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ORIGINAL ARTICLE

Modulation of heat shock protein expression and cytokine levels in MCF-7 cells through photodynamic therapy

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Abstract

In this study, we assess the impact of **photodynamic therapy** (PDT) using **aluminum phthalocyanine tetrasulfonate** ($AlPcS_4$) on the viability and cellular stress responses of MCF-7 breast cancer cells. Specifically, we investigate changes in cell viability, cytokine production, and the expression of stress-related genes. Experimental groups included control cells, those treated with AlPcS4 only, **light-emitting diode** (LED) only, and combined PDT. To evaluate these effects on cell viability, cytokine production, and the expression of stress-related genes, techniques such as **3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyl tetrazolium bromide** (MTT) assay, **enzyme-linked immunosorbent assays** (ELISA), and **real-time quantitative PCR** (RT−qPCR) were employed. Our findings reveal how PDT with $AlPcS_4$ modulates mitochondrial activity and cytokine responses, shedding light on the cellular pathways essential for cell survival and stress adaptation. This work enhances our understanding of PDT's therapeutic potential and mechanisms in treating breast cancer.

Keywords Photodynamic therapy · MTT assay · Cell viability · Cytokines · Gene expression · Heat shock proteins

Introduction

Photodynamic therapy (PDT) involves three key components: a **photosensitizer** (PS), light, and oxygen. The process begins when the photosensitizer is exposed to a specific wavelength of light, absorbing photons and transitioning from its essential singlet energy state to an excited state. This excited state may then undergo intersystem crossing, forming a more stable triplet state. In this triplet state, the photosensitizer can interact with molecular oxygen to produce **reactive oxygen species** (ROS). These ROS play a multifaceted role in PDT, directly killing cells, damaging the vascular system that supplies nutrients to tumors, and activating the immune response, thereby enhancing the overall efficacy of the therapy. The pivotal function of the photosensitizer is crucial, as it initiates these chain reactions that culminate in therapeutic effects. [1, 2]. PDT can cause changes in the protein expression of the cell adhesion structure and cytoskeletal integrity, which are critical points in reducing the metastatic potential of a tumour cell [3]. Changes in the adhesion of tumour cells to the substrate and other cells are some of the main consequences of PDT.

The photosensitizers, phthalocyanines, constitute a large class of compounds with high excitation coefficients in the red spectral region (630–750 nm), and have been found to have excellent tumor-localizing properties and high photosensitizing efficiency [4]. The aluminium phthalocyanine tetrasulfonate can confer unique properties to the compound, such as chemical and photophysical stability, and increase the efficiency of generating singlet oxygen, a type of reactive oxygen used in various biological and technological applications [5]. Aluminium phthalocyanine tetrasulfonate ($AlPcS_4$) and **Zinc phthalocyanine** (ZnPc), followed by

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