Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 11893 – 11908
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5788

Complex Wound Management: Nursing Intervention Protocols-An Updated Review

Hatem Hamijan Al-Mutairi[1], Hussam Saad Al-Mansour[2], Mohammed Saleh Al-Mutairi[3], Najla Al-Muraibid[4], Naif Nashi Al-Dajani[5], Sultana Mutab Al-Otaibi[6], Shujaan Shawan Al-Otaibi[7], Ahlam Matrouk Al Shamri[8], Mater Mazi Munahi Aldhafeeri[9], Haifa Abdulaziz Ali Alobaida[10], Aydah Nami Joman Almalky[11], Noura Al Homedi Almuteri[12], Shareefah Mubarak Alasamari[13], Samerah Mohammed Alasmari[14]

Abstract

Chronic or complex wounds present a significant healthcare challenge due to their multifactorial etiology and the complex nature of their healing process. These wounds often fail to heal with standard treatments, causing prolonged suffering for patients and considerable healthcare costs. This review discusses nursing intervention protocols for the management of complex wounds, emphasizing both local and systemic factors that influence wound healing. The need for a multidisciplinary approach is evident in improving outcomes for patients with complex wounds.The aim of this review is to provide an updated understanding of complex wound management through nursing intervention protocols, exploring methods for effective care, highlighting the importance of a team-based approach, and presenting new therapeutic strategies.The review adopts a comprehensive approach, discussing the anatomy and physiology of wound healing, contraindications for various therapies, and the roles of different healthcare professionals in wound care. A detailed analysis of key elements in wound assessment, such as infection, moisture balance, and tissue type, is provided.The review highlights the crucial role of personalized, evidence-based treatment strategies in complex wound management. Key interventions include debridement techniques, the use of appropriate dressings, and infection control measures. It also emphasizes the importance of collaborative care among specialists, such as vascular surgeons, dietitians, and pain management teams, to optimize healing.Effective management of complex wounds requires a multidisciplinary approach, considering both physiological and psychological aspects of patient care. By tailoring treatment to individual needs and focusing on advanced therapeutic options, it is possible to improve healing outcomes and reduce the burden of complex wound care on both patients and healthcare systems.

Keywords: *Complex Wounds, Chronic Wounds, Nursing Interventions, Wound Assessment, Debridement, Multidisciplinary Care, Healing Process, Wound Management.*

Introduction

Wound healing is a complex and dynamic biomechanical process where the body works to restore the integrity of damaged or devitalized tissues. Chronic wounds are defined as persistent tissue injuries that fail to heal with conventional methods of wound dressing or closure, often due to local or systemic factors [1].

[1] Ksa, Ministry Of Health, Al Dariyah Hospital
[2] Ksa, Ministry Of Health, Al Dariyah Hospital.
[3] Ksa, Ministry Of Health, King Fahad Medical City.
[4] Ksa, Ministry Of Health, Al Dariyah Hospital.
[5] Ksa, Ministry Of Health, Shaqra General Hospital
[6] Ksa, Ministry Of Health, Al Dariyah Hospital
[7] Ksa, Ministry Of Health, Luban Al Sharqi Health Center
[8] Ksa, Ministry Of Health, Al Dariyah Hospital
[9] Ksa, Ministry Of Health
[10] Al Seih Health Care Center
[11] Ksa, Ministry Of Health, Al , Nasigh Health Center
[12] Ksa, Ministry Of Health
[13] Ksa, Ministry Of Health
[14] Ksa, Ministry Of Health, King Salman Hospital

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These wounds present significant challenges in management and can have long-term impacts on individuals and healthcare systems. The term "complex wounds" has recently been adopted to describe chronic wounds, emphasizing the multifactorial and dynamic nature of their healing process. For a wound to be classified as complex, it must exhibit specific characteristics such as persisting for more than three months, compromised vascularity or necrosis, the presence of infection, or associated comorbidities that hinder healing [2]. Various factors influence wound healing and can be categorized into local and systemic causes. Local factors include the depth of the wound, infection, peripheral vascular disease, radiotherapy exposure, sustained pressure, and excessive moisture. Systemic factors involve conditions such as diabetes mellitus, immunodeficiency, and nutritional deficiencies, all of which can delay or complicate the healing process [3]. Complex wounds impose a substantial burden at both the individual and societal levels. For individuals, these wounds significantly affect health-related quality of life due to prolonged pain, limited mobility, and the psychological impact of long-term treatment. On a broader scale, the economic burden of managing complex wounds is considerable. In developed countries, it is estimated that approximately 1 to 3% of healthcare expenditures are allocated to complex wound care, amounting to around USD 25 billion annually in the United States alone. This figure is expected to increase as the prevalence of chronic conditions and associated morbidities continues to rise [4][5][6][7]. The growing demand for effective wound management underscores the need for advanced therapeutic strategies and innovations in wound care practices to alleviate both individual suffering and economic strain. In summary, complex wounds represent a significant medical challenge, requiring a multidisciplinary approach to address the various factors that impede healing while also managing the extensive economic and social implications associated with their care.

Anatomy and Physiology

The skin is the body's largest organ, comprising three primary layers: the epidermis, dermis, and subcutis. The epidermis, the outermost layer, is structured into five sublayers. The basal layer, or stratum germinativum, contains columnar cells that divide continuously to regenerate the skin. This layer also houses melanocytes, responsible for melanin production, and Merkel cells, which have neuroendocrinal functions. Above it lies the stratum spinosum, composed of polyhedral cells that form the bulk of the epidermis and include Langerhans cells, which serve as antigen-presenting cells. The stratum granulosum and stratum lucidum follow, featuring larger, flatter cells that eventually die and form the stratum corneum, the outermost barrier of the epidermis. Beneath the epidermis is the dermis, constituting 90% of the skin's thickness. It is primarily made up of collagen and elastin, providing structural integrity and elasticity. The dermis contains essential structures such as blood vessels, sweat glands, sebaceous glands, and hair follicles. It is divided into the papillary and reticular dermis. The innermost layer, the subcutis or hypodermis, is composed predominantly of fat and collagen, serving as an insulator and shock absorber [8].

The skin fulfills four critical functions: protection against external environmental threats, including ultraviolet radiation and pathogens; thermal regulation through blood vessels and sweat glands; sensation via nerve endings; and endocrine function, primarily the synthesis of vitamin D [9]. Wound healing involves a complex series of biological events that restore tissue integrity and can be categorized into four phases: hemostatic, inflammatory, proliferative, and remodeling. During the hemostasis phase, coagulation occurs through vasoconstriction, platelet aggregation, and activation of intrinsic and extrinsic coagulation pathways. The inflammatory phase follows, characterized by the migration of polymorphonuclear leukocytes (PMNs) to the wound site, where they clear debris. By days 3 to 4, macrophages dominate the site, promoting angiogenesis and fibroblast activity via cytokines. The proliferative phase, occurring between days 5 and 7 and lasting up to four weeks, is primarily mediated by fibroblasts. These cells regulate collagen type III deposition, angiogenesis, and epithelialization. The final remodeling phase involves the replacement of collagen type III with collagen type I, which continues for years. By 12 weeks, the wound achieves maximal tensile strength, although the final scar retains only 80% of the original skin's tensile strength [10][11][12].

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Contraindications

Contraindications for various wound management therapies must be carefully considered to avoid potential complications. Iodine-based dressings should be avoided in patients with thyroid disorders and those who are pregnant due to potential systemic effects and risks to fetal development [13][14]. Negative Pressure Wound Therapy (NPWT) is contraindicated when the wound bed is suspected to contain malignancy, unexplored fistulas, untreated osteomyelitis, or necrotic tissue. These conditions can complicate treatment and may worsen the underlying pathology [15]. Larval therapy should not be used near major organs, cavities, or blood vessels, as these locations pose risks for significant adverse events. Additionally, it is unsuitable for wounds that are excessively dry or prone to heavy bleeding, as these conditions can hinder the effectiveness and safety of the therapy [16]. Leech therapy has several relative contraindications, including arterial insufficiency, bleeding tendencies, and immunosuppressive states. It is also not advised for patients with diabetes, Jehovah's Witnesses, individuals with previous allergic reactions to leeches or fluoroquinolone antibiotics, and those with psychological aversion to the use of leeches. Each of these factors increases the risk of complications and may reduce the therapy's efficacy [17]. Hyperbaric oxygen therapy is contraindicated in patients with pneumothorax, severe reactive airway disease, or recent exposure to chemotherapy. These conditions may exacerbate respiratory or systemic complications, making the therapy unsafe for such individuals [18].

Personnel

The management of complex wounds requires an interprofessional team approach to optimize the wound-healing environment and address pre-existing conditions. Regular communication among team members is essential for successful outcomes. The team may include wound care specialists such as tissue viability nurses, plastic surgery nurse specialists, and plastic surgeons. The involvement of other specialists, including diabetic teams, vascular surgeons, lymphedema care teams, dietitians, and microbiologists, should be tailored to the individual patient's needs. Additionally, the pain management team and occupational therapists play critical roles, particularly during the transitional phase before discharging the patient to community care [2]. Early engagement of tissue viability or wound care nurses is particularly recommended for wounds that deteriorate or show no improvement within the first two weeks of treatment. Medical photography is an important tool for tracking wound healing progress. Urgent cases requiring surgical debridement, such as necrotizing fasciitis, or those needing complex reconstruction, should be discussed with a plastic surgeon [19].

Plastic surgery nurse specialists provide valuable postoperative care following reconstructive procedures like skin grafts or flap-based reconstructions. They also assist the nursing team with specialized dressing techniques, such as topical negative pressure therapy or larval therapy for wound debridement [20][21]. Diabetic patients with complex wounds should routinely consult with diabetic teams to optimize blood glucose and HbA1c levels. Adjustments to their meals, emphasizing increased caloric intake with a focus on proteins, minerals, and vitamins, are often necessary. Nutritional status should be monitored regularly through albumin, prealbumin, and transferrin levels, with dietitian referrals for patients at risk of malnutrition [22]. For infected wounds, the selection of antibiotics should align with antimicrobial policies and involve microbiology consultations to avoid prolonged or unnecessary usage. Patients with evident lymphedema should be referred to specialized care for compression dressing application. Vascular team involvement is crucial in cases requiring limb revascularization, urgent amputations to manage sepsis, ischemic limb conditions, or deep vein thrombosis [23]. Effective pain management is vital for patient compliance, necessitating the early involvement of pain specialists. Moreover, occupational therapists and psychological support are essential throughout hospitalization and post-discharge to ensure comprehensive care and successful reintegration into the community [24].

Preparation

Conducting a thorough patient history is a fundamental step in wound management, as it provides critical insights into factors influencing healing. Key elements of the history include the etiology of the wound, the patient's nutritional status, the wound's duration, any history of trauma or previous ulceration, prior

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treatment regimens, and potential allergies to medications or dressings. Accurate history-taking helps tailor individualized care strategies for optimal outcomes. Wound examination should follow a structured and systematic approach to ensure all relevant aspects are addressed. The TIMES framework is widely adopted for comprehensive wound assessment, focusing on Tissue type, Infection or inflammation, Moisture balance, Epithelialization, and the condition of the Surrounding skin [25].

- **Tissue Type**: Identifying the type of tissue within the wound bed is pivotal for guiding treatment decisions. A detailed assessment should evaluate the tissue's viability and specify its nature, which may include necrotic, sloughy, infected, granulating, or epithelializing tissue. Clinicians must also identify foreign bodies or exposed vital structures such as tendons or bones, as these findings can influence both the treatment plan and prognosis [26].

- **Infection or Inflammation**: Infection can significantly impair wound healing by prolonging the inflammatory phase. Distinguishing between mere contamination or colonization and an active infection is essential, as most wounds harbor some level of microbial presence. Signs of infection include fever, erythema, swelling, increased pain, and purulent discharge. A wound swab with >10 colonies/mm^3 indicates infection. It is crucial to recognize that immunocompromised and diabetic patients may exhibit subtle or atypical presentations. Systemic antimicrobial treatments should align with local antimicrobial policies and involve consultation with microbiology teams to ensure appropriate management [27][28].

- **Moisture Balance**: Adequate moisture levels are crucial for healing vascularized wounds, while excess moisture can encourage bacterial proliferation. A holistic patient assessment is necessary to determine the appropriate moisture level and dressing type. Documenting the amount, color, and odor of exudate provides valuable insights into the wound's condition. In cases involving vascular compromise, collaboration with vascular specialists can help optimize dressing selection [29].

- **Epithelialization**: The absence of epithelial advancement signals impaired healing. Factors such as hypergranulation, excessive moisture, or infection should be investigated and addressed to promote proper epithelialization.

- **Surrounding Skin**: Assessing the skin around the wound is equally important, as signs of inflammation or tissue breakdown may indicate the wound's progression or extension. Early identification and intervention are critical for managing these complications effectively [25].

Technique or Treatment

Following the completion of wound assessment, a tailored wound management plan should be developed. This plan should address the need for specialist input and prioritize optimizing the patient's overall health, infection control, wound cleaning, necrotic tissue debridement, pain management, and, where relevant, pressure relief measures for pressure ulcers. Optimal wound healing requires maintaining key physiological parameters, including blood glucose levels below 200 mg/dL, albumin levels above 3 g/dL, prealbumin levels over 15 mg/dL, a lymphocyte count exceeding 1,500, a well-vascularized wound bed, and smoking cessation for a specified duration to enhance vascular and tissue repair processes [25][30]. All wounds should be managed with strict adherence to aseptic, non-touch techniques using appropriate personal protective equipment (PPE) to prevent contamination and subsequent infections. Warmed saline is commonly used for wound cleansing due to its biocompatibility, while antiseptic solutions are recommended in cases with excessive exudate or signs of infection. Debridement, aimed at removing debris and non-viable tissue, can be performed using various methods depending on the wound's characteristics. These methods include:

- **Autolytic Debridement:** Utilizing the body's proteolytic enzymes to break down necrotic tissue.

- **Larval Therapy:** Employing sterile larvae to selectively debride necrotic tissue.

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- **Chemical Debridement:** Using agents such as hydrogen peroxide or prontosan.
- **Hydrosurgery:** Techniques like Versajet for precise removal of necrotic tissue.
- **Conservative Sharp Debridement:** Using a scalpel or scissors at the bedside.
- **Surgical Debridement:** For extensive tissue removal, often requiring specialist intervention [31][32][33].

Dressing

An optimal wound-healing environment is achieved in a clean and moist setting, as this facilitates epithelial cell migration, wound-edge contraction, and the action of growth factors. Dressing selection is guided by four primary principles:

- **Exudate Absorption:** For wounds with excessive discharge.
- **Hydration:** For dry wounds requiring moisture.
- **Antimicrobial Action:** For infected wounds.
- **Debridement:** For wounds with necrotic tissue [34][35].

Dressing choice should be holistic, considering the patient's overall health, the wound bed, and the specific properties of the dressing. An ideal dressing should:

- Maintain a moist, clean environment.
- Prevent desiccation.
- Absorb excess exudate.
- Be impermeable to microorganisms while allowing gas exchange.
- Be non-toxic and biocompatible.
- Conform to the wound with minimal discomfort during application and removal.
- Be cost-effective and easy to use.

Frequency of Dressing Changes

The frequency of dressing changes depends on wound condition. Infected wounds or those with high exudate levels require daily monitoring and frequent dressing changes. Non-infected wounds should be changed less frequently to preserve the moist environment and enhance the effects of biological dressings. Continuous wound evaluation at each dressing change ensures the appropriateness of the dressing regimen and the need for adjustments [30].

Dressing Categories

Dressings can be broadly categorized into three types based on their primary function:

- **Autolytic Debridement Dressings:** Stimulate the body's proteolytic enzymes to break down necrotic tissue.

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- **Moisture-Balancing Dressings:** Regulate wound hydration levels.

- **Antimicrobial Dressings:** Suppress bacterial growth and prevent infections.

Despite the variety of dressing options, evidence comparing their clinical effectiveness remains limited, with most studies relying on anecdotal reports and lacking rigorous randomization. This underscores the need for ongoing research to inform evidence-based practice in wound care [36].

Types of Wound Dressings and Their Applications

Gauze

Gauze dressings, universally available in healthcare settings, are highly permeable and non-occlusive, making them suitable for use as both primary and secondary dressings. However, they may adhere to the wound bed, potentially causing trauma upon removal. This characteristic can be beneficial for debriding necrotic tissue. Woven gauze can also lead to granuloma formation due to retained particles [37]. Impregnated gauze containing substances like iodine, petroleum, bismuth, or zinc is non-adherent and semi-occlusive. However, iodine and bismuth-impregnated gauze are cytotoxic and inhibit inflammatory cells, so they should be changed frequently, ideally within five days. Iodine-impregnated gauze is particularly effective in temporarily packing infected wounds with unpleasant odors after debridement until the infection is cleared [38].

Iodine Dressings

Iodine dressings, first described in 1882, were improved in the 1960s with iodophors such as povidone-iodine to reduce irritation and pain associated with iodine use. The exact mechanism of action remains unclear, though studies suggest that low-dose, slow-release iodine can effectively kill bacteria by penetrating their cells, demonstrating its antiseptic efficacy. However, high concentrations of iodine can delay wound healing due to its cytotoxic properties [39].

Transparent Film Dressings

Transparent film dressings are thin, flexible sheets made of polyurethane that maintain a moist wound environment, though they lack absorptive capacity. These dressings are ideal for covering surgical wounds or donor sites for skin grafts [40].

Foam Dressings

Composed of a polyurethane base, foam dressings are permeable to both water vapor and gases. They are suitable for use in wounds with moderate to heavy exudate, diabetic foot ulcers, and minor burns. However, foam dressings should not be used in dry eschar or arterial ulcers as they could impair healing. They can remain in place for up to a week but should be changed when saturated with exudate [41].

Hydrogel

Hydrogel dressings consist of approximately 90% water and are hydrophilic polymers. Their high water content limits their capacity to absorb excess exudate. Hydrogel dressings are primarily used to soften necrotic tissue in pressure sores and vascular ulcers, and for low-exudate wounds. It is essential to protect the surrounding skin from maceration [42].

Hydrocolloid

Hydrocolloid dressings contain a self-adhesive layer of gel-forming hydrophilic colloid particles, such as carboxymethylcellulose (CMC). This layer absorbs exudate, providing a moist healing environment, and thermal insulation. The outer protective polyurethane layer serves as a barrier against bacteria and foreign

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bodies. Available in various forms, including paste, granules, and powder, hydrocolloids are suitable for low to moderate exudating wounds, such as minor burns and pressure ulcers, but should be avoided in clinically infected wounds [43][44].

Alginate

Alginate dressings, derived from seaweed and treated with calcium or sodium salts, are highly absorbent, non-adherent, and biodegradable. When applied to a wound, these salts interact with the serum, forming a hydrophilic gel. Alginate dressings can absorb up to 20 times their weight in exudate and are effective for managing highly exudating wounds, abdominal dehiscence, pressure ulcers, sinus tracts, and wounds with exposed tendons. In clean wounds, alginates can remain in place for up to a week, while in infected wounds, they should be changed daily [45][46].

Hydrofiber

Made of 100% carboxymethylcellulose (CMC) fiber, hydrofiber dressings have similar properties to alginates, making them suitable for highly exudative wounds. They can also be used in partial-thickness burns and skin graft donor sites [47][48]. When combined with silver, hydrofiber dressings provide enhanced antimicrobial properties with a broader spectrum and longer duration of action [49].

Hydro Conductive Dressings

Hydro conductive dressings, introduced at the 2011 Symposium on Advanced Wound Care, are designed to absorb bacteria and harmful cytokines from the wound through capillary action, transporting exudate to a second layer of the dressing. These dressings can remain in place for 3 to 7 days until saturated [50][51].

Silicone Dressings

Silicone dressings are commonly used for abnormal wound healing, such as hypertrophic and keloid scars. Several studies indicate that these dressings help soften scars and prevent the development of hypertrophic tissue. The exact mechanism remains unclear, though it is believed that silicone dressings improve scar hydration by reducing vapor loss. However, most studies on this topic have had small sample sizes, short-term follow-up periods, and lacked control groups [52][53].

Silver Dressings

Silver is a broad-spectrum antimicrobial agent effective against bacteria, viruses, fungi, and yeast, including methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant enterococci (VRE) [54]. Silver dressings are primarily used in mild wound infections, as they do not penetrate deep tissues. A Cochrane review in 2007 concluded that there was insufficient evidence to recommend silver dressings for infected or contaminated wounds [55]. Silver is commonly combined with other dressing types, such as hydrogel, hydrocolloid, hydrofiber, and alginate. Silver nitrate sticks are also effective in treating hypergranulation tissue [57].

Polyhexamethylene Biguanide and Honey Dressings

Manuka honey, first recognized for its antibacterial properties in 1892, is effective against a broad spectrum of bacteria, fungi, yeast, molds, MRSA, and VRE. Its antimicrobial action is attributed to its high viscosity, which forms a protective barrier, its high sugar concentration inducing osmotic pressure, hydrogen peroxide (H_2O_2) production, its low pH, and the presence of bioflavonoids [57][58].

Negative Pressure Wound Therapy (NPWT)

NPWT, introduced in the 1990s, is now widely used for various wound types. It applies subatmospheric pressure to the wound bed through a unit connected to a sponge and semi-occlusive dressing. The precise

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mechanism is not fully understood, but it has been shown to remove excess exudate, enhance circulation, and promote granulation tissue formation. NPWT has been found to be more effective and conducive to faster healing of chronic wounds compared to conventional dressing methods. Contraindications include malignancy, unexplored fistulas, untreated osteomyelitis, and necrotic tissue in the wound bed [15][59].

Larval Therapy

Sterile larvae of the common green-bottle fly (Lucilia sericata) are used for debridement of necrotic tissue and hematomas when surgical management is not viable. The larvae secrete proteolytic enzymes that liquefy necrotic tissue. They can be applied in a free-range manner or contained in a dressing called a "Biobag," and should be left in place for 2 to 4 days according to the treatment plan. Treatment should be discontinued if the patient experiences pain, uncontrolled bleeding, or if the larvae die or dislodge from the dressing [60].

Leech Therapy

Leeches are used in cases of venous congestion in reconstructive flaps, aiding venous drainage. Prior to leech application, re-exploration is recommended to rule out hematomas or thrombosis. Leeches secrete several compounds, including hirudin, which inhibits fibrinogen conversion, and collagenase, which aids anticoagulation. Leeches also carry Aeromonas spp., bacteria that help digest blood but may be pathogenic. Antibiotic prophylaxis (ciprofloxacin) should be initiated before applying leeches and continue for a day after their removal. Leech application should occur every 4 to 6 hours to facilitate passive bleeding and feeding [61].

Skin Substitutes

Skin substitutes can be classified as biological or synthetic. Biological substitutes include autografts, which are taken from the same individual, allografts (homografts), which involve skin transferred between individuals of the same species (human-to-human), and xenografts, where skin is transferred between different species (animal-to-human). Additionally, the human amniotic membrane, often used in low-resource countries, can also serve as a biological dressing. Synthetic semi-biological dressings, produced using tissue engineering technology, can be permanently incorporated into the wound. These substitutes are primarily used to dress superficial wounds until re-epithelialization occurs, to optimize the wound bed of deep wounds until grafting, or when the patient is not a candidate for surgery due to multiple comorbidities or other factors. Skin substitutes are especially beneficial in treating composite wound defects, such as those resulting from high total body surface area burns, where there is a shortage of autologous skin for grafting [62].

Hyperbaric Oxygen

Hyperbaric oxygen (HBO) therapy has shown promising results in the management of complex wounds. During treatment, the patient is placed in a special pressurized sealed room, breathing 100% oxygen at pressures ranging from 1.5 to 3 atm for approximately three hours. This process can be repeated over several sessions depending on the wound's depth, with chronic wounds typically requiring between 20 and 40 sessions. The exact mechanism of action remains unclear, but it is thought to be related to increasing the oxygen-carrying capacity of the blood, thereby promoting angiogenesis and improving local tissue perfusion [63][64][65]. Contraindications for HBO therapy include pneumothorax, severe reactive airway disease, and the use of chemotherapy. Potential side effects include claustrophobia, ear discomfort, and neural toxicity due to high oxygen pressure. These effects can generally be minimized by allowing sufficient intervals between sessions [65][66][18].

Future Research

Future research in wound healing focuses on understanding the cellular processes involved and the various mediators that regulate healing. Mediators such as eicosanoids, leukotrienes, and prostaglandins can

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modulate the inflammatory phase, and their application has shown promising results in reducing wound size and healing time [67][68]. Cytokines like granulocyte-macrophage colony-stimulating factors have also demonstrated encouraging results in the treatment of chronic venous ulcers [69]. Recombinant platelet-derived growth factor (PDGF) has been FDA-approved for the treatment of diabetic foot ulcers, with some anecdotal evidence supporting its use in other chronic wounds. However, the risk of inducing malignancy due to the use of growth factors remains a concern [70][71]. More recent studies suggest that inflammatory dysregulation contributes to wound healing failure, marked by high levels of proteases, protease inhibitors, and other inflammatory markers. These findings support the development of targeted therapies to better manage complex wounds [72].

Complications

General Complications

Common complications in wound management include bleeding, failure of the treatment regimen, skin maceration, and infection.

Specific Complications

- **Leech Therapy:** Leech therapy, while beneficial in certain cases, carries the risk of infection due to the presence of *Aeromonas* spp. in the mouth and digestive tract of the leech. This bacteria aids in digestion but is pathogenic to humans, and the presence of venous congestion can lead to localized immunosuppression, necessitating antibiotic prophylaxis. Other complications include prolonged bleeding, which can be significant, especially in children, and requires daily monitoring of hemoglobin levels. Additional complications include allergic reactions, migration to healthy tissues, and pre-renal azotemia [61][73].

- **Hyperbaric Oxygen:** Hyperbaric oxygen therapy may lead to claustrophobia, ear discomfort, and potential neural toxicity due to high oxygen pressures [65].

Clinical Significance

For a complex wound to heal successfully, both systemic and local factors need to be optimized. Adequate debridement of the wound bed and the selection of the appropriate dressing are crucial. Additionally, the patient's overall condition, including comorbidities and nutritional status, should be addressed to support the healing process. An interprofessional team approach, involving various specialists, is often the most effective strategy for managing complex wounds [71].

Special Complex Wounds

- **Pressure Ulcer:** Pressure ulcers are localized injuries to the skin and underlying soft tissue, typically over bony prominences. Between 3% and 15% of hospitalized patients develop pressure ulcers, which are associated with high mortality rates in the elderly. Common sites include the sacrum, ischium, heel, trochanter, scapula, and occiput. The primary factors contributing to pressure ulcers are pressure, shearing, and friction. The healing of pressure ulcers is often complicated by the poor general condition of patients [74]. The American National Pressure Ulcer Advisory Panel (NPUAP) classifies pressure ulcers into four categories based on depth: Category I (non-blanching erythema), Category II (partial-thickness skin loss), Category III (full-thickness skin loss), and Category IV (full-thickness tissue loss) [75]. The Waterlow score is commonly used to assess the risk of pressure ulcers, considering factors such as BMI, sex, age, appetite, weight loss, mobility, continence, and special risks like malnutrition [76]. Prevention involves regular skincare, optimizing nutritional status, frequent mobilization, and using pressure-relieving devices such as pressure mattresses. Treatment aims to optimize the patient's general condition and manage any local infection before proceeding with reconstruction [77]. Surgical management of pressure

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ulcers often requires adequate excision of the ulcer and underlying bursa, followed by reconstruction using durable skin flaps, such as the gluteus maximus musculocutaneous flap for sacral ulcers, posterior thigh advancement flap for ischial ulcers, and fascia lata flap for trochanteric ulcers [78].

- **Diabetic Foot:** Diabetic foot ulcers are typically caused by a combination of neuropathy, ischemia, and infection, with most cases involving neuro-ischemic conditions [79]. Management requires an interprofessional approach, including general practitioners, diabetic nurses, podiatrists, orthotic specialists, and specialists in vascular surgery, plastic surgery, dietetics, and endocrinology [80]. Treatment focuses on patient education, blood glucose control, wound debridement (chemical or surgical), offloading pressure, and, when necessary, surgery, which may involve flap coverage, revascularization, or amputation [81].

- **Venous Ulcer:** Venous ulcers are a late consequence of varicose veins and venous hypertension and are difficult to heal, significantly affecting patients' quality of life. Treatment should address venous incompetency, if possible, with surgical intervention, and compression therapy (either multi-layer or intermittent compression). Skin grafting may be necessary for ulcers that fail to heal [82][83].

- **Radiated Wounds:** Radiation therapy can cause significant damage to the DNA of keratinocytes, fibroblasts, and endothelial cells, impairing their ability to regenerate. As a result, radiated tissues often suffer from residual endothelial damage and long-term endarteritis obliterans, making wound healing difficult. Hyperbaric oxygen therapy can help improve the wound environment and promote healing. In extensive cases, surgical excision of the affected tissue and coverage with a vascularized flap is often the most suitable treatment [84].

- **Malignant Wounds:** Early diagnosis of malignant wounds is critical for improving long-term outcomes. Common causes include basal cell carcinoma, squamous cell carcinoma, melanoma, Marjolin ulcer, and secondary malignancies. Diagnosis requires biopsy and possibly imaging to assess systemic spread. Treatment involves wide local excision of the tumor and potentially lymph node surgery. In non-operable cases, electrochemotherapy may be used to limit tumor extension and reduce pain and discharge.

- **Abdominal Wound Dehiscence:** Abdominal wound dehiscence can occur after the resection of abdominal wall tumors or following laparotomy due to trauma, aneurysms, sepsis, or pancreatitis. In primary cases, reconstruction should be performed immediately using a skin flap. In secondary cases, management is staged, beginning with temporary wound closure using a skin graft, followed by optimization of the patient's condition before definitive reconstruction, typically using component separation [85][86][87].

Enhancing Healthcare Team Outcomes

Managing complex wounds requires an interprofessional team that provides holistic assessment and treatment. Regular communication among team members is vital for achieving the best outcomes. The team should include wound care specialists, such as tissue viability nurses, dietitians, microbiologists, and occupational therapists, as well as specialists in diabetes, vascular surgery, and plastic surgery. The primary goal should be wound closure, though when this is not achievable, efforts should focus on optimizing the patient's quality of life [88][89][1].

Nursing Intervention Protocols and Long-Term Care

Complex wounds, such as pressure ulcers, diabetic foot ulcers, venous ulcers, and malignant wounds, require specialized nursing interventions due to their multifaceted nature. These wounds are often challenging to heal, necessitating an interprofessional approach involving various healthcare professionals, including

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 11893 – 11908
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5788

nurses, physicians, dietitians, and therapists. The nursing care protocols for these conditions focus on preventing further complications, promoting healing, and improving the patient's quality of life.

Nursing Interventions for Complex Wounds

Assessment and Monitoring: Nurses must conduct thorough assessments upon admission and throughout the patient's care to monitor the wound's condition and overall health. This includes regular documentation of the wound's size, depth, appearance, and signs of infection. Using standardized tools like the Braden Scale for pressure ulcer risk or the Waterlow Score for venous ulcers helps in evaluating the risk and monitoring any changes in the patient's condition. Additionally, nurses must assess the patient's nutritional status, comorbidities (e.g., diabetes, vascular disease), mobility, and cognitive function to plan the appropriate interventions.

Wound Cleaning and Debridement: Proper wound cleaning and debridement are vital steps in managing complex wounds. Nurses should use sterile techniques to cleanse the wound, ensuring that it is free from debris and bacteria. Depending on the type of wound, debridement can be done chemically (using enzymatic agents), mechanically (using forceps or dressings), or surgically. The goal is to remove necrotic tissue, as it can impede healing and increase the risk of infection. For diabetic foot ulcers or venous ulcers, debridement is crucial for reducing the bacterial load and promoting a clean wound bed for healing.

Dressing Selection and Application: The choice of wound dressing significantly impacts healing. Nurses should select dressings based on the wound type, size, and condition, considering the exudate level and infection risk. For example, for pressure ulcers, hydrocolloid or foam dressings may be used to protect the wound from pressure and moisture, while for diabetic foot ulcers, antimicrobial dressings may be preferred to prevent infection. Dressing changes should be done regularly, as indicated by the clinical condition of the wound, and nurses should monitor for signs of infection, including increased redness, swelling, and discharge.

Pain Management: Pain is a common issue in patients with complex wounds. Nurses should assess the pain level using appropriate pain scales (e.g., the Numeric Rating Scale) and implement pain management strategies. This may include administering analgesics as prescribed, providing comfort measures (such as positioning and temperature control), and using non-pharmacological methods such as relaxation techniques. Ensuring adequate pain control is essential not only for patient comfort but also to reduce stress, which can negatively affect wound healing.

Infection Prevention and Antibiotic Therapy: Infection is a common complication of complex wounds. Nurses should adhere to infection control protocols, including proper hand hygiene, use of sterile equipment, and dressing changes. For wounds at high risk of infection, such as those in patients with diabetic foot ulcers or malignant wounds, nurses must monitor for signs of infection and initiate antibiotic therapy as prescribed by the physician. This may include oral or intravenous antibiotics, depending on the severity of the infection and the patient's condition. Nurses should also educate the patient and caregivers on proper wound care and hygiene to reduce the risk of infection at home.

Nutritional Support: Nutrition plays a significant role in wound healing. Nurses should assess the patient's nutritional intake, paying particular attention to protein, vitamin C, and zinc, all of which are essential for tissue repair. In cases of malnutrition or where nutritional intake is inadequate, nurses should collaborate with dietitians to provide appropriate interventions, such as enteral or parenteral nutrition. Monitoring weight, serum albumin, and other nutritional markers will help determine the patient's nutritional status and guide intervention.

Mobility and Pressure Relief: For patients with pressure ulcers, particularly those confined to bed or a wheelchair, nurses must emphasize the importance of repositioning to relieve pressure on bony prominences. Patients should be repositioned at least every two hours, and special mattresses or cushions may be used to reduce pressure. In patients with diabetic foot ulcers, offloading pressure is critical to

Journal of Ecohumanism
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DOI: https://doi.org/10.62754/joe.v3i8.5788

prevent further tissue damage. Nurses should ensure that appropriate footwear is provided and that the patient is educated on the importance of avoiding walking on affected areas.

Long-Term Care for Complex Wounds

Continuous Wound Management: The long-term care of complex wounds focuses on ongoing monitoring and management. For pressure ulcers, diabetic foot ulcers, and venous ulcers, this often involves regular dressing changes, debridement, and the use of advanced wound care products. For malignant wounds, the goal may shift towards pain management and improving quality of life, particularly if the wound is unmanageable or part of a terminal condition. Ongoing monitoring for signs of infection and complications, such as sepsis, is also crucial in preventing further deterioration.

Prevention of Recurrence: Once a wound has healed, preventing recurrence is a priority. Nurses should educate patients and caregivers about the importance of regular skin checks, maintaining proper hygiene, and adhering to a prescribed care routine. For patients with diabetes, education on foot care is essential to prevent diabetic foot ulcers. In patients with venous ulcers, the use of compression stockings and leg elevation can help prevent new ulcer development.

Psychosocial Support: Complex wounds can lead to emotional and psychological challenges, particularly when healing is prolonged or if the patient is dealing with a chronic condition like diabetes or cancer. Nurses should provide emotional support, actively listen to patient concerns, and refer patients to psychological or social services as needed. Support groups for patients with chronic wounds or diabetes may also be beneficial for long-term coping.

Interdisciplinary Collaboration: The long-term management of complex wounds requires the collaboration of a multidisciplinary team, including wound care specialists, dietitians, physical therapists, and physicians. Regular team meetings can help assess the patient's progress, discuss any complications, and adjust the treatment plan accordingly. This collaborative approach ensures that all aspects of care, from nutrition to mobility, are optimized for the patient's recovery. Nursing intervention protocols for complex wounds are multifaceted and require careful, ongoing monitoring and management to prevent complications and promote healing. Nurses play a vital role in wound care by conducting thorough assessments, providing appropriate treatments, and offering education to patients and families. Long-term care focuses on preventing recurrence, managing psychosocial impacts, and maintaining optimal wound care and nutrition. An interprofessional approach is essential in ensuring the best outcomes for patients with complex wounds, emphasizing the importance of holistic, patient-centered care.

Conclusion

Complex wound management is a multifaceted and dynamic process requiring a comprehensive, evidence-based approach. Nurses play a crucial role in managing such wounds, from assessment and diagnosis to implementing and monitoring treatment protocols. A multidisciplinary team, including specialists such as wound care nurses, plastic surgeons, dietitians, and microbiologists, is essential for optimizing healing. The team's collaborative efforts aim to address both local and systemic factors that may impede wound healing, such as infection, moisture imbalance, vascular compromise, and malnutrition. The review emphasizes the importance of thorough wound assessment using frameworks like the TIMES model, which guides clinicians in evaluating the tissue type, infection status, moisture balance, epithelialization, and surrounding skin condition. Identifying these factors helps in tailoring treatment plans and selecting appropriate dressings. An optimal healing environment is created by maintaining moisture balance, preventing infection, and promoting tissue regeneration, all of which are central to the healing process. Debridement is a cornerstone of complex wound care, and several techniques such as autolytic debridement, larval therapy, and surgical debridement can be utilized depending on the wound's condition. Additionally, dressings that maintain a moist, clean environment are crucial for accelerating healing and preventing complications. The selection of dressings is guided by principles of exudate absorption, hydration, antimicrobial action, and

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2024
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DOI: https://doi.org/10.62754/joe.v3i8.5788

debridement, all of which are tailored to the specific needs of the wound. Moreover, the management of complex wounds extends beyond the wound bed itself to include the psychological and social aspects of care. The emotional and psychological burden of living with a chronic wound can be significant, and addressing these needs through psychological support and pain management is vital for improving the patient's overall quality of life. In conclusion, managing complex wounds effectively requires a holistic and individualized approach that considers not only the physical healing process but also the broader socio-psychological impact on patients. Advanced wound care therapies, combined with a coordinated, multidisciplinary team, are crucial for improving outcomes, reducing healthcare costs, and enhancing patients' quality of life.

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Volume: 3, No: 8, pp. 11893 – 11908
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
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2024
Volume: 3, No: 8, pp. 11893 – 11908
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5788

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إدارة الجروح المعقدة: بروتوكولات التدخل التمريضي - مراجعة محدثة

الملخص:

الخلفية: تشكل الجروح المزمنة أو المعقدة تحديًا كبيرًا في الرعاية الصحية نظرًا لسببها المتعدد العوامل وطبيعتها المعقدة في عملية الشفاء. غالبًا ما تفشل هذه الجروح في الشفاء باستخدام العلاجات التقليدية، مما يسبب معاناة طويلة للمرضى وتكاليف صحية كبيرة.

Journal of Ecohumanism
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Volume: 3, No: 8, pp. 11893 – 11908
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5788

تناقش هذه المراجعة بروتوكولات التدخل التمريضي لإدارة الجروح المعقدة، مع التركيز على العوامل المحلية والجهازية التي تؤثر في شفاء الجروح. هناك حاجة واضحة لنهج متعدد التخصصات لتحسين النتائج للمرضى الذين يعانون من الجروح المعقدة.

الهدف: تهدف هذه المراجعة إلى تقديم فهم محدث لإدارة الجروح المعقدة من خلال بروتوكولات التدخل التمريضي، واستكشاف الأساليب الفعالة للرعاية، مع تسليط الضوء على أهمية النهج القائم على الفريق، وعرض استراتيجيات علاجية جديدة.

الطرق: تتبع المراجعة نهجًا شاملاً، حيث تناقش تشريح وفسيولوجيا شفاء الجروح، موانع استخدام العلاجات المختلفة، وأدوار مختلف المهنيين الصحيين في رعاية الجروح. يتم تقديم تحليل مفصل للعناصر الرئيسية في تقييم الجروح مثل العدوى، توازن الرطوبة، ونوع الأنسجة.

النتائج: تسلط المراجعة الضوء على الدور الحاسم لاستراتيجيات العلاج الشخصية والمبنية على الأدلة في إدارة الجروح المعقدة. تشمل التدخلات الرئيسية تقنيات التنظيف، واستخدام الضمادات المناسبة، وتدابير التحكم في العدوى. كما تؤكد على أهمية الرعاية التعاونية بين المتخصصين مثل جراحي الأوعية الدموية، اختصاصي التغذية، وفرق إدارة الألم لتحسين الشفاء.

الاستنتاج: تتطلب الإدارة الفعالة للجروح المعقدة نهجًا متعدد التخصصات، مع مراعاة الجوانب الفسيولوجية والنفسية لرعاية المرضى. من خلال تخصيص العلاج لاحتياجات الأفراد والتركيز على الخيارات العلاجية المتقدمة، من الممكن تحسين نتائج الشفاء وتقليل العبء الناتج عن رعاية الجروح المعقدة على المرضى والأنظمة الصحية.

الكلمات الرئيسية: الجروح المعقدة، الجروح المزمنة، التدخلات التمريضية، تقييم الجروح، التنظيف، الرعاية متعددة التخصصات، عملية الشفاء، إدارة الجروح.