Part 1 Challenges in the treatment of burns

Background
Damage to the skin adversely affects these functions and places the individual at risk. Thermal injuries commonly referred to as "burns", catastrophically compromise the integrity and protective function of the skin. Extensive burns can therefore represent one of the most life-threatening and life-altering events an individual is ever likely to face and place enormous demands on health care services. The majority of burns are thought to be small, though as many of these injuries are never reported to medical practitioners there is little data to support this belief (Hermans, 2005). However, even in limited burns injuries the compromised status of the skin's integrity can provide a portal for bacterial ingress, pain remains a key feature and disfiguring scarring can result (Rockwell et al, 1989).

The severity of the actual burn injury is dependent on two factors; the size of the injury and the depth of tissue damaged by the heat source. Other events and health factors also need to be taken into account when estimating the severity of the injury on the individuals' constitution such as inhalation injury (from smoke and hot gases inhaled at the time of trauma) associated trauma injuries, (such as limb fractures sustained trying to flee from the event) and underlying medical conditions.

Types of Burn
Burns can be caused in a number of different ways:
- Direct contact with a hot object (contact)
- Contact with a flame or superheated gas (flame)
- Contact with a hot liquid (scald)
- From the passage of a high voltage electrical current through tissues
- Through exposure to chemicals
- From exposure to a source of radiation.

Mechanisms of injury

The mechanism of burn injury (cause) can have a bearing on the expected damage caused. The higher the temperature of the heat source and the longer the exposure to the heat the greater the damage to the skin and underlying structures. Protein denaturing occurs at temperatures above 60°C. Therefore, exposure to these temperatures will result in irreparable tissue damage. Boiling water has a temperature of around 100°C and so will destroy gives up its heat energy and so cooling occurs if water is spread over a wide surface area and is exposed to the cooler environment. Hot water poured on the skin causes deep damage at and close to the point of impact but as heat energy is lost (particularly at the periphery) less damage occurs. However if tissues are plunged into hot water (as in falling into an extremely hot bath) more widespread and deeper damage occurs.

Due to the high temperature experienced in flame burns deeper damage is more likely to occur. Similarly, electrical burns are likely to cause full thickness damage. Here, heat is generated as electricity passes through the tissue which acts as a resistor; the higher the amperage the more heat is generated and therefore the greater the damage (Sances et al, 1981). Heat causes coagulation and cell walls to explode. In electrical burns heat generation occurs not only at the point of contact but also throughout the path the current takes within the tissues. It is normal to find an entry and exit point for electrical energy transfer however there may be widespread areas of damage within the tissues.

Chemical burns may incur more than one process to initiate damage. Exposure to skin proteins to some chemicals will incite an exothermic reaction which will generate high levels of local heat. However some chemicals will produce a chemical reaction
which may affect local or systemic electrolyte imbalance resulting in local or systemic toxicity.

**Size of burn**
The size of the burn injury is the most significant factor in early burns trauma management. The greater the area burnt, the greater the effect on the body. In all but the smallest burns, damaged tissue is normally referred to in terms of the percentage of total body surface area burnt (%TBSA). This is estimated at the time of injury by use of a number of mathematical formulae such as “The Wallace Rule of Nines”, “the one percent hand rule” or the “Lund and Bowder” method. Generally, severe burns are considered those in which it is impossible for the individual to adequately maintain normal hydration without the use of intravenous fluid replacement. In adults this is at about 10% TBSA and in children this is at about 5% TBSA (NBCR, 2001). For many untrained people it is difficult to comprehend in real terms just how little burn is needed to cause fatal injury. It has to be remembered that in adults burns to both legs may equate to 30-40% TBSA and as so are life-threatening. In addition, full thickness burns are insensate and so individuals with extensive deep burns may show very little signs of pain or distress however their injuries may be so severe that they pose a significant risk to patient mortality. Some burns will also be considered “severe” due to other complicating factors such as inhalation injury (which significantly increases mortality and morbidity) or to localised but deep burns to vital structures.

Thermal damage to the skin affects the ability of the tissues to control moisture balance. In burns the capillaries immediately below the skin damage show changes in their permeability and are no longer able to retain plasma. This rapidly leaks out of the vessels leading to the formation of burns oedema. In addition, water is lost through evaporation at the site of injury. Circulating volume rapidly drops leading to burns shock. To preserve blood pressure the production of urine diminishes. Urine production is also affected by the by-products of erythrocyte breakdown. Red blood cells exposed to heat at the point of injury are destroyed releasing haemoglobin. This circulates to the kidney where it blocks the renal tubules leading to renal failure. One of the priorities of early burns management is to replace fluid loss to prevent circulatory collapse and death. Large volumes of fluid need to be given intravenously, especially for the first 72 hours. After this time many damaged capillaries will have recovered and so fluid loss is less of a problem.

In large burns there are also issues of temperature regulation and infection control. While the dissipation of exogenous heat from the burn is beneficial in preventing further tissue damage this is rapidly replaced by the need to preserve endogenous heat. Large areas of denuded skin enable massive amounts of heat to be lost through evaporation. The individual can rapidly become hypothermic even at normal room temperatures. It is therefore necessary to conserve heat energy and minimise shock in the period following first aid measures. Large surface areas of damage also provide an ideal environment for bacteria to colonise and invade the body. It is therefore important to augment the protective function of the skin with sterile dressings as soon as possible after burn injury.

**Burn depth**
As previously mentioned the depth of burn is dependent on the amount of heat energy (temperature and duration) applied to the tissues. The depth of injury has a major bearing on the longer-term management of the burn injury. Damage is described in terms of the structures affected. At one time the depth of burn injury was described in degrees. This method is now less popular as different centred adopted different methods of describing each state. Many used a 1st -3rd degree scale however some had 1st – 4th degree and in some specialist centres as many as 15 degrees of damage were classified.
Tissues exposed to even low levels of heat may produce changes in their characteristics. Sitting too close to a heat source will cause capillaries to dilate resulting in erythema (blanching redness). This is a transient state which may be accompanied with discomfort due to local inflammation (minor sun burn) but there is no significant change in the vascularisation of the area and the skin's integrity is not compromised. It is therefore not considered a true burn.

In superficial burns damage occurs to the capillary network and the upper layers of the epidermis. Burns oedema occurs and there may be some blister formation. These wounds are very painful. Patients are able to feel pin-prick sensation when tested as the nerve supply is not permanently damaged. In this type of injury the lower, regenerative layers of the epidermal tissues survive. Therefore, if the patient is given appropriate supportive therapy (fluid resuscitation if needed, analgesia, a moist wound healing environment and protection from bacterial infection) these burns usually heal within 7 days without scar formation.

In dermal burns a partial thickness injury occurs and the epidermis and upper levels of the dermis are damaged. These injuries may also be very painful, though pain perception may be dulled. With supportive treatment these wounds will also heal but this takes longer as many of the epidermal elements are lost. Re-epithelialisation therefore occurs from epidermal elements found in hair follicles and sweat glands. Some minor scarring may occur in these patients and there may be longer-term changes to skin pigmentation.

Deep dermal burns are a sub-group of the partial thickness injuries. Here, all the epidermis and most of the dermis are destroyed. The upper nerve fibres (which tend to be pain receptors) are destroyed but lower receptors may remain intact. Patients will be in pain however if tested with a sharp needle many will be unaware of pain, instead they may simply feel pressure. It must be remembered though that there may be areas of less deep damage within the wound, and the periphery of the wound will still have live pain receptors present. Previously this type of wound was treated conservatively with moist antimicrobial creams and dressings. However, due to the lack of regenerative tissue left in the wound bed these injuries are very slow to heal and produce extensive scarring and loss of function. Now it is more common to treat these wounds with early intervention surgical methods. Damaged skin is shaved off in layers (tangential excision) until a healthy wound bed is revealed. This is then covered with a split skin graft.

Damage which extends through all the layers of the epidermis and dermis is described as a full thickness burn. Such burns injuries may appear white and waxy (typically scalds) or charred (typically flame). The burn itself will be anaesthetic but the patient may experience pain from the surrounding structures. Many centres will also include a sub-category for damage which extends to underlying structures such as muscle, bone or bowel. Full thickness burns are unable to heal normally as there is no longer any regenerative tissue left in the wound. They therefore normally require surgical excision and repair.

It must be remembered that burn depth is a dynamic process. Damage may increase in depth if inappropriate management methods are undertaken including first aid measures and post burn wound care. Issues such as wound desiccation and infection can lead to partial thickness wounds developing into full thickness skin loss. Appropriate care and management, particularly dressing choice (Hermans, 1992) is therefore essential.
The management of burns
Burns injuries can be treated and managed in a variety of settings. The choice of setting is dependent on the severity of the injury and the resources available for specialist care.

At a global level, the majority of burn injuries are relatively small (less than 1% TBSA) and minor (not requiring specialist/surgical intervention). Many individuals acquiring these forms of injuries will self-treat with dressings obtained from local pharmacies. The aim of treatment is to relieve the initial pain following the trauma and to provide an environment in which natural healing can occur. If the burn injury fails to respond, becomes infected or is particularly troublesome these individuals may seek medical review from their local GP or practice nurse.

Patients with larger burns (still below 1% TBSA) or those anxious about the injury may seek the attention of a primary care physician immediately after injury. Here the wound will be assessed and a decision will be made whether referral to a secondary care environment is required. If the wound is assessed to be superficial or partial thickness (i.e. likely to heal with supportive therapy) and relatively small, it is likely that on-going treatment will be managed by the practice nurse under the supervision of the GP. Uncomplicated burns, (i.e. superficial or partial thickness injuries that do not include the face or perineum and do not have any other associated injuries) up to 10% may be managed in the community by the GP. However they frequently require close monitoring.

Most burn injuries about 10%TBSA and/or those with secondary associated injury will be referred to the Accident and Emergency department of the local district general hospital. Here the wound will be assessed and initial fluid replacement will commence (if appropriate). Those considered severe will be transferred to a specialist centre. Some will be considered to need hospitalisation for the management of pain, and dressing changes but do not require specialist intervention. These will be admitted to general medical or surgical wards for a few days. Other patients will be treated as an outpatient through the departments’ outpatient clinic. Referral to a specialist burns care facility is made for burns which are deep, extensive or complicated by other factors such as inhalation injury.

The term “complex burn” is often used by clinicians. This term is somewhat ambiguous and refers to both large (%TBSA) burns and those injuries which are complicated by the need to reconstruct or where other associated injuries are present which increase the patient morbidity/mortality. Currently, attempts are being made to obtain a consensus definition of this term. This will certainly assist in classification and lead to more accurate discrimination of burn management issues.

The key to all burns-injured individuals seen by clinical staff is assessment. The clinician must identify the extent of the burn (in %TBSA) to determine if, and how much fluid resuscitation is required and in what healthcare environment the patient should be managed. The depth of burn will also need to be accurately assessed as this will determine the expected outcome and will indicate if surgical intervention will be subsequently required. Depth of burn damage is determined by the patient history, the absence or altered pain status and the clinical appearance of the burnt tissue. A clear visualisation of the wound is therefore essential.

Priorities in selecting a burns dressing regime.
The management of a burns wound is dependent on the anticipated method of wound healing. If the wound is believed to be superficial or partial thickness it is likely
to heal provided an optimum wound environment is maintained. The priorities for these wounds are:

- To reduce pain
- To prevent infection
- To contain exudate
- To promote wound healing
- To prevent possible extension of the tissue damage (taken from Edwards, 2001)

Dressing materials are used to provide the optimum environment to facilitate wound healing if this is possible, or to provide a temporary protective skin substitute until such time as formal skin reconstruction can be undertaken.

The topical management of burns injuries can be divided into two distinct areas; the first-aid treatment of the burn, and the medical management of burns injuries.

**First-aid dressings**
The accepted first-aid treatment of burns is to rapidly cool the burnt area and so dissipate heat energy. This prevents the extension of the burn damage, minimises burn depth of injury and reduces pain (King and Zimmerman, 1965; King et al 1962). Following this the injury should be covered by a clean non-shedding cloth. Ambulance crews and emergency room staff frequently use domestic cling film as a primary dressing covered with clean cotton drapes. Although not sterile, this provides an easily accessible dressing which does not stick to the burn injury and enables the care team to visualise the wound surface. In some areas in the UK ambulance crews are supplied with specific hydrogel sheet dressings (Burnshield™, Water Jel™). These provide a cooling effect which can help dissipate any remaining heat energy, provide pain relief and are supplied in a sterile format.

First aid dressings are intended as a temporary cover for the wound. They are replaced with a formal burn dressing once assessment of the burn injury has been made by a qualified clinical practitioner and a treatment plan has been put in place.

**Medical management**
The dressing management approach to burns is dependent on the extent and severity of the injury and the intended management approach and is therefore dictated by the burn presentation. Medical management of the burn injury includes the management of airway, fluid balance, renal function, nutrition and cardiac function to name but a few. This is highly specialised and is beyond the scope of this paper. Therefore in this review we will focus on topical wound management alone.

Partial thickness and superficial burns
Partial and superficial burns will heal provided an optimum environment is maintained at the site of injury. The clinician needs to select dressing materials which are able to provide the dressing priorities outlined previously. Specifically;

Moist wound environment – a moist environment is essential to aid: the autolysis of damaged tissue, to promote migration of epithelial cells from keratinocytes within hair follicles and sebaceous glands, to prevent desiccation of exposed dermis, to keep exposed nerve endings moist and so reduce pain. Failure to maintain a moist environment not only delays tissue repair but can also lead to further tissue damage.

Exudate management – burn wounds leak large amounts of serous fluid in the first 72 hours following injury as capillary permeability is increased and epidermal tissue is lost. Burn exudate can rapidly soak through dressings providing a portal for bacterial contamination. Failure to manage burn fluid can also lead to evaporative moisture and heat loss.
Bioburden management – the burn injury is the only wound which is initially sterile (the heat which causes injury also destroys normal skin flora) however this is a transient state. Within hours the wound is rapidly colonised from surrounding skin flora, from contact with health care workers and from the surrounding environment. The moist, protein rich wound surface provides an ideal site for bacterial proliferation. In addition, host defences are compromised by changes to wound bed vascularity (even if this is only transient). These provide a potent opportunity for wound infection. The development of a burn infection will lead to the release of bacterial exotoxins causing further tissue damage and can result in further tissue destruction.

Pain management – the partial thickness burn exposes large numbers of pain receptors on, or close to the surface of the wound. Localised inflammation and burns oedema increase pain perception. Adequate coverage of the burn area needs to be maintained with an atraumatic wound product until healing occurs. Failure to protect the wound causes intense pain. This not only causes distress and inhibits wound healing but can also lead to substantial stress responses such as gastric ulcer formation. Poor management of the burn-dressing interface causes additional trauma to the burn and periwound tissues as dressings become adherent through the large amounts of sticky serous exudate leaking from the wound.

Until the advent of advanced wound dressings, superficial and partial thickness burns were covered with tulle gras to provide a low-adhesive wound interface. This was then covered with gauze soaked in antiseptic materials (such as silver nitrate solution) to reduce bacterial bioburden. Finally layers of absorbent materials such as cotton wool or gamgee were applied and held in place with retention bandages. This system was known as the “hyfa” dressing as was popular in burns management for many years.

In the 1960’s the introduction of silver sulfadiazine 1% (SSD) cream brought about changes to the management of these wounds. SSD was a far more practical antimicrobial product than silver nitrate as it did not tend to dry out, had a longer period of effectiveness, was less likely to cause systemic electrolyte imbalance, was less toxic to renal function and was available commercially in a sterile format. The cream could be spread directly on the burn area and covered with simple dressings or alternatively, it could be applied to sterile cotton dressings which were then applied to the patient. Many clinicians chose to use tulle gras between the cream and the absorbent dressing material as this reduced cream uptake into the cotton dressings which caused desiccation and dressing adherence.

The treatment of partial thickness and superficial burns with SSD cream is still commonplace. However, there are disadvantages to using this approach:

• In large burns the cream added extra weight to the dressing which when soaked with exudate restricts movement
• SSD requires changing every 24-36 hours to remain effective
• Removal and reapplication of the cream can be painful
• Repeated application of SSD can cause the development of discoloured “pseudo-slough” (Hermans, 1998). This can make visualisation and assessment of the wound bed difficult to undertake.
• Some authors claim that SSD is responsible for transient leucopenia (Fraser and Beaulieu, 1979; Choban and Marshall, 1987)

Alternative strategies have therefore been considered. Where antimicrobial activity is not considered vital, clinicians have previously used both semi-permeable film dressings and hydrocolloid wafer products. These products can provide a moist wound environment and are self adhesive, therefore relatively easy to apply. However both of these dressing groups have a poor absorbency and
moisture control action and can therefore be rapidly overwhelmed by the high exudate levels seen in most burns initially. They therefore tend to be reserved for small, late presentation burns injuries.

Due to their high moisture handling capabilities, alginate and hydrofibre products have been indicated by a number of writers as an effective method of partial thickness burns management. The recent addition of silver-based antimicrobial components to many of these products has seen an increase in their use in burns treatment. However these are primary dressing products and therefore require additional product use to maintain their position over the wound and to provide moisture control. They therefore need to be used with film dressings, hydrocolloid dressings or foam dressings to achieve optimal performance. This increases their cost in clinical use.

Foam dressings (both with and without silver-based antimicrobial components) provide moisture management and exudate control. They are available in a wide range of sizes to suit differing burn surface areas and can be cut to fit body contours. Those containing active silver elements can provide effective antimicrobial action.

Full thickness burns
Most full thickness burns will be considered for surgical debridement and reconstruction with skin grafts. This is undertaken soon after injury (within 5 days) if the patient’s condition allows. During the time before surgery, the wounds need to be dressed to reduce the risk of bacterial colonisation and subsequent infection of the graft site. Exudate handling is a high priority during this initial period; exudate levels may be very high and it is essential to adequately manage these to prevent strike-through which could provide a route for bacterial ingress. Reduction of bacterial bioburden may be considered a priority however this is determined on the operative plan for the patient. If early excision and grafting of the injury is to be undertaken (eg within 2-3 days of injury) many clinicians will prefer to avoid antimicrobial preparations. Patients unable to tolerate surgery or where surgery may have to be delayed run an increased risk of bacterial colonisation and infection. Therefore the dressing regime will need to include an antimicrobial component. Where surgical intervention can be achieved SSD cream is usually avoided as this tends macerate the eschar and wound bed and makes tangential excision difficult to achieve.

Full thickness burns have little or no sensation as nerve pain receptors have been destroyed during the injury, however the periwound area remains highly sensitive and due to the inflammatory response initiated by the trauma is likely to display a heightened perception of pain. It is therefore important that dressing selection should be aimed at reducing dressing change pain by the use of atraumatic wound care products.

Maintenance of a moist wound environment is not usually required if surgical intervention is required. Burns oedema and the covering of the wound bed with non-viable tissue is usually sufficient to prevent wound bed desiccation. However if conservative treatment of the individual is indicated an alternative strategy may be initiated. This may include the use of semi occlusive dressings, hydrogels and/or hydrocolloid dressings to facilitate autolysis.

Indeterminate depth injuries
In many cases it is difficult to assess the depth of burn at the time of injury. Where doubt exists, wound dressings are used to maintain the status of the skin and prevent infection until the wound “declares itself” (becomes obvious if this is full thickness or
partial thickness). This normally takes 2-5 days. During this time dressing selection is very important. As well as the previously mentioned priorities, it is important that any product used does not make burn depth assessment more difficult. The used of SSD cream is therefore controversial. Although this product is in common use for burns treatment its use can lead to discoloration of the wound bed, additional wound bed oedema and the formation of thick “pseudo eschar”. This thick coating is made up of cream debris and solidified burn exudate and can make the visualisation of the wound bed difficult.

Many clinicians therefore use alternative treatment strategies. These may include atraumatic dressing materials which do not contain antimicrobial agents or the use of alternative antimicrobial dressing products. As in general wound care, the most popular form of antimicrobial wound dressings utilise silver technology as their active ingredient. The development of Nano-crystalline silver dressings (the Acticoat range of products) came about in an effort to manage the burn wound. Alternatively, other silver-based products such as silver-impregnated algaines, hydrofibres and foams are used. Chlorhexidine-based antimicrobials (Bactigras) are still often used for this patient group.

Challenges within topical burns management
There are a number of key challenges faced in managing the burn wound. These are based around the clinical presentation of the injury, the desired treatment plan, the extent of the injury and the anatomical area burned. The variation in clinical presentation and therefore clinical management posed by the burn injury means that it is virtually impossible to identify an “ideal” burns dressing. The two factors which are almost always guaranteed to be important are pain and exudate management. Regardless of clinical presentation, all burns are painful whether in the burn itself (superficial and partial thickness wounds) or in the immediate periwound tissues (full thickness injuries). Similarly all acute burns have changes in their vasculature which, when combined with the break in skin continuity leads to leakage. Therefore any dressing material used needs to be able to manage exudate to prevent leakage and prevent further pain and trauma to the burn and periwound area.

As previously stated, the topical management of a burn injury is often dependent on the ability (or otherwise) of the tissues to regenerate and the need to minimise bacterial contamination and infection. Dressing choice and the approach taken to achieve the chosen end-point is therefore burn-specific. Burns injuries can occur anywhere on the human form however some particular body structures provide their own challenges to the clinician. Some of these may be relatively rare, however a number are seen frequently within burns centres.

Burn size
The size of area burnt can vary considerable. For instance the trunk appears to be a relatively easy area to dress. However it has to be remembered that this is an extensive body area and which whose actual dimensions vary considerably depending on the size of the patient. A child’s torso can be relatively small and so normal sized dressings (albeit the larger sizes) will adequately cover the area. However adults, (particularly the overweight and bariatric) require very large dressing products to cover the wound without leaving burnt areas exposed. In burns management it has to be remembered “size does matter”. For the clinician it is important that products are large enough to manage the very extensive injuries often encountered. Even with large wound care products it is invariably necessary to cover the burn piecemeal with the associated risk of separation, wound exposure and
contamination. In managing these patients dressing application can be difficult to achieve; such large dressings can be hard to handle, may need to be prepared in bulk and may require the services of several health care professionals to ensure correct placement; even holding limbs to enable dressing application may be a significant manual handling risk for clinicians.

**Hand burns**
Hand burns are extremely common and may vary from relatively minor, localised superficial injuries to extensive full thickness skin loss. As stated in previous sections of this report, hand injuries pose particular challenges. The hand is highly mobile, vascular, and sensory and has a highly significant role in normal function. The loss of a hand (or part thereof) can have serious long-term repercussions for independence and rehabilitation. Not only is the hand used to manipulate tools and objects, it has a central role in emotional expression and body image.

Maintenance of normal hand function is a high priority. Scar formation in the soft tissues of the hand can lead to deformation and loss of function. Therefore aggressive management is needed to ensure optimal wound healing outcomes. Until the advent of SSD, hand burns were invariably wrapped with non/low-adherent dressings. As burn contracture was found to be commonplace, hands were invariably placed in splints to minimise the effects of skin contractures. This "functional positioning" reduced the risk of “burns claw deformity” which is both difficult to correct surgically but also results in poor hand function.

The use of SSD cream in burns care enabled a new approach to be initiated. Rather than splinting the hand, the hand was placed in a cream-lined plastic bag which enables burns victims to mobilise and continue hand physiotherapy. This maintains hand function and reduces the risk of contracture. However, as previously stated SSD can significantly alter the appearance of both normal skin and burnt tissue making assessment of burn depth difficult. In addition, the SSD when mixed with copious burn exudate can make the burn dressing bag heavy which makes mobilisation difficult and can in fact lead to poor hand positioning (wrist flexion) with associated increased risk of contracture.

The more aggressive approach adopted by burns surgeons (early shave and graft) has meant that there has been some return to hand splinting with the hand immobilised until graft consolidation takes place. Hand grafting can be a time-consuming, laborious process. However, if correctly undertaken does have good outcomes. Dressing hands is never easy. Some surgeons now use adapted NPWT to maintain graft positioning and adherence post surgery.

**Face**
The face is obviously very important functionally and cosmetically. Scarring of the face leads to major social and psychological burns sequelae. It also can cause increased risk of damage to associated structures such as the eyes. In the 1940-50’s post-burn blindness secondary to eyelid retraction and corneal ulceration was commonplace.

The face is highly vascular, mobile and sensory. It is also very difficult to dress due to the need to maintain an adequate airway and enable eating and speech. Consequently there are differences in opinion on the best method of topical wound care. For conscious patients most clinicians adopt a semi-open approach with the skin covered in a light oil-based preparations (eg liquid paraffin) which is cleansed and re-applied regularly. Semi-occlusive dressings tend to be reserved for the unconscious patient and those with newly applied skin grafts.
**Perineum**
Burns to the perineum are surprisingly common. These are predominantly scald injuries as many individuals drop hot fluids into their laps when sitting. Apart from the issues of trying to get adequate coverage and protection of burnt tissue in this location, faecal and urinary contamination of the wound is a constant problem along with wound colonisation and infection. Urinary diversion via a urinary catheter is commonplace but is often seen as a short-term approach as the catheter poses an additional risk of sepsis in an already compromised individual.

**Burns management**
In burns, the surface of the skin is breached and an effective portal is established for infection. Therefore when managing these wounds some (though not all) clinicians will require a dressing product to be available which has an antimicrobial effect and which is capable of managing bioburden within the wound. These products will normally need to be a primary dressing material (i.e., they need to be kept in intimate contact with the wound bed). These may be used preventatively or in the active treatment of known bioburden. Antimicrobial efficacy needs to be maintained over the duration of the products wear time. This may be from 24 hours (in treatment) to seven days (in prevention). The antimicrobial agent used should be non-toxic to mammalian tissues, should not be absorbed systemically, should be biocidal against a wide range of pathogenic organisms and should not delay wound repair. It is open to debate whether the wound product should be part of a multi-layer topical dressing regime or should be of a single, composite dressing product. In the absence of evidence of clinical effectiveness and ease of use for each of these options, both strategies should be catered for in any product range. For ease of review both antimicrobial and standard dressing modalities will be considered in this review.

**Non-medicated wound care products.**
Currently, there are a number of products available which are advocated and used for this purpose in the field of burns and plastic surgery. Until relatively recently, tulle gras was the commonest non-medicated wound dressing material used in the treatment of burns. Despite the products numerous shortcomings it still remains popular in many clinical areas. Alternative dressing products have been introduced and trialled. The relative success of adoption has largely depended on the complexity of the presenting burn. In primary care burns tend to be limited in size and so standard wound care products are more likely to be used, (particularly self-adhesive products). However, in burns units the sheer scale of the burn injuries encountered has led to the adoption and utilisation of more burn-specific wound dressings.

**Medicated dressing materials**
Until recently, SSD cream was the most commonly used antimicrobial wound care product. As already discussed, this product has a number of disadvantages for wound healing, ease of use and subsequent patient management and so there has been a marked decline in its use within the specialist burns care environment. However there is still widespread use of the product in non-specialist areas, particularly within primary care. Alternative approaches to bioburden control in the burnt individual have been evaluated and trialled in clinical practice. These include a variety of foams and hydrofibres/alginites containing antimicrobials such as silver or PHMB.

A review of the evidence relating to the use of Molnlycke dressings is presented in Part 2 of this Review.
Part 2 Reviewing the evidence for Mölnlycke wound care products in the specialty

Mepilex Ag
Mepilex Ag has a significant role to play in the development of a burns and plastic surgery focus. Mepilex® Ag is a soft and highly conformable foam dressing that absorbs exudate, maintains a moist wound environment and inactivates wound pathogens within 30 minutes and for up to 7 days. The Safetac wound contact layer ensures that the dressing can be changed without damaging the wound and periwound area, or exposing the patient to additional pain. Mepilex Ag offers an alternative to SSD while also having the advantages of managing exudate and minimizing pain. In an open, parallel, randomized, comparative, multi-centre study Mepilex Ag was compared against SSD cream in the treatment of partial-thickness burns (Silverstein et al, 2010). Patients (n=101) were treated for 21 days or until healed. The Mepilex Ag group achieved faster healing rates (71.7% versus 60.8% at final visit) and were discharged from hospital almost 3 days earlier on average. Moreover, the median number of dressing applications during the study was 2 (range 1-5) in the Mepilex Ag-treated group and 13 (range 1-29) in the SSD-treated group. In another study, 18 patients with partial thickness burns treated with Mepilex Ag demonstrated antimicrobial protection that left the wounds with a clean appearance. Additionally, Mepilex Ag did not adhere to the wound, thereby giving clinicians the opportunity to either examine the wound or leave the dressing in situ for up to 7 days (Meites et al, 2008).

Silverstein’s study also noted the dressings’ ability to reduce pain. They found that patients reported a significant difference in pain scores, with the Mepilex group achieving statistically better average scores at dressing application (p=0.018) and during dressing wear (p=0.048) than those treated with SSD. Consequently, the cost of dressing-related analgesia was lower in the Mepilex Ag-treated group (p = 0.03) as was the cost of background analgesia (p=0.07). Analysis of the cost of treatment showed that Mepilex Ag was significantly more cost effective than the control group (Silverstein et al, 2010).

A study by Budkevich (Russian) has been identified but is not available in English and so cannot be evaluated in this report.

Mepilex Border Ag
No speciality-focused studies currently appear to be available for this product

Mepiform
Mepiform®, a soft silicone scar dressing with Safetac, has been evaluated in a number of studies for the treatment of hypertrophic scars. Saulsberry et al (1999) reported on four cases where Mepiform was used for scar management following surgical incisions and burns. Throughout the treatment period (at least 6 months for each patient), the dressing remained in place under a compression garment without displacement or interfering with joint mobility. The scars, originally hyper-pigmented, returned to a more normal colour with a smoother and more flexible texture.

In a study involving 87 adult and paediatric patients, assessment of the products effectiveness was undertaken on a variety of wound types including burns by individuals attending the hospital outpatients department. It was found that on evaluation the product was well tolerated, as well as improving scar quality and patient comfort (Cain et al, 2001).
In an open randomised study of 11 female patients following breast or abdominal surgery, the use of Mepiform was compared to a non-interventional control over a one-year period. Patients treated with the Mepiform product showed greater and more rapid improvements in their scar quality (Colom Maján, 2006).

**Mepitel**

Mepitel® was the first of the Safetac range of wound products and has been on the market for many years. As such it has been used in a wide variety of trials, studies and opinion papers. Not surprisingly, many of these have been based in the fields of burns and plastic surgery.

Mepitel® provides a moist wound environment, promotes wound healing, and is easy and relatively painless to use (Bugmann et al, 1998; Gotschall et al, 1998; Greenwood et al, 2000; Williams et al, 2001; Fowler, 2006). Mepitel is a porous, semi-transparent wound contact dressing, consisting of a flexible polyamide net coated with soft silicone. This layer is non-absorbent, but contains multiple pores (1.2 mm in diameter) that allow wound exudate to pass into the secondary absorbent layer. The dressing can be left in place for up to 14 days.

In a randomized controlled trial undertaken by Bugmann et al (1998), 76 children (age range: 3 months to 15 years) with previously untreated burns less than one day old were randomized to treatment with Mepitel (n=41) or SSD cream (n=35). For those patients assigned to Mepitel, one or more sheets of the dressing were applied directly to the burns in a single layer and covered with chlorhexidine-soaked gauze. In the comparator group, a thick layer of SSD cream was applied and covered by paraffin gauze followed by a layer of absorbent gauze. Wound dressings in both treatment groups were changed every 2–3 days until complete healing had been achieved. Mepitel-treated wounds were associated with significantly (p<0.01) faster healing time compared to those treated with SSD (7.6 days and 11.3 days, respectively). Moreover, the mean number of dressings used was significantly (p<0.05) less in the Mepitel-treated group compared to the control group (3.64 and 5.13, respectively). Mepitel was also reported to be easy to use and atraumatic on removal.

Mepitel was compared with SSD in a randomized control trial involving 63 children (aged 12 years or younger) with partial-thickness scald burns (Gotschall et al, 1998). Patients were randomized to treatment with Mepitel (n=33) or SSD (n=31); gauze dressings were applied over both treatments. Dressings were changed every second day. Wounds treated with Mepitel healed significantly (p=0.0002) faster (median time for complete healing was 10.5 days (Mepitel) and 27.6 days (SSD)), exhibited less eschar formation (p<0.05), and were associated with less pain at dressing change (p<0.05) compared to the SSD-treated wounds. Mepitel-treated wounds were also associated with significantly lower mean daily hospital charges (USD1937 versus USD2316, p=0.025), charges for dressing changes (USD413 versus USD739, p<0.02) and analgesia charges (USD52 versus USD132, p<0.001).

Mepitel has been demonstrated to be an effective non-adherent wound contact layer and has been reported to be effective in the treatment of skin graft donor site wounds (Edwards, 1998). In a case study series, two skin graft donor site wounds completely healed with no reported pain and healthy peri-wound skin after treatment with Mepitel (Barraziol et al, 2009). The authors highlight that Mepitel can be applied and re-applied without causing trauma, with the added advantage of minimizing pain at dressing changes. In another case study series, Mepitel was used to treat the donor
site of an auto-transplantation skin graft and to secure skin grafts (Marconi et al, 2009). Mepitel was reported to be effective, with healing to completion or near completion after 14 days. The dressing was easily removed without causing tissue trauma and pain to the patients.

Mepitel has been indicated as an alternative to tulle for almost 20 years. A number of published articles describe clinical evaluations in which Mepitel has been shown to be effective on newly grafted burns (Vloemans and Kreis, 1994; Platt et al, 1996; Atkinson, 1999; Chavez, 2004). In the Vloemans and Kreis study (1994) 38 children (age range: 6 months to 13 years) were enrolled in an open prospective study in which Mepitel was evaluated as an alternative graft contact layer for the fixation of skin grafts. In the study the outer dressings were changed every 1-2 days. With the Mepitel in situ, changing the outer absorbent dressings was painless, as was the final removal of the Mepitel itself. In addition, the use of Mepitel prevented disturbance of open wound areas at dressing changes. Healing was also reported to be good with 42 out of 45 cases reporting almost complete graft take.

Mepitel was also compared with paraffin gauze as the primary wound contact layer applied to 38 newly grafted burn wounds in a prospective RCT (Platt et al, 1996). Pain scores at the first postoperative dressing change were significantly (p<0.01) greater in the group treated with paraffin gauze. All patients with tulle gras dressings experienced some degree of pain on dressing removal, whereas 53% of patients in the Mepitel-treated group reported no pain. Mepitel was also found to be significantly (p<0.001) easier to remove. Further evidence of the usefulness of Mepitel in this indication has been presented in a case study in which the author states that the dressing proved to be ideal, providing the advantage of relatively painless removal, easy and effective graft fixation, and reducing operative time because no staples were needed for graft placement (Chavez, 2004).

The use of Mepitel instead of ‘tie-over’ dressings for lower limb split skin grafts has also been successfully reported. The method involves inserting tacking sutures or skin adhesive around the edge of the split thickness skin graft, applying paraffin gauze over the graft, followed by a layer of saline soaked gauze of foam; this is then covered with Mepitel dressing overlapping the edges of the graft by 2-3 cm. This technique has the advantages over the traditional ‘tie-over’ dressing of providing uniform pressure over the grafts, preventing shear on the skin graft site and reducing tension and the potential for soft tissue damage (Bache et al, 2008).

In discussing the different types of skin grafts that are managed in the community setting, Atkinson (1999) reports that Mepitel is commonly used to aid graft take, because it allows the free passage of exudate through its open mesh, adheres to the surrounding skin and not to the wound tissue, and facilitates atraumatic and pain-free removal. In addition, Mepitel has the advantage that it can be left in place for up to 14 days allowing only the secondary dressing to be changed if necessary and hence is more cost effective in the long term.

**Mepitel One**

Mepitel One is a variant to the Mepitel product range. It provides the benefits of Mepitel with a one-sided Safetac wound contact layer. Mepitel One can also be left in place for up to 14 days and offers higher transparency allowing assessment of healing progress without removing the contact layer and one-side only soft silicone aiding dressing handling. In a case study series involving 10 patients with hand burn injuries, Mepitel One was associated with low pain levels on application, while in situ, and on removal. The dressing was also rated highly in terms of ease of application and conformability (Mason and Edwards, 2010).
In essence, the evidence for Mepitel can be transferred to the Mepitel One product. However new evidence will be required for this product in the near future, especially as its design should overcome a number of the problems encountered with the earlier product.

**Mepilex**
Mepilex has been available for a number of years. However evidence of its effectiveness in the fields of burns and plastic surgery is very limited. An abstract of a Chinese study was identified on the internet. The full text was unavailable. From the abstract (author unknown-anon, 2010), the aim of the study was to determine the effect of Soft Silicone Foam Dressings in the Management of Middle-Thickness Skin Graft Donor Site Wounds. Thirty patients were included in this study. The skin graft donor site wounds were randomly divided into two groups to receive either petrolatum gauze (control group) or Soft Silicone Foam Dressings (Mepilex, therapy group). The outer dressings were changed at 3 days after operation and inner dressings were changed at 5 days after operation. Following this, dressings were changed every 2 days and observe the wound healing. The authors report that pain was released obviously in therapy group by 5, 7, 9 days post-operation. Better bacteriostatic effect existed in therapy group with significant difference compared with control group and there was significant difference between the two groups on the healing rate, with the Mepilex therapy group showing 97.4% (±5.3) and the control group 80.5% (±11.2) by 11 days post-operation (P<0.01). The authors concluded that in the management of middle-thickness skin graft donor site wounds, the application of soft silicone foam dressings (Mepilex) has obvious effect in releasing pain, depressing infection rate and accelerating wound healing.

**Mepilex border**
Where antimicrobial activity is not required, other foam dressings with Safetac technology have been reported to be of use in burn wound management. Mepilex Border is an all-in-one conformable dressing in an island presentation. Mepilex Border is useful for treatment of non-complex burns because it conforms well to the body’s contours and is shower-proof, without being bulky (Fowler, 2006). No substantial studies have been undertaken on this product.

**Mepilex Transfer**
Mepilex® Transfer is a relatively new product addition to the range. It is a thin and highly conformable foam interface dressing that is designed to enable exudate to move vertically into a secondary absorbent pad. This maintains a moist environment at the wound interface and enables the management of high levels of wound exudate through transfer of moisture into the secondary dressing. This product’s design and characteristics means it should be an ideal product for the management of SSG donor sites and burns which are not considered to need topical antimicrobial therapy. Fowler, (2006) stated that Mepilex Transfer is a useful dressing for burns as it is designed for application to exuding injuries covering large, awkward areas of skin while maintaining a moist wound environment. Currently, the supporting evidence for this product is weak. The effectiveness of Mepilex Transfer in the management of large donor sites was evaluated in 40 patients with burns (Kirsi et al, 2004). Mepilex Transfer was applied as a primary dressing and left in situ for 2–3 weeks. A secondary dressing, applied to absorb blood and exudate, was changed as necessary. A decrease in the number of painful dressing changes was observed after the introduction of Mepilex Transfer.

**Mepilex Lite/ Mepilex Border Lite**
Mepilex Border Lite is a low profile, absorbent, self-adhesive island dressing for situations where clinicians require a thin and highly conformable dressing for
anatomical or practical purposes, and where fluid handling requirements are low. It has been shown to be particularly useful in the treatment of paediatric burns (Meuleneire 2007; Morris et al, 2009).

An abstract of an article recently published in Chinese is available online. The work, authored by Wang et al (2011) describes a study using Mepilex Lite for the treatment of burns. The authors state that the objective of the study was to observe and compare the different clinical effects between applying mepilex (lite) dressing and vaseline gauze (tulle gras) to second-degree small-area burns. Seventy patients with second-degree small area burns were recruited and randomly divided into the observation group (Mepilex Lite) and the control group (tulle gras), with 35 cases in each study arm. The wound healing time, patient pain intensity, frequency of dressing changes, scar size and the presence/absence of keloid scar formation were observed and recorded. The authors found that the treatment effects of the observation group (Mepilex) were obviously better than that of the control group. The average healing time of the observation group was 11.80±3.88 days, compared to 15.44±4.50 days in the tulle gras group. Healing time of the observation group was significantly shorter than that of the control group. The patients' pain degree when changing the dressings: during changing the dressings, the total VAS pain score of observation group is (2.93±1.28), while that of the control group was (4.11±1.03). The total VAS scores of the observation group were significantly lower than that of the control group. The average frequency of wound dressing changes in the Mepilex group was 3.47(±1.27) times. The average frequency of the control group was 6.45 (±1.22) times. Comparing scar quality in the healed wound (using the regional scar healing rating) showed that in patients treated with Mepilex scar condition was assessed as: excellent in 12 cases, good in 16 cases, fair in 6 cases and poor in 1 case. In the control group scar quality was assessed as: excellent in 7 cases, good in 12 cases, fair in 13 cases and poor in 3 cases. The authors concluded that the effects of mepilex dressing applied to the small area burn can shorten the healing time, abate the pain of patients when changing the dressing, and reduce the frequency of dressing changes.

**Tubifast**

Tubifast was originally developed for use in the topical dermatological condition, an area where it has had great success. In addition, the product is used extensively in the management of leg ulceration as a sub-bandage dressing retention and additional absorptive layer. Although this product has great potential in the fields of burns and plastic surgery, there is little clinical evidence to support it currently.

**Tubigrip**

Despite the Mölnlycke website stating that shaped Tubigrip can provide compression therapy for post-burn scarring no evidence is offered.