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CHAPTER 11.5

Burn Surgery

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Free Skin Graft for Burn Wound (With Tangential Excision, Excision to Fascia, or Debridement)

Surgical Considerations

Description: Until the mid-1970s, management of burn wounds involved daily debridement, hydrotherapy, and spontaneous eschar separation, with subsequent skin grafts applied to the granulated tissue. Operative management has become much more aggressive with the description of **tangential excision by Janzekovic.** There are two surgical approaches to burn wounds—tangential excision and fascial excision.

Tangential excision (**TE**) is the more frequently performed procedure. The concept of TE is extremely simple, but requires considerable experience and teamwork. Thin slices of burn eschar (burned, necrotic tissue), are shaved sequentially with manual or power dermatomes until a healthy wound bed is developed. Assessment of the wound bed is done with visualization of bleeding and/or the clinical appearance of the excised bed. Blood loss is generally diffuse and can be massive; therefore, communication between anesthesiologist and surgeon is essential. In large excision, PRBCs should be available in the OR before excision so that the anesthesiologist does not get behind in blood and fluid replacement.

Diffuse bleeding, especially dermal, is controlled by laparotomy pads soaked with warm 1:100,000 epinephrine solution. These pads are replaced every 3–5 min and, after 10 min, are removed one at a time, with persistent bleeding points controlled by electrocautery. Although very high plasma epinephrine levels have been reported after major burn excision, systemic manifestations are very rare in acute burn patients (probably 2° chronic high-level endogenous catecholamine secretion).

TE in the extremities usually is accomplished with a pneumatic tourniquet to minimize blood loss. In some centers, subcutaneous injection of a diluted (1:1,000,000) epinephrine solution under the burn wound also is used to minimize blood loss; however, the resulting vasoconstriction makes the end-point of excision—i.e., bleeding—difficult to ascertain.

Fascial excision involves removing the burn eschar and all underlying fat en bloc to the level of muscle fascia, or beyond. Fascial excision can be performed more rapidly and with less blood loss than TE. Its disadvantages, however, are the marked cosmetic deformities and functional limitations that occur because of the loss of all soft tissue overlying the musculature. Because of its disadvantages, fascial excision is reserved for 4th-degree burns or for patients with very extensive, life-threatening, full-thickness (3rd-degree) burns.

In patients with serious burns (> 40% total body surface area [TBSA]), excision usually commences on postop day 2–5, after completion of fluid resuscitation, and is performed every 2–3 d, as the patient's condition permits. If eschar excision can be completed before secondary sepsis supervenes, management of the patient is easier and the complications and morbidity are lessened considerably.

The endpoints for surgical excision in large burns are: (a) operative time of 2–3 h; (b) core temperature of 35°C; or (c) blood loss of 10 U of PRBC. The violation of any of these parameters invites coagulopathy and increasing problems with hemostasis and VS stability. Adverse effects occurring after 3–4 h of operative time are usually the result of massive transfusion or hypothermia.

Due to loss of skin integrity and large exposed surfaces, these patients lose heat rapidly. Fluids, gases, and the OR should be warm, although there is no demonstrable benefit to warming the OR past the point of isothermic neutrality (82°F [28°C]). Many surgeons, however, will maintain the room at 100°F (38°C). All areas not in the operative field should be covered, and a warming blanket (Bair Hugger) is used frequently.

Coverage: After excision of wounds and attainment of hemostasis, wounds are covered, using either an autograft or temporary

coverage with an allograft, xenograft, or synthetic/biologic dressing. An autograft is used for coverage when the wound bed is deemed suitable, a donor site is available, and the patient is stable. A split-thickness skin graft (STSG) often is used for coverage of a burn wound. Since a STSG is harvested at the dermal level, bleeding also is controlled with topical epinephrine-soaked laparotomy pads before application of dressings. Depending on the location of donor sites, many surgeons use subcutaneous infiltration of diluted (1:1,000,000) epinephrine in saline solution to smooth out irregularities (e.g., underlying ribs) or to create a flat surface (e.g., scalp) to physically improve the ease of taking skin grafts. A substantial volume of saline may be infiltrated, and this should be added into the total fluids administered to the patient.

Intraop position change may be necessary between the burn excision and the STSG harvest. For example, donor skin may be harvested from the back for application to the chest or abdomen.

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The STSG is held temporarily in place with staples or sutures. Uncontrolled patient movement may dislodge the graft. To protect against this eventuality, grafts are secured with circumferential dressings and splints. This procedure may be time-consuming, and any uncontrolled patient movement should be avoided.

It has become apparent that early eschar excision is advantageous even if wounds are so extensive they cannot be covered with autografts. In this situation, temporary coverage of the excised wound is accomplished with the application of an allograft, porcine xenograft, or synthetic/biologic dressing. The wound is maintained in this way, with further debridement and biologic dressing changes as necessary, until autograft becomes available.

Usual preop diagnosis: Thermal, electrical, or chemical burn

Summary of Procedures

	TE	Fascial Excision
Position	Supine, prone, or lateral	
Incision	Anywhere eschar is to be excised.	
Special instrumentation	Dermatomes, as determined by the surgeon—manual or powered.	–
Temperature considerations	Keep room T at 82°F (28°C).	
Unique considerations	Possible subcutaneous infiltration of diluted epinephrine-saline solution.	None
Antibiotics	Cefazolin (adult = 1g; child = 15 mg/kg) iv on induction of anesthesia	
Surgical time	2–3 h	
EBL	Massive; limit to 10 U PRBC transfusion	250–500 mL
Postop care	Generally, patients can be extubated at the end of these procedures, recovered in the PACU, and returned to the burn center. If patient remains intubated, generally he/she is transported directly to the burn center, where body T can be maintained more easily.	
Mortality	18–40% (Mortality is a function of burn size, plus other associated conditions, especially inhalation injury [Figs 11.5-1, 11.5-2])	
Morbidity	Massive blood loss Sepsis Infection 2° to catheters and lines	–
Pain score	2–5 (Most patients are maintained on sustained-release methadone or iv morphine, for periop pain control.)	

Patient Population Characteristics

Age range	All
Male:Female	More commonly male
Incidence	45,000 burn center admissions/yr
Etiology	Scald; flame burns; chemicals; electric burns
Associated conditions	Generally few, except in elderly patients

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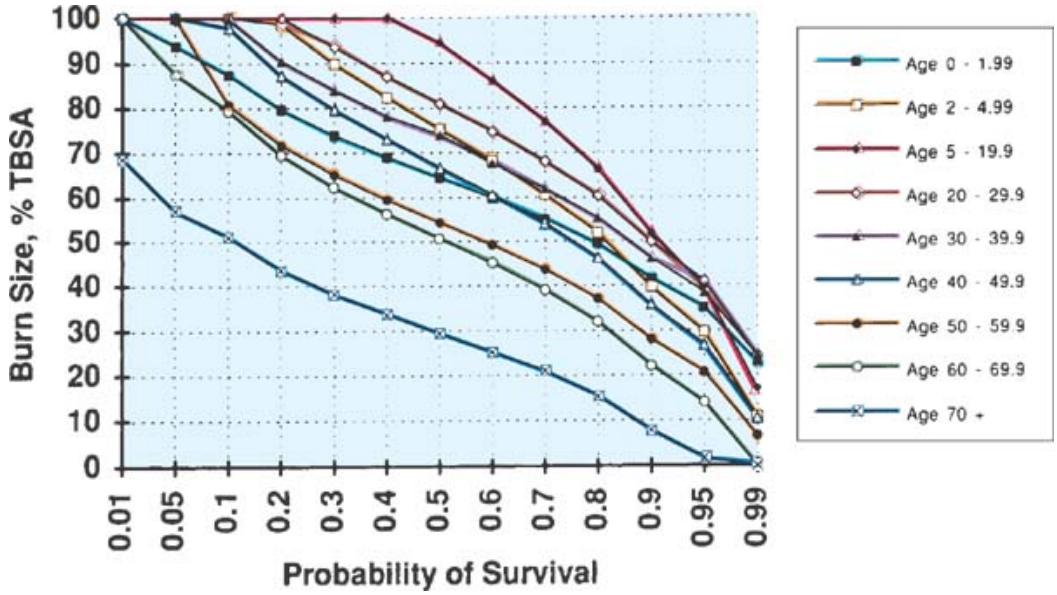

Figure 11.5-1. 1. Probit Survival Curves for 6,417 patients by age groups. (Reproduced with permission from Saffle JR, Davis B, Williams P, et al: Recent outcomes in the treatment of burn injury in the United States: a report from the American Burn Association Patient Registry. *J Burn Care Rehab* 1995; 16:219–32.)

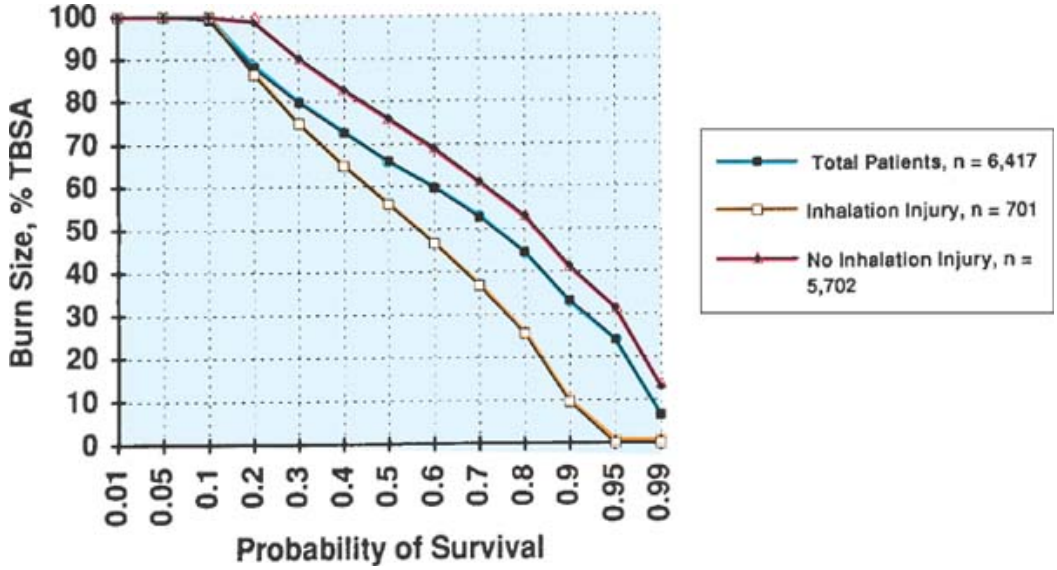

Figure 11.5-2. 2. Probit Survival for patients with and without inhalation injury. (Reproduced with permission from Saffle JR, Davis B, Williams P, et al: Recent outcomes in the treatment of burn injury in the United States: a report from the American Burn Association Patient Registry. *J Burn Care Rehab* 1995; 16:219–32.)

Table 11. 5-1. Burn wounds-Classified According to Depth of Burn

Degree	Burn Depth	Tissue Involved
1st degree	Superficial	Epidermis only
2nd degree	Partial thickness	Various thickness of dermis
3rd degree	Full thickness	Entire thickness of dermis
4th degree	To underlying tissue	Beyond dermis (e.g., subcutaneous fat, fascia, or muscle)

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Anesthetic Considerations

Preoperative

Burn injuries may result in a broad spectrum of physiologic impairments. These vary, depending on the percent of TBSA burned, location of burns, age of the patient, time elapsed since initial injury, and interim treatment. Ideally, burn patients are fluid-resuscitated and stabilized before being brought to the OR. Typically, skin grafts to cover the burn area start on post-injury day 3. Blood loss and hypothermia are the predominant considerations during surgery on burn patients. Blood loss can be rapid and massive, as much as 8 U in 15 minutes, and can be difficult to estimate as it generally is not collected into the suction.

Respiratory	**Upper airway:** A patient with burns around the airway (e.g., singed nose hairs) should be intubated as early as possible. Direct inhalational/thermal injury and fluid resuscitation may make delayed intubation more difficult 2° upper airway edema. **Lower airway:** Physiologic derangements may include pulmonary edema and ARDS. Additionally, burn patients can be severely hypermetabolic (e.g., a patient with 40% TBSA burns may have twice the normal metabolic rate) with corresponding increased CO_2 production. These patients may have high PIPs and high minute-ventilation requirements. Pressure control ventilation and high levels of PEEP may be useful. Other possible effects of severe burns include: ↓ lung and chest-wall compliance, ↓FRC, ↑ A-a gradient, ↑ carboxyhemoglobinemia, and ↑ methemoglobinemia. **Tests:** ABG, depending on pulmonary status; CXR
Cardiovascular	The hypermetabolism associated with burns increases cardiac demand, and burn patients have greatly elevated circulating levels of catecholamines →↑↑HR + ↑ CO. **Tests:** As indicated from H&P.
Neurological	Evaluate for burn encephalopathy. Characterize baseline mental status before anesthesia to allow evaluation of recovery postop.
Musculoskeletal	Damaged muscle →↑ acetylcholine receptor density, resulting in ↓ sensitivity to nondepolarizing muscle relaxants and potentially fatal elevations of K^+ in response to succinylcholine. In burns > 5% TBSA, avoid succinylcholine after 24 h postburn and for at least 1 yr thereafter for burns > 10% TBSA (→↑ K^+). Recovery of normal response to muscle relaxants does not occur until burns have healed completely.
Hematologic	Coagulopathies may result directly from the burn injury, as well as from rapid replacement of blood loss during operative procedures. **Tests:** Hb/Hct; electrolytes; coagulation profile
IV access	May be difficult; assess preop. Consider central line placement with a large-bore catheter, such as a Cordis.
Laboratory	Other tests as indicated from H&P.
	Patients are commonly placed on high-dose narcotics after the

Premedication	initial injury; additional narcotics are frequently required to provide adequate analgesia for transport and movement to the OR table.
Transport	For patients with severe ARDS, transportation from burn unit to OR may pose formidable challenges with regard to ventilation. Cardiopulmonary monitoring must be continued during transport; the ventilation system used in transport must be capable of delivering high minute-volumes, PEEP, and inspiratory pressures. These requirements may not be satisfied by standard bag-valve systems and may require a high-quality transport ventilator.

Intraoperative

Anesthetic technique: GETA. Regional techniques are rarely feasible, given the multiple surgical sites for harvesting and grafting. LMAs are not recommended, given the potential for significant fluid resuscitation and subsequent airway edema, as well as the frequent repositioning of patient intraop.

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Induction	If the patient is adequately volume-resuscitated, propofol (1.5–2.5 mL/kg iv) or thiopental (3–5 mg/kg) may be used. If the patient is intravascularly volume-depleted, etomidate (0.3 mg/kg) or ketamine (1–3 mg/kg) is recommended. Patients with extensive burns (> 30% TBSA) will develop a decreased sensitivity to nondepolarizing NMBs; therefore, 1.5 × the usual intubating dose of NMB is recommended: vecuronium (1.5 mg/kg), pancuronium (0.15 mg/kg), or rocuronium (1.5 mg/kg). If rapid-sequence induction is indicated, succinylcholine should not be used if the initial injury is > 24 h old. Under these circumstances, high-dose rocuronium (2 mg/kg) can be used. If the face is burned, awake FOI may be necessary and securing the ETT may be difficult. Alternatives to taping the ETT include suturing the tube to the teeth or using umbilical tape.
Maintenance	Standard maintenance (see p. B-2). Physiologic derangements of the respiratory system (ARDS, pulmonary edema) and a hypermetabolic state may require minute-volumes > 30 L/min, and high inspiratory pressures and PEEP, for adequate ventilation. Depending on equipment availability, a Siemens or ICU ventilator (capable of PPV) may be necessary and possibly a ventilator capable of high frequency oscillatory ventilation. Intraop, surgeons may use epinephrine-soaked sponges to ↓ blood loss. Systemic absorption of epinephrine will cause tachycardia and increase the probability of dysrhythmias; therefore, it is best to avoid halothane or desflurane. Isoflurane and sevoflurane are acceptable.
Emergence	Estimation of an adequate dose of narcotic to provide postop analgesia may be difficult since these patients are often receiving high doses of narcotics preop. Ketamine has been used with success in providing improved analgesia in the setting of escalating opioid doses. If large-volume resuscitation has occurred intraop, there is the possibility of clinically significant airway edema; use caution before extubating to ensure a patent airway.
Blood and fluid requirements	Extensive blood loss IV: 14–16 ga × 2 or a Cordis NS/LR @ 8–10 mL/kg/h Keep UO @ 0.5–1 mL/kg/h. Blood: 200 mL/1% BSA excised and grafted. Fluid warmer T&C 2–4 U PRBC (to keep ahead). Blood must be in OR before induction. The major blood loss generally is associated with eschar excision, usually the first part of the procedure. For patients without contraindications to hemodilution (e.g., CAD, anemia), it is often better to delay PRBC transfusion until major blood loss is complete. IV hyperalimentation should be continued during surgery, or, replace with 10% dextrose infusion to avoid hypoglycemia. If sudden ↓ BP occurs during very rapid infusion of blood (>150 mL/min), consider using Ca^{++} to counteract

		the chelating effect of citrate. Avoid fluid overload, especially if patient has ARDS, is a small child, or is elderly. As the surgical site is superficial, there is not much 3rd-space loss.
Thermal considerations	Room = 80–82°F Warm all fluids. Humidify gases. Warming blanket Reflective head cover	Temperature must be monitored throughout the case. The surgeon may be notified if patient's core T is dropping.
Monitoring	Standard monitors (see p. B-1). ± CVP line PA catheter	ECG may require needle electrodes or alligator clip electrodes to skin graft if there is no skin availability to apply adhesive electrodes. The hemodynamically unstable patient should be monitored with a PA catheter.
Positioning	and pad pressure points. eyes.	The burn patient may be uniquely susceptible to laryngeal or upper airway edema in the prone position; therefore, examination of the upper airway before extubation is recommended to avoid emergent reintubation.
Complications	Massive blood loss	

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Postoperative

Complications	Hypothermia Coagulopathy	May occur as the result of massive blood loss and replacement.
Transport	Continue cardiopulmonary monitoring. High minute-ventilation requirements ↑ PIP ↑ PEEP	Verify adequacy of transport ventilation system before departing OR.
Pain management	Oral methadone or sustained-release morphine sulfate IV fentanyl or morphine sulfate	Titrate analgesia to effect.
Tests	Hct, ABG, electrolytes, PT, PTT, Plt, if massive transfusion given.	

Suggested Readings

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8. Moran KT, O'Reilly TJ, Furman W, et al: A new algorithm for calculation of blood loss in excisional burn surgery. *Am Surg* 1988; 54(4):207–8.