Wound cleansing: a key player in the implementation of the TIME paradigm

Abstract
The concept of wound bed preparation can be implemented using the TIME paradigm. Chronic wounds are mostly characterised by prolonged inflammation and increased bioburden. Removal of wound biofilm and devitalised tissue, which is an ideal environment for bacterial growth, can help address the I in TIME. Wound cleansing aims to remove contaminants, debris, dressing remnants and superficial slough from the wound. Some wound cleansers contain surfactants, which reduce the surface tension of a liquid, enabling it to spread further over a surface. This article describes how these solutions can be used to debride the wound surface without damaging healthy cells.

Key words: biofilm • wound bed preparation • devitalised tissue • wound bioburden • wound cleansing • surfactants

With an estimated 200,000 people experiencing a chronic wound in the UK at any given time, representing an annual cost to the NHS of approximately £4bn,

1, it is critical that wound care is both clinically effective and cost-effective. One of the major approaches to the management of chronic wounds is the concept of wound bed preparation, which can be implemented using the TIME framework. This will enable health professionals to optimise the conditions within the wound bed to promote healing. This article describes the role played by wound cleansing in wound bed preparation.

Infection/inflammation control
The TIME acronym summarises the four main components of wound bed preparation:

• Tissue management
• Infection/Inflammation control
• Moisture balance
• Epithelial advancement at the wound edge

Given the increasing number of antibiotic-resistant strains of bacteria, which is being exacerbated by the overuse of antibiotics, the identification and management of wound infection, as stipulated in the TIME paradigm, is becoming ever more important. Patients can be at risk of wound infection if their host reaction to pathogens is less than optimal. This includes patients with poorly controlled diabetes, poor tissue perfusion, a poor nutritional intake, and/or who smoke and drink too much alcohol.

As every wound is different, the number of pathogens and variety of bacterial species in it will vary, which will in turn provoke a different host reaction. The varying levels of host reaction are characterised as contamination, colonisation, critical colonisation/localised infection and spreading/systemic infection. This range is known as the infection continuum (Table 1). All wounds contain bacteria but they may still heal normally. It is only when the microbial activity and bacterial count increase above an indeterminate threshold that the bacteria can become detrimental to wound healing. In such circumstances, interventions are required to reduce the bioburden.

Cutting et al. identified the characteristics of wound infection, which can be generalised as follows:

• Cellulitis/erythema
• Unexpected pain
• Friability of the tissues
• Wound malodour
• Wound breakdown
• Abnormal discharge
• Discolouration

Wound biofilm
Many regard the formation of biofilm as a precursor to infection. A wound biofilm is a colony of multiple bacterial species that is coated with a protective matrix (extracellular polymeric substance (EPS)), which can attach itself to a living or non-living surface. It can take only 4–6 hours for a biofilm to form sufficiently to provide a degree of protection from topical agents, with full maturity occurring within 2 days. Fig 1 shows a biofilm comprising meticillin-resistant Staphylococcus aureus (MRSA). Biofilms are microscopic and so cannot be detected by the naked eye, although if left to mature, they may show some pigmentation, which can enable identification. Phillips et al. postulated that biofilm production stimulates a chronic inflammatory response, with cells releasing high levels of matrix metalloproteinases (MMPs) and reactive oxygen species (ROS) in an attempt to dislodge the biofilm. These MMPs and ROS may also damage the extracellular matrix (ECM) and other healthy cells. Biofilms have been identified in up to 60% of chronic wounds compared with only 6% of acute wounds. The majority of biofilms are located in eschar or devitalised tissue, highlighting the importance of wound bed preparation in removing them from the wound.

Role of debridement
Chronic wounds often contain a degree of devitalised tissue, increasing the risk of bacterial colonisation and biofilm formation, which will impair healing. If the wound is to...

Matthew Pilcher
Vascular Specialist Nurse Practitioner, Vascular Surgery, Bradford Teaching Hospitals NHS Foundation Trust
Table 1. The infection continuum

<table>
<thead>
<tr>
<th>Description</th>
<th>Contamination</th>
<th>Colonisation</th>
<th>Critical colonisation/ localised infection</th>
<th>Spreading/systemic infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of non-multiplying bacteria in the wound</td>
<td>Presence of multiplying bacteria in the wound with no response from the immune system</td>
<td>Immune system is compromised and the patient is no longer able to control the multiplication of bacteria</td>
<td>Multiplying bacteria overwhelm the immune system resulting in clinical signs and symptoms</td>
<td></td>
</tr>
<tr>
<td>The wound is healing normally and the patient has no symptoms</td>
<td>The wound is healing normally and the patient has no symptoms</td>
<td>Includes slight odour, increased/new pain, increased exudate and localised erythema</td>
<td>Includes fever, malodour, excessive exudate, severe pain and spreading erythema. The wound is breaking down</td>
<td></td>
</tr>
</tbody>
</table>

have any chance of healing, the wound bed must resemble that of a healing acute wound. This can be achieved by debridement. In essence, debridement refers to the removal of devitalised and necrotic tissue in order to encourage healthy granulation tissue. Debridement and wound cleansing can also facilitate the physical removal of biofilm. As such, the debridement process should be considered an important aspect of wound care. The removal and management of biofilm formation has become an increasingly important aspect of wound management. However, repeated and targeted topical treatments and debridement, as required, are usually necessary to achieve the desired result. Repeated treatment is required due to the rapid onset of biofilm formation following contamination, as illustrated in in-vitro studies.

Wound cleansing as a management tool

Wound cleansing, which has been a routine part of wound management for centuries, aims to remove contaminants, debris, dressing remnants and superficial slough from the wound. However, for many years it has been performed in a ritualistic manner, with a minimal evidence base on its clinical efficacy. A literature review on the limited research, published in 2001, found that none of wound cleansing solutions used at that time— ranging from sterile saline, distilled water, tap water to povidone-iodine solution— were associated with a difference in wound infection rates. Despite this, wound cleansing followed by regular debridement is considered a basic principle of wound bed management.

The use of physical techniques, such as swabbing/scrubbing techniques, during wound cleansing has been shown to cause trauma to the tissue and therefore to delay healing. Wound irrigation has become more accepted, as it is more likely to preserve new granulation and immature epithelial tissue, although there is little consensus on the pressures required to effectively irrigate without causing wound trauma.

Octenidine

The indiscriminate use of antiseptics for cleansing and within topical dressings in wound bed preparation has been shown to be detrimental to wound healing. Antimicrobial dressings should be applied only when required and as indicated, in accordance with the manufacturer’s instructions. For example, silver dressings should only be used on wounds with localised or spreading infection and their use reviewed after 2 weeks. It is therefore important to limit the use of antiseptics to when bacterial levels are posing a problem.

One alternative to antiseptics is the use of products based on octenidine, which is available in the form of octenilin Wound Irrigation Solution and Wound Gel (Schülke & Mayr GmbH, Germany). Octenilin Wound Irrigation Solution, which contains the preservative octenidine dihydrochloride, is a safe and effective cleansing solution.

Octenilin Wound Irrigation Solution contains ethylhexylglycerin, which is a surfactant-type molecule. A surfactant is a substance that reduces the surface tension of a liquid, so that the liquid can spread further over a surface. By lowering the surface tension of the solution, octenilin increases the wetting effect (that is, it moistens the skin and loosens biofilm and devitalised tissue). Another wound cleanser containing a surfactant is Prontosan (B Braun), the surfactant found in Prontosan Solution and Wound Gel is called betaine.

Octenilin has a much lower surface tension compared with Ringer’s solution and Prontosan solution (Table 2). An in-vitro study showed that octenilin prevented biofilm formation, and appeared to have the potential to remove mature biofilms. A RCT investigating the use of an octenidine-dihydrochloride hydrogel on skin graft donor sites found that it can be used as an effective barrier dressing, preventing any wound contamination, while its markedly low toxic...
effect on healthy cells makes it safe to use in all stages of the wound healing process.20

The effective management of biofilm formation and tissue management could have a significant effect on aspects of the wound, such as its pH level. A non-healing chronic wound is likely to have a higher (alkaline) pH. This enables MMPs, whose number increases when the wound is in a state of chronic inflammation, to break down the ECM and wound proteins, which in turn increases the metabolic load, creating higher levels of tissue hypoxia.21 It could be argued that removing the cause of the inflammation will reduce the number of inflammatory mediators and cytokines, which will in turn reduce the wound pH to a more neutral or acidic level. Even a change in pH of 0.6, which will make the wound more acidic, can increase the oxygen perfusion into the wound.22

Conclusion
The contamination of a wound by either planktonic or biofilm bacteria can cause chronic inflammation, resulting in non-healing/poor healing wounds. A key aspect of wound management is to remove all necrotic and devitalised tissue from the wound bed, and eradicate as far as possible any biofilm formation. While antiseptic dressings can help to reduce the bioburden within the wound, they can also have detrimental effects on the healing tissue if not used in accordance with best practice guidelines and the manufacturer's instructions for use.23 Use of octenilin Wound Irrigation Solution (for wound irrigation) and octenilin Wound Gel (which helps decontaminate and supports the healing process) not only manages immature biofilm production but has also demonstrated the potential to disrupt established biofilms. Its low toxicity to healthy cells allows for its use throughout all stages of the wound healing process. The rest of this supplement comprises case studies demonstrating the efficacy of octenilin Wound Irrigation Solution and Wound Gel on a variety of wound types.

Table 2. Results of a comparison of the surface tension of three wound cleansing solutions17

<table>
<thead>
<tr>
<th>Solution</th>
<th>Surface tension (mN/m)</th>
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<tbody>
<tr>
<td>Ringer's solution</td>
<td>71.7</td>
</tr>
<tr>
<td>Prontosan</td>
<td>44.4</td>
</tr>
<tr>
<td>Octenilin</td>
<td>30.6</td>
</tr>
</tbody>
</table>

Surface tension was measured in the laboratory using the pendant drop method. The difference in surface tensions between octenilin and Ringer's/Prontosan was statistically significant (p<0.001)

17 Cutting, K., Westgate, S. The use of wound cleansing solutions in chronic wounds. Wounds UK 2012; 8: 4; 130–133.
18 Lloyd Jones, M. Wound cleansing: is it necessary, or just a ritual? Nursing & Residential Care 2012; 14: 8; 396–399.
21 Gettin, G. The significance of surface pH in chronic wounds. Wounds UK 2007; 3; 3; 52–56.