Contents lists available at ScienceDirect

European Journal of Pharmaceutics and Biopharmaceutics

journal homepage: www.elsevier.com/locate/ejpb

Review article

Recent advances on antimicrobial wound dressing: A review

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ARTICLE INFO

Keywords:
Antibiotics
Antimicrobial wound dressings
Nanoparticles
Natural products
Skin and soft tissue infections
Wound healing

ABSTRACT

Skin and soft tissue infections (SSTIs) have high rates of morbidity and mortality associated. Despite the successful treatment of some SSTIs, those affecting the subcutaneous tissue, fascia, or muscle delay the healing process and can lead to life-threatening conditions. Therefore, more effective treatments are required to deal with such pathological situations. Recently, wound dressings loaded with antimicrobial agents emerged as viable options to reduce wound bacterial colonization and infection, in order to improve the healing process. In this review, an overview of the most prominent antibacterial agents incorporated in wound dressings along with their mode of action is provided. Furthermore, the recent advances in the therapeutic approaches used in the clinic and some future perspectives regarding antibacterial wound dressings are also discussed.

1. Introduction

Skin is the largest and outermost organ that covers the entire body. Therefore, above all, skiń s primary function is to protect underlying muscles, bones, ligaments and internal organs from external biological, chemical, mechanical and physical agents [1,2]. Furthermore, skin is also involved in sensation, temperature regulation, immunological surveillance, prevention of water loss (dehydration) and synthesis of vitamin D3 [3]. However, the structure and functions performed by this organ can be affected by cuts, burns, surgical incisions or illnesses, such as diabetes [4]. After skin structure be compromised, its structure and functions must be re-established, as soon as possible to ensure the body homeostasis. To accomplish that, the wound healing process begins almost immediately after a skin injury occurs, in order to avoid the risk of bacterial contamination [5]. Non-healing wounds usually appear after this type of contamination occur [4].

Skin and soft tissue infections (SSTIs) are the most common types of infections and they affect approximately 14 million people every year in the United States [6,7]. Depending on the etiology and severity of the microbial invasion, SSTIs can range from minor superficial to life-threatening infections [8]. In the initial stage of the infectious process, gram-positive organisms such as *Staphylococcus aureus* (*S. aureus*) and *Streptococcus pyogenes* (*S. pyogenes*) are the dominant organisms involved, while gram-negative organisms like *Escherichia coli (E. coli)* and *Pseudomonas aeruginosa (P. aeruginosa)* are only found in later stages of the process, i.e. when a chronic wound is developed [7].

In a healthy human being, infection is avoided, by activating the immune system for abolishing the invading pathogens. In this process, macrophages initiate the migration to the wound site and subsequently perform phagocytosis of the pathogens (which are destroyed in a phagolysosome or by nitric oxide production). In a later stage of infection, the immune response is performed by the activation of lymphocytes T helper which secrete interferon-γ and CD40 ligand to coordinate the immune adaptive and humoral response to kill and remove the invading

Abbreviations: A. iwoffii, Acinetobacter iwoffii; AMPS-Na$^+$, 2-acrylamido-2-methylpropane sulfonic acid sodium salt; *B. cereus*, *Bacillus cereus*; *B. subtilis*, *Bacillus subtilis*; BC, Bacterial cellulose; CA, Cellulose Acetate; *C. freundii*, Citrobacter freundii; CMCS, Carboxymethyl Chitosan; CMGG, Carboxymethyl Guar Gum; CS, Chitosan; DHBA, 2,3-dihydroxybenzoic acid; *E.aerogenes*, *Enterobacter aerogenes*; *E.coli*, *Escherichia coli*; EDA, Ethylenediamine; *E. faecalis*, *Enterococcusi faecalis*; GMs, Gelatin Microspheres; HNTs, Halloysite Nanotubes; HA, Hyaluronic acid; *K. pneumoniae*, *Klebsiella pneumoniae*; MMSA, Methicillin susceptible *Staphylococcus aureus*; MRSA, Methicillin resistant *Staphylococcus aureus*; nAg, nano silver; NIPAAm, N-isopropyl acrylamide; OAlg, Oxidized Alginate; *P. aeruginosa*, *Pseudomonas aeruginosa*; PCD, β-cyclodextrin polymer; PCL, Polycaprolactone; PEI, Polyethyleneimine; PEO, Polyethylene oxide; PHEA, Poly(2-hydroxyethylacrylate); PLA, Poly(lactic acid); PLGA, Polylactic-co-glycolic acid; Plur, Pluronic F127; *P. mendocina*, *Pseudomonas mendocina*; PP, Polypropylene; PRP, Platelet rich-plasma; PSSA-MA, Poly(styrene sulfonic acid-co-maleic acid); PU, Polyurethane; PVA, Polyvinyl alcohol; PVP, Polyvinylpyrrolidone; *P. vulgaris*, *Proteus vulgaris*; SA, Sodium Alginate; *S. aureus*, *Staphylococcus aureus*; *S. epidermidis*, *Staphylococcus epidermidis*; *S. haemolyticus*, *Staphylococcus haemolyticus*; *S. pyogenes*, *Streptococcus pyogenes*; *S. typhi*, *Salmonella typhi*; *S. typhimurium*, *Salmonella typhimurium*; SF, Silk Fibroin; *V. vulnificus*, *Vibrio vulnificus*; ZN, Zein

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https://doi.org/10.1016/j.ejpb.2018.02.022
Received 22 December 2017; Received in revised form 7 February 2018; Accepted 16 February 2018
Available online 17 February 2018