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Targeted Nanoparticles for Anti-Cancer Drug Delivery: A Review

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Research Article

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ABSTRACT

It is a challenge to eradicate cancer cells while sparing normal cells. Only to improve the biodistribution of cancer drugs, nanoparticles are designed for optimal size and surface characteristics to broaden their circulation time within the blood circulation. They are also able to carry their loaded active drugs to cancer cells by using the unique functional changes of tumors, as like their enhanced permeability and retention effect and the tumor microenvironment. In this review report, we have discussed the current status of nanoparticles developed as targeting delivery systems for anticancer drugs.

INTRODUCTION

Over the years, it has been witnessed unprecedented growth in the area of Nanoscience and Nanotechnology. There is increasing hope that this technology will significantly improve the diagnosis and treatment of diseases [1].

Cancer, is characterized by the abnormal growth and spread of abnormal cells, is still the second most common cause of death in the U.S. The majority of patients with metastatic tumor eventually developing drug resistance and surrendering to the disease [2,3]. Chemotherapy Resistance can be divided into two categories i: e intrinsic and acquired. Though chemotherapy is one of the main modes of cancer treatment, its effectiveness is limited by drug resistance. Intrinsic resistance may be due to intra-tumor heterogeneity that a minor drug resistance subpopulation of cells was present in the original tumor [4,5]. Common cancer chemotherapy has the cancer therapeutic agents distributing non-exceptionally in the human body, therefore these drugs have an impact on both cancerous and normal cells [6]. This non-specific distribution of drugs limit the therapeutic dose within cancer cells while delivering excessive toxicities to normal cells, tissues, and organs; and thereby inflicting number of adverse side effects resulting hairloss, weakness, and organ dysfunction, leading to a low quality of life for cancer patients [7-10].

Nanotechnology refers back to the interactions of cell and molecular components and engineered substances-quite often, clusters of atoms, molecules, and molecular fragments into tremendously small particles [11,12]. The idea of nanoscale devices has ended up to the development of biodegradable self-assembled nanoparticles, which might be being engineered for the targeted delivery of anticancer drugs and imaging distinction agents [13]. Biodegradable nanometer-sized particles have novel physical and structural properties which might be attracting quality interests from prescription drugs for the certain delivery of anticancer medications and imaging distinction dealers [14,15]. These clever nanoparticles are designed to ferry chemotherapeutic agents or therapeutic or therapeutic genes into malignant cells while sparing healthy cells. Utility of nanotechnology for healing, checking and manage of organic frameworks has as of late been alluded to as "nanomedicine" by the NIH (National Institute of Health) [16-18].

Nanotechnology has emerged as an exciting strategy in the drug development process and among the different nanoparticles; silver nanoparticles were explored for its various medical applications. Phyto helped union of silver nanoparticles is an eco-accommodating and savvy approach for the advancement of silver nanoparticles

with added homes presented through the topping phytochemicals [19-21]. Nanoparticles amass in the tumor cells because of improved saturation and maintenance impact. A development of poly PLGA and serum egg whites manufactured and utilized as nanocarriers for conveyance of a promising anticancer treatment paclitaxel. Apart from, there is an inconceivable cluster of fascinating nanoscale particulate advancements absolutely fit for focusing on various kind of cells and extracellular components in the body to give signal drugs, hereditary materials, and indicative operators in particular to these areas [22,23]. Activating treatment discharge in tumor or health problem locales at unique times can also be one solution to deal with treating sickness effectively by limiting symptoms from high systemic exposure. The treatment could be activated to be discharged from a liposome gel by using appealing warming from Iron Oxide Magnetic Nanoparticles. Nanomedicine alludes to the utilization of accuracy built nanomaterials maintaining in mind the end goal to discover demonstrative devices for human utilization. The joint effort in the core of nanotechnology and nanomedicine precipitated the development of latest pattern in each remedial and pharmaceutical field [24-26].

Targeted Drug Delivery

Drug delivery methods have several advantages compared to the conventional forms of drugs. A drug is transported to the place of action that is the reason its impact on important tissues and undesirable side effects will also be minimized [27-30]. Gathering of therapeutic compounds in the targeted site increases and, accordingly, the required amount of drugs are lower. This modern type of therapy is exceptionally essential when there is a discrepancy between the concentration or the dose of a drug and its toxic results. Cell-specific focusing may also be accomplished by using drugs to specially designed carriers [31-35].

Targeted drug delivery systems were developed to elevate regenerative techniques. The system is based on a method that comprises a precise amount of a therapeutic agent for a chronic period of time to a targeted diseased area within the body [36,37]. This helps keep the specified plasma and tissue drug phases in the body, thereby limiting any damage to the healthy tissue through the drug [38].

There are various types of drug delivery vehicles, like liposomes, nano-particle drug carriers, lipoprotein-based drug carriers, dendrimers, etc [39,40]. A proper drug delivery vehicle must be non-immunogenic, non-toxic, biocompatible, biodegradable and restrict recognition by the host's defense mechanisms. Targeted drug delivery can be utilized to treat many diseases, like the cardiovascular diseases and diabetes. However, the most important application of targeted drug delivery is to treat cancerous tumors [41-45].

Nanoparticle as Drug Delivery Systems

Various nanostructures, liposomes, polymers, dendrimers, silicon or carbon materials, and magnetic nanoparticles, is tested as a transporter in drug delivery systems. In the process of drug delivery not only cellular targeting is important but also the fate of the nanoparticles within the cells. The Particles mostly end intracellularly in endosomes or lysosomes followed by degradation. The activity of the encapsulated drugs release into the cytosol is needed [46-52].

The sizes of Nanoparticles are in the range of 1-100 μm which are used as transporter for drugs and they are mainly polymers [53,54]. The drug is either entrapped within the polymer matrix or covalently bound to it. Only because of the small size, the nanoparticles can be easily interacted with bio molecules on the inside cells or cell surface. This small size also enables them to penetrate tissues such as tumours in depth with a high level of specificity improving the targeted delivery of drug [55-60].

Hydrogel nanoparticles have been in research in recent years as one of the most promising nanoparticulate drug delivery systems because of their unique potentials via combining the characteristics of a hydrogel method with a nanoparticle [61]. Few polymeric hydrogel nanoparticulate systems have been characterized in previous years, each with its own advantages and drawbacks and based on both natural and synthetic polymers [62-65]. Among the natural polymers, chitosan and alginate have been researched extensively for preparation of hydrogel nanoparticles and from synthetic group the hydrogel nanoparticles based on poly ethylene oxide, poly ethyleneimine, poly vinyl alcohol, poly vinyl pyrrolidone and poly-N-isopropylacrylamide have been reported with different features and aspects with respect to drug delivery [66-70].

Nanotechnology-Based Drug Delivery in Cancer

Usage of nanotechnology in medicine and specifically drug delivery is set to spread rapidly. Currently many substances are under research for drug delivery and more specifically for cancer therapy [71].

The gene delivery system and nanodrug is also another technique, which has the potential in various applications such as anti-tumour therapy by targeted delivery of therapeutic agents to the tumour cell mass. The treatment of Cancer is a great challenge for drug delivery [72-75]. Unique properties of cancer make cancer treatment a great challenge for drug delivery. So the development of a multifunctional drug delivery system is required so that it can specifically target the tumour cells and leave the healthy cells from damage [76-80].

Nanobiotechnologies have been targeted to improve drug delivery and to overcome few of the problems of drug delivery in cancer [81,82]. These can be classified into some categories that include the use of various nanoencapsulation, nanoparticles, delivery to tumors of many organs and combination with other ways of treatment of cancer. Nanoparticles are also used for gene therapy for cancer. Most of the technologies enable the combination of diagnostics with therapeutics which will be important for the personalized management of cancer [83-86].

The new era of nanotechnology-based drug formulations is challenging the current ways of cancer treatment. Multi-functional nanomaterial build have the capability to be delivered directly to the tumor site and destroy the cancer cells selectively, sparing the healthy cells [87-89]. The tailoring of the nano-construct design can be affective in enhanced drug efficacy mostly at lower doses in compared to free drug treatment, lower side effects and wider therapeutic window [90,91]. Nanoparticle carriers can also label several drug delivery problems, which could not be effectively solved in the past and include reduction of multi-drug resistance effects, penetration of the blood-brain-barrier and delivery of siRNA. Though challenges in finding toxicity, biodistribution, and paving an effective regulatory path must be met, nanoscale devices carry an alarming promise to change the ways cancer is diagnosed and treated [92-95].

CONCLUSION

Nano delivery systems hold a great potential to control some of the obstacles to target a number of diverse cell types efficiently. This shows an exciting possibility to overcome all the problems of drug resistance in target cells and to ease the movement of drugs throughout the barriers. However, the challenge remains the precise characterization of molecular targets and ensuring that the molecules affect only the targeted organs. Moreover, it is important to analyze the fate of drugs, once delivered to the nucleus and other cells organelles [96-98].

The occurrence of nanotechnology in medicine has raised many new prospects in the improvement of treatment of human diseases. Nanoparticles are getting their way into biology in the form of drug transporters. Physical sizes of nanomaterials create a powerful possibility for their interactions with biological systems. The property of their large surface area, available to load materials is utilized in ongoing therapies. By adapting their composition, size and surface chemistry, nanoparticles can be developed into a general platform with multifunctional capabilities to face the requirements of various drug delivery systems. It is visualized that specific drug delivery to targeted tissues will reduce toxicity and side effects [99,100].

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