

# Management of burns in the military

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*In recent wars, as many as 30% of all casualties had burns with or without associated injuries. The timely triage, diagnosis, and management of these burns is central to the survival and long term physical welfare of these patients.*

INCREASED MECHANISATION in modern warfare has led to the extensive use of various fuels. The ignition of these fuels has been largely responsible for the thermal burns seen in military casualties. Any use of thermonuclear weapons would make burns an even more frequent form of wounding. Flame or flash burns may be caused by various agents contained in explosives. Casualties with chemical burns, including those from phosphorus, require immediate wound care to prevent continuing damage to tissue by the active chemical.

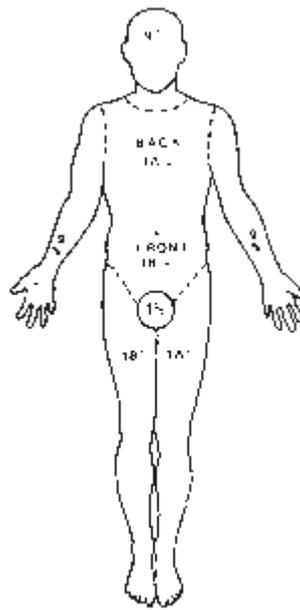
In treating burns, it is essential that the Australian Defence Force Medical Officer follows the logical sequence of triage, timely diagnosis, accurate assessment of surgical priorities, appropriate early treatment and evacuation.

## Triage

The following triage criteria apply:

1. Casualties with burns up to 10% of total body surface area (BSA) are classified as having minor injury, for which hospital care can be delayed and minimal treatment is required in the first instance.
2. Casualties with burns between 10%–60% BSA are classified as having major injury requiring early hospital care and intensive treatment.
3. Casualties with burns over 60% BSA are classified as having severe injury with unlikely salvage and should, except in ideal circumstances, be treated expectantly,

### I “Rule of nines” for estimating area of burns:



Percentage of total body surface area represented by each body part.

Source: Manual of Land Warfare, Part 2. Medical and Dental Training. Volume 3, Pamphlet 2. Australian Defence Force, 1985.<sup>1</sup>

tantly, without expenditure of significant medical resources.

These criteria are modified by factors such as co-existing inhalation injury (common when burns are sustained in armoured vehicles or other confined spaces) or significant associated mechanical trauma. Burns of the hands, feet, face and perineum, as well as circumferential full thickness burns (which threaten peripheral circulation), are considered an absolute priority in treatment.

Comprehensive triage should include taking a history outlining the time of burning, details of the associated event, nature of the burning agent, details of whether the burn occurred in an enclosed space and the nature of first aid treatment given. Thorough examination should include the assessment of associated injuries, particularly those of the abdomen and chest. Respiratory tract injury should always be suspected, especially in burns involving the head and neck. The necessity for intubation should be considered, especially in respiratory burns. The patient's weight in kilograms should be ascertained by questioning or by estimation and the extent and depth of the burn must be recorded.

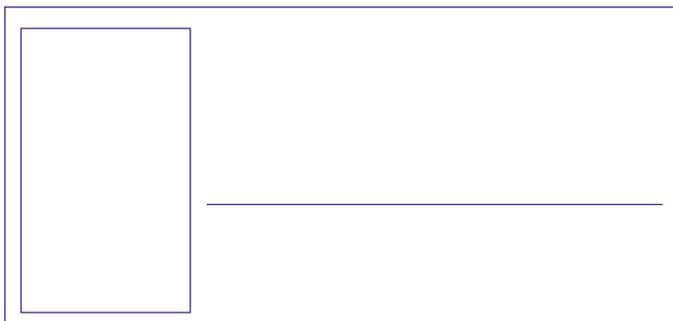
## Diagnosis

The severity of thermal burns depends on the depth and area of the burn. Area and depth are the two most important factors in determining probable morbidity and mortality, initial treatment, metabolic consequences, character of healing and ultimate functional and cosmetic result.

The burnt area is estimated as a percentage of the BSA. A cross-check should be done by estimating the area not burned. Estimating the percentage of body burnt is assisted by using the “rule of nines” (Box 1). The total area burnt and the area of full thickness burns are estimated.

Two depths of burn can be present:

- Superficial or partial thickness, where the epidermis is injured and the dermis is intact;
- Full thickness, where both epidermis and dermis are injured.



The depth of a burn is often overestimated in areas where the skin is thick (ie, scalp, palm, sole, buttock and back), and underestimated where the skin is thin (dorsum of the hands and feet, the anterior surface of the wrist, and around the eyes). The depth of the burn can only be determined with certainty by histological examination, but the clinical criteria in Box 2 permit an initial and reasonably accurate assessment.

Respiratory burns are common in war and can be expected in patients burned in confined spaces (eg, armoured vehicles and bunkers) and in patients who have burns to the head and neck, especially intraoral areas. The mucosa of the mouth should be inspected carefully for oedema, erythema, blisters and carbonaceous material.

The patient should be carefully observed for the presence of stridor.

### First aid treatment

Treating other life-threatening injuries always takes precedence over treatment of burns, except for chemical burns. Chemical agents should be washed immediately from the skin surface by copious water lavage.

The first consideration should always be to separate the victim from the source of injury. Burning clothing should be extinguished but not removed from the casualty unless it is constricting the tissues. Watches, rings, belts, boots and any other item likely to constrict tissue should be removed or loosened. Where practical, the burnt area is initially immersed in or liberally doused with cold water before being covered. Whenever possible, Melolin dressings or sterile polyurethane foam should be used to cover the burn, but, if these are not available, makeshift wrappings such as sheets can be used.

If there is any evidence of respiratory obstruction (ie, stridor or difficulty breathing), or if there is evidence of burn injury to the mucous membranes of the mouth or pharynx, the casualty should be intubated before evacuation. The development of upper respiratory tract oedema may render subsequent intubation difficult or impossible. Nasotracheal intubation, secured by a transfixing nasal septal suture, should be performed in preference to oro-tracheal intubation.

Casualties suffering from major burn wounds should be evacuated without delay to a treatment centre where immediate fluid replacement can be provided. The more extensive the burn, the greater the degree of urgency.

### Initial treatment of extensive burns

The burn patient should be managed, in the first instance, in a Level 2 or 3 medical facility. Initial consideration of the burn patient includes removal of clothing and a complete physical examination. The following treatment should be provided.

#### Analgesia

Pain is seldom a major problem in the patient with full thickness burns, but extensive partial thickness burns are often

extremely painful and require an adequate dose of parenteral pethidine or morphine based upon the patient's weight. Anxiety and restlessness may require mild sedation using intravenous midazolam or oral temazepam.

#### Antibiotics

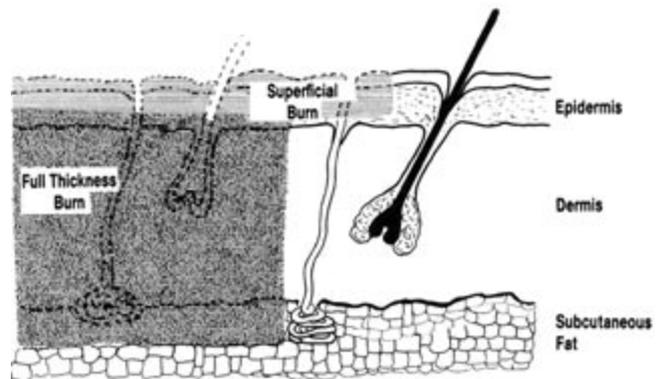
Antibiotic therapy must start at a Level 1 or 2 facility and should be continued until definitive treatment is reached at a specialist burns unit. The use of a broad spectrum antibiotic, such as cephalothin sodium, which covers skin commensal organisms, is the antibiotic of choice. This should be given either intravenously or orally in divided doses of 250mg every 6 hours. Tetanus prophylaxis should conform to accepted military practice and is essential in the management of burns, as in any other wound management.

#### Fluid resuscitation

Water, electrolytes and plasma are lost from the burnt surface and into the surrounding tissues. Fluid replacement must start as soon as possible to prevent hypovolaemic shock. Once a secure intravenous pathway has been established, resuscitation fluid requirements can be estimated. Delays of more than an hour should be avoided in burns of greater than 20% BSA. Until haemodynamic balance is regained, only local first aid should be performed. It is important to keep the patient warm.

To understand the fluid shifts that occur after a burn, it is necessary to go back to the basic mechanism of transfer of fluid from the vascular compartment to the interstitial space.

## 2 Burn depth



Source: Manual of Land Warfare, Part 2. Medical and Dental Training. Volume 3, Pamphlet 2. Australian Defence Force, 1985.<sup>1</sup>

### Burn characteristics

Superficial or partial thickness	Full thickness
Erythema	White and opaque or brown and charred
Blisters	No blisters
Moist	Dry
Soft	Thick, loss of elasticity
Painful to touch and pinprick	Little pain with touch or pinprick
Blanches on pressure	No capillary response to pressure

The balance of forces which regulates fluid transfer across the capillary wall is expressed in Starling's law of tissue equilibrium. The changes in fluid dynamics seen in burns result from the inflammatory response to the thermal injury. Inflammation is a reaction in damaged but viable tissue and consists of both a cellular and a fluid response.

The first inflammatory response is the release of mediators such as histamine, serotonin, thromboxane, prostaglandins and kinins. These cause capillaries to dilate and their walls to become more permeable to large molecules, such as albumin, with a consequent loss of fluid from the circulation. The cellular part of the inflammatory reaction starts with the adherence of neutrophils to the endothelium of the capillary and migration through the capillary wall. These are quickly followed by monocytes, which are important in controlling bacterial invasion, as well as contributing to the release of mediators and cytokines.

Loss of fluid from the circulation invokes a response throughout the whole body, integrated by the autonomic system and including release of catecholamines. The heart rate increases and there is selective vasoconstriction to conserve blood volume.

Even before hypovolaemia has caused a generalised response (including vasoconstriction), a massive burn wound has an immediate and ill-understood effect on the circulation. It causes reduction in cardiac output and an increase in the peripheral resistance.<sup>2</sup> It is only after some hours that loss of fluid from the plasma causes hypovolaemia, an increase in the concentration of red cells (haematocrit) in the blood and accumulation of oedema. Loss of fluid from the circulation is maximal in the first eight hours after the injury and the capillary membrane tends to stabilise after 48 hours.

These theoretical considerations are the basis of correct fluid management in burns.

Since loss of fluid starts immediately after the burn injury, fluid replacement should start as rapidly as possible. Large volumes of fluid will be needed, the exact amount depending on the extent of the burn and the patient's body weight. Because the fluid loss involves plasma with all its electrolytes, the fluid used for replacement must contain about the same quantities of electrolytes as plasma. Much debate is centred on whether the fluid should be a pure electrolyte solution or should contain colloid,<sup>3,4</sup> but, for practical purposes, particularly early on, the debate is academic. For practical reasons of availability, shelf life and cost, electrolyte solutions are preferred and the balanced composition of Hartmann's solution (ie, lactated Ringer's solution) makes it the best.

### 3 Burn injury



This patient received flame burns in an enclosed space. He is shown six hours after injury. Injuries included respiratory burns with moderate oedema, but he did not require intubation.

**To calculate fluid requirements:** Use the formula of 3 mL of Hartmann's solution  $\times$  kg of body weight  $\times$  percentage of BSA burnt. Half of the volume should be delivered in the first 8 hours after the burn and the second half in the next 16 hours.<sup>5</sup>

The patient's vital signs should be monitored to assess the response to fluid resuscitation. However, the single most useful guide to fluid needs is the urinary output. The acceptable limits of this output are defined as 0.5–2.0 mL/kg/hour. In a patient of average weight, this translates to a urinary output of about 50 mL per hour. Output should be averaged over 2–4 hours. If urinary output is unexpectedly low, exclude mechanical problems, such as blockage or displacement of a catheter, before changing the fluid regimen. In a patient with burns greater than 30% BSA, a central venous manometer is essential. Blood gas determinations, serum elec-

trolyte levels and haematocrit estimations are essential in the management of severe burns.

The volume of fluid replacement therapy for days 2–4 depends on the response to treatment, but is roughly half of that required on the first day.

After 4–5 days, fluid therapy will be regulated to allow a gradual return to normal. Blood is generally not required in the early post-burn period unless there are associated injuries. However, it may be needed as a prelude to, or during, excisional surgery.

## Specific treatment

### Respiratory burns

Respiratory burns are difficult to predict, although they are more common in confined spaces and when smoke has been inhaled. Only occasionally is there a thermal burn of the respiratory tract. Progressive pulmonary failure appears to result from the inhalation of toxic products in smoke and may occur without any skin burn at all.

Carbon monoxide poisoning is a potent cause of respiratory depression in respiratory burns and, if present or suspected, high concentrations of oxygen should be given early (hyperbaric therapy with oxygen is not usually required).

All patients with significant burns (ie, >40% BSA) should have regular chest x-rays and early blood gas and carbon monoxide level estimations to check for the onset of pulmonary insufficiency.

If pulmonary insufficiency develops and the use of humidified oxygen alone cannot maintain normal blood oxygenation, sophisticated respiratory support, including nasotracheal intubation and assisted respiration, may be necessary.

The use of corticosteroids is controversial. If there is an indi-

cation for their use, they must be given very early in the course of respiratory failure.<sup>6</sup>

### **Escharotomy (fasciotomy)**

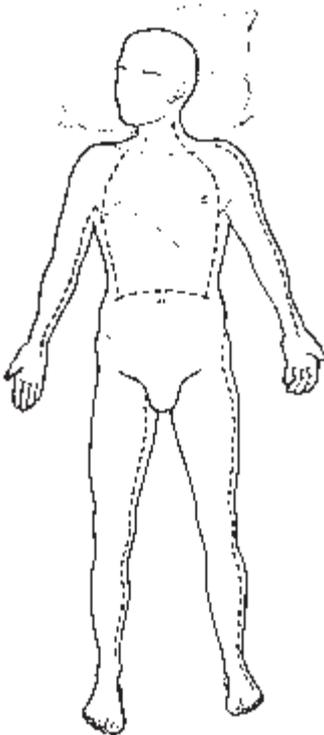
Circumferential full thickness burns of the limbs may result in impaired circulation to distal parts because of constriction caused by oedema beneath the inelastic eschar produced by the burn. In such cases an escharotomy is needed to prevent secondary ischaemic necrosis of these tissues. Similarly, escharotomy in a circumferential full thickness burn of the chest prevents respiratory restriction.

Swelling and coldness of distal, unburned parts are not absolute indications for escharotomy, but cyanosis, impaired capillary filling and progressive signs of neurological damage are.

If there is evidence of vascular impairment, escharotomy is carried out in the mid-lateral line of the involved extremity and, if distal blood supply is not improved, a second escharotomy incision is made in the mid-medial line in the longitudinal axis of the limb.

The procedure can be carried out without anaesthesia, as it is performed through insensitive, full thickness burned tissue. The escharotomy incision should be extended throughout the entire length of full thickness burns to ensure adequate release of vascular compression. The incision should be deep enough to incise fascia as well. A sufficiently

### **4 Recommended lines of incision for escharotomies**



Source: Manual of Land Warfare, Part 2. Medical and Dental Training. Volume 3, Pamphlet 2. Australian Defence Force, 1985.<sup>1</sup>

deep incision is indicated by the bulging of underlying tissue. Blood loss is usually minimal. Occasionally, incision of the deep fascia is required for decompression.

Escharotomy is of particular importance in relation to the forearm and hand, as necrosis of small muscles of the hand can occur rapidly. Escharotomy of fingers may be necessary.

Patients with circumferential truncal burns may require escharotomies in the anterior axillary line to relieve restriction of chest wall movement and permit more satisfactory ventilation. These patients will frequently be restless, agitated and hypoxic before escharotomy and show prompt clinical improvement as well as improved ventilatory exchange and blood oxygenation after escharotomy. An incision along the lower margin of the ribcage may be necessary in patients with deep burns extending onto the upper abdominal wall.

### **Management of the burn wound**

No treatment of burn injuries should be undertaken until the patient regains haemodynamic stability. General anaesthesia is not required for burn wound “clean up”, provided it is done gently and with adequate analgesia. Body hair should be shaved from the areas of injury and well back from the margins. Non-viable epidermal remnants are excised. Bullae are not necessarily excised, particularly when

they are on hands. Ingrained dirt or charring should be quickly washed off with a surgical solution such as Chlorhexidine. This procedure should be performed in a warmed room (25–30°C). During the period of active wound exudation, bulky absorbent dressings should be placed beneath the burned parts to absorb the serous exudate. These dressings should be changed as necessary.

Fractures associated with burns are best treated by skeletal traction. This permits the burns to be treated by exposure and topical antibiotics.

All burnt areas are kept covered with a topical antimicrobial agent. Silver sulphadiazine (SSD) should be applied liberally to the burn. The cream should be applied in a layer 3 mm thick to the whole burn with a sterile gloved hand and then the limb or part wrapped in a sterile Melolin dressing.

Twelve hours later, the coat of cream should be renewed on those areas where it has been removed by bed-clothes. Daily wound toilet should be carried out by gently cleansing the cream from the wound to the point of bleeding or pain, without employing anaesthesia. Any area of burn that is not dressed should be re-creamed as necessary. Facial

### **5 Escharotomy of the hand**



Without escharotomy, the hand muscles of this severely burned patient would have been at risk of ischaemic necrosis. The first image shows the patient's hands two hours after burning; escharotomy was performed as soon as possible.

burns are best covered with a thin layer of Neosporin antibiotic ointment.

### Evacuation

The following principles of evacuation for major burn casualties should be followed:

- IV therapy should commence within 60 minutes of sustaining the injury;
- As per normal procedure, all casualties should be evacuated on a stretcher by air;
- All initial assessment and wound management should be carried out in a Level 3 facility until haemodynamic stability has been achieved (usually 24–48 hours);
- Every effort should be made to evacuate the casualty to a specialised burns unit capable of undertaking comprehensive and definitive care (Level 5) within 72 hours.

In practice, particularly during military operations, it may not be possible to achieve this ideal.

## Treatment of specific burn injuries

### Chemical burns

The depth and severity of chemical burns are related to both the concentration of the agent and the duration of the contact with the tissues. The depth of chemical burns is often underestimated, as chemicals continue to penetrate tissues even after the burn victim is removed from the scene of injury.

The commonest causes of chemical burns are acids and alkalis. First aid measures in both cases involve immediate, constant irrigation with water for up to 10 minutes. Particular attention should be given to the eyes, as they are most vulnerable (acid and caustic soda burns of the eyes are common). Following irrigation and neutralisation of the acid or alkali, the treatment is the same as for any other burn.

### Phosphorus burns

Phosphorus is used in antipersonnel weapons, smoke screens, incendiary bombs and tracer bullets. White or yellow phosphorus is translucent, waxy and soft. It is insoluble in water but soluble in oil or fat solvents. When united with oxygen, it forms phosphorus pentoxide, which emits a green or bluish light. Phosphorus burns tissues with which it comes into contact, and phosphorus pentoxide is hygroscopic, thereby dehydrating tissues. When combined with water, phosphorus pentoxide produces phosphoric and phosphorous acid, which cause chemical burns. First aid treatment involves copious cold-water lavage and removal of phosphorus particles, after which the involved area is covered with saline-soaked dressings and kept moist until the patient reaches a definitive treatment centre.

At a Level 2 or 3 medical facility the burnt area is treated by rinsing with water or a suspension of Antiphos solution (5% sodium carbonate, 1% hydroxy ethyl cellulose, 3% copper sulphate, 1% sodium lauryl sulphate). This completely

## 6 Burns management training

All ADF Medical Officers who may be deployed into areas of military conflict should have successfully completed the course on Early Management of Severe Burns run by the Australian and New Zealand Burns Association.

Details of these courses can be obtained by contacting Kerry Williams (07) 3872 2224.

neutralises the ignition of phosphorus. The injury is then washed with water or saline. Some weapons use phosphorus and rubber mixtures, which are not soluble in water. In this instance, after rinsing with Antiphos, the injury is swabbed with ether.

Surgical removal of phosphorus particles may be necessary. If so, the procedure is performed with constant saline irrigation of the operative field, and the operating theatre is darkened to facilitate the location of phosphorus particles in the wound.

Systemic toxicity results from the effects of phosphorus absorbed through the burn wound. The patient should be monitored for electrocardiographic changes, including ventricular arrhythmias, as well as biochemical changes, such as a shift in the calcium–phosphorus ratio and abnormalities of liver enzymes.

### Electrical burns

The extent and severity of electrical burns are often underestimated. Limited areas of cutaneous necrosis may only be evident at points of entry, exit or arcing, but there may be extensive subcutaneous deep tissue involvement. Fasciotomy may be required to ensure viability of distal unburned parts. The presence of brawny, deep induration in a limb involved in electrical injury, with signs of vascular impairment, indicates the need for fasciotomy.

If extensive muscle necrosis has occurred, it is advisable to use a diuretic.

About a third of all patients with significant electrical injury of the extremities will require amputation of nonviable parts or extensive debridement and plastic surgical repair using local pedicled flaps or distant free-tissue transfer.

## References

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