

# The Role of Negative Pressure Wound Therapy in Burn Wound Healing

Sitti Khusnul Khatima<sup>1</sup>, Reeny Purnamasari<sup>2</sup>, Nurul Rumila Roem<sup>3</sup>, Agung Kurniawan<sup>4</sup>, Dian Amelia Abdi<sup>5</sup>

Program Studi Profesi Dokter, Fakultas Kedokteran, Universitas Muslim Indonesia, Makassar, Sulawesi Selatan

Burn injuries represent a major health concern with high morbidity and a substantial risk of complications, including infection, delayed wound healing, and skin graft failure. Negative Pressure Wound Therapy (NPWT) has emerged as an increasingly utilized therapeutic modality in burn management, working through mechanisms such as edema reduction, enhanced tissue perfusion, stimulation of granulation tissue formation, and effective exudate control. This study employed a Systematic Literature Review design conducted in accordance with the PRISMA guidelines. The findings indicate that NPWT provides significant positive effects on clinical outcomes, including accelerated wound healing, reduced infection rates, improved graft take following split-thickness skin graft procedures, and shorter hospital length of stay. Furthermore, NPWT has been shown to be effective in emergency department and intensive care unit settings as a bridging intervention prior to definitive surgical management in patients with severe burn injuries. Nevertheless, variability in study designs, negative pressure parameters, and application techniques remains a challenge for the standardization of therapeutic protocols. Therefore, further well-designed randomized controlled trials are required to optimize clinical guidelines and establish appropriate patient selection criteria. Overall, NPWT represents an effective and recommended therapeutic option in modern burn wound management.

**Keywords:** Negative Pressure Wound Therapy, Burns, Skin Graft, Emergency Room.

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## Corresponding Author:

Sitti Khusnul Khatima

Universitas Muslim Indonesia

Jl. Urip Sumoharjo KM. 05 Telp. (0411) 443280, Fax (0411) 432730, Makassar

Khusnulrahman26@gmail.com

## 1. Introduction

Burn injuries remain a major global public health problem, contributing to high morbidity and mortality rates and imposing a substantial economic burden, particularly in low- and middle-income countries. Vulnerable populations, such as children and older adults, are disproportionately affected and often require long-term medical care and rehabilitation, with an increased risk of complications including infection and functional impairment (Pelizzo et al., 2025).

From a pathophysiological perspective, burn injuries cause extensive tissue damage that triggers local inflammatory responses, edema, microcirculatory impairment, and excessive exudate accumulation. These processes delay granulation tissue formation and re-epithelialization, thereby increasing the risk of infection and skin graft failure, especially in extensive or deep burns. Consequently, therapeutic strategies focusing on edema reduction, exudate control, and improvement of tissue perfusion are essential to promote effective wound healing (Bernatchez, 2024).

Conventional burn management includes patient stabilization, fluid resuscitation when indicated, wound cleansing and debridement, pain control, and antibiotic therapy in the presence of infection, followed by wound closure using dressings, dermal substitutes, or skin grafts. However, in wounds with heavy exudation, donor sites, or during the pre- and post-grafting phases, standard dressings often require frequent changes and may be suboptimal in reducing bacterial burden and edema (Cretu et al., 2025).

Negative Pressure Wound Therapy (NPWT) has therefore emerged as a physiological approach aimed at optimizing the wound microenvironment through the application of controlled subatmospheric pressure via a closed dressing system. Reported mechanisms of action include effective exudate removal, reduction of edema, enhanced tissue perfusion, stimulation of angiogenesis and granulation tissue formation, and decreased bacterial load mechanisms that directly address key challenges in burn wound healing (Bernatchez, 2024).

Over the past five years, growing clinical evidence from meta-analyses and systematic reviews has demonstrated that NPWT accelerates wound healing, improves graft take, and reduces infection rates compared with conventional dressings in burn patients (Lou et al., 2024). Furthermore, in post-skin graft applications, particularly following split-thickness skin graft (STSG) procedures and in pediatric populations, NPWT used as a bolster has been shown to enhance graft adherence, reduce seroma and hematoma formation, and decrease dressing change frequency, thereby facilitating management in operating rooms and intensive care units. Nevertheless, variability in treatment protocols, negative pressure settings, duration of therapy, and clinical expertise has resulted in heterogeneous outcomes, highlighting the ongoing need for standardized practice guidelines (Villalba-Aguilar et al., 2025).

In emergency department and ICU settings, NPWT also serves as an effective temporary dressing for managing exudate in burn patients who are not yet eligible for grafting, helping to minimize wound manipulation, reduce dressing changes, and maintain wound stability in critically ill patients. However, its use in this population requires careful consideration of contraindications such as active bleeding or inadequately debrided necrotic tissue, as well as close clinical monitoring during therapy (Bernatchez, 2024).

Given these findings and the evolving body of evidence, a systematically structured literature review examining the role of NPWT in burn wound healing is warranted to develop clearer, evidence-based clinical recommendations regarding indications, optimal pressure settings, duration of therapy, and integration of NPWT into emergency, critical care, and reconstructive surgical pathways.

## 2. Methods

This study is a Systematic Literature Review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review aimed to analyze the role of Negative Pressure Wound Therapy (NPWT) in burn wound healing based on scientific evidence from international and national journals published within the last five years (2020–2025). Article searches were performed across multiple electronic databases, including PubMed, ScienceDirect, Scopus, Google Scholar, SpringerLink, Wiley Online Library, the Cochrane Library, DOAJ, as well as national databases such as Garuda and Neliti, including the journal repositories of Universitas Muslim Indonesia (UMI). Search keywords were developed using combinations of Boolean operators (“AND”, “OR”) with the following terms: “negative pressure wound therapy” OR “NPWT” OR “vacuum-assisted closure therapy” OR “VAC therapy” AND “burn injury.”

**Table 1.** Inclusion and Exclusion Criteria

| Inclusion Criteria  | Exclusion Criteria   |
|---|--|
| <ol style="list-style-type: none"><li>1. Addressed the use of Negative Pressure Wound Therapy (NPWT) in burn patients, either as a primary therapy or as a bolster following skin graft procedures.</li><li>2. Reported clinical data and outcomes related to wound healing, graft success rates, infection, exudate management, healing time, and complications.</li></ol> | <p>Articles were excluded if they:</p> <ol style="list-style-type: none"><li>1. Were not relevant to the topic of Negative Pressure Wound Therapy (NPWT) and burn injuries.</li><li>2. Did not provide full-text access or were available only as abstracts.</li></ol> |

| Inclusion Criteria   | Exclusion Criteria  |
|--|---|
| 3. Were published in Indonesian or English.                | 3. Were narrative reviews, editorials, or opinion commentaries without clinical data. |
| 4. Provided accessible full-text versions of the articles. | 4. Contained duplicate data or reported incomplete findings.                          |
| 5. Were published within the period 2020–2025.             | 5. Were animal studies or in vitro research without direct clinical application.      |

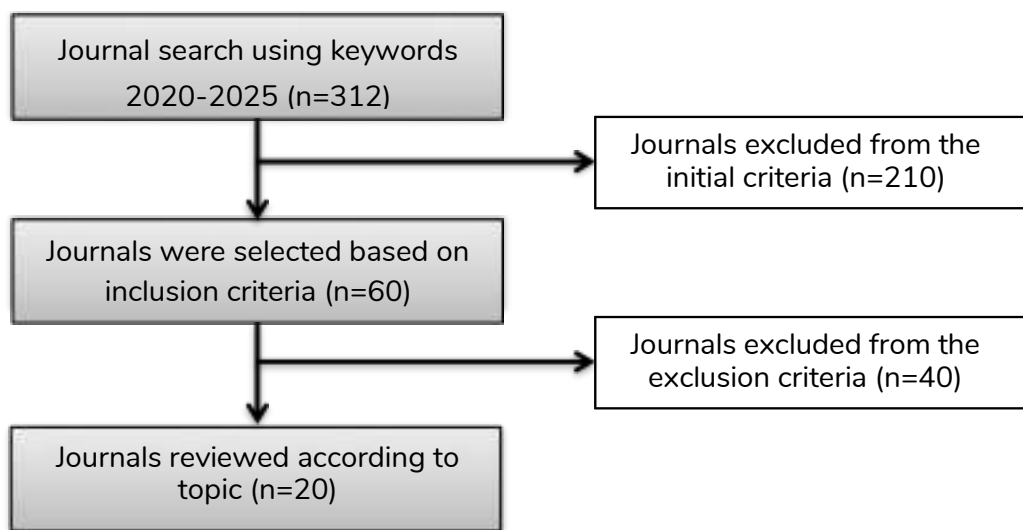


Figure 1. PRISMA Systematic-Narrative Literature Review Chart)

### 3. Results And Discussion

Table 2 summarizes the characteristics of studies included in this systematic review that evaluated the use of Negative Pressure Wound Therapy (NPWT) in burn wound healing, particularly within emergency department and critical care settings.

Table 2. Included Studies on NPWT for Burn Wound Healing in Acute and Critical Care Settings

| No. | Source (Author, Year)  | Topic/Etiology                                    | Intervention (Initial / Concurrent with NPWT)                            | ED / ICU Relevance   | Journal Type          |
|-----|------------------------|---|--|--|-----------------------|
| 1.  | (Lou et al., 2024)     | NPWT in pediatric burns (meta-analysis)           | Fluid resuscitation, wound cleansing, standard dressings                 | Demonstrates reduced healing time in children; relevant for early management in the ED and pediatric ICU | Meta-analysis         |
| 2.  | (Tapking et al., 2024) | NPWT in acute extremity burns (prospective study) | Debridement, wound cleansing, standard dressings (as comparison to NPWT) | Emphasizes NPWT as an alternative in the early phase; useful in ED/ICU for exudate control               | International journal |

| No. | Source (Author, Year)     | Topic/Etiology   | Intervention (Initial / Concurrent with NPWT)                       | ED / ICU Relevance   | Journal Type          |
|-----|---------------------------|--|---|--|-----------------------|
| 3.  | (Yurista et al., 2024)    | NPWT vs conventional dressing in deep dermal burns                                   | Early debridement + NPWT compared with conventional dressings       | Demonstrates anti-inflammatory effects; relevant for ICU patients requiring inflammation control     | International journal |
| 4.  | (Ma et al., 2025)         | Meta-analysis of NPWT for skin graft survival  | STSG + NPWT vs STSG + conventional dressings                        | NPWT improves graft take; important for postoperative care in the OR/ICU                             | Meta-analysis         |
| 5.  | (Anshor et al., 2025)     | Effects of NPWT on growth factors (FGF2)   | Applied NPWT with FGF2/angiogenesis analysis                        | Provides biological justification; not directly ED-based but relevant for ICU therapeutic strategies | International journal |
| 6.  | (Mirwanti et al., 2021)   | NPWT in pediatric burn wounds  | NPWT as an adjunct therapy  | Early evidence supporting pediatric NPWT; relevant for pediatric ED settings                         | National journal      |
| 7.  | (Bernatchez, 2024)        | State-of-the-science NPWT (guideline-oriented review)                                | NPWT use algorithms in acute and critical care                      | Provides guidance for NPWT application in acute and critical care environments                       | Review article        |
| 8.  | (Ardiansyah et al., 2024) | NPWT application in post-operative and septic patients                               | NPWT for wound drainage   | Demonstrates hospital-based implementation; relevant for critically ill ICU patients                 | National journal      |
| 9.  | (Yosef et al., 2024)      | NPWT in post-operative wound dehiscence and infection (including burn-related cases) | Re-debridement + VAC application to promote granulation and closure | Shows NPWT benefits in stabilizing wounds during advanced care phases; applicable in ICU settings    | National journal      |
| 10. | (Mislán et al., 2024)     | NPWT as prophylaxis for surgical site infection (SSI)                                | Prophylactic NPWT vs standard dressings                             | Relevant for preventing wound complications in major surgery and ICU patients                        | National journal      |
| 11. | (Syaiful et al., 2023)    | Burn wound care: topical therapy and NPWT (review)                                   | Topical agents combined with NPWT in selected cases                 | Emphasizes combined topical and NPWT approaches; applicable in ED/ICU                                | National journal      |

| No. | Source (Author, Year)            | Topic/Etiology  | Intervention (Initial / Concurrent with NPWT)  | ED / ICU Relevance  | Journal Type                       |
|-----|----------------------------------|---|--|---|------------------------------------|
| 12. | (Azaria & Surjantoro, 2025)      | NPWT in complex wounds (including extremity injuries)                         | NPWT for chronic and complex wounds  | Relevant for ICU patients with limb-threatening wounds  | National journal                   |
| 13. | (Heitham et al., 2025)           | Expert panel guidance on NPWT indications                                     | NPWT recommendations for complex wounds  | Useful for developing ED/ICU protocols  | Consensus / guidance (Open Access) |
| 14. | (Liu et al., 2023)               | Early rehabilitation combined with NPWT for deep partial-thickness burns      | Rehabilitation program + NPWT  | Demonstrates NPWT role in post-operative recovery pathways; relevant during ICU and ward care   | Original article (Frontiers)       |
| 15. | (Villalba-Aguilar et al., 2025). | NPWT in complex wounds and grafts (cross-condition study)                     | NPWT applied to ulcers and grafts  | Provides transferable evidence for burn wound management; useful in ICU settings  | Original article (MDPI)            |
| 16. | (Yusran et al., 2021)            | Comparison of modern dressings including NPWT for various wound types         | Discussion of NPWT, hydrogel, and silver dressings                                     | Evidence summary supporting NPWT for highly exudative and difficult-to-heal wounds in acute care  | Literature review                  |
| 17. | (Amestris, 2025)                 | Review/case reports linking NPWT to trauma and burn care                      | Debridement ± NPWT; discussion of modified NPWT techniques                             | Adds perspective on adaptable NPWT techniques for critically ill patients in ED/ICU   | National journal                   |
| 18. | (Hasmi et al., 2024)             | Diabetic and chronic ulcers with multifactorial etiology, including infection | Culture-guided antibiotics; NPWT identified as an effective non-pharmacological method | Emphasizes infection control and NPWT in reducing bacterial load and exudate; relevant for ED/ICU management of post-burn infected wounds | National journal                   |
| 19. | (Baek & Park, 2023)              | NPWT after hybrid reconstruction  | Post-operative NPWT as a bolster for graft monitoring                                  | Relevant for ICU and post-operative stabilization; reduces hematoma and seroma formation  | International journal              |
| 20. | (Holbert et al., 2024)           | NPWT implementation in acute pediatric burns (INPREP protocol)                | Adjunctive NPWT with structured implementation toolkit (INPREP)                        | Focuses on referral-center implementation; highly relevant for ED   | International journal              |

| No. | Source (Author, Year) | Topic/Etiology | Intervention (Initial / Concurrent with NPWT) | ED / ICU Relevance                  | Journal Type |
|-----|-----------------------|----------------|---|-------------------------------------|--------------|
|     |                       |                |   | management of acute pediatric burns |              |

Burn injuries represent a complex form of tissue damage and require a multidisciplinary approach to management in order to prevent serious complications such as infection, skin graft failure, or prolonged wound healing. (Pelizzo et al., 2025) highlights that burn injuries remain a global health problem with high morbidity rates, primarily due to persistent inflammatory processes, tissue edema, and a high risk of bacterial contamination.

From a pathophysiological perspective, tissue damage caused by thermal exposure triggers a systemic inflammatory response and disrupts microcirculation, leading to reduced oxygen delivery to cells and impaired tissue regeneration (Bernatchez, 2024). Under such conditions, wound care strategies that can accelerate the stages of healing while creating a more favorable environment for regenerative processes are critically needed.

Negative Pressure Wound Therapy (NPWT) is currently regarded as one of the key approaches in wound management because of its ability to create conditions that support wound healing. According to (Cretu et al., 2025), this therapy functions by reducing edema, enhancing blood flow to the wound area, stimulating granulation tissue formation, and decreasing bacterial burden through continuous removal of wound exudate.

Negative pressure also activates mechanotransduction processes that promote fibroblast proliferation and neovascularization, two essential components in the healing of deep burn wounds (Yurista et al., 2024). Therefore, the biological rationale for the use of NPWT is strong and aligns well with the clinical demands of severe burn cases.

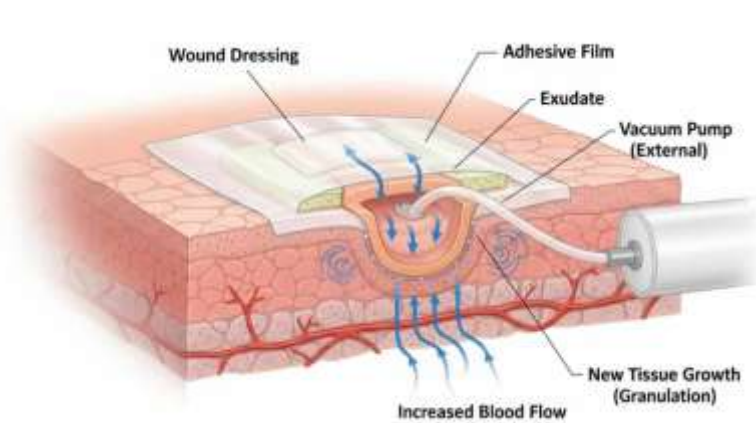
In clinical practice, several studies published over the past five years have demonstrated that NPWT yields superior outcomes compared to conventional dressings. (Lou et al., 2024) reported that in pediatric burn patients, NPWT enhanced granulation tissue formation and accelerated wound healing. Similar findings were reported by (Lin et al., 2021), who observed a significant reduction in infection rates and a decreased need for repeated debridement among patients treated with NPWT. Furthermore, a meta-analysis conducted by (Villalba-Aguilar et al., 2025) reinforced this evidence, concluding that NPWT provides superior clinical outcomes, particularly in wounds with high exudate levels and in skin graft procedures.



**Figure 2.** Negative Pressure Wound Therapy (NPWT)

One of the most critical applications of NPWT is its use as a bolster following skin graft procedures. (Tapking *et al.*, 2024) reported that NPWT helps maintain graft stability by minimizing the formation of seroma or hematoma and preserving optimal contact between the graft and the wound bed. (Lou et al.,

2024) also demonstrated that graft success rates significantly increased when NPWT was applied for 5–7 days postoperatively, compared with conventional dressings, which often fail to prevent graft displacement due to mechanical stress. Furthermore, a study by (Baek & Park, 2023) on distal extremity burn wounds showed that post-grafting NPWT improved graft stability, particularly in body areas with high mobility.



**Figure 3.** Negative Pressure Wound Therapy (NPWT)

In Indonesia, the effectiveness of NPWT is further supported by several local findings. (Mirwanti et al., 2021) demonstrated that NPWT reduced the frequency of dressing changes in pediatric patients, thereby decreasing psychological stress associated with procedural pain. A literature review by (Mislán et al., 2024) explained that NPWT accelerates recovery following reconstructive burn surgery by improving the quality of wound coverage tissue. (Ardiansyah et al., 2024) found that this therapy was effective in managing excessive exudate and preventing bacterial colonization, while (Syaiful et al., 2023) reported improved infection control and shortened hospital length of stay in complex wound cases. (Azaria & Surjantoro, 2025) further highlighted the potential of NPWT as a critical intervention in extremity injuries at risk of amputation.

In emergency and intensive care settings, NPWT serves as a bridge therapy before definitive interventions can be performed. (Bernatchez, 2024) explained that NPWT assists critically ill patients who are not yet stable enough for surgery by reducing exudate accumulation and limiting wound manipulation that could compromise hemodynamic stability. (Villalba-Aguilar et al., 2025) also emphasized the benefits of NPWT in the ICU for reducing the risk of nosocomial infections. Nevertheless, caution remains necessary due to potential complications such as bleeding and pain during application, which continue to be important clinical concerns (Heitham et al., 2025).

Despite the substantial evidence supporting its effectiveness, several limitations remain within the existing literature. Some studies employed observational designs or involved relatively small sample sizes (Mirwanti et al., 2021). Variability in therapeutic parameter such as applied pressure levels, duration of therapy, and types of interface materials also complicates the establishment of standardized protocols, highlighting the need for large scale randomized controlled trials to develop more comprehensive clinical guidelines (Holbert et al., 2024). Additionally, cost–benefit analyses, particularly in developing countries, should be a priority for future research (Cretu et al., 2025).

#### 4. Conclusion

Negative Pressure Wound Therapy (NPWT) is a modern wound care modality that has been shown to be effective in accelerating burn wound healing through mechanisms including edema reduction, enhanced tissue perfusion, stimulation of granulation tissue formation, and control of exudate and bacterial burden. Based on a review of 20 international and national studies published within the past five years, NPWT

demonstrates significant advantages over conventional wound care in reducing infection risk, improving skin graft success rates (graft take), shortening healing time, and decreasing the frequency of dressing changes. The application of NPWT as a bolster following split-thickness skin grafts has been proven to enhance graft stability and reduce complications such as seroma and hematoma formation. The use of NPWT in emergency departments and intensive care units has also been shown to be beneficial as a bridge therapy for patients with severe burns who are not yet eligible for definitive surgical intervention.

Nevertheless, limitations remain regarding standardized technical protocols, variability in applied pressure parameters, and the availability of large-scale randomized controlled trial-based evidence. Therefore, further research is required to establish standardized clinical guidelines, evaluate cost-effectiveness, and optimize the use of NPWT in special populations, including pediatric patients. Overall, NPWT can be recommended as a comprehensive therapeutic strategy in modern burn wound management.

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