Editorial

Photodynamic Therapy (PDT)

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Photodynamic therapy (PDT) is a comparatively novel therapeutic method involving a safe light source and a light-sensitive substance, termed as photosensitizers (PSs), such as methylene blue (MB), toluidine blue (TBO), sulfonated aluminum phthalocyanine, chlorine derivatives, nontoxic indocyanine green (ICG), and curcumin (CUR).[1] The combination of a nontoxic PS with low-intensity visible light in the presence of oxygen develops reactive oxygen species (ROS) that are toxic and can cause oxidative damage to microorganisms and tumor cells.[2-4] PSs do not induce cytotoxicity but are activated by laser irradiation at a proper wavelength and develop ROS.[5,6]

PDT was first used in 1903 for the treatment of tuberculosis. Its value in the treatment of skin cancer was discovered in 1975. In PDT, bacteria are destroyed using a low-level laser (light) mediated by coloring agents, such as MB and ICG.[7] This method has been considerably addressed in dentistry, in the treatment of bacterial and fungal infections as well as oral cancer, and the diagnosis of malignant transformations in oral lesions. Today's research mostly aims at the production of light-sensitive materials with selective inhibition properties to decrease opportunistic infections.[8]

The active ingredient of turmeric, namely CUR, has antibacterial, antiviral, and antifungal properties as well as anti-inflammatory and analgesic properties, similar to conventional analgesics.[9]

Some studies have proven the efficacy of PDT in the elimination of fungi and other microorganisms.[10] Studies by Azizi et al have demonstrated the positive effect of MB- and ICG-mediated PDT on decreasing the number of Candida albicans (C. albicans), Streptococci mutans (S. mutans), and lactobacilli when red lasers or 810-nm lasers are applied.[1,5,6]

MB is an alkaline PS derived from phenothiazines. MB is a dark green powder that produces blue color in water and permeates the bacterial cell membrane, affects the bacterial genome, and eradicates it. When combined with laser irradiation, MB produces free oxygen and eliminates bacteria.[5]

CUR is a diarylheptanoid from the curcuminoid group. Curcuminoids are natural phenols that cause the yellow color of turmeric.[11] In general, a PS stimulated by its optimal wavelength transforms from the low-energy state to a highly energized, high half-life triple state; this results in a reaction between the PS, environmental molecules, and intra-tissue oxygen. Finally, singlet oxygen and other free radicals are produced, which are responsible for tissue damage.[12]

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In general, PDT exerts its bactericidal impacts through the following two mechanisms:

1- DNA damage.

2- Bacterial cytoplasmic membrane damage by cytotoxic agents produced by PDT; these agents deactivate the membrane enzymes and transfer system, and increase the membrane permeability.[5,6]

The advantages of PDT are as follows:

1- This method is non-invasive.

2- There is low bacterial and fungal resistance against PDT.

3- There is no need for antibiotics or local anesthesia.

4- PDT destroys bacteria rapidly.

Moreover, PS-mediated PDT changes the function of ion channels and superficial receptors. Studies have presented that PDT inhibits the dihydrofolate reductase enzyme, which is used by bacteria for purine and pyrimidine synthesis for cell wall augmentation; therefore, the inhibition of this enzyme causes bacterial cell death. The leakage of ions disrupts vital cellular processes, leading to the leakage of main cellular elements, water imbalance, damaged membrane potential, adenosine triphosphate (ATP) synthase inhibition, and finally, cell death.[13]

According to previous studies, there are some other mechanisms involved in ICG- and MB-mediated laser irradiation and bacterial and fungal growth inhibition. The bacterial and fungal membranes are cellular structures that isolate the cell from its environment and vary among different species due to their particular configuration. Different membranes have been detected in gram-positive and gram-negative bacteria and among fungi, bacteria, and viruses. Studies have revealed that laser irradiation destroys bacterial membranes, leading to the release of bacterial intracellular contents.[1]

Conclusion:

It seems that PDT is a non-invasive, relatively inexpensive, and convenient technique to decrease infections induced by oral pathogens. It destroys streptococci, staphylococci, lactobacilli, oral candida, and viruses, such as human papillomavirus (HPV) and herpes.

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