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Review

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Advancements, applications, and safety of negative pressure wound therapy: a comprehensive review of its impact on wound outcomes

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Abstract

The increasing adoption and widespread acceptance of negative pressure wound therapy (NPWT) have paralleled the expansion of its indications in clinical practice. The spectrum of indications for NPWT now extends to encompass soft tissue defects arising from trauma, infection, surgical wound care, and soft tissue grafting procedures. Recent advancements in NPWT devices have introduced various adjuncts, such as instillation of fluids or antibiotics into the wound. These additions empower surgeons to enhance the wound healing environment and contribute to combatting infections more effectively. This review delves into the latest literature addressing the proposed mechanisms underlying NPWT's action, its cost-effectiveness, its impact on patient quality of life, and the essential components necessary for its safe use. The review examines the evidence supporting NPWT's application in managing traumatic extremity injuries, controlling infections, and wound care. While NPWT generally exhibits a low complication rate, surgeons must remain aware of the potential risks linked to its utilization. Moreover, the review explores the widening scope of indications for NPWT, shedding light on prospective avenues for innovation and research in this field.

Keywords: Negative pressure wound therapy, VAC, wound, outcomes

INTRODUCTION

In 1997, Argenta and Morykwas introduced a novel sub-atmospheric pressure method for wound management known as negative pressure wound therapy (NPWT)[1]. This technique expedites the healing process by removing exudate, contracting the wound margins, diminishing edema, promoting angiogenesis, and influencing tissue growth by eliminating impediments to cellular migration and proliferation[2]. NPWT also has a pivotal role in addressing soft tissue wounds[3]. In complex clinical situations necessitating soft tissue closure, NPWT serves as an advantageous interim solution by enabling wound isolation and priming it for subsequent coverage. Post-closure of a wound, NPWT serves as a supplementary therapy to enhance the viability of skin grafts and facilitate the healing process for delicate incisions[3].

Given its efficacy and adaptability, NPWT has become widespread in managing extremity trauma. Its applications consistently broaden, surpassing the existing scope of evidence available in this field[3]. Clinical studies have demonstrated NPWT's ability to accelerate wound healing in various settings including diabetic foot ulcers, pressure ulcers, infected surgical wounds, traumatic wounds, and burn injuries[4-8]. The use of NPWT has expanded beyond extremity trauma and is now utilized for wounds in various anatomical locations. Furthermore, technological advancements have led to the development of single-use disposable NPWT devices that provide more versatility in wound care delivery[9]. This review aims to provide surgeons and healthcare providers with a fundamental comprehension of NPWT, recognizing its essential role in the treatments, mechanisms underlying NPWT's action, cost-effectiveness, impact on patient quality of life, and the essential components necessary for the safe application of NPWT.

METHODS

From the databases' inception until December 2023, two authors independently conducted an extensive literature search encompassing PubMed, Embase, Cochrane Library, and Web of Science databases. Our search strategy utilized specific keywords and phrases, including "Negative Pressure Wound Therapy", "NPWT", "Vacuum Assisted Closure", "Vacuum Sealing Drainage", "VSD", "Vacuum-assisted Closure", "VAC", and "Sealed Surface Wound Suction" to identify relevant studies discussing NPWT within clinical settings. For this narrative review, we included all types of studies that discussed NPWT within clinical settings, encompassing randomized controlled trials, observational studies, case series, and cohort studies. The exclusion criteria were as follows: studies that did not focus on human subjects. Specifically, animal studies, abstracts, conference proceedings, and letters to the editor were not considered for inclusion. Our focus was strictly on peer-reviewed articles providing empirical evidence and detailed accounts of NPWT in clinical practice. The objective was to collate and analyze studies that provide a detailed narrative on the use, advancements, and safety of NPWT in treating wounds. Each identified study was screened for relevance based on our inclusion and exclusion criteria, ensuring a focused and relevant body of literature for this review.

NPWT COMPONENTS

The NPWT system is comprised of three fundamental components: an open-pore foam sponge, a semi-occlusive dressing, and a negative pressure source[10-12]. Two commonly utilized variants of the open-pore foam are a black polyurethane ether sponge and a white polyvinyl alcohol sponge. The black sponge, characterized by larger pores, facilitates the ingrowth of fibrovascular tissue, fostering the development of granulation tissue. Conversely, white sponges feature smaller pores that promote less ingrowth, making them more suitable for application over exposed nerves, vessels, or tendons[13-16]. The surgeon can customize the sponge to conform to the distinct shape of the wound bed. Following this customization, a semi-occlusive adhesive dressing is applied to seal the circuit effectively. Connecting the wound bed to the negative pressure source involves using a suction pad and tubing. The negative pressure source typically includes a control panel enabling adjustment of therapy settings alongside a canister designated for the collection of wound effluent[10,17].

NPWT components advancements

Though the sponge, adhesive, and negative pressure source constitute the foundational elements of NPWT, ongoing advancements continuously refine this technology. Specifically, introducing silver-impregnated sponges and fabrics has emerged as an advantageous complement to conventional NPWT. These innovations have helped reduce bacterial colonization within wounds, thereby reducing the need for debridement procedures and shorter hospital stays[18-23]. For instance, Silverlon, a fabric woven from silver ion-coated fibers, offers a safe application method by conforming the fabric to match the contours of the wound bed, followed by the placement of the vacuum sponge over it. According to the manufacturer's guidelines, this combination can remain in position for up to 7 days. This approach reduces the necessity for frequent debridement procedures and contributes to shorter hospital stays[19].

An alternative modification frequently employed is the utilization of antimicrobial-impregnated adhesive drapes for wound closure. Flexible strips of these adhesive drapes are adaptable for intricate regions, such as external fixation pins, potentially enhancing protection against bacterial colonization[24]. Before applying the adhesive drapes, moldable ostomy strip paste or gel adhesive dressings present an additional option around external fixator pins to enhance the efficacy of achieving a secure seal. Furthermore, the seal's effectiveness can be further reinforced by incorporating liquid adhesives like DuraPrep or Mastisol before the placement of the adhesive drapes[3,7].

Further methods exist to facilitate wound contraction. An approach involves employing vessel loops anchored at one end of the wound, subsequently interweaving them sequentially along the wound or incision edges. This process involves securing them with staples along the wound's length to create a crisscross pattern akin to a shoelace or Jacobs ladder. Quacinella *et al*. propose the placement of the foam sponge beneath the vessel loops[3]. Integrating the shoelace technique with NPWT demonstrates the potential for shortening the time required for closure compared to utilizing either method independently[25]. Figure 1 illustrates the step-wise approach to NPWT.

MECHANISM OF ACTION

Several proposed mechanisms elucidating the efficacy of NPWT are broadly classified into two categories: macrostrain and microstrain[10]. The prevailing evidence strongly indicates that microstrain stands as the primary mechanism[3]. It is primarily generated by establishing subatmospheric pressure within the wound environment, subsequently initiating mechanotransduction pathways[3]. The mechanical stimulation exerted on individual cells triggers the production of growth factors, subsequently initiating cell proliferation, angiogenesis, and granulation tissue formation[26]. The open-pore sponge functions like a scaffold, facilitating the infiltration of fibroblasts and tissue growth[27].

On the other hand, macrostrain primarily involves a mechanical process in which negative pressure induces contraction of the foam sponge, thereby reducing the wound's surface area. Additionally, the generated suction reduces interstitial tissue edema, removes infectious debris and exudates, and influences changes in tissue perfusion[28].

The occlusive dressing is pivotal in stabilizing the wound within a sealed environment. The risk of contamination or colonization diminishes with NPWT, necessitating less frequent dressing changes than traditional methods. Overall, the mechanism of action is multifaceted, and our comprehension of it

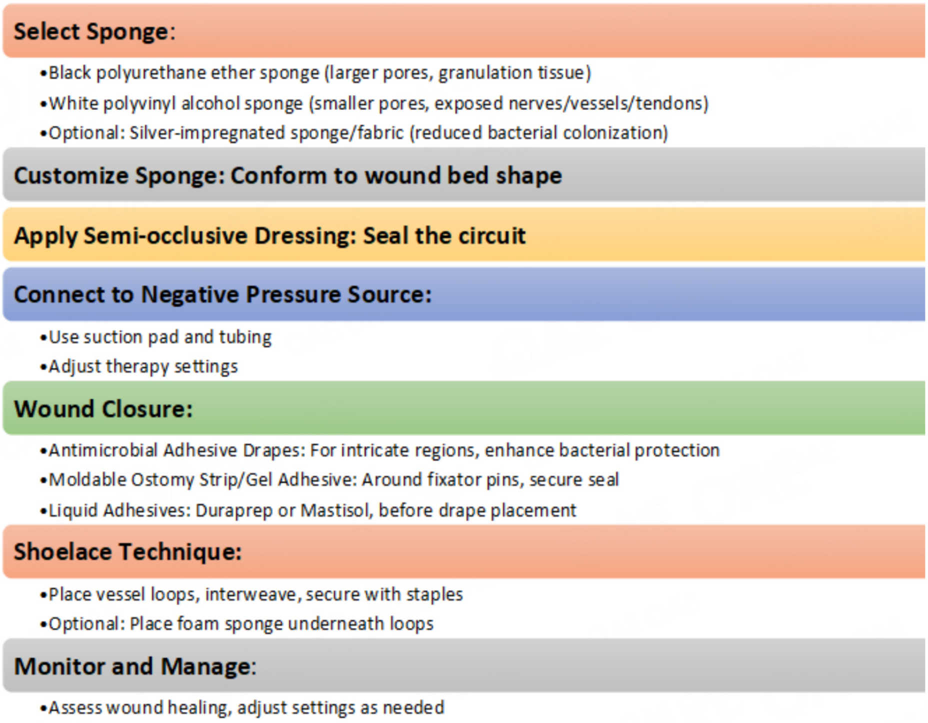

Figure 1. Step-wise approach to NPWT. NPWT: negative pressure wound therap.

continues to advance[3].

NPWT TYPES

When employing NPWT on a wound, numerous variables can be adjusted. Among these, the two most commonly modified settings include the level of negative pressure applied and the therapy mode governing the application of negative pressure. Typically, wounds are conventionally treated with a negative pressure of 125 mmHg, a value derived from animal models that showcased optimal perfusion and granulation tissue formation at this specific pressure[29]. Under a negative pressure of 275 mmHg, there is an increase in perfusion from the baseline, albeit not as robust as observed at 125 mmHg. However, at negative pressures surpassing 125 mmHg, perfusion is reduced compared to that at 125 mmHg. Moreover, exceedingly high negative pressures, specifically over 400 mmHg, tend to reduce perfusion below the baseline level[1]. Given the limited evidence available from human studies, the optimal negative pressure range likely falls between 75 mmHg and 125 mmHg, depending upon the therapeutic objectives[30].

The application mode of pressure to the wound bed can also be regulated, offering options such as intermittent, continuous, and variable pressure settings. Intermittent pressure is associated with improved generation of granulation tissue; however, patients might encounter increased discomfort during the transitions between pressure levels[3]. Consequently, continuous pressure is frequently preferred in clinical practice due to its smoother application. Variable pressure, however, presents an alternative method that yields a comparable quality of granulation tissue to intermittent pressure therapy while mitigating the discomfort during transitions between pressure states. This variable pressure feature may render it more tolerable for patients[31].

NPWT APPLICATIONS AND INDICATIONS

NPWT offers diverse applications tailored to individual clinical needs. It optimizes the soft tissue environment by stabilizing wounds, promoting contraction, and aiding drainage, which are vital for varied wound types[32]. In orthopedic trauma, the use of NPWTs spans from covering open fractures to managing infections and aiding in skin grafting. NPWT significantly reduces deep infections compared to traditional dressings in severe open fractures[32,33]. The meta-analysis by Grant-Freemantle *et al*. reinforced NPWT's efficacy in preventing infections and reducing subsequent procedures in open fractures, showcasing lower rates of skin grafting and flap failure[33]. NPWT's adaptability and proven benefits underscore its integral role in managing complex wounds, especially in orthopedic trauma scenarios[33].

The adoption of Incisional NPWT has become increasingly favored, especially in scenarios where achieving primary closure over high-risk fractures, delicate incisions, or traumatized soft tissues is crucial. Its utilization is correlated with reduced incidences of wound complications, notably lower rates of dehiscence, infection, hematoma, and seroma formation[34-36]. A recent meta-analysis indicates that the impact on infection reduction can be substantial, with reported decreases of up to 40%. In the application of Incisional NPWT, nonadherent dressings are applied to a surgically closed incision prior to the placement of the foam sponge[37]. This method shields the skin adjacent to the incision, preventing potential excoriation caused by the polyurethane foam. Simultaneously, it diminishes edema and enhances perfusion at the wound's edges. An alternative method involves placing the white sponge directly onto the skin incision. However, it necessitates removal within 72 hours to prevent ingrowth. To streamline and enhance the application of incisional NPWT, several single-use proprietary systems have been introduced to the market, making the application simpler and more accessible. Incisional NPWT finds utility in post-amputation care and has effectively minimized complications such as stump dehiscence, infection, and hematoma formation[38].

NPWT has proven to be a valuable adjunct in enhancing the survival of skin grafts. Its application over split-thickness skin grafts has demonstrated superior graft survivorship and integration compared to conventional dressings. Additionally, employing NPWT over split-thickness skin grafts has shown a lower relative risk of reoperation and contributed to reduced hospitalization durations. However, in low-risk wounds treated with split-thickness skin grafts, successful healing was comparable between NPWT and traditional bolster dressings[39,40]. A summary of the NPWT applications is presented in Table 1.

NPWT CONSIDERATIONS AND POSSIBLE COMPLICATIONS

NPWT is generally safe but requires caution in specific cases. Surgeons must be aware of potential complications. It effectively stabilizes wounds involving damaged tissue and bone but has limitations in those with exposed bone, implants, or non-vascularized structures. Inexperienced surgeons should involve plastic surgery early for optimal outcomes[41]. To avoid tissue damage or fatal bleeding, NPWT should not be directly applied to sensitive structures like nerves, vessels, or organs. Techniques such as repositioning sensitive structures, using healthy tissue coverage, or a saline-soaked sponge help prevent complications[41]. Careful consideration and expert involvement are crucial in utilizing NPWT to avoid adverse effects and optimize healing in complex wounds.

In high-energy blast injury cases, evidence suggests a potential association between NPWT utilization and heterotopic ossification (HO) development. Findings from observations in conflict zones such as Iraq and Afghanistan have indicated NPWT as an independent risk factor for HO in extremity blast injuries. Yet, these conclusions stem from a restricted retrospective study encompassing a small sample size. Additionally, when evaluating the risk of HO, variables like injury severity and the injury mechanism might exert a more substantial influence than the application of NPWT alone[42]. Subsequent investigations have not definitively

Table 1. Important NPWT applications in the clinical setting

Soft tissue Issues	- Used for wound stabilization, promoting contracture, and facilitating drainage to optimize the soft tissue environment
Orthopedic Trauma	- Open fractures: NPWT prevents infection and stabilizes subsequent coverage procedures
	- Significant decrease in deep infection rates compared to conventional dressings in severe open fractures
	- Efficient in preventing infections in temporarily covered open fractures
	- Reduces frequency of subsequent coverage procedures, skin grafting, and flap failure rates
Incisional NPWT	- Utilized for high-risk fractures, delicate incisions, or traumatized soft tissues to achieve primary closure
	- Reduces wound complications like dehiscence, infection, hematoma, and seroma formation
	- Nonadherent dressings shield skin adjacent to the incision, diminish edema, and enhance wound edge perfusion
Skin grafting	- Enhances survival of split-thickness skin grafts, leading to superior graft survivorship and integration over conventional dressings
	- Lowers relative risk of reoperation and reduces hospitalization durations when applied over split-thickness skin grafts
	- Comparable healing outcomes in low-risk wounds treated with split-thickness skin grafts between NPWT and traditional dressings

NPWT: negative pressure wound therap.

established a direct correlation between NPWT and HO in combat-related injuries. However, they have revealed an association between NPWT usage and escalated injury severity, as well as heightened wound bioburden among combat casualties who are more likely to undergo NPWT treatment[43].

The malfunction of NPWT systems due to concerns like loss of seal, punctures, blockages in the drainage system, or power failures can lead to prolonged discontinuation of therapy. Such interruptions have been associated with heightened risks of wound dehiscence and infection. Therefore, it remains critical to thoroughly educate caregivers and patients about the importance of promptly reporting system failures and instructing them on proficiently managing such incidents [44].

Numerous technical considerations are involved in applying NPWT to traumatic extremity injuries. The primary objective is to achieve a completely sealed enclosure, ensuring the continuous application of negative pressure without therapy interruptions. This approach aims to prevent harm to healthy, non-injured soft tissues.

Surgeons aim to decontaminate wounds initially, favoring primary closure if feasible after thorough debridement to prevent deep infection[45,46]. When primary closure is not viable, early definitive fixation or flap coverage outperforms delayed options[47]. NPWT becomes valuable in cases of significant contamination or when subsequent procedures are expected. Surgeons must protect delicate structures like nerves, vessels, or bone using specialized sponges or tissue rotation during NPWT to avert potential injury.

Some wound categories may present difficulties in utilizing NPWT safely. Establishing an airtight seal during NPWT application becomes challenging in cases of circumferential injuries. Moreover, the pressure exerted by NPWT on the extremity in such injuries might compromise adequate blood flow to the distal part of the limb. According to existing literature, employing circumferential NPWT appears to be safe, and it allows for the maintenance of oxygen saturations in the distal extremity at approximately 96%, even during extended periods of application[48].

The intricate structure of the hand and foot presents challenges in establishing a proper seal and closure for the NPWT circuit. Surgeons frequently encounter situations requiring judgment regarding the suitability of NPWT application over delicate structures such as exposed bones and tendons. It is imperative to exercise caution to safeguard arteries, nerves, veins, vascular anastomosis, or repaired nerves during this process[49]. In cases where wounds extend into the web spaces between the digits, establishing a pressure seal can be challenging. Yet, employing a surgical glove over the hand might assist in preventing leaks[50]. NPWT considerations and possible complications are summarized in Table 2.

SPECIAL MODALITIES OF NPWT

As the utilization of NPWT has expanded, advancements in the traditional technique have surfaced. NPWT with instillation and dwell time (NPWTi-d) entails the periodic introduction of topical solutions, irrigating both the wound and dressing for a specified duration[3]. The solutions are removed through suction, contributing to an enhanced therapeutic approach. These methods require additional components: a reservoir housing the instillation solution and a cassette integrated with tubing for conveying the solution to the pressure sensor pad. This pad is commonly connected to the occlusive dressing, constituting crucial elements for the successful application of NPWTi-d[3].

NPWTi-d employs an enhanced reticulated open-cell foam sponge featuring 1-cm diameter perforations positioned at intervals of 0.5[51]. Surgeons maintain control over solution selection, dwell time, negative pressure duration, and cycle frequency in NPWTi-d. Available instillation solution choices include saline, antimicrobial agents, and debridement solutions. Ongoing research suggests that NPWTi-d offers superior results compared to conventional NPWT, showcasing decreased requirements for debridement, accelerated wound closure, improved granulation, and reduced bacterial presence[52]. Nevertheless, the current body of research predominantly focuses on chronic or superficial wounds, with limited supportive investigations conducted on wounds concurrent with fractures.

Surgeons may contemplate utilizing local antibiotic delivery methods such as powdered antibiotics, bead pouches, or antibiotic cement spacers in highly contaminated wounds. This consideration becomes particularly relevant in scenarios marked by substantial contamination or sizable bony voids. Utilizing local antibiotics can be advantageous, particularly when encountering a loss of suction, resulting in the transformation of the wound into an antibiotic bead pouch or a similar wound environment[44]. Combining NPWT with antibiotic delivery methods does not significantly affect the release and concentration of antibiotics within the wound bed. Animal studies have shown that using these modalities concurrently with NPWT leads to a significant decrease in bacterial presence compared to using NPWT alone[53].

Incorporating a drain into an incisional NPWT dressing is a feasible tactic for managing dead space, particularly relevant for wounds slated for primary closure requiring deep drainage[3]. Within this approach, the black open-pore foam sponge is placed directly on the skin, facilitating the incorporation of the deep drain into the dressing. Therefore, it is advisable to remove this setup within 72 h postoperatively to prevent tissue ingrowth into the sponge[3].

NPWT applies sub-atmospheric pressure to the wound, reducing edema and increasing perfusion, thus accelerating tissue regeneration. The addition of growth factors such as PDGF, VEGF, and EGF further stimulates angiogenesis, cell proliferation, and migration, enhancing the reparative process. In surgical applications, particularly for chronic and complex wounds like diabetic foot ulcers, pressure ulcers, and post-surgical wounds, this combination therapy has shown promising results[54]. Growth factors delivered via NPWT are better retained at the wound site, providing sustained biological activity. Studies have demonstrated that this synergistic approach addresses the limitations of each modality alone, optimizing the healing microenvironment and improving clinical outcomes[54]. NPWT also helps maintain a moist wound environment, which is critical for optimal cell function and growth factor activity. This environment

Table 2. Summary of important points to consider when applying NPWT

General measures for NPWT	- Ineffective for wounds with exposed bone, implants, or non-vascularized structures
	- Should not be directly applied to sensitive structures like nerves, vessels, or organs to avoid tissue damage
	- Techniques like repositioning sensitive structures or using healthy tissue coverage help prevent complications
	- Inexperienced surgeons should get involved in plastic surgery early for optimal outcomes
	- Ineffective for wounds with exposed bone, implants, or non-vascularized structures
	- Early primary closure is preferred for preventing deep infection
	- Early definitive fixation and closure outperform delayed soft tissue coverage
NPWT and heterotopic ossification (HO)	- Some evidence suggests NPWT might pose a risk for HO in extremity blast injuries
	- Limited data indicate a potential link, but other factors like injury severity may be influential
	- Subsequent research has not conclusively established the NPWT-HO connection
	- Association between NPWT usage and higher injury severity, increased wound bioburden identified
NPWT system failures	- System failure may lead to prolonged discontinuation, increased risk of wound dehiscence, and infection
	- Education is crucial to promptly report system failures and manage incidents effectively.
Challenges in specific wound categories	- Circumferential injuries pose sealing challenges; pressure might compromise distal limb blood flow
	- Hand and foot wounds require caution to safeguard delicate structures; glove use is recommended for web space wounds

NPWT: negative pressure wound therap.

minimizes the risk of infection and promotes faster tissue granulation and wound contraction. The mechanical forces exerted by NPWT further stimulate cellular responses and extracellular matrix production, which are essential for wound healing[54]. This multifaceted approach, leveraging both mechanical and biological mechanisms, offers a comprehensive solution for managing difficult-to-heal wounds, paving the way for better surgical outcomes and reduced healthcare costs.

NPWT AND AESTHETIC OUTCOMES

NPWT has demonstrated efficacy in enhancing scar quality during wound healing[55]. For instance, a study on acute burns affecting the hand revealed that employing local NPWT resulted in favorable scar appearance and quality[56]. Conversely, when NPWT was utilized for open abdominal wounds, it was associated with a deterioration in scar appearance[57]. The available research concerning scar quality subsequent to skin grafts treated with NPWT remains limited, leaving the precise impact unclear. However, a randomized controlled trial demonstrated a significant enhancement in the appearance of split-thickness skin grafts (STSGs) two weeks post-surgery when NPWT was employed, as opposed to standard packaged dressings[58]. Additionally, another randomized controlled trial indicated that NPWT improved the scar coloration of STSGs[59]. Conversely, findings from other randomized controlled trials have contradicted these observations, suggesting that NPWT did not yield improvements in the quality or esthetic appearance of scars in STSGs compared to traditional dressings[60].

Numerous studies have indicated the potential of NPWT to enhance the appearance of incisional scars [61-63]. However, the aesthetic impact on skin grafts treated with NPWT remains uncertain. Mo *et al*. highlighted a notable difference in hand scars' surface smoothness or relief[64]. Despite unclear mechanisms, certain animal experiments have indicated that pressure may decrease the thickness of the scar dermis while not significantly affecting the thickness of the epidermis[64].

NPWT VERSUS STANDARD CARE IN SURGICAL SITE INFECTION

A recent meta-analysis by James *et al*. revealed significant reductions in the incidence of overall Surgical Site Infections (SSI) for both Class I and Class II surgical classifications when comparing NPWT to standard care[65]. The CDC's surgical wound classification serves as a means to pre-emptively categorize surgical wounds based on their risk for SSI[66]. Sub-analyses in the previous meta-analysis were conducted specifically for Class I and II surgeries since NPWT is presently not indicated for use in Class III/IV surgeries. Nonetheless, given that Class I and II surgeries constitute the majority of post-surgical wounds, they represent a significant portion of the surgical population[67]. Consequently, the outcomes of James *et al*. underscore the suitability of NPWT in preventing SSI across diverse patient populations, risk factors, and surgical procedures[65].

Saunders *et al*.'s work further reinforced the advantages of NPWT in reducing overall infection rates[68]. These outcomes potentially stem from NPWT's capacity to impact local moisture dynamics within the tissue at the surgical site[59]. This capability might facilitate lymphatic drainage and help mitigate inflammation, contributing to the clearance of deeply entrenched pathogens that could have originated from the surgical intervention[69].

PATIENT QUALITY OF LIFE (QOL)

Three studies in 2006 highlighted the benefits of NPWT for chronic wounds[70-72]. Braakenburg's randomized trial compared NPWT to various dressings, revealing that NPWT led to faster healing and wound size reduction with similar costs despite NPWT instruments and dressings being pricier[68]. Vuerstaek's study echoed these findings, showing quicker healing, reduced costs, and improved patient QoL with NPWT[71]. Augustin and Zschocke also reported a significant increase in QoL and satisfaction among patients post-NPWT[73].

Patient involvement emerged as a crucial aspect, aligning with the NHS agenda for shared decision-making in treatment options. Searle and Milne's review affirmed NPWT's cost-effectiveness compared to conventional therapies, while Abbott's report highlighted improved wound healing in most patients, although concerns such as smell, embarrassment, noise, and pain were noted[73,74].

The engagement of patients in the care process, such as preparing dressings and troubleshooting minor issues, was observed to reduce disruptions in healing, exposure to contaminants, and efforts by the staff. This aligns with the Department of Health's Quality, Innovation, Productivity, and Prevention (QIPP) program to improve care while reducing costs[74].

NPWT COST ANALYSIS

Dowsett *et al*.'s cost analysis underscored substantial savings (£4814 per patient) by implementing NPWT services in the community rather than in secondary care settings between 2009 and 2011[73,75]. This shift not only saved costs per patient but also potentially addressed a significant aspect of the NHS's financial deficit while bringing care closer to patients' homes. Searle and Milne's literature review examining cost analyses of NPWT established compelling evidence supporting NPWT's cost-effectiveness over conventional therapies[76]. Abbott's study documented enhanced wound healing in all but one patient within a sample size of 12[77]. Most patients expressed concerns regarding the exudate smell emanating from the canister and feelings of embarrassment, noise, and pain associated with NPWT[73].

Conversely, these patients exhibited proactive behavior by preparing the dressings before the nurse's arrival, gaining confidence in troubleshooting methods, such as addressing air leaks and clearing tube blockages[73]. Reducing the frequency of dressing changes can help diminish exposure to contaminants and lessen interference with the natural wound-healing process. Moreover, this heightened level of patient involvement can alleviate the time and effort expended by staff, potentially resulting in cost savings for the NHS while liberating nurses to allocate their time to other activities. This increased service productivity could further enhance the overall patient experience[73].

CONCLUSION

Using NPWT and NPWTi-d techniques signifies a significant stride forward in managing infected wounds, traumatic wounds, and high-risk surgical incisions. Their efficacy in addressing these intricate surgical scenarios, coupled with their demonstrated ability to diminish hospital stays, reduce the frequency of surgical procedures, enhance graft survival rates, and concurrently lower the overall cost of care, elucidates the burgeoning adoption of NPWT across various surgical subspecialties. The present body of literature notably lacks precise directives regarding the application of NPWT in intricate clinical scenarios, particularly concerning situations involving devitalized bone and tendons, as well as exposed neurovascular structures. Certainly, despite these knowledge gaps, NPWT remains a formidable asset in a surgeon's toolkit when managing intricate infections, soft tissue injuries, and high-risk incisions.

DECLARATIONS

Authors' contributions

Made substantial contributions to the conception and design of the study and performed data analysis and interpretation: Seth I, Gibson D, Bulloch G, Lim B

Performed data acquisition, as well as providing administrative, technical, and material support: Seth I, Gibson D

Writing, Editing and Formatting of the manuscript: Seth I, Xie Y, Marcaccini G, Lim B, Bulloch G, Cevik J

Supervision of the manuscript: Cuomo R, Rozen WM

Availability of data and materials

Data and materials are available in the manuscript.

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Conflicts of interest

Dr. Roberto Cuomo and Dr. Warren M. Rozen are Editorial Board members of the Plastic and Aesthetic Research (PAR) journal. All other listed authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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