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Versatility of Nanoparticles in the Modern Medicine

Joseph Francis PJ[1]* and Navas AA[2]

[1]*Department of Biochemistry, Oman Medical College, Oman*

[2]*Department of Internal Medicine, Oman Medical College, Oman*

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***Corresponding author:** Joseph Francis PJ, Department of Biochemistry, Oman Medical College, Oman, Fax: +968-26843545; +968-95715139; Email: josephp@omc.edu.om

Abstract

Nanotechnology has wide applications in medicine in the form of diagnostic imaging, treatment and prevention. Developments of nanorobots which are capable of tissue repair at cellular level are materialising. All these are achieved by the enhancement of gaseous and nutrient transport, promotion of tissue regeneration in which minimum cellular inflammation and less toxicity. Nanotechnology can uplift the medical imaging and biomarker detection by methods like extracellular deposition and cell adhesion. Biosensors, tissue engineering, targeted drug delivery and nanorobotics make the nanomedicine cutting edge. Nanoparticles enable the transport of drugs particularly to the infected sites very accurately and precisely. Biomarkers or tumor markers detection has become faster and more sensitive using nanotechnology enabling the doctors for an early diagnosis compare to tissue biopsies. This paper explores the potential and versatile applications of nanoparticles in the field of medicine.

Keywords: Nanotechnology; Biomarkers; Biosensors; Tissue engineering; Targeted drug delivery; Nanorobots

Abbreviations: DES: Drug Eluting Stents; BBB: Blood-Brain Barrier; AD: Alzheimer's Disease; RA: Rheumatoid Arthritis; NAREB: Nanotherapeutics for Antibiotic Resistant Emerging Bacterial Pathogens

Introduction

Nanoparticles are solid colloidal particles ranging in size from 10 to 1000nm (1µm) in which the active principle (drug or biologically active material) is dissolved, entrapped, adsorbed and/or attached to the carrier material [1]. Nanotechnology improves the performance and acceptability of dosage forms by increasing their effectiveness, safety, patient adherence, as well as ultimately reducing health care costs [2]. It also enhance the performance of drugs that are unable to pass clinical trial phases and definitely promises to serve as drug delivery carrier of choice for more challenging conventional drugs used for the treatment and management of chronic diseases such as cancer, asthma, hypertension, HIV and diabetes [3]. Medical applications of nanomedicine are expected to significantly improve disease diagnosis and therapeutic modalities. An essential requirement of modern drug is the controlled delivery of drug or an active substance to the site of action in the body in an optimal concentration versus time profile. The concept of using nanoparticles as a vehicle for drug delivery was first developed by Speiser and coworkers in the late 1960s and 1970s [4,5]. Nanotechnology can be used as a drug carrier for a large number of drugs such as antibiotics, antineoplastic agents and a variety of drugs, especially neuropeptides [6].

Nanomedicine and Atherosclerosis

Atherosclerosis is a multifactorial inflammatory process characterized by the deposition of lipid and macrophages leading to plaque formation in the arteries causing myocardial infarction and stroke. Conventional treatment of atherosclerosis is statins and stents. Clot formation and stent blockage are major concern. Drug eluting stents (DES) which are used currently for coronary restenosis also have hurdles like late thrombosis, and inflammation. Nanomedicine based polymer coatings and anti-proliferative drugs can improve DES. Nanoparticles conjugated with targeting ligands are capable of delivery of imaging and therapeutic agents within plaques in animal models [7]. Stent optimizations with nanoparticles which resemble the structure of endothelium are in the pipeline.

Versatile Applications in Diabetic Mellitus

Nanotechnology can control the diabetic management in various ways

Blood glucose monitoring can be done by nano sensors which are non or less invasive. Nano ink based tattoo is expected to perform a continuous glucose monitoring. Second important application is in the delivery of painless insulin by nanoparticle based insulin through nose or lung as sprays. In this case the release threshold is glucose sensitive and so it can minimise the risk of hypoglycaemia [7]. This is achieved by depositing subcutaneous insulin with glucose sensitive nanoparticle coating. Besides by using immune protective nano coating, the life of pancreatic islets, can be prolonged after the transplantation in type1 diabetes. This will lead to the medicine world the promising days without immunosuppressive drugs is not far.

Nanotechnology in Ophthalmology

The size difference of 1/1 nanometer 3 and an eyeball is the same as the size difference between the eyeball and the whole earth is surprising. Nanomedicine will contribute to the field of Ophthalmology in astonishing ways like preparing of valves for glaucoma drainage. Moreover in the design of intraocular pressure monitoring devices and light sensitive ion channels nano particles will make miracles [8]. Nanoparticle based eye drops which can assure constant and targeted drug delivery to cornea, aqueous and vitreous humor. In surgical ophthalmology nano needles and tweezer can do wonders like lasers in the past.

Nanotherapeutics in Antibiotic Resistances

NAREB (Nanotherapeutics for antibiotic resistant emerging bacterial pathogens) has an ongoing project on the development of nanoformulations to combat multidrug-resistant TB and MRSA infections. The project is to increase drug bioavailability inside the infected macrophages and across the bacterial cell wall.9Increased target specificity is another advantage when fighting superbugs with nanoparticles.

Nano Particles and Alzheimer's Disease (AD)

Alzheimer's disease (AD) is characterized by progressive deterioration of memory and cognitive dysfunction with personality changes. It is caused by the accumulation of Beta amyloid peptide leading to progressive neuronal damage, neurofibrillary tangles and the loss of the neurotransmitter acetylcholine. Neuronal loss is selective and it mainly affects hippocampus, amygdala, temporal neocortex, and subcortical nuclei. Early diagnosis and therapy of AD is crucial as it can arrest and even reverse the progress of the disease. Blood-brain barrier (BBB) is formed by the endothelial cells lining of the cerebral vessels, and it protects brain from toxins and abrupt changes in plasma chemistry [9,10]. But it also fences against drugs and diagnostics reaching the brain. Scientists have developed nanoparticles capable of crossing BBB which can in turn transport drugs and biologicals, such as genes, siRNa, antibodies or contrast agents, to the targeted brain sites. Nanotechnology is enhancing the sensitivity and specificity of MRI and they form as the specialised contrast agents for the positron emission tomography that can pick up amyloid plaques and neurofibrillary tangles in the early stages.

Nanoparticles in Rheumatoid Arthritis (RA)

Cartilage destruction and synovial inflammation leading to pain and disability are the main features of RA and Osteoarthritis. Currently the drugs used for RA treatment like steroids, NSAID, disease modifying agents or biologics have side effects in long run. Nanomedicine in the form nanoparticles help the drugs reach selectively to inflamed area with better penetration and retention.

Conclusion

The unique properties of nanoparticles make them highly attractive for the design of novel therapeutic or diagnostic agents for the disorders like arthritis, atherosclerosis, Alzheimer's disease, TB, MRSA and diabetes. Its versatility and the unique optical, magnetic, chemical and structural properties enable them to use in various potential applications in medicine such as drug delivery, medical imaging, diagnosis & sensing, and therapy.

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