BURNS

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The Burn Injury

Burn injury can result from many causes, the majority by these mechanisms:
Thermal injury - Hot and Cold including iatrogenic heating and non-accidental injury
Chemical - Acids and Alkalis (e.g. Do-It-Yourselfers and building workers can be burnt by cement.)
Electrical - Mains, High Tension, Railways and Lightning

Incidence

Deaths in England and Wales from smoke or fire related injury

	Females	Males	Total
2001	146	185	331
1997	174	262	436
1977	278	359	637
1968	337	454	791

The commonest cause of death is by smoke inhalation

Age range: In infancy scalds are the commonest injury. 70% of burnt children are toddlers. In old age, medical co-morbidity compounds the tendency to more severe burns (E.g. Epilepsy Parkinson's immobility and falls)

Other social risk factors, especially poverty and psychiatric illness mean that the burden of burn injury falls on the already disadvantaged.

Assessment

ATLS & APLS: These authorities emphasise a 'safe' approach for the rescuer and immediate life saving manoeuvres for the victim: 'ABCDEFG', stopping the burning process, gaining IV access, starting fluid resuscitation and providing appropriate pain relief are the cornerstones of the initial approach. Potential airway compromise will be suggested by the history, facial burns, soot staining around the nostrils, singed nasal hairs etc.

Assessment of the percentage of total body surface area of skin affected (%TBSA) is an important guide to the severity of the burn. The 'Rule of nines', is used over 14 years of age. Modified Lund & Browder charts for babies and children are available in A&E departments and in the APLS handbook. The patients own palmar surface (excluding fingers) is about 1%TBSA.

The depth of the burn is important for the planning of treatment.

Erythema (1°) is not included in the estimate of the burned area. Nevertheless these areas, rather like sunburn, may be painful but will not be blistered and will heal normally without treatment.

Superficial partial thickness (2°), **deep partial thickness** (2°) and **full thickness** (3°) areas are included in the estimated area.

The distinction between superficial and deep is of importance as the former has a better prospect of healing without scarring. Under-resuscitation can cause deterioration of burned areas to a more severe grade.

Complex burns include destruction of tissues deep to the skin such as tendon muscle and bone. Burns to the face, airway and perineum would also be included as complex burns.

Smoke inhalation and poisoning due to Carbon Monoxide (CO) and Cyanide (CN) must also be suspected where relevant. The finding of high carboxy-haemoglobin levels (>25%) should suggest not only the need to treat with 100% Oxygen and ventilation but also the possible need to test for cyanide intoxication. There is no high quality RCT evidence to direct the use of Hyperbaric Oxygen in Carbon Monoxide poisoning, especially if the Hyperbaric chamber is distant from the burns treatment centre.

Compartment syndromes and need for Escharotomies / Fasciotomies

Full thickness burns can produce compromise of respiratory excursion or distal tissue perfusion, suggesting the need for escharotomy. Effective releasing incisions go down to vital and often sensate tissues-indicating the **need for** anaesthesia. Such work would usually be done at the accepting Burn centre and only rarely at the referring hospital, after discussion with the accepting Consultant surgeon. The need for fasciotomy is rarer still and is usually associated with the exit point to earth of an electrical burn and associated muscle necrosis.

Burns less than 10% TBSA do not normally require formal resuscitation, although admission for assessment, pain relief and investigation of circumstances may be required (especially when children are injured). Concurrent medical illness may make **Oxygen** and **fluids** necessary even for <10%, for example in children with renal disease or with complex burns.

Burns greater than 10% and less than 30% may be classified as moderate in severity and will require **Oxygen, fluid resuscitation, pain relief and naso-gastric feeding**. As severity approaches 30% TBSA, a systemic inflammatory response of pyrexia, raised white count and raised CRP in the absence of infection becomes more likely but only if the burn remains unexcised and only after 24-48 hours. For less severe burns, close to the time of injury, pyrexia and raised indices of infection may indicate true infection. Cultures should be taken and the wound inspected by a senior opinion prior to starting antibiotic therapy. If pre-existing skin disease is present infection may occur early. (Including Toxic shock syndrome from toxin generating Staphylococcus Aureus.)

Concomitant smoke inhalation and cutaneous 10%<burn<30% indicates **at least** HDU based management.

Burns>30% TBSA represent a major injury where a systemic response is universal. Mortality is high if management is not optimal, even in young patients. The management of these more major burns involves **Oxygen, fluids, feeding & pain relief** as before, but with the need for invasive monitoring to guide therapy and for ventilation in a higher proportion of cases. Prophylactic antibiotics are not usually given except as part of a 'Selective Decontamination of the Digestive Tract',regimen in the more severe burns expected to be ventilated long term (in some units).

Resuscitation

Aims to:

1) Preserve life
2) Maintain Organ function
3) Ameliorate the injury
4) Restrict surgery to necessity and functional restoration
5) Limit Psychological damage

Fluid Regimens

These are guides for appropriate replacement. They are not ends in themselves. All 'recipes', require monitoring and adjustment. The commonest now used is the Parkland formula. This is calculated having an accurate assessment of the burned area and the body weight, suggesting a volume of Ringer-Lactate (Hartmanns Solution) given by:

2-4 mls per %TBSA per Kg body weight

This volume is given over the 24 hours following injury, half the (volume) being given over the first 8 hours from the injury. For example a 70 Kg Man with a 50% BSA Superficial partial thickness injury would require 7-14 (4x50x70/1000) litres over the first 24 hours. Experience suggests that those patients with smoke inhalation injury need still more fluids, as do those with extensive partial thickness burns.

If it has taken several hours for the patient to reach medical attention the first half may need to be given at a 'front loaded', accelerated rate for a couple of hours in order to catch up. It is important that under-resuscitation is avoided. The fluid should be warmed to ensure that the development of hypothermia doesn't complicate clotting function or cause inappropriate vasoconstriction.

Oliguria, haemoconcentration and hypotension are all signs of inadequate fluid administration under these circumstances.

Adequate cerebral function, brisk capillary refill, appropriate blood pressure and urine output in the range 0.5-1.0ml/kg/Hr output (1.0-2.0ml/kg/Hr urine output in children) suggest adequate resuscitation.

In larger burns and in patients with pre-existing impaired physiology, invasive monitoring with CVP or pulmonary artery flotation catheters may gauge adequacy of fluid replacement more effectively. These are best used early and removed before greater morbidity occurs due to infection. Experience is being gained with the oesophageal doppler monitor as a non-invasive guide to filling and in conjunction with CVP to guide SVR manipulation. Big burns themselves appear to have cardio-depressant effects.

If **Myoglobinuria** is seen it is appropriate to aim for higher levels of urine output driven by osmotic diuresis with Mannitol. Up to 12.5 grams of Mannitol can be given per litre of resuscitation fluid (ATLS). This can give a sense of false security as urine output may be maintained while the patient remains dry overall. The overall fluid balance requires more careful monitoring under these circumstances.

Maintenance fluids appropriate to the age and weight of the patient are also required. In small children the use of Dextrose 4%/Saline 0.18% solutions will exaggerate the hyponatraemia due to use of Hartmanns solution (Na 131 mmol/litre) particularly if hypovolaemia is present. This will increase the likelihood of seizures. Significant hyponatraemia can also be part of a Toxic Shock presentation. In any significant burn injury the use of the enteral route for administration of maintenance fluid as feed will reduce the tendency to low Sodium and will minimise the loss of muscle to the catabolic response over the full duration of the injury.

The continuation of the Parkland formula involves a further 24 hours of fluid resuscitation again based upon Hartmanns solution with 2ml/%TBSA/kg plus 0.5ml/%TBSA/kg of colloid-originally Albumin. Since the Cochrane review of the evidence base of Albumin use, this component has been dropped by many centres and starches have been substituted. Similarly the Muir and Barclay formulas of Albumin based resuscitation have largely been dropped. FFP is still widely used by Paediatric Anaesthetists for fluid resuscitation and treatment of sepsis in burned babies and infants.

Involvement of Anaesthetists

Early surgical assessment is required for:

1) Accurate reassessment of %TBSA,
2) Burn wound cleansing and coverage,
3) Early debridement of full thickness injury (when indicated)

Repeated anaesthetic input may be required for debridement and dressings until stable wound coverage and healing is obtained

Long term input is required into the care of the survivors of the biggest burns, both in their initial care and during subsequent reconstruction/revision

Anaesthesia and Intensive Care

Initial care requires attention to detail in terms of pre-operative assessment of the patient. Both the history and events following the injury and the patients' personal history are important. The priorities are to maintain safety for the individual undergoing treatment, while maintaining an eye to the future, protecting vascular access and making appropriate airway care decisions.

The interaction of anaesthetic agents with the patient's physiology changes over time. At initial presentation the anaesthetist may be faced with a patient who is undergoing resuscitation but remains hypovolaemic; their airway may be compromised by the oedema of both burn and crystalloid resuscitation (or is becoming so); their vascular access may be compromised by the

burn itself and there may be significant problems with the acute pain of the injury, including an acute neuropathic element. Significant also, from the psychological point of view, is the possibility that the injury may be self-inflicted.

As the injury matures, airway difficulties may be worsened by scarring and contracture. This can render conventional laryngoscopy impossible. Gas inductions and the use of spontaneous breathing techniques may allow placement of laryngeal masks or fibre optic aided intubation to be perfomed. Blind intubation techniques have a place for those skilled in their use. Awake intubation may also need to be performed.

If there is both an obvious difficult route to the larynx and laryngeal compromise, expert judgement is needed to decide between gas induction or direct surgical access to the airway under local anaesthesia.

The use of Suxamethonium is known to be potentially dangerous due to exaggerated hyperkalaemia. This can develop as cholinergic sensitive ion channnels migrate and increase in muscle beyond the motor end plate. Similar considerations apply to any ITU patient who is denervated, immobilised, or has had repeated sepsis. Suxamethonium can be used for rapid sequence induction early on provided it is thought essential. The same proliferation of binding sites, with changes in metabolism, increase the requirement for non-depolarising agents, of all classes, for a given duration of effect for many months after injury.

Outcomes

Advances in surgical techniques and dressings have meant that bigger burns can have an improved functional and cosmetic outcome – provided they survive. The management is aimed at excising dead tissue to minimise the inflammatory response. Areas that can recover are preserved and covered with dressings, including treated cadaver skin as a biological dressing. The priority is to gain coverage and avoid infection. That said, infection is universal as colonisation and is often tolerated without treatment provided that systemic sequelae are not occurring. Surveillance of the colonising flora gives a clue as to the appropriate treatment t should deterioration occur.

Grafting is taken from donor sites in unburned areas including the scalp. Donor sites can be revisited once they have healed well. The bigger the burned area the less donor site is available and the slower the native skin cover returns, despite meshing techniques etc.

Artificial dermal grafts and epidermal cell cultures offer the hope of reconstituting skin cover without scarring. However, all cell cultures and non immunologically active grafts dissolve in the presence of uncontrolled infection.

	Hours	**Days**	**Weeks**
Analgesics	Opiates IV as required. For example Morphine 30micrograms /kg repeated as necessary.	PCA +/_ Background Infusion Paracetamol, NSAIDs if stable and fed. Consider Co-Analgesics for neuropathic components and to reduce opiate impact on feeding.	Oral Opiates if required. Consider MST, Methadone, Oxycodone Paracetamol and NSAIDs as tolerated
Induction Agents	IV/ Inhalational as appropriate. Ketamine 1-2mg/kg sole agent. Propofol	Older agents less suitable for repeat administration. Newest agents give very rapid awakening. Desirable?	Patients become adept at their own chosen method of anaesthesia. Ask them where the veins are!
Maintenance	Inhalational /TIVA	Propofol contraindicated for ITU sedation under 16 yrs of age.	
Relaxants	Depolarizing agents OK if airway not currently compromised (RSI) Consider gas induction and no relaxant / awake intubation.	Depolarizers becoming dangerous for bigger burns >10% Non Depolarizers less effective and shorter acting.	Depolarizers usable once pt mobile and re-innervated Non Depolarizers return to normal patterns.
Co analgesics	Ketamine may help to avoid pain ‘wind up’. 0.1-0.15mg/kg/Hr may help reduce opiate requirement.	Consider Gabapentin and /or tricyclics/SSRI for neuropathic components	Itch may be a prolonged problem. Due to nerve regrowth and Starches.
Starvation	Not starved	Do not starve intubated patients. Feed overnight with daytime rest. Feed during operations.	Early well established nutrition improves outcome and speeds rehabilitation.

What is achievable?

Number of Risk Factors	Guide mortality
0	1/300
1	1/30
2	1/3
3	19/20

The biggest area burns require the greatest effort and input. They also have the longest period, while they are healing, during which they may deteriorate and die after their injury. Late death occurs most frequently due to sepsis.There is no fixed point where the size of a burn dictates that recovery is not possible.

The traditional relationship:

%TBSA size of burn		Likely %Mortality
+ Age in years	=	is out of date.

Risk factors for Mortality include

1. Size of burned area,
2. Smoke Inhalation and
3. Age >65years (Co morbidity with physiological impairment)

Age >65years is often used as a measure although the younger patient with significant pre-existing physiological impairment will score this point and the Marathon winning 75 year old would not!

Results like these are only obtainable in the best centres worldwide. Most British institutions are working towards them as a goal rather than achieving them at present.

Decision making to treat or not to treat needs case-by-case consideration of the individuals' circumstances from their own point of view, that of their physiology, their injury(ies), and their potential for eventual rehabilitation.

References

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