Negative Pressure Wound Therapy Versus Conventional Management in Poststernotomy Mediastinitis: A Comprehensive Review of Clinical Outcomes

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Abstract

Background: Poststernotomy mediastinitis is a serious and potentially life-threatening complication following cardiac surgery, associated with high morbidity, mortality, prolonged hospitalization, and increased healthcare costs. Despite improvements in surgical techniques and perioperative management, deep sternal wound infection remains a significant clinical challenge. Conventional management strategies, including surgical debridement, systemic antibiotic therapy, and delayed or primary wound closure, have been widely utilized; however, outcomes are often suboptimal, particularly in high-risk patient populations.

Negative pressure wound therapy (NPWT) has emerged as an innovative and increasingly adopted modality in the management of mediastinitis. By applying controlled subatmospheric pressure, NPWT promotes wound healing through multiple mechanisms, including enhanced tissue perfusion, reduction of interstitial edema, stimulation of granulation tissue formation, and improved removal of infectious material. These properties make it particularly valuable in complex sternal wounds. The aim of this review is to evaluate and compare the clinical effectiveness of NPWT versus conventional management in patients with poststernotomy mediastinitis. Emphasis is placed on clinical outcomes such as mortality, reinfection rates, duration of hospital stay, and overall wound healing. Current evidence suggests that NPWT is associated with improved clinical outcomes, including reduced mortality, lower rates of recurrent infection, and faster wound healing compared to conventional treatment approaches. Additionally, NPWT can serve as a bridge to definitive surgical reconstruction. However, careful patient selection and monitoring are essential to minimize potential complications.

Conclusion: NPWT represents a significant advancement in the management of poststernotomy mediastinitis, offering superior outcomes compared to traditional therapies.

Keywords: Negative Pressure Wound Therapy, Conventional Management, Poststernotomy Mediastinitis

Introduction

Poststernotomy mediastinitis represents one of the most devastating complications in cardiothoracic surgery, typically arising after median sternotomy, which remains the standard surgical access for the majority of cardiac procedures. Although the incidence is relatively low, ranging between 0.5% and 5%, its clinical impact is profound, with reported mortality rates reaching up to 40% in severe cases. The condition is characterized by deep sternal wound infection involving the mediastinal tissues, often leading to sternal instability, sepsis, and multi-organ dysfunction if not promptly managed. The evolution of cardiac surgery has significantly improved patient survival; however, mediastinitis continues to pose a critical challenge in postoperative care. [1]

The pathogenesis of poststernotomy mediastinitis is multifactorial, involving patient-related, procedural, and microbiological factors. Common risk factors include diabetes mellitus, obesity, prolonged operative time, bilateral internal thoracic artery harvesting, and re-exploration for bleeding. Additionally, microbial contamination—most frequently by Staphylococcus species—plays a central role in disease progression. The complexity of the mediastinal anatomy and the presence of foreign materials such as sternal wires further complicate infection control, making management particularly demanding from a surgical standpoint. [2]

Traditional management strategies for mediastinitis have historically relied on aggressive surgical debridement, systemic antibiotic therapy, and various closure techniques, including delayed primary closure or reconstruction using muscle or omental flaps. While these approaches remain fundamental, they are often associated with prolonged hospitalization, repeated surgical interventions, and suboptimal healing outcomes. Consequently, there has been a continuous search for adjunctive therapies that can enhance wound healing and reduce complications. [3]

Negative pressure wound therapy (NPWT), also known as vacuum-assisted closure, has emerged over the past two decades as a pivotal advancement in wound management. By applying controlled subatmospheric pressure to the wound bed, NPWT facilitates removal of exudate, reduces bacterial burden, improves microcirculation, and promotes granulation tissue formation. These mechanisms have made it particularly attractive in the management of complex wounds, including poststernotomy mediastinitis. [4]

Despite the growing adoption of NPWT, there remains variability in clinical practice regarding its timing, indications, and integration with surgical reconstruction strategies. Furthermore, while numerous studies have demonstrated favorable outcomes with NPWT, comparisons with conventional management approaches continue to generate debate, particularly in terms of long-term survival, reinfection rates, and cost-effectiveness. This highlights the need for a comprehensive and critically appraised synthesis of current evidence. [5]

The aim of this review is to evaluate the role of negative pressure wound therapy in comparison with conventional management strategies in the treatment of poststernotomy mediastinitis. Specifically, this review seeks to analyze clinical outcomes, elucidate underlying mechanisms, and identify optimal therapeutic approaches based on current evidence. Additionally, it addresses existing gaps in the literature, including the lack of standardized treatment protocols and high-quality randomized controlled trials, thereby providing a framework for future research and clinical practice. [6]

Poststernotomy mediastinitis is defined as a deep sternal wound infection involving the mediastinal tissues occurring after cardiac surgery performed through median sternotomy. It represents a severe form of surgical site infection that extends beyond superficial tissue layers to involve the sternum, retrosternal space, and potentially adjacent vital structures. The condition is distinct from superficial sternal wound infections, which are limited to the skin and subcutaneous tissue, and requires more aggressive and multidisciplinary management due to its life-threatening nature. The anatomical proximity to the heart, great vessels, and prosthetic materials further complicates both diagnosis and treatment. [7]

Historically, the definition of mediastinitis has evolved alongside advancements in cardiac surgery and infection control. Early descriptions emphasized clinical findings such as sternal instability, purulent discharge, and systemic signs of infection. However, modern definitions incorporate microbiological evidence, imaging findings, and intraoperative observations to establish a more standardized diagnostic framework. Consensus guidelines now emphasize the importance of combining clinical, radiological, and microbiological criteria to confirm the diagnosis, ensuring early recognition and appropriate intervention. [1]

Classification systems for poststernotomy mediastinitis have been developed to guide clinical decision-making and prognostic assessment. One of the most widely recognized systems is the classification proposed by El Oakley and Wright, which categorizes mediastinitis based on the timing of presentation, presence of risk factors, and prior treatment attempts. This classification ranges from early postoperative infections (Type I) to chronic or recurrent infections (Type V), each with distinct therapeutic implications and outcomes. Such stratification is essential in tailoring individualized treatment strategies. [8]

In addition to temporal classification, mediastinitis can also be categorized based on the extent and severity of infection. Localized infections may be confined to the sternum and adjacent soft tissues, whereas diffuse mediastinitis involves widespread contamination of the mediastinal space, often associated with systemic sepsis. This distinction is clinically relevant, as diffuse infections typically require more aggressive surgical debridement, prolonged antibiotic therapy, and advanced wound management techniques such as negative pressure wound therapy. [9]

Another important aspect of classification involves microbiological etiology. Mediastinitis is most commonly caused by Gram-positive organisms, particularly Staphylococcus aureus and coagulase-negative staphylococci; however, Gram-negative bacteria and polymicrobial infections are increasingly recognized, especially in prolonged or complicated cases. The identification of causative organisms is critical for guiding targeted antimicrobial therapy and improving clinical outcomes. Furthermore, emerging antibiotic resistance patterns have added complexity to the management of these infections. [10]

From a surgical perspective, classification also considers the presence of sternal instability and bone involvement, including osteomyelitis. Patients with sternal dehiscence and necrosis often require more extensive reconstructive procedures, including muscle or omental flap coverage. In contrast, stable sternums with limited infection may be managed with less invasive approaches. This highlights the importance of a comprehensive assessment that integrates anatomical, microbiological, and clinical parameters in defining mediastinitis. [11]

Poststernotomy mediastinitis remains a relatively infrequent yet highly consequential complication following cardiac surgery, with reported incidence rates ranging from 0.5% to 5% depending on patient population, surgical complexity, and institutional practices. Despite its low occurrence, the absolute number of affected patients remains significant due to the large volume of cardiac procedures performed globally each year. Importantly, even marginal reductions in incidence can translate into substantial improvements in overall surgical outcomes and healthcare resource utilization. [12]

The clinical burden of mediastinitis is disproportionately high compared to its incidence. Patients who develop this complication often experience prolonged intensive care unit stays, extended hospitalization, and increased need for reoperations. These factors contribute to a marked rise in healthcare costs and resource consumption. Moreover, the condition frequently necessitates multidisciplinary management involving cardiothoracic surgeons, infectious disease specialists, and wound care teams, further emphasizing its complexity and impact on healthcare systems. [13]

Mortality associated with poststernotomy mediastinitis remains alarmingly elevated, with rates reported between 10% and 40%, depending on severity and timeliness of intervention. Early diagnosis and aggressive management are critical determinants of survival. Delayed recognition or inadequate treatment can rapidly lead to systemic sepsis, multi-organ failure, and death. Even among survivors, long-term morbidity—including chronic pain, sternal instability, and reduced quality of life—is common. [14]

Several large cohort and multicenter studies have highlighted the significant association between mediastinitis and adverse postoperative outcomes. For instance, deep sternal wound infection has been shown to independently increase operative mortality and negatively affect long-term survival following cardiac surgery. Additionally, patients with mediastinitis are more likely to require readmission and experience recurrent infections, further compounding their clinical burden. [15]

From an economic perspective, mediastinitis imposes a substantial financial strain on healthcare systems. The costs associated with prolonged hospitalization, repeated surgical interventions, advanced wound care therapies, and long-term antibiotic use are considerable. Studies have consistently demonstrated that patients with mediastinitis incur several-fold higher treatment costs compared to those with uncomplicated postoperative recovery. This economic impact underscores the importance of effective preventive and therapeutic strategies. [16]

The epidemiology of mediastinitis has also evolved over time, influenced by changes in patient demographics and surgical practices. Increasing prevalence of comorbidities such as diabetes, obesity, and advanced age has contributed to a higher risk profile among cardiac surgery patients. Additionally, the use of more complex procedures and prolonged operative times may further increase susceptibility to infection. These trends highlight the need for continuous adaptation of management strategies to address evolving risk factors. [17]

Importantly, advances in wound care—particularly the introduction of negative pressure wound therapy—have begun to influence the epidemiological landscape of mediastinitis outcomes. Several studies suggest that the adoption of NPWT has contributed to reductions in mortality, reinfection rates, and length of hospital stay. While these improvements are promising, variability in access, protocols, and expertise continues to affect outcomes across different centers. [18]

In summary, poststernotomy mediastinitis represents a low-incidence but high-impact complication with significant clinical, economic, and societal consequences. Understanding its epidemiology and burden is essential for guiding preventive measures, optimizing treatment strategies, and evaluating the role of emerging therapies such as NPWT in improving patient outcomes. [12]

The development of poststernotomy mediastinitis is multifactorial, resulting from a complex interplay between patient-related, operative, and postoperative factors. Identification of these risk factors is essential for risk stratification, prevention, and optimization of management strategies. Numerous studies have consistently demonstrated that patients with certain comorbid conditions are at significantly higher risk of developing deep sternal wound infections. Among these, diabetes mellitus is one of the most prominent, as hyperglycemia impairs immune function, delays wound healing, and increases susceptibility to infection. Poor glycemic control in the perioperative period further exacerbates this risk. [19]

Obesity is another well-established independent risk factor for mediastinitis. Increased adipose tissue contributes to poor vascularity, reduced oxygen delivery, and higher tension on sternal closure, all of which predispose to wound dehiscence and infection. Additionally, obese patients often present technical challenges during surgery, including prolonged operative time and increased risk of tissue trauma. These factors collectively contribute to higher rates of postoperative complications, including mediastinitis. [20]

Advanced age and associated frailty also play a significant role in the development of mediastinitis. Elderly patients frequently have diminished physiological reserves, impaired immune responses, and multiple comorbidities, all of which increase vulnerability to infection. Furthermore, age-related changes in tissue quality may compromise wound healing and sternal stability, further elevating the risk. [12]

Operative factors are equally critical in influencing the incidence of mediastinitis. Prolonged cardiopulmonary bypass time, extended duration of surgery, and excessive intraoperative bleeding have all been associated with increased infection risk. Re-exploration for bleeding is particularly important, as it exposes the mediastinum to repeated contamination and disrupts early wound healing processes.

These factors highlight the importance of meticulous surgical technique and hemostasis in reducing postoperative complications. [21]

The use of bilateral internal thoracic artery (BITA) grafting has been a subject of considerable debate in relation to mediastinitis risk. While BITA grafts provide superior long-term patency, they may compromise sternal blood supply, particularly in diabetic or obese patients, thereby increasing the likelihood of sternal wound complications. Careful patient selection and surgical expertise are therefore essential when considering this technique. [22]

Postoperative factors, including prolonged mechanical ventilation, extended intensive care unit stay, and nosocomial infections, further contribute to the risk of mediastinitis. The presence of indwelling catheters, immunosuppression, and inadequate infection control measures can facilitate microbial colonization and **संक्रमण** of the surgical site. Additionally, delayed mobilization and poor nutritional status may impair wound healing and increase susceptibility to infection. [23]

Microbiological factors also influence the development and progression of mediastinitis. Staphylococcus aureus and coagulase-negative staphylococci remain the most commonly implicated pathogens; however, Gram-negative organisms and polymicrobial infections are increasingly encountered, particularly in hospital-acquired settings. The emergence of antibiotic-resistant strains further complicates treatment and may worsen clinical outcomes. [24]

Understanding these risk factors is crucial not only for prevention but also for tailoring therapeutic strategies. High-risk patients may benefit from early and aggressive interventions, including the use of advanced wound management techniques such as negative pressure wound therapy. By mitigating the effects of impaired healing and infection, NPWT offers a targeted approach to addressing many of the underlying risk mechanisms associated with mediastinitis. [25]

Pathophysiology and Microbiology of Mediastinitis

The pathophysiology of poststernotomy mediastinitis is complex and involves a dynamic interaction between local tissue injury, impaired host defenses, and microbial invasion. Following median sternotomy, disruption of normal anatomical barriers exposes the mediastinum to potential contamination. Surgical trauma, electrocautery use, and sternal retraction contribute to local tissue ischemia and necrosis, creating an environment conducive to bacterial proliferation. Inadequate perfusion, particularly in the sternum and surrounding soft tissues, plays a central role in impairing wound healing and facilitating infection. [26]

Sternal instability is a key factor in the progression of mediastinitis. Mechanical disruption of the sternum, whether due to poor fixation, excessive strain, or bone fragility, leads to micro-movements that impair tissue approximation and promote fluid accumulation. This environment favors bacterial colonization and biofilm formation, which further complicates eradication of infection. Once established, infection can rapidly extend into deeper mediastinal structures, increasing the risk of systemic dissemination. [27]

Impaired vascular supply is another critical component in the pathogenesis of mediastinitis. Harvesting of internal thoracic arteries, particularly in bilateral configurations, may significantly reduce sternal blood flow, thereby compromising oxygen delivery and immune cell function. This ischemic environment not only delays wound healing but also reduces the effectiveness of systemic antibiotic therapy, as drug penetration into poorly perfused tissues is limited. [28]

At the cellular level, mediastinitis is characterized by an exaggerated inflammatory response. The presence of bacteria and necrotic tissue triggers the release of pro-inflammatory cytokines, leading to increased vascular permeability, edema, and leukocyte infiltration. While this response is initially protective, excessive or prolonged inflammation can result in further tissue damage and delayed healing. Additionally, the accumulation of exudate and necrotic debris provides a nutrient-rich medium for bacterial growth. [29]

Microbiologically, poststernotomy mediastinitis is most commonly caused by Gram-positive organisms, particularly Staphylococcus aureus and coagulase-negative staphylococci. These pathogens possess virulence factors that facilitate adhesion to tissues and prosthetic materials, as well as biofilm formation, which confers resistance to antibiotics and host immune responses. Biofilms are especially problematic in the presence of sternal wires and other foreign bodies, where they act as reservoirs for persistent infection. [30]

Gram-negative bacteria, including Pseudomonas aeruginosa and Enterobacter species, are increasingly recognized in mediastinitis cases, particularly in nosocomial settings or in patients with prolonged hospitalization. Polymicrobial infections are also not uncommon and are typically associated with more severe disease and poorer outcomes. The diversity of microbial pathogens necessitates broad-spectrum empirical antibiotic therapy, followed by targeted treatment based on culture results. [31]

Another important aspect of mediastinitis pathophysiology is the role of systemic factors such as sepsis and immune dysregulation. Once infection spreads beyond the local wound, it can trigger a systemic inflammatory response syndrome (SIRS), leading to organ dysfunction and increased mortality risk. Early control of the infection source is therefore critical to prevent progression to severe sepsis or septic shock. [32]

Understanding these pathophysiological and microbiological mechanisms provides a strong rationale for the use of negative pressure wound therapy. NPWT directly addresses several key pathological processes, including removal of exudate, reduction of edema, improvement of tissue perfusion, and disruption of bacterial colonization. These effects make it particularly effective in managing the complex environment of mediastinitis and support its growing role in modern treatment strategies. [33]

Conventional Management Strategies

Conventional management of poststernotomy mediastinitis has historically been centered on a combination of prompt surgical intervention, systemic antibiotic therapy, and appropriate wound closure techniques. The cornerstone of treatment remains **early and aggressive surgical debridement**, which involves removal of all necrotic tissue, infected bone, and foreign material such as sternal wires when necessary. This step is critical for reducing bacterial load and preventing further spread of infection within the mediastinum. Adequate debridement also prepares the wound bed for subsequent healing or reconstruction. [34]

Systemic antibiotic therapy is an essential component of conventional treatment and is typically initiated empirically, followed by targeted therapy based on microbiological culture results. Broad-spectrum antibiotics are used to cover both Gram-positive and Gram-negative organisms, with particular attention to Staphylococcus species. However, antibiotic efficacy may be limited in poorly perfused or necrotic tissues, which are common in mediastinitis. Therefore, antibiotics alone are insufficient without adequate surgical source control. [35]

Wound management following debridement has traditionally involved either **open dressing techniques** or **delayed primary closure**. Open wound care allows for continuous drainage and monitoring of infection but often requires frequent dressing changes, prolonged hospitalization, and increased patient discomfort. Additionally, exposure of mediastinal structures during open management carries risks of desiccation, contamination, and mechanical injury. These limitations have driven the search for more effective wound management approaches. [36]

Delayed sternal closure is another commonly employed strategy, particularly in patients with severe infection or hemodynamic instability. In this approach, the wound is temporarily left open after debridement and closed at a later stage once infection is controlled. While this method can reduce the risk of trapping infection within the wound, it prolongs treatment duration and may increase the risk of secondary complications such as nosocomial infections. [37]

Reconstructive techniques play a pivotal role in the management of advanced or complicated mediastinitis. Muscle and omental flap reconstructions are widely used to provide vascularized tissue coverage, obliterate dead space, and enhance local immune response. Commonly utilized flaps include the pectoralis major, rectus abdominis, and omentum. Although effective, these procedures are technically demanding and associated with donor site morbidity, making them less desirable as first-line interventions in all patients. [38]

Another limitation of conventional management is the high rate of treatment failure and recurrence, particularly in high-risk patients. Persistent infection, sternal instability, and delayed wound healing are frequently encountered challenges. These issues often necessitate repeated surgical interventions, further increasing morbidity and healthcare costs. Moreover, prolonged immobilization and hospitalization negatively impact patient recovery and quality of life. [39]

Despite these challenges, conventional management remains an important foundation in the treatment of mediastinitis and is often used in combination with newer modalities. The integration of surgical debridement, antimicrobial therapy, and reconstructive techniques continues to evolve, particularly with the addition of adjunctive therapies such as negative pressure wound therapy. Understanding the limitations of traditional approaches is essential for appreciating the clinical advantages offered by NPWT. [1]

Overall, while conventional strategies have been the standard of care for decades, their limitations in terms of prolonged healing, recurrence, and resource utilization have prompted the adoption of more advanced therapies. This has led to a paradigm shift toward multimodal management approaches, in which NPWT plays an increasingly central role in improving outcomes for patients with poststernotomy mediastinitis. [34]

Principles of Negative Pressure Wound Therapy (NPWT)

Negative pressure wound therapy (NPWT), also referred to as vacuum-assisted closure, represents a major advancement in the management of complex wounds such as poststernotomy mediastinitis. The technique is based on the application of controlled subatmospheric pressure to a sealed wound environment using a specialized system composed of foam dressing, adhesive drape, and a vacuum pump. This closed system promotes a moist, protected environment that enhances wound healing while minimizing external contamination and infection risk. [26]

The application of negative pressure, typically ranging between −75 and −125 mmHg, facilitates continuous removal of wound exudate, necrotic debris, and bacterial contaminants. This mechanism is particularly important in mediastinitis, where fluid accumulation and tissue breakdown are common. Effective drainage reduces bacterial load and prevents the persistence of infection, thereby improving local wound conditions and preparing the site for further intervention. [27]

A fundamental principle of NPWT is the induction of mechanical forces at both macro- and micro-levels. Macrodeformation leads to approximation of wound edges and reduction of dead space, while microdeformation at the cellular level stimulates fibroblast proliferation, angiogenesis, and extracellular matrix production. These processes significantly accelerate granulation tissue formation, which is critical for healing in deep sternal wound infections. [28]

NPWT also enhances local tissue perfusion by reducing interstitial edema and improving microcirculatory blood flow. This results in increased oxygen delivery and improved immune response at the wound site. In addition, enhanced perfusion facilitates better penetration of systemic antibiotics, which is particularly important in poorly vascularized sternal tissues following cardiac surgery. [29]

Another key advantage of NPWT is its ability to maintain a stable and protected wound environment. The sealed dressing system prevents external contamination and reduces the risk of nosocomial infection. Furthermore, it protects exposed mediastinal structures, including the heart and great vessels, from mechanical injury and desiccation, which are significant risks in open wound management. [30]

Clinically, NPWT is often used as a **bridge to definitive closure or reconstruction**. By controlling infection and promoting healthy granulation tissue, it prepares the wound for delayed sternal closure or flap reconstruction. This staged approach has become increasingly important in high-risk patients, where immediate closure may not be feasible or safe. [31]

Despite its benefits, NPWT requires careful application and monitoring to avoid complications. Proper placement of the dressing, appropriate pressure settings, and protection of underlying structures are essential. In mediastinitis, special precautions must be taken to prevent direct contact between the foam dressing and cardiac tissues, reducing the risk of bleeding or cardiac injury. [32]

In summary, NPWT operates through a combination of mechanical, physiological, and microbiological mechanisms that directly address the challenges of mediastinitis management. Its ability to improve wound healing, control infection, and facilitate staged surgical intervention has made it a cornerstone of modern treatment strategies. [33]

Mechanisms of Action of NPWT

Negative pressure wound therapy (NPWT) exerts its therapeutic effects through a combination of **mechanical, cellular, and biochemical mechanisms** that collectively enhance wound healing in poststernotomy mediastinitis. Unlike conventional wound care, which primarily focuses on passive management, NPWT actively modifies the wound environment to promote tissue repair and infection control. These mechanisms directly target the key pathological processes involved in mediastinitis, including tissue ischemia, bacterial proliferation, and impaired healing. [33]

One of the primary mechanisms is **mechanical deformation**, which occurs at both macroscopic and microscopic levels. At the macroscopic level, negative pressure induces contraction of the wound edges, reducing wound size and eliminating dead space where fluid and bacteria may accumulate. At the microscopic level, deformation of cells within the wound bed stimulates mechanotransduction pathways, leading to increased cellular proliferation, angiogenesis, and synthesis of extracellular matrix components. These effects are critical for the formation of robust granulation tissue. [28]

NPWT also plays a significant role in **modulating wound fluid dynamics**. By continuously removing exudate, the therapy reduces interstitial edema and lowers tissue pressure, which in turn improves capillary blood flow. This reduction in edema not only enhances oxygen and nutrient delivery but also prevents the accumulation of inflammatory mediators that can impair healing. Efficient fluid removal is particularly important in mediastinitis, where exudate can rapidly accumulate in the deep sternal space. [27]

Another important mechanism is the **reduction of bacterial burden** within the wound. NPWT helps to physically remove microorganisms and disrupt biofilm formation, which is a major barrier to effective infection control. Biofilms, commonly formed by staphylococcal species, protect bacteria from antibiotics and host immune responses. By reducing bacterial load and altering the wound environment, NPWT enhances the effectiveness of systemic antimicrobial therapy. [30]

NPWT further contributes to healing through **enhanced angiogenesis and improved tissue perfusion**. The mechanical forces and reduction in interstitial pressure stimulate the formation of new blood vessels, increasing vascular density in the wound bed. Improved perfusion facilitates delivery of oxygen, immune cells, and antibiotics, all of which are essential for controlling infection and promoting tissue regeneration. This is particularly beneficial in sternal wounds, where blood supply may be compromised after internal thoracic artery harvesting. [29]

At the molecular level, NPWT influences the expression of key growth factors and cytokines involved in wound healing. Studies have demonstrated increased levels of vascular endothelial growth factor (VEGF), transforming growth factor-beta (TGF-β), and other mediators that promote tissue repair and remodeling. Additionally, NPWT has been shown to regulate matrix metalloproteinases (MMPs), helping to balance tissue degradation and formation. These biochemical effects contribute to a more favorable healing environment. [32]

Another critical function of NPWT is the **stabilization of the wound environment**. The sealed system maintains consistent temperature and moisture levels, which are essential for optimal cellular activity and tissue repair. It also acts as a protective barrier against external contaminants, reducing the risk of secondary infection. In the context of mediastinitis, this controlled environment is particularly important given the proximity to vital mediastinal structures. [31]

Finally, NPWT supports **clinical workflow and patient recovery** by reducing the need for frequent dressing changes and allowing better wound monitoring. This not only improves patient comfort but also decreases healthcare workload and potential exposure to nosocomial pathogens. These practical advantages, combined with its biological effects, make NPWT a highly effective modality in the management of complex sternal wound infections. [26]

NPWT Techniques in Mediastinitis

The application of negative pressure wound therapy (NPWT) in poststernotomy mediastinitis requires meticulous surgical technique and strict adherence to safety principles due to the proximity of vital mediastinal structures. Unlike superficial wounds, mediastinal NPWT must be initiated in a controlled operative setting, typically following thorough surgical debridement. All necrotic tissue, infected bone, and foreign materials must be removed prior to NPWT application to ensure effective infection control and optimize wound healing. [34]

A critical step in NPWT application is the **protection of underlying cardiac structures**, including the heart, great vessels, and coronary bypass grafts. Direct contact between the foam dressing and these structures must be strictly avoided to prevent erosion, hemorrhage, or catastrophic complications. This is typically achieved by placing a non-adherent protective interface, such as paraffin gauze or silicone-based dressings, over the mediastinal contents before applying the NPWT system. [32]

The selection and preparation of the dressing material are essential for effective therapy. Polyurethane foam is most commonly used due to its ability to distribute negative pressure evenly and facilitate efficient fluid evacuation. The foam is carefully tailored to fit the wound cavity without exerting excessive pressure on surrounding tissues. An occlusive adhesive drape is then applied to create an airtight seal, which is necessary for maintaining consistent negative pressure throughout treatment. [26]

Negative pressure is typically set between −75 and −125 mmHg, with continuous suction being the preferred mode during the initial phase of treatment. Continuous therapy ensures stable wound conditions and efficient removal of exudate and infectious material. While intermittent suction may enhance granulation tissue formation, its use in mediastinal wounds is limited due to concerns regarding hemodynamic stability and patient safety. [27]

Dressing changes are usually performed every 48 to 72 hours under sterile conditions, often in the operating room. Regular wound assessment is essential to evaluate infection control, granulation tissue development, and early detection of complications. Additional surgical debridement may be required during dressing changes to maintain an optimal wound environment. [35]

NPWT is commonly utilized as part of a **staged treatment strategy**, serving as a bridge to definitive wound closure. Once infection is adequately controlled and healthy granulation tissue has formed, delayed sternal closure or reconstructive procedures—such as muscle or omental flap coverage—can be performed. This staged approach significantly improves the likelihood of successful long-term outcomes. [36]

In cases of sternal instability or extensive tissue loss, NPWT may be combined with temporary stabilization techniques or followed by reconstructive surgery to restore chest wall integrity. Close monitoring is essential, particularly in the early phase of therapy, to detect complications such as bleeding, arrhythmias, or hemodynamic compromise. [37]

Overall, the effectiveness of NPWT in mediastinitis depends on proper surgical application, appropriate pressure settings, and vigilant multidisciplinary care. When applied correctly, NPWT provides a safe and highly effective method for infection control and wound optimization, facilitating improved clinical outcomes compared to conventional management strategies. [33]

Clinical Outcomes: NPWT vs Conventional Management

Clinical evidence consistently demonstrates that negative pressure wound therapy (NPWT) provides superior outcomes compared to conventional management in poststernotomy mediastinitis. Multiple cohort studies and comparative analyses have shown that NPWT significantly improves infection control, accelerates wound healing, and enhances overall patient recovery. These benefits are primarily attributed to its ability to simultaneously address key pathological factors such as bacterial burden, tissue perfusion, and wound stability. [33]

One of the most important outcome measures is **mortality reduction**. Studies comparing NPWT with traditional open dressing and delayed closure techniques have reported lower mortality rates in patients treated with NPWT. This improvement is largely due to better infection control and reduced progression to systemic sepsis. Early initiation of NPWT following debridement has been shown to play a crucial role in improving survival outcomes. [38]

In terms of **infection resolution**, NPWT has demonstrated higher rates of successful eradication compared to conventional methods. Continuous removal of exudate and disruption of bacterial biofilms contribute to more effective infection control. As a result, patients treated with NPWT experience lower rates of persistent or recurrent mediastinal infection, which is a major limitation of traditional approaches. [39]
NPWT is also associated with **faster wound healing and earlier closure**. The promotion of granulation tissue formation and improved local perfusion allow for quicker preparation of the wound bed for definitive closure or reconstruction. This reduces the overall treatment duration and minimizes the need for repeated surgical interventions. [28]
Another significant advantage of NPWT is the reduction in **length of hospital stay and intensive care unit duration**. Patients managed with NPWT typically require fewer dressing changes and less prolonged open wound care, which contributes to faster recovery and earlier discharge. This not only benefits patient outcomes but also reduces the burden on healthcare systems. [27]
From a surgical perspective, NPWT facilitates a more controlled and predictable treatment course. It serves as an effective bridge to reconstructive procedures, allowing surgeons to delay closure until optimal conditions are achieved. This staged approach improves the success rate of definitive surgical interventions and reduces complications such as flap failure or recurrent infection. [36]
Despite these advantages, it is important to recognize that NPWT is not without limitations. Complications such as bleeding, particularly in proximity to major vessels or cardiac structures, have been reported, although they are relatively rare when proper technique is followed. Careful patient selection and adherence to safety protocols are therefore essential to maximize benefits and minimize risks. [32]
Overall, current evidence strongly supports the use of NPWT over conventional management in poststernotomy mediastinitis. Its ability to improve survival, enhance infection control, and accelerate wound healing has led to its widespread adoption as a standard component of modern treatment strategies in cardiothoracic surgery. [1]

Conclusion

Negative pressure wound therapy (NPWT) has fundamentally transformed the management of poststernotomy mediastinitis, offering clear advantages over conventional treatment strategies. By combining effective infection control, enhanced wound healing, and improved tissue perfusion, NPWT addresses the core pathophysiological challenges of this complex condition. Clinical evidence consistently demonstrates its superiority in reducing mortality, minimizing reinfection rates, shortening hospital stay, and facilitating earlier and more successful definitive closure. Despite potential complications, which are largely preventable with proper technique, NPWT has become an integral component of modern cardiothoracic surgical practice. Its role as both a definitive therapy and a bridge to reconstruction underscores its versatility and clinical value. Future research should focus on optimizing treatment protocols and standardizing its application to further improve patient outcomes while maintaining cost-effectiveness within healthcare systems.

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