Guide to: Emergency burn care in the pre-hospital setting

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Throughout the UK, hospital emergency departments (EDs) treat approximately 175 000 burn injuries a year (Caroline, 2014). Serious burn injuries (requiring >72 hours in-hospital stay) account for 5–6% of serious trauma—fortunately, burn injuries of <10% total body surface area (TBSA) make up a greater percentage of the total.

The human body is covered in skin (integumentary system): it is the largest organ of the human body, providing protection from the environment, infection, disease, radiation, physical attack and unnecessary heat and fluid loss. It also provides protection to the primary systems of the human body, i.e. cardiovascular, respiratory, skeletal, nervous, muscular, etc.

The domestic setting is the most common for burn injury, especially for children, the elderly, and people with a disability. The depth of a burn is proportional to the amount of heat applied and the duration of exposure. Scald burns are caused by accidental exposure to hot liquids (<100°C thin liquid (Figure 1); >100°C thick liquid), and general burns by flame and contact with hot objects like hair tongs, hot ovens, fire grates, etc.

It does not take much to inflict serious heat damage to human skin. A hot liquid temperature of 70°C will inflict a full thickness burn injury in seconds. For example, domestic tea or coffee is poured between 80 and 100°C (classed as a thin liquid); even after the introduction of milk, there is enough excess heat present to do considerable damage to the skin. Moving up the scale to thicker liquids like chip pan oil, porridge, soup, etc, which are prepared well in excess of 100°C (classed as thick liquids), these will do much more harm over a shorter period of time, causing greater damage by depth and area than a thin liquid. Scalds with boiling water are frequently of short duration as the water flows off the skin rapidly. Those resulting from hot fat, and other thick liquids that remain on the skin, may cause significantly deeper and more serious burns (Joint Royal Colleges Ambulance Liaison Committee (JRCALC), 2016: Section 4).

Burns in the industrial setting span a complete spectrum of cause:

- Thermal
- Chemical
- Mechanical
- Electrical
- Radiation

Burn injuries can be life-changing events and must be responded to with effective and efficient management to help prevent permanent damage, and potentially life-threatening injuries. Burn-injured patients may also have suffered non-burn injuries before, during or after the burn has occurred, i.e. falling from a height, victim of an explosion or road traffic collision, etc (JRCALC, 2016).

This Guide provides an overview of emergency pre-hospital burn care. However, specific in-depth severe burns life support education is recommended to fully appreciate these complex injuries to the human body. Rapid assessment and treatment can be life-saving for burn-injured patients.

Burn categories

The basic stages of burn damage are to the two primary layers of the skin—the epidermis and dermis. Outcome will be dependent upon the patient's age and medical circumstance. The stages are:

- **Superficial (first-degree):** Dry and red; blanches with pressure; no blisters. May be painful, healing usually within 7 days, without concern for scarring
- **Superficial partial thickness (second-degree):** May be difficult to define in the pre-hospital setting. Can present as pale to dark pink, with small to large blisters; blanching with pressure or possible delayed capillary refill; will be painful; healing can be up to 21 days; and

depending on initial damage, there may be some risk for hypertrophic scarring

- Deep partial thickness (second-degree): Presenting as blotchy red; possible blistering with no capillary refill or sensation; possibly requiring grafting; and high risk of hypertrophic scarring
- Full thickness (third-degree): Presenting as white, waxy or charred without sensation, blisters or capillary refill; grafting required; and scarring inevitable

Historically, burn injuries have been described by three pathological zones, which radiate from a central zone of greatest damage (Jackson, 1953). Skin nearest the heat source suffers the most damage, with little or no blood flow to the injured tissue and is referred to as the zone of coagulation. The peripheral area around this zone is called the zone of stasis with decreased blood flow and inflammation. This area may undergo necrosis within 24 to 48 hours post injury; the aim is to maintain the viability of the zone of stasis if possible before it is compromised by burn shock. The outer area that is least affected is the zone of hyperaemia, where cell recovery is usually within 10 days.

Practical management

Patients with burn injuries are classified as trauma patients, and management will at all times follow local trauma guidelines (e.g. JRCALC, 2016). Adherence to trauma guidelines is essential and should not be influenced by the visual severity of burn damage, as there are changes in virtually every organ system in the body after a serious burn injury.

When the burn is less than 20% TBSA, these effects may not be of great practical significance. The cause of these changes is the release of inflammatory mediators and neural stimulation. The result is that there are major changes in the control of body functions and direct reactions in some organs to circulating mediators (Australian and New Zealand Burn Association (ANZBA), 2006). Seriously burned patients, especially the young, elderly and those with disabilities, may quickly become systemically unstable; a rapid response to a centre of higher clinical intervention should be considered with these patients.

Burn injury assessment/treatment

This section provides an overview of deciding factors for the onward management of the patient with burn injuries.

Paramedics must wear personal protective equipment for safety at all times, especially in cases of chemical and electrical events, and/or while stopping the burning process.

With catastrophic haemorrhage (<C>) and ABCDE-F concerns cleared, ongoing re-evaluation is required for patients with burn injuries. If fluids are required, see local guidelines for adult and child fluid formula (i.e. JRCALC (2016) in the UK):

- Adult: 0.9% sodium chloride; TBSA >15–<25% and time to hospital >30 minutes; or TBSA >25%, initial dose 1 litre (max 1 litre)

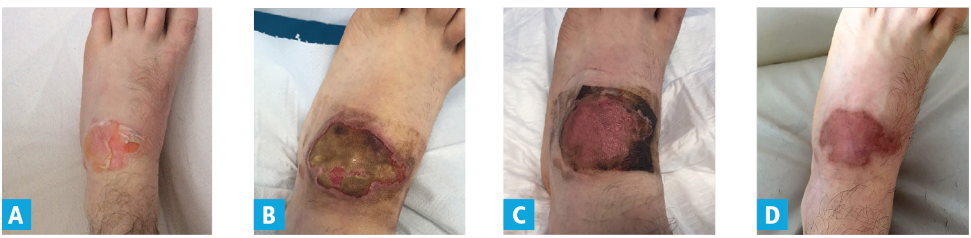

Figure 1. Domestic scald burn with boiling water. A. Day 1; B. Day 10; C. Day 24; D. 18 months

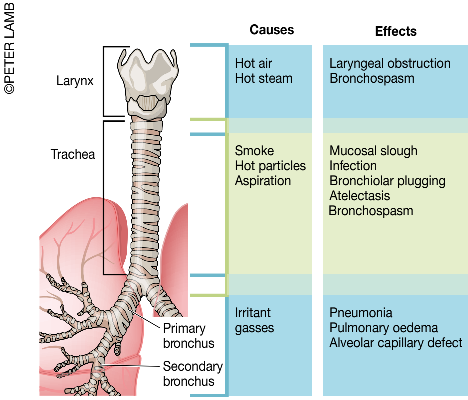

Figure 2. Absorption of the product of combustion may lead to serious toxicity

- Children: 0.9% sodium chloride: TBSA 10–20% and time to ED > 30 minutes; or TBSA >20% (variable 35–350 ml; age chart in JRCALC (2016: 353) initial dose=max).

Note: Cold fluid replacement may assist the onset of mild hypothermia. It is important to try and establish the mechanism of burn injury, and record the actual time of damage from the heat source. The patient's medical condition may be an influencing factor towards the cause of the burn, as a medical event may have occurred during or after the burn injury.

Inhalation injury

All cases of burn injury should be examined with a view to excluding the diagnosis of inhalation injury. The clinical signs and symptoms may evolve over a period of time; as with all trauma, the patient must be repeatedly re-evaluated, as this is a potentially fatal injury. A history of burns in an enclosed space such as a house, motor vehicle, aeroplane, etc, or burns with an associated explosion resulting from a gas or petrol fire, or bombs, should alert the responding paramedic to the likelihood of an associated inhalation injury (ANZBA, 2018). A burn patient presenting with confusion or an altered level of consciousness is deemed to have carbon monoxide (CO) poisoning until proven otherwise. Inhalation injury consists of three parts (Greaves et al, 2009):

- True airway burns, resulting in thermal injury to the supraglottic airway
- Lung injury, inhaled particulate resulting in chemical injury to the lower airways leading to pulmonary failure
- Systemic toxicity, absorption of products of combustion (e.g. CO, hydrogen cyanide (HCN)) through the alveoli into the systemic programme.

CO, HCN and particulate will be present on scene. Presence of facial burns, soot in the nares or oral cavity, and sputum, are indicators of smoke inhalation. Intubation may be required; breathing rate and depth should continue to be re-evaluated. Heat that caused the burn may also have entered and damaged the airway (above/below the larynx); the paramedic should therefore be prepared to assist ventilations. Respiratory complications can develop rapidly, particularly in infants and children. Absorption of the product of combustion may lead to serious local or systemic toxicity (Figure 2). Smoke inhalation is a killer; 80–90% of fire-related fatalities are attributed to smoke inhalation (Pilbery and Lethbridge, 2016).

One-hundred per cent supplemental oxygen should be provided via a non-rebreather mask. Pulse oximeter readings may prove false with inhalation injury (Gregory and Murcell, 2010) (some services may carry oximeters to measure carboxyhaemoglobin). Note: Administration of cold oxygen may assist the onset of mild hypothermia. The half-life of carboxyhaemoglobin is about 250 minutes for a patient breathing room air—this is reduced to about 40 minutes when breathing 100% oxygen, and the highest possible concentration of oxygen should be administered (Greaves et al, 2009). However, supplemental oxygen must never be brought to a smouldering patient, as this may result in an explosion. The patient may also be a victim of polytrauma with injuries other than their burns.

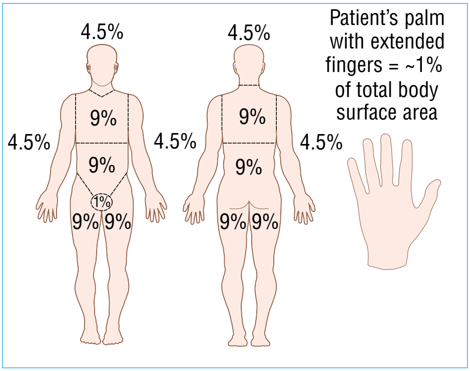

Figure 3. Wallace rule of nine's to estimate TBSA affected by burn and palmar surface

Burn shock is usually a delayed event (6–8 hours); when shock is present, look for other causes or injuries. Note: if pain management is required, analgesics may assist the onset of mild hypothermia.

Severity of burn injury

The percentage of TBSA (excluding simple erythema) and FHFFP [Face, Hands, Feet, Flexion points, Perineum] should be established. All circumferential burns must be pre-notified, especially chest burns. Burned skin contracts as it dries out; it begins to tighten over the now swelling underlying tissue owing to oedema being generated by the widespread release of inflammatory mediators, causing the restriction of adequate perfusion to the distal regions. A greater problem occurs with burns to the chest (axilla to axilla); but in this case, the lungs become compromised as they cannot take in a full tidal volume to adequately feed the systemic programme with oxygenated blood. This pressure is relieved by a surgeon performing an escharotomy to release this restrictive tension on the skin surface.

There are two burn injury markers to help identify the level of clinical response required, i.e. fluids, etc:

- Adult burns <20% TBSA, Child burns <10% TBSA (excluding simple erythema)
- Adult burns >20% TBSA, Child burns >10% TBSA (excluding simple erythema).

It must be noted that large burn areas may compromise the thermoregulatory programme, potentially leading to hypothermia. Patients' age and time of burn injury are very important for onward advanced management.

Estimating TBSA in the pre-hospital setting

The Wallace rule of nine's (Figure 3) allows the extent of the burn to be estimated with reproducible accuracy (ANZBA, 2006). It is the easiest pre-hospital programme for a relatively accurate estimate of adult TBSA, burned or not burned (some guidelines advocate serial halving). However, these estimates may be inaccurate in small children—therefore, separate local guideline calculations for children should be referenced.

The palmer measure (Figure 3) refers to the palmer surface area of the patient's extended hand (~1% TBSA) (ANZBA, 2006; New Zealand Guidelines Group (NZGG), 2007). It can be used as a supportive mechanism to estimate irregular TBSA (<15%, or large burns >85%); however, it may prove unreliable with patients who are obese or who have large breasts. The receiving ED should be pre-notified if either of these situations is the case.

Simple erythema should not be included in TBSA calculations, especially for fluid resuscitation (JRCALC, 2016). A burn injury results in a large amount of fluid loss into the area of injury; when the TBSA exceeds 20–30%, the process is generalised. The rate of fluid replacement must take into account the time of burn injury—not the time the paramedics arrive; there may therefore be a period of catch up (ANZBA, 2006). Fluid resuscitation in the pre-hospital setting is not an exact science and accurate records need to be kept for the receiving ED to help limit the possibility of over- or under-resuscitation of the patient.

Keeping the patient warm

A burns patient must be kept warm; these steps can be followed to achieve this:

- Heat the back of the ambulance
- Use warm blankets
- Administer humidified oxygen (if available)
- Resuscitation fluids should be warmed prior to infusion
- Cool only the burn injury, if possible, keeping it small and shallow

History

A complete scene, patient and pre-arrival cooling history are essential for the receiving ED. Responders are the eyes and ears of the ED staff at the scene. All histories should therefore be accurately recorded. Any history of anti-tetanus, epilepsy and diabetes are very important. Burn injuries may bring on tetanus, and the ED needs to guard against possible onset. Patients with diabetes suffer poor circulation and poor sensation; this causes concern for effective perfusion and extensive tissue damage as a result of an ineffective sensory programme at the time of incident.

Higher clinical intervention facility

The guidelines (Adult) for transfer/admission to a burns unit in the UK are as follows (ANZBA, 2006): Burns >10% TBSA; burns to face and head, hands, feet, genitalia, perineum and major joints; full-thickness burns >5% TBSA; electrical and chemical burns; burns with an associated inhalation injury; circumferential burns to the limbs or chest; burns at the extremes of age (children/the elderly); burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery or effect mortality; any burn-injured patient with associated trauma.

In children, transfer/admission occurs at a lower threshold than it does for adults; a child with >5% TBSA deep burns should be considered for transfer (ANZBA, 2006). Some children may need to be transferred for pain management if techniques such as continuous narcotic infusion are not available locally. The possibility of non-accidental injuries should prompt immediate transfer. Other criteria for adults are also valid for the transfer of children to the burns unit/centre (ANZBA, 2006).

En route to the facility, trauma overview should be maintained, and cooling continued. The facility should be pre-notified of the severity of burn injuries, any other concomitant injuries, and/or influencing medical history. Internal consultation with the burns unit, or the mobilisation of a burn assessment team (BAT) to the hospital ED for stabilisation, may be required prior to transfer.

For burns of the head and neck, the head should be elevated to limit upper airway swelling; if allowed, elevation of burned limbs is also useful during initial treatment and transport. Again, the burn-injured patient must be kept warm at all times. If evident, oedema must be allowed to occur. Restrictive clothing, jewellery, nappies, footwear, etc should be released or removed after ensuring they are not adherent to underlying tissue.

Cool clean running water

Thermal burns should be cooled as soon as possible and cooling the surface of the burn is an extremely effective analgesic (ANZBA, 2006). Cool, clean running water for 20 minutes is the recommended international guideline (ANZBA, 2006).

It is important to identify the heat source before cooling. All thermal events, i.e. flame, hot liquids, hot surfaces, sunburn, can be immediately managed by cooling with cool clean running water over a period of 20 minutes (approximately 65 litres per burn injury). Once the burn injury is fully cooled, cling film may be layered on to the wet burn site in loose strip lengths (never wrap around head, body or limb, to avoid constriction) to cover the wound from irritation, and possible infection. If there is an extensive burn, it may be necessary to reduce the period of application of cool water from the optimal 20 minutes in order to prevent hypothermia. Hypothermia should be prevented at all costs (ANZBA, 2006).

If possible, a sample of the source water used for cooling should be brought along to determine the pathogen content of the water. Salt water (seawater), chlorinated or brackish water should be avoided for burn injury cooling and/or irrigation (Scarfade, 2014).

Normal saline can be used if there is enough of it but the average ambulance carries between 4 and 6 litres, whereas cooling for 20 minutes of running saline (water) requires 35–65 litres per burn injury.

On occasion, emergency responders will encounter remote or austere locations where cool, clean running water is not readily available in sufficient quantity or quality to implement the recommended standard. Some examples include mid-flight in an aircraft; camping out in remote locations; at sea on fishing vessels or pleasure craft; during motorway incidents, multiple burn incidents, or fire scene entrapments; and for ongoing cooling in the back of an ambulance travelling a long distance for an extended period of time.

Gel-based dressings

The availability of a sterile supportive cooling mechanism that does not require water or induce hypothermia can be very useful in these circumstances. Water-Jel HA® hydrogel emergency burn dressings (Water-Jel Technologies LLC. Carlstadt, NJ USA), which are unique to any other pre-hospital emergency burn dressing available to the emergency services, offer an effective and efficient, supportive option in the pre-hospital/in-hospital setting. These heat-absorbing water-based burn dressings and blankets are sterile, and do not require a secondary covering (i.e. cling film), providing cooling comfort and pain relief to the burn patient in any circumstance or location devoid of water (Castner et al, 2000; Singer et al, 2006). The dressings also allow the provider two free hands to administer a more effective trauma response to the patient.

The original gel-based firefighting blanket invented in 1973 by Water-Jel Technologies was designed to be manually applied to a fire or burn victim. For over 40 years, Water-Jel Technologies has continued to invest in advanced laboratory research and development of new blankets and dedicated emergency burn dressings to ensure the best possible outcome for the burn-injured patient in all circumstances where cool, clean running water for 20 minutes is not available.

Water-Jel in the 21st century

As of the past 5 years, Water-Jel HA sterile pain-relieving emergency burn dressings are now saturated in an oil-free, odourless, crystal-clear, and water-based gel with hyaluronic acid (HA). It does not present as oily and opaque to the receiving emergency clinicians in the hospital ED or Burn Unit, allowing for a more effective visual assessment of the burn injury. One of the most biologically relevant properties of HA is its ability to absorb large quantities of water because of its many carbohydrate subunits. This causes it to become somewhat gel-like. Up until recently, the vast majority of hydrogel dressings were tea-tree oil-based. Tea-tree oil-based gel is opaque, and does not allow for effective visualisation of burn damage, usually prompting its immediate removal even before complete cooling has occurred. It is also oil-based, and inclined to leave an oily residue on the burn wound surface, making the wash-down/debridement procedure more difficult, especially for children and the elderly.

Because of their convective cooling action, Water-Jel HA emergency burn dressings do not support or induce hypothermia (Singer et al, 2006). They are 97% water-based and 100% water-soluble for wash-down/irrigation procedures in hospital. As HA is used throughout the world for various surgical procedures and is a product of the human body, there is little concern for an allergic reaction to its use.

Special circumstances

There are three anomalies to burn injury: chemical; electrical, and cryogenic (cold burn). Each will now be examined in further detail.

Chemical (liquid/powder)

All liquid chemical must be irrigated off injury site or neutralised prior to any form of cooling (some chemicals will require irrigation well in excess of 20 minutes). All powder chemicals must be brushed off injury site or neutralised prior to irrigation. This should be carried out with caution and responders and patients should be careful to prevent inhalation of chemical fumes, powder and dust during irrigation/brush-off procedure. Chemicals will continue to cause damage until neutralised by an agent or completely diluted with water. The Fire Brigade and/or HART team should be called out if available in the area. Many modern chemicals (e.g. sodium, potassium, magnesium, white phosphorous) require specialised management, where dilution and neutralising agents may need to be employed prior to rescue by fire and rescue services and/or the hazardous area response team (HART). Also, it must be noted that correct personal protective equipment must be worn for all chemical injury concerns.

The three primary offenders within the chemical category are alkali; acid; and hydro-carbon. Alkali is very common around the home and is most damaging to the human body. It generates a liquefactive process going deep into the skin, resulting in long-term tissue destruction. Once the liquefaction takes place, chemical neutralisation becomes very difficult, potentially disrupting the body's systemic programme. It must also be irrigated for longer than acid.

An acid burn is very painful; while causing a considerable amount of damage, it is generally coagulative in nature and inclined to remain on the upper layers of the skin's surface, making neutralisation more effective than in the case of an alkali burn. It must also be noted that hydrofluoric (HF) acid is very corrosive.

Hydrocarbons are a diverse group of organic substances including petrol, diesel oil, kerosene, mineral spirits, etc. Hydrocarbons are toxic and can vaporise (displacing oxygen), affecting pulmonary, neurologic, cardiac, gastrointestinal, renal and haematologic systems.

Damage can occur from one of two events: ignition or immersion. Bitumen burns are from the hot liquid. Tar burns are from heat and toxicity, and must be cooled with large quantities of water. In the case of cement burns, there is a late presentation of pain and burning. These burns are caustic with a pH of up to 12.9, and a long period of irrigation is required. It is important to bring information on the offending chemical (i.e. material safety data sheet (MSDS)/photograph of the container) to the ED so that staff can contact their local poison control centre for antidote advice to ensure effective patient management. Caution must be taken that if not de-contaminated on scene by fire and rescue services or a HART, the chemically contaminated patient must never be transported into a hospital ED without pre-notification, as contamination of the ED may cause an emergency evacuation.

Electrical injury

All sources of uncontrolled electrical supply must be disconnected or made safe prior to the implementation of patient management. Respiratory and cardiac complications are most acute with electrical injuries;

always consider cardiac monitoring and spinal immobilisation. Once precautions for chemical and electrical injury have been successfully implemented, the patient should be managed as per recommended trauma guidelines (JRCALC, 2016).

Summary

Burn-injured patients can be very complex. When a patient enters the burn care system, he or she will require intense and dedicated management. Injuries may be lifelong with permanent scarring and disfigurement. Children may have to undergo numerous surgeries before reaching adulthood.

Burn-injured patients are trauma patients, and must always be managed with great care and attention to the trauma management pathway, as their presentation can change rapidly, possibly catching the responders unaware until it may be too late. Certain areas of the human body (i.e. face, hands, feet, groin) are deemed critical for burn injury. An understanding of their importance and implementation of correct management will help towards a more positive outcome.

Upskilling on severe burns life support is recommended to ensure that emergency responders have a better understanding of this potentially very difficult emergency response call.

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