Steer Clear: Inadvertent Use Of Antimicrobials Can Cause Unintentional Harm To Wound Healing

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Introduction

Wound hygiene is considered the cornerstone of wound care.[1,2,3] In fact, it is only with an appropriate wound bed preparation that a wound is set up to heal in a timely manner. Effective management of bacterial balance depends on utilizing products that lower infection risks, foster an environment conducive to healing and prevent delays in the critical phases of wound healing, such as proliferation and remodelling.[3] While specific antimicrobial agents, such as iodine and iodine-releasing compounds, alcohol, hydrogen peroxide, acetic acid, hypochlorite and saline, have beneficial properties when used appropriately, their misuse can actually compromise wound healing and cause harm due to their adverse effects.[3] In this regard, many commonly used, easy-to-access, over-the-counter topical antimicrobials can cause unintentional harm, such as dryness of wound bed or cytotoxicity to new cells if used improperly.

Despite extensive literature detailing the proper use of antimicrobial products,[1,2,3] their misuse persists in clinical practice and community settings, underscoring the need for further education and guidance of individuals managing

wounds. As clinicians specialized in wound healing (first and third authors), we have observed prolonged misuse of antimicrobial products, such as iodine, to manage wounds, resulting in delayed healing and frustration among patients, families and health-care providers. Motivated by these observations, we hope to raise awareness of this issue and encourage health-care providers involved in wound care to assess and reassess product outcomes, making informed decisions based on their findings. Therefore, it is imperative to bridge this gap by reviewing the utilization of common antimicrobials in clinical practice and synthesizing evidence-based research and clinical guidelines and best practice recommendations. This review aims to determine the appropriate indications, concentrations, benefits, adverse effects, recommended duration of use and, ultimately, the ensure benefit over harm. By understanding the process of wound healing and carefully assessing and selecting the right product based on the specific characteristics of the wound bed and stages of the healing process, as well as the preferences and needs of individuals with wounds, clinicians can enhance the likelihood of achieving desired outcomes, thereby effectively supporting individuals along their healing journey.

Understanding The Dynamic Process Of Wound Healing

In general, the efficacy of wound healing depends largely on intrinsic and extrinsic factors concerning the cause, depth, healing process, time of occurrence, infection status and the individual's overall health.[4,5] For instance, an acute full-thickness burn covering 10% of the body's surface area in an otherwise healthy person will heal very differently than a diabetic foot ulcer. However, regardless of the etiology, wound healing occurs in four distinct yet overlapping phases, including hemostasis, inflammation, proliferation and remodelling.[5]

Immediately following an injury, damaged blood vessels constrict to reduce bleeding and hemostasis begins. Platelets begin aggregating at the injury site to form a clot, which creates a temporary barrier and helps stop bleeding, leading to the inflammation phase, where neutrophils and macrophages migrate to the wound site to remove bacteria, debris and damaged tissue. Concurrently, inflammatory mediators, such as pro-inflammatory cytokines and chemokines, are released to promote the recruitment of additional immune cells, while growth factors are released to stimulate the growth and deposition of the extracellular matrix (ECM).[4,5] The proliferation phase is characterized by the turnover of the ECM, the

formation of new tissue to replace the damaged tissue, and the production of collagen by fibroblasts, which provides structure to the wound and plays a vital role in this phase. New blood vessels are formed to supply oxygen and nutrients to the healing tissue and epithelial cells and then multiply to cover the wound surface via re-epithelialization, also known as the remodelling or maturation phase. In the remodelling phase, the newly formed tissue undergoes structural and functional changes, which progress into maturation—the development of newly formed tissue.[5] At this point, collagen fibres are reorganized and strengthened (collagen synthesis) and excess scar tissue is gradually broken down (degradation), making the wound stronger and more resistant to injury.[4,5]

To effectively determine the appropriate treatment for wounds, clinicians must grasp the dynamic nature of wound healing and recognize what phase the wound is in. It is crucial to comprehend the various factors influencing wound healing, including age, nutrition, environmental conditions and underlying diseases. Antimicrobial agents are crucial for preparing the wound bed, helping it move from the inflammatory phase to the later stages of healing. However, misuse of certain antimicrobial agents—either through inadequate dilution or prolonged use—can impede wound healing by exerting cytotoxic effects on fibroblasts, responsible for collagen synthesis.

Health-care providers involved in wound care must discern the optimal timing for initiating and discontinuing antimicrobial therapy, remembering that antimicrobials alone are insufficient treatment options. Therefore, conducting a comprehensive wound assessment is paramount to identifying the wound phase and any hindering factors, whether wound-related or patient-related. As clinicians continually assess patients and the wound bed, they can determine phase-specific treatments accordingly. As advocated by Sibbald and colleagues,[6] a holistic approach encompasses understanding the wound's etiology, addressing patient-centred concerns, evaluating wound healability, ensuring adequate blood supply and moisture balance, performing wound debridement and assessing for local or systemic infection.[6] It is important to note that wounds generally heal better in a moist environment, yet certain antimicrobials, such as iodine, tend to dry out wounds, thereby delaying healing.[3] Therefore, clinicians should exercise caution when selecting antimicrobial agents to avoid exacerbating this issue. Treatment should be reevaluated and potentially modified if a wound fails to demonstrate healing despite consistent assessments.

Assessing And Selecting Wound Cleansing And Antimicrobial Agents

Each wound cleanser and antimicrobial serve distinct purposes, contributing to wound healing when used correctly. However, misuse can exacerbate wound conditions, leading to increased wound size, delayed healing, heightened infection risks (both local and systemic) and prolonged discomfort for the individual. Thus, prior to selecting a cleansing solution or antimicrobial, it is imperative to assess the wound for signs of infection, both locally and systemically, as well as determine the current healing phase of the wound.[7]

Local infection is discernible through the presence of three or more NERDS criteria (Nonhealing, Exudate increase, Red friable granulation, Debris or dead cells and Smell).[6] The presence of local infection requires the use of topical antimicrobials according to product recommendations and directions for use. Conversely, evidence of deep and surrounding infection can be indicated by the STONEES criteria, which encompass increased Size, elevated Temperature (exceeding three degrees Fahrenheit comparing affected and unaffected locations such as both feet – mirror image), New or satellite areas of involvement, surrounding cellulitis (Erythema or Edema), probing to bone, increased Exudate and Smell.[6] The presence of four out of seven STONEES criteria signifies systemic infection and may warrant systemic antimicrobial intervention.[6]

Before initiating or continuing any cleansing solutions or antimicrobials, wound care professionals should employ the aforementioned criteria to evaluate treatment efficacy. Monitoring

the wound's healing rate is crucial; if there is less than a 20-40 percent reduction in wound size by week four, complete healing by week 12 becomes unlikely and necessitates reevaluation.[4,5] Various underlying factors, both local and systemic, can delay wound healing, including excessive inflammation, moisture loss, wound microbiome, hormonal imbalance, cytokines, growth factors, age, circulation and nutritional status.[4,5] Neglecting these criteria, risks inadvertent harm to the wound and undermines effective treatment outcomes.

Below, we provide an overview of the antimicrobial agents that are most commonly used, due to their over-the-counter accessibility, which often leads to misuse or overuse. Antimicrobial agents such as chlorhexidine (CHG) and polyhexamethylene biguanide (PHMB) are not covered in this paper, as they do not meet the inclusion criteria of being widely accessible over-the-counter by the community.

Iodine and iodine-releasing compounds: Povidone-iodine in solution is one of the most commonly used antimicrobials due, in part, to its relatively low levels of cytotoxic effects when compared to other antimicrobials. Although its bactericidal efficacy is also proportionally lower,[3,8] iodine can inhibit excessive protease levels in chronic non-healing wounds, thereby facilitating a faster wound-healing process.[3,9] Lodosorb (Cadexomer iodine) contains a modified starch matrix that absorbs moisture up to six times its weight. As the lattice swells, the size of its micropores expands, facilitating the steady release of iodine that reduces exudate, pus/debris, slough, bioburden and infection.[8,10] Research indicates that Iodosorb is ideal for chronic and infected wounds because of the slow iodine release, ease of application, lack of toxicity and antibacterial properties.[8-12] It also retains antibacterial properties against common chronic open-wound pathogens, such as *Pseudomonas spp*. and MRSA.[8]

The safety profile of iodine is well established, yet it becomes harmful when used in concentrations at or above 5% or for prolonged periods. Iodine can impair wound healing due to its cytotoxic effects on chondrocytes, which are important for cartilage regeneration and fibroblasts, the cells responsible for collagen production.[3] Furthermore, studies have demonstrated that diluted povidone-iodine can have deleterious effects on articular cartilage and can interact with other antimicrobials to form toxic byproducts.[3,8,13] Although iodoform has been used to prevent or manage wound infection for almost two centuries, currently there are more effective and non-toxic options for this purpose.

In our clinical experience, it is not uncommon to encounter patients with chronic wounds where non-specialized wound care providers have applied iodine directly during dressing changes for extended periods.

For example, HB, a lady who had a venous leg ulcer (VLU) for over six years, reported that the wound never completely healed and that iodine was the main solution being applied to their wound in the community setting. Figure 1, taken during the initial assessment on July 24, 2023, depicts iodine adhered to the wound bed. This is a typical situation where iodine was being used longer than the product recommendation and the care plan was not being adapted according to wound assessment. After discontinuing iodine and starting treatment according to best practice (e.g., compression therapy), this wound progressed to the proliferation and remodelling phases (Figure 2).

Figure 1

Figure 2

Considering the drawbacks highlighted in the literature and our own observation of iodine's tendency to dry out the wound bed and impede wound healing, we recommend a cautious approach to its usage. Limiting its application to short durations, such as two weeks, is advisable to

disrupt the bacterial biofilm and mitigate the risk of potential harm and delays in wound closure.

Alcohol: Alcohol, like ethanol or isopropyl alcohol, is frequently utilized for its cost-effectiveness and ability to eliminate both gram-positive and gram-negative bacteria, including *Mycobacterium tuberculosis*, various fungi and certain enveloped viruses.[3,13] However, despite its widespread use in wound care, alcohol has potentially cytotoxic effects on fibroblasts and inflammatory mediators, as well as a tendency to hinder wound closure via dehydration of tissue.[3,13] Additionally, prolonged exposure to alcohol can impede the formation of new blood vessels crucial for delivering oxygen and nutrients to healing tissue.[14] Considering the disadvantage of alcohol on open wounds, its recommendation should be restricted to intact skin and not open wounds. Healthcare providers should choose antimicrobials that favour wound healing and lead to wound closure as quickly as possible by assessing the wound bed to determine the appropriate treatment.

Hydrogen Peroxide: Hydrogen peroxide has been widely, and historically, used as a disinfectant and antimicrobial due to its ability to generate reactive oxygen species that kill anaerobic bacteria.[3] Mounting evidence suggests that hydrogen peroxide can prolong inflammation, angiogenesis and cell migration in concentrations below 0.5% and in exposure for less than five minutes.[15,16] At concentrations above 0.5%, or exposure greater than five minutes, however, it can impair wound healing through oxidative damage to tissues, causing cell membrane damage, protein denaturation, DNA damage and inflammation, and by inhibiting the migration and proliferation of fibroblasts and keratinocytes.[3] Additionally, hydrogen peroxide can impair the function of phagocytic cells, such as macrophages, which play a crucial role in clearing debris and promoting tissue repair. Indeed, as is common with topical antimicrobials, the extent of tissue damage depends largely on the concentration and duration of exposure.

As with many topical antimicrobials, the extent of tissue damage caused by hydrogen peroxide largely depends on the concentration and duration of exposure. Consequently, health--care providers should carefully reconsider its use in wound treatment, as the risks may outweigh the benefits for wound healing. Equally important is the need for comprehensive education initiatives targeting individuals and families who may be unaware of the potential drawbacks of hydrogen peroxide. Given its widespread availability over the counter, educating the public about its disadvantages is essential to prevent its inappropriate use and mitigate potential harm in the wound healing processes.

Acetic Acid: Acetic acid, commonly known as 'vinegar', is sometimes used as an antimicrobial agent in wound management. However, limited evidence exists supporting its efficacy across various wound types, with a substantial body of research indicating its cytotoxic effects on key wound-healing cells—particularly fibroblasts and keratinocytes.[3] Studies have demonstrated that concentrations of acetic acid exceeding 0.0025% can impair wound healing by impeding essential processes such as cell migration and proliferation, which are vital for achieving wound closure and re-epithelialization.[3,12,17] Prolonged exposure to acetic acid has been associated with delayed wound healing due to its disruptive effects on the normal inflammatory and proliferative phases of wound repair.[3,17]

Of particular note, the acidic nature of acetic

acid can exacerbate wound bed conditions if not properly diluted, potentially leading to further delays in healing.[12] Furthermore, overuse of acetic acid may result in initial discomfort, manifesting as burning sensations, and can progress to tissue damage over time.[12,17] Therefore, its application should be judiciously assessed for each wound, optimizing healing outcomes through expert evaluation and tailored treatment approaches.

Sodium Hypochlorite (Dakin's Solution): Sodium hypochlorite (popularly known as 'bleach') is a potent oxidizing agent that reduces bacterial bioburden within wounds while maintaining a relatively low toxicity profile.[3] Its efficacy lies primarily in its ability to eradicate bacteria, biofilms (such as those produced by *Pseudomonas spp*.), fungi and viruses.[3] It is also often employed as an irrigant to eliminate debris and contaminants from wound beds.

Although diluted hypochlorite has a good safety profile, it is crucial to exercise caution due to its cytotoxic effects on cells during the proliferation phase of wound healing. At concentrations above 0.005%,[12,18] or for prolonged periods, this cytotoxicity manifests as inhibition of fibroblast proliferation and collagen synthesis, ultimately impairing wound closure and tissue remodelling.[3] Consequently, while hypochlorite effectively eradicates pathogens, its potentially detrimental impact on wound healing underscores the importance of strategic application. Indeed, it is most effective when used during the active stage of infection,[12] rather than as a routine cleansing agent. Thus, its application should be carefully guided by the specific needs and stage of wound management to optimize therapeutic outcomes and because household bleach can cause significant tissue damage and delay healing, it should altogether be avoided for wound care.[3,12]

Saline: Saline is a fundamental tool in wound management, facilitating the cleansing and irrigation of wounds to create an optimal environment for healing. Its primary role lies in the effective removal of debris, exudate and bacteria from the wound site, thereby promoting a conducive milieu for tissue repair.[3] In addition, its biocompatibility enhances its utility, ensuring minimal risk of adverse reactions during irrigation and fostering patient comfort and safety. Moreover, saline's ability to maintain a moist wound environment is integral to supporting the natural healing process. This moist environment facilitates cell migration, proliferation and tissue regeneration, contributing to expedited wound closure and repair.[3] The mechanical action of saline in dislodging contaminants from the wound surface further augments its effectiveness, aiding in the removal of foreign materials and promoting wound cleanliness.

It is important to note that saline solution does not possess direct antimicrobial properties, limiting its ability to eradicate bacteria present in wounds.[3] Indeed, compared to specialized wound cleaning agents, saline may exhibit reduced efficacy in removing tenacious debris or biofilms from chronic or complex wounds.[19] Furthermore, improper handling or storage of saline solutions can introduce contamination, posing risks of secondary infection at the wound site.[20] Of course, the recommendation is to follow facility protocol first. When in doubt, consider 0.9% saline as a soak for no more than 10-15 minutes at a time.[20] When used to irrigate, apply pressure between 8 and 15 psi,[12] according to the wound treatment protocol.

Unfortunately, it is not uncommon in our practice to encounter cases where individuals have been advised by health-care providers to soak their wounds in saline for prolonged periods. Unfortunately, following well-meaning but incorrect advice can have serious outcomes. For instance, the first author encountered a case (See Figure 3) where a person with a diabetes who had an amputation of the left Hallux was advised by a non-specialist to soak his open wound in a saltwater solution. The patient diligently followed this advice for several months, during which time—regrettably—their bone began to decalcify and soften. The patient later observed a fragment of bone protruding from the wound, a distressing situation he reported to the first author. Fortunately, after being seen by the

Table 1 provides a concise summary of common antimicrobial agents, including their names, indications, benefits, adverse effects, and recommended concentrations and duration. This resource aims to assist health-care professionals in selecting the most appropriate antimicrobial agent for wound management, taking into account specific patient needs, wound characteristics and clinical guidelines and best practice recommendations. By referring to this table, clinicians can quickly access essential information to make informed decisions regarding antimicrobial therapy, optimizing patient care and promoting effective wound healing strategies.

Product	Common Names	Indication	Benefits	Adverse Effects	Optimal Concentration And duration
Iodine	• Povidone-Iodine • Inadine • PVP-I • Iodosorb	• Bite, stab, puncture and gunshot wounds[22] • Chronic open wounds[6] • Used only to clean to reduce bacterial load[6]	• Improves wound healing[3] • Stimulates epidermal regeneration[9] • Effective against *Pseudomonas spp*. and MRSA[9] • Can disrupt biofilms[9]	• In high concentrations, may interfere with the proliferation phase of healing by inhibiting fibroblast migration and collagen synthesis[3,13] • Should be used with caution in infants under six months and those with thyroid disorders, deep ulcerative wounds, burns or large injuries[26] • It is a potent allergen and is incompatible with silver nitrate, metallic salts, strong oxidizers and strong bases	• ≤5% [22,23] • Short period of time (e.g., 2 weeks)
Alcohol	• Ethanol • Isopropyl • Isopropanol • n-propanol	• Avoid in open wounds • Uncertainty in the estimates of benefits, risks and burden[3]	• Reduces bacterial burden[3]	• Interferes with the proliferative phase of healing • Impairs early inflammatory response • Inhibits wound closure, angiogenesis and collagen production • Alters protease balance • Causes tissue dehydration[13]	• 60% to 90%[3,15] • Short period on intact skin
Hydrogen Peroxide	• Peroxide	• Avoid applying after crust separation[15] • Use only as a cleanser to detach dry debris	• Reduces bacterial burden and debrides wounds[3] • Stimulates inflammation, angiogenesis and cell migration[15]	• At high concentrations, destroys fibroblasts, keratinocytes, platelets[3,13]	• 0.5% for <5 mins[16] • Short period of time
Acetic Acid Derivatives	• Acetate • Vinegar	• Paronychia • Moistened gauze dressings with acetic acid[12] • Not indicated as continuous treatment option • Wound irrigation[23]	• Reduces bacterial burden[3]	• In high concentrations, may inhibit keratinocytes, fibroblast migration and collagen synthesis • May decrease moisture in the wound bed[3,7]	• 0.0025%[12] • Short period of time
Hypochlorite	• Sodium Hypochlorite • Dakins Solution • Bleach	• Most effective during the active stage of infection[12] • Contaminated acute and chronic wounds[22] • Should not be used on or packed in clean wounds[26]	• Reduces bacterial burden[3,18]	• In high concentrations, may inhibit fibroblast migration and collagen synthesis[12,21,24-26]	• 0.005%[12,25,26] • Short period of time
Normal Saline	• Saline • Salt Water • Sterile Salt Water	• Paronychia • Improves local fluid balance • Not indicated to soak wounds for long periods of time • Recommended as a cleanser, but not as first-line antimicrobial option	• Removes exudate below the visible wound bed[19] • Mechanical removal of pathogens and debris when used as an irrigant[18]	• Alters local fluid balance • Limited bactericidal efficacy[25]	• 0.9% • As a soak, 10-15 mins[20] • As an irrigant, between 8 and 15 psi[12]

first author, a wound specialist, who advised the patient to discontinue soaking the wound with salted water and adjusted treatment according to evidence-based practice, the wound healed completely (See Figure 4). Complications of prolonged wound soaking or continuous irrigation include visibly damaged bone, potential bacterial seeding into the bone marrow and delayed healing.[21] Additionally, high-pressure lavage may inadvertently push surface contaminants into the mucosal epithelium, further complicating the wound healing process.[21]

Figure 3
Before - Open wound with maceration due to soaking it with salted water.

Figure 4
After adjusting treatment leading wound to close.

It is crucial to emphasize the importance of using the listed antimicrobial agents as intended and adhering to the recommendations provided by the product developer. However, it is equally essential to exercise clinical judgment and expertise or consult with a wound care specialist to evaluate individual cases and consider alternative treatment options aligned with clinical guidelines and best practice recommendations.

Caution: Discontinue The Overuse/ Misuse Of Antimicrobial Agents

In summary, overuse or misuse of topical antimicrobials can hinder wound healing progress, making them detrimental to the process of wound healing. Therefore, their application in wound care should be reserved for cases where there is a clear indication, such as the presence or high risk of infection. However, they should never be used routinely or without a specified treatment duration. When signs of infection are present, topical antimicrobials may be necessary to control bacterial growth. It is crucial to consider the long-term health of the tissue and select antimicrobial agents that support tissue viability, especially in patients with compromised immune systems or underlying health conditions, such as those with surgical wounds or traumatic injuries. For chronic or non-healing wounds, or those susceptible to biofilm formation, topical antimicrobials can be useful for managing bacterial load and disrupting biofilm structure. Nonetheless, they should not be relied upon as the sole treatment for wound healing, particularly when more effective options are available. Overall, the decision to use topical antimicrobials should be based on a comprehensive assessment of the wound, taking into account risk factors for infection (using NERDS and STONEES criteria), and following wound-specific and facility-specific protocols to ensure appropriate and efficient wound management.[27]

Closing The Gap: Advancing Clinical Practice Through Evidence-Based Research

Because health-care practices and guidelines evolve over time based on new research and changing health-care needs, it is crucial for health-care professionals to stay current with the latest evidence and best practice recommendations in their field. This may involve attending continuing education courses, participating in professional development activities and actively seeking out new research findings related to the specialized field. Involving the individuals in their own care is crucial to ensuring positive outcomes.[28] It is important to use a patient-provider collaborative approach that considers individual needs and preferences and values their expertise in what is working for their wound and what is not. [29] For instance, if an individual with a wound states that they are using a product on their wound, but it is not showing results, the health-care provider should consider making changes to the treatment plan.

As articulated by Sibbald and colleagues,[27]

tailoring wound care plans to meet individual needs necessitates sensitivity to various factors, including socioeconomic status, cultural background, psychosocial dynamics and other personal aspects. A model proposed by Keller and colleagues,[27,30] emphasizes the importance of enhancing patient communication by incorporating the four 'Es' during every patient interaction: Engaging, Empathizing, Educating and, perhaps most importantly, Enlisting them in their care. Furthermore, the importance of advocating for the availability of the right products and the correct use—and intent—of the products to nursing managers cannot be overemphasized. Nursing managers play a key role in ensuring health-care facilities have access to the appropriate products and resources to deliver quality patient care. Wound care specialists should advocate for the availability of evidence-based wound care products and educate their colleagues about the importance of their proper usage.[3,27] This advocacy may involve disseminating information on the latest research findings, sharing best practice recommendations and highlighting the potential risks associated with the misuse and/or overuse of certain products. By advocating for the correct use of wound care products, wound care specialists can contribute to positive outcomes for individuals and mitigate the risk of complications arising from improper product usage.

Conclusions

In conclusion, while commonly used topical antimicrobials in wound care offer beneficial properties when appropriately applied, caution is warranted due to limited evidence regarding their clinical effects on wound healing and potential cytotoxicity controversies. To prevent misuse of antimicrobial solutions that may be harmful for fibroblast, best practices recommend their use only when there is a high bacterial load. However, once the deep infection is controlled, these solutions should be discontinued and moist interactive dressing instituted to promote healing and optimal wound bed preparation.[6,31] Therefore, understanding their mechanisms of action, correct application, potential adverse effects and appropriate indications is crucial to ensure careful use and optimize best therapeutic outcomes. Each antimicrobial has its role in wound bed preparation, but extra vigilance is necessary to prevent inadvertent harm. Therefore, institutional policies should prioritize evidence-based practices, benefits and patient outcomes over cost considerations. By embracing evidence-based approaches, institutions and wound care specialists can elevate the quality of wound care, enhance patient safety, minimize risks and improve patient outcomes. Fostering research, collaboration and knowledge-sharing is essential to advance wound care practices and meet the evolving needs of individuals with wounds.

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References

1. Andriessen AE, Eberlin T. Assessment of a wound cleansing solution in the treatment of problem wounds. Wounds. 2008 Jun;20(6):171-5.
2. Romanelli M, Dini V, Barbanera S, Bertone MS. Evaluation of the efficacy and tolerability of a solution containing propyl betaine and polihexanide for wound irrigation. Skin Pharmacol Physiol. 2010;23 Suppl:41-4. DOI: 10.1159/000318266
3. Wilkins RG, Unverdorben M. Wound cleaning and wound healing: a concise review. Adv Skin Wound Care. 2013 Apr;26(4):160-3. DOI: 10.1097/01.ASW.0000428861.26671.41
4. Wilkinson HN, Hardman MJ. Wound healing: cellular mechanisms and pathological outcomes. Open Biol. 2020 Sep;10(9):200223. DOI: 10.1098/rsob.200223

5. Beitz JM. Wound healing. In: McNichol LL, Ratliff CR, Yates SS, editors. Wound ostomy and continence nurses society core curriculum: wound management. 2nd ed. Alphen an den Rijn (NL): Wolters Kluwer; 2022. p. 39–52.
6. Sibbald RG, Elliott JA, Persaud-Jaimangal R, Goodman L, Armstrong DG, Harley C, et al. Wound bed preparation 2021. Adv Skin Wound Care. 2021 Apr 1;34(4):183-195. DOI: 10.1097/01.ASW.0000733724.87630.d6
7. Kramer A, Dissemond J, Kim S, Willy C, Mayer D, Papke R, et al. Consensus on wound antisepsis: update 2018. Skin Pharmacol Physiol. 2018;31(1):28-58. DOI: 10.1159/000481545
8. Müller G, Kramer A. Biocompatibility index of antiseptic agents by parallel assessment of antimicrobial activity and cellular cytotoxicity. J Antimicrob Chemother. 2008 Jun 1;61(6):1281-7. DOI: 10.1093/jac/dkn125
9. Leaper DJ, Durani P. Topical antimicrobial therapy of chronic wounds healing by secondary intention using iodine products. Int Wound J. 2008 Jun;5(2):361-8. DOI: 10.1111/j.1742-481X.2007.00406.x
10. Woo K, Dowsett C, Costa B, Ebohon S, Woodmansey EJ, Malone M. Efficacy of topical cadexomer iodine treatment in chronic wounds: Systematic review and meta-analysis of comparative clinical trials. Int Wound J. 2021 Oct;18(5):586-597. DOI: 10.1111/iwj.13560
11. Moberg S, Hoffman L, Grennert ML, Holst A. A randomized trial of cadexomer iodine in decubitus ulcers. J Am Geriatr Soc. 1983 Aug;31(8):462-5. DOI: 10.1111/j.1532-5415.1983.tb05117.x
12. Schultz GS, Sibbald RG, Falanga V, Ayello EA, Dowsett C, Harding K, et al. Wound bed preparation: a systematic approach to wound management. Wound Repair Regen. 2003 Mar;11 Suppl 1:S1-28. DOI: 10.1046/j.1524-475x.11.s2.1.x
13. Atiyeh BS, Dibo SA, Hayek SN. Wound cleansing, topical antiseptics and wound healing. Int Wound J. 2009 Dec;6(6):420-30. DOI: 10.1111/j.1742-481X.2009.00639.x
14. 14. Guo S, Dipietro LA. Factors affecting wound healing. J Dent Res. 2010 Mar;89(3):219-29. DOI: 10.1177/0022034509359125
15. Gruber RP, Vistnes L, Pardoe R. The effect of commonly used antiseptics on wound healing. Plast Reconstr Surg. 1975 Apr;55(4):472-6.
16. Romano V, Di Gennaro D, Sacco AM, Festa E, Roscetto E, Basso MA, et al. Cell toxicity study of antiseptic solutions containing povidone–iodine and hydrogen peroxide. Diagnostics. 2022 Aug 21;12(8):2021. DOI: 10.3390/diagnostics12082021
17. Chen Q, Zhou K. Acetic acid use in chronic wound healing: a multiple case series. J Wound Ostomy Continence Nurs. 2022 May-Jun 01;49(3):286-289. DOI: 10.1097/WON.0000000000000863
18. Hotaling PB, Black JM. Ten top tips: myth-busting wound care. Wounds. 2022;8(1).
19. Smart H. The soak versus compress in wound care. Adv Skin Wound Care. 2021 Jun 1;34(6):334-5. DOI: 10.1097/01.ASW.0000749656.41487.06
20. El-Amawy HS, Sarsik SM. Saline in dermatology: a literature review. J Cosmet Dermatol. 2021 Jul;20(7):2040-2051. DOI: 10.1111/jocd.13813
21. Bahrs C, Schnabel M, Frank T, Zapf C, Mutters R, von Garrel T. Lavage of contaminated surfaces: an in vitro evaluation of the effectiveness of different systems. J Surg Res. 2003 Jun 1;112(1):26-30. DOI: 10.1016/s0022-4804(03)00150-1
22. Bigliardi PL, Alsagoff SA, El-Kafrawi HY, Pyon JK, Wa CT, Villa MA. Povidone iodine in wound healing: a review of current concepts and practices. Int J Surg. 2017 Aug;44:260-268. DOI: 10.1016/j.ijsu.2017.06.073
23. White RJ, Cooper R, Kingsley A. Wound colonization and infection: The role of topical antimicrobials. Br J Nurs. 2001 May 10-23;10(9):563-78. DOI: 10.12968/bjon.2001.10.9.9387
24. Jeffcoate WJ, Price P, Harding KG; International Working Group on Wound Healing and Treatments for People with Diabetic Foot Ulcers. Wound healing and treatments for people with diabetic foot ulcers. Diabetes Metab Res Rev. 2004 May-Jun;20 Suppl 1:S78-89. DOI: 10.1002/dmrr.476
25. Lindfors J. A comparison of an antimicrobial wound cleanser to normal saline in reduction of bioburden and its effect on wound healing. Ostomy Wound Manage. 2004 Aug;50(8):28-41.
26. Orsted HL, Keast DH, Forest-Lalande L, Kuhnke JL, O'Sullivan-Drombolis D, Jin S, et al. Best practice recommendations for the prevention and management of wounds. In: Rosenthal S, Orsted HL, Bassett K, editors. Foundations of best practice for skin and wound management. Toronto (ON): Wounds Canada; 2018. Available from: www.woundscanada.ca/ docman/public/health-care-professional/bpr-workshop/165-wc-bpr-prevention-andmanagement-of-wounds/file
27. Sibbald RG, Woo K, Ayello EA. Increased bacterial burden and infection: the story of NERDS and STONES. Adv Skin Wound Care. 2006 Oct;19(8):447-61. DOI: 10.1097/00129334-200610000-00012
28. Costa IG. Unfolding patients' preferences in wound care. Wound Care Canada. 2022;19(2):52-4. Available from: https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2022-v20-n1/2577-wcc-summer-2022-v20n1-final-p-52-55-unfolding
29. Costa IG, Jones-Bonofiglio K. Promoting autonomy, empowerment and self-management in patients with wounds. Wound Care Canada. 2022;20(1):28-31. Available from: https://www.woundscanada.ca/docman/public/wound-care-canada-magazine/wcc-2022-v20-n1/2574-wcc-summer-2022-v20n1-final-p-28-31-autonomy
30. Keller V, White MK, Carroll JG, Segal E. Physician-patient relationships workbook. West Haven (CT): Bayer Institute for Health Care Communication; 1995.