British Journal of Hospital Medicine

MMC
Modernising Medical Careers

Modernising Medical Careers

In Next Month's MMC Supplement

Cardiac disease on chest X-ray: a pictorial review

Emergency management of burns

Introduction

Burns are an important cause of mortality and morbidity, with potentially severe local and systemic consequences. An estimated 250 000 burns are treated annually in UK emergency departments and primary care and patients may deteriorate rapidly. Their emergency management is therefore a crucial skill for junior staff in many specialties. This article provides the reader with the theoretical knowledge necessary to undertake this competently.

Definition and classification

A burn is an area of necrosis which may result from thermal, chemical, electrical and radiation injury. These aetiologies can be further subdivided as in *Table 1* (Enoch et al, 2009).

Thermal burns

Thermal burns result from exposure to heat, via a number of different mechanisms (*Table 1*). Flame burns are the most common, causing half of all adult burns (Hettiaratchy and Dziewulski, 2004). Often, these mechanisms may be synergistic; for example a flame burn igniting clothing to cause a contact burn (American College of Surgeons, 2008). Burns are mediated by heat transfer, dependent upon the duration of contact of the burning agent, its temperature, specific heat and heat capacity and the specific heat and conductivity of the contact surface (for example skin thickness) (Weaver et al, 1993; Sheridan and Tomkins, 2000).

Table 1. Causes of burns

Thermal	Scalds (hot liquid, steam, spill or immersion)
	Gas
	Contact (hot surfaces)
	Fire (flame and flash)
Chemical	Acid
	Alkali
Electrical	Low voltage
	High voltage
	Flash
Radiation	Flash (brief intense radiation)

Mr John M Findlay *is Core Surgical Trainee 2 in the Department of General Surgery, Royal Berkshire Hospital, Reading RG1 5AN, and* **Mr Alex Shaw** *is Core Surgical Trainee 2 in the Department of Plastic Surgery, Wexham Park Hospital, Slough*

Correspondence to: Mr JM Findlay

Chemical burns

These may result from many industrial and domestic sources, most commonly acids and alkalis, but also petroleum products, phosphorous and even airbags, fabric detergents, hair highlighting and garlic (Friedman et al, 2006; Scarlett and Gee, 2007; American College of Surgeons, 2008; Lund et al, 2010; Mathew et al, 2010). In addition to direct chemical damage, ensuing exothermic reactions may cause superadded thermal burns. Chemical burns (particularly alkali) tend to be deep, with the responsible agent continuing to penetrate tissues until it is completely removed (Hettiaratchy and Dziewulski, 2004; Benson et al, 2006).

Electrical burns

These account for 4% of adult burns (Maghsoudi et al, 2007) and are classified as low and high voltage (in excess of 1000 volts). Voltage is the primary determinant of severity. Flash burns, whereby an electrical arc adjacent to the patient induces burns, are a variant of high voltage burns. Electrical current may cause damage at entry and exit sites, and to intervening tissue. Low voltage burns (for example, domestic electricity) tend to cause small but deep burns at the entry and exit points, whereas higher voltage injuries may cause significant intervening necrosis. Complications include rhabdomyolysis and cardiac arrhythmias (Benson et al, 2006; Maghsoudi et al, 2007).

Radiation burns

These are uncommonly caused by industrial electromagnetic and particle radiation and acutely manifest similarly to thermal burns (Miller and Rudolph, 1990).

Skin anatomy and function

The skin consists of the epidermis, dermis and hypodermis. The outer keratinizing stratified squamous epithelial layer, the epidermis, is avascular. Deep to this is the dermis, a supporting layer of cellular and fibrous connective tissue containing blood vessels, nerve endings and appendages. It is composed of two layers: the papillary and reticular dermis. The latter is extremely variable in depth, and becomes atrophic with age. Below the dermis is the hypodermis, containing connective and adipose tissue, with deep arteriovenous plexuses (Hunter et al, 2002).

Burn depth

Burns may be superficial, partial and full thickness, with partial burns subdivided into superficial and deep dermal (*Table 2*; Benson et al, 2006). This classification helps guide management, but burn depth is dynamic and may require a period of observation. This gives a window of opportunity during which ultimate depth can be improved by supportive treatment, but also worsened by complications (Heimbach et al, 1992; Sheridan and Tomkins, 2000; Enoch et al, 2009). Clinical assessment is subjective, but more accurate techniques such as laser Doppler assessment are often prohibitively expensive (La Hei et al, 2006).

Burn pathophysiology

The consequences of burns relate to the loss of skin function, and to local and systemic responses.

Loss of skin function

The skin functions as a barrier to entry of microorganisms, and prevents egress of fluid, electrolytes and heat. Consequently burns may be complicated by infection, hypovolaemia, electrolyte derangement and hypothermia.

Local response

The burn produces an area of irreversible tissue damage, surrounded by an area of potentially reversible damage (Sheridan and Tomkins, 2000). Full thickness burns consist of three concentric three-dimensional zones: a central zone of non-viable coagulative necrosis, surrounded by a zone of (potentially viable) vascular stasis. This in turn is surrounded by a (usually viable) zone of inflammation and hyperaemia (Jackson, 1953). It is the aggressive preservation of perfusion to this threatened zone that underlies supportive treatment (Hettiaratchy and Dziewulski, 2004).

Systemic response

Burns provoke a significant local inflammatory response, driven by mediator systems including cytokines, prostaglandins, kinins and complement. This response becomes greater with increasing burn severity and area, with physiological and multisystem sequelae evident when approximately 15% of total body surface area is involved. This results in multisystem effects as described in *Table 3* (Sheridan and Tomkins, 2000), ultimately culminating in the systemic inflammatory response syndrome, shock and multiorgan dysfunction (Hettiaratchy and Dziewulski, 2004).

Emergency assessment and management

The management of major burns can divided into seven stages (*Figure 1*, National Burn Care Review, 2001).

Figure 1. The seven stages of burn management. From National Burn Care Review (2001).

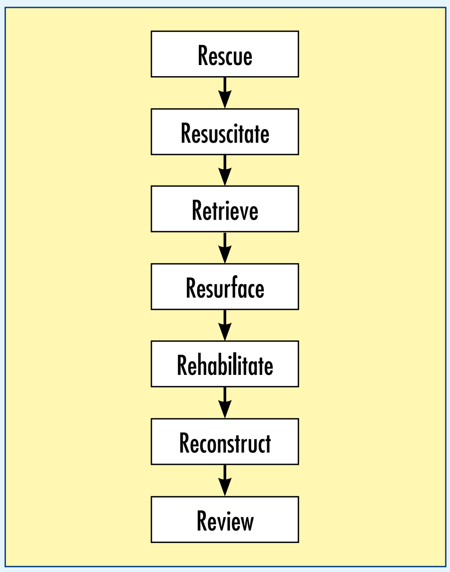


Table 2. Clinical assessment of burn depth

Type	Layers	Colour	Blisters	Capillary refill	Sensation	Healing
Superficial	Epidermis	Red	No	Brisk	Painful	Yes
Superficial partial thickness	Epidermis plus superficial dermis	Pink	Yes	Brisk	Painful	Yes
Deep partial thickness	Epidermis plus deep dermis	Fixed red	Sometimes	Absent	Insensate	Scarring
Full thickness	All layers	Charred or white	No	Absent	Insensate	Scarring

From Benson et al (2006)

Table 3. Systemic consequences of burns

Systemic inflammatory response syndrome	
Metabolic	Increased basal metabolic rate
	Catabolic state
	Immunosupression
Cardiovascular	Increased vascular permeability
	Fluid loss from burn site
	Myocardial depression
	Shock as a result of a combination of distributive, hypovolaemic and cardiogenic processes
Respiratory	Airway and parenchymal inflammation
	Acute respiratory distress syndrome
Gastrointestinal	Ischaemia
	Mucosal atrophy and intestinal failure

From Hettiaratchy and Dziewulski (2004)

Rescue

Pre-hospital management comprises extrication of the patient, rapid assessment and stabilization, and transport to an appropriate centre. Burning clothing should be extinguished with the 'drop and roll' method and blankets removed, unless adherent to burnt skin (Robertson and Fenton, 1990). Copious cold water should be applied for at least 20 minutes (longer with chemical burns), but excessively cold water or ice may impair perfusion and induce hypothermia (Benson et al, 2006). Chemicals should be brushed away. If possible, burns should be covered with sterile, transparent sheets, and liberal analgesia (such as nitrous oxide or opioids) provided.

Resuscitate

Initial in-hospital assessment and management should be rapid and focussed, following a framework such as Advanced Trauma Life Support (American College of Surgeons, 2008). This follows an ABCDE primary survey approach of synchronous assessment and resuscitation. Burn injuries may be associated with multi-system organ dysfunction with rapid deterioration, and other injuries which increase the overall 'trauma load' on the patient. Obtaining the history is important, but should not delay resuscitation attempts. Information from pre-hospital staff is crucial (*Table 4*). The most important predictors of mortality are increasing age, burn surface area and the presence of inhalational injury (National Burn Care Review, 2001; Galeiras et al, 2009).

Airway

This is crucial, and is susceptible to injury via heat, smoke and gases, and also direct obstruction. A number of indicators suggest airway involvement (*Table 5*), which may progress rapidly from inflammation to oedema and obstruction. Therefore any suspicion requires early and prompt anaesthetic input, with a low threshold for provision of a definitive airway by an experienced clinician.

Breathing

The respiratory system may be involved directly via the burning process and inhalation of toxic gases (causing pulmonary oedema or pneumonitis), or indirectly via mechanical factors such as chest trauma or circumferential burns (which may require escharotomy). The need for early mechanical ventilation is unsurprisingly a poor prognostic variable (Galeiras et al, 2009). 100% oxygen should be administered immediately, and in those with carbon monoxide poisoning (such as those burned in an enclosed area) this is therapeutic, driving its dissociation. Arterial blood gases assess both gaseous exchange and acid–base status. Chest films or thoracic computed tomography scans may demonstrate evidence of inhalation injuries and also chest wall injuries.

Circulation with haemorrhage control

Circulatory status should be rapidly assessed via indicators of cardiac index (including pulse rate, volume and character, blood and pulse pressure, and capillary refill time). At least two large bore venous cannulas should be inserted (ideally through unburned skin) and a full blood set of trauma blood tests taken. If access is difficult, saphenous vein cut down, interosseous and central venous lines may be required (American College of Surgeons, 2008).

Intravenous fluid therapy should be commenced as appropriate, and hourly urine output assessed with insertion of a urethral catheter. Hourly urine outputs of 0.5 ml/kg in adults and 1.0 ml/kg in children should be the minimum accepted (American College of Surgeons, 2008). Circumferential burns (for example, of a limb) may cause distal ischaemia, and are treated by escharotomy. Electrical burns may require cardiac monitoring (Benson et al, 2006; Maghsoudi et al, 2007).

Disability and exposure

Neurological status should be rapidly assessed using either the Alert Voice Pain Unresponsive (AVPU) method or Glasgow coma score. Reduced conscious level may indicate inadequate cerebral oxygenation or perfusion, or direct cerebral injury (American College of Surgeons, 2008). Hypothermia must be prevented, and burns dressed. Abdominal distension or vomiting require insertion of a nasogastric tube. This is recommended especially with burns greater than 20% of total body surface area (American College of Surgeons, 2008). A full secondary survey should then be performed to identify any other injuries.

Fluid resuscitation guidelines

Several regimens exist for managing burn victims (*Table 6*), none of which have been shown to be definitively superior (Hettiaratchy and Papini, 2004). These serve as guidelines, however, and must be modified as indicated by haemodynamic parameters. There is some doubt as to the best fluid, although current opinion is that a balanced crystalloid (such as Hartmann's) is preferential to normal saline (Enoch et al, 2009). While use of colloid is also commonplace, this has not been shown to be

Table 4. Important information about an accident leading to a burn
Nature (e.g. fire, steam, immersion, electrical, chemical, radiation)
Nature of burning materials (e.g. furniture, chemicals)
Was there an explosion?
Was the patient in an enclosed space?
For how long was the patient exposed to the burning agent?
When did the burn occur?

From Fenton and Robertson (1990)

Table 5. Indicators of airway involvement
Facial or neck burns including blistering around mouth
Singeing of hair, eyebrows or nose
Soot in sputum
Oropharyngeal inflammation
Voice changes
Stridor
Confusion
Burns within confined space
Explosion with torso or head burns
Carboxyhaemoglobin levels more than 10%

From American College of Surgeons (2008)

Table 6. Examples of fluid regimens

Regimens	Initial 24 hours (crystalloid: Ringer's lactate or Hartmann's)	Maintenance fluids (crystalloid or colloid)
Parkland	3–4 ml/kg/% burn, 50% volume in first 8 hours	20–60% estimated plasma volume, titrated to urine output 30 ml/h
Brooke	1.5–2 ml/kg/% burn with colloid 0.5 ml/kg/% burn and 2 litres 5% dextrose	50% of first 24-hour volume with 2 litres 5% dextrose
Cleveland	4 ml/kg/% burn with 50 mEq sodium bicarbonate/litre	0.45% saline titrated to urine output with 1U fresh frozen plasma/1 litre of 0.45% saline with 5% dextrose (for hypoglycaemia)
Evans	0.9% saline 1 ml/kg/% burn with 2 litres 5% dextrose with colloid 1 ml/kg/% burn	50% of first 24-hour volume with 2 litres 5% dextrose
Cincinnati (paediatrics) Check local guidelines	4 ml/kg/% burn 1.5 litre/m^2 burn surface area first 8 hours with 50mEq sodium bicarbonate/litre, second 8 hours alone, third 8 hours with 12.5 g 25% albumin/litre Or standard 4 ml/kg/% burn 50% volume in first 8 hours	Standard maintenance: 0.45% saline with 5% dextrose. Titrate to nasogastric feed or oral intake, 100 ml/kg for first 10 kg, 50 ml/kg for next 10 kg, 20 ml/kg each kg after

From Baxter and Shires (1968), Yowler and Fratianne (2000)

superior to crystalloid (Perel and Roberts, 2007). It is generally considered that adults with burns greater than 15% body surface area, and children greater than 10% require fluids (National Burn Care Review, 2001; American College of Surgeons, 2008).

Burn area assessment

This is commonly performed by the 'rule of nines'. The adult body is divided into anatomical regions representing 9%, or multiples of 9% (*Figure 2*). The palmar aspect of the (patient's) hand represents 1%. Specialized paediatric charts, such as the Lund and Browder chart, are available.

However, it is important to recognize that correlation of burn surface area and effect is a simplistic assessment. Burns injuries strike a heterogenous casemix, and are dependent upon a great number of interacting variables, both of the injury itself and the victim. For example, a 5% burn to the torso of a fit and well adult may require nothing more than outpatient management. Contrast this with a 5% burn affecting the face (with significant facial oedema threatening the airway and function) or the hands (inflicting significant disability).

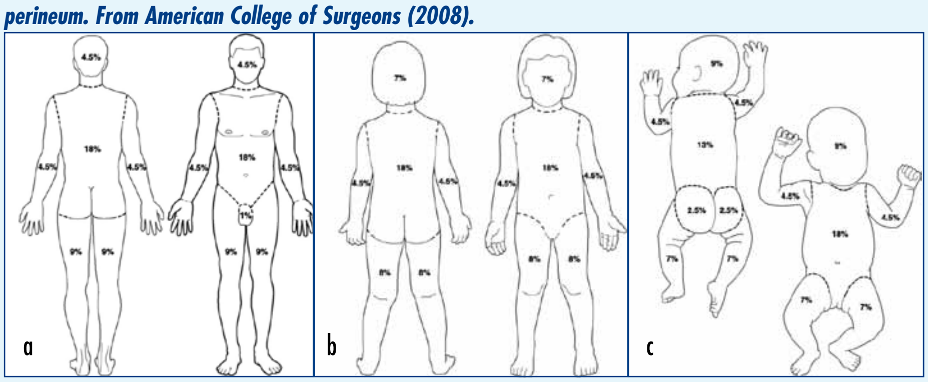
Retrieve

At this stage, the patient may require transfer to a specialist burns centre. Suggested criteria are given in *Table 7*.

Resurface

Skin repair may be undertaken with dressings and adjunctive therapy, or a form of skin replacement. Significant burns may require early, aggressive debridement dependent upon physiological fitness for such a procedure, and the nature of the burn itself (National Burn Care Review, 2001; Benson et al, 2006). Skin replacement may take the form of autologous skin grafts, keratinocyte grafts or composite skin grafts comprising fibroblasts, keratinocytes and cadaveric dermal scaffolds (Enoch et al, 2009).

Figure 2. Wallace's rule of nines. a. Adult burns assessment. b. Child burns assessment. c. Infant burns assessment. In adults 18% each for chest, back and legs, 9% for each head and arms and 1% for perineum. From American College of Surgeons (2008).



Rehabilitate

Rehabilitation should begin immediately, and involve a multidisciplinary approach including physical and occupational therapy, and psychosocial and psychiatric support.

Reconstruct

Reconstructive procedures may be necessary, such as further grafting procedures or release of scar tissue.

Review

As befits the complex and chronic nature of burns injury, multidisciplinary follow up is crucial, often over a long period of time.

Table 7. Indications for referral to burns centre

Children <5 years old or adults >60 years old
Involvement of face, hands, perineum or any flexure
Circumferential or full thickness burns
>10% surface area in >16 years old
>5% surface area in <16 years old
Inhalation injuries or chemical burns >5% surface area
Exposure to ionizing radiation or high tension electrical injury
High pressure steam injury
Associated injuries, e.g. fractures, head injury or crush injuries
Suspected non-accidental injury in a child
Pregnancy
Pre-existing medical conditions

From Enoch et al (2009)

Conclusions

Burns are a common and important cause of significant and rapid morbidity and mortality. Both emergency and specialist management are continually evolving fields, with a number of unanswered questions. However, early appropriate management is a prerequisite for a successful outcome, and often it is a junior member of the medical team who has the responsibility and opportunity to provide this. BJHM

Conflict of interest: none.

American College of Surgeons (2008) *Advanced Trauma Life Support for Doctors course manual.* 7th edn. American College of Surgeons, Chicago, USA

Baxter CR, Shires T (1968) Physiological response to crystalloid resuscitation of severe burns. *Ann N Y Acad Sci* **150**(3): 874–94

Benson A, Dickson WA, Boyce DE (2006) Burns. *BMJ* **332**(7542): 649–52

Enoch S, Roshan A, Shah M (2009) Emergency and early management of burns and scalds. *BMJ* **338**: b1037

Friedman T, Shalom A, Westreich M (2006) Self-inflicted garlic burns: our experience and literature review. *Int J Dermatol* **45**(10): 1161–3

Galeiras R, Lorente JA, Pértega S et al (2009) A model for predicting mortality among critically ill burn victims. *Burns* **35**(2): 201–9

Heimbach D, Engrav L, Grube B, Marvin J (1992) Burn depth: a review. *World J Surg* **16**(1): 10–15

Hettiaratchy S, Dziewulski P (2004) Pathophysiology and types of burns. *BMJ* **328**: 1427–9

Hettiaratchy S, Papini R (2004) Initial management of a major burn: II--assessment and resuscitation. *BMJ* **329**(7457): 101–3

Hunter JAA, Savin JA, Dahl MV (2002) *Clinical Dermatology.* 3rd edn. Blackwell Science Limited, Oxford

Jackson DM (1953) The diagnosis of the depth of burning. *Br J Surg* **40**: 588

La Hei ER, Holland AJA, Martin HCO (2006) Laser Doppler imaging of paediatric burns: burn wound outcome can be predicted independent of clinical examination. *Burns* **32**: 550–3

Lund JJ, Unwala R, Xia L, Gottlieb V (2010) Chemical scalp burns secondary to the hair highlighting process: clinical and histopathologic features. *Pediatr Dermatol* **27**(1): 74–8

Maghsoudi H, Adyani Y, Ahmadian N (2007) Electrical and lightning injuries. *J Burn Care Res* **28**(2): 255–61

Mathew RG, Kennedy K, Corbett MC (2010) Wave of paediatric eye injuries from liquid detergent capsules *BMJ* **340**: c1186

Miller SH, Rudolph R (1990) Healing in the irradiated wound. *Clin Plast Surg* **17**(3): 503–8

National Burn Care Review (2001) National burn injury referral guidelines. In: *Standards and strategy for burn care*. National Burn Care Review, London: 68–9

Perel P, Roberts I (2007) Colloids versus crystalloids for fluid resuscitation in critically ill patients. *Cochrane Database Syst Rev* (**4**): CD000567

Robertson C, Fenton O (1990) ABC of major trauma. Management of severe burns. *BMJ* **301**(6746): 282–6

Scarlett A, Gee P (2007) Corneal abrasion and alkali burn secondary to automobile air bag inflation. *Emerg Med J* **24**(10): 733–4

Sheridan RL, Tomkins RG (2000) Acute burns. In: Morris PJ, Wood EC, eds. *Oxford Textbook of Surgery.* 2nd edn. Oxford University Press, Oxford

Weaver AM, Himel HN, Edlich RF (1993) Immersion scald burns: strategies for prevention. *J Emerg Med* **11**(4): 397–402

Yowler CJ, Fratianne RB (2000) Current status of burn resuscitation. *Clin Plast Surg* **27**(1): 1–10

KEY POINTS

- Burns are a common form of injury presenting to junior doctors both in the emergency department and also in primary care.
- Rapid assessment and management of patients is vital to preserve viable tissue and optimize outcome.
- Burns may be associated with significant systemic and multi-organ dysfunction, and rapid deterioration.
- Patients should be managed within the context of recognized trauma protocols to identify associated injuries.
- Management should be guided by a number of parameters, including the cause, mechanism and extent of the burn; a focused history is therefore vital.