Acute Burn Procedures

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INTRODUCTION

The early management of burn patients requires a set of supportive procedures in addition to excision and closure operations. Most supportive procedures related to vascular access, tracheostomy, and enteral feeding access are identical to those required by trauma patients and are not covered here. Unique to this group of patients are the decompression procedures generally required in the first 12 to 24 hours of care. Subsequently, acute excision and closure operations dominate patients’ needs.

DECOMPRESSION PROCEDURES

Decompression is an important part of early burn care for several reasons. Extremity ischemia can be severe, resulting in frank muscle necrosis with overt functional consequences. There are also systemic consequences of muscle ischemia, which include renal failure and sepsis. Less overt compression can lead to neurologic injury and more subtle degrees of long-term functional compromise. Unaddressed torso compression can lead to reduced central venous return and higher volume resuscitation, compromised ventilation, and overt abdominal compartment syndrome.

KEYWORDS

- Burn procedures
- Decompression procedures
- Burn excision

KEY POINTS

- Early compression torso ischemia can compromise hemodynamics and ventilation.
- Consequences of compression extremity ischemia range from neurologic injury through frank muscle necrosis with renal failure and sepsis.
- Superficial and mid-depth second-degree burns will heal in most patients within 3 weeks and are best left to do so utilizing topical agents and/or membrane dressings.
- Burn excisions should be carefully planned. Intraoperative communication and coordination are important priorities. Burn excisions should be minimally ablative and performed using hemostatic techniques.

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Escharotomies are hemostatically done using coagulating electrocautery (Fig. 1). Fasciotomies are required most commonly in patients after high-voltage electrical injury, very deep thermal burns, crush injury, and delayed resuscitation with postreperfusion edema. In the presence of overlying thermal burns, escharotomy incisions can be done such that subsequent fasciotomies, if needed, can be done through the same incision (Fig. 2).

Abdominal compartment syndrome will occur in some burn patients, especially those with very large burns and delayed resuscitation. This syndrome may be less common with resuscitations that include colloid. It should be suspected in the presence of oliguria and increased inflating pressures in the presence of a firm abdomen. It is confirmed with bladder pressure measurements and treated with decompression. In some patients, drainage of peritoneal fluid suffices; but most patients with visceral edema require laparotomy (Fig. 3).

In rare patients with large burns, diffuse edema, and deep burns around the eye, elevated retrobulbar pressures can occur from edema. This condition threatens vision, as it can limit retinal artery blood flow. It is diagnosed by tonometry and treated by lateral canthotomy (Fig. 4), a simple bedside ophthalmologic procedure that can save vision.

**EXCISION AND CLOSURE OF ACUTE BURNS**

Before the 1970s and 1980s, deep burns were allowed to liquefy and separate over weeks or months, the resulting granulating wounds being autografted in survivors. Since then, early excision, which involves the identification, excision, and closure of deep burns before heavy wound colonization, has emerged as a dominant paradigm in developed countries. In patients with large burns, these operations can be bloody and physiologically stressful, requiring extensive blood bank and critical care resources. However, techniques of excision have matured significantly; the operations can be much more controlled and less physiologically stressful.

**The Operating Room Environment**

Excision and closure of burn wounds is conceptually simple but can be hazardous if not prudently practiced. The operating room environment is a critical consideration. Transport to and from the operating room should be carefully planned. Airway and vascular access devices must not be dislodged, and body temperature should be maintained. The operating room should be heated if operations of any magnitude

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**Fig. 1.** Escharotomies can be done with minimal blood loss using coagulating electrocautery.
Fig. 2. In the presence of overlying deep thermal burns, escharotomy incisions can be done such that subsequent fasciotomies, if needed, can be done through the same incision.

Fig. 3. Abdominal compartment syndrome should be suspected in the presence of oliguria and increased inflating pressures in the presence of a firm abdomen. It is confirmed with bladder pressure measurements and treated with decompression. In some patients, drainage of peritoneal fluid suffices; but most patients with visceral edema require laparotomy. Decompressive laparotomy can be done in the intensive care unit with proper preparation, as pictured here. Abdominal compartment syndrome is infrequently required if resuscitation is accurate and timely and includes colloid.
are to be successfully performed, especially in critically ill children with large burns. Intraoperative hypothermia leads to acidosis, poor peripheral perfusion, and coagulopathy. All intravenous and topical fluids should be warmed. Operating room personnel will become accustomed to any discomfort associated with the extreme operating room heat.

Constant respectful communication between surgical, nursing, and anesthesia personnel optimizes the conduct of the operation. The Anesthesia team should understand the operative plan, so they can anticipate fluid and blood needs accordingly. The level of stimulation changes substantially during burn cases, for example, increasing sharply during donor harvest; this should be anticipated by the anesthesia team. Substantial bleeding can occur and should be anticipated.

Burn operations often require relative extremes of positioning, as no surface is immune from burns. In addition to added heating circuits, burn operating rooms are ideally equipped with positioning aids, such as overhead suspension systems such as that illustrated in Fig. 5. Such aids can substantially reduce operative time.

Wound Evaluation

Accurate burn excision assumes an ability to accurately determine the likelihood that a burn will heal. In general, only burns of at least deep second degree are excised and grafted. Superficial and mid-depth second-degree burns will heal in most patients within 3 weeks and are best left to do so. Although several adjuncts exist, an experienced eye remains the standard of care for burn-depth determination. Intraoperatively, a series of very light passes with a handheld dermatome over small representative areas can give useful guidance as to depth, with viable tissue identified by fine capillary bleeding. In situations of mixed-depth injury, time spent in thoughtful planning before the initial excision will speed the overall operative time and reduce intraoperative physiologic stress to patients.

Determination of Need and Timing of Operation

Injuries vary in their degree of physiologic threat, which is a major driver in decisions on operative timing. The physiologic threat presented by the injury is primarily a function
of injury size, more than depth. Patients with deep dermal or full-thickness burns involving more than 20% of the body surface are at risk for the rapid development of wound and then systemic infection. This complication is best avoided by early excision of full-thickness areas.

Small indeterminate-depth injuries (commonly pediatric scalds) are often best managed nonoperatively initially, while wounds evolve and the depth becomes clearer. Wounds capable of healing in under 3 weeks are unlikely to become problematic or hypertrophic. Patients with small but obviously full-thickness burns (commonly contact burns) are best served by early operation.

A more aggressive surgical approach is often appropriate in patients with larger mixed-depth burns, greater than 20% of the body surface, as the injury size alone presents a physiologic threat. Ideally, full-thickness components are identified, excised, and closed before wound colonization and systemic inflammation occur. In patients with very large burns, greater than 40%, this may require serial operations. In such patients, temporary biologic closure can be achieved with a variety of temporary membranes such as human allograft. These wounds can be subsequently closed with autograft when donor sites have healed.

Most practitioners define early as being within 1 to 5 days after injury, before local infection and systemic inflammation have occurred. The primary advantage of waiting toward the end of this window is that burn wounds have evolved to the point that intraoperative decision making is easier. When wounds are large, earlier staged operations are safest. In the hands of experienced practitioners, if patients are well monitored and

Fig. 5. In addition to added heating circuits, burn operating rooms are ideally equipped with positioning aids, such as overhead suspension systems. One is illustrated here.
supported, excision and closure even within hours of injury can be safely and effect-
ively done.\textsuperscript{14}

In some cases, patients will initially present with wound cellulitis or infection (Fig. 6). The practical decision in this situation is if excision is needed to control the infection. If burns are extensive and full thickness, this is generally advisable. If burns are small and partial thickness, most cases of simple cellulitis can be treated with topical antimicrobials and systemic antibiotics alone.\textsuperscript{15} Clinical judgment is required in intermediate cases.

\textit{Techniques of Burn Wound Excision}

Superficial wounds likely to heal should not be excised. They should be debrided and dressed with topical medications or temporary biologic dressings to prevent desiccation and infection. Enzymatic debridement has a role in some programs. Full-thickness burns are addressed operatively, depending on the depth of the wounds and status of the patient, by layered excision to deepest dermis or subcutaneous fat, fascial excision, or subfascial excision.

Layered excision to viable deep dermis can be appropriate for some very deep second-degree burns, which are unlikely to heal in less than 3 weeks. Even if they do eventually heal, such wounds frequently become very hypertrophic and pruritic. This result is a particular problem where skin is thin and has few appendages. Deep dermal excisions are best reserved for those few situations in which it is clear that the bulk of the dermis is not viable. Layered deep dermal and full-thickness excisions can be done with handheld or powered dermatomes. Deep dermal excisions can be associated with substantial capillary bleeding, so it is important to use techniques to minimize blood loss, including subeschar epinephrine clysis and exsanguination with proximal tourniquet inflation.\textsuperscript{16} Perhaps the most useful technique is careful planning with marking of surgical margins, followed by a brisk pace of excision and immediate application of hemostatic wraps (Fig. 7).

Layered excision of full-thickness burns to viable subcutaneous fat optimizes contour, appearance, and function. The conventional wisdom that fat accepts grafts less reliably is probably not true. Rather, it may be more difficult to appreciate the viability of fat; the bed tolerates desiccation and shearing forces poorly. Careful evaluation of the wound bed, and minimizing open interstices, results in a reliably good graft take in most situations. An excellent result usually follows coverage of well-excised

\textbf{Fig. 6.} Smaller injuries complicated by localized wound sepsis or cellulitis may benefit from acute eschar excision. Septic partial-thickness burns can often be effectively treated with topical antimicrobials and systemic antibiotics alone.
subcutaneous fat covered with sheet grafts or minimally expanded meshed grafts. It is essential that grafts conform to the many small irregularities in beds of subcutaneous fat and that fat is not left exposed to desiccate between expanded intestices. Widely meshed grafts do poorly on beds of subcutaneous fat.

Although quite common in the early years of acute burn excision, fascial excisions are not frequently done today. They are indicated if burns involve subcutaneous fat in patients with massive, full-thickness burns. In such patients, the risks of poor graft take on a questionable bed may be worse than the functional and aesthetic consequences of a fascial excision. Some fragile elderly patients may be candidates for fascial excision, as this technique minimizes blood loss and provides a highly reliable bed for autograft coverage. The disadvantage of contour deformity must be considered. Fascial excision can be hemostatically performed with traction and coagulating electrocautery (Fig. 8). The electrocautery plume can be substantial but can be minimized with high-efficiency suction devices incorporated into the electrocautery handpiece.

Subfascial excision of devitalized deep tissue is required in high-voltage injury, crush and blast injury, soft tissue trauma, or occasionally in very deep thermal burns. Muscle compartments can be explored through standard fasciotomy incisions,
allowing simultaneous decompression and debridement. Definitive closure of such wounds can be difficult. Negative-pressure devices can be useful in preparing such wounds for grafting. Local or distant flaps may be needed.

Throughout surgery, the patients’ physiology should be continuously monitored. This is enhanced by constant communication between the surgical and anesthetic teams. Hypothermia must be anticipated and prevented by operating room heating, as the degree of patient exposure commonly required during these operations renders other devices to support body temperature ineffective.

**Techniques to Minimize Blood Loss**

Blood loss during acute burn excision has been estimated as 3.5% to 5.0% of the blood volume for every 1% of the body surface excised. However, this degree of blood loss occurs when free capillary bleeding serves as the primary indicator of wound bed viability. There are other ways to determine viability of the bed during wound excision. Bright, moist yellow fat, patent small blood vessels, the absence of thrombosis of small vessels, and absence of extravascular hemoglobin are signs of a viable bed. Accurate identification of tissue viability, in the absence of free bleeding, is an acquired skill that is essential to master and maintain to reliably perform hemostatic excisions.

The techniques to reduce intraoperative blood loss include careful operative planning before incision, extremity exsanguination and application of proximal pneumatic tourniquets before excision, dilute subeschar epinephrine clysis for torso and head excisions, use of coagulating electrocautery for fascial excision, and maintenance of normal body temperature.

**Graft Stabilization and Care**

An important part of the craft of burn surgery involves methods of postoperative graft stabilization. It is essential to eliminate shear between grafts and underlying wounds, prevent desiccation and colonization of interstices, and minimize blood and serous collections beneath grafts. Postoperative dressings should minimize the degree to which patients must be immobilized after surgery. On most extremities, simple but very carefully applied gauze wraps suffice. It is important that these not be applied so snugly as to cause distal ischemia. On the anterior torso,
moderately tightly stretched mesh can be secured over grafts, resulting in excellent fixation and minimal bulk. On the posterior torso, grafts can be stabilized with multiply layered gauze secured to the underlying soft tissues (Fig. 9). This technique is suitable for extensive meshed grafts and allows topical agents to be applied. Prone positioning is almost never required when such posterior dressings are used. Standard tie-over dressings suffice for small grafts in a wide variety of locations (Fig. 10). Negative-pressure dressings work well if there is intact skin surrounding well-defined wounds.

**Donor Site Management**

Donor-site dressings can be broadly classified as open or closed. Open dressings include a wide variety of nonocclusive dressings, such as fine-mesh gauze or petroleum based-impregnated dressings. Open management is forgiving of donor-site colonization and fluid collections but is associated with significant discomfort in the days immediately following surgery. Closed dressings include a wide variety of occlusive membranes and hydrocolloid dressings. The major advantage of this type of dressing is reduced pain. The major disadvantage is a relative inability to tolerate fluid collections, wound colonization, and patient movement. When membranes fail in this fashion, adjustment and replacement can be unpleasant and uncomfortable.

**SUMMARY**

Advances in the operative care of burn wounds have been at the heart of progress in burn care over the past 30 years. Surgery has become less ablative, less bloody, and less physiologically stressful. These techniques have facilitated the successful practical application of the concept of early burn excision and closure before the development of sepsis and systemic inflammation.

**REFERENCES**


