Use of Negative Pressure Wound Therapy with Instillation in Diabetic Foot Ulcers

This modality plays a positive role in wound healing and assists with wound closure.

BY TIFFANY K. HOH, DPM AND JOHN S. STEINBERG, DPM

Introduction

Negative pressure wound therapy has been used for several years in the assistance of wound healing for many types of wounds on the body. Its use in wound healing of diabetic foot ulcers has been reported in several published studies. The use of negative pressure wound therapy is recommended in highly exudative wounds with increased slough formation as well as wounds that are acutely infected requiring surgical debridement. Some key mechanisms of negative pressure wound therapy are to promote wound healing by drawing wound margins together, reducing edema, and promoting granulation tissue formation.

Studies have shown that this therapy increases cellular activity by the stretching of cell cytoskeleton causing a release of intracellular messengers which then leads to an increase in granulation tissue.[1] However, wound healing in some acutely infected wounds may be difficult to obtain with negative pressure wound therapy alone. Negative pressure wound therapy with instillation has been introduced as an additional treatment modality for infected wounds that have not responded to other conventional wound treatment therapies.

Goals of Therapy

The goals of negative pressure wound therapy with instillation include decreasing the amount of biofilm on the infected wound bed, increasing granulation tissue formation for closure or grafting of the wound, decreasing the length of hospital stay, and aiding in limb salvage. The use of negative pressure wound therapy with instillation involves irrigating and soaking the wound with the fluid of choice for a specific amount of time, removal of the fluid with negative pressure at specified timed intervals, and repeating this cyclic process for the duration of therapy that the foam dressing remains intact on the wound bed. Irrigating the wound with topical solutions helps locally cleanse the wound and decrease the amount of bacterial burden. By soaking the wound with the topical solution, the viscosity of the exudates from the wound bed is decreased, which then allows negative pressure to help facilitate its removal.[2]

Methods

In our practice, wounds are assessed for the presence of any nonviable tissue or local infection. Initial wound cultures are often taken prior to the initiation of any antibiotic therapy. Broad-spectrum antibiotic coverage is initiated and adjusted accordingly at a later date when culture speciation and antibiotic sensitivities are obtained. Appropriate surgical debridement of wounds is oftentimes necessary prior to the initiation of negative pressure wound therapy with instillation. Pre-debridement and post-debridement cultures are obtained intra-operatively to confirm

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that the wound is clean of infectious materials and adequate debridement was done.

Following surgical debridement of nonviable tissue, it is important to obtain hemostasis prior to placing the foam dressing on the wound bed. The negative pressure unit is connected to the wound site, and then the settings for amount of soaking time of instillation fluid and the amount of time for negative pressure therapy are determined.

The foam dressings on the wound bed are changed every three to four days, and the wound is inspected and reassessed at that time. If there is no evidence of clinical infection and post-debridement cultures are negative for any infectious micro-organisms, then negative pressure therapy may be continued or closure of the wound may be done. However, if clinical infection is persistent and post-debridement cultures are positive for infectious microorganisms, then repeat surgical debridement is necessary. Patients may undergo several surgical debridements of wounds until a clean wound free of infectious micro-organisms is obtained.

Negative pressure wound therapy with instillation should be continued until there is adequate granulation tissue coverage. It is discontinued once the wound is ready for an alternative treatment therapy, closure of the wound, or coverage with grafting.

Irrigation Solutions

There have been several different topical solutions that have been used for irrigation as noted in recent literature, including Dakin's solution, acetic acid, and solutions with various antibiotics.[3] There are no studies in the literature that confirm the superiority of one solution to use as instillation on wounds.

Gabriel, et al.1 described a pilot study on the use of negative pressure wound therapy with instillation in 15 patients that compares the use of normal saline, sterile water, and silver nitrate solution. The authors concluded that silver nitrate was useful in preventing further bacterial penetrance by acting as a barrier, thus prevented recurrent infections during the length of therapy; it also helped decrease odor and pain at dressing changes.

Back, et al.[3] reviewed the current literature on the various solutions that have been reported as instillation solutions. The authors concluded that polyhexanide and acetic acid solutions are best used for acute and chronic wounds, and providone iodine is a solution that may be used as prophylaxis for virally infected wounds.

Phillips, et al.[4] assessed the effect of several various antimicrobial solutions on mature Pseudomonas aeruginosa on a porcine skin explant biofilm model utilizing negative pressure wound therapy with instillation. The different antimicrobial solutions tested in this study included sterile saline, 10% providone iodine, 1% providone iodine, 0.1% polyhexamethylene biguanide, 0.2% polydiallyldimethylammonium chloride, and 0.05% chlorhexidine gluconate. Sterile porcine skin explants were prepared and then inoculated with 106 colony-forming units of Pseudomonas aeruginosa POA1 bacteria.

Treatment with negative pressure wound therapy with instillation included a 10-minute soak time with the antimicrobial solution, followed by four hours of negative pressure at negative 125 mm Hg over a 24-hour period for a total of six cycles of instillation. It was found that negative pressure wound therapy alone reduced the amount of bacterial load by less than 1-log compared to the untreated control group. This was not statistically significant; however, negative pressure wound therapy with instillation of sterile saline reduced bacterial load by 1-log, which was statistically significant.

The authors note that the reduction of bacterial load by the use of sterile saline was mainly from the bacteria (unattached to the wound) that were removed. Instillation with 10% povidone iodine, 1% povidone iodine, 0.1% polyhexamethylene biguanide, 0.2% polydiallyldemethylammonium chloride, and 0.05% chlorhexidine gluconate all significantly reduced the total colony-forming units (CFUs) compared to the untreated control group and the negative pressure wound therapy with instillation of the saline group.

Instillation with 10% providone iodine reduced CFUs by 5-log compared to the control group, which was the most reduction of bacterial load compared to the other antimicrobial solutions used. Compared to the saline instillation group, the 0.1% polyhexamethylene biguanide group and 0.2% polydiallyldemethylammonium chloride reduced CFUs by 4-log, 0.05%. Chlorhexidine gluconate and L-solution reduced CFUs by 3-log, and 1% providone iodine reduced CFUs by 2-log, which were all statistically significant.

Negative pressure wound therapy with instillation should be continued until there is adequate granulation tissue coverage.

The use of antimicrobial solutions effectively reduced the bacterial load of the wound by mechanically reducing unattached bacteria, as well as increasing the destruction of the biofilm of bacteria for removal.

Discussion

Currently, there is minimal published research data on the use of negative pressure wound therapy with instillation on diabetic foot wounds. Most of the publications in literature are case reports and small case series.

Kim, et al.[5] presented a study that compared the outcomes for patients who received the negative pressure wound therapy with instillation compared to patients who received the negative pressure wound therapy alone. They looked at the number

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of visits to the operating room, the length of hospital stay, the time to final surgical procedure during hospital admission, the percentage of surgical wounds closed prior to discharge, the percentage of wounds that continued to be closed 30 days after discharge, and the reduction in micro-organisms in the wound.

There were a total of 142 patients included in the study with 74 of those patients in the negative pressure wound therapy group, 34 patients in the 6-minute dwell time negative pressure wound therapy with instillation group, and 34 patients in the 20-minute dwell time negative pressure wound therapy with instillation group.

The authors found a lower number of visits to the operative room with both the 6-minute and 20-minute dwell time negative pressure wound therapy with instillation compared to the negative pressure wound therapy group, shorter length of hospital stay in the 20-minute dwell time instillation group compared to the no instillation group, shorter amount of time to final surgical procedure during hospital admission in both the 6-minute and 20-minute dwell time groups compared to the no instillation group, and higher percentage of wounds closed prior to discharge in the 6-minute dwell time group compared to the no instillation group, which were all statistically significant.

There was no statistical difference in the reduction in micro-organisms between the two groups; however, when gram-negative bacteria, Corynebacterium, and yeast were excluded, there was a statistically significant improvement with the 6-minute dwell time instillation group compared to the no instillation group. The authors use a combination solution, Prontosan, consisting of 0.1% polyhexanide and 0.1% betaine as the instillation solution in this study. Polyhexanide has been shown to be less effective in gram-negative bacteria, which is consistent with the results of this study. The results from Georgetown suggest that negative pressure wound therapy with instillation is a more viable option than negative pressure wound therapy alone to decrease length of hospitalization and micro-organisms in infected inpatient wounds.

Brinkert, et al.[6] reported the use of negative pressure wound therapy with instillation utilizing saline solution only in 131 patients with wounds of various etiologies. The etiology of wounds presented in this study include open fracture, infected hematoma, pressure ulcer, non-healing postoperative dehiscence, diabetic foot ulcer, necrotizing fasciitis, limited exposure to hardware, and leg ulcer. Depending on the wound and the patient, 20 to 30 ml of saline was instilled through the wound with the appropriate volume of fluid set manually. The soak time was set for 10 minutes and negative pressure was set between 4 to 12 hours, with an average of 4 instillation cycles every 24 hours. Dressings were changed every 3 days with an average period of use of 12 to 19 days total. There were 128 out of 131 wounds that were closed. These wounds were closed by skin graft in 74%, skin flap in 22%, and primary closure in 32%.

This study demonstrates that regularly instilled saline solution alone was adequate enough to allow granulation tissue and wound healing to occur in various wounds. The authors recommend that further studies are needed to determine if any specific antimicrobial solutions used for instillation may be appropriate.

Timmers, et al.[7] utilized negative pressure wound therapy with instillation of polyhexanide solution in 59 patients for osteomyelitis of the pelvis or lower extremity compared to 94 control patients who received historical standard surgical debridement, systemic antibiotics, and implantation of gentamicin beads. The principle bacterial specimens isolated as the cause of osteomyelitis were Staphylococcus aureus and Pseudomonas aeruginosa. The authors found that the patients treated with negative pressure wound therapy with instillation had a shorter length of hospital stay, decreased rate of recurrence of infection, and quicker closure of wound compared to the historical control group.

Dalla Paola[8] described the use of negative pressure wound therapy with instillation of polyhexanide solution in two cases. The first case involved a patient with wet gangrene to the 4th and 5th rays of the right foot with compartment syndrome of the plantar midfoot and critical limb ischemia. The second case involved a patient with wet gangrene to the 4th ray of the right foot with necrotizing fasciitis of the lateral leg and critical limb ischemia. Methicillin-resistant Staphylococcus aureus (MRSA) was isolated in both patients, with additional Serratia marcescens in the second patient as well. Both patients received appropriate antibiotic treatment.

Negative pressure wound therapy with instillation was used in both cases after surgical debridement with a 15-minute soak time utilizing polyhexanide and 2 hours of negative pressure at -125mmHg until evidence of granulation tissue was obtained to allow for application of dermal substitute or skin grafting. The author demonstrated examples of the successful use of negative pressure wound therapy with instillation; however, they suggest that larger studies are needed to determine its efficacy.

Summary

From the available early clinical data, it appears that the use of negative pressure wound therapy with instillation plays a positive role in wound healing and assists with wound closure. There have been several studies that show its use decreases the amount of biofilm on the infected wound bed, increases granulation tissue formation for closure or grafting of the wound, decreases hospital stay, and aids in limb salvage. The addition of instillation with various antimicrobial solutions with negative pressure therapy has been shown in ex vivo porcine models to not only facilitate the removal of unattached bacteria on the wound but also increase the destruction of attached biofilm of bacteria for removal.

Further studies in relevant patient populations are necessary to evaluate the clinical utility of the various antimicrobial solutions on

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infected wounds. These studies will also need to evaluate the degree of cytotoxicity of specific solutions to assure their safety in wound healing protocols. The use of negative pressure wound therapy with instillation appears to be emerging as a viable option to aid in wound closure and limb salvage. **PM**

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Dr. Hoh is a 1st year resident at MedStar Washington Hospital Center Podiatric Residency Program, Washington DC

Dr. Steinberg is Program Director at MedStar Washington Hospital Center Podiatric Residency and Associate Professor at the Georgetown University School of Medicine Washington DC.