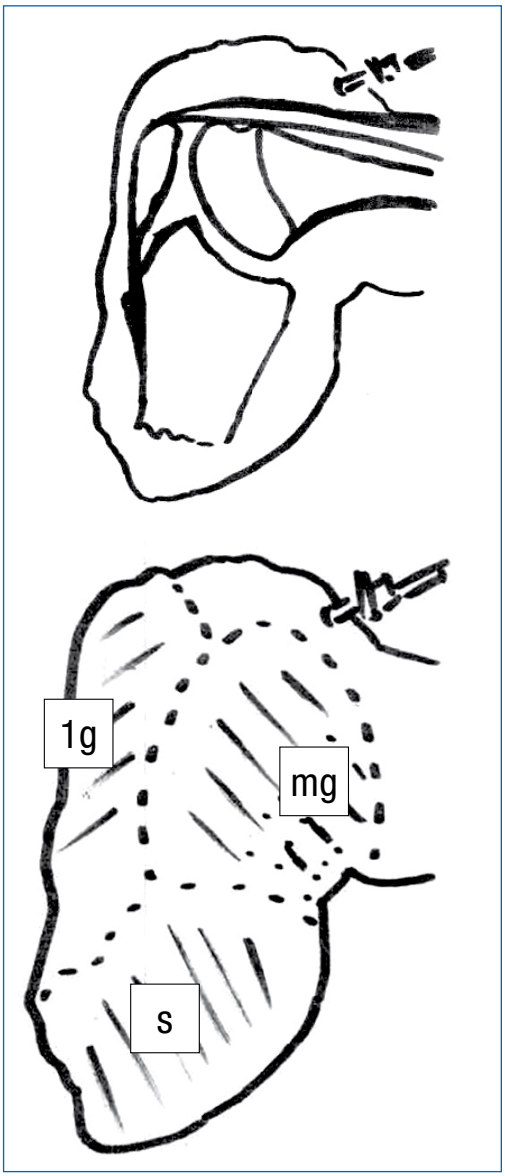
Negative pressure dressings were applied, with the instillation of Prontosan® (BBraun, Switzerland), and making use of VAC VeraFlo™ Therapy (KCI, USA). Three days later, meshed deceased donor allograft skin was applied and covered with negative pressure dressings. This was replaced with definitive autografting from thigh donor sites and further negative pressure dressings were applied after three days. The dressings were removed after five days. Full skin graft take was noted at this time. All of the wounds had healed well enough by postoperative day 10 to leave the stumps open to air, and to initiate the regular application of a water-based moisturiser. Full passive and active range of knee-joint motion was demonstrated. Some of the salient features of the operative course are demonstrated in Figures 1-4.

Discussion

Despite significant improvements in prosthetics in recent times, successful rehabilitation following amputation directly relates to the level of the amputation. Patients with below-knee amputations are three times more likely to comfortably and effectively use their prostheses than those with above-knee amputations.[1,2] This difference is additive when bilateral extremities are involved.

Here we describe a case, with few similar examples in the literature,[1,2] where knowledge of the dominant pedicles of gastrocnemius was applied to obtain optimal padded coverage of the knee and proximal tibia, which had been exposed due to deep burns and the ensuing debridement. Homogenous, well vascularised padding for the stumps was obtained, using posterior compartment muscle and thick split-thickness grafts for closure.

Gastrocnemius is a type 1 muscle, according to the Mathes and Nahai classification, although each half has a distinct dominant pedicle, and therefore may be used individually to maintain function, and is a mainstay for regional flap coverage of the knee and the proximal third of the leg. Soleus is also safely bisected, but differs in



lg: lateral gastrocnemius, mg: medial gastrocnemius, s: soleus

Figure 1: Diagram of right below-knee amputation, showing the underlying bones requiring coverage, and the muscles used for coverage

Note the transtibial metalwork to facilitate elevation of the limbs during surgery, and the transverse scoring of the medial gastrocnemius muscle to obtain greater coverage.

Figure 2: The right below-knee amputation, prior to allografting

Figure 3: The stumps covered by allograft, prior to autografting

Dressings were not required at this stage.

Figure 4: The day 10 postoperative result

that it is a type 2 muscle, and is frequently used to cover defects of the middle third of the leg.[3]

Negative pressure dressings are a well accepted adjunctive measure to optimise wound bed preparation and subsequent graft take, and the ability to instill antimicrobial solutions via the commercially available device (VAC VeraFlo™ Therapy) onto the wound bed improves this process further, while also addressing any residual infection and biofilm present.[4,5] Kairinos et al are credited with demonstrating the biomechanism of negative pressure wound therapy. They specifically showed that this modality uniformly applies a positive pressure to the wound bed, thus facilitating graft take during the early phases of imbibition and inosculation, while also stimulating healing by angiogenesis and granulation by reducing perfusion to the wound bed as the pressure is applied.[6,7]

Prontosan® has been shown to be an excellent antiseptic solution as a result of its limited cytotoxicity and its efficacy in addressing biofilm-related wound infections.[8] Available as both a wound irrigation solution and wound gel, Prontosan® comprises purified water, polyhexamethylene biguanide (PHMB) 0.1%, and betaine 0.1%. PHMB is similar to naturally occurring broad-spectrum antimicrobial peptides able to compromise the integrity of the lipopolysaccharide layer of the bacterial cell wall, with minimal effect on the neutral lipids in human cell membranes. Betaine is a surfactant, facilitating effective irrigation, while also disrupting the biofilm colonies by interfering with homoserine lactone manufacture. Prontosan® is the preferred antiseptic solution for use with VAC VeraFlo™ Therapy. It holds considerable promise, given its lower cytotoxicity profile, when compared to its chief competitors, sodium hypochlorite, povidone iodine, acetic acid and mafenide acetate.

Cadaveric allograft skin is frequently used to temporarily close and also to “test” the wound bed.[9,10] In this case, allograft was used to make certain that when autografting was undertaken, optimal graft take could be ensured. On removal of the allograft, the wound where the allograft is not adherent is carefully inspected, and these areas are marked with methylene blue. Further debridement is undertaken there, either my sharp means (scalpel, Guillian blade or Humbey knife, as required), or by making use of the Versajet™ Hydrosurgery

System (Smith and Nephew). Further debridement is not required in those areas where the allograft has taken, and the autograft can be confidently applied.

Biobrane® is perhaps best known for its capacity to facilitate spontaneous healing in exfoliative skin conditions and superficial partial-thickness burn wounds, especially on the faces of children. It comprises a bilaminar temporary skin substitute, composed of an inner layer of nylon mesh which allows fibrovascular ingrowth; and an outer layer of silastic, which serves as a vapour and bacterial barrier. It has also been proved to be useful for the more rapid coverage of excised burn wounds in unstable patients, but does not offer the same physiological benefits as allograft, and is more prone to infection in the context of an equivocal wound bed.[11]

Conclusion

This case report outlines the management strategy applied to optimize outcomes following bilateral lower extremity burn injuries in the presence of an accompanying severe closed head injury. Biobrane was applied after excision of the full thickness burns to expedite temporary coverage and reduce operative time. Once amputations were deemed necessary, length was maintained at the below knee level by covering exposed tibia and patella with divided gastrocnemius and soleus flaps. Allograft skin was used to test the wound bed after debridement. Negative pressure wound therapy prepared the wound bed, addressed possible infection by instilling prontosan, and also served as an effective bolster to optimize both allograft and autgraft take. At the time of writing, this patient was making an excellent recovery from a neurological point of view, and therapy was well underway with bilateral lower extremity prostheses.

Conflict of interest

There was no conflict of interest to declare.

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