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REVISÃO

Low laser therapy (photobiomodulation) on bacteria of pressure ulcers: in vitro studies *Laser de baixa potência (fotobiomodulação) sobre bactérias de úlceras de pressão: estudos in vitro*

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Resumo

Os efeitos biológicos promovidos pelo laser de baixa potência resultam em cicatrização mais rápida das feridas. No entanto, as feridas são sistemas muito complexos, tanto do ponto de vista microbiano quanto do hospedeiro. Como a infecção é uma causa comum de cicatrização retardada, é importante entender o efeito da terapia com laser de baixa intensidade no crescimento bacteriano. Esta mini-revisão resume as evidências atuais sobre os efeitos do laser de baixa intensidade em estudos de bactérias in vitro.

Palavras-chave: laser de baixa potência, lesão infectada, bactérias.

Abstract

The biological effects promoted by low power laser result in faster wound healing. However, wounds are very complex systems from both host and microbial point of view. Since infection is a common cause of delayed wound healing, it is important to understand the effect of low-level laser therapy in bacterial growth. This mini-review summarizes the current evidence about effects of low level laser on bacteria vitro studies.

Key-words: Low power laser, infected injury, bacteria.

Introduction

Chronic wounds include pressure injuries, diabetic ulcers, venous ulcers, and arterial ulcers, and affect approximately 5-7 million people per year in the United States [1]. More recently, the cost for the treatment of a single ulcer has increased to US\$ 8000, and the cost of an infected ulcer has increased to approximately US\$ 17,000 per year. Global wound care expenditures amount to US\$ 13 to US\$ 15 billion annually [2]. These are very complex systems from both host and microbial point of view [3].

Infections of the dermis affect over a million people, cause thousands of deaths and cost billions of dollars in direct medical costs annually. The infection chronic wound care accounts for an estimated cost of US\$ 15 billion annually in the United States. In underdeveloped nations and in areas of conflict the numbers are significantly higher [4,5]. Infections caused by opportunistic bacterial pathogens are a primary cause of morbidity and mortality in both the developed and developing world [1].

It is now recognized that bacterial infections are one of the main driving factors for the development of a chronic wound [3]. Infection is known to extend the inflammatory phase and impair wound healing, potentially causing pain, discomfort and distress for the patient [6].

Chronic nonhealing wound is one of the major therapeutic and economic issues in medicine today. Currently, efforts are being made to explore novel strategies, pharmacotherapeutic agents, bioactive dressings, tissue engineered scaffolds, stem cell-based therapy as well as drugless, noninvasive, biophysical therapeutic interventions using light-based treatment (photobiomodulation, PBM, or low power laser, LPL) [4].

The biological effects promoted by low power laser are related to the decrease in inflammatory cells, increased fibroblast proliferation, angiogenesis stimulation, formation of granulation tissue and increased collagen synthesis, which result in faster wound healing [7].

Since infection is a common cause of delayed wound healing, it is important to understand the effect of low-level laser therapy in bacterial growth. This mini-review summarizes the current evidence about effects of low level laser on bacteria.

In vitro studies

Bacteria are the most common reason for poor wound healing and there is an increasing worldwide rise in antibiotic resistance bacteria which calls for the development of novel antimicrobial strategies, of which photobiomodulation is one approach that can be further developed to avoid using ever more potent and potentially clinically toxic antibiotics [7].

These infections are often characterized by robust growth of the pathogen in the infection site and increasingly high resistance to antibiotic treatment [1]. In addition, studies (using a combination of traditional culture methods, microscopic analyses, and molecular techniques) involving wound samples from human patients support the presence of mixed populations of microorganisms in different types of chronic wounds [9]. Advances in molecular diagnosis have provided sensitive methods for identifying microbes present in wounds and standard culturing techniques detected 12 different bacterial genera populating the wounds, molecular methods revealed up to 106 different bacterial genera [5]. *Staphylococcus (S.) aureus*, *Escherichia (E.) coli*, and *Pseudomonas (P.) aeruginosa* were commonly associated with wound infections.

Bacteria irradiated with continuous and pulsed modes (810 nm, 0.015 W/cm²; 1–50 J/cm²) shows that bacterial growth increased overall, independent of species, using continuous mode laser, significantly so at 1 J/cm². Analysis of individual species demonstrated that laser mediated growth of *S. aureus* and *E. coli* was dependent on pulse frequencies and pulsed mode seems to have the potential to induce growth effects in *P. aeruginosa* that could seriously impact on wound healing [10].

Photobiomodulation at 810 nm, in continuous mode, but in different irradiance of 0.015 W/cm² 1–50 J/cm² 0.03 W/cm² shows that decreased growth of *P. aeruginosa* and increased growth of *E. coli*, the effect being greater at irradiance of 0.03 W/cm² than with irradiance of 0.015 W/cm² for identical radiant exposures. *S. aureus* growth was not affected by irradiation at either irradiance. Optimum bacterial inhibition was found at radiant exposures of 20 J/cm² or less, regardless of irradiance and species [11].

Strains of these bacteria were irradiated by red (630 nm), infrared (904 nm), green (525 nm), blue (465 nm), and UV (350 nm). Low power laser in this study had no effect on bacteria growth. However, when used different fluences (0-24 J/cm²) at wavelengths of 660, 830, and 904 nm, laser irradiation inhibited the growth of *S. aureus* at all wavelengths and fluences higher than 12 J/cm², showing a strong correlation between increase in fluence and bacterial inhibition. However, for *P. aeruginosa*, low power laser inhibited growth at all wavelengths only at a fluence of 24 J/cm². *E. coli* had similar growth inhibition at a wavelength of 830 nm at fluences of 3, 6, 12, and 24 J/cm². At wavelengths of 660 and 904 nm, growth inhibition was only observed at fluences of 12 and 18 J/cm², respectively [12].

Irradiation on *E.coli* with red and infrared lasers at high fluences (250, 500 and 1000 J/cm²) is lethal, induce a filamentation phenotype, and alter the morphology of the *E. coli* cells.

Low-intensity red and infrared lasers have potential to induce adverse effects on cells, whether used at unusually high fluences, or at high doses [13]

Most bacterial pathogenesis studies have focused on mono-culture infections; however, it is clear that many bacterial infections are not simply the result of colonization with a single species, but rather ensue from the action of polymicrobial communities, microorganisms are social creatures that build complex communities such as biofilms. Microbes within polymicrobial infections often display synergistic interactions that result in enhanced colonization, persistence and antibiotic resistance in the infection site [14].

A review about the use of low power laser to promote biofilm killing and wound healing, conclude that lack of credible studies using reproducible models and light dosimetry restricts the analysis of current data [16]. It was shown that the laser treatment (NIR, 10 W, 148 J/cm²) has not affected the biofilms biomass neither the cell viability, although a small disruptive action was observed in the structure of all biofilms of *Staphylococcus aureus* and *Pseudomonas aeruginosa* [15]. A Pubmed search found no other data about biofilm formation induced by exposure to low power laser at therapeutic fluencies associated with wound.

Conclusion

The variable characteristics and parameters of light devices is one of the factors that complicate the interpretation of research results about the effects of low power laser on skin wounds. Low power laser inhibited bacterial growth at high fluences and different wavelength, indicating a correlation between bacterial species, fluences, and wavelength. However, some protocols increased bacterial growth and induce adverse effects, hence, there is a need to reinforce the importance of accurate dosimetry in therapeutic protocols. In addition, it is necessary more studies about the effects of low power laser on polymicrobial communities, because microbial communities can be highly spatially organized throughout the human body and within sites of infection.

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