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THERAPEUTIC POTENTIAL OF SILVER NANOPARTICLE-BASED DRESSING IN THE HEALING PROCESS

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ABSTRACT

Introduction: The skin covers the entire surface of the human body, and is considered its largest organ. The resistance of bacteria to antibiotics represents a growing concern in wound infections, this is evidenced by the fact that wounds associated with a heavy bacterial load often present healing failures, increasing healthcare costs for the patient and healing time. **Objective:** To evidence through national and international literature the therapeutic potential of silver nanoparticle-based dressings in the healing process. **Methodology:** This is a literature review of a dissertative and explanatory nature. To theoretically support this review, the Brazilian Digital Library of Theses and Dissertations (BDTD) and the Nursing Databases (BDENF) were used. The search period was from February to April 2022, with temporal delimitation from 2017 to 2022, because these were the years that most studies on the topic of interest were obtained. The Boolean searchers (AND and OR) were used: "Nanoparticle-based dressing OR "Pressure injury" AND "Nanoprene therapy" AND "Multiprofessional team" in BDENF and BDTD, interrelated with the Boolean operators AND and OR. This study included original articles, available in full, case studies, clinical studies, randomized studies, theses and dissertations on the topic in question, published from 2016 to 2022, in English and Portuguese. As exclusion criteria, it was decided not to use articles that were not adjusted to the object of study, which ran away from the theme proposed by the authors, those that were duplicated in electronic databases, incomplete texts, unavailable in full, literature reviews, guides, technical manuals and letters to the reader. A total of 211 articles were found in the BDTD and 17 in the BDENF database, totaling 228 studies found. Of these, after applying the inclusion and exclusion criteria, 211 were excluded and 17 studies were selected because they met the study objective. **Results:** The AgNP-based dressing, presents great potential in pharmaceutical, therapeutic and biomedical applications, and can be applied in the composition of topical products such as ointments, gels and adhesives. **Conclusion:** Dressings based on silver nanoparticles (AgNP) are being widely used in biomedical sciences, being relevant to circumvent bacterial resistance to antibiotics, improving the quality of life of affected patients and consequently reducing hospital costs.

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INTRODUCTION

The skin covers the entire surface of the human body, being considered its largest organ. It is the body's first line of defense, being responsible for performing several functions, such as protection against physical and chemical trauma, toxins, pathogenic microorganisms, preventing excessive loss of water and proteins, ensuring the regulation of body temperature and electrolyte excretion (CARDOSO, 2017). Due to its extreme importance, in case of injury to the skin, rapid intervention is necessary to ensure the possibility of regeneration and recovery of its functions and avoid the appearance of physiological imbalance, which can lead to the death of the individual (ONOFRE, 2019). Wounds are represented not only by the rupture of the skin and subcutaneous cellular tissue, but also, in some cases, by injuries to muscles, tendons and bones, i.e. wound infection is treated as a major cause of mortality followed by surgery (SAMPAIO et al., 2019). Dressings can be, on some occasions, the definitive treatment itself, on others, only an intermediate step towards surgical treatment (MORAES, 2019). These products have undergone scientific and technological advances over the years, which can be used in different stages of wound treatment that promote healing, including inputs aimed at protecting the skin against injuries, prevention of infections, hygienization, antiseptics, chemical, enzymatic, autolytic or mechanical debridement. The dressings aim not only to accelerate the healing process, but also to reduce possible complications (SANTANA, 2021). The resistance of bacteria to antibiotics represents a growing concern in wound infections, as evidenced by the fact that wounds associated with a heavy bacterial load often present healing failures, increasing the patient's health care costs and healing time (ARAGÃO, 2018). Therefore, this study aims to demonstrate, through the national and international literature, the therapeutic potential of silver nanoparticle-based dressings in the healing process.

METHODOLOGICAL

This is a literature review of a dissertative and explanatory nature. To theoretically support this review, the Brazilian Digital Library of Theses and Dissertations (BDTD) and the Nursing Databases (BDENF) were performed, the search period occurred between February and April 2022, with temporal delimitation from 2017 to 2022, because they were the years that most studies on the topic of interest were obtained. The following Health Science Descriptors (DeCS) were used to guide the search: *Nanoparticle-based dressing*, *Pressure lesion*, *Nano silver therapies* and *Multiprofessional Team* and MeSH (*Medical Subjects Headings*): *Nanoparticle-based dressing*, *Pressure lesion*, *Nano silver therapies* and *Multiprofessional Team*, with their variations in Portuguese and English. For the combination of the aforementioned descriptors, used alone or combined with the Boolean searchers (AND and OR): "*Nanoparticle-based dressing* OR "*Pressure injury* " AND "*Therapy with nanoprene*" AND "*Multiprofessional Team*" in BDENF and BDTD, interrelated with the Boolean operators AND and OR.

This study included original articles, available in full, case studies, clinical studies, randomized studies, theses and dissertations on the topic in question, published from 2016 to 2022, in English and Portuguese. As exclusion criteria it was decided not to use articles that were not adjusted to the object of study, which ran away from the theme proposed by the authors, those that were duplicated in electronic databases, incomplete texts, unavailable in full, literature reviews, guides, technical manuals and letters to the reader. During the search, 211 articles were found in the BDTD and 17 in the BDENF database, totaling 228 studies found. Of these, after applying the inclusion and exclusion criteria, 211 were excluded and 17 studies were selected because they met the study objective. Since this is a literature review, the research was not submitted to the Research Ethics Committee (CEP), however, the guarantee of ethical and legal precepts is reaffirmed throughout the writing process of this study.

RESULTS AND DISCUSSION

From the selection and analysis of the articles found, a table was built to expose the title of each of these studies, as well as the respective authors, year, objectives and the main findings/conclusion (Chart 1). Silver nanoparticle (AgNP) based dressings are quite popular in wound care, these may be associated with a salt, or compound, today we have the introduction of silver nanoparticles, due to enhanced antibacterial activity, reduced toxicity and ease of incorporation, there has been an increase in demand for their medical applications including dressings for the treatment of open infectious wounds (DANTAS, 2017).

Among the factors associated with the risk of developing LP, we highlight systemic arterial hypertension, diabetes, unconsciousness, immobilization, loss of sensation, loss of motor function, loss of urinary or fecal continence, presence of muscle spasms, nutritional deficiencies, anemia, very high or very low body mass index, circulatory diseases, peripheral arterial disease, immunodeficiency or use of corticosteroids, and smoking (ACCIOLY, 2017).

During healing it is necessary to use dressings made of materials with antibacterial action to prevent infection, because in burn patients and debilitated patients the metabolism is altered due to systemic inflammatory reaction, which compromises healing (NOGUEIRA, 2018). The AgNP-based dressing has great potential in pharmaceutical, therapeutic and biomedical applications, and can be applied in the composition of topical products such as ointments, gels and adhesives (ALTRAN, 2022). As shown in Figure 1 below, AgNP-based dressings are used in the treatment of pressure ulcers (PU).



Source: SANTANA, 2021.

The dressing composed of silver hydroalginate has a very interesting feature compared to other treatments, which is the ability to allow the changes of the dressing to be made by the patient himself, providing greater autonomy in the care of their wounds, and thus can bring greater safety and does not depend on professionals (BUKZEM, 2018).

The hydroalginate with silver is advantageous because it can be exchanged by the patient at home, providing greater comfort for patients and convenience for health professionals (COSTA, 2022). In this sense, the development of new therapeutic devices is important as a possibility to circumvent multidrug resistance, improving the therapeutic efficacy of infectious processes.

Chart 1. Studies selected for the construction of the review

Nº	Title	Author/Year	Objectives	Type of Study	Conclusion
01	Applicability of hydrogel-based dressings with silver nanoparticles on pressure ulcers	CARDOSO, 2017.	To evaluate the applicability of hydrogel membranes with silver nanoparticles in the treatment of PUs (PMLs) in	Therapeutic intervention study, of the uncontrolled clinical trial type	They proved to be effective in the treatment of PMLs, as they provided the wound with conditions for epithelialization. There was a decrease in the odor, the fabrics
02	Application of nanoparticles for antimicrobial purposes.	COSTA et al, 2022	SUS users, through clinical protocol.	Randomized study	Devalitized and pain, items that when present delay healing. However, further studies are needed, involving these dressings with a larger number of patients.
03	Development and characterization of polymeric films from agar, agarose and kefirana with incorporation of silver nanoparticles	ONOFRE, 2019.	To develop polymeric films based on agar, kefirana and agarose, with incorporation of NPsAg, for potential use as a temporary substitute for skin.	Study of therapeutic intervention, of the controlled clinical trial type.	The films obtained were transparent and homogeneous, with flexible consistency and the characterization confirmed the incorporation of nanoparticles inside.
04	Development and characterization of gelatin/chitosan membrane with silver nanoparticles.	MORAES, 2019	To evaluate the characteristics of the membranes, physical-chemical and morphological tests were performed, such as X-ray diffraction (XRD)	Clinical Trial	In vitro assays, it was possible to verify the biocompatibility of membranes with low nanoparticle concentration (10 mM, 5 mM and with 2 mM). Only the samples that contained high molar concentrations of silver nanoparticles (30 mM, 20 mM and 10 mM), showed antibacterial effects.
05	Analysis of inflammation and oxidative stress in healing process	SANTANA, 2021	To develop and characterize biomembranes based on latex containing curcumin, and	Clinical Trial	In our study, it was observed throughout the treatment a faster healing in animals
06	after the combined use of liposomes with curcumin in natural latex biomembranes and led therapy for tissue regeneration in diabetic ulcer patients	ALTRAN, 2022	Papain liposomal as well as to evaluate the effect of these biomembranes as a dressing in association with LED therapy on wound healing in diabetic rats.	Controlled clinical trial.	Of the groups that received treatment with LED therapy associated with the use of biomembrane containing liposome with curcumin with 99% and biomembrane containing curcumin and papain with 95% wound closure. Thus, the association of curcumin and papain with latex proved to be a good strategy to enhance the effectiveness of treatment in lesions of diabetic.
07	Evaluation of cutaneous wound healing treated with polyjuice and chitosan hydrogels associated with therapeutic laser.	ARAGÃO, 2018	To evaluate the healing and antioxidant effects of 2% chitosan hydrogel in the treatment of skin lesions	Randomized study	Given the results obtained, it is possible to infer that the 2% chitosan hydrogel has healing activity, since it accelerated cell proliferation and angiogenesis. This effect could be partially attributed to the antioxidant action of the hydrogel that decreased the generation of reactive oxygen species modulating the inflammatory response and, consequently the healing time.
08	Preparation and characterization of skin substitutes from agarose films	ACCIOLY, 2018	Characterize the behavior of the extract and of NPsAg	Therapeutic intervention study, such like	Regarding the antimicrobial activity of the NPsAg by synthesis
09	Incorporated with silver nanoparticles and extract of <i>Syzygium cumini</i> (L.) Skeels	DANTAS, 2019	Incorporated into polymeric films evaluating their antimicrobial activity	Controlled clinical trial.	Were effective in the diffusion method in liquid culture medium and not effective in the diffusion in semi-solid culture medium and polymeric film. A new protocol developed indicated that the NPsAg when associated to polymeric films possess antimicrobial activity restricted to the films surfaces, being limited to its diffusion in semi-solid culture medium solid.

Source: Survey data (2022).

CONCLUSION

The prevention and treatment of LPP have been the focus of multiprofessional actions in different health care settings. The correct use of the concept and terminology in LP enables these professionals to more effectively evaluate and develop coping strategies. Dressings based on silver nanoparticles (AgNP) are being widely used in biomedical sciences, being relevant to circumvent bacterial resistance to antibiotics, improving the quality of life of affected patients and consequently reducing hospital costs. Dentre os elementos de aplicação, são as nanoparticulas de prata, ouro e titânio que apresentam amplo espectro de ação antimicrobiana e antifungal no tratamento de lesão por pressão. Thus, this work serves as a subsidy for researches aimed at the application of silver nanoparticles in several areas, such as in the treatment of LP.

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