Introduction

Burns are a global public health issue because wound infections are a common complication that delay, or prevent, healing. Reductions in overall wound infection rates will be beneficial to patient outcomes and reduce overall costs. Inevitably, all wounds will be colonized by some bacteria. However, Staphylococcus aureus bacteria accounts for the majority of wound infections. Outbreaks of various multidrug-resistant (MDR) bacterial strains happen at an alarming rate, and physicians and patients are in need of alternative treatment options.

This review assesses an alternative treatment, photodynamic therapy (PDT), for the treatment of burn and wound infections. PDT uses light, a photo-sensitizer, and molecular oxygen to form an excited state of oxygen, known as singlet oxygen to cause cell death and kill microbial cells. PDT offers multiple advantages over antibiotics and UV therapy. In particular, PDT shows broad antibacterial activity, offers rapid action, localized treatment, lower risk of systemic side effects, and leads to effective inactivation of bacteria regardless of drug resistance. However, there are some challenges pertaining to the use of PDT, such as imperfect selectivity for bacteria over proteins and cells. Currently, it has not been demonstrated if bacteria can develop resistance to PDT. In this literature review, I will discuss the applications of PDT in burns and wounds; assess the level of bacterial inactivation; summarize recent clinical trials and consider possible uses of PDT to treat other dermatological conditions.

Methods

- **Search items:** Photodynamic Therapy (PDT); Antibacterial Photodynamic Therapy; Photodynamic Therapy: Applications in Wounds and Burns; PDT in burn healing; in vivo and in vitro studies, PDT of infection in Burn patients; Staphylococcus Aureus infected wounds; PACT.
- **Electronic Data Base Search:** PubMed, American Chemical Society (ACS), ScienceDirect, International Journal of Nanomedicine.
- **Inclusion Criteria:** studies had to be peer-reviewed, employ experimental design, investigate the effects of PDT.

Objective

- To investigate the applications of PDT on the healing of wounds and burns.
- Assess current study limitations in vivo and in vitro, and suggested theories.
- Evaluate side effects and potential for clinical studies.
- Compare the use of PDT to alternative treatment, such as antibiotic use.

Results

- **Fig. B - Jablonski Diagram for ROS Generation by PDT**
- **Fig. C - Cytokine expression levels analysis**
- **Fig. D - Cytokine expression levels analysis**
- **Fig. E - Light Dose vs. Bacterial Growth**
- **Fig. F - Wound Healing vs P5 concentration at different days**
- **Additional findings:**
  - Additionally, illumination alone can exert a damaging effect. Reduction of the light dose could therefore be beneficial to the wound healing process. (Lambrechts, et al).
  - It has been studied that the major side effect could include residual phototoxicity due to PDT accumulation (Hu X, et al). When exposed to sunlight, it can be characterized by burning, redness, and swelling until the drug leaves the system. It is then strictly advised to avoid sunlight (Hu X, et al). Some other side effects have been noted, such include temporary coughing, stomach, pain, and pain at the site treated, trouble swallowing (Hu X, et al).
  - Since the PS is applied topically/locally onto infected area, systemic absorption is thought to be minimal (Hu X, et al).
  - We still question if bacteria can develop resistance to PDT. It has been studied that Gram negative bacteria can control the uptake of photosensitizer using their outer membrane, that is the reason positively charged PS would only be effective (Maisch, et al).

Significance

- PDT offers broad antibacterial activity, localized treatment, and lower risk of systemic side effects. Various factors discussed below have to be investigated before PDT can be safely used as a treatment regimen.
- PS drug administration has to be optimized as most papers demonstrated dose-dependent efficacy.
- There is a variety of light sources with a wide range of wavelengths being used in PDT, it is important to understand that each treatment regimen will require a specific light and PS dosage.
- Factors that affect the susceptibility of different microbial strains to PDT need to be studied.
- Currently, it has not been demonstrated if bacteria can develop resistance to PDT (Maich, et al).
- Studies need to be done on how to improve selectivity for bacteria over proteins and cells.
- It has been suggested that efflux pump mechanism could play a role in protecting the bacteria against photoinactivation (Tegos GP, Hamblin MR, 2006). Efflux pump inhibitors mechanism and inhibitors should be investigated.
- Our future studies include investigation of efflux pump mechanism and inhibitors, PDT selectivity; evaluation of potential side effects, and optimized PDT pharmacokinetics (incubation time and the irradiation time).

References


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