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Nanocarriers For Herbal Based Drug Delivery to Manage Tumor Cells

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Abstract

Breast cancer is the most common cancer for females both in the USA and other countries in the world. In the USA alone, approximately 61,000 new in situ breast cancer cases and 249,000 new invasive breast cancer cases have been estimated to occur in 2020, Breast cancer is the second leading cause of cancer death in women all over the world. Prevention of breast cancer is better than its treatment. Because of the molecular variation and complexity underlying breast cancer occurrence, its treatment by using chemotherapy and/or radiotherapy is very complicated and often leads to undesirable side effects. Despite advanced treatment modalities, the systemic toxicity remains a major side effect resulting in patient morbidity and mortality. Current breast cancer treatment includes surgery (mastectomy and lumpectomy), radiotherapy, chemotherapy, and hormone therapy. A significant shortcoming associated with these therapies is the lack of specificity. To overcome these problems, current research is emphasized to explore herbal remedies that selectively targets cancer cells. Besides this, unlike other cancer types, breast cancer has diverse genetic mutations that affect several pathways Over the last decades, the development of cancer treatment has been significantly promoted by cancer nanomedicine, which is an interdisciplinary field focusing on the design and medical applications of materials and technologies at the nanoscale (typically up to 100 nm). Nanoparticulate-based delivery systems provide many potential benefits, including increased biocompatibility, multifunctional encapsulation of active agents, reduced degradation during blood circulation, passive or active targeting, effective delivery, and reduced or eliminated side effects. Recently, natural products are being targeted for drug discovery because of their major role in cancer prevention and treatment. Plants have been the main source of natural compounds that are being used in medicine. However, most of the herbal bioactives are hydrophobic in nature resulting in their limited bioavailability and in turn their therapeutic efficacy. To overcome this problem, different nanocarriers such as nanoparticles, nanocapsules, liposomes, quantum dots, pyrosomes, dendrimers, and nanoemulsions have been conjugated with anticancer herbal bioactives. Such nanochemotherapeutic agents exhibit increased bioavailability, enhanced pharmacological activity, and stability with reduced systemic toxicity. While the majority of the reviews focus upon herbal loaded nanoformulations for various biological applications, this report is an attempt to particularly highlight the potential of nanotechnology in the delivery of herbal bioactives for breast cancer management. Photodynamic therapy (PDT) is a relatively new and promising modality for the treatment of cancer. PDT involves administering a photosensitizing dye, i.e. photosensitizer, that selectively accumulates in tumors and shining a light source on the lesion with a wavelength matching the absorption spectrum of the photosensitizer, that exerts a cytotoxic effect after excitation. The reactive oxygen species produced during PDT are responsible for the oxidation of biomolecules, which in turn cause cell death and the necrosis of malignant tissue. PDT is a multi-factorial process that generally involves apoptotic death of the tumor cells, degeneration of the tumor vasculature, stimulation of anti-tumor immune response, and induction of inflammatory reactions in the illuminated lesion.

Mechanism of PDT

PDT destroys malignant tissue through three distinct mechanisms, namely (1) direct damage to cancerous cells, (2) vascular damage within the tumor tissue depriving it of oxygen and nutrients, and (3) activation of an anti-cancer host immune response. In recent years there has been a movement towards the use of natural substances and herbal drugs instead of synthetic chemotherapeutic drugs since they are environmentally sustainable and lack major side effects. Recently, investigations have demonstrated that herbal extracts, including tumor-targeting compounds, can be used in numerous cancer treatments, especially skin cancers. Thereafter, plants containing phototoxic compounds were discovered in various plant families. The main challenges preventing the treatment of patients with phototoxic and photogenotoxic agents extracted from plants and herbal materials, is their safety, need for regulatory approval, and demonstration of equivalent effectiveness to synthetic photosensitizers (PSs)

Photosensitizer. Photosensitizers, whether naturally or artificially obtained, contain a chromophore. A chromophore is a set of conjugated unsaturated bonds, which absorb visible light at a particularly visible wavelength with a high molecular absorption coefficient. Choosing the appropriate PS is one of the most critical steps in PDT and is essential for the most effective and efficient therapy. Much effort has been made in defining the characteristics of the ideal PS for cancer and for other conditions. The PS should be easily obtained, a pure compound and its chemical properties must have been previously established in the literature.. Lack of toxicity in dark conditions, Soluble and stable in aqueous solvents, High absorption coefficient within the spectral range of 600–800 nm where light penetration of tissue is maximal, Have high quantum yields for triplet state formation and the production of singlet oxygen and other reactive oxygen species, Binds to intracellular locations that are highly sensitive to oxidative damage, Selectively absorbed into the target tissue, Excreted from the body rapidly, in order to avoid post-treatment phototoxicity, Optimum pharmacokinetic properties, Short drug light interval to facilitate

out-patient treatment, No toxic effects on healthy tissues and organs.

Combinations of PDT with other treatment methods, such as chemotherapy, radiotherapy, immunotherapy, or even herbal medicine therapy, could be a promising approach against various types of cancer, where the results obtained with monotherapy have been less than stellar. It is worth mentioning that, in comparison to single-agent therapies, combination therapy tends to have diminished side effects, and can more effectively reduce cancer cell proliferation

In some cases, combination therapy can increase the uptake of anticancer chemotherapy drugs into the cancer cells and tumors resulting in an improved response. Thus, PDT combination therapy may be a useful technique to overcome drug-resistant tumors. Although there have been several PSs developed during the last 30 years, only a handful of them have been used in human clinical applications.

Conclusion

The first and foremost goal of cancer treatment is to kill all the cancer cells without affecting or destroying the healthy cells. This will be possible by achieving the targeted and site-specific delivery of herbal drugs with emerges of PTD in the body to achieve the maximum therapeutic potential. In the future, it will be the most leading and promising co-therapy to treat cancer

Keywords: Nanocarriers, herbal drug loading, breast cancer