Gelling alginate dressings and their contribution to wound management

The authors of this article discuss the development of alginate technology and its use within the management of exuding wounds and assess how ActivHeal Aquafiber® performs, and observe wound progression within standard care. A clinical market evaluation was conducted in two UK sites. The primary objective of the study was to observe the wound progression in terms of wound size and condition of the wound bed. The outcome of the evaluation demonstrated Activheal Aquafiber® effectively manages exudate, can assist in autolysis and improves peri-wound status.

KEY WORDS
- Exudate management
- Pressure ulcers
- Alginates
- Fibre dressings

Posnett and Franks (2008) have calculated that 200,000 people in the UK have a chronic wound, with an estimated treatment cost of between £2.3billion and £3.1billion per year. Chronic wounds have proven costly to the NHS due to prolonged treatment periods, frequent dressing changes, more nursing time used and the potential for further deterioration (Harding et al, 2007). The challenge of chronic wounds remains significant in terms of clinical management, impact on patients and cost to the NHS. Chronic wounds by nature often have clinical features that are challenging to treat and are complicated by the presence of other comorbidities. Chronic wounds may be large in size, have sloughy or necrotic tissue present, be at risk of infection and may have excessive levels of exudate (Vuolo, 2009). The management of wound exudate is one of the key components of an effective wound dressing. How effectively a dressing manages wound exudate affects a number of factors, including condition of the surrounding skin, wear time and healing rates and patient quality of life (World Union of Wound Healing Societies [WUWHS], 2007). The challenge in managing exuding wounds is to maintain a moist wound-dressing interface, while at the same time possibly effectively absorbing and retaining exudate, keeping exudate away from the skin, performing under compression bandaging, being easy to remove, and being cost-effective (White and Cutting, 2006). Fibrous dressing are a popular absorptive dressing that are indicated for wounds with moderate to high levels of exudate. There are two main types of fibrous dressings in wound care: natural fibres and synthetic fibrous dressings. Synthetic fibrous dressings, also commonly known as hydrofiber dressings, are similar to alginate dressings and are indicated for the same wound types.

EXUDATE MANAGEMENT

Wound exudate is a key component of wound healing in a healthy wound. It is produced throughout the healing process from inflammation to epithelialisation and must be managed to maintain a moist wound environment that promotes healing (Collins et al, 2002). Wound exudate can give clinicians many challenges and it is important to achieve and maintain an optimum moist environment. The challenges include:

- Removing harmful bacteria and enzymes from the wound to reduce instances of delayed healing
- Retaining and controlling exudate levels to prevent maceration
- Minimising patient pain and discomfort during dressing changes or when dressing is *in situ*
- Containing cost while providing effective care (WUWHS, 2007).

Exudate is defined as a fluid produced in wounds, made up of serum, leukocytes and wound debris.

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The volume of exudate reduces as healing progresses. Exudate is thought to have bacterial and nutrient properties (Adderley, 2008). It facilitates the migration of vital tissue-repairing cells and provides essential growth factors and nutrients for wound healing (White and Cutting, 2006). Exudate facilitates wound bed autolysis of dead or devitalised tissue and transports essential cell metabolising nutrients, growth factors and immune cells as well as preventing the wound drying out (WUWHS, 2007). In non-healing wounds, excessive amounts of exudate can prolong the inflammatory phase, impede growth factors, and prevent or delay cell proliferation (WUWHS, 2007). If wound levels increase and are not effectively managed, the wound bed will become over hydrated, leading to excessive moisture forming on the peri-wound skin and further tissue damage (Tickle, 2012). Poor management of exudate can lead to increased demands on clinicians' time and resources.

Dressing selection should be tailored to the condition of the wound and the peri-wound skin following a full wound assessment. Thomas (2008) identified key characteristics of effective wound dressings that included that the dressing absorbs and retains exudate, keeps harmful exudate away from healthy intact skin, performs under compression therapy, is non-traumatic on removal and is effective in both cost and wear time.

DRESSING DEVELOPMENT AND USE

The term 'fibre' dressings is used to describe products manufactured using alginates or carboxymethylcellulose products, which are also known as hydrofibers. These dressing products have similar uses in clinical practice, in that they are used primarily to absorb wound exudate. Once dressings becomes moistened, they retain the exudate, forming a gel product. As such they are able to assist in the debridement of soft slough.

Alginates have been used within the wound care industry since the early 1940s and are still considered a complex and versatile dressing, despite newer technologies becoming available (Clarke, 2012). The manufacture of alginates was first reported in the 1800s with the first commercial production in the 1930s (Thomas, 2000a), with alginates being used for a variety of applications. Rinaudo (2014) discusses that alginates have also been used in food for their gel-forming ability in jams and jellies along with use in packaging, paper, textiles and the pharmaceutical industry. The use in medical textiles was a growing field, and the use of alginates showed great expansion in wound management products. The first clinical reports were recorded using alginates in 1983; being used for haemostasis, absorption of exudate, absorbability in tissue and lack of toxicity (Fraser and Gilchrist,1983; Gilchrist and Martin, 1983). The upsurge in the use of alginates in the early 1980s arose through the growing interest in the treatment of acute and chronic wounds (Clarke, 2012).

ALGINATE TECHNOLOGY

Alginates in their natural form are the cell-wall constituents of marine brown algae (Phaeophycea). Alginates are extracted from a variety of species of seaweed, mainly laminaria, Macrocytis and Ascophyllum (McHugh, 1987). Alginic acid is extracted from seaweed and then purified. Alginic acid is a linear polymer with two monomers known as D-mannuronic acid (M) and L-guluronic acid (G) (Draget et al, 2005). Different seaweeds and different parts of the seaweed, i.e. leaves and stem, give rise to varying ratios of the two monomers M and G. The alginic acid is then reacted with sodium chloride to form sodium alginate, and dried to form a powder. Sodium alginate is dissolved in water to form a thick solution. This is forced under pressure through tiny apertures into a solution of a calcium salt. An ion exchange reaction occurs where sodium in the alginate is replaced by calcium. The calcium crosslinks the polymer to make it insoluble and form the fibres (Thomas, 2000b). This is the foundation for alginate wound dressings. The proportions and arrangements of the M, G and MG blocks have an effect on the chemical and physical characteristics of the alginate and any fibre dressing made from it. The higher the content of guluronic acid in the alginate, the greater the interaction and the more stable and harder the gel, therefore giving the alginate wet strength and one-piece removal (Thomas, 2000a). In high M alginates there is an increased fibre swelling and faster gel formation. High M alginates form softer gels than those rich in high G (Thomas, 2000a).

The differences in gel structure caused by the differences in chemical structure have important implications for the products' clinical use. When the alginate dressing comes into contact with an exuding wound, an ion exchange takes place between the calcium, ions in the dressing and the sodium ions in the wound fluid. When a significant proportion of the calcium ions on the fibres have been replaced by sodium the fibre swells and partially dissolves, forming a gel-like structure (Rinaudo, 2014). In this way they produce moist wound healing conditions that create a moist wound healing environment as well as promoting autolysis (Benbow, 2005).

Coagulation is an important part of haemostasis and is an essential part of the healing process for both acute and chronic wounds. Blaine in 1951 demonstrated that alginate dressings were haemostatic. Calcium ions released from the dressing in exchange for sodium ions in the blood activate the clotting cascade by stimulating platelets and clotting factors. In certain clinical situations the absorption of blood by dressings is paramount. Alginates are used to pack or cover the wound to aid in haemostasis, absorb blood or exudate and provide a moist wound healing environment. Alginates can act as a haemostat to control minor bleeding in superficial wounds (Thomas, 2000b). Alginates are also known to break down to simple monosaccharide type residues and be totally absorbed. The wound exudate converts the calcium to the sodium salt, facilitating the removal of the dressing by dissolution. Any residual fibres remaining in the wound are biodegradable thus eliminating the need for complete removal (Barnett and Varley, 1987). Alginates are viewed as being biocompatible, hydrophilic and biodegradable under normal physiological conditions (Becker et al, 2001). Once in a gel form, alginate dressings will also promote healing and epidermal regeneration (Timmons, 2009).

FIBRE DRESSINGS AND ECOLOGY

The use of 'natural' products is attractive to a number of individuals, and as such the use of alginates manufactured by Advanced Medical Solutions (AMS) are harvested from renewable sources in Scotland.

AMS is one of a few British manufacturers who produce their products in a purpose-built environmentally friendly facility in the UK, with the aim of reducing the impact on the environment. This includes measures to produce lower power usage, emissions and less waste.

ActivHeal Aquafiber®

ActivHeal Aquafiber® is a highly absorbent, non-woven high M gelling alginate fibre dressing with a reinforced hidden web, which is needled into the felt during the manufacturing process. This reinforcement gives the dressing a high wet tensile strength, so that it can be removed intact without leaving any fibres in the wound (Kesteven et al, 2012). When the dressing fibres come into contact with exudate, they swell and form a soft cohesive gel dressing that provides an ideal moist environment to support wound healing. Once in a gel form, alginate dressings will also promote healing and epidermal regeneration (Timmons, 2009). The dressing provides an environment that aids in the facilitation of autolysis of devitalised tissue and managing excess exudate (Hawkins, 2010). It is indicated for use as a primary dressing in exuding acute and chronic wounds; however, a secondary dressing may be required based on the level of exudate. It is designed for use in the management of medium to heavily exuding full thickness, partial thickness, acute and chronic wounds. Aquafiber® is able to absorb a large amount of wound exudate. *In vitro* testing indicates 23 g of fluid per 100 cm^2 of dressing over a 24-hour period (AMS, 2013). Aquafiber® is not recommended for use on patients with dry wounds but can be used as a haemostat to control minor bleeding (Thomas, 2000a).

Activheal Aquafiber® has the capability to absorb exudate vertically into the dressing, reducing the risk of maceration and damage to the peri-wound skin or to the wound itself (Timmons, 2008; Ousey et al, 2011). ActivHeal Aquafiber® meets the key characteristics of the absorption and retention of exudate, reduced lateral wicking, aiding of autolysis and providing a moist wound healing environment (Ousey et al, 2011). It is vital when selecting dressings to absorb and manage exudate that the product's components and its mode of action are fully understood in order to ensure correct selection.

Table 1. Number of patients and range of wound types

Wound types	Number of patients	Wound diagnosis	Number of wounds
Pressure ulcers	6	Grade 3 Grade 4	2 4
Leg ulcers	4	Venous Arterial	4 1
Surgical wounds	6	New surgically debrided wound Dehisced/delayed healing	1 5
Other	4	Moisture lesion Cellulitis Haematoma Diabetic	1 1 1 1

EVALUATION

An evaluation of ActivHeal Aquafiber® was undertaken in two sites within the UK, to observe the clinical outcome and clinician's opinion of the dressing. The design was a product evaluation, where the dressing was used within the standard practice delivered by the centre. This was the preferred design to generate information on a wide range of patients, some of which may be excluded in a more controlled study, and to observe current practice when alginate dressings are used.

Within this design, the clinicians were not restricted by a protocol to control the process, but were provided with guidelines in which information on the dressing was included, the inclusion and exclusion criteria and the maximum length of time for the evaluation, which was four weeks. A copy of the guidelines was attached to the data capture documentation that included a form which was signed by the evaluating clinician before the patient was included, to confirm that consent was obtained from the relevant organisation, the patient (which included medical photography for publication) and the patient's medical practitioner.

The primary outcome of the study was to observe the wound progression in terms of wound size and condition of the wound bed. Secondary objectives included the frequency of dressing change, the level of exudate, infection status and peri wound skin condition at the start and end of the evaluation.

Once the patient was assessed as suitable for the evaluation and the appropriate consent given and documented, the dressing was applied according to the manufacturer's instructions for a maximum of four weeks or until the clinician assessed that the dressing was no longer appropriate and an alternative product would be more beneficial or the wound had healed. Patient comfort was also assessed during the evaluation and, if requested by the patient, the dressing would be discontinued.

At the initial assessment, the patient's age, sex, comorbidities and medication were documented. Patient confidentiality was maintained throughout both in the documentation and wound photographs. Following this specific wound information was recorded to include the aetiology, site, size and the percentage of healthy and unhealthy in the wound bed tissue which was estimated by the clinician undertaking the assessment. A baseline assessment of exudate level, infection status, and condition of the periwound skin was included and an initial photograph taken. These parameters were re-assessed and recorded at each subsequent dressing change.

Although ActivHeal Aquafiber® was being evaluated, no other changes to clinical practice were made. The clinicians would clean and debride the wound as planned for each patient within the standard practice, and supporting therapies such as compression bandaging and offloading of the wound would be as required. However, as this product requires a secondary dressing, this was left to the discretion and clinical judgement of the clinician.

All data was recorded on a standardised data capture form by the clinicians who treated the patient and at the end of the evaluation process was analysed using a simple Excel spreadsheet. Because of the small numbers of patients and study design, statistical analysis was not planned, although the outcomes of the evaluation may be used to power larger, more controlled comparative studies.

OUTCOMES

The evaluation was undertaken in two different environments — a ward environment within an acute hospital, and a podiatry clinic, which treated complex foot wounds on an outpatient basis. As a result, the wounds varied in aetiology, size and duration; however, they were all assessed as requiring an alginate primary dressing at the wound bed to facilitate the management of excess exudate.

The evaluation took place over a 6-month period, where ActivHeal Aquafiber® was used on 20 patients

(5 males and 15 females) with ages ranging from 43 to 88 years with a mean of 72.3 years. *Table 1* demonstrates the range of wound aetiologies included.

The primary objective of the product evaluation was to observe wound progression when using ActivHeal Aquafiber® within standard care. This was determined by initially measuring the size of the wound by clinicians using a sterile ruler to measure the maximal length by the maximal perpendicular width (Gethin, 2006). Deep cavities were probed to identify the full extent of tissue damage. There was a wide range of wound sizes and depths included in the evaluation.

Pressure ulcer wounds

- 30% (*n*=6) of patients presented with pressure ulcers (1 of which was grade 3, the remaining were grade 4). These ranged from 32 to 300 cm^2, with a mean of 110.6 cm^2. These wounds had cavities that required packing, one of which was extensive and extended down to bone, and one of which undermined by 18 cm. At the end of the evaluation all wounds had improved although the mean size was still 81.8 cm^2, but only three patients had cavities that required packing, the maximum depth of which was 7 cm.
- Initially all of these patients were assessed as having high levels of exudate, but at the end of the 4-week evaluation period this was considered to be 'moderate' by the clinician in four patients, and the frequency of dressing change was reduced to alternate days or every 3 days.
- The secondary dressing used in conjunction with ActivHeal Aquafiber® was a foam adhesive dressing (20% of patients, *n*=4) and an absorbent pad (10% of patients, *n*=2).
- 25% of patients (*n*=5) initially had excoriated or inflamed skin in the periwound area. At the end of the evaluation period they were all assessed as having healthy tissue present.

Leg ulcers

- Four patients with leg ulcers were treated in the evaluation, which was 20% of the total number. The wound area was similar in these patients, ranging from 118 cm^2 to 122 cm^2, with a mean of 120 cm. A patient who presented with a large arterial wound was also documented as having bone and tendon exposed. At the end of the evaluation period this had been covered with granulation tissue, and the mean wound size of all wounds had reduced to 67.5 cm^2.
- All of the leg ulcers included in the evaluation were initially exuding high amounts of exudate. This decreased in two patients by the end of the evaluation period, with data missing for the remaining one.
- Again either a foam adhesive or adhesive pad was used as a secondary dressing. The data evaluation form did not indicate whether compression therapy was also used on the patients with venous disease.
- Three patients were identified to have peri-wound skin damage at the start of the evaluation, which, resolved by week 2.

Surgical wounds

- Two patients in this cohort were treated by a specialist podiatry service, as they were digital amputations in diabetic patients. The remaining four patients were in patients in an acute care setting.
- The wound sizes ranged from 2.8 cm^2 to 270 cm^2, with five of the wounds presenting with a cavity that required packing. The depth of the cavities varied from 1.4 cm to 15 cm. One patient healed and wound size reduction was recorded in the three remaining patients. The wound size increased in the two diabetic patients, but this may have been attributed to the radical debridement of the wound margins to remove callus.
- Overall the mean wound size reduced from 473.6 cm^2 to 50.5 cm^2, with a reduction in cavity depth observed in all patients.
- Five patients were initially assessed as having high levels of exudate, with the remaining being moderate. At the end of the 4-week evaluation period, two patients no longer required the alginate dressing as the exudate level was too low, and the remaining two patients were considered to have moderate amounts.
- The wounds of the four patients treated within the acute hospital, were treated with a foam secondary dressing. Those patients treated by the specialist podiatry team had a secondary dressing of sterile gauze. This was used to minimise bulk in the specialist footwear that

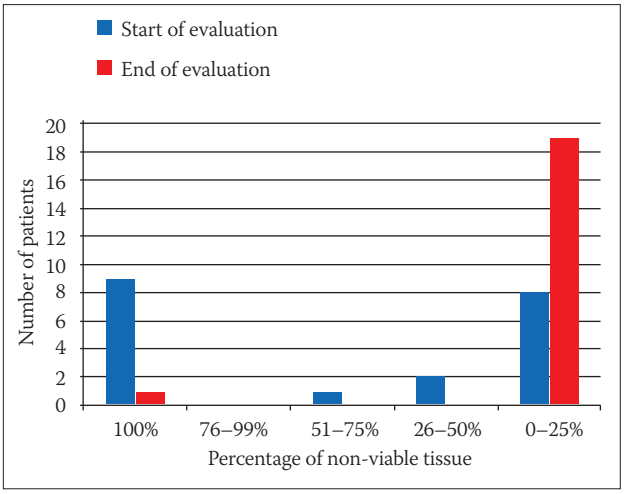

Figure 1. Non-viable tissue in wound bed at the start and end of evaluation.

was required for offloading the wound.

Other wound types

These included a diabetic foot ulcer, a haematoma, a circumferential cellulitis of the leg, which was weeping copious amounts of fluid and a small moisture lesion on the buttocks.

- All of these wounds were assessed as having high levels of exudate, and therefore were suitable for an alginate dressing. In all four patients a non adherent pad or gauze dressing was applied. This was because of the risk of faecal contamination (moisture lesion) or the wound required daily observation as a result of the presence or risk of infection.
- Only the peri-wound skin of the cellulitic leg was recorded as damaged through excoriation, and this only improved slightly over the evaluation. In the remaining patients, the skin remained intact.
- The wound size of the cellulitic leg was not measured, although the sizes of the remaining wounds ranged from 2 cm^2 to 20 cm^2. At the end of the evaluation period, the moisture lesion had healed, the haematoma wound had reduced in size, but again there was increase in the wound margins of the diabetic foot ulcer, but extensive debridement had been part of the treatment.

The condition of the wound bed was also observed, with reduction in devitalised tissue indicating a progression towards healing. Although alginate dressings are not always the first choice for debriding wounds, the gelling action of the product can assist in autolysis, which can be an additional benefit to managing excess exudate. This was demonstrated in *Figure 1* where a decrease in viable tissue was observed. At the start of the evaluation, 45% (*n*=9) patients were recorded as having 100% of non-viable tissue which reduced to 5% (*n*=1) at the end. In addition, 40% of patients (*n*=8) were recorded as having 25% or less viable tissue in the wound bed, which then increased to 95% (*n*=19) at the end of the evaluation. This suggests that ActivHeal Aquafiber® can provide an environment to support wound progression by not only managing exudate balance but also providing a maintenance debridement function.

The secondary objectives of the study were to observe the effectiveness of ActivHeal Aquafiber® in managing wound exudate. Alginate dressings are indicated for moderate to highly exuding wounds, and because of their ability to absorb up to 20 times their own weight in fluid can reduce the frequency of dressing change (Thomas, 2000b). Excess wound exudate that leaks on to the peri-wound skin can cause excoriation and maceration, which can be uncomfortable for the patient and promote further wound deterioration.

The outcome of the evaluation demonstrated that:

- 90% of patients (*n*=18) were recorded to have high levels of exudate at the start. At the end of the evaluation period the exudate levels had reduced in 90% of patients (*n*=18), with the final data missing for 1 patient (*Figure 2*). Clinicians had been asked to assess the exudate level using the preset criteria of low, moderate and high — and while this may be subjective and inconsistent, this is reflected in how it is measured in everyday practice.
- Only 25% of patients (*n*=5) were initially observed to have healthy tissue surrounding the wound, indicating that the previous dressing regimen was not protecting peri-wound skin from excoriation or maceration. An improvement in the peri-wound skin was observed at the end of the evaluation period when this increased to 90% (*n*=18) after the plan of care was changed to include ActivHeal Aquafiber®.
- 35% (*n*=7) of patients were identified to have a wound infection at the initial assessment, all of which were treated with systemic

antibiotics. While ActivHeal Aquafiber® is not an antimicrobial dressing, daily dressing changes were undertaken and no new infections developed in the evaluation wounds.

- The choice of secondary product was either a foam or non woven dressing. As a product evaluation, the choice of secondary dressing was left to the discretion of the clinician, and as such may have contributed to the outcome of the evaluation.
- All clinicians reported that the dressing was easy to use, and was conformable to the wound bed.

DISCUSSION

This simple product evaluation has demonstrated that ActivHeal Aquafibre® is suitable for use in a range of wounds within two very different clinical environments. The study was limited in that practice was observed rather than controlled, but it suggests that while alginate products have a long history of use, their use is still important in managing chronic wounds. ActivHeal Aquafiber® has the ability to manage moderate to high levels of exudate effectively and aid/facilitate autolytic debridement of devitalised tissue. ActivHeal Aquafiber® demonstrated effective management of exudate and demonstrated wound progression. The dressing provided good clinical outcomes while allowing easy dressing usage and not causing pain and trauma to the patient on removal.

CONCLUSION

Caring for patients with chronic wounds and controlling exudate is one of the biggest challenges for clinicians. Managing wet wounds is costly in terms of resources, including dressing choice and nursing time. In the present climate, healthcare needs to ensure that resources are used efficiently. Alginate dressings remain a successful method to treat a variety of wounds due to the additional benefits from its composition and therefore should be considered as a cost-effective treatment in managing highly exuding wounds. There is a need for a higher level of wound dressing absorbency, as well as the importance of clinical effectiveness alongside cost effectiveness.

While remaining cost-effective the natural composition of alginate dressings also offers clinicians a number of additional benefits to aid healing. The ActivHeal Aquafiber® ranges of dressings have been clinically proven to aid wound healing in a wide variety of wound types where exudate management is a treatment aim. Clinical feedback has also provided evidence that the additional properties provide an invaluable offering; which can be considered during dressing selection (Ousey, 2011). Alginates have an important role to play in wound care due to their ability to absorb, conform and provide moist wound healing properties and they shouldn't be forgotten when determining the most suitable dressing for a wound and the patient.

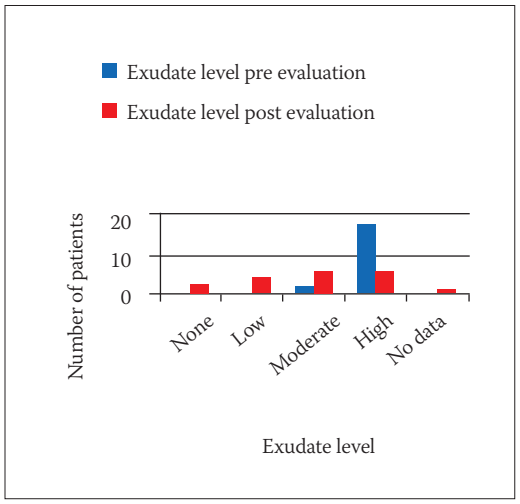

Figure 2. Exudate levels pre and post evaluation.

CASE STUDY

Treating complications of injection anthrax using ActivHeal Aquafiber® and ActivHeal Foam Adhesive®

Patient A is a 32-year-old male intravenous drug user who had injected heroin into his right femoral artery. Unknown to the patient the heroin had been mixed with a substance that contained anthrax spores. The patient presented with an area of blistering, extensive bruising and oedema to the right groin (*Figure 3*) and also bruising to the right anterior hip (*Figure 4*) due to tissue destruction. The patient was admitted to ICU with multiple organ failure and sepsis. He presented with gross oedema of the right groin, with skin blistering and areas of necrotic tissue. Initially, it was suspected that the patient was suffering from necrotising fasciitis. However, the diagnosis of *Bacillus anthracis* was confirmed from blood cultures. The patient underwent exploratory surgery to ascertain the depth of the tissue destruction,

Figure 3. Right groin. Initial assessment (Day 1).

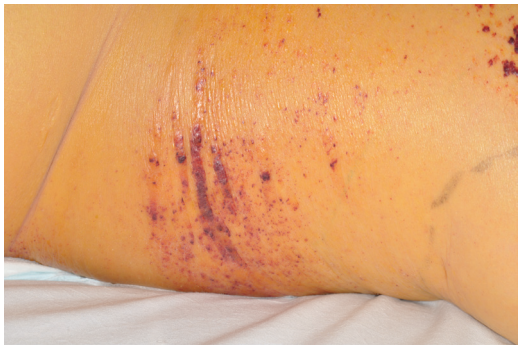

Figure 4. Right lateral hip. Initial assessment (Day 1).

Figure 5. Right lateral hip after surgical debridement (Day 1).

Figure 6. Right lateral hip (Day 27).

which resulted in the surgical debridement of the two necrotic areas to viable tissue, which was then reffered to tissue viability for further treatment.

Following holistic wound assessment from tissue viability, it was decided that, due to the size of the wound and the complications of gross oedema of the trunk and lower limbs, the larger wound would be managed with topical negative pressure due to the size of the wound and the amount of exudate being produced by the wound. With the smaller wound being treated with ActivHeal Aquafiber® and ActivHeal Foam Adhesive® as a secondary dressing. Treatment aim:

- Exudate management
- Creation of a moist wound healing environment
- Promotion of granulation
- Protection of peri wound skin from maceration due to excessive exudate production.

MANAGEMENT

The second wound (*Figure 5*) was dressed using ActivHeal Aquafiber® to manage exudate, promote healing and reduce the risk of further infection.

The wound was assessed and found to contain 5% necrosis and 10% slough with very high exudate levels due to the gross oedema of the patient due to complications from anthrax infection. The wound margins were clear and there were no signs of maceration. However, there was some minor blistering of the surrounding skin due to the infection. The wound was initially dressed on a daily basis with ActivHeal Aquafiber® as primary dressing and ActivHeal Foam Adhesive® as secondary dressing. This was due to the gross oedema of the patient due to the infection.

The wound was re-assessed by tissue viability on day 6. The wound was found to contain no necrosis or slough; however, the wound signs of granulation tissue (30%) and epithelial tissue (10%) The peri-wound skin was intact. Due to the very high exudate levels, the wound still required daily dressing changes.

The wound was re-assessed again on day 10 by tissue viability. The wound continued to improve, with the levels of exudate reducing. The wound bed remained clean with no signs of slough or necrosis. Furthermore, there was granulation (40%) and epithelial tissue (20%) as the exudate levels were reducing. The wound was now re-dressed on alternate days.

A further assessment was carried out on day 20. The wound continued to show signs of improvements having almost healed with the wound bed containing 80% granulation and 60% epithelial tissue. Peri-wound skin was good and exudate levels had greatly reduced. By day 27 the wound had completely healed and no longer required dressing.

DISCUSSION

Anthrax is an infectious disease caused by bacteria known as *Bacillus anthracis*. The bacterium can exist in a form known as a spore, which allows survival in the environment (for example, in the soil). Occasionally, humans may contract anthrax if they come into contact with infected animals or contaminated products.

Anthrax can enter the human body through the intestines (ingestion), lungs (inhalation), or skin (cutaneous); however, a new type has emerged. Injection anthrax was described first in 2000 in a heroin-injecting drug user in Norway (Grunow et al, 2013). This occurs as a result of the patient injecting heroin that has been contaminated by anthrax spores. Symptoms are similar to cutaneous anthrax but there may be infection deep under the skin or into the muscle where the drug was injected. Furthermore, injection anthrax can spread throughout the body faster and be harder to recognise and treat (Hendricks et al, 2014).

The presence of infection and inflammation in

the wound will influence the amount of exudate produced (Wounds UK, 2013). In this case the patient was suffering systemic infection-sepsis, multi-organ failure and oedema, which all contributed to the high levels of exudate produced from the wound. High levels of exudate could have potentially led to complications such as pooling of exudate, and damage to peri-wound skin so the challenge was to select a dressing that would remove excess moisture while maintaining an optimal moist wound environment for healing (Wounds UK, 2013). Furthermore, prolonged or excessive contact with moisture will cause the keratinised cells in the epidermis to swell and become waterlogged, leading to epidermal stripping and breakdown of the skin (Wick, 2012).

Managing the exudate levels in the wound was vital in this case. The correct dressing used as part of holistic care of the patient can have a significant impact on the healing of chronic or problem wounds (Morris, 2006). In this case the correct choice of dressings provided a positive patient outcome and also demonstrated a good healing time despite the comorbidity of the patient.

CONCLUSION

The patient responded well to the treatment and made a full recovery from his exposure to anthrax, as this potentially could have been fatal. The correct dressing choice in this case meant that the patient, despite having intensive and complex wounds, was managed quickly and effectively without an overly long treatment time WUK

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