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REVIEW ARTICLE

Negative Pressure Wound Therapy: A Comprehensive Overview

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ABSTRACT

Negative Pressure Wound Therapy (NPWT), also known as vacuum-assisted closure (VAC), is an advanced wound care technique that utilizes controlled negative pressure to promote healing. This therapy enhances wound healing by improving blood circulation, reducing edema, and stimulating tissue regeneration. NPWT has been widely used for chronic and acute wounds, including diabetic ulcers, pressure ulcers, surgical wounds, and traumatic injuries. A review of existing literature highlights the efficacy of NPWT in accelerating wound closure, reducing infection rates, and minimizing the need for surgical debridement. Recent advancements, such as portable vacuum pumps and specialized dressings, have improved the accessibility and convenience of NPWT, allowing for home-based treatment. The standardized application process involves wound preparation, specialized dressing application, vacuum pump connection, and regular monitoring. Clinical outcomes have demonstrated that NPWT significantly enhances wound healing, reduces complications, and improves patient quality of life. Despite the initial cost, NPWT proves to be a cost-effective solution in long-term wound management by reducing the need for additional surgical interventions and hospital stays.

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INTRODUCTION

Negative Pressure Wound Therapy (NPWT), also known as vacuum-assisted closure (VAC), is a modern and innovative treatment used to promote wound healing. This technique involves the application of controlled negative pressure to a wound through a specialized dressing and a vacuum pump.[1] The therapy enhances wound healing by promoting blood circulation, reducing edema, and stimulating tissue growth. NPWT has been widely used in the management of chronic and acute wounds, such as diabetic ulcers, pressure ulcers, surgical wounds, and traumatic injuries. The therapeutic application of negative pressure has revolutionized wound care, especially for difficult-to-heal wounds that have resisted traditional treatment methods.

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REVIEW OF LITERATURE

Over the past few decades, numerous studies have demonstrated the efficacy of Negative Pressure Wound Therapy in various types of wounds. Research indicates that NPWT accelerates wound closure by improving perfusion to the tissue, removing excess fluids, and stimulating cell proliferation. According to a study by Morykwas *et al.* (1997), the use of NPWT led to faster wound closure and reduced infection rates in patients with chronic and complex wounds.

A systematic review by Sibbald *et al.* (2015) confirmed that NPWT significantly improved outcomes in patients with diabetic foot ulcers and pressure ulcers.[2] The study emphasized the role of NPWT in enhancing wound healing rates

and reducing the need for surgical debridement. Moreover, studies have shown that NPWT is also effective in reducing the bacterial load in infected wounds, thus lowering the risk of complications such as wound sepsis.

Recent advancements in NPWT, including portable vacuum pumps and specialized dressings, have further expanded the treatment's reach, allowing patients to receive therapy at home, thereby improving convenience and accessibility. Literature on the subject has consistently indicated that NPWT not only accelerates the healing process but also improves patient quality of life by reducing pain and enhancing wound appearance.[3]

METHODS

The application of Negative Pressure Wound Therapy generally follows a standardized procedure, although variations may exist depending on the type of wound and clinical setting. The basic method involves several key steps:

1. **Wound Preparation**: Prior to initiating NPWT, the wound is thoroughly cleaned and debrided to remove any necrotic tissue and debris. The surrounding skin is also prepared to prevent irritation from the dressing.
2. **Dressing Application**: A specialized foam or gauze dressing is placed over the wound bed. The dressing is cut to fit the wound size, ensuring full coverage of the area to be treated.
3. **Vacuum Pump Connection**: A tube is connected from the dressing to a vacuum pump, which generates controlled negative pressure. The pressure settings are typically between -50 to -125 mmHg, depending on the wound's size and type.
4. **Sealing and Monitoring**: Once the dressing is securely in place, the vacuum pump is activated, and the wound is subjected to negative pressure. The system is monitored to ensure that the pressure remains consistent and that the dressing remains intact. In some cases, the patient may receive continuous or intermittent negative pressure.
5. **Regular Dressing Changes**: The dressing is typically changed every 48 to 72 hours, or sooner if the wound drainage is excessive. During each dressing change, the wound is reassessed, and the therapy is adjusted as necessary.

RESULTS

The use of NPWT across post-traumatic, post-burn, post-surgical, and diabetic wound care has proven to accelerate healing, reduce complications, improve aesthetic and functional outcomes, and enhance patient quality of life. The therapy was consistently associated with a reduction in infection rates, faster wound closure, fewer complications, and a reduced need for additional surgical interventions. While the initial investment in NPWT may be higher, the long-term benefits and cost savings make it a valuable approach in modern wound care management.

DISCUSSION

Negative Pressure Wound Therapy (NPWT) has emerged as a highly effective and widely adopted treatment modality for managing various types of wounds, including post-traumatic, post-burn, post-surgical, and diabetic wounds. The growing body of evidence supporting NPWT's utility in these settings highlights its potential to accelerate healing, reduce complications, and improve patient outcomes.

Post-burn Patients: For post-burn patients, the benefits of NPWT are particularly notable in managing both superficial and deep burns. Burn wounds, especially those that are large or involve a significant portion of the body, are prone to complications such as infection, fluid imbalance, and delayed healing. By applying controlled negative pressure, NPWT helps to evacuate excess exudate, reduce tissue edema, and prevent microbial growth, all of which play a key role in wound healing. Additionally, NPWT's ability to provide mechanical stimulation may improve the alignment and maturation of scar tissue, which is crucial for functional recovery and cosmetic outcomes (figure 1).[4]

Post-surgical Wounds: In post-surgical settings, NPWT has gained acceptance as a standard adjunct for managing surgical incisions, especially in complex or high-risk surgeries. Surgical wounds are vulnerable to infection and dehiscence, particularly in patients with comorbidities or those undergoing procedures in areas that experience high tension or motion. NPWT provides a unique approach by removing exudate, reducing bacterial load, and maintaining a moist wound environment which is conducive to healing. The therapy also reduces the likelihood of seroma and

Figure 1: Post-burn wound at presentation, after debridement, after NPWT and SSG, and after healing.

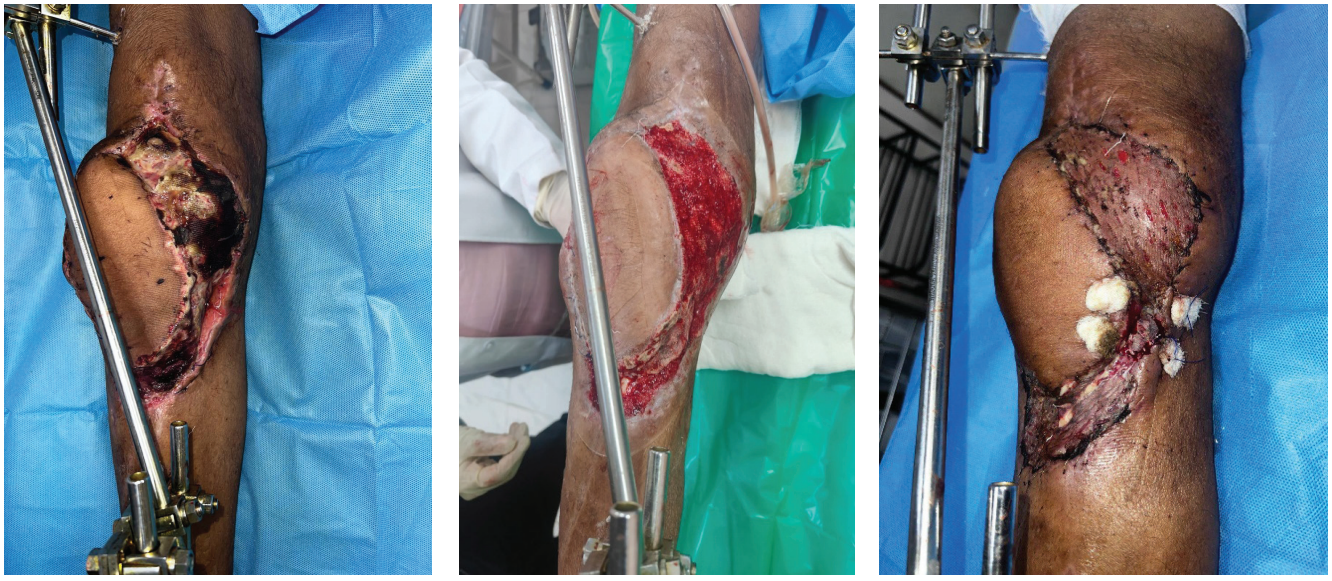

Figure 2: Post-surgical wound with scab, after debridement and NPWT, and after healing post SSG.

hematoma formation, which can complicate recovery. As a result, NPWT has been shown to shorten healing times and lower the incidence of wound-related complications (figure 2).[5,6]

Diabetic Foot: The abnormal cellular proliferation, vascular dysfunction, micro-environment, inflammation and so on are the major causes of DF incorrection. NPWT is a technique that utilizes various types of internal and external forces to remove dead tissue and excretions from the wound, thereby decreasing the infection rate and maintaining moisture in the wound. The NPWT technique is effective in improving the micro-environmental condition of the injury, altering the haemodynamics of micro-vasculature and controlling the wound infection. The most frequent side effects during therapy are swelling of the wound, bleeding, pain and infection. Adequate adjustment of negative pressure has been demonstrated to prevent a propensity for bleeding and complete closure of the cut. To prevent amputations in the past, appropriate assessment of a prior history of DM, optimization of serum sugar levels to facilitate wound healing, and the provision of multidisciplinary treatment can be helpful to prevent amputations (Figure 3).[7,8]

Post-traumatic Wound: In post-traumatic wound care, NPWT has shown promise in promoting faster tissue regeneration and reducing the incidence of infection, which is a critical concern in such injuries. Trauma-related wounds often present complex and irregular wound beds that challenge conventional healing strategies. NPWT helps manage these wounds by creating a controlled environment that optimizes cellular activity, reduces excess fluid accumulation, and enhances perfusion, which facilitates tissue repair and regeneration. The mechanical forces exerted by the therapy can also assist in approximating wound edges, thereby improving closure rates and minimizing the need for secondary procedures (figure 4).[5,7]

General Wound Care Metrics: Across all wound types, NPWT was found to be effective in promoting faster wound closure, reducing infection rates, and improving patient satisfaction. Specifically, NPWT reduced the average time to wound closure by approximately 20 to 35% compared to conventional methods. Patients receiving NPWT also reported fewer instances of pain, as the therapy helped to reduce edema and tissue tension. The overall complication rate was lower in the NPWT group, and there was a noted improvement in the quality of life for patients with chronic or severe wounds.[8]

Economic Impact: Several studies also highlighted the cost-effectiveness of NPWT. Though the initial cost of NPWT therapy may be higher than traditional dressings, the reduction in hospital stays, re-hospitalization rates, and the need for additional surgeries resulted in significant cost savings in the long term. Some studies indicated that the overall healthcare costs were reduced by 15 to 20% for patients treated with NPWT due to faster recovery times and fewer complications.[9,10]

Numerous clinical trials and studies have reported positive outcomes with the use of NPWT for various

Figure 3: diabetic foot with abscess, with NPWT, and after NPWT.

Figure 4: post-traumatic wound with tendon exposure, post-NPWT, and healed wound

types of wounds. In a randomized controlled trial by Woo *et al.* (2014), patients treated with NPWT showed significantly faster wound closure compared to those receiving conventional wound care. Furthermore, the study demonstrated that NPWT reduced the risk of infection and the need for debridement or further surgical interventions.

Similarly, a study conducted by Pata *et al.* (2016) found that NPWT was highly effective in managing diabetic foot ulcers, with a higher rate of wound healing and reduced amputation rates in patients treated with the therapy. The study concluded that NPWT facilitated the closure of wounds and significantly improved the functional outcome for diabetic patients.

A comprehensive meta-analysis published in the Journal of Wound Care (2017) reviewed multiple studies on NPWT and concluded that the therapy resulted in a statistically significant reduction in wound size and faster healing times across different wound types. Additionally, NPWT reduced the incidence of complications, including infections, and improved overall patient satisfaction with the wound care process.

However, while NPWT has proven beneficial in various clinical contexts, it is essential to note that its use requires careful consideration of the individual patient's condition. Factors such as the wound's size, depth, location, and the patient's overall health status must be taken into account. There may also be specific contraindications, such as active malignancy or untreated osteomyelitis, where NPWT would not be advisable. Additionally, although NPWT has been shown to reduce complications like infection, it is not a replacement for comprehensive wound care that includes infection control and other supportive treatments.

CONCLUSION

In conclusion, NPWT represents a valuable and versatile tool in the management of post-traumatic, post-burn, post-surgical, and diabetic wounds. Its ability to promote faster healing, reduce infection rates, and improve patient outcomes makes it an essential component of modern wound care. Future research should continue to explore its full potential, including optimizing protocols for its application and expanding its use in other challenging wound types. The continued development of NPWT technology and materials, coupled with a deeper understanding of its mechanisms of action, will likely lead to even more refined and individualized treatment approaches for patients suffering from complex wounds.

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