**Application of nanotechnology in medicine**

**Introduction:**

Nanotechnology, a Greek work, where nano meaning dwarf refers to a reduction of size, or time, 10-9 fold, which is one thousand times smaller than a micron. One nanometer is one billionth of a meter, and it is also equivalent to ten Angstroms. As such, a nanometer is 10-9 meter, and it is 10000 times smaller than the diameter of a human hair.[1] The US National Science and Technology Council states: “The essence of nanotechnology is the ability to work at the molecular level, atom by atom, to create large structures with fundamentally new molecular organization.[2] The aim is to exploit these properties by gaining control of structures and devices at atomic, molecular, and supramolecular levels and to learn to efficiently manufacture and use these devices.” The United States National Science Foundation defines nanoscience/nanotechnology. It describes nanotechnology/nanoscience as the studies that deal with materials and systems having the following key properties:

1. Dimension: at least one dimension from 1–100 nanometers (nm).

2. Process: designed with methodologies that show fundamental control over the physical

and chemical attributes of molecular-scale structures.

3. Building block property: they can be combined to form larger structures. Nanoscience, in

a general sense, is quite natural in microbiological sciences considering that the sizes of many bio particles dealt with (like enzymes, viruses, etc.) fall within the nanometer range.[2]

There is a clear distinction between nanoscience and nanotechnology. Nanoscience is a convergence of physics, materials science and biology, which deal with manipulation of materials at atomic and molecular scales; while nanotechnology is the ability to observe measure, manipulate, assemble, control, and manufacture matter at the nanometer scale.[3] Nanomedicine meaning nanotechnology and medicine together is being described as applying nanotechnology to the field of medicine and using it for health improvement.[4]

Nanomaterials are now being designed to aid the transport of diagnostic or therapeutic agents through biologic barriers; to gain access to molecules; to mediate molecular interactions; and to detect molecular changes in a sensitive, high- throughput manner. In contrast to atoms and macroscopic materials, nanomaterials have a high ratio of surface area to volume as well as tunable optical, electronic, magnetic, and biologic properties, and they can be engineered to have different sizes, shapes, chemical compositions, surface chemical characteristics, and hollow or solid structures. These properties are being incorporated into new generations of drug-delivery vehicles, contrast agents, and diagnostic devices, some of which are currently undergoing clinical investigation or have been approved by the Food and Drug Administration (FDA) for use in humans.[5]

**Application of Nanotechnology in cancer therapy**

Nanotechnology is developed focusing on the smaller molecular structures and particles as tools for delivering drugs. Nano-carriers such as liposomes, dendritic macromolecules, quantum dots, carbon nanotubes etc have been widely used in cancer treatment.[6]

**Liposomes:** Liposomes are one of the most widely studied nano-carriers.[6] Specific properties of liposomes that have been leveraged to enable them as nano-carriers are (i) the ability of liposomes to contain both hydrophilic and hydrophobic molecules, enabling incorporation of a wide range of imaging or contrast agents; (ii) the use of functionalization strategies to attach new biomolecules to the surface of liposomes, enabling the surface display of recognition units such as peptides or DNA aptamers; and (iii) the use of lipids that can be selectively degraded by enzymes such as phospholipase C and PLA2.[7]

**Carbon nanotubes:** These are long, needle-like, C-60 fullerene- based tubes that act as bio-persistent fibers. There are two types of carbon nanotubes that are single- walled carbon nanotubes (SWCNT) and multi-walled carbon nanotubes (MWCNT).[1] These can be used to target tumour cells because of the property of absorbing light from the near-infrared region causing the thermal effect by making the nanotubes to heat up. These can be helpful in finding the exact location of the cancer-related DNA changes hence also helps in diagnostics.[8]

**Nanotechnology in detection of cancer biomarkers**

Nanotechnology offers high selectivity and sensitivity and the ability to conduct simultaneous measurements of multiple targets. Nanoparticles/nanomaterials can be used to improve Biosensors in order to provide specific targeting. Quantum dots (QDs), gold nanoparticles (AuNPs), and polymer dots (PDs) are three common nanoparticle probes used in diagnosing cancer. Nanotechnology can help in detection of extra cellular cancer biomarkers. It facilitates protein detection, ctDNA detection, microRNA detection, DNA methylation detection, extra cellular vesicle detection.[8]

There is usually seen that cancer cells develop resistance to the drugs, thereby decreasing the efficacy of the treatment and various therapeutic agents.[1]Nanotechnology can be used to overcome the resistance and increasing the effectiveness of the treatment. Nanotechnology is involved in detection of circulating tumour cells.[8]

**Nanotechnologies in Gene therapy**

Successful gene therapy depends on two important aspects.

(1) Efficient and safe delivery of genes to the target cell in vitro and in vivo. To achieve this goal, it is necessary to improve transduction efficiency, viral titer when using viral gene therapy, or transfection efficiency when using nucleic acids.

 (2) Effective monitoring of modified cells or modifying agents by noninvasive imaging techniques. This will allow tracking of gene delivery and gene expression.

Nanoparticles can be used for MRI. These nanoparticles can be classified according to several parameters : their magnetic behavior means they can be superparamagnetic or paramagnetic; in terms of biodistribution, they can be classed as extracellular agents, blood pool agents, organ-specific agents, and cell-labeling agents. Their core composition enables an enormous number of materials to be used, for instance iron oxides (Fe3O4, Fe2O3) and manganese oxides (MnFe2O4, Mn2O3), gadolinium oxide (Gd2O3), gold nanoparticles (Au-citrate, Au-Fe3O4, Fe3O4- Au, Au-Gd conjugate), quantum dots.[9]

**Nanonephology**

The branch of nanomedicine that includes the study of kidney protein structures at the atomic levels, nano-imaging approaches to study cellular processes in kidney cells and nano medical treatments that utilises nanoparticles to treat various kidney disease.[1]

There are kidney targeted nano particle drug delivery system. These act as potential drug carries to proximal tubules.[10] By altering the characteristic features of nano particles of the drug delivery system, the goal of targeting the kidney can be achieved.[10]Nano-scale engineering advances permit programmable and regulated nano- scale robots to perform curative and reconstructive procedures in the human kidney.[1]

Nanotechnology can at the same time used for the treatment of neurodegenerative disorders including Parkinson’s disease, Alzheimer’s disease, as Nano pharmaceutical, Antibiotics resistance.

**Challenges with Nanotechnology in medicine**

Despite its varied applications and several benefits, nanomedicine cannot be termed as flawless. The smaller size means the larger surface area. As the surface area becomes larger, the problems like inter particular friction and sticking become significant. The nanoparticles may have their clearance rate from the body high enough to preclude their use in diagnosis or drug delivery because of the smaller size.[1]Growing speculation about the nano particle toxicity have been demonstrated.[5]The high expense is also one of the major limitations of nanotechnology in medicine.[1]

**Conclusion**

So nanotechnology is the emerging field that is combining with medicine to form nanomedicine. This origin of nanotechnology can be traced to the genesis of revolutionary advances across medicine, communication, genomics and robotics.[11] There are challenges to face in the field of nanomedicine but understanding challenges, failures and successes of nanoparticles is the key for future nanomedicine success.[12]

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