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A Birds Eye View of Nanotechnology in Medicine

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Introduction

Nano is a popular science with at least one characteristic dimension measured in nanometer. Nanotechnology is a dwarf technology in the creation of nano particles and devices at atomic, molecular and supramolecular level. These nanotechnological features in biomolecular field can provide the quick look of activities at cellular, subcellular and molecular level. The ever growing importance for nanotechnology is due to its unique enhanced magnetic, catalytic, optical, electrical and mechanical properties in comparison with classical formulation that has made a constructive approach in medicine [1]. These unique properties have guided to novel tissue substitutes and regeneration in bone, cartilage, vascular, neural, biosensors, diagnostic systems, drug delivery systems and protein mediated cell interaction. Moreover, researchers are in search for new nanomaterials for biomedical application. The field of nanomedicine has grown exponentially and has ventured beyond therapeutic activity enabling the detection of diseases much earlier than ever before. Clearly, nanosystems are having a broad spectrum of application disease diagnosis, treatment and prevention. Furthermore nanoscale technologies are capable of targeting cells, extracellular elements in the body for the drug delivery, genetic information, and diagnostic agents specifically for disease locations [2]. A sprouted concept of nanomedicine should have helping hands from physics, biochemistry, and biotechnology for the creation of molecular devices and for designing therapeutic and diagnostic procedures in nanoscale. The ultimate aim of the nanomedicine is the nanotechnological intervention of the medicine in diagnosis and curing of diseases related to cancer, cardiovascular, neurodegenerative, diabetes, inflammatory, Parkinson's, orthopedic and thereby improving the quality of life.

Moreover, the nanodelivery systems concentrate on specific target of deceased site thereby improving the efficacy and minimizing side effects. Using, researchers are making constant effort in pushing nanomedicine enabling the drug delivery to the target region; release the drug at a controlled rate and finally escaping from the degradation processes of the body without adversely affecting the internal systems. The major disadvantage with the conventional chemotherapeutic agents is the use of low molecular weight compounds with high pharmacokinetic volume which leads to high cytotoxicity. Hence high concentration of low molecular weight contributes to high toxicity which is risky. Additionally, when chemotherapeutic agents are administered alone, these lack specificity which may cause significant damage to the non-cancerous tissue contributing to side effects such as bone marrow suppression, hair loss and sloughing of gut epithelial cells [3]. These chemotherapeutic agents have low solubility and bioavailability and hence should be formulated with toxic solvents. Delivery of Cisplatin found to be ineffective in releasing the drug at the target after its accumulation at the tumour site [4]. Hence nanocarriers are currently used in the nanodrug formulation for cancer treatment which includes Doxil [5] and Abraxane [6]. Drug delivery field has experienced a dramatic increase due to development of liposomes, quantum dots, virosomes, polymer coated nanoparticles, nanosuspension and polymer therapeutics.

Some Selected Nanomedicine Tools Currently in Use in Medical Diagnostic Field

Nanopore sequencing

The current-time profile is converted into electronic signatures for unique identification of each DNA by the creation of the potential. The potential so created draws the charged DNA through 1-2 mm diameter α-hemolysin.

Microneedles

Painless drug infusion, cellular injection for diagnostic procedures.

Drug delivery using microchips

These are necessary for long term patient treatment condition after implantation. The controlled drug release mechanism is based on pulsative release by thin anode membranes from micro reservoirs filled with drugs.

Carbon nanotubes

Carbon nanotubes are localized into cytosolic and mitochondrial region without disrupting the membrane. However, in vivo toxicity of carbon nanotubes are still questionable.

Quantum dots

By variation of the size of the quantum dots fine tuning of the luminescence property can be carried out. These quantum dots have a greater flexibility compared to fluorescent materials for nano scale computing. These structures present multicolor coding in gene expression studies, high throughput screening and in vivo imaging.

Dendrimers

The internal cavities create cages and channels in which the surface are subject for modification and tailoring for unique application. These contain three different regions namely core, branching units and packed surface. Surface groups can be modified for therapeutic and diagnostic application.

Polymeric micelles

In polymeric micelles, cavities are created by hydrophilic and hydrophobic component in which the centre of the core is occupied by hydrophobic components. These are used in the systemic delivery of water insoluble drugs. Drugs can be trapped in hydrophobic core physically.

Liposomes

Liposomes are closed vesicles that form on hydration of dry phospholipids, these are classified as multilamellar (1-5 µm), large unilamellar (100-250 nm) and small unilamellar (20-100 nm). Therapeutic agents can either be entrapped in aqueous space or intercalated into phospholipid bilayer depending on physicochemical characteristics of drug for targeting cancerous cell.

Nanospheres

Drug of interest is dissolved, entrapped, encapsulated inside the polymeric matrix. The releasing characteristic of the incorporated drug can be controlled. Room for surface modification with the polymeric and biological materials for targeting the specified locations of the body is wide open.

Carbohydrate-ceramic nanoparticles

The central core is composed of calcium phosphate or ceramic diamond nanocrystal with oligomeric film. Drugs or antigens are attached to the surface of this particle.

Polyplexes or lipoplexes

These are assemblies of nucleic acids, polycations or cationic liposomes (or polycations conjugated to targeting ligands or hydrophilic polymers) that are being used in gene transfer therapy.

Metallic nanoparticles

Prime circulatory metals that are used include, silver and gold nanoparticles in drug delivery specially in the treatment of cancer. Controlled delivery of the bioactive material, targeted delivery of bioactive particles to macrophages and in liver targeted delivery.

Destiny of Nanotechnology in Medicine

Nanomaterials are explored for various quantity of application that includes cell, tissue screening and in vivo targeting of cancer system. The entire process of targeting the human system will take quantity of time beginning from the small animal models to primate models which provide a route for solid foundation in long term advancement in the nanotechnology in medicinal field. Above all, small sized nanoparticles are versatile therapeutic tools for diagnosis and treatment but we cannot overrule the undesirable effects after the insertion. For example metabolism of CdSe quantum dots leads cadmium toxicity which in turn adversely affects physiological system. For instance, freshly isolated rat hepatocytes are affected with reference to the function, viability and morphology [7]. Moreover, it is possible that the nanomaterials can enter the vital organs which can further lead to toxicity. Hence regulatory bodies of nano in toxicological science should have a closer attention on its consequential effect.

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