Manual of Burn Therapeutics

An Interdisciplinary Approach

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Little, Brown and Company
Boston/Toronto

First Edition

Library of Congress Catalog Card No. 82-83180

ISBN 0-316-769584

Printed in the United States of America

HAL

Preface

Advances in the care of the thermally injured patient in the past 25 years have decreased the mortality from shock, inhalation injury, and infection. As witness to this improved survival, greater concern is now being given to postburn morbidity and to finding ways to hasten the patient's return to normal patterns of life.

Partial credit for these successes is unquestionably due to improved IV formulas, topical chemotherapeutic agents, and improved monitoring equipment, but it is ultimately the human element that has led to improved burn care delivery. Special burn care facilities with dedicated multidisciplinary personnel are now available in most parts of the country, in places that once lacked access to special treatment. Enthusiastic and knowledgeable EMTs and transportation crews are ensuring that the patients are reaching burn care facilities alive and in stable condition.

Although protocols and treatment regimens differ at burn treatment centers, the debates on these issues are vigorous and often productive. We should not dwell on differences, however, but should realize that often the same clinical results can be achieved by different modes of therapy. Our major concern is the dissemination of information to smaller hospitals and to interested individuals with less experience but with the desire and enthusiasm to treat burn patients.

This manual is an attempt to achieve that goal. It describes in an organized fashion the ways in which one burn center team cares for patients. Our audience is the health team member in training or burn team individual who needs a quick reference for a reasonable "way to do it." We hope the problems and solutions are presented in a lucid and interesting style that will stimulate further reading.

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Contents

1 Initial management of burns: triage and outpatient care

Roger E. Salisbury

Thermal injury, like all other major forms of trauma, should be evaluated in a precise, systematic fashion. The following presentation is intended as a clinical outline for the initial evaluation and subsequent disposition of the individual with thermal injury.

I. Initial evaluation

A. Airway, circulatory status, ventilation. As in all forms of injury, the first priority in thermal injury is the maintenance of a patent airway, ventilation, and the support of systemic perfusion. This implies endotracheal intubation and assisted ventilation, restoration of circulatory volume, and cardiovascular support, when necessary.

B. General physical examination. Although a patient may present as "a burn" to the emergency room, associated injuries must be sought, for the thermal wound itself may not be the most immediate life-threatening problem. For example, a burn injury associated with an automobile accident requires evaluation for internal thoracic and abdominal damage, closed head injury, and major long-bone and spinal fractures.

C. History. The mechanism of the burn injury is important for providing clues to other associated injuries. For instance, a history of a burn sustained in a closed space raises the question of inhalation injury and the possibility of acute upper airway obstruction.

D. Burn wound. When the preceding factors have been assessed, the burn wound is evaluated. The primary physician must determine whether the wound is major or minor. If it is minor, the physician should have no difficulty rendering appropriate care. If the insult is major, the physician must determine the type of facility that can provide optimal care.

1. **Size of burn.** The size of the burn may be evaluated by applying the rule of nines to estimate the percent of total body surface area involved in the injury (Fig. 1-1). This technique is moderately effective in estimating injury in adults but is less accurate in children because of the different relative proportions of the head, trunk, and extremities, as compared to the fully grown individual. A more accurate assessment of the area involved in the injury in adults and children can be obtained by employing the Lund-Browder chart (Fig. 1-2). This chart not only takes into consideration variations in body proportions with age but also provides a permanent medical record of the initial injury.

2. **Depth of burn.** Although completely accurate assessment of the depth of a burn injury is not always possible, an estimation can be made and recorded by using clinical guidelines (Table 1-1). The depth of injury is important, as the more superficial wounds have potential for spontaneous healing, but the deeper wounds require surgical intervention.

II. Triage. Table 1-2 provides a triage scheme for thermally injured patients. These suggestions must be modified according to local resources and the individual physician's experience. Any major or critical burn patient should be referred to a burn unit or burn center because care of these individuals is facilitated by the availability of a

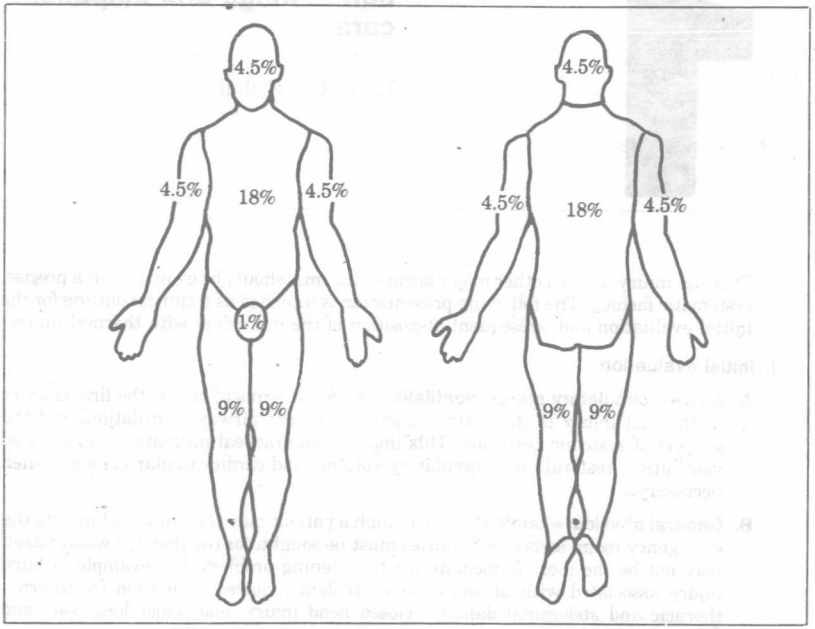

Fig. 1-1. Rule of nines.

multidisciplinary team. Although the local physician may possess considerable expertise in caring for burns, the community hospital usually lacks this ancillary support for their patients. Similarly, the physician with a large practice may not be able to devote the time required for the care of a large burn injury, even with the necessary medical expertise.

III. Initial management of the burn patient requiring hospitalization. The following are guidelines for emergency room personnel in managing the patient with severe thermal injury until the patient can be transferred to a burn care facility.

A. General management

1. Wear sterile gloves when examining the patient.
2. Remove all burned clothing.
3. Conduct a complete physical examination and be sure there are no associated traumatic injuries.
4. Ensure a patent airway. In most cases, a face mask with humidified 40% oxygen is satisfactory. If the patient is in respiratory distress and needs assistance, insert an endotracheal tube and avoid a tracheostomy if possible. The only indication for an emergency tracheostomy is the inability to intubate.
5. Obtain a history of the accident from the patient, family, or rescue squad in addition to a brief patient medical history, including present medications, allergies, and preexisting medical conditions.
6. Insert a large intravenous catheter either percutaneously or by cutdown (in unburned skin if possible). Do not use a scalp vein. Administer lactated Ringer's solution titrated to urine output. The IVs should be titrated to produce 30 to 50 ml per hour in adults, 20 to 30 ml per hour in a child over 2 years of age,

Area	Birth–1 yr	1–4 yr	5–9 yr	10–14 yr	15 yr	Adult	Partial thickness 2°	Full thickness 3°	Total
Head	19	17	13	11	9	7			
Neck	2	2	2	2	2	2			
Anterior trunk	13	13	13	13	13	13			
Posterior trunk	13	13	13	13	13	13			
Right buttock	2½	2½	2½	2½	2½	2½			
Left buttock	2½	2½	2½	2½	2½	2½			
Genitalia	1	1	1	1	1	1			
Right upper arm	4	4	4	4	4	4			
Left upper arm	4	4	4	4	4	4			
Right lower arm	3	3	3	3	3	3			
Left lower arm	3	3	3	3	3	3			
Right hand	2½	2½	2½	2½	2½	2½			
Left hand	2½	2½	2½	2½	2½	2½			
Right thigh	5½	6½	8	8½	9	9½			
Left thigh	5½	6½	8	8½	9	9½			
Right leg	5	5	5½	6	6½	7			
Left leg	5	5	5½	6	6½	8			
Right foot	3½	3½	3½	3½	3½	3½			
Left foot	3½	3½	3½	3½	3½	3½			
						Total			

Fig. 1-2. Lund-Browder chart for burn estimate: percentage of body area.

Table 1-1. Burn depth categories

Degree	Cause	Surface appearance	Color	Pain level
First	Flash flame, ultraviolet (sunburn)	Dry, no blisters; no or minimal edema	Erythematous	Painful
Second	Contact with hot liquids or solids, flash flame to clothing, direct flame, chemical, ultraviolet	Moist blebs, blisters	Mottled white to pink, cherry red	Very painful
Third (full thickness)	Contact with hot liquids or solids, flame, chemical, electrical	Dry with leathery eschar until debridement; charred vessels visible under eschar	Mixed white, waxy, pearly; dark, khaki, mahogany; charred	Little or no pain; hair pulls out easily
Fourth (involves underlying structures)	Prolonged contact with flame, electrical injury	Same as third degree, possibly with exposed bone, muscle, or tendon	Same as third degree	Same as third degree

Table 1-2. Triage of burn patients

Triage to	Minor Injury: outpatient treatment	Major injury: admit to burn unit of general hospital	Critical injury: admit to burn center
Children			
Partial thickness	< 10% TBSA	10–15% TBSA	> 15% TBSA
Full thickness	< 2%	2–10%	> 10%
Adults			
Partial thickness	< 15%	15–30%	> 30%
Full thickness	< 2%	2–10%	> 10%
Age		Patient < 2 yr with minor injury	Patient < 10 yr with major injury
Involvement of hands, face, feet, perineum	Never	Minor injury with involvement	Major injury with involvement
Electrical injury	Never	Desirable	Preferred
Chemical injury	Never	Desirable	Preferred
Frostbite	Never	Desirable	Preferred
Inhalation injury	Never	Desirable	Preferred
Major associated medical illness	Never	Desirable	Preferred
Associated fractures, multiple trauma	Never	Desirable	Preferred

TBSA = total body surface area.

and 1 ml/kg/hour for a child under 2 years of age. A rough estimate of the amount of fluid to be administered in the first hour can be obtained by the Parkland formula:

$$\frac{\text{patient weight (kg)} \times \% \text{ burned} \times 4}{24 \text{ hr}}$$

Insert a Foley catheter to monitor urine output accurately. Record the volume hourly and adjust IV fluids as needed.

7. Insert nasogastric tube and maintain gastric decompression with low intermittent suction.
8. Administer small increments of morphine intravenously if the patient is in pain. **Do not give intramuscular narcotics.**
9. Dilute all chemical burns with copious amounts of water or other specific neutralizing agent if available. Start water lavage immediately.
10. Place the patient between sterile sheets and do not debride the burn wound or cover it with a topical chemotherapeutic agent. Do not allow the patient to become hypothermic.
11. Weigh the patient.
12. Administer tetanus toxoid and hyperimmune tetanus globulin if necessary.
13. Monitor pulses on circumferentially burned extremities immediately on admission and every 30 minutes thereafter. The disappearance of a peripheral pulse may indicate inadequate resuscitation or local compression secondary to edema. The latter is a surgical emergency and necessitates an escharotomy and possible fasciotomy before transfer to another hospital.

a. Upper-extremity escharotomy

(1) Supinate the arm.

(2) Mark the midlateral line of the arm, using the acromioclavicular joint, lateral epicondyle, and thumb as anatomic guides.

(3) Incise laterally (radial aspect), using an electrocautery or cutting current, through the entire depth of the eschar. The circumferential eschar must be cut its entire length to relieve constriction.

(4) Incise the investing fascia to expose the muscle in electrical and fourth-degree thermal trauma.

(5) Reassess the adequacy of blood flow (presence or absence of pulse) by direct palpation or by using an ultrasonic flowmeter.

(6) Add a medial (ulnar) incision to the extremity if there is still no pulse. This incision is on a line drawn anteriorly to the medial epicondyle extending to the wrist.

(7) Extend all incisions across the wrist onto the thenar and hypothenar eminences.

(8) Perform midlateral digital escharotomies if the fingers are circumferentially burned.

b. Lower-extremity escharotomy

(1) Perform escharotomy of the lower extremity in either the lateral or medial midaxial line.

(2) Avoid the peroneal nerve when performing escharotomy over the fibular head.

c. Chest escharotomy. Perform thoracic escharotomy for restrictive circum-

ferential chest burn by incising the eschar along the anterior axillary lines bilaterally, extending the incisions to the midline along the costal margins. A vertical midsternal incision may be added as necessary.

B. Special considerations for high-voltage electrical injury

1. **Urine.** Examine the urine grossly for evidence of hemochromagens, which are indicative of severe muscle destruction. If present, increase the rate of intravenous infusion and administer a bolus of mannitol (12.5 g) to maintain an osmotic diuresis of 75 to 100 ml of urine per hour in the adult. In the pediatric population, administer mannitol sufficient to produce a urine output of 2 ml/kg/hr instead of the customary 1 ml/kg/hr. This will decrease the potential for acute tubular necrosis.
2. **Extremities.** Examine all extremities closely for evidence of compressive phenomena that may indicate the need for fasciotomy (as opposed to escharotomy).
3. **Antibiotics.** Administer intravenous penicillin prophylactically because of the danger of anaerobic infection in the presence of necrotic muscle.
4. **Radiographs.** Obtain x-rays (long bone, spine) if there is any suspicion of associated fractures that might have occurred from tetanic contractions at the time of electrical contact or from a fall associated with the electrical accident.

IV. Management of outpatient burn injuries

A. Local care

1. Remove the clothing, lavage the wounds with room-temperature saline, and wash with mild soap (hexachlorophene should be avoided because of the possibility of significant systemic absorption from open wounds).
2. Apply cool sponges or towels over the burn to help decrease the pain. Prolonged cooling (more than 20 min) should be avoided to minimize the possibility of hypothermia.
3. Debride ruptured blisters and bullae. The intact blisters are not opened unless they impede movement or obstruct a vital function, such as vision, in which case they are aspirated using sterile technique.
4. Apply an impregnated gauze (e.g., Xeroflo) and a bulky dressing to protect the wound and increase comfort. Topical chemotherapeutic agents are not used for outpatient burns.
5. Apply a good moisturizing cream liberally to the skin to avoid cracking once the wound has healed.

B. Medications

1. Administer narcotics, a mild sedative, or both after checking the patient's blood pressure. Intramuscular narcotics and sedatives should never be given in large burns because of the risk of decreasing further the blood pressure in the hypovolemic patient and causing respiratory depression from sudden absorption of the depot drug once circulation has been reestablished.
2. Avoid prophylactic antibiotics in minor burns, as they merely cause proliferation of resistant organisms. Gram-positive burn cellulitis should be treated if it becomes manifest on follow-up.
3. **Administer tetanus prophylaxis**
   a. Give tetanus toxoid booster to the patient who has not had one within the past five years.
   b. Administer 250 units of tetanus immune globulin to the patient who has never been immunized or who has a questionable tetanus immunization history. These patients are also scheduled to complete a full course of tetanus toxoid immunization.

c. Regional considerations

(1) Face. Wash the face carefully with mild soap several times daily and apply petrolatum to dry lips for patient comfort, leaving the face exposed.

(2) Eyes. Stain the corneas with fluorescein to rule out direct thermal injury. Always obtain an ophthalmology consult when the potential for ocular burns is present.

(3) Ears. Apply topical chemotherapeutic agent routinely to this region because of the susceptibility of the underlying cartilage to bacterial infection and the resulting chondritis that may occur. A fluffy, bulky dressing should be applied over the ears to protect them from further trauma. To prevent undue pressure on the ear, avoid using pillows at night.

(4) Hands. Elevate the hands with a compression dressing and splint them for 72 hours to help decrease edema and improve patient comfort. After this time, exercise should be started to prevent stiffness.

(5) Legs. Observe strict bed rest and elevate the legs for 72 hours to help retard edema.

(6) Genitalia. Apply topical chemotherapeutic agent and bathe the area several times daily to prevent bacterial superinfection and conversion to full-thickness skin loss. All but the most minor burns involving the genitalia require hospitalization for optimal treatment.

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2 Fluid and electrolyte therapy in the burn patient

G. Peter Dingeldein, Jr.

Resuscitation and fluid management in the thermally injured individual is controversial, and no one answer can be considered correct. A recent National Institutes of Health Consensus Development Conference on burn care produced only two points of agreement: (1) sodium in some concentration is required and (2) no universal formula will suffice in every clinical situation. Therefore, some understanding of burn shock is necessary in order to make a choice among the various fluid regimens.

I. Pathophysiology of burn shock. Table 2-1 lists the contributing factors that create **burn shock,** the state of organ hypoperfusion seen in the immediate postburn period. This state is due to lack of circulating volume, but it differs from hemorrhagic shock in that loss of circulating red blood cell mass is a relatively small component of burn shock in most cases. The immediate reduction in red blood cell mass is usually 8 to 13 percent (based on human and animal studies) and is higher only under extraordinary circumstances, such as lengthy scald immersion injury.

Destruction of the epidermis eliminates the body's effective barrier to evaporation of water and therefore provides one of the major sources of water loss in the thermally injured individual. This is a factor not only in the acute period but also in the post-resuscitation phase.

The greatest initial volume loss, however, is into the interstitial space in the form of edema. In burn wounds of 30 percent of the body surface or less, this edema is limited largely to the region of the burn, but in larger injuries, extracellular fluid is sequestered in all body tissues, including those not involved directly in the injury. While the exact mechanism of mediation for this interstitial accumulation of fluid is not known, it is manifested by a dramatic increase in capillary permeability to such an extent that plasma constituents with molecular weights exceeding 350,000 move readily from the vascular space into the interstitium. This initial loss of vascular integrity is most profound in the first several hours after the injury, with resolution beginning at approximately 12 hours and rapidly improving at 18 to 24 hours. Although full capillary integrity may not be restored for a number of days, for clinical purposes it may be considered restored at 24 hours. This massive increase in capillary permeability accounts for the observation that crystalloid and colloid are equally effective in maintaining plasma volume during the first 24 hours of resuscitation. Once the capillary leak has ceased, plasma products will remain intravascularly where their oncotic influence can be exerted and thus can be effective in restoring plasma volume.

Armed with this information, we should not be surprised to find that the protein and albumin content of burn wound edema is similar to that of plasma. This fact has led to the resistance of some clinicians to using colloid in the first 24 hours following a burn. Reasons for this are listed in Table 2-2.

This section is not intended to be a comprehensive review of edema formation in the burn patient, but brief mention of certain mechanisms should be made. Factors, including histamine, bradykinin, and the increased affinity of denatured collagen for sodium and water, may be involved. Also, an increased uptake of water into normal cells may account for some of the long-term edema formation. For a more detailed understanding of this complex process, see Suggested Reading.