Burn wound progression and the importance of first aid

KEY WORDS
- Burns
- Burn progression
- Cool water
- First aid

Burn injuries are often seen as a challenge to clinicians due to their complexity. Healing is dependent on the quality of the initial management of the wound. Best practice involves cooling the wound with water for 20 minutes within three hours of the initial injury and yet this is not widely known. This simple action can prevent the wound from increasing in size and can offer a better psychological, social, physical and functional outcome for the patient. National educational strategies and awareness campaigns to promote a standardised approach to first aid for burns and scalds are needed. This article looks at what happens to the burn wound following injury and discusses the importance of timely and appropriate first aid.

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A burn injury is one of the most severe forms of trauma that can be sustained (National Burn Care Review Committee Report [NBCR], 2001). Burns and scalds can have a wide variety of causes such as thermal, mechanical, chemical, electrical or radiation, but all will involve coagulative destruction of the skin (Rawlins, 2011).

About 250,000 people sustain burn injuries in the UK every year; 175,000 people visit A&E for treatment and almost 13,000 require admission for their injuries (NBCR, 2001). Wound severity can vary wildly (Evers et al, 2010). Flame injuries account for more than half of all burns (55%) and are often associated with inhalation injury and other concomitant trauma (Hettiaratchy and Dziewulski, 2004). Scald burns account for 40% of all burns injuries with 70% of childhood burns caused by contact with hot liquids or being exposed to hot bath water (Evers et al, 2010). Children under four years are most at risk and they make up 20% of all paediatric burn injuries. Fortunately, the majority (80%) of all burn injuries are classified as being minor and can be managed successfully by non-specialist healthcare professionals in primary and secondary care (Alsbjorn et al, 2007; Rowley-Conwy, 2012).

The quality of initial management of burns can greatly influence long-term outcomes such as aesthetic, psychological, social, physical and functional outcomes (Falder et al, 2009). Therefore, it is essential for all clinicians involved in the care of patients with burn injuries to understand how interventions can affect healing and outcomes. Mortality and length of stay are no longer used as singular parameters to quantify the success of burn care. Healthcare professionals must consider success in terms of patients' resulting satisfaction with life and physical, functional and emotional wellbeing (Stavrou et al, 2014), with the goal of treatment being to recover the patient to their pre-injury state with unaltered potential (NBCR, 2001).

CONCEPT OF BURN PROGRESSION

The skin is an efficient, self-repairing barrier that offers protection from the external environment (Butcher and Swales, 2012). A burn wound disrupts the intricate tissue architecture and cellular processes, affecting the following major functions of the skin (Tortora and Grabowski, 2000):

- Temperature regulation
- Sensory interface
- Immune response
- Protection from bacterial invasion
- Control of fluid loss.

Burns evolve over time (Duncan and Dunn, 2006), exhibiting a dynamic process that peaks at three days (Evers et al, 2010), thus complicating assessment and allowing a phenomenon known as burn wound conversion. As a result, burn progression and wound healing follow opposing pathways (Tobalem et al, 2013).

Burn injuries are classified according to the amount of tissue loss (Hettiaratchy and Papini, 2004) and can be described as partial thickness or full thickness. Partial thickness burns are most prevalent (Chipp et al, 2008) and are further divided into:

- Superficial: the burn affects only the epidermis, presenting without blistering and healing rapidly (Butcher and Swales, 2012).
- Superficial partial thickness: the injury extends into the uppermost layers of the dermis and papillary dermis, presenting with blistering and pain from exposed nerves. These wounds have the regenerative capacity to heal within ten days (Butcher and Swales, 2012).
- Deep dermal: the burn extends into the deeper layers of the dermis, but not as far as subcutaneous tissues. The healing is prolonged and can result in scarring, contractures and loss of pigmentation (Butcher and Swales, 2012; Wounds International, 2014).

Full thickness burns cause the most debilitating damage by extending through all the skin layers and underlying structures, such as subcutaneous tissues, muscle and bone. The tissues appear inelastic, waxy and leathery and are likely to require surgical excision and repair in order to heal. Considerable scarring and contraction is likely in a burn injury of this depth (Wounds International, 2014).

Jackson (1953) was the first to describe a process where superficial partial thickness burns have the ability to spontaneously develop into full thickness burns up to 48 hours following injury. This is mainly due to the histological and microcirculatory tissue changes that occur in all burns (Goutos and Tyler, 2013). In clinical practice this means that areas which initially appear superficial may later declare themselves as deeper during a repeat wound assessment.

Jackson (1953) referred to three concentric, three-dimensional zones (*Figure 1*), where the burn injury could progress in size and depth over time:

- Zone of coagulation – is the focal point of the burn injury, consisting of unsalvageable tissue and coagulated blood vessels. In this zone, the tissue loss is irreversible due to coagulative necrosis
- Zone of stasis – represents an area of static blood flow and ischaemia. This tissue has the potential to progress, causing permanent damage, or to heal, if tissue perfusion is increased. Effective resuscitation measures, such as optimal first aid and cooling, fluid resuscitation, prevention of infection and good wound care, would result in tissue recovery (Rawlins, 2011) (*Figure 2*)
- Zone of hyperaemia – is the most peripheral zone, characterised by increased perfusion and vasodilation. These tissues are likely to have a complete recovery.

Wound conversion refers to a three-dimensional, dynamic process whereby the zone of stasis progresses to tissue necrosis, with resulting increase to both wound size and depth (Hettiaratchy and Dziewulski, 2004) (*Figure 2*). Burn progression and wound healing have opposing pathways (Tobalem et al, 2013).

Lack of effective resuscitation measures and further infection, reduced perfusion, wound desiccation, increased inflammation, excessive oedema and the build up of surface exudate will all extend the zone of coagulation and the extent of tissue necrosis (Duncan and Dunn, 2006; Butcher and Swales, 2012). Environmental factors, such as delayed or inappropriate management, have also been suggested to be instrumental in the conversion of a burn. However, given the right conditions, the margin of the central zone is able to remain static and the zone of stasis will shrink and be replaced by the zone of hyperaemia (Duncan

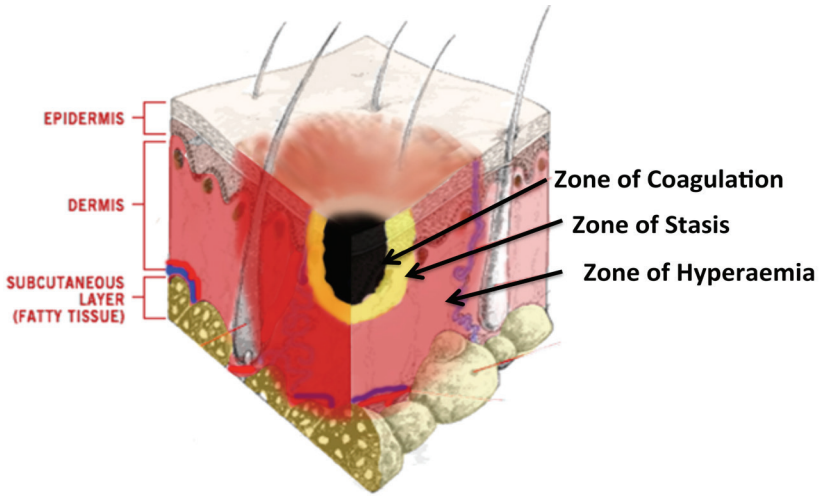

Figure 1. Jackson's burn model. Image courtesy of Australian & New Zealand Burn Association (2014) *Emergency Management of Severe Burns (EMSB) Course Manual, 17th edn.* QLD, Australia

and Dunn, 2006). Wounds that heal within two weeks of initial injury, have a reduced likelihood of scarring (Cuttle et al, 2010). Consequently, the initial management of the burn wound — especially in the early stages — will influence how the wound progresses.

COOLING THE BURN WOUND

Effective first aid and initial management of the burn wound can limit tissue damage and can make a difference to the long-term outcome for the patient (Goutos and Tyler, 2013). First aid is defined as assessments and interventions that can be performed by a bystander or patient with minimal specialist equipment before regular medical aid can be obtained (American Heart Association [AHA] and American National Red Cross [ARC], 2005). Therefore, any first aid intervention should be simple, effective and universally accessible, and should not hinder later wound assessment and management (Graham et al, 2012). The aim of first aid should be to stop the burning process, cool the burn, provide pain relief and cover the burn wound (Hudspith and Rayatt, 2004; Australia and New Zealand Burn Association [ANZBA], 2009).

Early application of cool water is the most important factor in reducing burn wound severity and has been shown to reduce wound damage and increase wound healing (Jandera et al; 2000 Alsbjorn et al, 2007). Immediate cooling of thermal burns with tepid running water at 2–15°C removes heat, significantly improves the speed of re-epithelialisation of superficial partial thickness and deep dermal burn injuries (Cuttle and Kimble, 2010), and prevents progression that occurs in an untreated burn in the first 24 hours after the injury (ANZBA, 2009). Cooling interrupts the negative evolution of the burn wound by impeding coagulation and inflammation, reducing swelling and depth of injury, providing pain relief and cleansing the wound (Tobalem et al, 2013). It also negates the need for grafting and promotes more rapid healing (Jandera et al, 2000; Nguyen et al, 2002; Hudspith and Rayatt, 2004; Venter et al, 2007). Prevention of the burn wound progression will result in a more superficial burn with potential to heal with less scarring or contractures (Tobalem et al, 2013).

Wound irrigation using clean running tepid tap water is at least as effective as wound irrigation with normal saline in improving healing and reducing infection rates (Hollander et al, 1998; Griffiths et al, 2001; Fernandez and Griffiths, 2012). Ordinary tap water is recommended by the British Burn Association [BBA] (2014) as the treatment of choice for the first aid management of burns and scalds in recognition that tap water may be readily available (AHA and ARC, 2005). Other techniques, like spraying or sponging over the wound are also quite efficient when access to running water is limited (Schnell and Zaspel, 2008). Wet towels are less efficient as they heat up due to proximity to the body, so if used they must be changed frequently (ANZBA, 2009).

Although cooling of the burn wound has been shown to have a positive effect for the patient, there is a risk of hypothermia when patients are cooled to excess (Allison, 2002). The very young and very old are particularly susceptible as they have a thinner dermis (Durrant et al, 2008). Application of ice or cold water can lead to frostbite injury, vasoconstriction and negative evolution of the burn wound (Cuttle and Kimble, 2010; Tobalem et al, 2013). Therefore, if hypothermia is detected by taking the patient's temperature or if shivering is observed, application of cooling should cease and active warming measures began. Burn patients are known to lose heat from the non-epithelialised areas of skin due to evaporation (Singer et al, 2010), with burn injury pathophysiology disabling their body's ability to raise their temperature.

Image developed by the Centre for Children's Burns and Trauma Research, Queensland, Australia

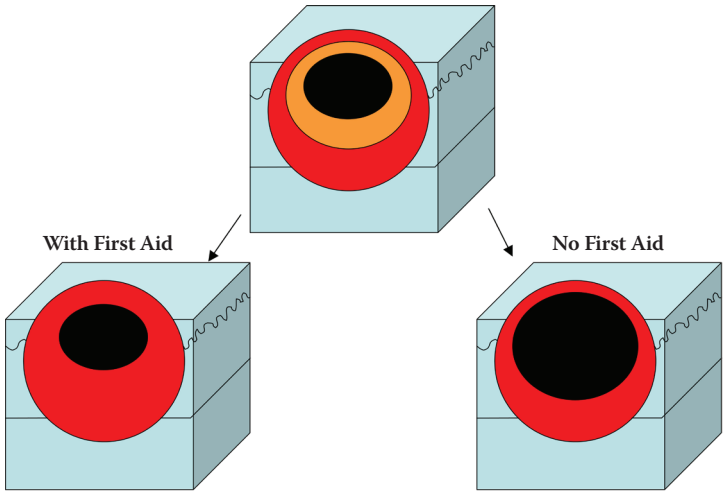

Figure 2. Effects of initial treatment on burn wound progression. Picture courtesy of Connolly S (2014)

Table 1: Recommendations from various organisations concerning the first aid treatment of burn injuries

Organization	Recommendation
St John Ambulance, UK (2015)	Cool water for 10 minutes
British Red Cross (2015)	Cold running water for at least 10 minutes
Joint Royal Colleges Ambulance Liaison Committee [JRCALC] (2013)	• Cool with water for 20-30 minutes up to 3 hours after the burn injury • Do not use ice or ice water.
British Burn Association (2014)	Cool with running tap water for 20 minutes
Australia and New Zealand Burn Association (2009)	• Cool with running tap water at 15°C (or between 8°C-25°C) for 20 minutes up to 3 hours after the injury has occurred. • Keep patient warm • Do not use ice or iced water

This inability to generate heat and the resulting hypothermia has negative effects on infection rates and wound healing, increasing the morbidity and mortality of these patients (Muehlberger et al, 2010). It is essential, therefore, to take precautions against the development of hypothermia, maintain normothermia and follow the maxim 'cool the burn, warm the patient' (Allison, 2002). Warm (37°C) water application has been suggested to have a beneficial effect on vasodilation and increased blood flow, reducing extension of tissue necrosis and delaying burn progression (Tobalem et al, 2013). With this in mind, Tobalem et al (2013) suggest that future refinements in emergency treatment of burn injuries may include both cooling (heat removal and anti-inflammatory action) and warming (improved perfusion).

RECOMMENDATIONS FOR FIRST AID TREATMENT

Various recommendations regarding first aid of burn injuries have been proposed by medical, ambulance and burns organisations (*Table 1*). These support the application of cool water, however there is still a lack of consensus concerning the temperature of the coolant, time period of application and the effect of delay between a burn and the commencement of cooling (Venter et al, 2007).

This lack of a standardised approach, however, translates into poor awareness of appropriate burn first aid (Cuttle and Kimble, 2010; Davies et al, 2013; Wallace et al, 2013), and is further confused by traditional cultural beliefs and superstition (World Health Organization [WHO], 2008; Graham et al, 2012; Bazargani et al, 2013). More alarmingly, evidence suggests there is an equally poor overall knowledge in burns first aid in healthcare workers (Breederveld et al, 2011; Tay et al, 2013). In clinical practice, this lack of knowledge and clarity has led to patients presenting with toothpaste, butter, ink, sugar water, soy sauce, oil, honey, eggs, mashed potato, ice and other household products applied to their burns (WHO, 2008; Cuttle et al, 2009; Graham et al, 2012). This highlights the urgent need to offer education to the general public and clinicians about burn prevention and appropriate first aid measures (Chipp et al, 2008), as correct initial first aid is widely recognised to improve burn outcome and reduce pain. Attendance on a formal course such as Emergency Management of Severe Burns [EMSB], run by the British Burn Association, would enable medical, nursing and emergency practitioners to deal competently and confidently with the challenges that a burn-injured patient presents (Wilson, 2013).

Based on the evidence to date, the British Burn Association has recently published its First Aid Position Statement (BBA, 2014) — a nationally agreed consensus regarding optimum first aid for burns and scalds, establishing a practical and effective guide for the home or pre-hospital environment.

BBA (2014) advises that the best first aid for burns should consist of cool running tap water for a period of 20 minutes in duration, ideally applied as soon as possible, but still effective up to three hours after injury (Cuttle and Kimble, 2010). This is the most superior and effective treatment that has been shown to reduce tissue damage, improve wound re-epithelialisation, and decrease scarring (Cuttle et al, 2010). Cool running water at 2°C to 15°C is most beneficial, whereas ice has been shown to have no effect on improving wound outcome and therefore should not be used (Cuttle and Kimble, 2010). Clothing and nappies can retain heat and jewellery can restrict blood flow following oedema and therefore should always be removed (Hudspith and Rayatt, 2004). Best efforts should be made to minimise heat loss when using cool water, treating only the burn area, while keeping the rest of the patient warm (Alsbjorn et al, 2007). A cooled burn wound should be covered with cling film, serving to reduce the risk of bacterial colonisation and prevent evaporative fluid and heat loss until

it is possible to perform a definitive wound assessment (Goutos and Tyler, 2013).

CONCLUSION

Burn injuries present many challenges to healthcare professionals, not least of which is the dynamic nature of the burn wound, which can progress in depth and size over days and is dependent on adequacy of initial management in the minutes and hours following injury. Frequent occurrences of inappropriate or neglected first aid treatment illustrate that there is largely a lack of awareness and clarity on appropriate burn first aid among the general population, patients and even clinicians. Cooling of the burn wound with tepid water for 20 minutes within three hours of the injury is recognised as the most important factor in reducing burn wound severity and has been shown to reduce wound damage and increase wound healing. The quality of this initial management will have long-term psychological, social, physical and functional consequences for patients with a burn injury. WUK

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