BACKGROUND: Our clinical experience suggests that the effectiveness of negative pressure wound therapy is enhanced by adding collagen alginate to the dressing regimen, applying foam over areas that are undermined or tunneled, and approximating and securing wound edges prior to applying foam.

CASES: The use of this combined technique is described in 4 cases, including 2 patients with spinal cord injury and category IV pressure ulcers and 2 patients with extensive postsurgical wounds.

CONCLUSION: Our outcomes demonstrate the feasibility of this technique and suggest that patients with significant wound size benefit from adding collagen alginate to negative pressure wound therapy and by applying foam over areas that are undermined or tunneled and/or approximating and securing wound edges prior to applying foam.

Introduction

Negative pressure wound therapy (NPWT), also known as topical negative pressure, employs subatmospheric pressure to promote wound healing and manage exudate. Actions of NPWT that promote wound healing include (1) increased local blood flow, (2) diminished bacterial load, (3) promotion of granulation tissue, (4) wound contraction, and (5) epithelialization. NPWT also enables accurate measurement of exudate. NPWT use has increased over the last decade; Medicare payments for NPWT pumps increased 583% between 2001 and 2007.

NPWT and Wound Healing

Appropriate patient selection and attention to management of systemic as well as local factors are needed to ensure optimal outcomes when using NPWT. Systemic issues requiring management often include nutritional support, control of underlying disease processes such as diabetes mellitus, prudent use of immunosuppressant or anticoagulant medications, and offloading in the case of a pressure ulcer. Wounds managed with NPWT should be adequately prepared by cleansing and debridement when indicated. The periwound skin should be protected with skin sealants or barrier dressings. In addition, adjunctive dressings may be used to manage pain, odor, or bacterial load.

Clinical experience suggests that the effectiveness of NPWT is enhanced by the skill of the clinician applying the dressing. Effectiveness also may be enhanced by dressing techniques utilized. The advanced wound care team at our Long Term Acute Care Hospital has incorporated innovative techniques when applying one foam-based NPWT system (Wound VAC; KCI, San Antonio, Texas) to select wounds.

Pressure Ulcers Following Spinal Cord Injury

Mr A and Mr B are young adult African-American males with histories of paraplegia secondary to gunshot trauma. Both had seating surface-related pressure ulcers on their ischial tuberosities. Both had been treated for some time as outpatients prior to inpatient admission for their pressure ulcers. Each of these men had a history of prolonged wheelchair sitting without adequate pressure redistribution.

Mr A had a category IV right ischial pressure ulcer with undermining. On admission, his pressure ulcer measured 11.5 cm × 8 cm × 5.3 cm with an 8.3-cm tunnel at 11 o'clock and 11 cm undermining from 12:00 to 2:00 o'clock (Figure 1). On admission, Mr A's prealbumin was 12.5 g/dL (125 g/L SI units). He was placed on a low air loss mattress.
and maintained a prone position during much of the day. His wheelchair sitting was limited to 1 hour twice daily. Due to the sloughy tissue in the wound base and purulent exudate, Mr A’s pressure ulcer was initially treated with Dakin’s solution 0.25% twice daily. After 2 weeks of treatment, the dead space measured in the wound was 13.5 cm. At that point, Dakin’s solution was discontinued and NPWT initiated. A collagen alginate (Fibrocol Plus, Systagenix, Warren, New Jersey) was placed into the undermined area and foam was placed in the wound base. The periwound skin was protected with skin sealant (Cavilon No Sting, 3M, St Paul, Minnesota) and a transparent film drape, and a foam overlay was placed over the undermined area. (The foam overlay technique is depicted in Supplemental Digital Content 1, http://links.lww.com/JWOCN/A3.) NPWT was set to deliver a continuous negative pressure of $-200$ mm Hg; and dressings were changed 3 times weekly.

After 3 days, Mr A experienced a 10.8% decrease in wound area and 8.2% decrease in wound volume (Figure 2). After 10 days, he achieved a 24.1% decrease in wound area and 18.2% decrease in wound volume. After one month, his pressure ulcer was noted to have a 37.7% decrease in wound area and 30.2% decrease in wound volume (Figure 3 and Supplemental Digital Content 2, http://links.lww.com/JWOCN/A4). At the time of discharge, his prealbumin was 31.6 g/dL (316 g/L SI units). He was counseled to maintain his limited sitting schedule and discharged home with follow-up scheduled in the outpatient wound clinic. Unfortunately, Mr A did not return for clinic appointments and was ultimately lost to follow-up.

Mr B also suffered paraplegia because of a gunshot wound. He was admitted to our facility with a category IV right ischial pressure ulcer with undermining. On admission, his prealbumin was 13.3 mg/dL (133 mg/L SI units). He was placed on a low air loss surface and wheelchair sitting was limited to 1 hour twice daily. NPWT was used for 5 weeks with a 59.5% reduction in wound area and volume (Figure 4). Five weeks into treatment, an area of undermining was discovered that measured 7.5 cm and extended from 11:00 to 4:00 o’clock (Figure 5, outer markings). Collagen alginate was placed in the undermined area, and foam was placed into the wound base. The periwound skin was protected with transparent film drape, and a foam overlay was placed over the undermined area. NPWT was set to deliver a continuous negative pressure of $-200$ mm Hg; and dressings were changed 3 times weekly.

After 2 days of treatment using the approach described earlier, Mr B experienced a 15% reduction in wound area and a 17.4% reduction in wound volume. After 6 days, the patient had additional 3% wound area decrease and 9.7% wound volume decrease (Figure 5, inner markings and Supplemental Digital Content 3, http://links.lww.com/JWOCN/A5). At discharge, his prealbumin had improved to 22.9 mg/dL (229 mg/L SI units). He was discharged to a nursing home with follow-up scheduled in the outpatient wound clinic. He was seen in the outpatient clinic for 4 months.
Unfortunately, he failed to maintain his limited sitting schedule and his nutritional status deteriorated as reflected in a prealbumin of 12.5 mg/dL (125 mg/L SI units) 1 month following discharge. After 4 months of nonadherence to the care regimen, Mr B was discharged from the clinic.

Extensive Postsurgical Wounds

Extensive postsurgical wounds can also be challenging to bring to closure. When fascia has been incised and removed, a wide tissue defect often remains. In our experience, many patients who have large surgical defects or fasciotomies require secondary grafting procedures to cover this defect.

Ms C is a 52-year-old woman who was admitted to our facility following fasciotomy of the left arm. The exact cause of the rhabdomyolysis that led to compartment syndrome is unknown. Postoperative wound healing was influenced by a less than optimal nutritional status (her prealbumin was 12.5 mg/dL, 125 mg/L SI units). In addition, she had required hemodialysis for acute renal failure, although it had been discontinued by the time she was admitted to our facility.

Ms C had been treated with a foam-based NPWT several days prior to admission. Upon initial assessment, we observed a wound measuring 24 cm × 2.9 cm × 1.4 cm with small pieces of black foam embedded in granulation tissue. Following sharp debridement of the residual foam (Figure 6), a collagen alginate was placed into the wound bed. The wound edges were approximated and held together with closure strips (Steri-Strip, 3M, St Paul, Minnesota). NPWT was resumed using foam overlay; continuous negative pressure was applied at −150 mm Hg.

In 24 days, Ms C experienced a 66.5% reduction in wound area and 90.4% reduction in wound volume (Figure 7 and Supplemental Digital Content 4, http://links.lww.com/JWOCN/A6). She did not require skin grafting, thus avoiding another surgery and donor site wound. At this point, NPWT was discontinued and her wound was dressed with a foam dressing (Biatain, Coloplast, Minneapolis, Minnesota) that was changed twice weekly. Ms C’s nutritional deficit was addressed and her prealbumin subsequently rose to 29.2 mg/dL (292 mg/L SI units). She achieved complete wound epithelialization shortly after discharge from the facility.

Ms D is a 74-year-old woman who was admitted to our facility following renal transplantation. She also underwent external iliac endarterectomy because of peripheral arterial disease. Postoperatively, she experienced a pulmonary embolus that was treated with an infrarenal Greenfield filter. Two weeks postoperatively, her surgical incision was opened to evacuate a large clot associated with a previous renal biopsy. The incision was left open and NPWT initiated as part of a wound management plan.
She was admitted to our facility’s transitional care unit 6 days after incision and drainage of the clot. Her postsurgical wound measured 5.5 cm × 21.5 cm × 5 cm (Figure 8). Her tenuous nutritional status was reflected in a serum albumin of 2.5 g/dL (250 g/L SI units) on admission. In addition to continuing NPWT using a continuous pressure of −200 mm Hg, collagen alginate was placed into the wound base and the wound edges were approximated with skin closure strips (Steri-Strip, 3M, St Paul, Minnesota). We protected the skin immediately adjacent to the wound with transparent drape and black foam placed over the incisional and periwound area.

Five days later, Ms D’s wound measured 0.5 cm × 20.5 cm × 1.1 cm (Figure 9). The dressing regimen was continued and 8 days later, her wound measured 0.4 cm × 20 cm × 0.2 cm (Figure 10) representing a reduction of 93.2% in wound area and 99.7% diminution of wound volume since admission. NPWT was discontinued and the incision line remained approximated with closure strips.

Discussion

We regularly use collagen alginate as an adjunct to NPWT because of its integral role in each phase of wound healing. During homeostasis, platelets accumulate around exposed collagen and secrete factors that stimulate the clotting cascade. During the inflammatory phase of wound healing, elevated levels of matrix metalloproteases lead to degradation of viable and nonviable collagen. Collagen dressings provide a substitute for wound collagen during this process of degradation. When the wound moves into a proliferative phase, collagen stimulates fibroblast and keratinocyte proliferation. We place foam over the approximated wound and deliver NPWT, using

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select higher pressures (~150 mm Hg to ~200 mm Hg), because we hypothesize that the layers of tissue are pulled together under the influence of the NPWT. We suspect that the combined action of the NPWT and collagen alginate facilitates bonding of tissue layers in the wound bed. In selected cases, we have found this technique facilitates closure of undermining more effectively than application of VAC white foam or drains. We also find that the tissue approximation technique described in this article leads to less surface scarring, a reduced likelihood of subsequent grafting procedures, and a better cosmetic outcome.

**Conclusion**

Our results with these 4 cases suggest patients with significant wound size may demonstrate appreciable reductions in wound area and volume by adding collagen alginate to the dressing regimen and by employing unique dressing application techniques including applying foam over areas that are undermined or tunneled and/or approximating and securing wound edges prior to applying foam.

We will continue to use these techniques with future patients and report ongoing results. Nevertheless, additional research is needed to confirm our findings and then determine outcomes with other types of wounds and alternative NPWT devices.

**References**