An Introduction to Burn Care: The Sequel

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GENERAL PURPOSE: To review burn care, with an emphasis on burn-specific issues and treatment.

TARGET AUDIENCE: This continuing education activity is intended for physicians, physician assistants, nurse practitioners, and nurses with an interest in skin and wound care.

LEARNING OBJECTIVES/OUTCOMES: After participating in this educational activity, the participant will:

1. Select the appropriate treatment guidelines for patients who have burn injuries.
2. Identify common complications of major burns.
3. Choose the recommended pharmacologic approaches to burn care.

ABSTRACT

Care of burns, particularly those that are deep and/or extensive, requires a very specific approach from a multidisciplinary team of different types of experts. In contrast to many chronic lesions, large burns are also immediately life-threatening and have significant systemic effects that require specialized treatment as well. This article provides a high-level overview of burn care with an emphasis on these burn-specific issues and treatment.

KEYWORDS: burns, burn team, excision, grafting, inhalation injury, shock

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INTRODUCTION

Burns are a common injury but a major health burden, as indicated by burn victims' high level of disability-adjusted life-years (a measure of overall disease burden, expressed as the number of years lost due to poor health, disability, or early death).[1] Globally, an estimated 180,000 casualties are caused by burn injuries each year. The vast majority of these deaths occur in low- and middle-income countries, which have relatively low numbers of burn centers and often limited treatment options.[2] In high-income countries, burn injuries are relatively less common, and better treatment options exist; in the US, for example, approximately 40,000 patients per year are hospitalized because of burn injuries, and approximately 60% of these patients are treated in specialized burn centers.[3]

This article presents an in-depth, but not exhaustive look at burn care. It is a follow-up to an earlier article published in this journal,[4] in which the authors presented a broad overview of some aspects of burn care, such as the incidence and the type of burns, and how to determine the depth and size of a thermal injury. That article also provided a broad overview of the treatment of burns and donor sites and discussed long-term sequelae such as hypertrophy and keloid and contracture formation.

In the present article, the author continues this discussion, describing what is specific to burn care and why, in larger burns, many bodily systems are involved in the disease process and need to be addressed. It addresses topics such as emergency care, burn disease (the fact that

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a lesion of the skin can acutely cause a serious and sometimes deadly illness) and its sequelae, how to prevent or treat associated complications, and surgical aspects of burn treatment. It addresses specifics of burn center requirements as well as the all-important members of the burn team. Important nonsurgical or nondirect wound-related aspects such as dietary support are briefly discussed. The article also addresses some specifics on the type of patients, particularly those who are the subject of abuse or experience serious psychological problems leading to attempts to commit suicide through self-immolation.

THE BURN CENTER AND BURN TEAM

Small, non-life-threatening burns form the majority of thermal injuries. They may cause substantial morbidity because they often are very painful and may lead to significant long-term sequelae such as keloid and contracture formation, as well as hypertrophic scarring. Large, deep burns require specific care and also have significant systemic effects.

These factors have led to the development of burn centers[5] with specialized burn care and rehabilitation practitioners. Burn centers combine high-level technical and medical knowledge and expertise with wound care treatments and techniques that are particular to burn care. A burn center typically is a separate, dedicated department within a larger hospital that can accommodate and treat acutely injured patients with burns and those who are recuperating. Although some centers include beds for reconstructive surgery, other centers (and patients) prefer that reconstruction take place in other parts of the hospital (eg, the regular plastic surgery ward).

Because a burn center is an acute admission department, it should have its own ORs that are readily available for emergency surgery such as escharotomies and tracheostomies.[6] A designated OR in the burn center itself also ensures that patients do not have to be transported through the hospital, thus avoiding exposure.

Burn centers are verified by organizations such as the European Burn Association and American Burn Association. A burn center must have a number of architectural features, including intensive care facilities with access to extensive treatment options (eg, artificial ventilation, hemodialysis, equipment for extracorporeal membrane oxygenation).[7] Temperature control (ie, maintaining rooms at 37 °C) is necessary because of patients' large bodily areas that are exposed to heat loss during dressing changes. Step-down beds and regular beds are also typically located in the same center.

Because different patients often have different levels and types of contamination or infection, ideally patients should be isolated through the use of access docks with air-pressure hierarchy. This is also particularly important when patients are accepted from other hospitals and from abroad: they carry the risk of colonization with unknown and possibly multiple multidrug-resistant microorganisms upon admission.

A burn center also needs to have proper facilities for changing dressings, bathing, or showering (although, on this topic, major differences of opinion exist); physiotherapy; occupational therapy; and the measuring and application of orthopedic devices such as splints. There is also a need for facilities to accommodate patient visits: often patients are too ill to allow for visitors in the same room. Closed-circuit television offers possibilities. Long-stay accommodation for family members is recommended as well and is sometimes provided as a charity. The center should also have access to equipment and treatments such as music therapy or virtual reality that help with patient distraction as a support measure for pain relief.

Burn Team

As important, or perhaps even more important than the physical structure of a burn center, are its personnel. Burn care is multidisciplinary and includes a "standard" series of specialized physicians and other medical professionals. Although surgeons, plastic surgeons, intensivists, pediatricians, microbiologists, internists, and anesthesiologists form the core physician staff, the burn team needs to have access to other physicians as well, such as psychiatrists, nephrologists, hepatologists, ophthalmologists, radiologists, hematologists, and neurologists.

Other medical staff are equally important. On a daily basis, this includes physiotherapists, occupational therapists, and dietitians. Physical and occupational therapists are essential for preventing stiffness and may help reduce scarring and contracture formation. Therapy includes anticontracture splinting and positioning and range-of-motion exercises. Restoration of daily activities, which requires early mobilization, is essential for the best functional outcomes. Further, pedagogical staff, psychologists, social workers, pastors, and others may not always be involved in daily care, but where and when necessary, access is important for emotional and spiritual (or religious) support and help in returning to society.

The final medical person to be mentioned is perhaps the most important person on the team: the burn nurse. Nurses are among the most critical team members during the acute phase of burn care when the physiologic status of hospitalized patients is continuously monitored to ensure that cardiac, metabolic, respiratory, urologic, nutrition, and psychological responses are treated. Nurses have the most frequent and intense contact with patients and thus can detect any life-threatening deviations requiring immediate response.[8] They play a key role in daily briefings and discussions that take place in every burn center. Nurses also provide the majority of wound care with dressing changes that may unintentionally inflict pain as a result of dressing removal and reapplication when general anesthesia is not indicated. This is a major physical and psychological burden on both the nurse and the patient. Nurses also use newer innovations in the care of patients with burns by installing and using nonmedication techniques such as virtual reality devices to distract patients during care to alleviate pain.

Expert burn nurses have one of the most physically and psychologically demanding positions on the burn team, typically working long shifts in difficult circumstances where heightened vigilance is essential to provide the best outcome for patients. Physical demands include turning immobilized patients with attached ancillary equipment such as respirators, catheters, and IV tubing attachments while wearing multiple layers of personal protective equipment to mitigate infection. The psychological aspects of being a burn nurse are perhaps among the most challenging because they directly witness patients' pain and the impact of family members and also sometimes have to deal with patients who are delirious, aggressive, or displaying inappropriate behavior.

FIRST AID/EMERGENCY CARE

The impact of the burn injury can be decreased by taking immediate action to counter the causing agent and its effects. In patients with both burns and other major trauma, however, treatment of the skin-related aspects of burns may be postponed (with the exception of fasciotomies) in favor of other aspects of acute trauma care, such as treating major circulatory and pulmonary problems and intra-abdominal bleeding and stabilizing fractures:[9] Treatment at this stage may be something of a balancing act.

Thermal Burns

The first measure of treatment in thermal injuries is removing the heat source by cooling with water. The guideline is to cool the injury with cold (but not ice-cold) running water, typically for at least 10 minutes, but specifics on the optimal length of cooling and water temperature are contradictive.[10] Virtually any type of cooling helps in reducing the heat impact and pain. In most countries, regular tap water is clean enough to be used. However, particularly with large burns, and in small children with even relatively small burns, there is a risk of hypothermia because of the loss of the protective top layers of the skin. Using thermal blankets after cooling and during transportation is advised.[11]

Chemical Burns

With regard to chemical lesions, there are four major types of burn agents: acids, bases, organic solutions, and inorganic solutions.[12] First-line treatment includes removal of the chemical agent; in many cases, dilution of the agent is sufficient. Rapidly applying water is important in chemical lesions as well because as long as the inciting agent is present, tissue destruction will continue.[10] Once the chemical agent has been removed, care can progress to relevant treatment of systemic toxicity, general support, and treatment of the specific skin lesions.

Using pH-neutralizing agents for chemical burns seems logical but in practice is difficult. Controlling the quantity of the neutralizing agent is a key difficulty. Moreover, exothermic reactions may add to the chemical injury, and the neutralizing agent itself may also be toxic. Some chemical injuries, however, do require a very specific treatment. For example, hydrogen fluoride burns (Figure 1) require treatment with calcium gluconate,[13] and lesions caused by phosphorous continuously need to be kept wet while the agent is being removed (white phosphorus ignites spontaneously if the temperature exceeds 34 °C).[14] New ways of reducing the impact of chemicals are being researched.[15]

Treatment After Burn Agent Removal

After cooling and neutralizing or inactivating chemicals, clean partial-thickness (PT) and full-thickness (FT) burns with soap and water or nonirritating skin disinfectants, and perform superficial debridement to remove devitalized and necrotic tissue or epithelium. General burn wound management also includes ensuring an up-to-date tetanus immunization status and early prevention and treatment of pain and anxiety.[16]

Burn size needs to be measured quickly. In combination with preexisting comorbidities and/or burn accident-related complications such as an inhalation injury or

Figure 1. HYDROGEN FLUORIDE BURN: ASPECT ON POSTBURN DAY 2

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additional trauma, the size of a burn injury helps determine the type of initial systemic therapy (eg, shock prevention).[17] Burn-depth assessment in an early stage is crucial to assess whether urgent fasciotomies are necessary (see below). In this context, it is important to note that burn depth and size are often incorrectly measured.[18]

Extensive burns, even when not very deep, have a major influence on the body's fluid balance. Because of the acute and massive inflammatory response, an increase in capillary permeability causes complex fluid, electrolyte, and protein shifts that result in fluid transport into the interstitial spaces. This leads to hypovolemia and shock, which providers must prevent by intravenously replacing lost fluids.[19] Fluid loss via the exposed subcutaneous tissues also contributes to complications. Different types of volume calculations (ie, with modified Brooke, Muir and Barclay, or Parkland formulas) are used with fluids such as Ringer lactate and colloid solutions.[20]

Fluid extravasation also results in the development of edema. Elevation of the limbs may help reduce edema, but, particularly when circumferential, a tight (deep PT or FT) eschar may jeopardize the circulation to a limb, causing compartment syndrome. Such an eschar in the neck may also obstruct the trachea. Thus, escharotomies or fasciotomies, incisions through the eschar into the deeper tissues, may be necessary to release the pressure on the airways or the vascular supply. A fasciotomy is also often necessary in electrical injuries. An escharotomy to reduce intrathoracic or intra-abdominal hypertension may be required in FT burns of these bodily cavities.[21] Chemical escharotomies are being researched.[22]

Another frequent early complication in patients with serious trauma is the development of delirium. Although delirium is more often seen in older adults, it also occurs in children. It is characterized by a decreased awareness of the environment and is accompanied by symptoms such as disorientation, fear, aggression, hallucinations, and problems with memory. Delirium typically fades over time as the patient's injuries improve, but it sometimes seriously interferes with the day-to-day care for patients with burns.[23]

INHALATION INJURY AND ACUTE RESPIRATORY DISTRESS SYNDROME

Inhalation injury is caused by toxic and/or hot gases. It is common in major (flame) burns and remains a substantial problem: Patients with inhalation injuries have a significantly higher morbidity and mortality rate than those without.[24] When an inhalation injury is suspected, the patient should be transported in a prone position. The development of acute respiratory distress syndrome (ARDS) is a major threat, and a prone position improves gas exchange in the lungs.[25] Patients with ARDS require immediate intubation, but its severity in burn care is not always recognized by "nonburn" (ie, emergency care) personnel. Diagnostic bronchoscopy cannot always be (rapidly) performed, and results are often subjective.[26] Diagnostic biomarkers for ARDS are being identified.[27,28]

Inhalation injury in its different forms has many challenges, and its treatment has not kept pace with the care of cutaneous thermal injury.[29] The pathophysiology is complex and not yet fully understood,[30] but new methods of artificial ventilation and extracorporeal membrane oxygenation are being used with significant success.

SHOCK PREVENTION, DIURESIS, AND INFLAMMATION

Hypovolemic shock is an immediate concern in patients with large burns but can be prevented by administering substantial amounts of infusion fluids. Large veins (ie, jugular, subclavian) are almost always used for the infusion. Because of the risk of infection of, and via, the venous lines, these need to be changed quite regularly, which is a burden for both the patient and the treating staff.

The amount of fluid that needs to be administered depends on the size of the burn and the patient's weight. The Parkland formula[31] prescribes 4 mL of (crystalloid) fluid per % total body surface area (TBSA) × bodyweight (in kilos). Thus, a patient with 50% TBSA who weighs 80 kilos requires 16 L of fluid during the first 24 hours postburn, of which 50% should be administered during the first 8 hours. Children weighing less than 30 kilos require additional fluid, typically with added glucose and sodium because these patients are prone to hypoglycemia and hyponatremia. The total amount of fluid that needs to be administered is guided by the urinary output, which should be 0.5 mL/kg per hour for adults and 1.0 mL/kg per hour for children.

Circulatory permeability begins to restore approximately 2 to 3 days postburn. At this point, excess fluid must be evacuated from the interstitial space to avoid more edema. Diuresis, using drugs such as furosemide, becomes a priority.[28] However, there is a very delicate balance between fluid supplementation and diuresis.[28]

Systemic inflammatory response syndrome (SIRS) is an exaggerated inflammatory defense response of the body to a noxious stressor, including trauma, (massive) surgery, ischemia/reperfusion injury, malignancy, and others.[17] It is a serious complication that frequently occurs in major burns. Inflammation is a normal response to injury, but if excessive (as occurs with major injuries), massive systemic leukocyte activation leads to damage to multiple organs.[32] Indeed, SIRS can lead to organ dysfunction and organ failure, and there is a strong relationship between SIRS and sepsis with regard to physiologic responses, symptoms, and cause and effect.[33] In addition to direct external injury to the lungs, SIRS contributes to the development of ARDS through multiple inflammatory mediators.

Coagulation dysfunctions such as disseminated intravascular coagulation are relatively common complications in patients with major burns.[34] Multiorgan failure may involve many organs such as the liver and brain, but kidney failure is the most common complication.[35] Rhabdomyolysis and other systemic complications may also occur.[36]

BURN EXCISION

Both FT burns and deep PT burns that have not healed within 14 to 21 days should be excised and grafted. Healing of burns that take an extended period causes increased aggravation for patients because of the additional painful dressing changes and interference with daily activities. When a burn takes a long time to heal, the resulting scar usually becomes hypertrophic, and contractures may develop because the body attempts to reduce the wound surface not only by re-epithelialization but also by contraction (Figure 2).[37,38] Early excision has a number of advantages, including overall reduction of treatment time, a better-quality (easier to excise) eschar, a decrease in mortality (in adults), and better long-term outcomes.[39,40]

The downside of excision, whether early or late, is massive blood loss, which, according to different measurements, typically is approximately 0.8 mL/cm^2 of excised tissue. The timing of the excision (ie, the number of days postburn) also influences the levels of bleeding: early excision causes more blood loss.[39] Measures to decrease blood loss include using epinephrine-soaked dressings, applying a tourniquet when a limb is excised, or injecting epinephrine underneath the area to be excised.[41]

Excision is performed using hydrosurgery or with a hand, electric, or air-driven dermatome. For smaller burns or deep burns within larger, more superficial areas, tangential excision can be performed with a Weck dermatome.[38] With this technique, thin layers of necrosis are excised until a well-bleeding wound surface (which is an indication of vitality of the wound bed) is reached. Hydrosurgery, which uses a narrow and powerful saline jet, is used for the same indications.[42] For larger areas, excision can be performed with a Humby-Braithwaite dermatome (generally called the Humby knife).[43] Both the Humby knife and the Weck dermatome are manual dermatomes; many surgeons prefer using these devices over mechanical tools because they offer a higher degree of control over the excision. Electric and air-driven dermatomes are available in different formats and can be used for the same purpose.

For large, contiguous FT burns, the avulsion technique (also called excision to fascia or excision to fat) can be used.[44] With this technique, the necrotic skin layers are grabbed with sturdy hooked forceps, and the dead tissues are pulled off. The advantage of this seemingly inelegant and brutal technique is speed, reduced bleeding (because smaller arteries withdraw and contract instead of being cut open), and a natural plane of separation that is ready for grafting.

Figure 2. HYPERTROPHIC SCARRING

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TOPICAL AGENTS

Microbial infection is an obstacle to healing and, particularly in large burns, a threat to survival. Patients with burns typically experience a variety of bacterial and fungal infections, and the presence of multiresistant bacteria (ie, *Acinetobacter* species) is an increasing problem.[45] In large burns, it is not uncommon for one area of the burned body to have a microbiologic biotope that is very different from another, even adjacent, area.

Burn care uses regular topical agents such as triple antibiotics and similar over-the-counter materials for small and superficial burns. Requirements for topical antimicrobial agents used in large wounds or for a lengthy period are more stringent, however. Dressing changes are performed over extended periods, and aspects such as ease of application and pain-free (as much as possible) removal are important considerations because often these materials are changed daily or even twice a day.

The absence of topical and systemic toxicity is also imperative, the latter particularly because the agent may be used on large, exposed (and thus absorbing) areas.[46] Absorption of some agents that are used because of their high level of efficacy (or lack of alternatives) may lead to systemic, but not toxicity-related, effects that need to be addressed (eg, metabolic acidosis is related to the use of mafenide).[47]

Further, topical antiseptics must be able to penetrate through the burn eschar. Gentamicin sulfate, povidone-iodine, silver sulfadiazine, silver nitrate solution, mafenide acetate, and nitrofurazone can penetrate eschar to varying extents.[48] Mafenide acetate, silver nitrate solution, nitrofurazone, and cerium silver sulfadiazine[49] (cerium-nitrate in silver sulfadiazine) are compounds that are used virtually exclusively in burn care.[50] Broad-spectrum coverage, including against yeasts and fungi, is often required; to prevent resistance, topical compounds are sometimes alternated.

Because of this complexity, many burn centers regularly culture their patients' wounds, even without clinical signs of infection, so that they know beforehand what microorganisms may cause the next breakthrough infection. The enormous variety of infecting microorganisms that are seen in burn care and the frequent occurrence of resistance also mean that sometimes "old remedies," such as acetic acid, have to be used, despite known adverse effects.[51]

Septic shock is a problem in burn care, particularly in view of the increasing presence of multiresistant microorganisms.[52,53] Because of the complexity of the microorganisms and infections and the severe morbidity of the patient, atypical infections, such as necrotizing colitis caused by systemic aspergillosis or toxic shock syndrome, can occur in patients with burns.[54]

BURN WOUND COVERAGE

For PT burns, particularly small injuries, providers often use "standard" wound care dressings (eg, those that are also used in ulcer care); these are not discussed here.

In addition to the aforementioned topical creams and solutions, burn care uses a variety of other materials and techniques. Xenografts were first used in burn care and are still quite common as temporary dressings.[55] Xenograft materials include porcine skin, banana peel, potato peel, and frog skin.[55] Many dermal templates (also called extracellular matrices) also include animal-derived components, such as collagen, or are more or less processed complete tissues.[56,57] There are too many dermal templates and xenografts to describe here in detail, but their main function is to provide a temporary cover; in addition, some templates provide an artificial or alternative dermis upon which an autograft can be applied.

The first commercially available dermal template was designed as a temporary coverage for patients with major burns, who typically have a limited total possible excision area because they do not have enough donor sites available. This matrix is bilayered and consists primarily of a modified bovine collagen matrix. When applied onto an excised wound, vasculature grows into the matrix, and a Silastic membrane prevents desiccation and damage of the underlying tissues. The material thus allows for massive excision and protection of the excised areas until reharvesting of previously used donor sites is possible: the outer Silastic membrane is removed, and the collagen-created wound bed can be grafted.[58]

A variety of different matrices and tissue engineering materials based on similar principles are now available,[59] many of which offer pain relief and protection of the underlying wound bed against external trauma and desiccation or stimulate tissue ingrowth.[60] Some templates can be populated with dermal or epidermal cells to enable a faster and more real-skin-like healing.[61] Others are designed to prevent or treat contractures.[62]

Allografts, particularly amnion and cadaver skin, also have been used in burn care for a long time.[63] Amnion is primarily used as a biological dressing for PT burns of the face: the use of this material offers tremendous pain relief, and it is, in principle, a one-time application. Similar to the use of amnion, the application of cadaver skin in PT burns is, in principle, a one-time intervention, with the material offering pain relief and "falling off" when the underlying lesion is re-epithelialized. In addition to use as a dressing for PT burns, cadaver skin can also be applied as a cover dressing on widely meshed autografts. Two main forms of preservation are used, cryopreservation and glycerol preservation.[64] Cryopreservation preserves some level of viability after thawing, whereas glycerolization kills the cells but keeps their structure intact. In a literature review, no clinical differences between these forms of preservation were found with regard to time to re-epithelialization or other short- and long-term effects.[64]

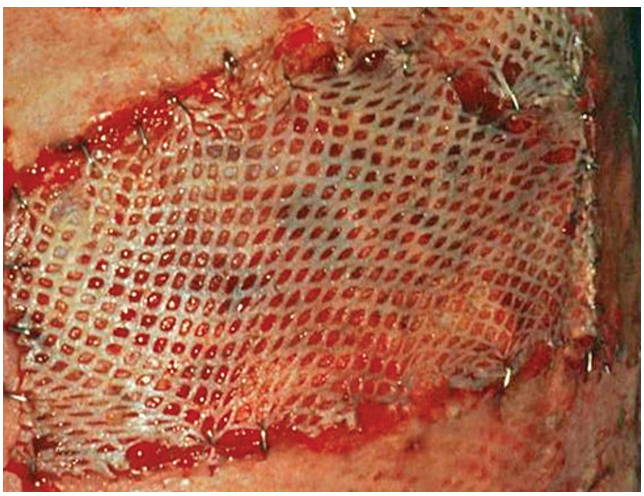
In the end, FT excised burns require closure with an autograft. Full-thickness (grafting the entire thickness of the skin) autografts are rarely used and then only for small and very specific excised areas. As opposed to split-thickness skin graft (STSG) donor sites, which will re-epithelialize within 1 to 2 weeks, FT donor sites need to be closed by a surgical procedure. An STSG is used either "as is" (full sheet) or as a meshed graft. A full-sheet skin graft will provide the best cosmetic results, particularly when efforts are made to use a donor site with a skin structure that is similar to the recipient site. Full-sheet grafts are sometimes perforated to allow for drainage. The word "dermatome" (literally "skin-cutter") refers to both the device that creates the donor sites as well as the device that cuts an STSG for expansion. The commonly used donor-site-creating dermatomes are electric or air-driven devices and use oscillating or rotating blades.

When larger areas need to be grafted, donor site availability becomes a limiting factor, although, in principle, skin from virtual all parts of the body, such as the scalp and scrotum, can be used. Larger donor sites also contribute to overall morbidity, thus limiting full-sheet availability. To address this issue, techniques have been developed to expand the STSG, using either mesh grafting or Meek-Wall expansion. Meshing is a technique that has been around for a long time.[65] The typical mesh-graft machine cuts parallel rows of staggered longitudinal slits in the graft. By pulling the graft out, a mesh pattern occurs, which is applied over the wound (Figure 3). Re-epithelialization occurs through outgrowth from the mesh over the interstices. Most mesh machines use a carrier, a special piece of plastic on which the skin is applied prior to cutting, but some are carrierless. The Meek-Wall dermatome (Humeca) cuts an STSG into small squares, which are glued onto a carrier. The carrier then can be expanded and is applied, skin-side down, onto the wound. The effective expansion with Meek-Wall is bigger than with the mesh-graft technique, meaning that, with the same amount of STSG, a larger burn can be treated.[66]

Expansion through meshing or with Meek-Wall can be performed at different rates of expansion, up to 1:9. However, the expanded skin is extremely fragile to external forces and difficult to manage, and outgrowth takes a great deal of time. To protect the fragile STSGs and the underlying wound, the grafted area can be covered with a narrowly meshed allograft, typically cadaver skin.[67] This so-called sandwich technique results in acceptable appearance and function and has significant advantages to graft extensive burns on patients who have limited donor sites.[68]

Burn wound coverage can also be performed with cultured autologous epithelium, with or without fibroblasts in the culture.[69] The initial outcomes with these techniques were not too encouraging because of properties of the grafts themselves (eg, fragility), but also because the lengthy culture time meant leaving the burn wound exposed or delaying the excision until the grafts were ready. However, significant progress has been made in this area,[70,71] and cell culturing has become a more or less standard option. One of the methods for cell culturing uses a specifically designed device that separates diverse types of skin cells from a small sample.[71] These separated cells are then collected in a gel that can be applied over a wound surface. Among the advantages are the limited need for donor sites and acceptable cosmetic results.

Figure 3. MESHED GRAFT ON AN EXCISED BURN



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Tissue expanders are balloons that are inserted subcutaneously and gradually inflated.[72] Over time, surplus skin will develop over the ballooned area, which then can be used as a defect-closing flap. For expansion, an area with undamaged skin next to the area to be covered is preferable. In burn care, tissue expansion is seldom used for primary coverage; the expansion process is slow and takes a long time to generate enough skin, leaving the burned areas exposed in the meantime.

Similar to skin expansion, flaps are not typically used for primary covering because only relatively small areas can be "flapped." Many different types of flaps exist, from simple local (rotation) flaps to pedicled flaps to free flaps with microvasculature, and all have their own techniques and indications.

NUTRITION MANAGEMENT

Serious burns lead to significant metabolic changes: The body responds to a serious burn injury with the highest hypermetabolic response of any critically ill patient population, with catecholamines as the primary mediators of hypermetabolism. Caloric requirements may be such that protein breakdown becomes a necessary and large source of energy, and skeletal muscle cachexia results from a long-lasting imbalance between protein synthesis and breakdown.[73]

Thus, hyperalimentation must be used, but these patients often are too ill to eat or be intubated. Different formulas exist to calculate the required number of calories. For example, the Curreri formula[74] calculates that a 25-year-old man with a body weight of 80 kg, a body surface of 2.0 m^2, and 60% TBSA needs 4,400 kcal (approximately 18,400 kJ). It is impossible to eat this number of calories, so both enteral feeding (ie, preferably with a gastric tube) and parenteral feeding are used. The types of calories that are administered (fat vs carbohydrates vs proteins) are very important, and certain micronutrients and compounds such as vitamins C and D, omega-3 fatty acids, and antioxidants may have to be repleted or supplemented. However, evidence for the addition of some of these nutrients is not very strong, and further research is needed. Pharmacologic compounds can be used to influence the metabolism of patients with severe burns by lowering the heart and metabolic rate. For example, propranolol treatment for 12 months after re-epithelialization has positive long-term effects such as the accumulation of lean body mass.[75]

SELF-HARM AND (CHILD) ABUSE

Self-inflicted burns are relatively rare, but the prevalence depends on the country, society, ethnicity, culture, general background, and so on.[76] Deliberately setting oneself on fire may be done for a number of different reasons, including hallucinations, stress release (via automutilation), or as a form of protest or martyrdom.[77] The most common psychological disorders that lead to a patient with burns being admitted in a burn center are substance use disorder (44%) and mood-related (28%), personality (20%), and psychotic disorders (10%).[78] In 42% of patients who tried to commit suicide by self-immolation, a psychotic disorder is present (2017, US data).[78] Burns as a result of self-immolation typically lead to injuries that are larger than average and need prolonged admission times. Further, the complexity of this group of patients has a major impact on their care: Nurses who care for these patients for long periods experience increased stress and disorganization, including the fear of a new suicide attempt by the patient.[79]

Honor killings, which may involve male family members setting a woman on fire as punishment for violating the family honor, are not uncommon in certain parts of the world and within certain societies and religions.[80] Inflicting burns is also sometimes used as non-religion-related revenge. A lethal punishment in certain parts of Africa is "necklacing," in which a gasoline-soaked rubber tire is placed around a victim's chest and arms and set on fire.

Cutaneous conditions may indicate abuse, but patients, both children and adults, may also cause lesions themselves in attempt to mimic abuse.[81] However, specific skin lesions, with a pattern of regularly occurring trauma, particularly in children, may indicate abuse.[82]

Although the physical treatment of burns caused by self-harm or abuse does not differ from that of accidental burns, these patients require additional psychological and social support.[83]

TREATMENT AND NONTREATMENT DISCUSSION: TRIAGE

Major trauma often is immediately life-threatening and requires early and significant intervention. In most cases, patients with major trauma have a concussion or other serious head trauma and thus are not conscious of their situation. In contrast, many patients with major burns are conscious and thus may realize, at least to some extent, the gravity of their medical situation. Therefore, these patients sometimes can and want to be heavily involved in whether they should be treated.

If a nontreatment wish is sincere and expressed by a patient for whom the absence of treatment (other than symptomatic or palliative care) would result in rapid death, discussions between the patient, family, and the medical staff may lead to only palliative care or even (passive) euthanasia. This type of decision has significant implications for all involved, and outcomes depend on many factors, including societal influences, religion, legal issues, culture, and actual available treatment options.

There are several indices to calculate purely physical aspects regarding mortality and survival. The more general tools, such as the Modified 5-Item Frailty Index, are not reliable predictors of burn-in-hospital mortality. Mortality can be accurately predicted, however, by linking the APACHE II (Acute Physiology and Chronic Health Evaluation II) score to the TBSA. More specific tools include the Baux and modified Baux indices and the Abbreviated Burn Severity Index.[84] The age of the patient, TBSA, the percentage of FT burn, whether an inhalation injury is present, and the burn type are all factors that play a role in determining mortality. The Abbreviated Burn Severity Index seems to include all the factors in the most reliable way. These indices are used to support discussions with the patient.

Mass casualty incidents often have more patients with burns than with other types of trauma. These events compromise the efficacy of indices because of factors such as lack of transportation and trained personnel and overwhelmed facilities. Local triage becomes important. Several countries and regions are setting up burns incidence response teams to prepare for mass casualty burn incidents with triage tables that are designed to manage large numbers of victims.[85,86]

CONCLUSIONS

Patients with burns, particularly those with large injuries, with or without inhalation injury and/or other types of trauma, have very specific requirements with regard to their treatment, the people who treat them, and the environment in which they are treated. ●

PRACTICE PEARLS

- Deep PT and FT burns need to be excised and grafted to avoid prolonged healing with cosmetically poor results.
- The initial treatment of thermal and chemical injuries is cooling/dilution with running water, but specific chemicals require specific types of treatment.
- In large burns, copious amounts of fluids must be administered initially to avoid shock, but later on, excess fluid must be evacuated from the interstitial space with diuretics to avoid massive edema.
- The treatment of inhalation injury is still complicated.

• Scars continue to evolve long after re-epithelialization; scar quality can only be judged after a significant period, but scar prevention needs to begin immediately.

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