

Pain in the patient with burns

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Thermal injury can be one of the most painful and disfiguring forms of trauma, as it affects the skin, the largest and most visible organ. The National Burn Care Review (British Burn Association, 2001) determined that as many as 500,000 people suffer a burn injury each year in the UK. Most are minor. Around 13,000 people, of which 45% are children, are admitted to hospital; only a small proportion have severe injuries requiring resuscitation.

Burns anaesthesia and, when required, intensive care can form a significant part of the anaesthetic workload in the hospital with a burn centre. An appreciation of analgesia management related to the pathophysiology of the burn is also important, and the role of the anaesthetist in supporting analgesia for burn patients is crucial. The generalist anaesthetist cannot escape entirely, as patients with burns present initially at local hospitals; the early management of pain can have a significant impact on the pain experience thereafter.

Mechanisms and characteristics of burn pain

Anatomy

The functions of the skin include protection, having a major role in immunocompetence, sensation, thermoregulation and metabolism. It has an outer epidermis of keratinized squamous epithelium (Fig. 1). The inner dermis consists of vascular fibro-connective tissue that supports the epidermis, houses specialized epidermal tissues such as hair follicles, and sweat and sebaceous glands, and gives the skin its elastic recoil properties. The hypodermis connects the organ to deeper structures and contains varying amounts of adipose tissue.

The sensory structures are contained within the dermis and consist of free nerve endings (for pain, temperature and touch), Meissner's corpuscles (light discriminatory touch) and Pacinian corpuscles (pressure). Fibres from

Key points

Major thermal injuries are a significant cause of pain and disability.

Burn pain is affected by the size and depth of the burn; it is exacerbated by infection.

Burn pain has several facets and is difficult to manage; it is therefore often under-treated.

Pre-emptive, multimodal analgesia is the best approach and can include regional nerve block and non-pharmacological methods.

Not all pain is due to the burn; consider other causes such as fractures, compartment syndrome, infection and rarer complications of the burn.

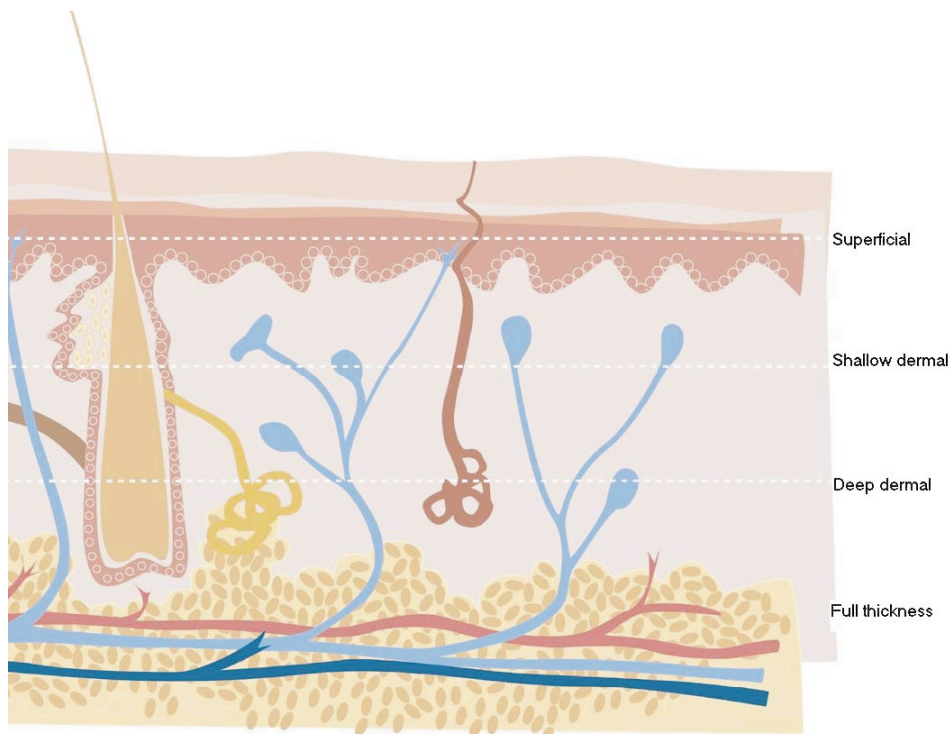


Fig. 1 Section through skin showing depths of thermal injury.

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the free nerve endings travel in A δ fibres (fast pain) and unmyelinated C fibres ('slow' and chronic pain) to synapse in the substantia gelatinosa of the dorsal horn of the spinal cord. Fibres then cross the midline of the spinal cord to ascend to the thalamus in the lateral spinothalamic tracts and from there to the post-central gyrus, where conscious perception of the stimulus may occur.

Mechanisms of pain

The instant pain that follows a burn injury is due to stimulation of skin nociceptors that respond to heat (thermoreceptors), mechanical distortion (mechanoreceptors) and a selection of stimuli including chemical stimuli – exogenous (*e.g.* hydrofluoric acid) and endogenous (*e.g.* inflammatory mediators, notably histamine, serotonin, bradykinin, leukotrienes and prostaglandins). Nerve endings that are entirely destroyed will not transmit pain, but those that remain undamaged and exposed will generate pain throughout the time and course of treatment. These immediate pain sensations are elicited by activity in the unmyelinated C- and thinly myelinated A δ -primary afferent neurons that synapse with neurons in the dorsal horn of the spinal cord.

Subsequently, the clinical picture becomes complicated by the emergence of both primary and secondary hyperalgesia.

Primary hyperalgesia

A burn induces a potent inflammatory response, and the release of inflammatory mediators sensitizes the active nociceptors at the site of injury. This causes the wound and immediately adjacent skin to become sensitive to mechanical stimuli such as touch, rubbing or debridement, as well as chemical stimuli such as antiseptics or other topical applications.

Secondary hyperalgesia

Continuous or repeated peripheral stimulation of nociceptive afferent fibres leads to increased sensitivity in surrounding unburned areas. This is mediated by the spinal cord and exacerbated by the mechanical stimulation that occurs as a result of frequent dressings changes.

Classification of burns and relationship to pain

Different sizes and degrees of burn result in differing amounts of pain. Burns are conventionally classified by area (percentage of total body surface area burned) and depth (superficial, shallow and deep dermal, full thickness, and full thickness with deep tissue involvement) (Fig. 1). Simplistic observation might conclude that the larger the burned area the more the pain, and the deeper the burn for a given area the less the pain (because of the greater destruction of nerve endings). In reality, burn injuries consist of a combination of deep dermal or full thickness wounds intermingled with more shallow areas in which some nerve endings remain undamaged. All burn victims therefore experience pain, which simple humanity dictates must be treated well.

Psychological factors play an important part in the pain experience.

Initial acute pain

The energy from the burn source causes cell damage and release of inflammatory mediators, as described above. Reflex activity may be initiated to remove the affected area from further harm, although where this is not possible, a more severe injury results. Descending pathways from the thalamus and release of endorphins and other neurotransmitters in the spinal cord may result in there being little or no pain for the first few hours after injury (stress-induced analgesia).

First aid

As a first-aid measure, cooling the patient with tepid or cold water will terminate the burning process and reduce the pain of injury. However, this and the evaporation of oedema fluid can quickly cause hypothermia, so it must be accompanied by measures to prevent general heat loss. The correct balance is summed up in the aphorism, 'Cool the burn, warm the patient'.

On admission to hospital

A stress response is triggered by the injury. An initial neural component from the affected area releasing norepinephrine from the sympathetic nervous system is followed by a slower hormonal response with elevated levels of cortisol, epinephrine and aldosterone. This is designed to protect vital organs and mobilize substrates for wound healing. The stress response depends on the magnitude of the injury, and an important goal of analgesia is to prevent the undesirable consequences of the stress response.

For a patient with a large burn needing immediate, vigorous cleaning, the only viable recourse may be general anaesthesia. This will be especially true if there is an inhalation injury or multiple trauma requiring stabilization, surgery or transfer to an appropriate specialist centre. Continuous intravenous infusions of opioids provide the mainstay of analgesia for this group. For the patient without threat to the airway, the gold standard remains intravenous morphine. This can be titrated in small (1–2 mg) boluses until the patient is comfortable. Due diligence must be exercised to avoid the side-effects of excessive sedation and respiratory depression; nevertheless, high doses are sometimes required. Absorption of opioids given intramuscularly may be unpredictable.

Tissue damage releases multiple inflammatory mediators such as hydrogen ions, prostaglandins and bradykinin. Non-steroidal anti-inflammatory drugs (NSAIDs) inhibit the formation of prostaglandins and therefore provide analgesia. They may be useful alone in smaller burns or as an adjunct to opioids. However, the severely burnt patient may be hypovolaemic and therefore at risk of gastric erosions. NSAIDs should be used with caution in the

shocked patient or the elderly. If NSAIDs are contraindicated, then tramadol may be useful as an intermediately potent analgesic. If there is concern over the patient's condition, keep it simple (*i.e.* intravenous morphine with adequate fluid resuscitation).

Pain after hospitalization

Following the acute injury, pain can be classified as follows:

- (i) procedural pain of short to medium duration and sometimes high intensity during or after wound cleaning, skin grafting and physiotherapy of affected joints;
- (ii) resting pain, dull in nature but of long duration when the patient is between procedures; and
- (iii) breakthrough pain of short duration associated with rest pain.

It is now recognized that changes in regenerating and damaged nerve fibres and tissues may result in the development of chronic pain syndromes. Control of pain is required for humanitarian reasons, to allow further wound management, to stabilize the sleep/wake cycle and to improve morale. The pain associated with thermal injury can be predictable, given a good understanding of the mechanism and response. It should therefore be amenable to prevention and multimodal analgesic techniques.

Pain associated with procedures

Following initial admission and resuscitation, the patient may undergo a number of procedures such as skin grafting, wound debridement, physiotherapy and dressings changes, all of which contribute to the pain experience. Each procedure will trigger a fresh painful stimulus and further stress response. Therefore, analgesia should be preventive, as some of these events are predictable. Pain, and thus poor analgesia, may interfere with sleep, which is felt to be a significant part of the healing process.

During the early part of the in-patient stay, prolonged procedures may be best performed under general anaesthesia. This is especially true if access to the patient will be difficult or in the case of children where fear of repeated potentially painful procedures will be a significant barrier to trusting the staff.

Surgery

Intraoperative and postoperative analgesia will usually be based on opioids. The concept of balanced analgesia will encourage the additional use of regional block and NSAIDs, depending on the extent of injury and site of graft harvest. However, as with other critically ill patients and if large volumes of fluid or blood are required, coagulopathy may occur. This may preclude the use of neuraxial techniques. Likewise, a risk of haematoma formation underneath a critical skin graft may preclude the use of non-specific COX inhibitors.

Large raw areas produced during surgery, in particular donor sites, are amenable to analgesia by a number of methods. At

surgery, local anaesthetic gel may be applied under the dressings. Bupivacaine is effective (0.5% plain mixed with an equal quantity of aqueous gel), although there is a theoretical risk of local anaesthetic toxicity following unpredictable absorption over a large area (studies have not demonstrated this to date).

An appropriate regional block may be used. However, regional techniques are less often used than might be expected because of practical difficulties such as infection at or close to the insertion site, generalized sepsis and coagulation abnormalities. For the lower limbs and abdomen, a continuous epidural infusion may be possible. Opioids may be added to the regimen, giving a reduced risk of local anaesthetic toxicity and therefore side-effects. Brachial or lumbar plexus block is also an effective technique. Appropriate selection of local anaesthetic agents allows the block to persist into the postoperative period; this may be prolonged further by the addition of α_2 -antagonists such as clonidine. Single-shot regimens are less effective; however, interest is growing in the placement of catheters alongside the nerve plexus to allow repeated bolus doses or infusions. The placement of epidural or limb catheters has a potential for bacterial colonization, and they may fall out if attached to mobile areas of skin or close to the burn where fixation is difficult.

Once again, the mainstay of early postoperative pain management is based on opioids. These can be administered transdermally, orally, intramuscularly and intravenously with a combination of background infusion and boluses. All have their merits, but intramuscular administration may be difficult due to the site of surgery, the extent of dressings, injection site discomfort and unpredictable absorption. There is a vogue for patient-controlled analgesia (PCA), which has been found to be effective in burns in several studies. However, this is not ideal, as it requires a cooperative patient able to use the device (not possible with burned hands) and plasma opioid concentrations may fall during sleep. A background infusion will reduce the likelihood of this; however, opioids have a tendency to accumulate, leading to undesirable side-effects. Nursing vigilance must be maintained and protocols must be in place to prevent or deal with these events. Similar constraints apply to the use of opioids by continuous infusion, which is an effective approach immediately after operation if carefully monitored. The inflammatory component of pain and opioid use can be reduced by regular NSAID analgesia, unless the risk of haematoma formation outweighs the benefits.

Dressings changes

The management of pain during dressings changes is the most extensively investigated aspect of burn pain management, yet no single technique has been shown to be better than any other. A large burn dressing may take 1–2 h and may include active wound debridement or postoperative removal of items such as staples. General anaesthesia is often appropriate; deep intravenous sedation may be given and supervised by an anaesthetist.

For smaller dressings, analgesia is commenced before the procedure takes place by a bolus of opioid or local anaesthetic; time is

allowed for onset of the analgesia. Depending on the level of stimulus, further doses can be used during the procedure supplemented by a benzodiazepine. Entonox is useful for short procedures to supplement opioids, reduce breakthrough pain and avoid prolonged sedation.

Ideally, easily titratable sedative and analgesic agents with few side-effects and short half-lives are required. Few drugs have all these properties. Sedation with many agents has been reported, including lidocaine infusions, benzodiazepines and volatile inhalation agents. Ketamine is analgesic and sedative. Although loss of airway is unlikely at normal doses, its use is limited in adults by side-effects including hallucinations. The latter can be mitigated by adding a small dose of a benzodiazepine.

Boluses or infusions of shorter-acting opioids such as alfentanil and fentanyl are suitable for short procedures. They can nevertheless accumulate and may result in respiratory depression, particularly if given to a patient already receiving opioids. Combination with a low-dose infusion of propofol (administered by an anaesthetist) gives adequate conditions for dressings changes. The effects of propofol terminate within minutes if a target-controlled infusion at a dose range of 1–2 µg ml⁻¹ is used. Further flexibility can be introduced by adding remifentanyl. Because the half-life of remifentanyl is short, supplementation with opioids, NSAIDs, or both, is necessary to control pain in the post-procedural period.

The requirement for procedures can be reduced by using suitable dressings, such as a synthetic temporary skin substitute, especially in children. Biobrane[®] (a porcine collagen-based material) and similar synthetics are used on superficial wounds that are expected to heal; they are left in place until healthy skin has formed, thus reducing distress and infection risk and also allowing early mobilization.

Physiotherapy

Physiotherapy is an important part of rehabilitation. Moving damaged areas causes pain and further exacerbation of the stress response. On the other hand, the patient is engaged in the process and therefore motivated. This type of pain is predictable and again amenable to multimodal management using oral analgesics. The scope of strong painkillers and anaesthesia is limited because of the requirement for cooperation; however, the physiotherapists will often take the opportunity of a visit to theatre or the dressings station to perform passive range of movement exercises in the early stages.

Background pain in the ward

After initial treatment and between procedures, the patient most commonly suffers low-grade but persistent discomfort, the nature of which has been repeatedly shown to be under-appreciated even by experienced staff. This is difficult to treat adequately while minimizing the patient's exposure to side-effects, but adequate treatment is essential to patient well-being. A multimodal

approach using low-dose oral opioids in combination with NSAIDs provides best results. Careful titration by measuring the extent of pain relief regularly and adjusting doses accordingly is essential; it can be integrated into the work of the Acute Pain Team or managed by the burns nurses according to well-designed protocols. Pre-emptive, regular dosing with supplemental prescriptions for breakthrough pain is most effective in practice.

Pruritus

Pruritus is another disabling condition that is poorly understood. It may disrupt normal physiology, and scratching may cause damage to forming skin. The mechanism is thought to involve histamine and prostaglandin release. Treatment is again difficult and usually involves combinations of antihistamines and NSAIDs. Empirical observation that heat may trigger the reaction has led to treatment by cold compresses and control of the environmental temperature.

Chronic pain

Damaged and regenerating nerve tissues can give rise to complex neuropathic pain syndromes whereby the sensation of the painful stimulus far outlives its expected duration. This can destroy the sleep pattern, result in depressive symptoms and impair rehabilitation. There may be hyperalgesia (an increased response to a painful stimulus) and allodynia (a painful response to a normally innocuous stimulus). This may be a significant problem starting quite early in the post-injury course and persisting for many years after the initial injury (Table 1). This type of pain is very difficult to treat using conventional analgesics, unless there is ongoing inflammation or tissue damage. The severity of chronic symptoms is often related to the size of the burn and the number of skin grafts performed. Treatment includes antidepressants (amitriptyline), anticonvulsants (gabapentin and sodium valproate), regional nerve block and cognitive behavioural therapy.

Adjuncts and alternative techniques

Non-pharmacological techniques have been investigated. Hypnosis has been well described in conjunction with traditional medi-

Table 1 Types of chronic sensation experienced by patients recovering from burns

Type of sensations	Patients affected (%)
Tingling	58
Stiffness	52
Cold/freezing	42
Numbness	33
Warmth	26
Pins and needles	23
Electric shock	13
Other (cramp, itching, etc.)	13

Adapted from Choiniere M, Melzack R, Papillon J. Pain and paresthesia in patients with healed burns: an exploratory study. *J Pain Symp Manage* 1991; 6: 437–44.

cation. Case reports exist of patients having successful ‘rapid induction analgesia’ for burns dressings who have adverse reactions to opioid-based medication. Other methods investigated include cognitive behavioural techniques (*e.g.* avoidance strategies) and reappraisal techniques (reconceptualizing the painful stimulus in a positive light). For appropriate patients who are not too fatigued or sick, relaxation techniques can be helpful. With the advent of new technology, virtual reality (VR) scenarios have been investigated. During painful procedures, patients use the VR helmets to place them in another world. Although requiring advanced equipment, this has been shown to be as effective as other treatments.

Children

The whole experience of trauma, hospital admission and treatment cycles is especially distressing for children. They require the same standard of analgesia and treatment as adults but are more difficult to assess in terms of pain. Behavioural assessments are important, especially in babies and toddlers where, for instance, quiet inactivity should be considered abnormal; administration of analgesia may restore play. Instead of a Visual Analogue Score, several scales are available, the best known of which is the Children’s Hospital of Eastern Ontario Pain Scale (CHEOPS) which uses ‘smiley faces’.

It has been shown that PCA can be used successfully in children as young as 4 yrs old. Psychological strategies have also been shown to work in children. The role of the Hospital Play Specialist is crucial in this respect; every burn unit should have at least one. The role of appropriate dressings material in children (*e.g.* Biobrane[®]) has been emphasized previously.

Propofol is not licensed for younger children, so other intravenous techniques must be used for dressings changes. For a first procedure, general anaesthesia is a kindness that minimizes later aversion to procedures. Ketamine is still widely used for children, in whom side-effects seem to be less of a problem. Addition of a small dose of benzodiazepine reduces the incidence of hallucinations.

Other causes of pain

The burn wound and donor sites are not the only possible causes of pain in the burned patient, especially in major or multiple injuries.

In the initial assessment, a secondary survey must be performed to locate other injuries. Pain from fractures may be severe. Current guidelines recommend the stabilization of the fracture and the titration-to-effect of intravenous opioid. Likewise, the pain of abdominal injuries should be managed appropriately.

Compartment syndrome in a limb may be a concern with a circumferential burn or in association with a fracture and can be caused or exacerbated by fluid resuscitation. If untreated this will result in limb ischaemia. Surgical decompression is required.

Pain should be also considered as a harbinger of infection in the recovery phase. Hot, erythematous, swollen areas may indicate cellulitis or pus formation, which necessitates systemic antibiotics, surgical incision and drainage, or both. Major burns are associated with a multitude of complications including perforation of an abdominal viscus, colonic pseudo-obstruction, abdominal compartment syndrome and heterotopic bone deposition; in all of these scenarios, a change in the magnitude or type of pain may be the first indicator of trouble.

Acknowledgement

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See multiple choice questions 44–46.