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Mini Review

The Role of Nano Particles in Cancer Immunotherapy

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ABSTRACT

Nanotechnology has been widely read and abused for malignant growth treatment as nanoparticles can play a significant part as a medication conveyance framework. Contrasted with regular medications, nanoparticle-based medication conveyance has specific favourable circumstances, for example, improved security and biocompatibility, upgraded porousness and maintenance impact, and exact focusing on. The application and improvement of half breed nanoparticles, which joins the consolidated properties of various nanoparticles, has driven this kind of medication transporter framework to the following level. Furthermore, nanoparticle-based medication conveyance frameworks have been appeared to assume a part in defeating malignancy related medication obstruction. The components of malignancy drug obstruction incorporate overexpression of medication efflux carriers, deficient apoptotic pathways, and hypoxic climate. Nanoparticles focusing on these components can prompt an improvement in the inversion of multidrug opposition. Moreover, as more tumour drug opposition instruments are uncovered, nanoparticles are progressively being created to focus on these systems.

Moreover, scientists have recently started to investigate the role of Nano particles in immunotherapy, which assumes a more significant part in disease treatment. In this survey, we examine the parts of nanoparticles and cross breed nanoparticles for drug conveyance in chemotherapy, directed treatment, and immunotherapy and depict the focusing on instrument of nanoparticle-based medication conveyance just as its capacity on turning around drug obstruction.

Keywords: Nanoparticle, Drug delivery, Hybrid nanoparticles, Targeted cancer therapy, Drug resistance

Finding new and innovative treatments for cancer is a major problem across the world. With an increase in the number of methods that can treat cancer and the concept of an individualized treatment, the therapeutic efficacy of some malignant tumours has greatly improved. Chemotherapy is a conventional and widely used cancer treatment method. While chemotherapy works through a number of different mechanisms, its major function includes indiscriminately killing vigorously growing cells, including tumour and normal cells, which causes some serious side effects including bone marrow suppression, hair loss, and gastrointestinal reactions. Therefore, developing drugs that more accurately target tumour cells, instead of normal cells, has been the purpose of a large proportion of cancer-related research in the past few decades [1]. Although the emergence of targeted therapy has made great progress in precision therapy, there are still many unavoidable adverse effects, and the development of drug resistance has always been a problem. Currently, cancer remains the second leading cause of death, and current therapies for many cancers are inadequate. Hence, increasingly more studies are seeking precise therapy of cancer and solutions for drug resistance [2]. Over the last few decades, nanotechnology has been increasingly used in medicine, including applications for diagnosis, treatment, and tumour targeting in a safer and more effective manner. Nanoparticle (NP)-based drug delivery systems have shown many advantages in cancer treatment, such as good pharmacokinetics, precise targeting of tumour cells, reduction of side effects, and drug resistance. NPs used in drug delivery systems are usually designed or chosen based on their size and characteristics according to the pathophysiology of the tumours [3]. Mechanically, Nano-carriers in cancer therapy target to tumour cells through the carrier effect of NPs and the positioning effect of the targeting substance after being absorbed. Next, they release the drugs to tumour cells in order to induce killing. Drugs located on the inside of the Nano-carriers include traditional chemotherapy agents and nucleic acids, indicating that they can play a role in both cytotoxic and gene therapy. In addition, for some poorly soluble drugs, NPs offer a platform that can help encapsulate them and deliver the drugs into circulation. Due to the size and surface characteristics of NPs and their function of enhancing permeability and retention, Nano-carriers can increase the half-life of drugs and induce their accumulation

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into tumour tissues [4]. Meanwhile, the targeting system protects normal cells from the cytotoxicity of drugs, which helps ease the adverse effects of cancer therapy. For example, doxorubicin loaded PEGylated liposomes reduced cardio toxicity compared to free doxorubicin. Additionally, nanoparticle albumin-bound paclitaxel exhibited less side effects and allowed higher tolerated doses than solvent-based taxanes. In addition to chemotherapy and gene therapy, various studies have reported the application of NP drugs in immunotherapy and ablation treatment for cancer. The nanoparticle-based drug delivery system is believed to enhance immunotherapy, as well as reverse the tumour immunosuppressive microenvironment. In recent years, an increasing number of Nano therapeutic drugs have been commercialized or entered the clinical stage. The first phase I clinical trial that used a targeted nanoparticle based system to deliver small interfering RNA (siRNA) in patients with solid cancers was conducted in 2010 [5]. Another clinical study reported a more favourable tumour treatment efficacy of an actively targeted polymeric nanoparticle containing the chemotherapeutic docetaxel (DTXL) compared to a solvent-based DTXL formulation. The development of hybrid NPs has made even more progress in the arena of NP-based drug delivery systems. Hybrid NPs combine the properties of different NPs, thereby enhancing the function and stability of each drug delivery system. In addition, NPs have shown certain advantages when it comes to anti-tumour multidrug resistance (MDR), as they provide platforms for drug combination therapy as well as inhibit the function of some mechanisms of drug resistance, such as efflux transporters on cell membranes. Nowadays, nanoparticle-based therapy has been reported to have potential in overcoming MDR in several types of cancers, including breast cancer, ovarian cancer, and prostate cancer. Nanotechnology in medicine has opened a new stage of cancer treatment, and the combination of the set two fields deserves more in-depth research. This review outlines the basic principles of the application of the Nano-carrier system in cancer therapy, presents the current challenges, and describes the directions of future research [6].

The development of immunotherapy has brought cancer treatment into a new era. NPs not only play an important role in delivery chemotherapy but have also shown great potential for applications in immunotherapy. Cancer immunotherapy is mainly achieved by activating the anti-tumour immune response. NP-associated immunotherapy includes Nano vaccines, artificial antigen-presenting cells (aAPCs), and targeting of the immunosuppressed tumour microenvironment (TME). Nano vaccines deliver tumour-associated antigens (TAAs) and adjuvants to APCs, such as dendritic cells (DCs). Additionally, NPs can be used as adjuvants themselves to increase APC antigen presentation and promote DC maturation, leading to the activation of the anti-tumour function of cytotoxic T-cells. NPs, such as liposomes, gold NPs, PLGA NPs, micelles, and dendrimers all have the capability of cytoplasmic delivery of TAAs into DCs, thus enhancing the immune response against tumor cells. Among different types of NPs, inorganic NPs such as mesoporous silica and polymers such as acetylated dextran (AcDEX) have been shown to function as an adjuvant in immunotherapy, leading to a stimulation of the immune response. Unlike Nano vaccines, artificial APCs function with MHC-antigen complexes and cost imulatory molecules that directly bind to T cell receptors (TCRs) and co-stimulatory receptors on T cells, respectively, resulting in T cell activation [7].

Targeting the immunosuppressive TME is mainly achieved by targeting tumour associated macrophages (TAMs), myeloid derived suppressor cells (MDSCs), and regulatory T cells (Tregs), all of which are important cell types in the TME. Furthermore, in order to minimize interactions with the reticulo endothelial system, NPs are usually modified with PEG. In addition, the combination of chemotherapy and immunotherapy is a promising strategy of cancer treatment [8]. For example, one study showed that co-loading of the chemotherapeutic agent Nutlin-3a and the cytokine GM-CSF in spermine-modified AcDEX NPs led to improved proliferation of cytotoxic CD8(+) T cells and stimulated immune response, leading to tumour cell death while avoiding toxicity in immune cells. Alternative approaches of combined chemo-immunotherapy includes co-delivery of chemotherapeutics and monoclonal antibodies into porous silicon NPs, which have been effective in stimulating complement activation, antibody-dependent cell cytotoxicity (ADCC), and immune response against cancer cells.

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