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CLINICAL REVIEW

Emergency and early management of burns and scalds

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Sources and selection criteria

We searched Medline, Ovid, Burns, and the Cochrane Library until June 2008 for randomised controlled trials, systematic reviews, evidence reports, and recent evidence based guidelines from international burn associations.

Burn injuries are an important global health problem. Most simple burns can be managed by general practitioners in primary care, but complex burns and all major burns warrant a specialist and skilled multidisciplinary approach for a successful clinical outcome. This article discusses the principles behind managing major burns and scalds using an evidence based approach and provides a framework for managing simple burns in the community.

What is the burden of burns injuries?

Annually in the United Kingdom, around 175 000 people attend accident and emergency departments with burns from various causes (box 1).[1] This represents 1% of all emergency department attendances, and about 10% of these patients need inpatient care in a specialist unit.[2] A further 250 000 patients are managed in the community by general practitioners and allied professionals. Of patients referred to the hospital, some 16 000 are admitted, and about 1000 patients need active fluid resuscitation. The number of burns related deaths average 300 a year.[1]

Globally, the World Health Organization estimates that 322 000 people die each year from fire related burns.[3] This could be an underestimate, however, because we have no valid comprehensive statistics from developing countries, where >95% of these deaths occur.[3 4] High population density, illiteracy, poverty, and unsafe cooking methods contribute to the higher incidence in developing countries.[4]

How is the area of a burn estimated?

In adults, Wallace's "rule of nines" is useful for estimating the total body surface area—18% each for chest, back, and legs apiece, 9% each for head and arms apiece, and 1% for the perineum. It is quick to apply and easily remembered, although it tends to overestimate the area by about 3%.[5] The Lund and Browder chart takes into account changes in body surface area with age (and growth). It is useful across all age groups and has good interobserver agreement.[5] Another useful, but rather subjective, guide is to use the surface area of the patient's palm and fingers, which is just under 1% of the total body surface area. This method is useful for estimating small burns (<15%) or large burns (>85%). In large burns, the burnt area can be quickly calculated by estimating the area of uninjured skin and subtracting it from 100.[6] A common mistake is to include erythema—only de-epithelialised areas should be included in these calculations.

How is the depth of a burn assessed?

Clinical estimation of burn depth (fig 1) is often subjective—an independent blinded comparison among experienced surgeons showed only 60-80% concurrence.[7] Burn wounds are dynamic and need reassessment in the first 24-72 hours, because depth can increase after injury as a result of inadequate treatment or superadded infection.[8] Burn wounds can be superficial in some parts but deeper in other areas (fig 2). The table shows some characteristic features of burns of varying depth.

A blinded rater comparison of laser Doppler imaging, which assesses skin blood flow, with clinical assessment and histopathology found that imaging was 90-100% sensitive and 92-96% specific for estimating burn depth.[7] However, the high outlay costs for this equipment preclude its use outside specialist burns units. Other methods such as transcutaneous videomicroscopy (direct visualisation of dermal capillary integrity) and infrared thermography (temperature gradient between burnt and intact skin) remain largely experimental.[9 10]

The terms "partial thickness" or "full thickness" burns describe the level of burn injury and indicate the likelihood and estimated duration for healing to occur. Superficial burns usually heal (by epithelialisation) within two weeks without surgery, whereas deeper burns probably need excision and closure of the area, often with skin grafts. Hypertrophic scarring is more common in deeper burns treated by surgery and skin grafting than in superficial burns.[11]

What factors influence outcome?

Logistic regression analysis of survival data from 1665 burns patients from the Massachusetts General Hospital identified three risk factors for death: age over 60 years, more than 40% of body surface area injured, and inhalation injury.[12] As survival outcomes have

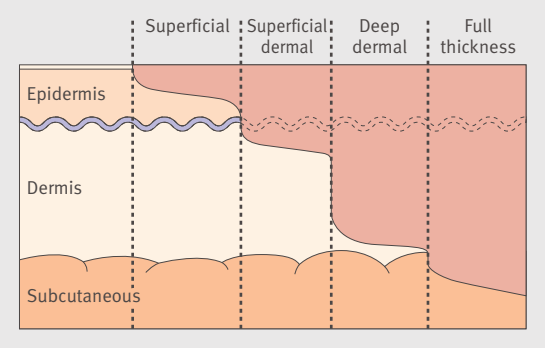

Fig 1 | Burn depth nomenclature

improved (mortality about 5-6% in resourced centres),[13] however, assessment of outcome has shifted from mortality to quality of life measures.[14] Thus, the current focus in burns patients is the preservation of function, reconstruction, and rehabilitation.[13]

How are minor burns managed?

Flowchart 1 (web fig 1 on bmj.com) provides a guideline for managing a "minor" burn in the community. The European working party of burns specialists recommends cleaning burns with soap and water (or a dilute water based disinfectant) to remove loose skin, including open blisters.[15] Although the clinical evidence for "deroofing" of blisters is poor, without deroofing burn depth cannot be assessed. All blisters should therefore be deroofed, apart from isolated lax blisters <1 cm^2 in area, which can be left alone.[16] A simple non-adhesive dressing, such as soft silicone (for example, Mepitel), padded by gauze is effective in most superficial and superficial dermal burns. However, biological dressings such as Biobrane are better, especially for children, because they reduce pain and the wound bed can be inspected through the translucent sheet.[17] New non-animal derived synthetic polymers such as Suprathel look promising for treating partial thickness burns, but further studies are needed. Silver sulfadiazine can be used for deep dermal burns. Dressings should be examined at 48 hours to reassess depth and the wound in general, and dressings on superficial partial thickness burns can be changed after three to five days in the absence of infection. If evidence of infection exists, daily wound inspection and dressing change is indicated. Deep dermal burns need daily dressings until the eschar has lifted and re-epithelialisation is under way, after which dressings can be changed more often.

Characteristic features of burns of different depths

Burn type	Feature			
	Appearance	Blisters	Capillary refill	Sensation
Epidermal	Red, glistening	None	Brisk	Painful
Superficial dermal	Pale pink	Small	Brisk	Painful
Deep dermal	Dry, blotchy cherry red	May be present	Absent	Dull or absent
Full thickness	Dry, white or black	None	Absent	Absent

Box 1 Some important causes of burns and scalds

- Flame burns
- Scalds (hot liquids)
- Contact burns (hot solid)
- Chemicals (acids or alkalis)
- Electrical burns (high and low voltage)
- Flash burns (burns resulting from brief exposure to intense radiation)
- Sunburns
- Friction burns
- Radiation burns
- Burns from lightning strike

When is referral to a specialist burns unit needed?

Box 2 shows the criteria for referring a "complex" burn to the specialist burns unit. Small area burns that take more than 14 days to heal; become infected; or are likely to lead to considerable aesthetic, functional, or psychological impairment (face, hands, feet, across flexures, genitalia) may also need to be referred.[1]

How should major burns be managed?

All major burns should be managed initially according to trauma resuscitation guidelines.[18] Box 3 shows a consensus summary on first aid management (prehospital care) for burns,[18] and box 4 shows the principles for managing any large burns.

Prompt irrigation with running cool tap water for 20 minutes provides optimal intradermal cooling.[19] Ice and very cold water should be avoided because they cause vasoconstriction and worsen tissue ischaemia and local oedema.[20] Hypothermia should be avoided, especially in children. Patients with chemical burns may need longer periods of irrigation (up to 24 hours), and specific antidote information should be obtained from the regional or national toxicology unit.

Prehospital consensus guidelines emphasise that dressings help relieve pain from exposed nerve endings and keep the area clean.[18] Polyvinylchloride film (such as

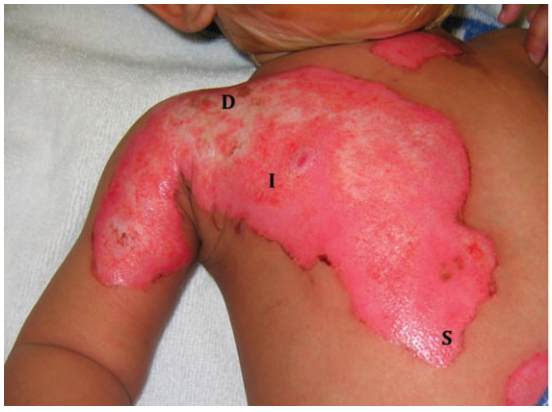

Fig 2 | Tea scald over the chest and shoulder of a child showing heterogeneity of burn depth. S=superficial, I=intermediate, D=deep

Box 2 National burn injury guidelines for referral to a burns unit

All complex injuries should be referred. Such injuries are likely to be associated with:

Extremes of age (<5 or >60 years)

Site of injury

- Face, hands, or perineum
- Any flexure including neck or axilla
- Circumferential dermal burns or full thickness burn of the limb, torso, or neck

Inhalation injury (excluding pure carbon monoxide poisoning)

Mechanism of injury

- Chemical burns >5% total body surface area (except for hydrofluoric acid when >1% area needs referral)
- Exposure to ionising radiation
- High pressure steam injury
- High tension electrical injury
- Hydrofluoric acid burns >1%
- Suspected non-accidental injury in a child (if delayed presentation, unusual pattern of injury, inconsistent history, discrepancy between history and clinical findings, multiple injuries, or old scars in unusual anatomical locations)

Large size

- Child (<16 years old) >5% total body surface area
- Adult (≥16 years) >10% total body surface area

Coexisting conditions

- Serious medical conditions (such as immunosuppression)
- Pregnancy
- Associated injuries (fractures, head injury, or crush injuries)

clingfilm) is useful, but remember that circumferential wrapping can cause constriction. Cellophane films can worsen chemical burns, so the area should be irrigated thoroughly until pain has decreased and only wet dressings should be applied. Intravenous opiates or intranasal diamorphine should be used for analgesia.

All patients with facial burns or burns in an enclosed area should be assessed by an anaesthetist and the need for early intubation ascertained before transfer to a specialist unit. In full thickness circumferential burns—especially to the neck, chest, abdomen, or limbs—escharotomy may be needed to avert respiratory distress or vascular compromise of the limbs from constriction. Flowcharts 2 and 3 (web figs 2 and 3 on bmj.com) show the management of patients in the emergency department or the specialist burns unit.

Box 3 Consensus guidelines for prehospital management of burns[18]

Approach with care and call for help

Stop the burning process

Help the person to "drop and roll" if the clothing is alight

Turn the power off if electricity is involved

Assess patient as per guidelines for emergency management of severe burns (see box 4) and manage appropriately

Cool the area but prevent hypothermia

Assess burn severity

Cover or dress the area with clingfilm or cellophane

Suspect inhalation injury in burns sustained in an enclosed area, facial burns, or when nasal hair has been singed

Early intubation may be needed if there is evidence of inhalation injury

Cannulate and administer fluids (Hartmann's solution or Ringer's lactate)

Provide adequate analgesia

Transfer to appropriate hospital or burns care centre

What is the role of fluid resuscitation?

Effective fluid resuscitation remains the cornerstone of management in major burns. If more than 25% of the body is burnt, intravenous fluids should be given "on scene," although transfer should not be delayed by more than two attempts at cannulation.[18] The aims are to maintain vital organ perfusion and tissue perfusion to the zone of stasis (around the burn) to prevent extension of the thermal necrosis. In the UK, expert consensus recommends that fluid resuscitation be initiated in all children with 10% burns and adults with 15% burns; children who had early (within two hours) fluid resuscitation had a lower incidence of sepsis, renal failure, and overall mortality.[8 21]

How much fluid?

Several formulae, based on body weight and area burnt, estimate volume requirements for the first 24 hours. Although none is ideal, the Parkland formula (3-4 ml/kg/% burn of crystalloid solution in the first 24 hours, with half given in the first eight hours) and its variations are the most commonly used. Resuscitation starts from the time of injury, and thus any delays in presentation or transfer to the hospital or specialist unit should be taken into account and fluid requirement calculated accordingly. Resuscitation formulae are only guidelines, and the volume must be adjusted against monitored physiological parameters.

Which fluid?

The preferred resuscitation fluid varies greatly. Currently, the most popular one is crystalloid Hartmann's solution, which effectively treats hypovolaemia and extracellular sodium deficits. Sodium chloride solution (0.9%) should be avoided because it causes hyperchloraemic metabolic acidosis. A recent Cochrane meta-analysis of 67 randomised controlled trials (RCTs) of trauma, burns, and post-surgery patients found no evidence that colloid resuscitation reduces mortality more effectively than crystalloids.[23] Although the addition of colloids in burn resuscitation may decrease total volume requirements, RCTs are needed to evaluate its other benefits.[24] Many burns units add a colloid after the first 12 hours for large area burns.[22]

How is resuscitation monitored?

The use of urine output to assess adequate fluid resuscitation in burns has been challenged.[5w1] Invasive haemodynamic monitoring with central venous pressure or pulmonary artery catheters are not recommended for routine monitoring of fluid replacement in burns because of the risk of infection. Less invasive monitoring

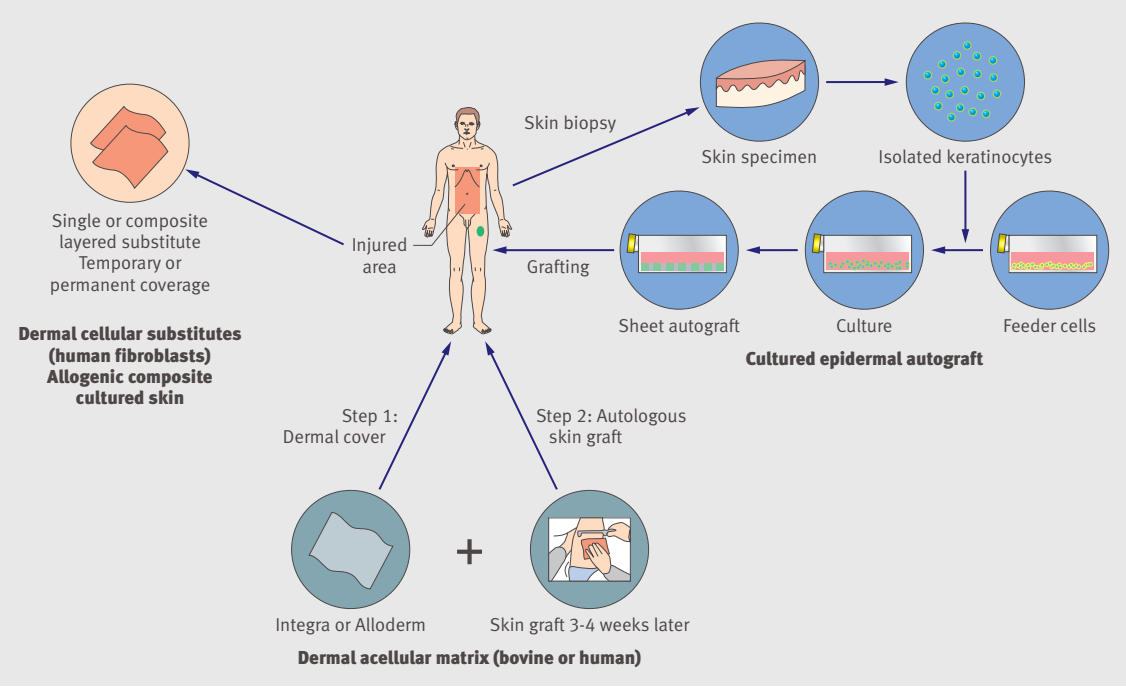

Fig 3 | **Newer tissue engineering directions in burns management. Cultured epidermal autografts (right), staged dermal acellular substitutes (bottom), single application dermal cellular substitutes or allogenic composites (left)**

using thermodilution methods to measure intrathoracic blood volume, cardiac output, and cardiac index have recently received attention. Although preliminary studies have suggested that this may aid resuscitation, one RCT failed to support these findings in burns.[w5]

What is the role of nutrition?

The role of nutritional support in major burns has shifted from one of preventing malnutrition to one of disease modulation.[w6] Nutritional requirements are dynamic, and early debridement and skin cover result in a 50-75% increase in energy expenditure. Thus, a nutritional plan—that takes account of factors such as the extent and depth of the burn, the need for repeated surgical interventions, the appropriateness of the enteral or parenteral route, and the pre-injury health status of the patient—should be implemented within 12 hours.

Box 4 Emergency management of severe burns approach (adapted from the Australian and New Zealand Burns Association)

Order of management priority in patients with severe burns

A. Airway with cervical spine control

B. Breathing and ventilation

C. Circulation with haemorrhage control

D. Disability—neurological status

E. Exposure preventing hypothermia

F. Fluid resuscitation

Adults

Resuscitation fluid alone (first 24 hours):

- Give 3-4 ml (3 ml in superficial or partial thickness burns, 4 ml in full thickness burns or those with associated inhalation injury) Hartmann's solution/kg body weight/% total body surface area. Half of this calculated volume is given in the first eight hours after injury. The remaining half is given in the second 16 hour period

Children

Resuscitation fluid as above plus maintenance (0.45% saline with 5% dextrose, the volume should be titrated against nasogastric feeds or oral intake):

- Give 100 ml/kg for first 10 kg body weight plus 50 ml/kg for the next 10 kg body weight plus 20 ml/kg for each extra kg

Psychosocial aspects

The psychological requirements of patients and their carers change over the early resuscitative phase, acute phase, and rehabilitation phase. The prevalence of depression is estimated to be high (up to 60%) in burns inpatients, and up to 30% have some degree of post-traumatic stress disorder.[w7] All burns centres offer specialist advice on long term psychosocial adjustment in burns patients. Changing faces in the UK and the Phoenix society in the United States provide excellent support for burns survivors.

How are scar and burn areas managed after healing?

A retrospective cohort study of 337 children with up to a five year follow-up found hypertrophic scarring in less than 20% of superficial scalds that healed within 21 days but in up to 90% of burns that took 30 days or more to heal.[11] Appropriate treatment must therefore be instituted early and infection prevented to encourage rapid healing. Healed burns do not have adnexal structures, and are therefore dry, sensitive, and irregularly pigmented. Hence the area should be moisturised and massaged to reduce dryness and to

SUMMARY POINTS

- Most minor burns can be managed in primary care
- Appropriate first aid limits progression of burn depth and influences outcome
- Assessment of area and depth is crucial to formulating a management plan
- Burn depth may progress with time, so re-evaluation is essential
- All major burns require fluid resuscitation, which should be guided by monitoring of the physiological parameters
- A multidisciplinary approach is crucial for a successful clinical outcome

keep the healed area supple. A sun cream, with a sun protection factor of 30, is advised to prevent further thermal damage and pigmentation changes.

New directions in burn wound management

Although autografting is the gold standard for skin replacement in burns, limited availability of donor skin precludes this option in large area burns. Hence, various tissue engineered skin substitutes (fig 3) have been developed to provide temporary or permanent wound coverage.

Autologous keratinocyte grafts (obtained after biopsy and culture of the patient's own keratinocytes) and allogenic keratinocyte grafts have been developed for large area superficial burns. Other developments include a keratinocyte suspension in a fibrin sealant matrix aimed at increasing the adherence of keratinocytes to the wound bed (keratinocyte-fibrin glue suspension) and a total lysate of cultured human keratinocytes made up of growth factors, cytokines, and matrix molecules in a hydrophilic gel.[w8]

Processed skin from human cadavers—in which the cells are removed to leave a non-antigenic dermal scaffold—is used as a dermal replacement for treating deeper burns. Allogeneic fibroblasts, obtained from neonatal human foreskin and cultured in vitro, seeded on a biologically absorbable scaffold or on a nylon mesh, have also been developed. The proliferating fibroblasts secrete collagen, matrix proteins, and growth factors and aid healing. Composite skin substitutes comprising allogeneic keratinocytes (epidermal equivalent) and fibroblasts (dermal equivalent) are also available.[w9]

Although a recent meta-analysis of 20 RCTs has shown these substitutes to be safe, their efficacy could not be determined on the basis of current evidence.[w9]

Additional educational resources

Resources for healthcare professionals

Burn Surgery (www.burnsurgery.org)—Good resource for health professionals regarding all aspects of burns

Resources for patients

Fire Safety in the Home (www.firekills.gov.uk)—Government website with burn prevention and fire safety information

Changing Faces (www.changingfaces.org.uk)—UK charity that supports and represents people who have disfigurements of the face or body from any cause

Salamanders (www.kernoweb.myby.co.uk/salamanders)—Provides networking and education opportunities for young burns survivors

Phoenix Society (www.phoenix-society.org/resources)—Patient resource directed at burns survivors and families

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