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Recent Advances in Nanotechnology Based Breast Cancer Chemotherapy

Medical Science

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ABSTRACT

Breast cancer is the commonest type of malignant tumor in women, comprising of about 30% of all cancers in women worldwide. In the past decades, the mortality of breast cancer patients has significantly been reduced due to the adoption of periodic breast cancer screening and the emergence of various treatments, such as radiotherapy, chemotherapy, and surgery. Currently, chemotherapy is one of the most effective treatments for breast cancer. Its side effects, however,
Pose a long-term challenge on a patient's health. Thus, it is highly desirable to focus on new therapies that can specifically target carcinoma cells without damaging normal and healthy cells. A number of novel carrier based drug delivery systems incorporating the traditional and newer anticancer agents have been shown incredible promise to target the site the action, reduce dosing frequency and enhance the drug bioavailability with the objective of improving patient compliance. Nanoparticulate system have unique and comparatively more effective drug delivery carriers, including polymeric nanoparticles/microparticles, liposomal –mediated drug delivery, solid lipid nanoparticles, nanosuspensions, nanoemulsions, niosomes, dendrimers, metal/ cyclodextrin inclusion complexes and other nanosystems exploiting the extraordinary properties of matter at the nanoscale. Nanoparticles show the invasive and non-invasive route of delivery for chemotherapy of breast cancer. This manuscript have been made to highlight and overviews the present WHO estimated burden of breast cancer globally, recent discovery of safe and effective newer anticancer drug molecules for MDR.

INTRODUCTION:

Breast cancer is still the second deadliest disease of women in the United States, despite advances in surgery, radiotherapy, and chemotherapy. Surgical therapy is effec-tive only if the cancer can be diagnosed early. Radio- and chemo-therapy are powerful, but cause many short- and long-term side effects, including cardiovascular complications [1]. Most antitumor therapeutic agents, such as paclitaxel, doxorubicin, capecitabine, cyclophosphamide, and vinflunine, destroy cancer cells by inhibiting their DNA synthesis [2-4]. Thus, they are either cytotoxic or immune sup-pressors, or both. Upon administration and entering into the body circulation system, these agents diffuse and penetrate into almost all of the organs, killing tumor cells, but at the same time, damaging normal and healthy cells.

Nevertheless, these adverse effects can potentially be minimized if antitumor agents can be delivered exclusively to tumors without damaging the surrounding normal and healthy tissues and organs. This requires endowing these antitumor agents with some sort of molecular recognition elements that can differentiate tumor cells from normal cells and guide drugs to diffuse or penetrate only into tumor cells. This becomes even more challenging when breast tumors become metastatic and start invading into the bone, brain, and other organs. The state-of-the-art targeted drug delivery, with a specific focus on chemotherapy utilized for combating breast cancer, is constantly changing with the advent and discovery of new chemicals for treatment. To systematically examine the field, we described and highlighted in this re-view a variety of targeted drug delivery technologies developed to date for breast cancer therapy. We emphasized the unique drug carrier systems specifically designed for breast cancer treatment and underlined the achievements gained recently in the targeted delivery of therapeutic agents for minimizing the cytotoxicity of the agents to normal tissues.

RECENT DEVELOPMENT IN NANOPARTICLES ENGINEERING

Generally, nanoparticles have been realized in polymers, ceramics, metals, and biological materials with various forms. Nanoparticles might take spherical, branched, or shell structures. Each structure offers unique characteristics that make it a suitable drug delivery candidate for a particular therapy.

ADVANTAGES

- Nanoparticulate drug delivery offers enormous advantages [5].
- Reduced toxicity and side effects [6].
- The availability of the drug at the site of action results in increased bioavailability and efficiency of treatment [7].
- Nanoparticles are also advantageous for the delivery of poorly water soluble drugs as they improve the uptake of such drugs and increase their bioavailability [8].
- Nanoparticles as drug delivery systems are now playing a major role in the area of targeted drug delivery systems. Nanoparticles indicate nanostructures with intermediate size between microscopic and molecular structure [9]. Nanoparticles can exist in different shapes of spherical, filamentous, tubular, and irregular [10]. They even have applications in various other fields related to cosmetics, cancer therapy [11], food addictives etc. [12]. Nanoparticles exhibit the characteristics of crystalline and amorphous nature and adsorb or encapsulate the drug which has to target to a specific site [13]. The various types of nano particulate drug delivery systems include Nano-based Drug delivery systems constitutes of a significant portion of nano-medicine which includes drug-polymer conjugates, polymeric nanoparticles, solid-lipid nanoparticles, liposomes, dendrimers and polymer micelles etc. [14]. Oral formulation of insulin using nanoparticulate technology is one of the greatest achievements which has increased patient comfort and compliance among the diabetic patients [15].

POLYMERS

There are several classes of polymers which are used in the formulation of nanoparticles. These polymers help in designing the dosage form in such a way that they release the drug at the targeted site at a predetermined rate and at the targeted site [16].

The various classes of polymers used in the formulation of nanoparticles [17].

1. Polysaccharides – Starch, Chitosan
2. Proteins – Gelatin, Albumin
3. Lipids

POLYMERIC NANOPARTICLES

Significant research has been devoted to investigating a number of polymeric types of nanoparticles, particularly biodegradable polymers [20, 23]. These particles can be fabricated in a wide range of sizes and varieties. In addition to the steady drug release for weeks, biodegrad-able nanoparticles do not accumulate in the body; as a result, they have drawn considerable attention. Earlier reviews [24] were dedicated to biodegradable nanoparticles pre-paration methods, drug loading, and their potential use in drug delivery systems. Biode-gradable nanoparticles have the ability to carry

various therapeutic agents including DNA, proteins, peptides, and low molecular weight compounds. Furthermore, these particles recently have been synthesized to be sensitive to the level of acidity in their environment [18]. Consequently, polymeric nanoparticles can be possible drug carriers for a diverse number of pharmacologi-cal therapies for various types of tumors, diabetes, bone healing, and vaccination.

Polymeric micelles are another form of non-biodegradable nanoscale polymeric structures. These nanostructures are physiologically stable in biological environment, and thus can deliver drugs securely to the targeted location. Further-more, the ability to engineer their hydrophobic segments makes them an appealing system to deliver water-insoluble drugs. A reveals that polymeric micelles can be an effective candidate to deliver drugs for fight-ing solid tumors [21,22]. Because of their small size (<100 nm) and the flexibility to engineer their drug/nanoparticle attachment, polymeric micelles can effectively target solid tumors and destroy only the cancer cells.

LIPOSOMES

Liposomes are small spherical systems that are prepared from cholesterol and non-toxic phospholipids. Liposomes can be engineered to possess different characteristics depending upon the lipid of choice in the production process. Because they are natural materials, liposomes are considered attractive, harmless drug delivery carriers that can circulate in the blood stream for a long time. A recent review indicates that liposomes are being investigated to carry anticancer drugs using various encapsulating technologies [19]. Liposomes that carry anticancer drugs can sustain a long releasing process targeting the cancer cells without harming the normal cells.

CONCLUSION:

The success of cancer therapies are dependent on the development of new vectorization capable of delivering effective loads of anticancer drugs and molecules, while lessening the impact of adverse side effects on normal tissues and organs. In recent years considerable effort has been directed to development of novel nanotechnology based therapeutic approaches that have a favorable blood half life and physiologic behavior with minimal off target effects, effective clearance from the human organism, with minimal or no toxicity to healthy tissues and simultaneously improve the therapeutic index.

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