Acute Burn Surgery

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1 Introduction

Burn care has markedly improved over the last decades. The probability to survive extent burn injuries is higher than ever before (Fig. 1). Thus, the main goal of current burn care extends beyond the preservation of life to re-integration of burn victims into their families, communities, work, and daily life. But before this can be achieved, the patient has to survive. Beside intensive care treatment, evaluation of sepsis using the current sepsis-3 definition/criteria, adequate analgesia, enough resuscitation, and prevention of infections the surgical intervention is a central aspect of the whole treatment in acute burns. This chapter describes the surgical part on how to handle acute burn injuries.

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2 Burn Wound Evaluation

One of the major challenges any burn surgeon must face is the decision on the nature of the further treatment of his or her burn patient (i.e., conservative versus surgical treatment). This decision depends on factors like localization, depth, and extent of the burn injury. However, current literature agrees that accurate burn wound evaluation is crucial for the further treatment. Today, there are many tools which can assist when it comes to the evaluation of burn depth and burn extent. Just to mention the Laser Speckle and Laser Doppler for burn depth assessment or different software tools like Burn Case 3D or the Rapid Burn Assessor mobile app for objective burn size evaluation.

3 Escharotomy/Fasciotomy

In burn surgery, the indication for an immediate surgical intervention occurs in the presence of circumferential deep burns affecting the upper/lower extremities or the chest wall. While in the extremities the development of a compartment syndrome is the main problem, in the chest wall ventilation problems can occur due to chest wall restriction. In order to prevent compartment syndrome or ventilation problems, an escharotomy should be performed. In high-voltage burn injuries, a fasciotomy of the different muscle compartments of the upper/lower extremity should be considered too.

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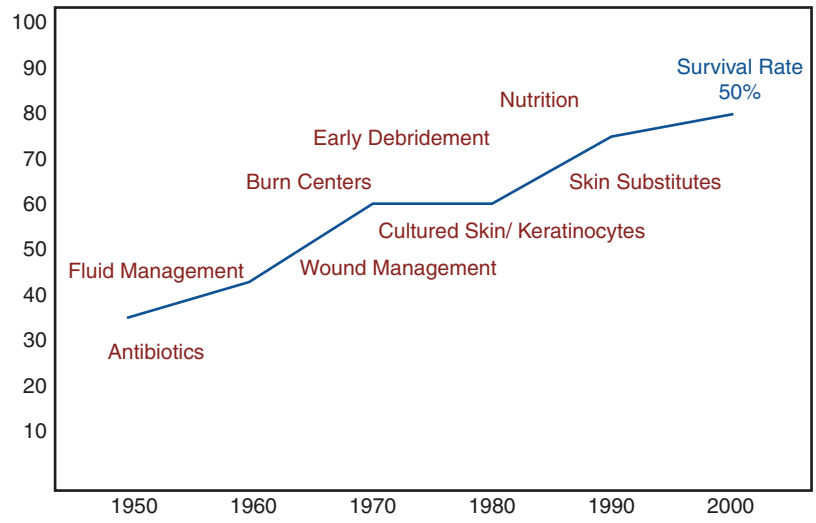

Fig. 1 Factors which had major impact on survival. The 50% survival rate has increased from 35% TBSA to 80% TBSA within the past decades

4 Surgical Burn Wound Management

Once the decision has been taken whether an escharotomy/fasciotomy is necessary, the next steps for the surgical treatment must be planned. The main goal of the surgical treatment is the replacement of the destroyed necrotic tissue. Superficial dermal burns will heal without operation within 2–3 weeks, but deep dermal and full-thickness burn will require operation. It is widely accepted that if skin does not regenerate within 3 weeks, morbidity and scarring will be severe. Further, it has become apparent that early excision is better than late excision because after 7 days the incidence of sepsis and graft failure increases. So, the trend regarding the treatment of deep dermal and full-thickness burns is going towards very early excision and grafting within 72 h after injury in order to reduce the risk of infection, decrease scar formation, shorten hospital stay, and thereby reduce total costs.

The excision of the necrotic tissue should be performed whenever the patient is hemodynamically stable. The operation should never be carried out if the patient is unstable and the risk of mortality is increased. In that case, the operation should be suspended until the patient is sufficiently stable. In patients associated with additional risk factors such as inhalation injury, patients of high age, or patients with cardiac problems, the surgical treatment differs and the decision when and how much to excise should be evaluated individually from case to case.

Sequential layered tangential excision to viable bleeding points, even to fat, while minimizing the loss of viable tissue, is the generally accepted technique. Excision of burn wounds to the fascia is reserved for large and deep burns where the risks of massive blood loss and the possibility of skin slough from less vascularized grafts on fat may lead to higher mortality. Enzymatic debridement with bromelain-based agents (e.g., Nexobrid®) is an alternative method to debride smaller deep dermal and non-life-threatening burns. The advantage is that it selectively removes the eschar without damaging the vital dermis.

After tangential excision of deep dermal burn injuries, the resulting defects can be covered with autologous or allogeneic skin grafts, xenografts, keratinocytes, or by use of synthetic materials like Suprathel ® (Fig. 2). In case of full-thickness burns, we dominantly use autografts to cover the wounds if there are enough available donor sites. In large burns, we normally use expanded autografts (mesh or Meek). Expansion rates of graft to wound area cover ranges from 1:1 to 1:9.

Fig. 2 Superficial to deep dermal burn—tangential excision of the deeper parts and coverage with Suprathel®, late results

Expansion rates higher than 1:3 heal in a suboptimal manner leading to contractures and unstable scars. Therefore, we like to combine these large meshed autografts in combination with allografts (Fig. 3) or keratinocytes (sandwich technique), or we will use the Meek technique (Fig. 4). In functional important regions like hands and over joints, a combined reconstruction of skin by use of a dermal matrix (Integra®, Matriderm®) and split-thickness skin graft seems to be superior to skin grafts alone (Fig. 5).

Donor sites for autografts in smaller burns, less than 40% total body surface area are seldom a problem unless the patient has a higher risk for surgical complication resulting from age, cardiopulmonary status, or coagulopathy. In patients with very extensive burns >60 total body surface area, the scarcity of harvesting areas for autologous skin grafts is one of the main problems. Therefore, we use cadaver skin (allografts) or xenografts (Fig. 6) as a temporary transplant and cover. These temporary transplants decrease the size of open wound until autografts become available as the partial-thickness burn area is healed or previously harvested donor sites heal.

This temporary covering helps to:

- Control wound infection.
- Prevent wound contracture.
- Relieve pain.

Sometimes, since burn wounds are often a mosaic of different burn depths, different techniques are combined in order to optimize burn wound closure regarding healing time and skin quality (Fig. 7).

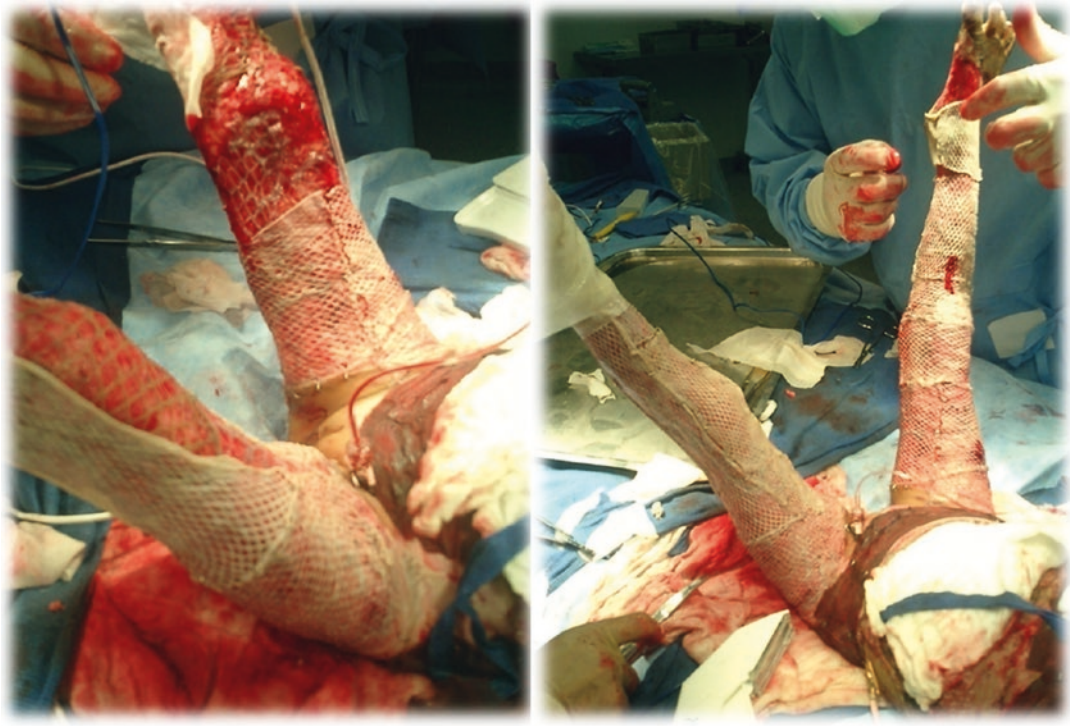

Fig. 3 "Sandwich technique": widely expanded autografts in combination with less expanded allografts

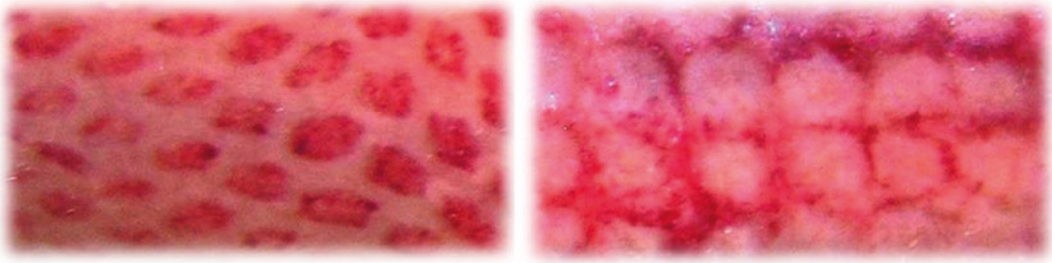

Fig. 4 Direct comparison of mesh and Meek grafted area

5 Location-Specific Treatment

5.1 Face

Deep dermal burns will be debrided and covered with keratinocytes or by silver-containing dressings like Acticoat Flex®. Full-thickness burns will be excised and grafted with unmeshed skin grafts according to aesthetic units of the face.

5.2 Hands

Deep dermal burns will be debrided and covered with keratinocytes, unmeshed skin grafts, or synthetic materials like Suprathel®. Full-thickness burns will be excised and grafted with unmeshed skin grafts, sometimes in combination with dermal substitutes.

Fig. 5 Dermal to full thickness burn: excision and combined grafting (Matriderm® and unmeshed skin graft); early and late results

Fig. 6 Pig Skin (EZ-Derm®) as a temporary coverage of full-thickness burns in case of a lack of donor sites for autologous skin grafting

Fig. 7 Dermal to full-thickness burn: tangential excision and grafting: deep dermal parts with Suprathel®, full-thickness parts with meshed skin grafts (1:2)

6 Treatment Standards in Burns Larger than Sixty Percent Total Body Surface Area

Body regions can be organized according to the probability of skin take rate, functional importance, and ultimately determined for surgical priority (Figs. 8 and 9). The aim of the surgical approach is to remove the necrotic tissue within 9 days after injury; in large burns, the dorsal aspects of the lower extremities, dorsum, gluteal and dorsal femoral regions can be preferably preconditioned in a fluidized microsphere beads-bed, and the final debridement is normally not performed before days 10–14 after injury. Excision and grafting sessions can be organized in a timeline scheme described in Fig. 9:

Definition	Body region
funtional & aesthetic importance	face hands feet
superior take-rate	thorax, abdomen upper limb lower limb
inferior take-rate	flanks of torso gluteal region dorsal aspect of thighs

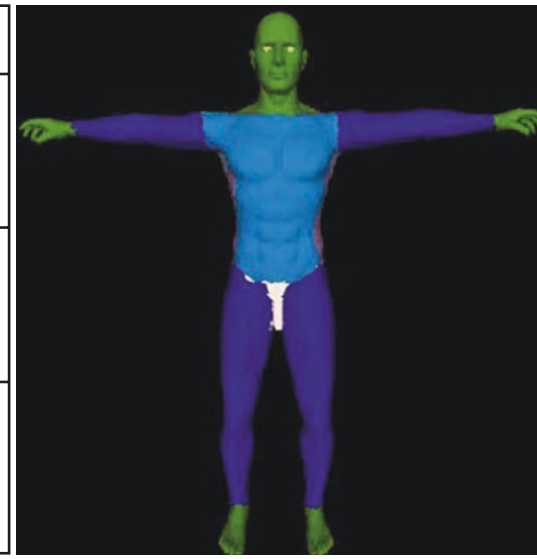

Fig. 8 Body region organization based on the functional importance and take rate

Fig. 9 Surgical timeline (This is an example for a typical surgical timeline; there might be differences in different countries and from center to center)

Timeline	Body region	Preferred technique
Day 3-9	hands	unmeshed split-thickness skin grafts (STSG)
	thorax, abdomen upper extremity ventral lower extremity	Meek (1:6 or 1:9) Mesh (1:1.5 or 1:3)
Day 10-14	face	unmeshed (STSG)
	dorsum dorsal lower extremity gluteal regions dorsal aspect of thigh	Meek (1:6 or 1:9) Mesh (1:1.5 or 1:3)
> Day 14	residual defects	Mesh (1:1.5 or 1:3)

- In young and clinically stable adult burn patients, we aimed to remove necrotic tissue and provide cover for full-thickness burns in two operative sessions within the first 14 days after injury.
- Individuals aged 65 years and above usually required more than two operative sessions within the first 14 days because the area operated on per session had to be restrained and adapted to the patient' general condition.

Whenever possible, unmeshed split-thickness skin grafts (STSG) are used for face and hands; all other areas are covered with either Meek grafts (expansion ratio 1:6 or 1:9) or, if respective donor sites enough, with mesh grafts using an expansion ratio of 1:1.5 or 1:3. Expansion ratios exceeding 1:3 to achieve sufficient coverage for full-thickness burns are regarded as indication for using the Meek technique (1:6 or 1:9).

7 Temporary Coverage

If harvested STSG did not suffice for coverage of full-thickness areas (i.e., third degree), we prefer to use allogeneic STSG as a temporary alternative. However, if allogeneic skin is not available, we use xenografts or a synthetic material (e.g., Epigard®) to temporarily cover debrided full-thickness areas.

Further, allograft is also used for protection of widely meshed autografts (>3:1 mesh) during healing. The allograft is applied over the meshed autograft in sandwich technique (Fig. 3). Surgical priority is given to areas of functional and aesthetic importance and superior take rate. Body regions with inferior take rate are normally preconditioned.

8 Fluidized Microsphere Beads-Bed

Fluidized microsphere beads-beds are good method for wound preconditioning but also for postoperative wound care. It removes moisture in order to keep the burn wounds dry and to permit maintenance of constant temperature levels in areas in direct contact with the bed's superficial fabric. Only thin sterile covers are employed to shield dorsal burned areas while in these beds, and no extra ointments are applied. For wound coverage of freshly operated areas, we prefer to use fatty gauzes and dry sterile compresses. Patients with arising difficulties in respiratory management or temperature control while in fluidized microsphere beads-beds are temporarily transferred to standard intensive care beds.

9 Negative-Pressure Wound Therapy (Vacuum-Assisted Closure)

Negative-pressure wound therapy or vacuum-assisted closure (VAC®) can be used in the local therapy of STSG receiver regions of inferior take and allowed for early mobilization in functionally important zones.

9.1 Early Mobilization

Early individual physiotherapy and ergotherapeutic splinting accomplishes the therapeutic strategy.

10 Nutrition and Anabolic Agents

Catabolism as a response to thermal trauma can only be modulated, not completely reversed. The burn wound consumes large quantities of energy during the healing process due to the large population of inflammatory cells and the production of collagen and matrix by fibroblasts. Therefore, adequate nutrition is of utmost importance for burn wound healing.

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