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The Role of Reconstructive Surgery for Treating Pressure Injuries – A Review of Literature

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ABSTRACT

Pressure injuries (PIs) represent a significant global health challenge, affecting approximately 10.8% of the European population in 2019. Their development is primarily attributed to ischemia and tissue necrosis resulting from prolonged pressure. According to the NPIAP classification, PIs are categorized into four stages, with surgical intervention predominantly indicated for stage III and IV ulcers. Reconstructive surgery encompasses various techniques, with debridement (the removal of necrotic tissue) being the most frequently performed procedure. An essential component of the healing process is negative pressure wound therapy (NPWT), which facilitates oxygen delivery to deeper tissue layers and promotes faster regeneration. Promising outcomes have also been observed with the use of regional flaps, particularly in the management of large bedsores and cases where other options are no longer viable. Despite advancements in surgical treatments, challenges such as graft rejection and high recurrence rates persist. The selection of the surgical approach should be guided by the patient's overall health status and the specific characteristics of the ulcer. Effective management of PIs is critical for preventing prolonged hospitalizations and mitigating the risk of hospital-acquired infections, thereby significantly improving patients' quality of life.

Keywords: pressure injuries, reconstructive surgery, plastic surgery, chronic wounds, surgical management

1. Introduction

Pressure injuries (PIs) pose a common health challenge among bedridden patients, and their consequences impact quality of life, length of hospitalization, and treatment costs. These are skin lesions resulting from prolonged pressure on tissues, leading to ischemia and, consequently, necrosis [1]. Contemporary approaches to the treatment of PIs require an interdisciplinary effort that encompasses preventive, diagnostic, and therapeutic aspects.

Although the prevalence of PIs in Europe has gradually decreased, they still affected approximately 10.8% of Europeans in 2019 [2]. Among the elderly population, the prevalence is higher due to chronic comorbid conditions. The risk of developing PIs is greater in patients hospitalized in intensive care units or those undergoing prolonged surgical procedures [3].

Pathophysiology of PIs

The pathophysiology of PIs is based on ischemia and tissue necrosis. In healthy individuals with preserved mobility, sensory perception, and mental state, prolonged pressure on tissues triggers the need to change position before pathological changes occur. PIs develop as a result of prolonged pressure exerted on soft tissues, particularly over bony prominences such as the sacrum, heels, ischial tuberosities, and greater trochanters [4]. The COVID-19 pandemic highlighted the role of SARS-CoV-2 infection in contributing to the development of PIs through generalized inflammation, coagulation disorders, and cytokine storm [5].

Risk Factors and Prevention

Key risk factors for the development of PIs include prolonged pressure on specific body parts, inability to change body position, inadequate skin care, moisture, and the presence of infection. These factors are incorporated into the Braden Scale, which enables the assessment of the risk of PIs development [6]. Prevention of PIs involves regular repositioning of patients, the use of pressure-relieving mattresses, appropriate skin care, avoiding excessive moisture, and using specialized dressings that can support the healing process [2].

Classification of PIs by the National Pressure Injury Advisory Panel (NPIAP) [7]

<u>Stage I</u>

Intact skin with an area of non-blanchable erythema that does not subside with pressure. The presence of redness that blanches under pressure or changes in sensation, temperature, or firmness may occur before non-blanchable erythema develops. In individuals with darker skin tones, the area may appear differently. Color changes do not include purple or maroon discoloration, which may indicate deep tissue injury.

Stage II

Partial-thickness loss of skin, with a red or pink wound bed. The lesion may also appear as an intact or ruptured blister filled with serous fluid. Neither adipose tissue nor deeper tissues are visible. Granulation tissue, slough, and eschar are absent. Such injuries often result from shear forces due to friction or sliding, particularly in areas prone to such stress, such as the sacrum, heels, and ischial tuberosities.

Stage III

Full-thickness loss of skin with visible subcutaneous tissue but without exposure of deeper structures. The wound bed may contain granulation tissue, slough, and/or eschar (dry necrotic tissue). The depth of tissue damage varies by anatomical location; areas with more adipose tissue may lead to deeper wounds. Undermining and tunneling may also be present.

Stage IV

Full-thickness skin and tissue loss with exposed or directly palpable fascia, muscles, tendons, ligaments, cartilage, or bone in the ulcer. The wound bed may contain necrotic tissue and/or eschar. Undermining and tunneling are often present. Depth varies depending on anatomical location.

If necrosis or eschar obscures the extent of tissue loss, the injury is classified as an Unstageable Pressure Injury.

2. Indications for reconstructive surgery

Conservative treatment is typically reserved for stage I and II ulcers, highlighting the critical importance of prevention. Preventive strategies include regular dressing changes, the use of antibiotics and antiseptics, and meticulous skin care. For stage III and IV PIs, surgical intervention is often necessary, particularly in treatment-resistant cases where conservative measures have failed [8].

Surgical management involves the debridement of unhealthy and necrotic tissue, removal of underlying bursae (fibrotic capsules), or even bone, with or without immediate soft tissue coverage [9]. The success of surgical reconstruction depends not only on the chosen surgical technique but also on several other factors. These include the quality of local tissues, the underlying etiology of the ulcer, and patient-related factors such as comorbidities, education level, and motivation [9].

3. Techniques of reconstructive surgery

Prior to reconstructive procedures, the removal of necrotic tissue and management of any infection within the wound are crucial steps. Debridement serves as the foundation for subsequent surgical wound treatment and helps optimize the site for closure or further intervention [9].

In cases where the wound does not respond to conservative treatment and there are no contraindications to surgical closure, the PIs should be closed. This intervention minimizes fluid and protein loss, reduces the risk of infection, and prevents the potential development of malignancy [10].

3.1 Primary wound closure

It is a straightforward method, though not commonly used on its own, being more frequently applied after NPWT (Negative Pressure Wound Therapy) [11]. This technique involves approximating the edges of a PI where tissue loss has occurred. However, it may result in increased tension on the superficial tissues and the formation of a deep cavity—factors that contribute to the recurrence of PIs and the risk of dehiscence. In certain cases, where tissue loss is relatively minor, direct suturing might be feasible and is then recommended [12].

3.2 Skin grafts

one of the most common techniques in wound management, involving the harvesting of a thin piece of skin to cover a defect or wound area. This can be performed using either autologous grafts (from the patient's own body) or allogenic grafts (from a donor). Typically, the harvested skin is taken from a different part of the body and applied to the wound site to facilitate rapid wound coverage and effective healing. The healing process can be further enhanced by optimizing the wound microenvironment. This may involve the use of vacuum-assisted closure (VAC), systemic drug administration (e.g., low-molecular-weight heparin, LMWH), or local application of bioactive substances, such as platelet gel [13].

Despite their effectiveness, skin grafts are associated with several potential complications and limitations. Common complications include graft failure due to infection, poor vascularization, hematoma or seroma formation under the graft, and rejection in the case of allogenic grafts. Other challenges may arise from donor site morbidity, such as pain, scarring, or delayed healing [13].

3.3 Local random pattern flaps

The described method utilizes skin grafts derived from local tissues surrounding the wound site. Skin flaps are classified based on their origin and the pattern of their blood supply. Predominantly, these flaps rely on a nonspecific or "random" pattern of blood supply provided by the subdermal vascular plexus. A major contributing factor to flap failure is improper flap design, which may result from an inadequate flap size, compromised blood supply, or pre-existing damage to the flap caused by trauma or prior exposure to radiation. Ensuring optimal design and vascular integrity is therefore critical to the success of the procedure [14].

3.4 Regional flaps

In the surgical management of sacral PIs, regional flaps are the preferred method for wound closure and reconstruction. This approach is generally undertaken only after ensuring that the wound bed is free of devitalized tissue and shows no signs of infection. Primary closure of such lesions has been associated with high recurrence rates, which has led most surgeons to favor flap-based techniques over direct suturing [15].

Classification of Regional Flaps:

- Muscle or Musculocutaneous Flaps

This technique involves the mobilization of an entire muscle or a portion of it, along with its associated blood supply. The flap may include an overlying skin island to ensure wound coverage. For sacral ulcers, the gluteus maximus myocutaneous flap, advanced in a V-Y configuration, is a commonly used option due to its robust vascular supply and versatility [16].

- Fascial or Fasciocutaneous Flaps

In this method, a fascial-based island of tissue, sometimes accompanied by skin, is transferred while preserving its blood supply. Rotational fasciocutaneous flaps are frequently utilized for sacral reconstructions due to their reliability and adaptability [17].

- Perforator Flaps

Perforator flaps represent an evolution of musculocutaneous and fasciocutaneous techniques. These flaps are based on specific perforating blood vessels, which are meticulously dissected to maximize mobility while minimizing muscle sacrifice. This refinement allows for component separation, enhancing the functional and aesthetic outcomes of the reconstruction [18].

3.5 Free flaps

This technique involves the excision of a defined island of tissue, along with its associated artery and vein, which is then transferred to the wound site. To restore blood flow to the transplanted tissue, microvascular anastomosis is performed, reconnecting the artery and vein to the recipient site's vascular system. Free flap reconstruction is particularly valuable in cases where local flap options are unavailable, such as patients with multiple PIs or those with significant tissue depletion in the affected area. This method is also highly effective in managing advanced stages of PIs, as it enables coverage of large and complex wounds [19]. However, achieving successful anastomosis with efficient and sustained blood flow remains a challenging aspect of this approach. The procedure requires precise surgical technique and is associated with several potential risks. These include the possibility of intraoperative or postoperative blood transfusion, wound healing complications such as infection or delayed healing, and, most notably, wound dehiscence. Additionally, flap necrosis may occur if vascularization is insufficient or compromised, underscoring the importance of meticulous vascular planning and monitoring during the procedure. Despite these risks, free flap reconstruction remains a critical option in complex wound management, particularly when other techniques are contraindicated or unavailable [20].

3.6 Tissue expansion

The technique involves the gradual recruitment of tissue surrounding the PIs through controlled expansion. A tissue expander is placed into a subcutaneous pocket adjacent to the ulcer site and gradually filled with saline at a defined rate to expand the overlying skin and soft tissues. Once sufficient tissue volume has been achieved to cover the PIs, the expander is removed, and the expanded tissue is repositioned and inset to close the wound [21].

Although the procedure is generally effective, complications such as infection, expander extrusion, and wound dehiscence may occur [22].

3.7 NPWT

In patients for whom surgical reconstruction is not feasible, NPWT can be employed once the tissues are adequately debrided and prepared. It facilitates faster wound healing, reduces pain, and decreases the frequency of dressing changes. This technique offers multiple benefits, including minimizing seroma and hematoma formation, reducing bacterial colonization, and significantly shortening healing times. Evidence suggests that NPWT is effective in treating stage III/IV PIs, as demonstrated by increased rates of complete ulcer healing and reduced wound healing times. Additionally, NPWT has been associated with decreased patient-reported pain, reduced workload for medical staff, and lower overall treatment costs for patients [23,24].

4. Discussion

The choice of surgical method for PIs reconstruction is influenced by a multitude of factors, including the location and size of the injury, the patient's comorbidities, the risk of infection, and the patient's overall health status [9]. Studies have demonstrated that elderly patients and those immobilized or hospitalized in intensive care units exhibit a significantly higher rate of PIs recurrence [25]. This highlights the importance of tailoring the surgical approach to individual patient characteristics to optimize outcomes.

Optimizing modifiable risk factors before proceeding with flap reconstruction is critical. Poorly controlled diabetes is a well-documented risk factor for complications, including wound dehiscence, infection, and PIs recurrence. Diabetic patients are twice as likely to develop PIs perioperatively and are at heightened risk for postoperative infections. Perioperative glucose control is therefore essential to mitigate these risks [26,27]. Additional risk factors such as peripheral vascular disease and inadequate wound bed preparation must also be addressed. Ensuring an infection-free wound bed and achieving optimal vascular supply to the area are prerequisites for successful surgical outcomes [28].

The selection of a flap for PIs coverage does not necessarily require the inclusion of muscle tissue. However, some studies claim that fasciocutaneous flaps offer better blood supply than skin grafts; however, they are less mobile and movable, which can limit their application in some anatomical locations [29]. Additionally, while fasciocutaneous flaps present fewer donor-site complications, they are linked with higher recurrence rates, particularly in high-risk populations. Musculocutaneous flaps provide durable coverage and lower recurrence rates but are associated with higher donor-site morbidity, increased rates of infection, and wound dehiscence [30].

Free flaps should be reserved for cases where local flap options have been exhausted. Free flaps are particularly beneficial for patients prone to recurrent PIs, such as those with limited mobility or altered sensorium, including paraplegics or individuals with spinal cord injuries. The decision regarding flap selection should balance these factors while addressing patient-specific risks and wound characteristics [19].

Wound dehiscence remains the most common complication after flap reconstruction for PIs treatment. Most patients with PIs belong to high-risk groups, characterized by a predisposition to both wound dehiscence and surgical site infections [31]. Other complications, including hematoma, seroma formation, and recurrence of PIs, are also prevalent across all surgical methods [29].

NPWT has shown considerable promise in managing stage III/IV PIs, both as a standalone therapy and in conjunction with surgical interventions. NPWT facilitates wound healing by reducing bacterial colonization, decreasing seroma and hematoma formation, and enhancing tissue perfusion. Furthermore, NPWT is associated with reduced postoperative complications, including surgical site infections and wound dehiscence, particularly in high-risk patients [24].

There is also growing evidence supporting the use of incisional NPWT (iNPWT) in patients at high risk for surgical complications. Its application can lead to significant reductions in the rates of surgical site infection and wound dehiscence, making it a valuable adjunct to surgical management. While these findings are promising, further validation through high-quality, multicenter randomized controlled trials (RCTs) is necessary to establish definitive recommendations [23].

Unfortunately, there is still a lack of studies comparing all methods of PIs reconstructive surgery. Typically, only two methods are compared, making it difficult to evaluate all approaches collectively. Certain methods, as mentioned earlier in the text, are more preferred than others in specific clinical situations involving the patient [9].

5. Conclusion

The management of PIs, particularly in high-risk populations, requires a comprehensive and individualized approach. While musculocutaneous and fasciocutaneous flaps remain the mainstay of surgical treatment, the selection should be tailored to patient-specific factors and wound characteristics. Addressing modifiable risk factors, such as glucose control and wound bed preparation, is imperative to improving surgical outcomes. NPWT, both as a preoperative and postoperative adjunct, represents an emerging strategy with the potential to enhance healing and reduce complications. Further research is warranted to refine these approaches and optimize care for patients with PIs.

6. Disclosure

Author's contribution

Conceptualization: MŁ; methodology: MŁ; software: MW; check: MŁ; formal analysis: MŁ; investigation: MŁ and MG; resources: AS; data curation: MG and AS; writing- rough preparation: MŁ; writing-review and editing: AS and MW, visualization: MG; supervision:

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