Chapter 48
Nanomedicine:
Therapeutic Applications and Limitations

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ABSTRACT

Nanomedicine, an offshoot of nanotechnology, is considered as one of the most promising technologies of the 21st century. Due to their minute size, nanomedicines can easily target difficult-to-reach sites with improved solubility and bioavailability and reduced adverse effects. They also act as versatile delivery systems, carrying both chemotherapeutics and imaging agents to targeted sites. Hence, nanomedicine can be used to achieve the same therapeutic effect at smaller doses than their conventional counterparts and can offer impressive resolutions for various life-threatening diseases. Although certain issues have been raised about the potential toxicities of nanomaterials, it is anticipated that the advances in nanomedicine will furnish clarifications to many of modern medicine's unsolved problems. This chapter aims to provide a comprehensive and contemporary survey of various nanomedicine products along with the major risks and side effects associated with the nanoparticles.

INTRODUCTION

Nanotechnology has been proved significantly beneficial to society by producing major advances in areas of energy, food and agriculture. However, the role of nanotechnology in the advancement of healthcare is most promising. Nanomedicine is an application of nanotechnology to healthcare which utilizes improved physicochemical and biological properties of nanoscale structures for better diagnosis and treatment of diseases. Nanostructures usually possess unique properties. They allow the miniaturization of biomedical devices, leading to quicker and integrated operations. Again, nanometer size of these structures permits them to efficiently interact with the biology of living organism. These aspects keep

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the promise to render achievements in nanomedicine, resulting in big impact on preventive medicine, diagnosis, therapy and follow-up care.

Nanotechnology could provide improved *in vitro* diagnostic tests with more sensitive detection technologies or advance nano-labels detectable with high sensitivity after binding to disease-specific biomarker present in the sample. Moreover, nanotechnology allows size reduction of biomedical lab tests leading to significant reduction of the sample volume, potentially expensive reagents like monoclonal antibodies and most importantly time required. These advantages of nanomedicine in the area of diagnostics render quick and cost effective detection of a disease.

Since last decade, the role of nanotechnology in therapeutics has been studied extensively. Nanotechnology based delivery systems has shown promising results in targeting only diseased tissue and hence increasing the efficacy and limiting the side effects of therapeutics. Moreover, nanotechnology based delivery systems also have the ability to combat with drug solubility, permeability and early clearance issues associated with small molecules and biologics. Multifunctional nano-delivery systems evolved recently have the capability of simultaneous targeting, diagnostic and therapeutic action. Therefore, targeted delivery systems and nanotechnology-assisted regenerative medicine will play the central role in future therapy. This chapter discusses about various nanostructures and their application in diagnosis and therapy of diseases.

NANOSTRUCTURES IN MEDICINE

Nanoparticles are materials with overall dimensions in the nanoscale i.e., under 100 nm and offers exiting prospects for the development of novel, clinically pertinent diagnostic and therapeutic multifunctional systems. In recent years, these materials have emerged as imperative players in contemporary medicine, with clinical applications extending from carriers for drug and gene delivery into tumor to contrast agents in imaging (see Figure 1). Indeed, there are few instances where nanoparticles facilitate analyses and remedies that merely cannot be implemented otherwise. The aim of this chapter is to highlight the major categories of nanoparticles employed in modern medicine and their uses.

Polymer Based Nanocarriers

Polymeric nanoparticles are biodegradable systems in the range of 10-200 nm. Ease of surface modification and ligand functionalization renders them excellent pharmacokinetic control and can be used to deliver a plethora of chemotherapeutic agents.

Polymeric Drug Conjugates

Polymeric nanoparticles comprises of nanosized solid particles or capsules consisting of natural or synthetic polymers such as albumin, chitosan, poly ethylene glycol (PEG) etc. to which the drug is attached. Drug molecule can either be adsorbed or encapsulated on the polymeric nanoparticle structure (Luo et al., 2010; Mora-Huertas et al., 2010) and the release occurs via desorption, diffusion or nanoparticle erosion in target tissue (Torchilin, 2008). Recently Abraxane nanoparticles (albumin bound paclitaxel) have been employed in clinics for metastatic breast cancer treatment (Gradishar et al., 2005). HPMA and PEG are the most extensively used non-biodegradable synthetic polymers (Duncan, 2003). PEG coating