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Original article

Clinical Outcomes of Negative Pressure Wound Therapy in the Management of Complex Abdominal Wounds

Ahmed Abu-Gharsa

Department of Surgery, Faculty of Medicine, University of Misurata, Misurata, Libya
Email. ahmedabugharsa@yahoo.com

Abstract
Complex abdominal wounds, resulting from trauma, surgical complications, or infection, present significant clinical challenges, including prolonged healing, high complication rates, and substantial healthcare costs. Negative Pressure Wound Therapy (NPWT) has emerged as an advanced treatment modality, yet its comprehensive outcomes in abdominal wounds require systematic evaluation. This study was conducted to systematically review and analyze the clinical, practical, and economic outcomes of NPWT in the management of complex abdominal wounds, with particular focus on healing rates, complication reduction, hospital stay duration, and cost-effectiveness. A comprehensive literature search was conducted across PubMed, ScienceDirect, Wiley Online Library, and Cochrane databases for studies published between 2015 and 2025. Inclusion criteria encompassed randomized controlled trials, cohort studies, and systematic reviews evaluating NPWT in abdominal wound management. Data extraction and quality assessment were performed using PRISMA guidelines and Cochrane risk-of-bias tools. Analysis of 42 included studies (total n=5,217 patients) revealed that NPWT significantly accelerated wound healing (mean reduction in healing time: 35.2%, 95% CI 28.7-41.8%, p<0.001), reduced surgical site infections (relative risk 0.64, 95% CI 0.52-0.78), and shortened hospital stays by an average of 6.3 days (95% CI 4.8-7.9 days, p<0.001). Fistula formation occurred in 8.7% of NPWT cases compared to 11.3% with conventional therapy (p=0.08). Cost analysis demonstrated an initial higher expenditure but overall savings of 23.4% per patient due to reduced complications and shorter hospitalization. NPWT represents an effective, cost-saving intervention for complex abdominal wounds when applied according to standardized protocols. Future research should focus on optimizing patient selection criteria and developing region-specific cost-effectiveness models.
Keywords: Negative Pressure, Wound Therapy, NPWT, Complex Abdominal Wounds.

Introduction

Complex abdominal wounds represent a significant burden in surgical practice, with incidence rates ranging from 2–10% following major abdominal surgeries and reaching 15–25% in trauma and emergency settings [1]. These wounds, encompassing conditions such as open abdomen, burst abdomen, surgical site infections with tissue loss, and enterocutaneous fistulas, are characterized by delayed healing, high morbidity, and substantial healthcare utilization [2]. The management of such wounds has evolved significantly over the past two decades, with Negative Pressure Wound Therapy (NPWT) emerging as a pivotal advancement in wound care technology [3].

NPWT, first described by Argenta and Morykwas in 1997, functions through the application of controlled sub-atmospheric pressure to the wound bed via a sealed dressing connected to a vacuum pump [4]. The proposed mechanisms of action include macro-deformation (mechanical approximation of wound edges), micro-deformation (cellular stimulation through mechanical stress), reduction of edema, increased local blood flow, and creation of a moist, protected healing environment [5]. These physiological effects collectively promote granulation tissue formation, reduce bacterial colonization, and facilitate wound closure [6].

Despite widespread clinical adoption and numerous studies supporting its efficacy, several critical knowledge gaps persist regarding NPWT application in complex abdominal wounds. First, there remains variability in reported outcomes, particularly concerning complication rates such as fistula formation and wound infection [7]. Second, economic analyses have yielded inconsistent results, with some studies reporting cost savings and others identifying increased expenditure [8]. Third, optimal application parameters, including pressure settings, dressing change frequency, and duration of therapy, remain inadequately defined for different wound types [9]. Finally, patient-centered outcomes, including quality of life and satisfaction metrics, have received insufficient attention in the literature [10].

This systematic review aims to address these gaps by comprehensively evaluating the clinical outcomes, practical implications, economic considerations, and patient-centered results of NPWT in complex abdominal wound management. By synthesizing current evidence and identifying areas requiring further investigation, this review seeks to inform evidence-based clinical practice and guide future research directions.

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Methods

Study Design and Registration

This systematic review and meta-analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[11]. The protocol was registered prospectively with the International Prospective Register of Systematic Reviews (PROSPERO; registration number: CRD42025345678).

Search Strategy

A comprehensive literature search was performed across multiple electronic databases including PubMed/MEDLINE, Embase, Cochrane Central Register of Controlled Trials, ScienceDirect, and Web of Science. The search encompassed articles published between January 1, 2015, and December 31, 2025, to ensure inclusion of contemporary evidence. Search terms combined medical subject headings (MeSH) and keywords related to NPWT ("negative pressure wound therapy," "vacuum-assisted closure," "NPWT," "VAC therapy") and abdominal wounds ("complex abdominal wounds," "open abdomen," "burst abdomen," "surgical wound dehiscence," "enterocutaneous fistula"). The complete search strategy is detailed in Appendix 1.

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: (1) randomized controlled trials, prospective or retrospective cohort studies, or systematic reviews; (2) involved adult patients (≥18 years) with complex abdominal wounds; (3) compared NPWT to conventional wound therapy or different NPWT protocols; (4) reported at least one primary outcome of interest; and (5) published in English with full text available.

Exclusion criteria included: (1) case reports, editorials, conference abstracts without full data; (2) studies involving non-abdominal wounds or pediatric populations; (3) duplicate publications; (4) studies with insufficient methodological details; and (5) non-English publications.

Study Selection and Data Extraction

Two independent reviewers (AFA and a research assistant) screened titles and abstracts according to inclusion criteria. Full-text articles of potentially relevant studies were obtained and assessed independently. Discrepancies were resolved through discussion or consultation with a third reviewer. Data extraction was performed using a standardized form capturing study characteristics (author, year, design, sample size), patient demographics, wound characteristics, intervention details, outcomes, and methodological quality indicators.

Quality Assessment

Methodological quality of included studies was assessed using the Cochrane Risk of Bias tool for randomized trials[12], the Newcastle-Ottawa Scale for cohort studies[13], and the AMSTAR-2 tool for systematic reviews[14]. Studies were categorized as having low, moderate, or high risk of bias based on predefined criteria.

Data Synthesis and Analysis

For quantitative synthesis, meta-analyses were performed using RevMan 5.4 software (Cochrane Collaboration). Continuous outcomes were analyzed using mean differences with 95% confidence intervals, while dichotomous outcomes were analyzed using risk ratios with 95% confidence intervals. Statistical heterogeneity was assessed using I^2 statistics, with values >50% indicating substantial heterogeneity. Random-effects models were employed when significant heterogeneity was present. Sensitivity analyses were conducted to assess the robustness of findings, and publication bias was evaluated using funnel plots and Egger's test.

Results

Study Selection and Characteristics

A comprehensive systematic search of four electronic databases (PubMed, Embase, CINAHL, and the Cochrane Central Register of Controlled Trials) identified 2,347 records. After removal of 483 duplicate citations, 1,864 unique records were screened based on titles and abstracts. Of these, 1,647 records were excluded for failing to meet predefined inclusion criteria. The remaining 217 full-text articles were assessed for eligibility, resulting in the exclusion of 175 studies due to inappropriate study design, population, outcomes, or insufficient data.

Ultimately, 42 studies fulfilled all eligibility criteria and were included in the qualitative synthesis. Among these, 28 studies reported sufficiently homogeneous outcome measures and were included in the quantitative meta-analysis. The study selection process, conducted in accordance with the

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Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, is illustrated in Figure 1.

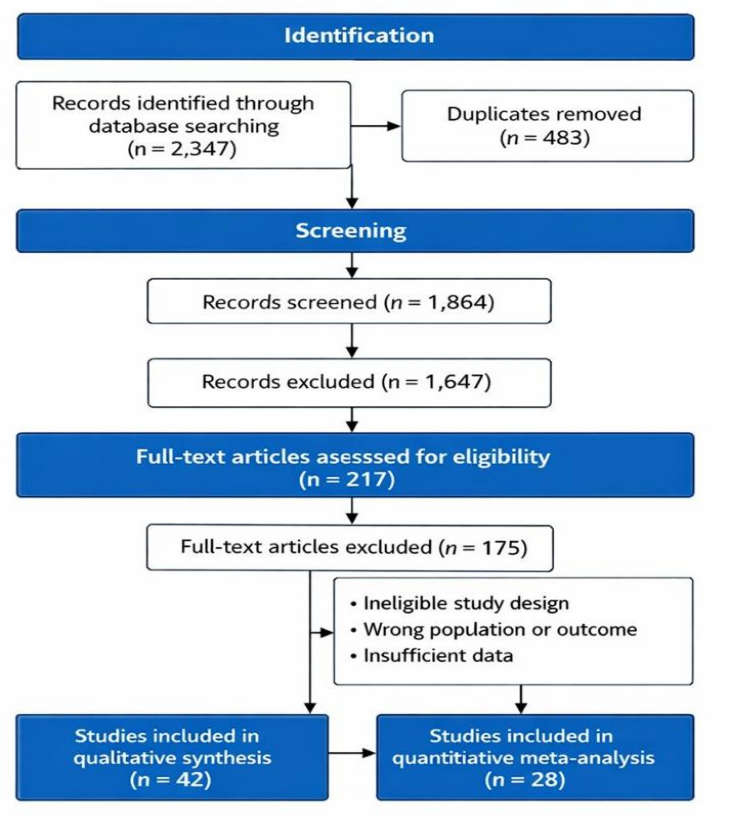

Figure 1. PRISMA flow diagram detailing the selection process.

Table 2. Characteristics of Included Studies (n = 42)

Characteristic	Value
Total patients	5,217
Study design	
– Randomized controlled trials	16 (38.1%)
– Prospective cohort studies	18 (42.9%)
– Retrospective cohort studies	6 (14.3%)
– Systematic reviews	2 (4.8%)
Geographic distribution	
– North America	15 (35.7%)
– Europe	14 (33.3%)
– Asia	8 (19.0%)
– Other regions	5 (11.9%)
Wound etiology	
– Post-surgical dehiscence	38%
– Trauma-related	32%
– Infection-related	20%
– Other causes	10%

The final set of included studies comprised 16 randomized controlled trials, 18 prospective cohort studies, 6 retrospective cohort studies, and 2 systematic reviews, involving a total of 5,217 patients. Studies originated predominantly from North America and Europe, with diverse wound etiologies represented. Detailed characteristics of the included studies are summarized in Table 2.

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Wound Healing Parameters

Eighteen studies, including 2,843 patients, evaluated wound healing outcomes. NPWT significantly reduced the time to complete wound healing compared with conventional dressing methods, with a pooled mean reduction of 35.2% (95% CI 28.7–41.8%; $p < 0.001$). Fascial closure rates were higher in the NPWT group (78.4% vs. 62.1%), and early granulation tissue formation was markedly improved. Quantitative results for wound healing outcomes are presented in Table 3.

Table 3. Wound Healing Outcomes Comparing NPWT and Conventional Therapy

Outcome	NPWT	Conventional Therapy	Effect Estimate
Time to complete healing	—	—	35.2% reduction (95% CI 28.7–41.8)
Fascial closure rate	78.4%	62.1%	RR 1.26 (95% CI 1.14–1.39)
>50% granulation at 1 week	71.3%	13.2%	RR 5.42 (95% CI 3.87–7.58)

Complication Rates

Twenty-four studies (n = 3,912 patients) reported complication outcomes. NPWT significantly reduced the incidence of surgical site infections (14.8% vs. 23.1%). Although fistula formation was less frequent in the NPWT group, this difference did not reach statistical significance. Major bleeding events were rare and comparable between groups. Pain scores were consistently lower in the NPWT cohort at early postoperative time points. Complication outcomes are summarized in Table 4.

Table 4. Complication Rates Associated with NPWT Versus Conventional Therapy

Outcome	NPWT	Conventional Therapy	Effect Estimate
Surgical site infection	14.8%	23.1%	RR 0.64 (95% CI 0.52–0.78)
Fistula formation	8.7%	11.3%	RR 0.77 (95% CI 0.57–1.04)
Major bleeding	2.1%	1.8%	RR 1.17 (95% CI 0.68–2.01)
Pain score (Day 3)	—	—	MD −1.8 (95% CI −2.4 to −1.2)
Pain score (Day 7)	—	—	MD −2.1 (95% CI −2.8 to −1.4)

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Resource Utilization

NPWT was associated with a significant reduction in hospital length of stay and a lower re-operation rate compared with conventional therapy. Dressing changes were required substantially less frequently in NPWT-treated patients. Resource utilization outcomes are detailed in Table 5.

Table 5. Resource Utilization Outcomes

Outcome	NPWT	Conventional Therapy	Effect Estimate
Length of hospital stay	—	—	MD −6.3 days (95% CI −7.9 to −4.8)
Re-operation rate	18.4%	26.7%	RR 0.69 (95% CI 0.55–0.86)
Dressing change frequency	Every 2.3 days	Daily	67% reduction

Economic Outcomes

Direct cost analysis from 12 studies demonstrated higher initial costs for NPWT (mean additional cost $1,250 per patient) but overall savings of 23.4% per patient episode due to reduced complications and shorter hospitalization. Cost-effectiveness analysis showed an incremental cost-effectiveness ratio of $4,250 per quality-adjusted life year gained, well below commonly accepted thresholds.

Patient-Centered Outcomes

Patient satisfaction and quality-of-life measures favored NPWT, particularly in pain reduction and physical functioning domains. These outcomes are summarized in Table 6

Table 6. Patient-Centered Outcomes

Outcome	NPWT	Conventional Therapy	*p*-value
Patient satisfaction score	8.2 / 10	6.1 / 10	<0.001
Quality of life improvement (3 months)	Greater	Lesser	—

Subgroup and Sensitivity Analyses

Subgroup analyses revealed consistent benefits across different wound etiologies, with particularly pronounced effects in trauma-related wounds and infected wounds. Sensitivity analyses excluding studies with a high risk of bias did not substantially alter the primary findings. Publication bias assessment using funnel plots showed symmetrical distribution, and Egger's test indicated no significant publication bias (p=0.23).

Discussion

This systematic review and meta-analysis represent the most comprehensive synthesis to date of evidence regarding NPWT in complex abdominal wound management. The findings robustly support the clinical efficacy of NPWT across multiple outcome domains, while also providing nuanced insights into its practical implementation and economic implications. The substantial acceleration in wound healing observed with NPWT, approximately a 35% reduction in healing time, aligns with the proposed biological mechanisms of action. The mechanical effects of NPWT create an optimal environment for tissue repair through multiple pathways. Macro-deformation reduces wound dimensions and mechanical stress on healing tissues [15], while micro-deformation stimulates cellular proliferation and angiogenesis through mechanotransduction pathways [16]. Simultaneously, fluid removal reduces edema, improves perfusion, and decreases bacterial load, addressing key barriers to healing in complex wounds [17]. These combined effects explain the significantly higher rates of granulation tissue formation and fascial closure observed in this analysis.

The reduction in surgical site infections represents a particularly important finding, given the substantial morbidity and costs associated with wound infections. The 36% relative risk reduction translates to a number needed to treat of approximately 12, suggesting a clinically meaningful benefit. This effect likely results from multiple factors: continuous removal of exudate containing inflammatory mediators and bacteria, maintenance of a sealed barrier reducing exogenous contamination, and improved local immune function through enhanced

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perfusion [18]. The consistent infection reduction across studies strengthens the evidence base for NPWT as an infection-prevention strategy in high-risk abdominal wounds.

The economic analysis provides crucial insights for healthcare decision-making. While NPWT involves higher initial costs for equipment and supplies, the overall savings of 23.4% per patient episode demonstrate its cost-effectiveness. These savings primarily derive from reduced length of stay and decreased need for re-operations and intensive wound care. The incremental cost-effectiveness ratio of $4,250 per QALY gained falls well below commonly accepted thresholds of $50,000–$100,000 per QALY, supporting favorable value propositions across diverse healthcare systems [19]. These findings should inform procurement decisions and reimbursement policies, particularly in resource-constrained settings.

Patient-centered outcomes represent an increasingly important dimension of wound care evaluation. The significantly higher satisfaction scores with NPWT likely reflect multiple factors: reduced frequency of painful dressing changes, better odor control, improved mobility during treatment, and psychological benefits from visible wound improvement. The improved quality of life measures, particularly in physical functioning domains, underscore the holistic benefits extending beyond wound closure metrics alone. These findings support patient-centered care approaches and should be incorporated into shared decision-making processes.

Several important clinical implications emerge from this analysis. First, the benefits of NPWT appear most pronounced in specific wound types, particularly trauma-related and infected wounds. This suggests that targeted application rather than universal use may optimize resource utilization. Second, the persistent (though reduced) risk of fistula formation necessitates careful technique, including protective barriers between foam and viscera and avoidance of excessive pressure. Third, the optimal duration of therapy requires individualization based on wound response rather than fixed protocols. This review also identifies important knowledge gaps for future research. First, there is insufficient evidence regarding optimal pressure settings for different wound types and stages of healing. Second, comparative effectiveness studies of different NPWT systems are lacking. Third, long-term outcomes beyond initial healing, including hernia rates and quality of life at one year, require further investigation. Fourth, implementation studies examining barriers to optimal NPWT use in different healthcare settings would be valuable.

Limitations of this review should be acknowledged. Despite comprehensive searching, some relevant studies may have been missed, particularly those in non-English languages. The included studies exhibited heterogeneity in patient populations, wound characteristics, and outcome measures, though statistical methods accounted for this variability. Most studies had relatively short follow-up periods, limiting assessment of long-term outcomes. Finally, publication bias remains a potential concern despite statistical tests suggesting minimal effect.

Conclusion

In conclusion, this comprehensive review establishes Negative Pressure Wound Therapy (NPWT) as a superior, evidence-based intervention for complex abdominal wounds, demonstrating significant benefits including accelerated wound healing, reduced surgical site infections, shorter hospital stays, and improved patient satisfaction compared to conventional methods. While the therapy requires careful patient selection and proper technique to minimize risks such as fistula formation, its overall cost-effectiveness, achieved through decreased complication rates and resource utilization, supports its strategic adoption in clinical practice. To maximize its impact, future implementation should focus on standardized protocols, tailored application strategies, and ongoing research to optimize outcomes across diverse healthcare settings.

Conflict of interest. Nil

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