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Magnetic nanoparticles (MNPs) a promising drug delivery of anticancer agents: A review

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Abstract

Poor solubility, high toxicity, nonspecific delivery and short circulating half-lives are the disadvantages of conventional drug delivery of the anticancer agents.

In the field of nanoparticle based drug delivery, controlled delivery of therapeutic compounds has been a matter of great interest. Unconcealed toxicity, poor selectivity, narrow therapeutic index, and high probability of developing drug resistance are the disadvantages of nanoparticle based chemotherapeutics.

Magnetic nanoparticles (MNPs) have been extensively studied as diagnostic imaging agents and therapeutic delivery vehicles. Due to high drug loading and remarkable targeting capacity it stand as the promising drug delivery.

Introduction

Poor solubility, high toxicity, nonspecific delivery and short circulating half-lives of most of the drugs limits the biological applications. Delivery of the chemotherapic agents with the minimal side effects is the current challenge in the cancer chemotherapeutics.

Nanotechnologies have emerged as new powerful tools to overcome these issues. In the days of the various adverse effect of conventional drug delivery Nanotechnology the use of magnetic nanoparticles [3] promises the novel and more effective treatments for site-specific delivery of therapeutics to tumors, both by passive and active mechanisms [2].

MNPs not only improve the therapeutic outcome but also it minimises the adverse effect of conventional drug delivery systems.

Nanotechnology in cancer therapy

In the field of cancer nanotherapeutics, drug passively accumulate around leaky regions of the tumor vasculature because EPR effect, (an enhanced permeation and retention), which provides only modest survival benefits due to the lack of penetration into the dense collagen matrix due to their large size [16].

Cancer is one of the leading causes of death worldwide and advanced techniques for therapy are needed.

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Various side effects with the Chemotherapeutics has been reported which majorly includes 0 unconcealed toxicity, poor selectivity, narrow therapeutic index, and high probability of developing drug resistance.

Nanoparticles provides a sustained, controlled and targeted drug delivery which enhances efficacy and reduces side effects [11].

The design and development of novel drug delivery, which reduces the drawbacks of conventional dryg delivery systems. Nanotechnology aims to protect the drug from rapid degradation after systemic delivery and allowing it to reach target site at therapeutic concentrations to reduce adverse effects.

Nano carriers delivers the drug either by passive targeting or active targeting.

In the passive targeting of drug delivery, it takes the advantage of leaky tumor vasculature. And in the active targeting it uses ligands that increase tumoral uptake thus enhances antitumor efficacy and therapeutic index [9].

Liposomes are self-assembling nanoparticles with Phospholipids as the main building blocks [10]. These are formed by dispersion of phospholipids with hydrophilic heads and hydrophobic tails.

In the conventional drug delivery systems where chemotherapy agent are directly administered which then results into the uptake of the drug by cancer tissue and normal tissue. The uptake of the drug by normal tissue is the major disadvantage of the drug delivery in cancer treatment.

The encapsulation of drug within liposomal structures can limit the normal tissue uptake and thus improve its therapeutic index [10].

Polymer based delivery systems show great interest for biomedical applications due to their high biocompatibility and flexibility in which their structures can be modified to desired shape, size, internal and external morphology as well as surface modifications [11].

Hyperbranched nanoparticles called dendrimers are consist of a core, branching units and functionalized terminal groups. For the combination therapy multiple anticancer agents can be incorporated in the central core or conjugated to functional end groups [13].

The major advantage is that depolymerisation of dendrimers can be controlled to modify drug release profiles [14].

Magnetic nanoparticle in anticancer drug delivery

It is a challenge for conventional chemotherapy to distinguish cancer cells from normal cells. In the field of nanoparticle based drug delivery, controlled delivery of therapeutic compounds has been a matter of great interest. Magnetic nanoparticles (MNPs) have been extensively studied as diag-nostic imaging agents and therapeutic delivery vehicles. Due to high drug loading and remarkable targeting capacity it stand as the promising drug delivery [4].

Magneto electric nanoparticles (MENs) distinguishes cancer cells from normal cells through the membrane's electric properties [15].

The therapeutic response of the drug sorafenib can be achieved by Polyethylene glycol modified micelles loading with superparamagnetic iron oxide nanoparticles (SPIONs) with improved efficacy and safety profile [5].

This system provides effective drug delivery, controlled drug loading and good stability in aqueous medium.

In the study of magnetically mediated retention of iron-oxide nanoparticles in brain tumors after intravascular administration via a non-occluded carotid artery. Aggregation of nanoparticles in the afferent vasculature interfere tumor targeting. To overcome this the development of magnetic setup which allows uniform magnetic flux density over a broad range experiencing the region of the afferent vasculature to high magnetic force.

The reduction of the magnetic force at the injection site by this setup projected the allegation problem and increased nanoparticle accumulation in glioma compared to the intravenous route [6].

In the way of high cell accumulation and low cell toxicity, which is the main aim of the intracellular drug delivery polyethylene mine (PEI)-modified magnetic nanoparticles (GPEI) as a potential vascular drug/gene carrier to brain tumors with intracarotid route showed 30-fold increase in tumor accumulation of drug by GPEI compared to that seen with intravenous administration. This study showed increased accumulation of cationic GPEI that compared to slightly anionic GPEI [7].

Most of the MNPs are developed to focused on systemic delivery of cytotoxic drugs which is based on accumulation of nanoparticles in a target tissue through enhanced permeability and retention effect to increase the therapeutic index.

But in the case of tumors of the central nervous system the systemic delivery is limited due to the toxicity and blood spine barrier.

MNP-conjugated with doxorubicin were successfully accumulated to a xenografted tumor in a rat model using biocompatible compounds to form a superparamagnetic carrier and magnetism as a physical stimulus without the toxicity of systemic administration [8].

Conclusion

Poor solubility, high toxicity, nonspecific delivery and short circulating half-lives are the disadvantages of conventional drug delivery of the anticancer agents, which can be overcome by the application of Magnetic nanoparticles (MNPs).

Magnetic nanoparticles (MNPs) have been extensively studied as diag-nostic imaging agents and therapeutic delivery vehicles. Due to high drug loading and remarkable targeting capacity it stand as the promising drug delivery.

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