Evidence of Intensive Autolytic Debridement With a Self-Adaptive Wound Dressing

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Abstract: Background. Chronic venous leg ulcers (VLUs) can be challenging to manage and heal. Despite the observed efficacy of surgical debridement, many patients with VLUs refuse the procedure due to the associated pain. Autolytic debridement induces no pain, but is slow or disrupted in chronic VLUs. Elucidation of the wound dressing functions that are sufficient to support autolytic debridement is needed.

Materials and Methods. The authors report 2 challenging cases with large, nonresponsive VLUs. A 52-year-old female patient, Case 1, presented with a VLU of 91.4 cm² (10.5 cm x 8.7 cm); and a 58-year-old female patient, Case 2, presented with bilateral VLUs, the larger of which was 50 cm² (10 cm x 5 cm). Both VLU cases were covered with yellow slough, and case 1 had a small area of black necrotic tissue. The patients had received standard care for more than 16 months, but their VLUs were worsening. A self-adaptive wound dressing (SAWD) with a compression wrap was applied 2 to 3 times a week.

Results. Within 21 days, the VLUs of both cases had shed the yellow slough, and healthy granulation tissue was visible.

Conclusion. In summary, the SAWD removed excess exudate with liquefied components of slough and nonvital tissue; provided sufficient moisture for preventing wound desiccation; sequestered microorganisms, thereby blocking their multiplication; and supported efficient autolytic debridement, clearing most of the slough and all crusted necrotic tissue within 3 weeks. The effect of SAWD on autolytic debridement is a promising mechanism for promoting healing of VLUs and warrants further study.

Key words: venous leg ulcer, self-adaptive wound dressing, autolytic debridement, yellow slough, necrotic tissue, trauma

The prevalence of venous leg ulcers (VLUs), the most advanced stage of chronic venous insufficiency, ranges from 0.2% to 1% in Western countries,1 with a higher prevalence in people older than 80 years. A minor injury may initiate a skin break on the leg, and delayed healing can be aggravated by comorbidities such as diabetes, persistently high blood pressure, and chronic venous insufficiency. Chronic (VLUs) in a prospective clinical trial at one clinic ranged in size from 1.1 cm² to 19.2 cm², and the duration ranged from 6 weeks to 104 weeks.2 The proportion of wounds healed within 2 years ranged from 68% for leg wounds...
to 51% for ankle wounds. Patients with chronic bacterial infections with *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, or *Enterococcus faecalis* in their chronic VLU delayed healing of the wound, although *S. aureus* and *Proteus spp.* did not appear to inhibit healing in a different clinic. Guidelines for the management of VLUs encompass diagnosis, necessity of debridement and compression therapy, antibiotics, and adjunctive therapies such as isotonic exercise and leg elevation. Despite these guidelines, healing of chronic VLUs can be challenging, and novel approaches for restarting the healing of chronic VLUs are warranted.

Wound bed preparation for renewed healing requires attention to the healthy tissue and removal of necrotic tissue and slough; control of infection and inflammation; maintenance of correct moisture; and preservation of the growing healthy tissue at the edge of the wound during wound dressing changes, as indicated by the TIME framework for wound healing. Wound dressings typically were designed to address 1 or more, but not all, of these critical conditions.

Debridement usually is performed before application of the dressing. Debridement of chronic VLUs removes necrotic tissue, any debris, and bacteria from the wound; and it exposes the viable tissue to facilitate healing. Types of wound debridement techniques include autolytic debridement, enzymatic debridement, such as with collagenase-based products; biomechanical debridement using sterilized maggots; mechanical debridement; and surgical debridement. Autolytic debridement usually causes no pain and leaves the wound bed at the correct moisture balance to promote granulation and growth of epithelial cells, but it can be a slow process. A chronic VLU has difficulty employing adequate autolytic debridement because the wound environment is not conducive to the process, in that there is too much exudate with an increased number of matrix metalloproteinases. Enzymatic debridement requires frequent dressing changes, and the specificity of the protein cleavage is determined by the collagenase or the collagenase/papain preparation. Mechanical debridement may involve wound cleansing at 4-14 psi, hydrosurgery at 15,000 psi, whirlpool, atomized saline, polyester fiber pad, or ultrasonic techniques. These techniques are nonspecific, can provide fast results, but can be painful and harm viable tissue. Chemical debridement often includes the use of antimicrobials, and its short-term use can be effective; but it may be painful and may harm healthy tissues. From a pain standpoint, autolytic debridement is the clear choice for patient comfort, but inadequate autolytic debridement, insufficiently controlled inflammation, and infection contribute to nonhealing VLUs. Autolytic debridement may be supported by dressings with hypertonic saline and/or honey via osmosis, and by semiocclusive dressings containing hydrocolloids or hydrogels. Removal of excess exudate and cellular debris appears to assist in maintaining the process of autolytic debridement. Hydration response technology, negative pressure wound therapy, and a self-adaptive wound dressing (SAWD), among other dressings, can remove excess exudate. The optimal moisture levels vary for the different stages of wound healing: a moist milieu is needed to promote granulation and growth of epithelial cells, whereas a drier milieu is needed on the new skin at the wound edge.

Wound bed preparation and healing involves the recurrent removal of excess exudate, microorganisms, semisolid slough debris, degraded necrotic tissue, hypertonic fluids containing toxic and/or corrosive components, and maintenance of moisture balance at the wound edge and low-exuding or nonexuding wound areas. Minimal or no tissue damage during dressing removal maintains the progress of the healing process. The SAWD can continuously remove the exudate; sequester wound bed microorganisms from debris that may act as food sources; confine absorbed exudate and hypertonic fluids containing toxic and/or corrosive components, regardless of compression and gravity; maintain moisture balance in distinct microzones of the wound bed; adjust moisture in microzones as...
needed; and be removed without damage to newly formed epidermis. The authors hypothesized these 6 conditions provided by the novel SAWD are not only necessary but also sufficient to support efficient autolytic debridement. These case studies examined the ability of SAWD and compression wraps to support relatively rapid autolytic debridement of 2 large VLUs that had been unresponsive to various treatments for 16.8 months and 19.2 months.

Methods and Materials

Demographics. The personal medical history for each patient—demographic (ie, age, race/ethnic origin, and gender), health status (ie, weight, height, and comorbidities), and previous history of VLUs including initiating event, size, prior treatments, and trend of wound—was recorded. Patients were queried on their pain level using a scale of 1 to 10, where 1 indicated no pain and 10 indicated the worst pain. The presence of odor and quantity of exudate were recorded.

Self-adaptive wound dressing. The SAWD (Enluxtra, OSNovative Systems, Inc, Santa Clara, CA) consisted of multiple complex layers. Each layer of the dressing was manufactured to gather secretions from the wound bed in microzones and promote optimal conditions for healing. A vapor-permeable layer exhibited a rapid moisture vapor transmission rate (2500 g/m²/24 hours). Other advantageous properties included an absorbent pad that remained flexible even when near capacity, and the vapor-permeable layer that blocked migration of any microbes to the surface. Microzones of the liquid and vapor-permeable layer changed from a high rate of vapor removal for wound beds releasing exudate to a low rate of vapor removal for the periwound skin and wound edge, as needed to maintain the optimal moisture conditions for each area. The authors used 4-in gauze wrap (Kerlix, Covidien, Mansfield, MA) and 4-in self-adherent wrap (Coban, 3M, St. Paul, MN) for compression.

The authors’ private practice wound clinic treats approximately 20-30 patients with VLUs each month. In approximately 50% of the patients, the treating clinicians perform surgical debridement, but 45% of patients with VLUs refuse it due to pain. Thus, the authors sought alternative methods that might support painless autolytic debridement. The clinic’s current treatment procedure shifted to SAWD since July 2014. Since the shift toward SAWD began, the authors have treated 100 patients with VLUs. Here, the authors report 2 of the more challenging recent cases at the clinic to illustrate the effect of the SAWD on autolytic debridement.

Case Reports

Case 1. An African-American female of 52 years presented at the author’s clinic with hypertension, varicose veins, gastroesophageal reflux disease, prednisone use, depression, and renal transplantation (5 years prior) in May 2013. Her medications included Loestrin, (Allergan, Parsippany, NJ), Prograf (Astellas Pharma US Inc, Northbrook, IL), furosemide, Protonix (Pfizer Inc, New York, NY), and Cellcept (Genentech, San Francisco, CA). She presented with 2 VLUs measuring 10.5 cm x 8.7 cm (91.4 cm²) and 8 cm x 5.4 cm (43.2 cm²), which were located on her anterior mid-leg and had arisen from bumping her leg against a sharp corner. The patient’s major complaints included the nonhealing open wound, pain at 10 on the previously described scale of 1 to 10, odor, reduced quality of life (QoL), edema, and an exuberant amount of drainage. Prior treatment for the wound included compression, multiple courses of oral antibiotics, a gel containing platelet-derived growth factor (Regranex, Smith & Nephew, St. Petersburg, FL) for 3 months, and surgical debridement 5 times. The patient refused additional surgical debridement due to pain.

The 2 VLUs showed widespread slough and some dried necrotic tissue in the proximal ulcer before the first SAWDs (2 dressings, each measuring 6 in x 6 in) were applied on January 30, 2014 (Figure 1A), at 16.8 months post-VLU injury. The self-adaptive wound dressings and compression wrap were changed every 2 days releasing exudate to a low rate of vapor removal for the periwound skin and wound edge, as needed to maintain the optimal moisture conditions for each area. The authors used 4-in gauze wrap (Kerlix, Covidien, Mansfield, MA) and 4-in self-adherent wrap (Coban, 3M, St. Paul, MN) for compression.

The authors’ private practice wound clinic treats approximately 20-30 patients with VLUs each month. In approximately 50% of the patients, the treating clinicians perform surgical debridement, but 45% of patients with VLUs refuse it due to pain. Thus, the authors sought alternative methods that might support painless autolytic debridement. The clinic’s current treatment procedure shifted to SAWD since July 2014. Since the shift toward SAWD began, the authors have treated 100 patients with VLUs. Here, the authors report 2 of the more challenging recent cases at the clinic to illustrate the effect of the SAWD on autolytic debridement.

Keypoints

• The authors’ private practice wound clinic treats approximately 20-30 patients with venous leg ulcers each month.
• 45% of these patients refuse surgical debridement due to pain.
• The clinic’s current treatment procedure shifted to self-adaptive wound dressings to support painless autolytic debridement.
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harboring dried black necrotic tissue had decreased. After 21 days and 9 dressing changes (Figure 1D), the lower ulcer did not show slough but instead showed a healthy wound bed. The upper ulcer showed mostly a healthy wound bed with slough only in the areas that had previously been covered with black necrotic tissue. The odor had declined by day 7 and completely disappeared between days 14 and 21. The healthier appearance of the ulcers suggested that the dressings had supported autolytic debridement. The care continued for several months.

Case 2. A white female of 58 years presented to the clinic on January 30, 2014 with bilateral ulcers, hepatitis C, and a history of illicit drug abuse. Her medications were vitamin A, vitamin C, gabapentin, and methadone. She presented with bilateral VLUs due to scratching her legs. The patient’s major complaints included the open wound and pain scored at 7 out 10. Other patient symptoms included odor, reduced QoL, edema, and a severe amount of exudate. Treatments had included debridement, medicinal honey, silvadene cream, Unna boot, and compression with a self-adherent wrap. The patient reported she had undergone surgical debridement of the VLU at least 10 times during 19.2 months of wound care. The larger VLU just prior to the application of the SAWD and compression wraps measured 10 cm x 5 cm (50 cm²) and was covered with nonviable yellow slough (Figure 2A). The first SAWDs, 2 dressings measuring 6 in x 6 in each, were applied February 18, 2014. The SAWD and compression wraps were changed 2 times per week by the clinic staff. After 2 days and 1 dressing change, the ulcer showed a small area of healthier looking wound bed near the top, but the vast majority still remained covered with yellow slough (Figure 2B). On day 21, after 6 dressing changes (Figure 2C), the wound bed appeared to be healthy tissue, and the wound edge appeared to be beginning to grow inward. The odor disappeared between day 14 and day 21. These results supported the hypothesis that SAWD and compression wraps promoted autolytic debridement of this patient’s wound.

Discussion

The 2 presented cases indicate that SAWDs applied together with compression wraps promoted autolytic debridement of large fibrous wound beds measuring 43.2 cm² and 91.4 cm² (Case 1) and 50 cm² (Case 2) within 21 days. The conditions outlined for autolytic debridement and wound bed preparation by the TIME framework were met by the combined functions of the SAWD. First, excess exudate carrying degraded or infectious biomass was absorbed into the SAWD. Second, the microbial biomass was sequestered despite compression. The dressing material chemically bound water molecules, thereby critically reducing available water for microbial growth. The odor disappeared by day 21 in both cases, indicating that microbial replication had declined. Third, the exudate containing the liquefied slough and necrotic debris was confined within the SAWD, as no weeping was observed between SAWD changes despite compression.

Figure 1. Progression of autolytic debridement with self-adaptive wound dressings (SAWDs): (A) Case 1 before treatment with SAWDs; (B) day 4 of treatment with SAWDs and compression wraps; (C) day 11 of treatment; and (D) day 21 of treatment.
appropriate moisture balance was maintained at the wound edge and low-exuding or nonexuding wound areas. Fifth, the change from slough and crusted necrotic tissue to healthy granulation bed involved microzone management of moisture balance, and likely required the dynamic and reversible switching from absorption and hydration properties of SAWD. Moisture levels on the wound bed were adjusted by the SAWD's absorbent pad, the 2 permeable layers for both liquids and vapors are engineered to adjust moisture build-up in wound microzones, and feature a vapor-breathable layer of hygroscopic nonwoven fabrics and membranes. Sixth, the SAWD removal did not induce noticeable damage to the wound bed or wound edge, so autolytic debridement was able to proceed efficiently. Since the VLUs had changed from slough covered (Cases 1 and 2) and bordered with necrotic tissue (Case 1) to a healthy wound bed that could support granulation and reepithelialization (Figures 1, 2), these 6 conditions were not only necessary, but were also sufficient, for enabling efficient autolytic debridement in these 2 large chronic VLUs. Self-absorbtent wound dressing applications had efficiently supported autolytic debridement during the initial 3 weeks of their use, which was a shorter time period than previously documented.

Despite hydration-controlling dressings and antimicrobial-impregnated dressings, wound care for VLUs, especially large ulcers (> 20.0cm²), is extremely challenging due to patient variability, the complexity of the wound healing process, and myriad range of available dressings. However, Wolcott and Fischenich recently reported SAWDs perform satisfactorily for numerous types of wounds, such as diabetic ulcers, venous ulcers, chronic wounds, pressure ulcers, and surgical wounds. Since debridement is a critical step in healing all types of wounds, these results suggest that the wide appli-

**Figure 2.** Progression of autolytic debridement with self-adaptive wound dressings (SAWDs): (A) Case 2 before treatment with SAWD; (B) day 2 of treatment with SAWDs and compression wraps; and (C) day 21 of treatment.

**Key Points**
- The 2 presented cases indicate that self-adaptive wound dressings (SAWD) applied with compression wraps promoted autolytic debridement of large fibrous wound beds measuring 43.2 cm² and 91.4 cm² (Case 1) and 50 cm² (Case 2) within 21 days.
- These 2 cases were challenging because the venous leg ulcers (VLUs) were large, chronic, had not responded to many types of dressings and treatments, and both patients had refused surgical debridement due to the pain of the procedure.
- An SAWD in conjunction with compression wraps supported efficient autolytic debridement along with significant pain reduction by the dressing's removal of excess exudate, slough, necrotic tissue, and microbial bioburden, as well as its facilitation of the formation of healthy granulation tissue.
cability of the SAWD may arise at least in part from this dressing’s support of autolytic debridement and its ability to evacuate and sequester microorganisms within the layers, thereby preventing microbial growth and reinfection even under compression.

**Limitations**

One limitation of this study was the small number of cases. These 2 cases were challenging because the VLUs were large (91.4 cm² and 50 cm²); chronic (16.8 months and 19.2 months); had not responded to many types of dressings and treatments; and both patients had refused surgical debridement due to the pain of the procedure. Wound healing of the first patient’s ulcers was further complicated by her medications, including prednisone and immunosuppressive medication for her renal transplant.

A second limitation of this study was the short duration of 3 weeks. However, within 3 weeks of initiating SAWD, the wound bed of both cases appeared to undergo significant improvement. The rapid transition from slough to granulation tissue bed suggests the SAWD provides the appropriate wound environment for rapid autolytic debridement.

Case 1 utilized SAWDs for 3 months for wound closure. Subsequently, a bioengineered skin substitute (Apligraf, Organogenesis, Canton MA) was applied to both of the patients’ ulcers and covered with SAWDs. At 9 months and 8 days, the top VLU of Case 1 had completely healed, and the large VLU had almost healed as shown in Figure 3. The patient’s pain level had declined by 90% after 5 months of treatment. Case 2 was treated with SAWDs for 2 months and then the patient was lost to follow-up. During the 2 months of treatment with SAWD the ulcer base transitioned to a fully granular base with complete absence of slough and healthy margins.

**Conclusions**

In summary, treatment of VLUs with an SAWD in conjunction with compression wraps supported efficient autolytic debridement along with significant pain reduction within 21 days by the dressing’s removal of excess exudate, slough, necrotic tissue, and microbial bioburden, as well as its facilitation of the formation of healthy granulation tissue in 2 challenging chronic VLUs. Autolytic debridement supported by SAWDs is a promising step toward healing of VLUs and warrants further studies.

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