BMJ Best Practice

Cutaneous burns

Straight to the point of care

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Table of Contents

Summary

Cutaneous burns can usually be managed in an outpatient setting. Early management affects long-term outcome.

Severity is assessed by burn size (% total body surface area) and depth (first to fourth degree).

Initial treatment of minor burns consists of wound cooling, cleaning, and dressing. Pain management and tetanus prophylaxis are important.

Serious burns are most effectively managed in regional burn centres.

Prognosis varies from excellent to poor depending on the severity of the burn. Associated injuries (such as inhalation injury or trauma) adversely affect the prognosis.

The majority of patients will have satisfying outcomes.

Definition

Burns are very common injuries, predominantly to the skin and superficial tissues, caused by heat from hot liquids, flame, or contact with heated objects, electrical current, or chemicals. Burn injuries can result in local and systemic responses. The local response involves the coagulation of injured tissue, and to some degree incites progressive microvascular reactions in the surrounding dermis. As burns become larger than about 20% of the total body surface area, a systemic response ensues, driving fluid loss and release of vasoactive mediators from the injured tissue. Clinically this results in early capillary leak, interstitial oedema, and organ dysfunction.

THEORY

Epidemiology

Although burns are a common injury, the exact prevalence of burn injuries is difficult to determine, as many people will not seek medical advice.[1] Globally, in 2017 nearly 9 million people were recorded as injured by fire, heat, or hot substances.[2] An estimated 180,000 people die every year after burn injuries; the vast majority in developing countries. Death rates from burns have been decreasing in many developed countries, and the rate of child deaths from burns is over 7 times higher in developing than in developed countries. [WHO: fact sheet - burns] (http://www.who.int/en/news-room/fact-sheets/detail/burns) Children surviving very serious burns may be at risk for other physical and emotional health issues as they grow older, emphasising the importance of ongoing burn aftercare programmes.[3]

Country-specific annual data are as follows:

UK[4]

- Around 13,000 people require hospital attention from specialist burns injury services.
- 5% of the significant trauma workload in England and Wales is a result of burn injury.
- In-hospital mortality for burn patients is 1.51%.

US[5]

- An estimated 398,000 people with burn injuries receive medical treatment.
- 29,165 people require hospitalisation. Of those admissions, 15,280 are for minor injuries not requiring surgical treatment, 9340 for deep burns requiring surgical treatment without prolonged ventilation, and 1290 for extensive burns necessitating surgical treatment and prolonged mechanical ventilation. Overall in-hospital mortality for burn patients is 2.7%.
- Additionally, fire/smoke inhalation accounts for about 3800 deaths.

Bangladesh [WHO: fact sheet - burns] (http://www.who.int/en/news-room/fact-sheets/detail/burns)

- Nearly 173,000 children are moderately or severely burned.

Bangladesh, Colombia, Egypt, and Pakistan [WHO: fact sheet - burns] (http://www.who.int/en/news-room/fact-sheets/detail/burns)

- 17% of children with burns have a temporary disability and 18% have a permanent disability.

Nepal [WHO: fact sheet - burns] (http://www.who.int/en/news-room/fact-sheets/detail/burns)

- In rural areas burns are the second most common injury, accounting for 5% of disabilities.

Aetiology

Burn injuries are caused by a number of mechanisms.[6]

Thermal burns:

- Caused by heat, from hot liquids, flame, or contact with heated objects
- In young children, about 70% of burns caused by scalding from hot liquids
- In older children and young working adults, flame injuries are more likely
- In older adults, scalds and cooking accidents are most common.

Electrical burns:

- Caused by low-, intermediate-, and high-voltage exposures, producing a variety of local and systemic injuries.

Chemical burns:

- Caused by exposure to industrial or household chemical products.

Non-accidental burns:

- Approximately 20% of burns in younger children involve abuse or neglect.

Pathophysiology

Burn injuries can result in local and systemic responses.

Local response

- Involves the coagulation of injured tissue, and to some degree incites progressive microvascular reactions in the surrounding dermis.[7]
- In animal models, the secondary injury caused by these microvascular changes has been truncated by a variety of administered substances, but none has been demonstrated to be clinically useful.[8]

Systemic response

- As burns become larger than about 20% of the total body surface area (TBSA), a systemic response ensues, driving fluid loss and release of vasoactive mediators from the injured tissue. Clinically this results in early capillary leak, interstitial oedema, and organ dysfunction.[9] [10]
- In well-resuscitated patients, this physiology will self-extinguish and be replaced by a hypermetabolic response, with a near doubling of cardiac output and resting energy expenditure over the next 24 to 48 hours. The magnitude of this response, peaking in those with injuries of 60% or more TBSA, is as high as twice the normal basal metabolic rate.[11] Accelerated gluconeogenesis, insulin resistance, and increased protein catabolism are associated with this response and have major implications for subsequent support of burn patients. The mechanism is not well understood, but it is assumed to involve a combination of factors including a change in hypothalamic function; increased glucagon, cortisol, and catecholamine secretion; deficient gastrointestinal barrier function with translocation of bacterial byproducts; bacterial contamination of the burn wound with systemic release of similar products; and some element of enhanced heat loss via transeschar evaporation of fluid. Nutritional support of this physiological response is essential. Numerous efforts to modify this process pharmacologically have proven less routinely effective.[12] Growth hormone has been advocated in seriously burned children, but data are not compelling and this is not widely practised at present.[13] Data suggest that use of anabolic steroids may favourably influence burn physiology while also being less expensive, but this practice has not been broadly adopted either.[14]
- The subsequent natural history of burns is driven by the wound. A burn wound is initially clean but is rapidly colonised by endogenous bacteria. As these bacteria multiply, proteases liquefy the eschar, which then separates, leaving a bed of granulation tissue or healing burn depending on the depth of the injury. In healthy patients with small burns, this septic process is often well tolerated. However, when injuries are larger, systemic infection develops, resulting in poor survival of patients with burns involving >40% TBSA managed without early wound excision.[15]

Classification

Standard clinical classification of burns according to depth

First-degree burns:

- Erythema involving the epidermis only
- Usually dry and painful
- Typical of severe sunburn.

Second-degree burns:

- Superficial partial-thickness burns involving the epidermis and upper dermis
- Deep partial-thickness burns involving the epidermis and dermis
- Usually wet and painful
- Typical of scalding injury.

Third-degree burns:

- Full-thickness burns involving the epidermis and dermis and damage to appendages
- Usually dry and insensate
- Typical of flame or contact injury.

Fourth-degree burns:

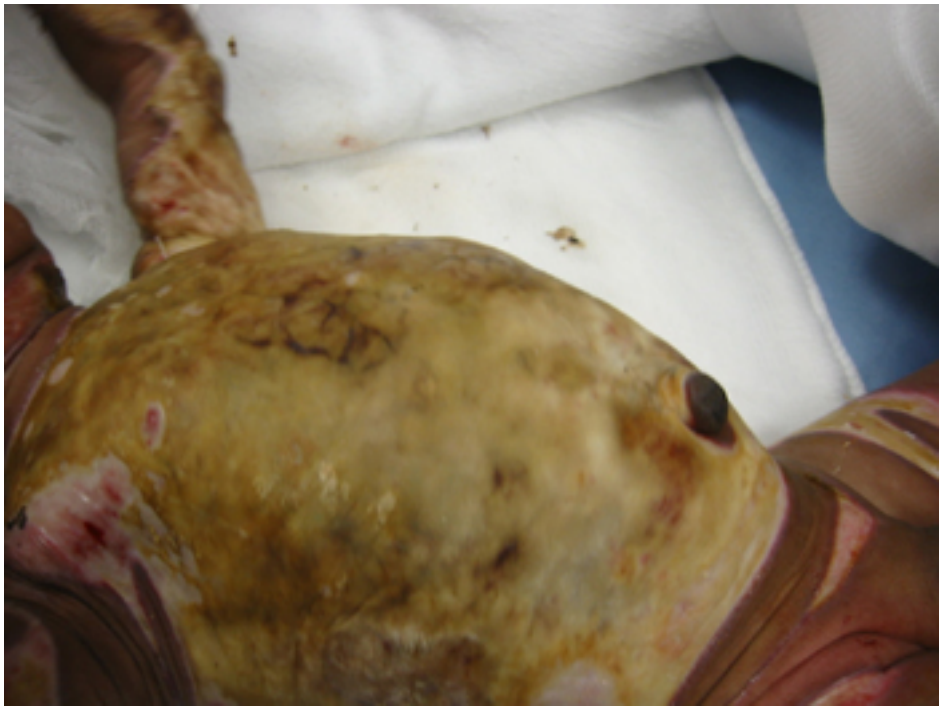
- Involve underlying subcutaneous tissue, tendon, or bone
- Typical of high-voltage electrical injury.

First-degree burn

From Dr Sheridan's personal collection

Second-degree burn

From Dr Sheridan's personal collection



Third-degree burn

From Dr Sheridan's personal collection

Fourth-degree burn

From Dr Sheridan's personal collection

Case history

Case history #1

As a result of an accident in the kitchen, a 20-month-old toddler had boiling pasta and water spilled onto her head, face, and upper body. Physical examination reveals blistering sloughing skin with underlying wet, tender erythema.

Case history #2

A 50-year-old electrician was servicing a high-voltage transformer when a distant switch inadvertently sent current to the transformer, with a resulting arc and electrocution. The worker was thrown back by the force and his clothing was ignited. Physical examination reveals charring of the dominant hand, with deep arching injury across the antecubital fossa and axilla, consistent with passage of high-voltage current. The upper torso demonstrates leathery deep burns consistent with flame injury.

Approach

Assess burn severity by the burn size (% total body surface area [TBSA]) and depth (first to fourth degree). Associated injuries, such as inhalation injury or trauma, adversely affect the prognosis.

Initially sort burn patients into those who can be reasonably managed in the outpatient setting and those who require inpatient care. This important practicality is based on:

- A proper and complete evaluation of the patient
- A careful evaluation of the wound.

Most burn injuries are minor, and patients are discharged following outpatient treatment.

Evaluation of the patient

Systematically evaluate burn patients using the primary and secondary surveys recommended by the American Burn Association alongside any immediately necessary treatment.

Primary survey (ABCDE):[24]

- Airway maintenance; with cervical spine protection if a fall or blunt force trauma is suspected.
- Breathing and ventilation.
    - Circumferential full-thickness burns of the trunk and neck may impair ventilation and require close monitoring.
- Circulation and cardiac status.
    - Increased circulating catecholamines often elevate the adult heart rate to 100-120 bpm; higher heart rates may indicate hypovolemia from an associated trauma, inadequate oxygenation, or unrelieved pain or anxiety.
    - Abnormal cardiac rhythms may be due to electrical injuries, underlying cardiac abnormalities or electrolyte imbalances.
    - Circulation in a limb with a circumferential or nearly circumferential full-thickness burn may be impaired by oedema.
    - Typical indicators of compromised circulation (pain, pallor, paresthesia) may not be reliable in a burned extremity.
    - Absence of a radial pulse below an upper limb circumferential burn suggests impaired circulation.
- Disability, neurological deficit and gross deformity. Typically, the patient with burns is initially alert and oriented. If not, consider associated injury, carbon monoxide poisoning, substance abuse, hypoxia, or pre-existing medical conditions.
    - Determine the patient's level of consciousness using the AVPU method:
        - A – Alert
        - V – Responds to verbal stimuli
        - P – Respond only to painful stimuli
        - U – Unresponsive
    - The Glasgow Coma Scale (GCS) is a more definitive tool used to assess the depth and duration of coma and should be used to follow the patient's level of consciousness.

- Exposure and environmental control. Expose and completely undress the patient, and examine for major associated injuries. Stop the burning process, if applicable
    - Maintain a warm environment to prevent hypothermia.[25]

Secondary survey: (burn-specific; begins after the primary survey is completed and after initial fluids are started):[24]

- History (injury circumstances including time and mechanism of injury, and medical history) and accurate pre-injury weight.
- Complete head-to-toe evaluation of the patient.
- Determination of burn severity, including percentage TBSA burned and burn depth.
- Initial investigations to assess for dysfunction of other organ systems, or establish baseline function (e.g., full blood count [FBC], metabolic panel including urea and glucose).
- Consideration of the possibility of abuse or neglect.
- Consideration of associated trauma, with additional specialised tests (e.g, blood tests, imaging) as needed.
- Management elements of the secondary survey include further adjustment and monitoring of fluid resuscitation (after TBSA determination), pain and anxiety management, psychosocial support, and wound care. See Management approach for further details.

The burn may be the most obvious injury, but other serious and life-threatening injuries may be present. A thorough history and physical examination are necessary to ensure that all injuries and pre-existing diseases are identified.[24]

Evaluation for abuse or neglect

Consider the possibility of abuse or neglect as the injury mechanism as part of the evaluation of every burn patient.[26] Although more common in young children, abuse is also seen in the setting of domestic violence. File suspicious injuries with the appropriate government agency.[27]

Data can be obtained during the initial evaluation and may be helpful later. This includes water temperature (if there is scalding), duration of contact, caretakers involved, conflicting reports from involved caretakers, delay in seeking treatment, and prior injuries.[28]

Important points of examination include uniformity of burn depth, absence of splash marks, sharply defined wound margins, porcelain contact sparing (which occurs when flesh in forced contact with a basin or bath is protected from the surrounding hot water), flexor sparing, stocking or glove patterns, dorsal location of contact burns of the hand, and localised very deep contact burns.[29] Stressful social circumstances are often a factor.[30] Child maltreatment has been shown to be associated with TBSA burned >20%, and with burns of the lower limbs.[31] Photographic documentation is ideal.

Admit patients to hospital for evaluation even if the injury is of little physiological significance. Consider screening radiography.

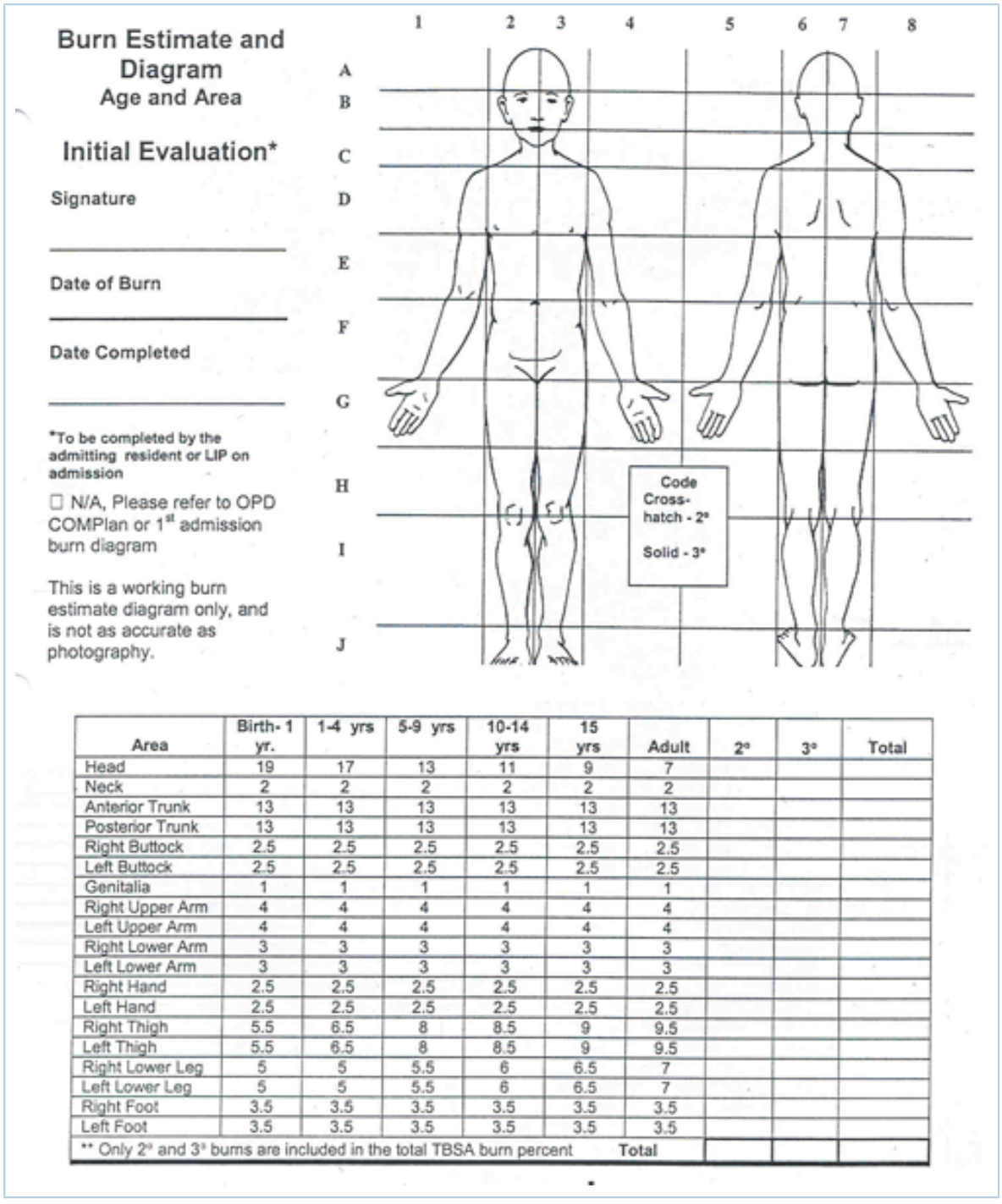
Evaluation of the burn wound

Make initial estimates of burn wound extent and depth.[32] Although a wide variety of devices have been advocated to help determine burn depth and vascularity, none have been widely adopted, as burn thickness and vascularity are only two of the many variables that determine the likelihood of a burn to heal, which is the variable that drives decision-making in burn care. Note the presence of fully or near-

circumferential components. Decisions regarding outpatient care, hospitalisation, or transfer depend on this information.

Burn extent:

- Most accurately estimated using a Lund-Browder diagram that compensates for changes in body proportions with age

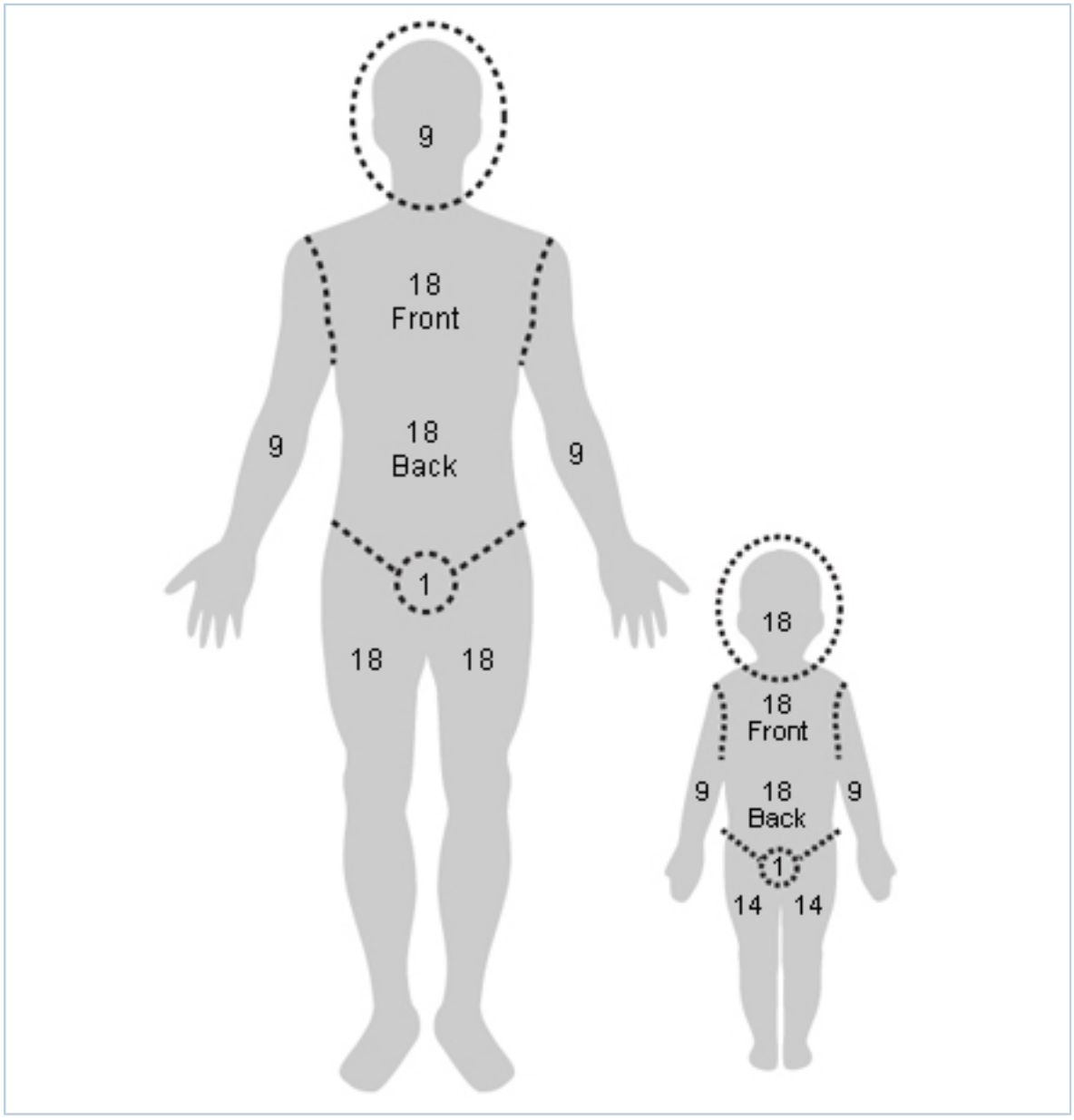


Area	Birth- 1 yr.	1-4 yrs	5-9 yrs	10-14 yrs	15 yrs	Adult	2°	3°	Total
Head	19	17	13	11	9	7			
Neck	2	2	2	2	2	2			
Anterior Trunk	13	13	13	13	13	13			
Posterior Trunk	13	13	13	13	13	13			
Right Buttock	2.5	2.5	2.5	2.5	2.5	2.5			
Left Buttock	2.5	2.5	2.5	2.5	2.5	2.5			
Genitalia	1	1	1	1	1	1			
Right Upper 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	2.5	2.5	2.5	2.5	2.5	2.5			
Left Hand	2.5	2.5	2.5	2.5	2.5	2.5			
Right Thigh	5.5	6.5	8	8.5	9	9.5			
Left Thigh	5.5	6.5	8	8.5	9	9.5			
Right Lower Leg	5	5	5.5	6	6.5	7			
Left Lower Leg	5	5	5.5	6	6.5	7			
Right Foot	3.5	3.5	3.5	3.5	3.5	3.5			
Left Foot	3.5	3.5	3.5	3.5	3.5	3.5			
** Only 2° and 3° burns are included in the total TBSA burn percent						Total			

Lund-Browder diagram

From Dr Sheridan's personal collection

- A simpler alternative is the 'rule of nines':



Rule of nines

From Dr Sheridan's personal collection

- The head and neck represents 9% TBSA (18% in infants)
- Each lower extremity is 18% (15% in infants)
- Each upper extremity is 9% (10% in infants)
- The anterior and posterior torso are 18% each (16% in infants), and
- For scattered or irregular burns the palmar surface of the patient's hand represents approximately 1%.

Burn depth:

- First-degree burns

First-degree burn

From Dr Sheridan's personal collection

- Erythema involving the epidermis only
- Usually dry and painful.

- Second-degree burns

Second-degree burn

From Dr Sheridan's personal collection

  - Superficial partial-thickness burns involving the epidermis and upper dermis
  - Deep partial-thickness burns involving the epidermis and dermis
  - Usually wet and painful.
- Third-degree burns

Third-degree burn

From Dr Sheridan's personal collection

- Full-thickness burns involving the epidermis and dermis and damage to appendages
- Usually dry and insensate.

- Fourth-degree burns

Fourth-degree burn

From Dr Sheridan's personal collection

- Involve underlying subcutaneous tissue, tendon, or bone.

- Burns are commonly deeper than they appear at first examination, so often it is prudent to describe initial impressions and re-evaluate wounds the following day.[33]

Burn location:

- Near- or completely circumferential burns should be identified for special monitoring

Circumferential burn

From Dr Sheridan's personal collection

- If involving the torso, such wounds can interfere with ventilation, or even contribute to intra-abdominal hypertension
- When burns involve an extremity, limb-threatening ischaemia may occur 12 to 24 hours after the injury.

Burn wound sepsis:

- Can be diagnosed by clinical examination, cultures of wound biopsies, and burn wound histology. Most authors advocate diagnosis by clinical examination only
- Most common organisms are *Staphylococcus aureus* and *Pseudomonas aeruginosa*
- A classification scheme includes:[34]
    - 'Burn impetigo' or superficial infection with loss of epithelium (usually associated with *S aureus* and *Streptococcus pyogenes* and particularly common in burns of the scalp)
    - Open burn-related surgical wound infection (develops in excised wounds and donor sites)
    - Burn wound cellulitis (spreading dermal infection in uninjured skin around a burn wound or donor site)
    - Invasive burn wound infection.

Investigations in patients with significant burns

Inspect the globes of the eyes prior to the development of facial oedema, which can make evaluation difficult. A clouded cornea suggests a serious burn. Subtle corneal burns require fluorescein staining. Any suspicion of eye injury warrants an ophthalmological consultation.

A computed tomography scan of the head and axial spine may be indicated based on injury mechanism and history.

The torso should be assessed for stiffness and expansion. Extensive and deep torso burns can interfere with ventilation and may require escharotomy. Rarely, usually in patients with very large injuries and delayed resuscitation, abdominal compartment syndrome can develop.

Carboxyhaemoglobin and arterial blood gas determinations are important if inhalation injury is suspected.

Initial routine electrolyte and haematological testing may be useful.

History and exam

Key diagnostic factors

presence of risk factors (common)

- Key risk factors include young children, age >60 years, and male sex.

erythema (common)

- Indicative of a first-degree burn.

First-degree burn

From Dr Sheridan's personal collection

dry and painful burns (common)

- Classified as first-degree burns and involve the epidermis only.

First-degree burn

From Dr Sheridan's personal collection

wet and painful burns (common)

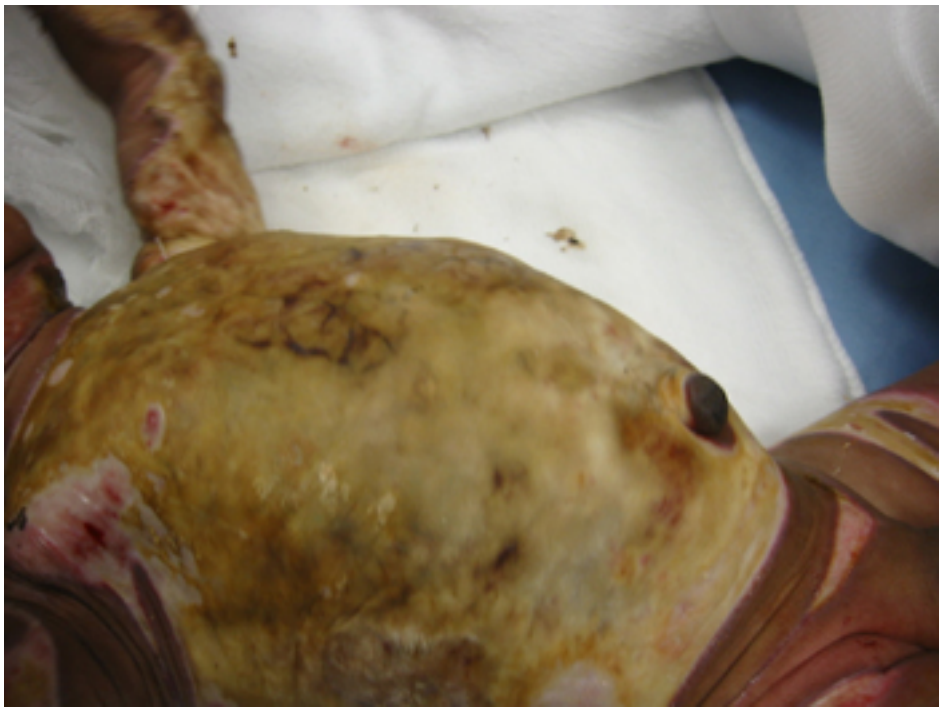
- Classified as second-degree burns and involve the epidermis and upper dermis.

Second-degree burn

From Dr Sheridan's personal collection

dry and insensate burns (common)

- Classified as third-degree burns and involve the epidermis and dermis and damage to appendages.



Third-degree burn

From Dr Sheridan's personal collection

burns affecting subcutaneous tissue, tendon, or bone (common)

- Classified as fourth-degree burns.

Fourth-degree burn

From Dr Sheridan's personal collection

cellulitis (common)

- The most common wound infection in small outpatient burns is cellulitis, usually caused by *Staphylococcus aureus* . This infection presents with expanding wound erythema, which, if untreated, will progress to lymphangitis and systemic toxicity.

Cellulitis

From Dr Sheridan's personal collection

clouded cornea (common)

- Suggests a serious burn. Any suspicion of eye injury warrants an ophthalmological consultation.

Risk factors

Strong

young children

- Increased risk of burning due to the lack of co-ordination, dependency, and poorly developed self-protective mechanisms.[16] [17]

age >60 years

- Increased risk of burning due to the lack of co-ordination, dependency, and poorly developed self-protective mechanisms.[16] [17] [18]

Weak

female sex (thermal burns)

- Worldwide, females have slightly higher rates of death from burns compared to males. [WHO: fact sheet - burns] (http://www.who.int/en/news-room/fact-sheets/detail/burns) This may be due to increased risks associated with cooking (open fire or other unsafe cooking environments) especially if loose clothing is worn, open flames for heating and lighting, and possibly also from self-directed or interpersonal violence. This contrasts with the usual injury pattern, where rates tend to be higher in males (e.g., due to increased risk-taking behaviours, occupational exposures), and in some countries

burn rates may be higher in males for these reasons. Chemical and electrical burns are generally more common in males.[4]

Investigations

1st test to order

Test	Result
full blood count • Indicated in patients with significant burns. Neutropenia and thrombocytopenia may be indicators of sepsis.	**may show low haematocrit, hypovolaemia, neutropenia, thrombocytopenia**
metabolic panel • Indicated in patients with significant burns.	**may show high levels of urea, creatinine, glucose; hyponatraemia, hypokalaemia**
carboxyhaemoglobin • Indicated if inhalation injury is suspected.	**high levels in inhalation injury**
arterial blood gas • Indicated if inhalation injury is suspected.	**may show metabolic acidosis in inhalation injury**
fluorescein staining • Subtle corneal burns require fluorescein staining. Any suspicion of eye injury warrants an ophthalmological consultation.	**damaged corneal epithelial cells in corneal burns**
computed tomography scan of head and spine • May be indicated based on injury mechanism and history.	**may show brain injury or fracture in cases of head or spine trauma**
wound biopsy culture • Indicated if sepsis is suspected.	**positive for causative organism in wound infection**
wound histology • Indicated if sepsis is suspected.	**may show wound infection**

Differentials

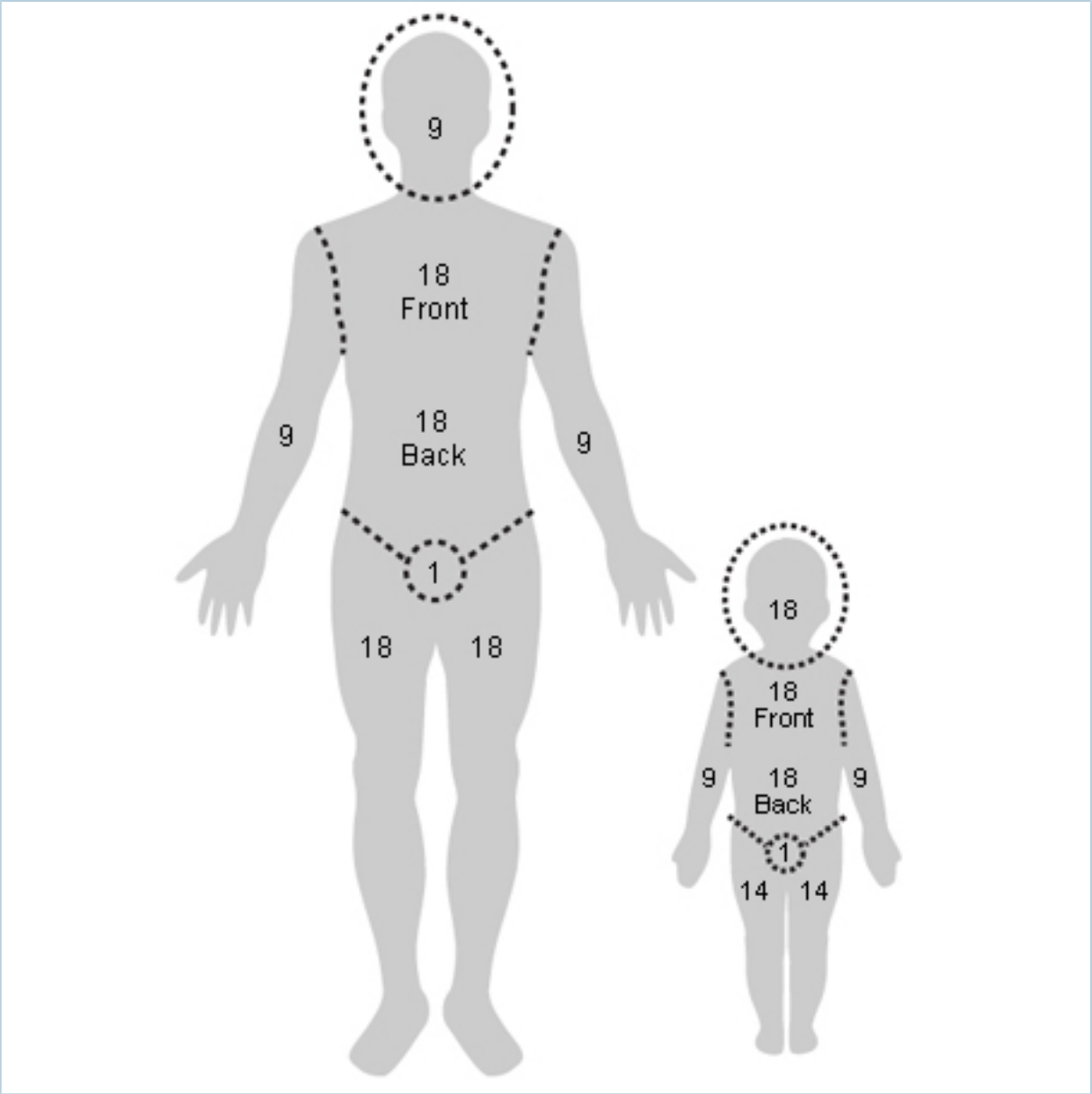
Condition	Differentiating signs / symptoms	Differentiating tests
Rash in children	• No accident in the history.	• No specific test.
Toxic epidermal necrolysis (Stevens-Johnson syndrome)	• Rash and blisters develop after a new medication (often anticonvulsants). Ulceration may occur in areas that could not be exposed to thermal or chemical agent, and on mucous membranes or conjunctivae.	• Skin biopsy shows keratinocyte apoptosis with detachment of the epidermal layer of the skin from the dermal layer. The area of separation may contain a number of CD8-positive T lymphocytes, and the dermis may contain CD4-positive T lymphocytes and macrophages, depending on the stage of the disease when the biopsy is taken.[35]
Staphylococcal scalded skin syndrome	• Most common in infants. Exfoliation usually follows erythematous cellulitis and rash. Preceding *Staphylococcus aureus* infection of skin, throat, mouth, nose, and/or umbilicus, often with fever, malaise, and irritability.	• Culture of local or distant focus of colonisation (often negative). Gram stain may confirm staphylococcal infection. • Biopsy shows separation at granular layer of epidermis.

Criteria

Wallace's 'rule of nines' of body surface area burn coverage[36]

Burn extent is estimated as a percentage of total body surface area (TBSA):

- Head and neck represent 9% (18% in infants)
- Each lower extremity is 18% (15% in infants)
- Each upper extremity is 9% (10% in infants)
- Anterior and posterior torso are 18% each (16% in infants)
- For scattered or irregular burns the palmar surface of the patient's hand represents approximately 1%.



Rule of nines
From Dr Sheridan's personal collection

Lund and Browder classification[36]

Burn extent is most accurately estimated using a Lund and Browder diagram that compensates for changes in body proportions with age. This approach evaluates the surface area of the burn on the basis that a patient's palm is approximately 1% TBSA.

Burn Estimate and Diagram
Age and Area

Initial Evaluation*

Signature

_____

Date of Burn

_____

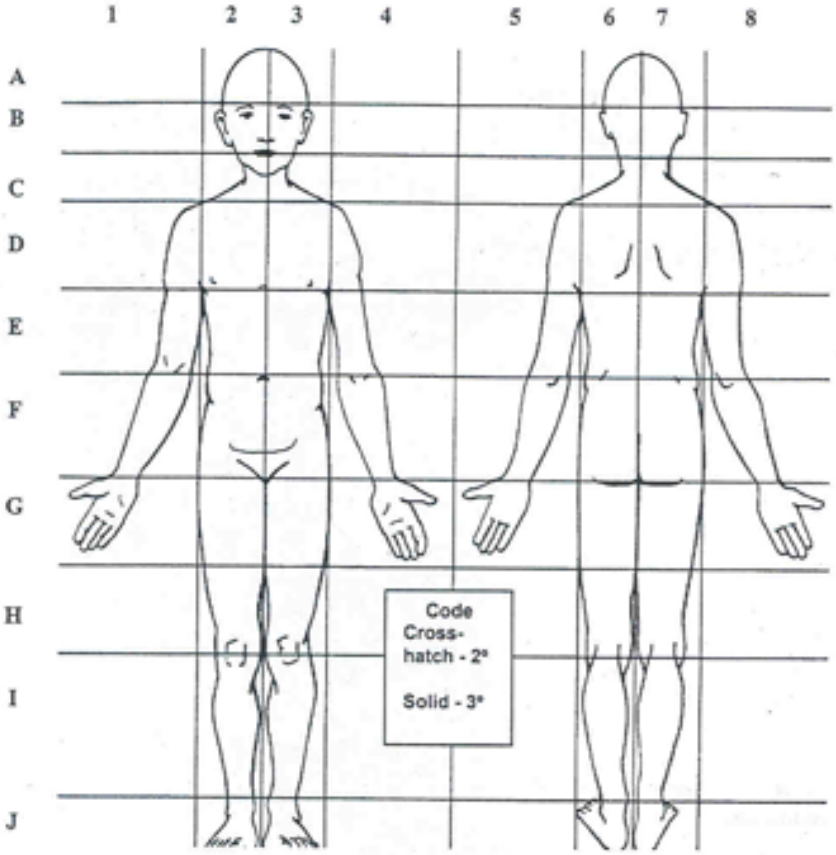
Date Completed

_____

*To be completed by the admitting resident or LIP on admission

☐ N/A, Please refer to OPD COMPlan or 1st admission burn diagram

This is a working burn estimate diagram only, and is not as accurate as photography.



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Left Foot	3.5	3.5	3.5	3.5	3.5	3.5			
** Only 2° and 3° burns are included in the total TBSA burn percent						Total			

Lund-Browder diagram
From Dr Sheridan's personal collection

Approach

Acute burn management

Initial evaluation of burns should follow a systematic approach emphasising patient stability, including early identification and control of airway and breathing problems, appropriate fluid resuscitation, recognition and treatment of associated injuries, and prompt consultation with burn specialist services where appropriate.[24] Limited burn-specific initial first aid should be provided. This includes:[37]

- Cooling thermal burns with running water (up to 20 minutes; although optimal duration of cooling remains unclear, and guideline recommendations vary).[25] [37]
- Rinsing chemical burns on the skin or in the eyes with running water.
- Covering a burn with a clean wet cloth or plastic cling wrap to protect it during transit to medical care (burns on an extremity should be covered rather than wrapped to allow for possible swelling).[25]
- Do not deroof or aspirate blisters, as this may increase the risk of infection.

Outpatient burn management

- Most burns can be managed in the outpatient setting by non-specialists, but inadequately co-ordinated outpatient burn care can make for a frustrating and painful experience for the patient.[38] The key is careful patient selection and a well-rehearsed care plan.
- Patients with smaller burns who have adequate support at home can generally be managed in the outpatient setting if this is deemed appropriate. Wounds of the face, ears, hands, genitals, and feet have a functional and cosmetic importance out of proportion to the wound size. In such cases, early specialty evaluation is advisable, unless the injuries are very superficial. Most burns selected for outpatient management are superficial and heal within 2 weeks. If this is not the case, patients may benefit from specialty evaluation.

Inpatient and specialist burn management

- Patients who cannot take fluid by mouth, need burn resuscitation, potentially have inhalation injury, or cannot be managed in the outpatient setting should be admitted for inpatient care. Where possible, consult with a specialist burns centre and arrange transfer as appropriate.[39] [40]
- Some patients initially managed in the clinic setting will subsequently require admission. Reasons prompting admission include:
    - Increased pain and anxiety
    - Inability to keep scheduled appointments
    - Delayed healing
    - Signs of infection
    - Wound that appears deeper than initially estimated. Burn depth is commonly underestimated during the first days after injury
- Serious burns are most effectively and least expensively managed in organised programmes focused on burn care. An increasing body of data support the efficacy of concentration of serious burns in regional programmes.[41]
- The American Burn Association (ABA) has established criteria for determining which patients require referral to a specialised burn centre, but local resources and practice patterns should be taken into account. The ABA states that the following burn injuries should be referred:[41]
    - Partial-thickness burns of >10% total body surface area

- Burns that involve the face, hands, feet, genitalia, perineum, or major joints
- Third-degree burns in any age group
- Electrical burns, including lightning injury
- Chemical burns
- Inhalation injury
- Burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery, or affect mortality
- Burned children in hospitals without qualified personnel or equipment for the care of children
- Burn injury in patients who will require special social, emotional, or rehabilitative intervention
- Any patients with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient's condition may be stabilised initially in a trauma centre before transfer to a burn centre. Physician judgement will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.

An expert consensus panel has proposed updating and extending the original ABA referral criteria to include the following additional referral criteria/considerations:[42]

- Full-thickness burns ≥ 5% TBSA burned.
- Children and older adults (>55 years of age). These patients may benefit from referral to a burn centre to access the multi-disciplinary team resources, even when TBSA burned is less than 10% (partial or full thickness).
- Smaller burns should be followed up in burn centre outpatient settings as soon as possible after injury, and preferably within a week.
- Consider telemedicine consultations as an alternative to immediate transfer or outpatient referral for selected patients.

- Internationally, burn centre transfer criteria vary and may depend on local resources and/or configuration of specialist burn services.[43] In UK practice, for example, specialised burn services are designated as burn facilities, burn units, and burn centres according to the level of injury complexity they manage. A burn facility offers inpatient care for non-complex burn injuries at the level of a standard plastic surgical ward (criteria include burns of TBSA 2% to 4.9%). Burn units will accept patients requiring higher levels of care (including TBSA burned ≥5%), while burn centres accept the most severe and complex cases (e.g., TBSA burned ≥30% for adults and older children, or ≥15% if under 1 year old).[40]
- A survival benefit has been demonstrated for patients with serious burns if they are managed in a dedicated high-volume burn centre.[44]
- A number of non-burn medical and surgical conditions (e.g., frostbite, Stevens-Johnson syndrome/TENS, and necrotising soft-tissue infection) require the same specialised resources as burns. These conditions are increasingly recommended for referral to burn units for initial assessment and care.[42] [45]

Outpatient treatment: wound care and inspection

Most minor burns can be managed in an outpatient setting. Initial treatment consists of wound cooling, cleaning, and dressing. Pain management and tetanus prophylaxis are important. Access for regular follow-up through the healing period is important. The frequency of follow-up will vary with a number of wound-related and other factors, including:

- Wound severity
- Patient age

- Patient comfort
- Family competence
- Availability of community nursing resources

All patients should be told to return immediately if they have problems, questions, or signs of infection prior to their scheduled appointments.

Cleaning

- Clean burn wounds with lukewarm tap water and a bland soap

Topical antibiotic prophylaxis

- Systemic antibiotic prophylaxis is not routinely recommended as prior studies demonstrated no compelling benefit.[46] Topical prophylaxis remains a common practice, but it may not be necessary as supportive data is weak.
- Topical agents range from aqueous solutions to antibiotic-containing ointments and debriding enzymes. Very little efficacy data exist.[47] Empiric practices are poorly supported. There are a great number of approaches to the care of small burns.[48] Common sense and regular reassessment of wounds as they heal are central to successful treatment.
- Silver is an excellent antiseptic and there is a long history of its use in burn dressings despite a relative lack of evidence for efficacy.[49] It is applied in several forms, including silver sulfadiazine cream, aqueous silver nitrate solution, and dressings containing nanocrystalline silver.[50] Topical sulfadiazine silver is commonly used, as it is painless on application and has a broad spectrum of antibacterial activity, although some in vitro evidence suggests it may slow epithelialisation to a modest degree and some guidelines advise against its use.[37] [49] [51] [52]
- There is limited experience with debriding enzymes in the outpatient setting, with no evolved standard of care. In some centres they play an important role, but in others their utility is limited by expense.
- Superficial burns can be treated with viscous antibacterial ointments containing low concentrations of various antibiotics.
- Wounds around the eyes can be treated with topical ophthalmic antibiotic ointments.
- Treat deeper ear burns with mafenide, as it is the only agent that will penetrate relatively avascular cartilage. This is important as infection of the cartilaginous skeleton of the external ear can cause significant deformity.

Dressings

- Simple gauze wraps minimise soiling of clothing and protect the wound from trauma.
- Wound membranes are increasingly popular and effective, providing pain control, prevention of wound desiccation, and reduction of wound colonisation. They help to create a moist wound environment with a low bacterial density, and are generally intended for use on selected clean superficial wounds and donor sites.[52] They should be used with caution, as deeper wounds placed in membrane dressings may become septic if they are not carefully monitored. Many will release silver for several days, reducing bacterial proliferation.[53] [54]
- In the first days immediately after burning, when wound depth is unclear, topical agents are often ideal. When it is clear that the wound is clean and superficial, a transition to membranes may be appropriate. The experience and comfort level of the treating physician is a major consideration when contemplating the routine use of membrane dressings.

Dressing changes

- The wound should be kept generally clean and regularly inspected for infection.

- Outpatient burns tend to be small and superficial, presenting a relatively low risk of infection, so clean rather than sterile technique is reasonable.
- Accumulated exudate and topical medications should be gently cleansed with lukewarm tap water and a bland soap.
- Soaking adherent dressings prior to removal will minimise any pain associated with their removal.
- Gently cleanse wounds with a gauze or clean washcloth, inspect for any sign of infection, pat dry with a clean towel, and re-dress.
- Inspection for infectious complications is important: the patient and family should be advised to return promptly if they notice erythema, swelling, increased tenderness, lymphangitis, odour, or drainage.
- Wound inspection and cleansing will cause many patients significant anxiety and pain; some will benefit from an oral opioid given 30 to 60 minutes before a dressing change.
- The interval between dressing changes will vary, but most small burns are adequately managed with a daily cleansing and a dressing change.
- If wounds are clean and superficial and if surgery is not needed, wound check frequency can be reduced, or a membrane dressing can be applied.

Tetanus immunisation is recommended in the absence of a history of adequate immunisation.

Scar management

- Scar management is an essential aspect of comprehensive burn care.
- Unfortunately, grading of scars is not uniformly done, although a variety of scales do exist.[55] Scar evaluation remains a largely subjective practice.
- In long-term scar management, pressure garments have been promoted for many years, although a meta-analysis failed to demonstrate reliable benefit. It may be that further study of subgroups with better scar measurement tools may demonstrate a benefit, but, for now, use is likely to remain programme-dependent and anecdote-based.[56]
- Early experiences with tuneable dye and fractional carbon dioxide lasers have been encouraging; however, controlled data do not exist.[57] Laser interventions seem to work well only when used as part of a multi-modality scar management programme.[58]

Inpatient treatment: fluid resuscitation, wound care, critical care, and surgery

Care of severe burns can be divided into 4 phases:[59]

1. Initial evaluation and resuscitation
2. Initial excision and biological closure
3. Definitive wound closure
4. Rehabilitation and reconstruction

The phases overlap, and intensive care plays an important role in the first 3 phases.

1. Initial evaluation and resuscitation

- Usually the first 24-72 hours after injury.
- Document the full extent of the injury (including non-burn trauma) and perform fluid resuscitation.
- Patients with airway involvement or major burns generally require intubation and mechanical ventilation, although intubation should be done selectively.[25] [60] [61]

Airway oedema

From Dr Sheridan's personal collection

- Carbon monoxide intoxication is best treated acutely by effective ventilation with 100% oxygen, but can be associated with delayed neurological sequelae. Hyperbaric oxygen treatment is appropriate in selected stable patients with serious exposures, but it is not indicated for routine wound healing.[62]
- If burns involve >20% of the body surface, reduced capillary integrity becomes clinically important, with a resulting need for fluid resuscitation.[24] [25] [63] Capillary integrity is typically restored at approximately 24 hours. Any of the several burn formulae available may be used to initiate resuscitation; however, none can be assumed to be accurate in an individual patient. Bedside titration of infusions, based on physiological endpoints, is important. Gentle titration is advised: for example, if the urine output falls to 0.25 mL/kg/hour, consider increasing the infusion rate by 10% and re-assessing in 60 minutes, rather than infusing a large bolus of fluid. The Parkland formula is often used, and suggests 4 mL/kg/% burn over the first 24 hours, half in the first 8 hours. Young children should receive 5% dextrose in lactated Ringer's solution at a maintenance rate to ensure that they do not develop hypoglycaemia.
- While all burn resuscitation formulae are meant to guide only the initial rate of fluid infusion, the choice of formula may be important. Some studies suggest that use of the Modified Brooke formula or alternative approaches may adequately resuscitate patients while limiting resuscitation volumes, compared to the widely-used Parkland formula.[64] The Modified Brooke formula suggests 2 mL/kg/% burn (% TBSA), where half of the total fluid requirement is given in the first 8 hours, and the other half is given in the next 16 hours.[24] The rate of fluid administration is adjusted based on the patient's urine output. During the second 24 hours, 0.33 to 0.5 mL/kg/% TBSA burned of colloid plus D5W is given to maintain urine output.[65] The American Burn Association (ABA) Clinical Practice Guideline (CPG) recommends 2 mL/kg/% TBSA burn for initial fluid resuscitation in adults with burns ≥20% TBSA in order to reduce resuscitation fluid volumes.[64]
- Lactated Ringer's solution is generally administered to burn patients, as specified in the Parkland formula.[63] However, the evidence for choice of crystalloid fluids for critically ill patients in general is conflicting, with very little good data specific to burn resuscitation.[63] [66] [67] [68]
- The role of colloid in burn resuscitation remains controversial. Many clinicians advise inclusion of colloid (generally albumin) in burn resuscitation when burns are large to reduce anasarca (severe, generalised interstitial fluid accumulation) despite evidence to the contrary from a meta-analysis and conflicting recommendations from some guidelines.[69] [70] [71] The ABA CPG advises to consider giving albumin in burn patients with >20% TBSA in the first 24 hours of burn resuscitation to improve urinary output and to reduce the total volume of resuscitation fluids.[64] The strength of

this recommendation is greater for patients with larger burns and weaker for patients with smaller burns. As studies are also conflicting as to whether to start albumin before or after the first 12 hours, the ABA suggests in situations where albumin is part of the general resuscitation plan, versus in an acute rescue situation, that it is preferable to start the albumin after the first 12 hours until more is known.[64] Solutions containing hydroxyethyl starch (HES) are not recommended due to their increased risk of adverse outcomes including kidney injury and death, particularly in critically ill patients, and their use has been suspended in Europe.[24] [63] [72] [73]

- Even patients with massive burns can have a good outcome if managed in a comprehensive burn programme. Fluid resuscitation becomes increasingly challenging as burn size increases. War-time experience has added to our understanding of the resuscitation needs of the very severely injured.[74]
- Even during resuscitation, it is important to ensure attention is paid to patient comfort. Pain and anxiety can have adverse physiological and emotional consequences.[75] Successful early pain control can enhance important aspects of long-term outcome.[76]
- Heparin has been proposed as an adjunct to care of burns, but it is not part of the standard of care and data are not convincing.[77] [78]
- Tetanus immunisation should be updated in patients with wounds deeper than a superficial partial-thickness burn.

2. Initial excision and biological closure

- Identification and removal of large areas of full-thickness burn before wound sepsis and systemic inflammation develop. This should be done using staged haemostatic and minimally ablative techniques.[79]
- Near- or completely circumferential burns should be identified for special monitoring and possible escharotomy:[24] [25]

Circumferential burn

From Dr Sheridan's personal collection

- Burns of this sort on the torso can interfere with ventilation or even contribute to intra-abdominal hypertension.
- On extremities, such burns may cause limb-threatening ischaemia within 12-24 hours.
- Escharotomy can decompress such problems and can be done with coagulating electrocautery; anaesthesia or sedation is generally required in children.
- When performing escharotomy it is important not to damage uninjured skin or superficial neurovascular structures.
- 

Escharotomy

From Dr Sheridan's personal collection

- Ideally, close wounds with autograft. Temporary wound membranes can be useful for large wounds. This strategy changes the natural history of the injury from inevitable systemic sepsis and inflammation to a more controlled wound-closure situation.
- Amniotic membrane can be an accessible and effective temporary membrane, but blood-borne infectious disease screening remains a concern and should be considered.[80]
- The role of antibiotic prophylaxis during acute burn surgery remains unclear.

3. Definitive wound closure

- Duration varies depending on wound size and complexity.
- The objective is to replace any temporary membranes with autograft and to close small complex wounds, such as on the hands and face.
- May take many weeks if donor sites are severely limited.
- Intensive care is an important component of the first 3 phases of care. Ideally, an embedded intensive care unit is part of the burn programme, so that co-ordination between the medical and surgical needs of the patients is seamless. A burn critical care capability can be organised in various ways, but must always foster a strong collaboration between the surgical, medical, nursing, and other disciplines.[81]

- Deep venous thrombosis is a risk in all injured patients. There are few studies of this in burn patients to support a specific approach. Each unit should develop its own policy for monitoring, prophylaxis, and treatment.[82]

4. Rehabilitation and reconstruction

- This is the longest phase of care.
- Ideally, begins with early ranging and splinting, and anti-deformity positioning.
- As wounds are closed and patients moved from intensive care, passive and active motion and strengthening become important.
- Scar management and emotional support are extremely useful for most patients.
- Burn reconstructive procedures are ideally planned as soon as functional or aesthetic deformities hinder further recovery.
- Long-term follow-up is essential to optimise recovery, particularly for those with larger injuries.[83] This includes support of the family group.[84] Patient and family education efforts enhance understanding and participation in aftercare needs.[85]
- Pruritus can be a persistent discomfort in the first months after wound closure and should be addressed with non-pharmacological as well as pharmacological means.[86]
- Planning for long-term plastic and reconstructive surgery needs should be considered in disaster scenarios, as this need will continue after the flurry of initial activity and attention.[87]
- Attention to pain and anxiety are essential in all phases of care. This is usually done by infusion of opioids and benzodiazepines (e.g., morphine sulphate and midazolam). Each unit should establish their own protocols and dosing regimens. Non-pharmacological therapies, such as music therapy, can be useful in selected patients. Virtual reality is an innovative, new, non-pharmacological, non-invasive analgesic technique. Although only few studies are available, positive initial experiences have been reported and a systematic review found it to be an effective adjunct for treatment of pain during wound dressing changes and physiotherapy.[88] [89]
- Burn patients typically remain alert and oriented even with major burns, and can remember events at the time of the injury and for several hours afterwards. Health care providers should be sensitive to the variable emotions experienced by burn patients and their families at all stages of treatment, and consider the psychosocial needs of the survivor during and following hospitalisation and rehabilitation.[24]

Treatment of wound infection

Regular monitoring of burn wounds allows for the early recognition of infection. All suspected burn infections require aggressive management, which may include admission, intravenous antibiotics, observation, and surgery excision if wounds are deep.

- Burn wound cellulitis responds readily to antibiotics in most cases.
- Burn impetigo is usually associated with *Staphylococcus aureus* and *Streptococcus pyogenes*, and is particularly common in burns of the scalp. Treatment requires wound cleansing, which often mandates shaving of nearby hair-bearing areas, and grafting of full-thickness areas.
- Treat open burn-related surgical wound infections with debridement of necrotic and infected material with delayed wound closure.
- Invasive burn wound infection is a serious problem, usually addressed by excision and systemic and topical antibiotics.

Cellulitis

From Dr Sheridan's personal collection

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute (summary)		
suitable for outpatient care		
	1st	wound cleaning and topical antibiotic prophylaxis
	adjunct	tetanus immunisation
	adjunct	opioid analgesic
■ with suspected wound infection	plus	antibiotics ± surgical debridement
requires inpatient care		
	1st	assessment for admission to a burn centre
	adjunct	fluid resuscitation
	adjunct	supplemental oxygen and supportive care
	adjunct	tetanus immunisation
	adjunct	surgery
	adjunct	deep venous thrombosis (DVT) prophylaxis
	adjunct	intravenous opioid plus benzodiazepine ± non-pharmacological therapy
■ with suspected wound infection	plus	antibiotics ± surgical excision

Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute

suitable for outpatient care

1st **wound cleaning and topical antibiotic prophylaxis**

Primary options

» silver sulfadiazine topical: (1%) apply to the affected area(s) once or twice daily

OR

» mafenide topical: (8.5%) apply to affected area(s) once or twice daily

» Patients with smaller burns who have adequate support at home can generally be managed in the outpatient setting. Wounds of the face, ears, hands, genitals, and feet have a functional and cosmetic importance out of proportion to the wound size. In such cases, early specialty evaluation may be prudent. Most burns selected for outpatient management are superficial and heal within 2 weeks. If this is not the case, patients may benefit from specialty evaluation.

» Clean burn wounds with lukewarm tap water and a bland soap.

» Systemic antibiotic prophylaxis is not routinely recommended as prior studies demonstrated no compelling benefit.[46]

» Superficial burns can be treated with viscous antibacterial ointments containing low concentrations of various antibiotics, although supportive data is weak. Silver is an excellent antiseptic and is used in burn wound care in several forms, including silver sulfadiazine cream, aqueous silver nitrate solution, and dressings containing nanocrystalline silver.[50] Topical sulfadiazine silver is commonly used, as it is painless on application and has a broad spectrum of antibacterial activity, although some in vitro evidence suggests it may slow epithelialisation to a modest degree and some guidelines advise against its use.[37] [49] [51] [52]

» Treat deeper ear burns with mafenide, as it is the only agent that penetrates relatively

Acute

avascular cartilage. This is important as infection of the cartilaginous skeleton of the external ear can cause significant deformity.

adjunct **tetanus immunisation**

Treatment recommended for SOME patients in selected patient group

» Indicated in patients with no current immunisation.

adjunct **opioid analgesic**

Treatment recommended for SOME patients in selected patient group

Primary options

» morphine sulfate: 10-30 mg orally (immediate-release) every 4 hours when required initially, titrate dose according to response

» Many patients will have significant anxiety and pain with wound inspection and cleansing.

» Some will benefit from an oral opioid given 30 to 60 minutes prior to a planned dressing change.

with suspected wound infection

plus **antibiotics ± surgical debridement**

Treatment recommended for ALL patients in selected patient group

Primary options

» cefadroxil: 1 g orally/day given in 1-2 divided doses

» Regular monitoring of burn wounds allows for the early recognition of infection. Once infection has been identified, it requires aggressive management, which may include admission, intravenous antibiotics, observation, and surgical debridement if wounds are deep.

» Burn wound cellulitis responds readily to antibiotics in most cases.

» Burn impetigo is usually associated with *Staphylococcus aureus* and *Streptococcus pyogenes* and is particularly common in burns of the scalp. Treatment requires wound cleansing, which often mandates shaving of nearby hair-bearing areas, and grafting of full-thickness areas.

» Follow local protocols for selection of antibiotic and appropriate dosing.

Acute

requires inpatient care

1st **assessment for admission to a burn centre**

» Patients who cannot take fluid by mouth, need burn resuscitation, potentially have inhalation injury, or cannot be managed in the outpatient setting should be admitted for inpatient care. Where possible, consult with a specialist burns centre and arrange transfer as appropriate.

» Some patients initially managed in the clinic setting will subsequently require admission. Reasons prompting admission include: increased pain and anxiety; inability to keep scheduled appointments; delayed healing; signs of infection; and wounds that appear deeper than initially estimated (burn depth is commonly underestimated during the first days after injury).

» Serious burns are most effectively managed in organised programmes focused on burn care. The American Burn Association (ABA) states that the following burn injuries should be referred to a burn centre: partial-thickness burns of >10% total body surface area (TBSA); burns that involve the face, hands, feet, genitalia, perineum, or major joints; third-degree burns in any age group; electrical burns, including lightning injury; chemical burns; inhalation injury; burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery, or affect mortality; burned children in hospitals without qualified personnel or equipment for the care of children; burn injury in patients who will require special social, emotional, or rehabilitative intervention; and patients with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality.[41]

» An expert consensus panel has proposed updating and extending the original ABA referral criteria to include the following additional referral criteria/considerations:[42] full-thickness burns ≥ 5% TBSA burned; children and older adults (>55 years of age, who may benefit from referral to a burn centre to access the multi-disciplinary team resources, even when TBSA burned is less than 10%); smaller burns should be followed up in burn centre outpatient settings as soon as possible after injury, and preferably within a week; consider telemedicine consultations as an alternative to immediate transfer or outpatient referral for selected patients.

Acute

» Internationally, burn centre transfer criteria vary and may depend on local resources and/or configuration of specialist burn services.[43]

adjunct **fluid resuscitation**

Treatment recommended for SOME patients in selected patient group

» If burns involve >20% of the body surface, reduced capillary integrity becomes clinically important, with a resulting need for fluid resuscitation (usually given as crystalloid solutions). Capillary integrity is typically restored at approximately 24 hours. Any of the several burn formulae available may be used to initiate resuscitation, but none can be assumed to be accurate in an individual patient. Bedside titration of infusions, based on physiological endpoints, is important.

» The Parkland formula is often used and suggests 4 mL/kg/% burn over the first 24 hours, half in the first 8 hours, generally as lactated Ringer's solution. The evidence for choice of crystalloid fluids for critically ill patients in general is conflicting, with very little good data specific to burn resuscitation.[63] [66] [67] [68]

» The Modified Brooke formula suggests 2 mL/kg/% burn, half of the total fluid requirement is given in the first 8 hours, and the other half is given in the next 16 hours.[24] The rate of fluid administration is adjusted based on the patient's urine output. The goal is to maintain an hourly urine output of 30-50 mL for a 70 kg adult. During the second 24 hours, 0.33 to 0.5 mL/kg/%TBSA burned of colloid plus D5W is given to maintain urine output.[65]

» The American Burn Association (ABA) Clinical Practice Guideline (CPG) recommends 2 mL/kg/% TBSA burn rate for initial fluid resuscitation in adults with burns ≥20% TBSA, in order to reduce resuscitation fluid volumes.[64]

» Young children should receive 5% dextrose in lactated Ringer's solution at a maintenance rate to ensure that they do not develop hypoglycaemia.

» Even patients with massive burns can have a good outcome if managed in a comprehensive burn programme. Fluid resuscitation becomes increasingly challenging as burn size increases. War-time experience has added to our understanding of the resuscitation needs of the very severely injured.[74]

Acute

» The role of colloid remains controversial. Very little relevant data exist. Many clinicians advise inclusion of colloid (generally albumin) in burn resuscitation when burns are large to reduce anasarca (severe, generalised interstitial fluid accumulation) despite evidence to the contrary from a meta-analysis and conflicting recommendations from some guidelines.[69] [70] [71]

» ABA CPG advises to consider giving albumin in burn patients with ≥20% TBSA in the first 24 hours of burn resuscitation to improve urinary output and to reduce the total volume of resuscitation fluids.[64] The strength of this recommendation is greater for patients with larger burns and weaker for patients with smaller burns. It also suggests in situations where albumin is part of the general resuscitation plan, versus in an acute rescue situation, that it is preferable to start the albumin after the first 12 hours.[64]

» Solutions containing hydroxyethyl starch (HES) are not recommended due to their increased risk of adverse outcomes including kidney injury and death, particularly in critically ill patients, and their use has been suspended in Europe.[24] [63] [72] [73]

adjunct **supplemental oxygen and supportive care**

Treatment recommended for SOME patients in selected patient group

» Patients with airway involvement or major burns generally require intubation and mechanical ventilation, although intubation should be done selectively.[25] [60] [61] Carbon monoxide intoxication is best treated acutely by ventilation with 100% oxygen, but can be associated with delayed neurological sequelae. Hyperbaric oxygen treatment is appropriate in selected stable patients with serious exposures, but it is not indicated for routine wound healing.[62]

» Wound healing requires adequate nutritional support. General needs are debated and individual needs vary, but in general 25-40 kcal//kg/day, depending on the extent and severity of injuries, is a reasonable starting estimate of caloric needs for most patients. More refined calculations can be achieved with other equations, such as the Harris-Benedict equation, or needs can be measured using indirect calorimetry. A reasonable protein target is 1.5 to 2 grams/kg/day, and trace element and vitamin needs should also be met.

Acute

» Nutritional needs in most patients can be effectively provided by the enteral route. In occasional very ill patients, parenteral nutrition can be safely administered with good effect.[90]

» Wound dressing frequency and type vary substantially between burn centres and the individual needs of patients. In general, when eschar exists, agents with a broad antibacterial spectrum and penetration are advisable. In superficial burns or postoperative wounds, prevention of desiccation is particularly important. In the presence of skin grafts, graft stability is an essential consideration. Within these general principles, the variety of possibilities and practices is vast, and a single best practice cannot be defined. Familiarity with a programme of care leads to optimal results.

» Burn patients experience exaggerated heat loss from their wounds and should be managed in settings where environmental heating is available.

adjunct **tetanus immunisation**

Treatment recommended for SOME patients in selected patient group

» Indicated in patients with no current immunisation.

» Update tetanus immunisation in patients with wounds deeper than a superficial partial-thickness burn.

adjunct **surgery**

Treatment recommended for SOME patients in selected patient group

» In patients with severe burns, identification and removal of large areas of full-thickness burn is required, before wound sepsis and systemic inflammation develop. This should be done using staged haemostatic and minimally ablative techniques.[79] Near- or completely circumferential burns should be identified for special monitoring and possible escharotomy.[24] [25] If involving the torso, such wounds can interfere with ventilation or even contribute to intra-abdominal hypertension. When they involve an extremity, limb-threatening ischaemia may occur 12 to 24 hours after the injury. Escharotomy can decompress such problems. The procedure can be done with coagulating electrocautery. When performing escharotomy it is important not to damage uninjured skin or superficial neurovascular

Acute

structures. Anaesthesia or sedation is generally required in children.

» Ideally, close wounds with autograft. Temporary wound membranes can be useful in patients with large wounds. This strategy changes the natural history of the injury from inevitable systemic sepsis and inflammation to a more controlled wound-closure situation.

» Amniotic membrane can be an accessible and effective temporary membrane, but blood-borne infectious disease screening remains a concern and should be considered.[80]

» Definitive wound closure is achieved by replacing any temporary membranes with autograft and closing small complex wounds, such as on the hands and face. When donor sites are severely limited, this phase may take many weeks.

» The role of antibiotic prophylaxis during acute burn surgery remains unclear.

adjunct **deep venous thrombosis (DVT) prophylaxis**

Treatment recommended for SOME patients in selected patient group

» DVT is a risk in all injured patients. There are few studies of this in burn patients to support a specific approach. Each unit should develop its own policy for monitoring, prophylaxis, and treatment.[82]

adjunct **intravenous opioid plus benzodiazepine ± non-pharmacological therapy**

Treatment recommended for SOME patients in selected patient group

Primary options

» morphine sulfate: consult specialist for guidance on dose
-and-
» midazolam: consult specialist for guidance on dose

» Attention to pain and anxiety are essential in all phases of care. This is usually done by infusion of opioids and benzodiazepines (e.g., morphine and midazolam).

» Each unit should establish their own protocol and dosing regimens. A typical initial dosing of infusion is shown below.

MANAGEMENT

Acute

» Even during resuscitation, it is important to ensure attention is paid to patient comfort. Pain and anxiety can have adverse physiological and emotional consequences.[75] Non-pharmacological therapies, such as music therapy, can be useful in selected patients. Virtual reality is an innovative, new, non-pharmacological, non-invasive analgesic technique. Although only few studies are available, positive initial experiences have been reported and a systematic review found it to be an effective adjunct for treatment of pain during wound dressing changes and physiotherapy.[88] [89] Successful early pain control can enhance important aspects of long-term outcome.[76] The psychosocial needs of the patient should be considered during and following hospitalisation and rehabilitation.[24]

with suspected wound infection **plus** **antibiotics ± surgical excision**

Treatment recommended for ALL patients in selected patient group

Primary options

» benzylpenicillin sodium: 0.6 to 1.2 g intramuscularly/intravenously every 6 hours, increased if necessary in more serious infections

OR

» cefadroxil: 1 g orally/day given in 1-2 divided doses

Secondary options

» vancomycin: 15-20 mg/kg intravenously every 8-12 hours

» Regular monitoring of burn wounds allows for the early recognition of infection. Once infection has been identified, it requires aggressive management, which may include intravenous antibiotics, observation, and surgical excision if wounds are deep.

» Burn wound cellulitis responds readily to anti-staphylococcal antibiotics such as a first-generation cephalosporin (e.g. cefadroxil) in most cases. If resistant species are suspected or documented by culture and sensitivity, appropriate antibiotics should be prescribed. If MRSA is suspected or documented by culture, it is reasonable to begin treatment with vancomycin.

Acute

» Burn impetigo is usually associated with *Staphylococcus aureus* and *Streptococcus pyogenes* , and is particularly common in burns of the scalp. Treatment requires wound cleansing, which often mandates shaving of nearby hair-bearing areas, and grafting of full-thickness areas.

» Open burn-related surgical wound infections are treated by debridement of necrotic and infected material with delayed wound closure.

» Invasive burn wound infection is a serious problem, usually addressed by excision and treatment with systemic antibiotics (e.g., penicillin) or a first-generation cephalosporin (e.g., cefadroxil).

» Follow local protocols for selection of antibiotic and appropriate dosing.

Emerging

Chemical debridement

The use of strong chemical debriding agents is gaining traction in the early treatment of selected burns.[91] [92] Pain control during treatment is an important consideration.[93] Presently, use should be limited to burn centres.

Autologous epithelial cell suspension

Immediate application of low-density epithelial cell spray has been proposed as an adjunct to healing in selected burn wounds.[94] [95] It can be used alone or in combination with dermal replacements.[96]

Primary prevention

There is a pressing need for burn prevention, particularly in the developing world.[19] Extensive efforts have been made to diminish the incidence of burn injury through public education and legislation, with mixed results.[20] Simple education does not seem to translate into demonstrable reductions in burn incidence. A working knowledge of the local population and culture will help greatly in increasing the effectiveness of burn prevention programmes.[21] Legislative efforts have been more successful.[22] Examples include fire-retardant infant sleepwear and fire-safe cigarettes. Most successful has been legislation mandating lower temperatures for hot water heaters and requiring installation of smoke detectors.[23]

Patient discussions

Advise patients and their families to inspect for infectious complications, most notably: erythema, swelling, increased tenderness, lymphangitis, odour, or drainage. Home care of burns should include gentle cleansing with soap and lukewarm tap water using clean, but not sterile, technique. Burns at risk of being soiled should be ideally covered with gauze dressings.

FOLLOW UP

Monitoring

Monitoring

Wounds should be surveyed for signs of infection. Patients with a suspected wound infection should be admitted immediately to minimise the risk of systemic infection.

With increasing survival from serious burns, and increasing expectations of the quality of survival, burn aftercare programmes have assumed an increasingly important role.[101]

Burn aftercare care programmes have several interacting components and objectives.

- Durable and functional wound closure:
    - The primary objective
    - Requires attention to areas of fragile healing and to any residual or new areas of functionally limiting contracture.
- Scar management:
    - Particularly important in the first years after injury
    - Although the available tools are limited, attention to programmes of massage and compression, supplemented with judicious use of surgery, can improve function and appearance, and reduce pruritus.
- Emotional support:
    - Essential to a complete recovery, for both the patients and their loved ones[102]
    - Ideally co-ordinated through the burn centre.

Feelings of guilt, fear, anger, and depression must be recognised and addressed. In cases where intentional burning is suspected, either from self-immolation or abuse, efforts should be instituted to protect the patient from further harm.[24] Aftercare is best provided in a multi-disciplinary burn clinic, in co-ordination with the acute care and reconstructive staff. When managed in a comprehensive follow-up programme, even those who have suffered devastating burns can have a satisfying quality of life.[103]

Complications

Complications	Timeframe	Likelihood
sepsis	**short term**	**high**
Managing large burns entails successful management of a series of complications while the wound is progressively closed. Most complications are related to sepsis.[97] Neutropenia, thrombocytopenia, and disseminated intravascular coagulation are common indicators of impending sepsis, and should prompt appropriate investigations and treatment. Topical antimicrobial agents are rarely the cause. Global immunological deficits associated with burn injury contribute to a high rate of infectious complications. Prompt wound closure is the best prophylaxis. The most common wound infection in small outpatient burns is cellulitis, usually caused by *Staphylococcus aureus* . This infection presents with expanding wound erythema, which, if untreated, will progress to lymphangitis and systemic toxicity. All suspected burn infections require aggressive management, which may include admission, intravenous antibiotics, observation, and surgical excision if wounds are deep.		
pneumonia	**short term**	**high**
May occur with or without antecedent inhalation injury, and is treated with pulmonary hygiene and antibiotics.[100]		
chondritis	**short term**	**high**
Occurs as a result of bacterial invasion of cartilage and results in the rapid loss of viable tissue. Prevented by the routine use of topical mafenide acetate on burned ears.		
hepatic dysfunction	**short term**	**high**
Hepatic dysfunction, as the result of transient hepatic blood flow deficits and manifested as transaminase elevations, is extremely common during resuscitation from large burns. Resolves with volume restitution.		
acalculous cholecystitis	**short term**	**high**
Can be encountered as sepsis without localised symptoms or signs, accompanied by rising cholestatic chemistries. A standard radiographic evaluation can be followed by bedside percutaneous cholecystostomy in patients in unstable condition.		
gastroduodenal ulceration	**short term**	**high**
May occur as the result of splanchnic blood flow deficits that degrade mucosal defences. Extremely common, and often life-threatening if routine histamine receptor blockers and antacids are not administered.		
urinary tract infections	**short term**	**high**
Minimised by maintaining bladder catheters only when absolutely required. Treated with appropriate antibiotics. Neither catheterisation nor colonic diversion is routinely required for the treatment of perineal and genital burns.		

FOLLOW UP

Complications	Timeframe	Likelihood
Candida cystitis occurs in patients treated with bladder catheters and broad-spectrum antibiotics. Catheter change and amphotericin irrigation for 5 days is generally successful. If infections are recurrent, upper tracts should be screened by ultrasonography.		
transient delirium	**short term**	**medium**
Occurs in up to 30% of patients, and generally resolves with supportive therapy when the possibility of anoxia, metabolic disturbance, and structural lesions are eliminated by appropriate studies.		
seizures	**short term**	**medium**
Most commonly result from hyponatraemia or abrupt benzodiazepine withdrawal. Prevention is the best treatment.		
acute renal failure	**short term**	**medium**
Early acute renal failure follows inadequate perfusion during resuscitation or myoglobinuria. Treatment is with careful fluid and electrolyte support and occasional dialysis. Late renal failure complicates sepsis and multi-organ failure or the use of nephrotoxic agents. Treatment is with careful fluid and electrolyte support and occasional dialysis. Protein loads are ideally not reduced to facilitate treatment, because this may impair wound healing.		
acute adrenal insufficiency	**short term**	**medium**
Occurs as the result of haemorrhage into the gland. Presents with hypotension, fever, hyponatraemia, and hyperkalaemia. Diagnosis is by adrenocorticotrophic hormone-stimulated and random serum cortisol level determination. Treatment is glucocorticoid replacement at stress levels with empirical tapered reduction.		
endocarditis	**short term**	**medium**
Occurs with fever and bacteraemia without signs of local infection. Diagnosis may require ultrasonography or surgical exposure of peripheral veins.		
suppurative thrombophlebitis	**short term**	**medium**
Occurs with fever and bacteraemia without signs of local infection. Diagnosis may require ultrasonography or surgical exposure of peripheral veins.		
deep venous thrombosis (DVT)	**short term**	**medium**
Infrequent in patients with large burns, so routine prophylaxis is not currently recommended. Iatrogenic catheter insertion complications are minimised by meticulous technique. Catheter-related DVT is minimised by using the smallest possible catheter.		
intestinal ischaemia	**short term**	**medium**
Can progress to infarction. Results from inadequate resuscitation and splanchnic blood flow deficits.		

Complications	Timeframe	Likelihood
corneal abrasion	**short term**	**medium**
Corneal ulceration, which develops after initial epithelial injury or later exposure as the result of ectropion, can progress to full-thickness corneal destruction if secondary infection occurs. This is prevented by careful globe lubrication with topical antibiotics in the former case, and acute lid release in the latter. Other eye-related complications include ectropion, from progressive contraction of burned ocular adnexa, which results in exposure of the globe. This requires acute eyelid release. Tarsorrhaphy is rarely helpful, and may result in injury to the tarsal plate as contraction forces pull out tarsorrhaphy sutures. Symblepharon, or scarring of the lid to the denuded conjunctiva after chemical burns or corneal epithelial defects that complicate toxic epidermal necrolysis, is prevented by daily examination and adhesion disruption with a fine glass rod.		
compartment syndrome	**short term**	**low**
Rarely, abdominal compartment syndrome can develop, usually in patients with very large injuries and delayed resuscitation.		
hypertension	**short term**	**low**
May occur, particularly in pre-adolescent boys, and is best treated with beta-blockers, after inadequate pain and anxiety treatment are excluded.		
hypertrophic scarring	**long term**	**high**
A major cause of long-term functional and cosmetic deformities seen in burn patients. This poorly understood process is heralded by a secondary increase in neovascularity 9 to 13 weeks after epithelialisation. Treatment options include compression garments, massage, judicious steroid injections, topical silicone products, and scar release and resurfacing procedures.[98]		
heterotopic ossification	**long term**	**high**
Develops weeks after injury, and is encountered most commonly around deeply burned major joints such as the triceps tendon. Accompanied by pain and decreased range of motion. Most patients respond to physiotherapy, but some require excision of heterotopic bone to achieve full function.		
Marjolin ulcer	**long term**	**low**
A squamous cell carcinoma that occurs in chronic ulcerated open areas in old burn wounds.		
respiratory failure	**variable**	**high**
May occur early after the injury as the result of inhalation of noxious chemicals, or later in the course of therapy as the result of sepsis or pneumonia.		

FOLLOW UP

Complications	Timeframe	Likelihood
hepatic failure	**variable**	**high**
Late hepatic failure, beginning with elevations of cholestatic chemistries and progressing through frank liver failure, complicates sepsis and multi-organ failure.		
pancreatitis	**variable**	**high**
Pancreatitis, beginning with amylase and lipase elevations and ileus and progressing through haemorrhagic pancreatitis, is generally coincident with splanchnic blood flow deficits early and sepsis-induced organ failures later in the hospital course.		
nerve injury	**variable**	**medium**
Some peripheral nerve injuries occur because of direct thermal injury or compression from compartment syndrome, overlying non-elastic eschar, or improper splinting techniques. Delayed peripheral nerve and spinal cord deficits develop weeks or months after high-voltage injury as the result of small vessel injury and demyelinisation.		
post-traumatic stress disorder	**variable**	**medium**
Occurs in up to 30% of patients, and is probably exacerbated by inadequate treatment of pain and anxiety. Symptoms include hypervigilance, reliving the incident, night terrors, and chronic fearfulness. Recognition and treatment with supportive psychotherapy and pharmacotherapy greatly facilitates recovery.[99]		

Prognosis

It can vary from excellent to poor depending on the severity of the burn. Most burns are minor and the prognosis in these patients is excellent; however, major burns can be fatal.

Important factors influencing prognosis and healing time of a burn include:

- Location and extent of the burn
- Depth
- Patient factors (e.g., age, comorbidities)

First-degree and second-degree burns typically heal within one to two weeks and do not result in scarring. Deeper burns take longer to heal and may result in contraction and scarring with possible temporary or permanent disability.

Diagnostic guidelines

Oceania

NSW burn transfer guidelines, 4th edition (https://www.aci.health.nsw.gov.au/resources/clinical-guidelines)

Published by: New South Wales Agency for Clinical Innovation **Last published:** 2022

Treatment guidelines

United Kingdom

Management of burns in pre-hospital trauma care (https://fphc.rcsed.ac.uk/education-resources/resources/consensus-statements)

Published by: Royal College of Surgeons of Edinburgh Faculty of Pre-Hospital Care; British Burn Association **Last published:** 2020

Clinical guidelines: burns management (https://cats.nhs.uk/clinical-guidelines)

Published by: NHS Children's Acute Transport Service **Last published:** 2018

Europe

Guidelines for the management of partial-thickness burns in a general hospital or community setting (http://www.ncbi.nlm.nih.gov/pubmed/17280913)

Published by: Working Party of European Burn Specialists **Last published:** 2007

International

International first aid and resuscitation guidelines (http://www.ifrc.org/en/publications-and-reports/general-publications)

Published by: International Federation of Red Cross and Red Crescent Societies **Last published:** 2020

North America

First aid (https://cpr.heart.org/en/resuscitation-science/first-aid-guidelines)

Published by: American Heart Association; American Red Cross **Last published:** 2020

Guidelines for the operation of burn centers (https://academic.oup.com/jbcr/issue/28/1)

Published by: American Burn Association; American College of Surgeons **Last published:** 2007

Practice management guidelines for nutritional support in trauma patients (http://www.east.org/resources/treatment-guidelines)

Published by: Eastern Association for the Surgery of Trauma **Last published:** 2004

Oceania

NSW burn transfer guidelines, 4th edition (https://aci.health.nsw.gov.au/resources/clinical-guidelines)

Published by: New South Wales Agency for Clinical Innovation **Last published:** 2022

ANZCOR guideline 9.1.3 - burns (https://resus.org.au/guidelines)

Published by: Australian and New Zealand Committee on Resuscitation **Last published:** 2023

Online resources

1. WHO: fact sheet - burns (http://www.who.int/en/news-room/fact-sheets/detail/burns) *(external link)*

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Images

Figure 1: First-degree burn

From Dr Sheridan's personal collection

Figure 2: Second-degree burn

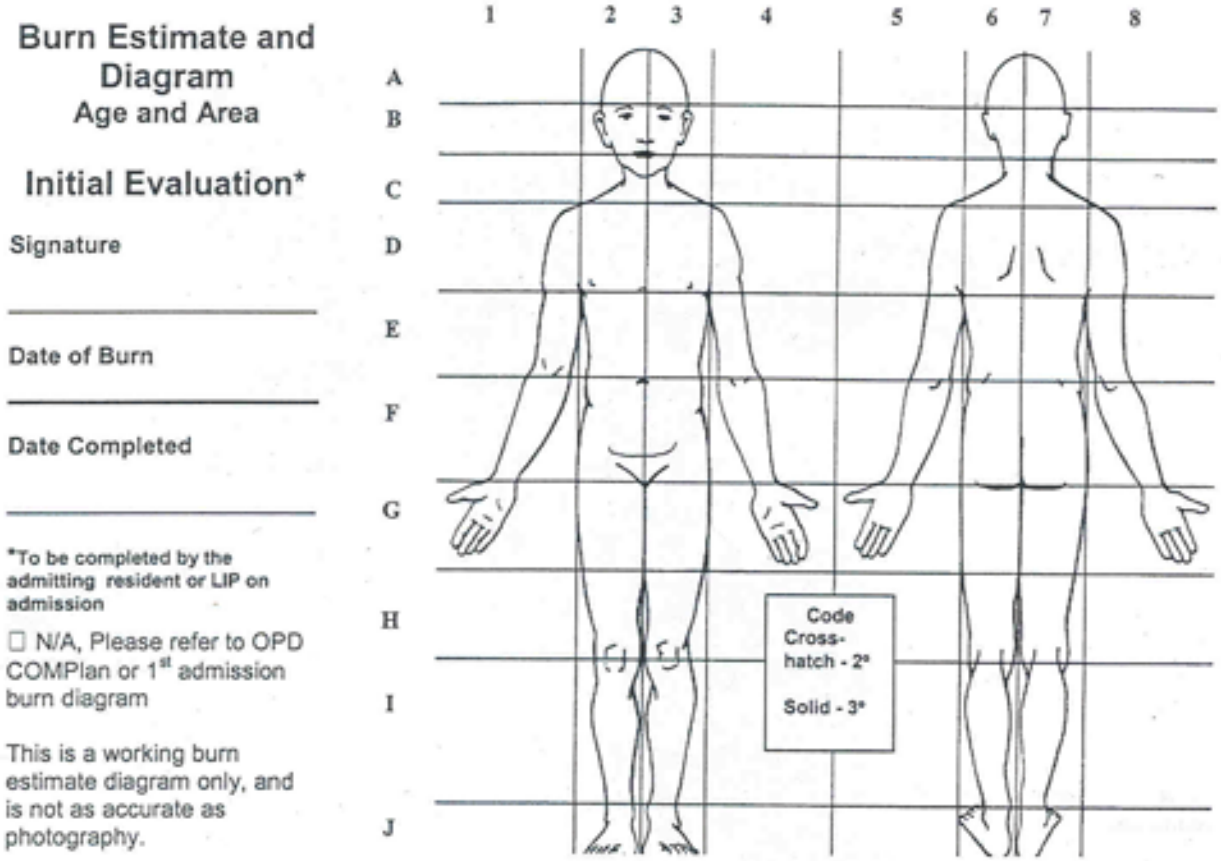
From Dr Sheridan's personal collection

Figure 3: Third-degree burn

From Dr Sheridan's personal collection

Figure 4: Fourth-degree burn

From Dr Sheridan's personal collection



Area	Birth- 1 yr.	1-4 yrs	5-9 yrs	10-14 yrs	15 yrs	Adult	2°	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	2.5	2.5	2.5	2.5	2.5	2.5			
Left Buttock	2.5	2.5	2.5	2.5	2.5	2.5			
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	2.5	2.5	2.5	2.5	2.5	2.5			
Left Hand	2.5	2.5	2.5	2.5	2.5	2.5			
Right Thigh	5.5	6.5	8	8.5	9	9.5			
Left Thigh	5.5	6.5	8	8.5	9	9.5			
Right Lower Leg	5	5	5.5	6	6.5	7			
Left Lower Leg	5	5	5.5	6	6.5	7			
Right Foot	3.5	3.5	3.5	3.5	3.5	3.5			
Left Foot	3.5	3.5	3.5	3.5	3.5	3.5			
** Only 2° and 3° burns are included in the total TBSA burn percent						Total			

Figure 5: Lund-Browder diagram

From Dr Sheridan's personal collection

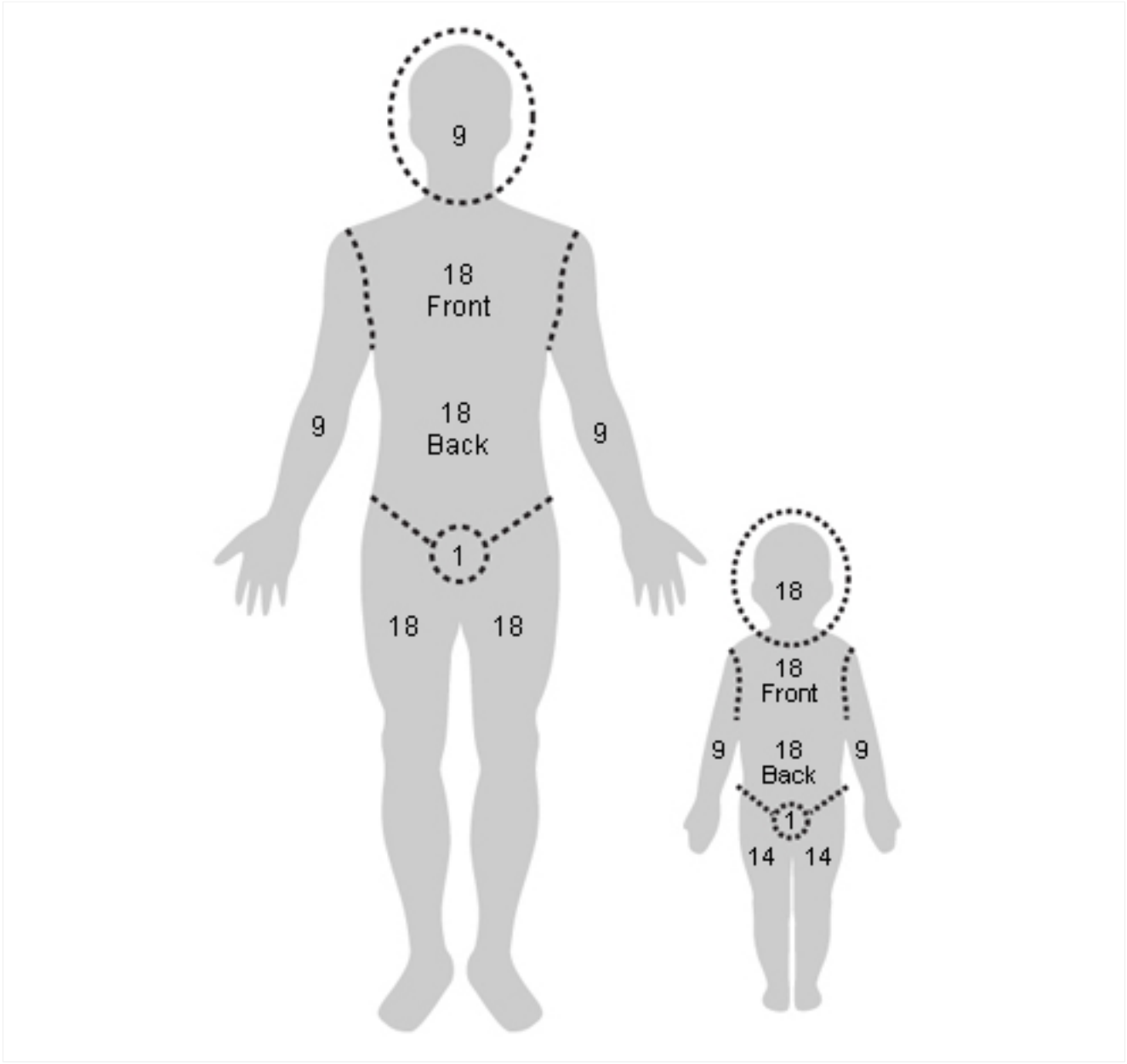


Figure 6: Rule of nines

From Dr Sheridan's personal collection

Figure 7: Circumferential burn

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Figure 8: Cellulitis

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Figure 9: Airway oedema

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Figure 10: Escharotomy

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Figure 1 – BMJ Best Practice Numeral Style

5-digit numerals: 10,000

4-digit numerals: 1000

numerals < 1: 0.25

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