Use of Gold Nanoparticles in Photodynamic Therapy for the Treatment of Cancer

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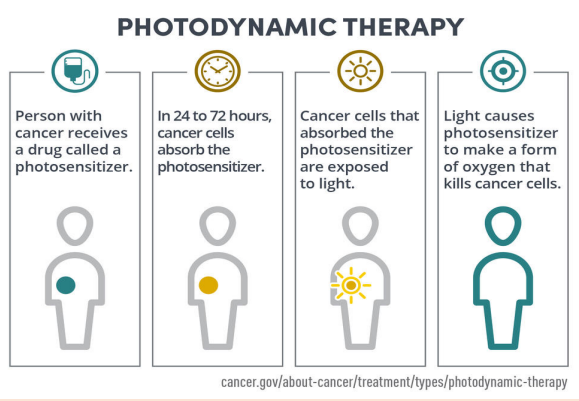
BACKGROUND

- Cancer is the second leading cause of death worldwide and accounts for approximately 600,000 in the United States alone.
- Cytotoxic agents have been able to treat some cancers effectively, however many can lead to adverse side effects including hair loss, nausea, vomiting, and overall fatigue, which can be prevented with photodynamic therapy (PDT).
- PDT is the process of applying light to a photosensitizer (PS) and through a cascade of energy transfers produces reactive oxygen species (ROS). PDT is able to thus induce cancer cell death through; (1) ROS mediated killing, (2) vasculature damage, and (3) induced immunogenic defense.[1]
- Typically the PS is directly injected into a tumor leading to more localized effects. Without being exposed to light the PS remains inactive leading to less damage to surrounding healthy cells thus minimizing adverse side effects.
- Some of the **advantages** of using PDT are that it is less painful, minimally invasive, and shows low cancer recurrence rates.[2,3]
- Some of the **disadvantages** of PDT include prolonged photosensitivity of the skin, expensive procedure, and the variation in response based on the light's ability to penetrate deep within tumors.[2,4]
- PDT is currently being used to treat breast, brain, intraocular, esophageal, gastric, head, neck, and colorectal cancer as well as non-cancerous conditions such as atherosclerosis, rheumatoid arthritis, and macular degeneration. [5,6]



INTRODUCTION

- Nanoparticles delivery systems are great for use in PDT due to their low cost and easy synthesis.
- Metallic nanocarriers are of interest because their size can be customized therefore can be loaded with drugs, DNA, RNA, or biomolecules, in order to pass the blood brain barrier.[7]
- Smart nanocarriers must be able to avoid the immune system, accumulate at the tumor site, and only release cargo at the site of interest. Nanocarriers can be modified with ligands matching overexpressed proteins unique to cancer cells.
- Tumor cells as they grow and proliferate become dependent on blood supply for nutrients. Eventually, they grow their own vessels to derive their nutrients from, these vessels have increased permeability compared to normal tissue. According to the enhanced permeability and retention (EPR) effect, nano-based drug carriers are able to take advantage of being able to penetrate abnormal, newly formed blood vessels.
- Some of the nanocarriers that are able to take advantage of this phenomenon are liposomes, dendrimers, micelles, and gold nanoparticles
- Gold nanoparticles are also chemically inert and have minimal cytotoxicity. [8] Gold nanoparticles also demonstrate the surface plasmon resonance phenomenon. Therefore when GNPs are irradiated with light the light can be converted into heat and is scattered to induce cell death in cancer cells. [7]

OBJECTIVES

- This poster will focus on recent developments in photodynamic therapy, and the utility of gold nanoparticles.

METHODS

- Keywords were entered into PubMed and google scholar to find studies. MeSH terms such as photodynamic therapy, cancer, and gold nanoparticles were utilized.

RESULTS

- Essentially, gold nanoparticles generate singlet oxygen alone which is called photothermal therapy and the photosensitizer is a component of photodynamic therapy.
- The photosensitizer encapsulation in gold nanoparticles creates synergistic PTT and PDT effects.

The synergistic effect of photodynamic therapy and photothermal therapy in the presence of gold-gold sulfide nanoshells conjugated Indocyanine green on HeLa cells

- In one study gold-gold sulfide nanoshells were conjugated to indocyanine green and their effects were tested on HeLa cells derived from cervix cancers.
- The compound exhibited a stronger photodynamic and photothermal effect on the cells, exhibiting the synergism between these therapies. [9]

Meso-Tetrahydroxyphenylchlorin-Conjugated Gold Nanoparticles as a Tool To Improve Photodynamic Therapy

- In another study mTHPC was loaded into gold nanoparticles and tested in human neuroblastoma (SH-SY5Y) cells.
- The conjugate demonstrated higher rates of cell death in tissue treated with the gold nanoconjugates compared to the free photosensitizer. The free mTHPC usually demonstrates nonspecific cytotoxicity at higher concentrations, the conjugate only demonstrated cell death upon irradiation. Due to minimal toxicity, the conjugated compound can be given at a higher dose and can exert a stronger effect. The conjugate also demonstrated better solubility in water, higher cell death rate, and was most effective with multiple irradiation sessions.[11]

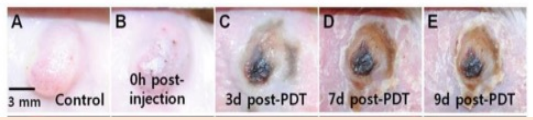


Figure 1 taken from reference [11], which demonstrates the efficacy of PDT.

CONCLUSIONS

- Historically, photodynamic therapy has not been very popular clinically due to its inability to target deep tumors. However, with the development of photosensitizers responding to deeper wavelengths photodynamic therapy, many of these agents are expected to translate well into clinical trials.
- In the coming years we hope to see more clinical trials involving photodynamic therapy, especially gold nanoparticles since they have a dual mechanism of PDT and PTT.
- As well as providers to be more aware of advancements as well as the utility of photodynamic therapy. In order to provide a less invasive, more effective way to treat cancer patients.

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