Guidelines for Burn Care Under Austere Conditions: Surgical and Nonsurgical Wound Management

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GUIDELINES FOR BURN CARE UNDER AUSTERE CONDITIONS: WOUND CARE

Introduction

The burn wound is central to all aspects of burn care. The size, depth, and condition of the burn wound directly impacts fluid resuscitation, hypermetabolic response, immune system dysfunction, and predicted survival. Optimal care of the burn wound requires specialized facilities and experienced burn nurses and surgeons, all of which are in limited supply under normal circumstances. These resources may become overwhelmed or unavailable as a result of a large-scale disaster in a developed country or the need to provide care in an austere or far-forward environment. In this monograph, we discuss adaption and modification of normal burn wound practices to accommodate austere or disaster environments.

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Rationale

The integumentary system is the largest organ in the body. Intact skin is semipermeable to water and impermeable to bacteria. It functions as a barrier to infection, a regulator of heat and water loss, and a sense organ for pain, temperature, and touch. A burn converts intact skin into an open wound, disrupting these functions. The primary goal of burn wound care is to achieve wound closure. For partial-thickness burns, this usually involves debridement and placement of temporary dressings with the goals of avoiding infection, maintaining a protective environment, and facilitating normal wound healing. For full-thickness burns, surgical excision and skin grafting is necessary. There are thus four different circumstances in which burn dressings are required: partial-thickness burns (either debrided or not debrided); full-thickness burns with intact eschar; full-thickness burns with eschar excised but not grafted; and partial- or full-thickness burns which have been excised and grafted. No one dressing or antimicrobial is ideal for all of these circumstances.

Before the practice of early excision and grafting, burn eschar was left in place for weeks to spontaneously separate from the underlying wound bed, leaving granulation tissue suitable for grafting. Because bacterial action was necessary for this process, burn wound sepsis was both common and expected. To address this problem, three effective topical agents were developed in the 1960s. The introduction of mafenide (Sulfamylon®) in 1963 was followed

by the introduction of aqueous silver nitrate solution in 1965 and silver sulfadiazine (Silvadene®) in 1968.[1–5] These antimicrobials did not sterilize the burn wound, but rather kept the level of bacterial colonization to a manageable level.[6]

In contemporary practice, even the largest full-thickness burns are rapidly excised, often within 24 hours of burn center admission, making the choice of topical antimicrobial less important. In a large-scale disaster, the facilities and personnel needed to rapidly excise all full-thickness burn will be unavailable and eschar may need to remain in place for extended periods. This may revert us to standards of care practiced by burn centers in the 1960s. Review of burn textbooks from this period provide insight into how burn wounds can be managed when timely excision is not feasible.

Preparation and Planning. There are many situations in which burn care must be provided under austere conditions. In each such environment, the provider must develop a specific strategy to enable effective wound care. There are, however, some principles common to all situations:

- The provision of austere burn care "requires flexibility, common sense and an appreciation of imposed limitations."[7]
- New burn care routines must be developed "based on available material, personnel, operating room time and patient condition."[7] For example, it may be necessary to involve family in daily patient care or even physical therapy.
- Forget how you "do things back home."[7]
- In a mass casualty incident, standards will be diluted, ignored, or forgotten; personnel will be used beyond their usual roles or comfort zones.

The importance of the physical plant cannot be overlooked when considering burn wound care and the risk of death from invasive infection. By means of what would now be called a "bundle" of interventions (individual isolation rooms, hand washing, microbial surveillance, and antimicrobial stewardship), McManus et al[8] sustained a decrease in Gram-negative infections. Can these principles be transferred to an austere environment? Recent data from Iraq indicate that the answer is yes.[9] Even in austere environments, basic infection control concepts can and must be pursued. Unfortunately, there may be a lack of adequate facilities for showering or bathing patients, a major problem requiring creative solutions.[10]

When beds for inpatient admission are lacking, outpatient care may be needed. Family members or others in the community must be trained to perform outpatient care, and follow-up may be challenging. In such situations, a dressing that does not need to be changed daily, such as a silver-impregnated dressing, may be preferable (see below). A lack of inpatient beds also argues in favor of early, aggressive excision and grafting in order to reduce inpatient length of stay, even if operating room time is limited. When a burn wound is closed surgically, the problem of burn wound care is largely solved and mortality reduced.[11]

Adequate resources will be lacking in a mass casualty situation, including burn-experienced personnel and supplies. A strategy for identifying, motivating, and training a team of personnel to perform burn wound care under supervision should be developed as part of the disaster plan. This is, perhaps, the single most important aspect of providing wound care in an austere environment. Supplies may also be limited. Topical antimicrobial agents, dressings, and medications (analgesics, sedation) will likely not be available.[7] For example, mafenide acetate is commonly used for contaminated burn wounds, but this topical agent may be in limited supply. Topical antimicrobial (mafenide acetate) ability to reduce burn mortality is both age- and burn-size-specific.[12] The maximal mortality benefit is achieved in young adult patients with the mid-range of wound size, that is, 40 to 79% TBSA.[12] This provides a basis for triage in the face of a shortage of supplies.

Prerequisites for Wound Care. The best location for wound care should be identified. Although the operating room is often used for initial wound debridement, in a mass casualty wound care will need to occur in the ward or intensive care unit. Ideally, a dedicated wound care area allowing for patient bathing, privacy, and hand washing should be identified. Other requirements include a dressing supply cart and printed instructional handouts. Patients should be premedicated with narcotics and benzodiazepines if supplies permit. Ketamine should be used for large wounds; given the limited number of anesthetists, physicians and nurses will likely need to independently administer this drug. Family members should be brought into the wound care process to facilitate the transition to outpatient care.

Choice of Topical Antimicrobial. Before discussing the *choice* of topical antimicrobials, the *process* of dressing changes must be emphasized. This includes the following points: wound care including debridement and cleaning; premedication; inspection of the wound; and identification and rapid, thorough excision of infected wounds.[13,14]

Truly early excision is defined as removal of all full-thickness eschar 24 to 48 hr after injury, and

concomitant closure of the wound with autograft and/or allograft. Early closure decreases the need for topical antimicrobials. Because the ability to excise and graft burns acutely is limited in most austere locations, patients often present in delayed fashion with heavily colonized or infected wounds caused by inadequate, infrequent, or nonexistent wound care.

In this setting, mafenide acetate 11% cream (Sulfamylon®) has been effective.[2] Mafenide acetate has unparalleled efficacy against Gram-negative organisms, penetrates full-thickness eschar and other poorly vascularized tissue beds, and has been effectively used in the treatment of combat wounds during several armed conflicts over a 50-year period.

Mafenide acetate use resulted in a dramatic decrease in invasive Gram-negative burn wound infections and associated mortality in multiple wartime situations.[3,15] The proven efficacy in combat wounds, which often have delays in excision and grafting, makes it attractive for use in austere care situations. Mafenide acetate has superior coverage for multidrug-resistant organisms (*Pseudomonas aeruginosa*, extended-spectrum β-lactamase-producing *Klebsiella pneumoniae*, *Acinetobacter baumannii* complex, and methicillin-resistant *Staphylococcus aureus*), but limited efficacy against yeast.[16,17] Silver sulfadiazine (Silvadene®) may thus be used alternately to broaden coverage in a practice termed "alternating agents."[18] Silver sulfadiazine has poor coverage against *Enterobacter* species, and there are some known resistant strains of *Pseudomonas*.[16] Wound care is performed twice daily; mafenide acetate cream is applied in the morning; and silver sulfadiazine cream is applied in the evening.

Twice-daily dressing changes with alternating agents, though ideal, may not be feasible in austere environments.[19] In many countries, mafenide acetate is not available. In that situation, use of silver sulfadiazine as a sole agent may be necessary. The twice-daily timing of dressing changes reflects the duration of action of topically applied burn creams. This practice is labor- and supply-intensive. An alternative is to perform care only once daily.[20] However, that care must be exceedingly thorough.

There are a variety of both "new" and "older" topical dressings effective for burn and acute or chronic wound care that can be employed when mafenide and silver sulfadiazine are not available. These include silver-based dressings, Dakin's solution, and cerium-based products.

Silver-based dressings are commonly used for both burn-wound care and in wound-healing centers. There is now over 10 years of military experience with silver-nylon dressings used for burn and trauma care under austere and combat conditions.[21] Silver-nylon dressings in 4 or 6 in rolls or sheets have been used in combat practice in Bagram Airbase, Afghanistan, and the Combat Support Hospital (Baghdad) in 2003.[22] These dressings are easy to apply by inexperienced personnel and can be left in place for several days, obviating the need for twice-daily dressing changes. The stretch nature of silver nylon makes it an ideal dressing over split thickness autograft, as uniform compression can be obtained. Compared with mafenide or silver sulfadiazine cream, silver-nylon dressings require less storage space, are easier to ship, and were not sensitive to extremes of temperature in transit or storage. Finally, for a large-scale U.S.-based burn mass casualty incident, silver-based dressings could be useful for patient self-care. Since the dressings can be left in place for several days, patients can be sent home to return several days later for wound examination.

Silver dressings are not a substitute for mafenide and silver sulfadiazine creams in those patients with heavily contaminated wounds or in those wounds with a heavy burden of devitalized tissue.[19] Surgical excision (when available) or twice-daily dressing changes with creams remains the standard for these indications.

Aqueous 10% mafenide solution also has years of proven effectiveness under combat conditions. Mendelson demonstrated increased survival and efficacy of topical 10 and 20% aqueous mafenide hydrochloride solutions against both *Pseudomonas aeruginosa* and *Clostridium perfringens* in an animal model of combined blast, open fracture, and devitalized-tissue injury with concomitant surgical delay.[1,2,23,24] Aqueous mafenide has been used effectively in austere conditions in the Vietnam War.[1,25] Fifty milliliters of sprayed solution will cover approximately 50% of the body surface of an average-sized adult. Five pounds of mafenide powder, when mixed with clean water, provides enough 10% aqueous spray to cover 50% of the body surface for 455 dressing applications or enough 5% solution for 910 applications.[2,7,26] Finally, aqueous mafenide is an effective topical when used as a surgical adjunct for open fractures, necrotizing fasciitis, and Fournier's gangrene.[2,27]

Dakin's Solution. Dilute solutions of sodium hypochlorite are bacteriocidal against a broad spectrum of burn pathogens including *Pseudomonas aeruginosa*, *Enterococcus* species, *Staphylococcus aureus* and *Staphylococcus epidermidis*, *Escherichia coli, Klebsiella pneumoniae*, *Enterobacter cloacae, Serratia marcescens*, and *Proteus mirabilis*.[28–30] The Carrel-Dakin technique of mechanical cleansing, surgical debridement, and every-2-hour topical

application of Dakin's solution revolutionized the management of burns and combat wounds in World Wars I and II.[31,32] Dakin's solution was commonly used for burn care until the development of mafenide and silver sulfadiazine. Sodium hypochlorite remains bacteriocidal down to a concentration of 0.025% and is universally available as laundry bleach (Chlorox™), which is a 5.25% solution of sodium hypochlorite.[28] An inexhaustible supply of burn antimicrobial is thus obtainable in nearly any disaster by simply visiting the local market. Of note, sodium hypochlorite solution has a limited shelf life and must be made daily.

Cerium Compounds. The addition of cerium nitrate to silver sulfadiazine enhances antipseudomonal activity.[33,34] A combination of cerium nitrate [$Ce(NO_3)_3$] and silver sulfadiazine is marketed in Europe as Flammacerium® but is not approved by the U.S. Food and Drug Administration for use in the United States.[35] Cerium nitrate produces a "leather-like" eschar that serves as a microbial barrier, which reportedly allows excision and grafting to be delayed.[36] The cerium nitrate may also bind toxic byproducts of thermal injury, and thus decrease the systemic inflammatory response to the wound.[37] Cerium nitrate has been made locally and used to treat patients in whom early complete excision of deep burns was not feasible. Of note, methemoglobinemia can occur with this agent; methemoglobin levels should be available if ongoing patient is envisioned.[38]

Other Nontraditional Dressing Options. Read and Ashford used commercial polyethylene cling film as a temporary short-term dressing after the Bali, Indonesia, bombing in 2002.[39] Cling film was compact, easier, and less painful to remove than conventional burn dressings and allowed easy surveillance of the burns.[39] This is a short-term solution; cling film has no antimicrobial properties. When dressings are unavailable or in scarce supply, honey is an alternative. Growing literature indicates the broad-spectrum antimicrobial efficacy of this substance in the treatment of burn wounds.[40] Daily dressing changes as described above are recommended if honey is used.

Subeschar Clysis With Intravenous Antibiotics. Providers working in an austere environment are likely to encounter invasive Gram-negative burn wound infection in patients who have received limited or no wound care during the first several days after injury. These patients will present with sepsis and with the local *tinctorial signs of infection* described by Pruitt and colleagues.[13] While it is tempting to take the patient for immediate excision, the bacteremia resulting from excision of such heavily contaminated wounds may result in death. Subeschar clysis with a semisynthetic penicillin may be advantageous in preparing these patients for surgery.[41]

Clysis involves the subeschar injection of intravenous antibiotics. One-half of the daily dose of a semisynthetic penicillin (piperacillin or carbenicillin) is mixed in a liter of saline and injected into the eschar with a spinal needle.[7,41] This is performed on admission and then repeated 6 hours prior to surgery. When surgery must be delayed, clysis can be performed twice a day for several days.

Recommendations

Although every austere environment is different, the following steps should be taken in developing a plan for burn wound care:

- Identify and train a wound-care team.
- Prepare a venue for wound care.
- Establish a process for daily wound care and inspection.
- Determine availability of topical antimicrobials and plan their rational use.
- Provide adequate analgesia and anxiolysis.
- Decrease inpatient workload by doing early surgery and outpatient follow–up.
- Mafenide and silver sulfadiazine creams should be used when available.
- Alternatives include silver-based dressings and aqueous mafenide acetate solution.

GUIDELINES FOR BURN CARE UNDER AUSTERE CONDITIONS: OUTPATIENTS WITH MINOR BURNS

Introduction

Disasters have and will include a substantial number of burn-injured patients (burn disasters), overwhelming local and regional resources.[42–45] While planning efforts typically focus on managing the critically burned patient, the reality is that many patients from a burn disaster will present with minor or nonemergent burns.[46,47] This guideline focuses on the definition, treatment, and wound care for patients with minor burn injuries treated by clinicians with limited expertise in situations where there are limited supplies.

Rationale

A burn injury is heat damage to skin, the body's largest organ. Skin is composed of two main layers: epidermis or outer layer and dermis or inner layer. Located within the dermis are the underlying structures such as hair follicles, oil glands, pigment cells, a blood supply, and nerve endings. As heat penetrates

down into these layers, it compromises the function of these structures. The higher the temperature or the longer the skin is exposed to a heat source, the greater the depth of a burn.

The American Burn Association defines minor burns in a disaster as those involving noncritical sites and less than 10% TBSA for partial-thickness burns.[48,49] Critical sites are all major joints, hands, feet, face, and perineum. Excluded from this category are patients with minor burns who also have smoke inhalation or associated traumatic injuries. Minor burns are classified as *outpatient* in the matrix developed to aid clinicians with triage decisions during a disaster.[50]

Evaluating Burn Injuries: Superficial Burn (First-Degree Burn)

The most common burn injury is a superficial burn, also described as a first-degree burn.[51,52] Superficial burns involve only the epidermal layer and are characterized by pink to reddened areas (more prominent in patients with lighter skin tone/complexion) and generally are described as painful. The most common cause of a superficial burn is sunburn. While painful, especially when much of the body is involved, this condition is typically not an emergency, based on the burn injury alone. Superficial burns should not be included in TBSA calculations. Because of the progressive nature of burn wounds, it should be noted that burns presenting as superficial burns early on may in fact progress deeper into tissue and will have to be reclassified and managed as partial-thickness or full-thickness burns.

Evaluating Burn Injuries: Partial-Thickness Burn (Second-Degree Burn)

Heat penetration through the epidermis and into part of the dermis is considered a partial thickness or second-degree burn. It is characterized by blistering, red discoloration, warm or hot to touch, and is quite painful.[50,51] It should also be noted there is a more serious classification of the partial thickness burn called "deep partial thickness" but is not applicable for this work. Since portions of the dermis below the burned tissue remain intact, partial-thickness burns eventually will heal. The deeper the injury, the longer it takes for healing to occur. Wound closure should be monitored closely as healing may not occur and surgery may be required.

Evaluating Burn Injuries: Full-Thickness Burn (Third-Degree Burn)

The full-thickness burn, also described as a third-degree burn, results when all of the epidermal and dermal layers are damaged by heat. A full-thickness burn will not heal and requires grafting in order to close this wound. Full-thickness burns are characterized by either charring or a dry, leathery appearance of the skin and may be cool to the touch from an inadequate blood supply in the skin's layers. Since nerve endings are destroyed, these wounds generally lack any sensation; however, patients often report the injury is painful. Pain alone is an unreliable symptom, as patients may report mild to extreme pain caused by adjacent partial-thickness burns or concomitant traumatic injuries.[7,53]

Recommendations

Initial Actions for the Management of All Burn Injuries

For all burn injuries, it is imperative to stop the burning process. Remove clothing in the area of the burn injury, including diapers, to fully expose both the burn and all areas contiguous to the burn. Items such as rings, watches, or other metals that could absorb heat or compromise circulation should also be removed.

If the burn has just occurred, it should be initially flushed for a few minutes with any readily available water source. For burns more than a few hours old, this step is not necessary. While current reference materials discuss the use of cool water (not ice), warm water may be better.[52] Regardless, water stops the burning process by preventing heat from penetrating any further into tissue layers. Water application also provides some initial pain relief. For minor, small burn injuries, continued application of clean water not associated with hypothermia may continue as needed for pain relief. Patients with larger burns will be unable to maintain sufficient thermoregulation. Once the wound is cooled, continued application of water or wet dressings to burns greater than 10%TBSA for pain relief should be discontinued.

The most ideal conditions for minor burns to be managed outside of the hospital environment and achieve good outcomes include a home or shelter environment where others can and are willing to support care for the patient. Other considerations include a patient who has no other injury or underlying medical condition to interfere with good health or injury healing; can the patient swallow over-the-counter (OTC) medications and drink sufficient amounts of fluids? It is essential that all burn patients remain well hydrated, and this specifically applies to the pediatric and older patients, as they can become dehydrated more quickly over a shorter period of time.

General Wound Management: Superficial Burn Injuries

If initial evaluation determines the burn is limited to a superficial injury only, management includes rest and oral hydration.[54] OTC topical antibacterial and/or anesthetic ointments may be applied if available, and application does not interfere with managing patients with more serious injuries. Ideally, topical OTCs are given to the patient or caregiver for self-application. There are a wide variety of OTC gels, sprays, creams, and liquids that may be used for a superficial burn, as discussed in the previous section of this document. The superficial burn requires no dressing other than clothing to keep it clean and protected from the sun or other heat sources.

General Wound Management: Partial- and Full-Thickness Burn Injuries

During a disaster, supplies for dressing a burn wound may be inconsistently available and may require creativity on behalf of the clinician. Unless there is a compelling need as previously discussed, avoid using dressings for superficial burns.

For small partial-thickness or full-thickness burns that meet the definition of minor and can be managed as an outpatient, use what is readily available for dressings. Options may range from soap and water and clean dressings to the more ideal use of topical creams and sterile or silver-impregnated dressings, as described in the document on wounds, which require less frequent changes and may be included in a burn cache.

Specific Wound Management for the Minor Burn

There are four specific steps for managing a minor burn. These include cleaning the injury, treating the injury, applying a dressing and, where appropriate, a bandage to secure the dressing. Pain management is an omnipresent issue with burn injuries and should be evaluated during minor burns as well.

Cleaning the Wound: Cleansing and Debridement. Prior to beginning any dressing change, pain medication should be administered. All burn wounds should be cleaned with clean water and patted dry. For cleaning the wound, it is preferable to use an "antimicrobial" cleanser such as Hiboclens®. However, during a disaster, the only soap products readily available may be common household products. These are acceptable.

For partial-thickness burns, blisters should be broken and cleansed as described above with available antiseptic/antibacterial solutions.[48] (Note: Chlorhexidine gluconate is commonly used as an oral rinse to prevent gingivitis and may be found with dental supplies sold under the brand names: Biotene®, PerioRx®, and Peridex®.) This process should be repeated every 12 to 24 hr. As the wound begins to show signs of closure, generally within 5 to 10 days, this process can be repeated less often. Once the wound is closed, an OTC moisturizer may be applied to relieve any dryness or itching, usually present at this stage.

For larger burns that meet criteria to be managed in the outpatient setting, it may be necessary to aid the healing process by manually debriding or removing unhealthy tissue. This dead tissue becomes a source of infection, and leaving it in place complicates the healing process.[55,56]

Wound debridement is accomplished by gently washing the wound with soap and water and using a tweezers to gently pull loose, dead tissue away from the wound. Alternatively using a washcloth or clean piece of linen moistened with water and an antimicrobial cleanser to gently wipe away loose tissue is effective.

If available, the use of specialized moist dressings, known as hydrogels or hydrocolloids, may also be used for autolytic (the body naturally rids itself of dead tissue) debridement. Examples of these dressings include Derma-Gel®, CarraGauze®, Woun'Dres Collagen®, Carrasyn-Hydrogel®, Dermagran®, Tri-Calm®, and Medela®.

For truly austere situations well outside the traditional standard of care, debridement options may include enzymatic debridement using mashed papaya. Biological debridement can include larvae of *Lucilia sericata*, also known as maggots from the green blowfly.[57,58]

If circumstances permit, minor partial- and full-thickness burns should be cleaned and debrided within the first 24 hr of the injury. Typically, this process is delayed until the patient reaches the burn center; however, in a disaster this may need to be started prior to transfer.[48] The goals for effective wound management are to keep the wound clean, avoid infection, and shorten the time from injury to healing. Regardless of size, full-thickness burns typically need surgical debridement and grafting to close the injury. Dressing changes should be discontinued once the wound is sufficiently closed over. If dryness or itching is present at this stage, an OTC, commercially available moisturizer may be applied.

Treating the Wound: OTC Antibacterial, Antimicrobial, and/or Topical Anesthetics. Topical or antimicrobial creams are designed to inhibit colonization of the burn wound to limit or prevent

infection. Examples include silver sulfadiazine, commercially available as Silvadene®/Silverex®/Silvazine®/Flamazine®/Thermazene®/SSD, and mafenide acetate, commercially available as Sulfamylon®. (These agents should not be applied if the patient has a sulfa allergy) Topical Gram-positive selective alternatives, such as bacitracin ointment, may also be used. Examples include bacitracin, Polysporin®, and Neosporin®. These topical antibiotic agents help protect the open wound from bacteria normally found on the skin.

If topical antibacterial creams are available, they should be applied to partial- or full-thickness burns and then covered with a clean, dry dressing. If traditional dressings are in short supply, some alternatives include feminine napkins or clean white (no dye) dry cloth. Dressings should be secured with tape or a torn strip of cloth if rolled bandages are limited or unavailable. (Note: Dressings cover the wound and should be clean and preferably sterile, while bandages secure dressings and should be clean.) When using a rolled bandage, start distal to proximal and wrap snugly, keeping in mind edema will be present in an extremity for the first 24 to 48 hr after burn.

Silver-impregnated dressings or silver-based antimicrobial creams/gels should be applied to partial-thickness burns greater than 10% TBSA, or to all full-thickness burns (excluding the face). For further description, see the wound missive following this document. Instruct family or caregivers to change the dressing at least daily, except for silver-impregnated dressings, which can be left in place for 5 to 7 days. For wounds involving the face, an antibacterial ointment such as bacitracin, Neomycin®, Polysporin®, or similar products are superior to a water-based cream.

Specific Wound Management for the Minor Burn: Dressing the Wound

Dressings/bandages should be changed at least daily based on soiling, availability, and manufacture recommendations for product usage for topical creams. In all cases, topicals should be completely removed at each dressing change and the wound inspected for signs of healing before redressing. During dressing changes, look for pink moist tissue and other signs of healing, such as the presence of granulation tissue. Also, evaluate for signs of infection, such as increased temperature of the tissue surrounding the burn, the presence of purulent drainage, or a distinct unpleasant odor. For minor partial- or full-thickness burns involving the extremities not significantly involving high impact areas (face, genitalia, over a joint, or circumferential), edema may develop. Elevation will minimize the swelling.

Specific Wound Management for the Minor Burn: General Pain Management Overview for the Outpatient Burn Injury

Oral pain management typically includes nonsteroidal anti-inflammatory drugs such as ibuprofen. Acetylsalicylic acid (aspirin), also an anti-inflammatory, is preferred over acetaminophen. Acetaminophen products relieve pain but provide no anti-inflammatory benefits. Combining OTC pain relievers is another option. Simultaneous use of both an nonsteroidal anti-inflammatory drug and acetaminophen at the recommended doses minimizes pain and limits complications that may result from excessive use of a single OTC medication. Regardless, OTC remedies should be evaluated on a case-by-case basis for each patient and administered based on underlying history and indications/contraindication.

During a disaster, there may be an array of medications in short supply including enteral opiates. However, supplies may be commonly found in many household medicine cabinets as old prescriptions and, during truly austere conditions, offer additional options for pain management. Any aspect of pain management includes psychological support. Discuss the plan of care with the patient, be honest but reassuring.

Equipment Caches

During a disaster, the types and quantities of equipment may vary widely and, over time, could come from an array of sources. Equipment caches often contain burn-specific dressings. In addition to the topical antibiotics previously discussed, there is an array of commercially available, *burn-specific dressings* impregnated with a variety of additives. Providers should use what is available, aiming to change the dressings/bandages daily, recognizing that this may not be possible in mass casualty incidents.

Conclusion

Patients presenting with minor burns in a disaster must be cared for in a manner that provides sufficient treatment to manage the injury, but judiciously reflects the limited availability of vital medical supplies and resources. Providing optimal care for every burn-injured patient in a disaster may exceed the capability of local responders and lead to ethical dilemmas in determining who ultimately receives what care.[59] Flexibility is key. Attempt to follow the accepted standard of care, but recognize when altered standards of care may have to be applied during a time of crisis/disaster.

Whenever possible, place patients with minor burns away from those more seriously wounded. Be judicious with supplies, pharmaceuticals, and equipment. Consider implementing the alternatives discussed within this guideline once resources are exhausted. Early on in the disaster, the flow of equipment, personnel, and supplies will be sporadic and unpredictable. Eventually you may begin to receive supplies from a variety of sources ranging from local grocery stores or pharmacies to regional caches.

The most critical element for good wound care is access to clean water. From cleaning the wound to keeping the patient properly hydrated, an ample source of clean water is critical for the burn patient. For minor burns to remain minor and minimize complications that require more resources, the wound has to be kept clean and the patient well hydrated. Without clean water, sustainability of the disaster response will be compromised well beyond those with minor burn injuries.

As previously noted, this section was developed assuming there may or may not be sufficient clinicians and should be read from your perspective based on your training and credentials. Attempt only those skills you are either qualified to perform or comfortable performing. Early into the disaster, the flow of equipment, personnel, and supplies will be sporadic and unpredictable. Following the disaster, you may receive supplies from a variety of sources ranging from federal caches to local grocery and drug stores donating items. While outpatient and minor burns should be managed out of the main flow and patient care area for the more seriously injured, continue to monitor your patient for improvement. Stay focused on the critical objectives of keeping the wound clean, support the patient's fluid, pain, and nutritional needs, and continue to monitor your patient for improvement.

Recommendations

- Use available dressings and bandages with clean water being a critical resource.
- Minor burns can clog an overtaxed system; the triage process should aid with streamlining and steering minor burns out of the emergency care area.
- Keep the wound clean and change dressings with topicals at least every 24 hr, if possible.
- Pain management options will be dictated by availability of supplies.
- Reassess the wound(s); a burn may be worse than initially determined and infection may develop. Assess and reassess for changes within situational constraints.

GUIDELINES FOR BURN CARE UNDER AUSTERE CONDITIONS: BURN SURGERY

Introduction

The austere environment poses significant challenges to the surgical care of burn patients. The *Emergency War Surgery* handbook cautions: "Definitive burn care, including surgery and rehabilitation, is manpower and resource intensive; therefore, it is inadvisable to perform excision and grafting of burns in a theater of operations."[60] We stand by that statement. If a patient can be safely evacuated from the austere environment to a location with well-established, high-quality burn care facilities, this should be the preferred course of action. Such, for example, was the strategy employed in the care of U.S. casualties injured during the Vietnam War and the recent conflicts in Iraq and Afghanistan. For a small number of Iraqi children who presented to the Combat Support Hospital in Baghdad, evacuation to the United States for definitive care in a Shriners Institute was also possible.

Those identified as requiring surgery should be transferred to an appropriate facility, using a triage tool such as that described by Saffle and updated by Palmieri.[51,61] Nevertheless, evacuation of burn patients out of the austere environment is most often impossible; the local burn center may be involved with the disaster and may be unable to accept additional patients.[42,62] As a result, burn surgery is frequently necessary on the battlefield, in the area of the disaster, and in resource-scarce third world scenarios.[63] Burn surgery in these environments will depend on the availability of providers, supplies, equipment, and physical plant. This section builds on recent battlefield experience, which may be applicable to the third world as well.[64]

Rationale: Planning and Preparation

There should be a realistic appreciation of what can, and cannot, be accomplished in an austere environment. At the U.S. Army Combat Support Hospital in Baghdad, it became necessary to triage most local national patients with burns >50% TBSA to the expectant category. The presence of superficial burns (which might heal spontaneously) vs deep burns (which would require surgery) modified this rule of thumb on a case-by-case basis. Several factors influenced this practice. In the context of ongoing combat and a fixed number of beds, there was a critical lack of space. More importantly, it appeared that local national patients (ie, Iraqis) with burns of 50%

of the TBSA or greater had a poor prognosis. Several factors contributed:

- Infection control in a substandard, crowded physical plant
- Lack of experience and training on the part of ancillary personnel
- Minimal rehabilitation, nutrition, psychological support, and related services for inpatient local nationals
- Absence of critical wound-closure technologies to include cadaver allograft

The last is particularly important and establishes a ceiling for what can be reasonably accomplished surgically in the austere environment.

In U.S. burn centers, initial debridement and certain urgent procedures such as escharotomy are frequently performed at the bedside or in procedure/hydrotherapy rooms inside the burn intensive care unit. In an austere setting, however, the operating room may be a better venue for these initial procedures. The operating room is more likely than the ward to have the environment, personnel, equipment, supplies, and anesthetic support needed for extensive wound care. This may or may not be possible in an austere environment.

The decision to commit a patient to excision and grafting in an austere environment must be made carefully, and every aspect of the operation must be given careful thought. The value of communication and team education cannot be overemphasized. In contrast to burn team members in U.S. burn centers, personnel staffing deployed hospitals may have no prior exposure to burn surgery and its salient features, to include significant blood loss, disfiguring operations, and a hot environment. Before embarking on surgery in an unfamiliar austere environment, the surgeon should assemble the operating room team prior to the contemplated procedure and review the procedure in detail, to include the following checklist:[65]: warm environment, extent and duration of excision, hemostatic strategies (tourniquets, epinephrine solutions-topical and by clysis, Bovie electrocautery), blood and plasma (in the room), surgical tools (hand dermatome for excising, power dermatome for harvesting, skin mesher, stapler), dressings (sponges, gauze, surgical netting, roller gauze, Xeroform gauze, plaster), and postoperative burn wound coverage (silver dressings, Biobrane, xenograft, mafenide acetate solution depending on availability). Personnel should also review alternatives to the above. These may include, for example, use of hand dermatomes to harvest skin, and use of scalpels to mesh skin.

Operation. Except for modifications imposed by equipment problems, surgical technique in the austere environment should not differ substantially from that in a modern burn center, with the following caution. The surgeon must modify his pace and the extent of operation in order to match the experience level of the other members of the team. The old rule of thumb that excision should be limited to 20% TBSA or 2 hr time should indeed be considered in the austere environment, especially if the other team members are inexperienced or if the team, however experienced, is working together in the austere setting for the first time.

If an adequate blood supply is not available, the TBSA that can be excised at a single setting will likewise be limited. The availability of antibiotics, pain medication, and anesthetic agents may also be limiting factors. Excision may be performed with or without tourniquet control. The excision may be tangentially performed through the dermis with a manual dermatome (Humby, Watson, Goulian/Weck, etc.) or an electric or air-powered dermatome. The key is to preserve as much tissue as possible (dermis or adipose tissue). For inexperienced surgeons, the correct depth into the adipose tissue may be more difficult to determine and fascial excision, although more deforming, may be the best alternative. Excision to the fascial plane is also more rapid and is usually associated with less blood loss.

Hemostasis during excision is obtained by epinephrine-soaked pads (10 mg in 1000 ml normal saline), electrocautery, bipolar coagulation, and compression. If tourniquets are used, epinephrine-soaked pads and compression (such as Ace bandages on the extremities) should be used, the tourniquet deflated, and compression applied continuously for a minimum of 10 min. Once the compression and pads are removed, complete homeostasis is obtained with the electrocautery, bipolar coagulation, or absorbable sutures.

Postoperative care is particularly challenging in the austere environment. As mentioned above, infection control is problematic. Surgeons must be especially attentive to frequent inspection of the wounds and must have a higher index of suspicion for graft failure. Positioning and splinting and postoperative rehabilitation will be challenging if colleagues from occupational and physical therapy are not available. In the absence of thermoplastic splints, plaster may be used. If available, negative-pressure wound therapy devices may be particularly useful for postoperative wound care. Patients and their family members will require instruction in self-rehabilitation. Intercultural differences will influence a patient's response to injury, to include his

level of participation in rehabilitation. Providers must be aware of these differences and must be resourceful in managing them to optimize patient outcomes.

Although the majority of this section has been devoted to acute burn surgery, surgeons deploying to an austere environment may also be asked to take care of a variety of burn reconstruction problems. Mature judgment is required in deciding how best to respond to these needs. During the acute phase of burn care, ectropion release of the upper and lids may be required to prevent corneal exposure (which places the patient at risk of keratopathy, ulceration, and blindness). Other procedures can be performed in a more elective fashion by qualified surgeons, but may be important to restoring a burn survivor to a functioning role in his or her community. Such procedures include release of burn scar contractures including the major joints, neck, palm, or Web space.

The care of the severely burned patient under less-than-ideal circumstances—on the battlefield, following a disaster, or in a third world country—is surely one of the more challenging experiences a health care provider can experience. May we be up to the task.

Recommendations

- When possible, evacuate patients who require burn surgery out of the austere environment
- When evacuation is not possible, establish and communicate policies and procedures for burn surgery
- Anticipate the need to perform both acute and reconstructive surgery
- Rehearse the operative plan with a designated burn surgery team
- Review supply and equipment requirements using checklists
- Limit the pace and extent of surgery to match the skills and experience of the team
- Be extra-vigilant for postoperative infection
- Train patients, family members, and staff in physical and occupational therapy goals and exercises

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