Impact of Nano Medicines in Human Life

A. Abubakkar
Assistant Professor, Department of Mechanical Engineering, Kongu Engineering College, Tamil Nadu, INDIA

ABSTRACT
In the present scenario of medical innovations, nanotechnology is having its wave on the treatment and prevention of disease, especially by enabling early disease detection, as well as precise and effective therapy. The growing interest in the medical applications of nanotechnology has given the path to the emergence of a new field called nanomedicine. In this paper, the various diseases and disorders that can be treated by nanotechnology is discussed. The positive impacts of nanotechnology can be seen in surgery, diagnosis, implant technology and tissue engineering. Most of the various ongoing research in the development of nanomedicines shows a positive result. But still many question regarding the safety aspects remains unanswered.

Keywords— Diagnosis, Drug delivery, Nano medicine and Tissue engineering.

I. INTRODUCTION
Drug delivery is an emerging field focused on targeting drugs or genes to a desirable group of cells. The goal of this targeted delivery is to transport proper amounts of drugs to the desirable sites (such as tumors, diseased tissues while minimizing unwanted side effects of the drugs on other tissues [1]. Conventional preparations like solution, suspension or emulsion suffer from certain limitations like high dose and low availability, first pass effect, intolerance, instability, and they exhibit fluctuations in plasma drug levels and do not provide sustained effect, therefore there is a need for some novel carriers which could meet ideal requirement of drug delivery system.

Recently nanoparticle based delivery system has been proposed as colloidal drug carriers. Nanoparticles (NP) are a type of colloidal drug delivery system comprising particles with a size range from 10 to 1000 nm in diameter. Nanoparticles may or may not exhibit size-related properties that differ significantly from those observed in fine particles or bulk materials[2]. The key advantages of nanoparticles are
(i) improved bioavailability by enhancing aqueous solubility,
(ii) increasing resistance time in the body (increasing half life for clearance/increasing specificity for its cognate receptors and
(iii) targeting drug to specific location in the body (its site of action).

This results in concomitant reduction in quantity of the drug required and dosage toxicity, enabling the safe delivery of toxic therapeutic drugs and protection of non target tissues and cells from severe side effects [3]. It is increasingly used in different applications, including drug carrier systems and to pass organ barriers such as the blood-brain barrier, cell membrane etc[4].

Nanoparticles are taken by cells where large particles would be excluded or cleared from the body. A Nanoparticle (NP) carries the pharmaceutical agent inside its core, while its shell is functionalized with a ‘binding’ agent. Through the ‘binding’ agent, the ‘targeted’ NP recognizes the target cell. The functionalized NP shell interacts with the cell membrane. Then the NP is ingested inside the cell, and interacts with the biomolecules inside the cell. Finally the NP breaks, and the pharmaceutical agent is released. A smart, controlled delivery system needs synergistic consideration of several factors. It is difficult to get all consideration factors in a smart controlled delivery system due to other influencing factors. Also high quality, reliability, efficiency and reproducibility are the most significant issue while designing such a smart system. Also the smart systems have to induce the drug release and stop the release by their own manner. It would be highly benefited, if the system recognizes the disease affected part, estimated the disease affected ratio, and then acted to release the exact quantity of active drugs. This kind of drug delivery system can fulfil the medicine and
healthcare requirements. A simple mechanism of drug delivery system is shown below.

Fullerenes, Solid lipid nanoparticles (SLNs), Liposomes, Nanostructured lipid carriers (NLC), Nanoshells, Quantum dots (QD), Superparamagnetic nanoparticles and Dendrimers are the various nanoparticles used in the present drug delivery system. Micro-capsules containing easily harvested replacement pig islet cells could be implanted beneath the skin of some diabetes patients. Supplying encapsulated new cells to the body could also be a valuable way to treat other enzyme- or hormone-deficiency diseases, including encapsulated neurons that could be implanted in the brain and then be electrically stimulated to release neurotransmitters, possibly as part of a future treatment for Alzheimer’s or Parkinson’s diseases. An 18 nm pore membrane showed high enough glucose and insulin diffusion rates to allow proper passage of the molecules to encapsulated pancreatic islets while preventing the passage of the majority of immune molecules such as IgG.

II. OPHTHALMIC DRUG DELIVERY

Generally, when it comes to ophthalmic drug delivery, because of the critical and pharmacokinetically specific environment that exists in the eye, two methods are used to improve the poor bioavailability of topically applied ocular drugs: the first is prolonging precorneal retention time, and the other is improving drug penetration across the cornea. With respect to the first solution, traditionally, common approaches, such as viscous solutions, suspensions, ointments, gels and so on, can prolong corneal retention of ocular drugs to some extent, but some side-effects such as irritation and inconvenience such as increasing instability times can occur. Their application is limited because of poor patient compliance. Therefore, only increasing the precorneal retention time of ocular drugs is inadequate in bringing about a significant improvement in bioavailability. Another method to improve the ability of the drug to penetrate the ocular membranes must also be considered. Various lipophilic ocular prodrugs have been synthesized which represents a promising approach to increasing the efficiency of corneal absorption of ocular drugs. Nonetheless, these prodrugs present numerous problems such as poor aqueous solubility and stability, severe irritation, and so on, which to some extent limits the clinical application of ocular prodrugs. With the development of nanotechnology, nanotechnology-based drug delivery systems provide more opportunities for ocular drug delivery.

The eye is a relatively isolated organ divided into anterior and posterior segments with numerous avascular structures. In this regard, the efficacy of topical drug delivery via eyedrops is only limited to the treatment of anterior segment eye diseases. Drugs can enter the posterior segment of the eye via three distinctive noninvasive routes: (i) through conjunctiva/sclera after topical application; (ii) from the cornea and aqueous humor after topical application; and (iii) from the systemic circulation after topical, parenteral, oral, or other administration routes that deliver drug to the blood circulation.

The eye, particularly the posterior segment, is composed of tissues that are difficult for drugs to penetrate because of structural peculiarities such as the barrier function. Thus, many research studies on nano-sized drug carriers have been conducted in the field of ophthalmology. Examples of nanoparticles for intravitreal drug delivery include albumin nanoparticles for delivery of ganciclovir and a formivirsen analog, and tamoxifen-loaded nanoparticles. Cyclodextrin nanoparticle suspension in eye drops offers a new and promising drug delivery method for the posterior segment of the eye. It is effective with a variety of drugs, including steroids and sulfonamides, such as carbonic anhydrase inhibitors, and may be used with many small lipophilic molecules. Cyclodextrin derivatives which have been applied in ophthalmology include the hydroxypropyl derivatives of β-cyclodextrin, the randomly methylated β-cyclodextrin, and sulfobutylether β-cyclodextrin. A GCV intraocular implant is the first FDA-approved sustained-release formulation that is nondegradable in vivo and is being used in the treatment of cytomegalovirus retinitis in AIDS patients. When fluorescent 200 nm, 200 nm, and 50 nm nanospheres were injected into the vitreous body of rabbits, the 200 nm particles were found in the intravitreal cavity and the trabecula, whereas the 200 nm and 50 nm particles were found even inside the retina.
III. DENTAL DRUG DELIVERY

It has been shown that ZnO nanoparticles show significant antibacterial activity over a broad range of bacterial species and in particular against Staphylococcus aureus. There is range of potential antibacterial applications for ZnO nanoparticles to be implemented into such as ointments, surface coatings, disinfectants for dentistry and in medical facilities[15].

Also, Min et al. [16] in an in vitro study presented the application of hydroxyapatite nanoparticles which, if added to soft drinks for athletes, could prevent teeth erosion. Furthermore, Kim et al. [17], in laboratory conditions, tested the effect of nano-carbonate apatite (n-CAP) in the prevention of late discoloration of teeth after bleaching. They found that 10% n-CAP can substantially maintain achieved color after whitening and provide adequate recovery of tooth enamel. Based on the current knowledge, it is certain that nanotechnology has a great potential for prevention of dental caries. Tschope et al. [18] found in their study that toothpaste and preparations for the caries prevention that contain nano-hydroxyapatite (n-HAP) can enhance the process of remineralization in enamel and dentin. In an in vitro study, they compared the effect of toothpaste with added n-HAP or zinc-carbonate/nanohydroxyapatite particles with conventional fluoride toothpastes on bovine enamel and dentin remineralization. They found similar or better effects when used tooth-paste with nanoparticles.

Chen et al. [19] have synthesized hydroxyapatite nano-rods which have a structure similar to the enamel prisms (enamel-prism-like hydroxyapatite nanorods). These hydroxyapatite nano-rods possess a feature so called self-connection and switching (self-assembly) and may become nano-restoration that mimic naturally occurring processes, and as such, could be used to restore tooth structure. Similar nano-structures that could also be used for the restoration of tooth substance are nanospheres; genetically engineered peptides that bind to the surface of inorganic materials.

IV. ANTI CANCER DRUG DELIVERY

Cancer is one of the leading causes of death worldwide, occupying the second place in developing countries, and showing a growing incidence over time. Current cancer therapy strategies are based in surgery, radiotherapy and chemotherapy, being the chemotherapy the one that shows the greater efficiency for cancer treatment, mainly in more advanced stages. Moreover, in cancer, there is a small subset of cancer cells-cancer stem cells (CSC)-that, like normal stem cells, can self-renew, give rise to heterogeneous populations of daughter cells, and proliferate extensively[20].

Infantile hemangiomas (IH) are the most common congenital vascular tumor of infancy with a reported incidence of 5%-10%. The incidence is higher (20%-30%) in extreme low birth weight babies. Topical propranolol agent has a well documented long-term safety for IH. We suggest that topical nano-propranolol hydrogel could be an alternative option for the treatment of uncomplicated superficial IH with satisfactory tolerability and optimal effectiveness. However, propranolol for hemangiomas is an off-label-indication and the parents have to be well informed and to assent[21].

Uncoated gold nanoboxes are biologically inert, can be subjected to biodegradation and can penetrate into lung cancer cells even in complex co- and 3D-culture microenvironments[22]. GNPs could possibly be employed in the delivery of diatomic therapeutic agents, like singlet oxygen, or nitric oxide. Singlet oxygen, a cytotoxic species, is involved in the photodynamic therapy of cancer[23]. Gold Nano-Particles have a special property called the EPR Effect (Enhanced Permeability and Retention Effect). It is the property by which certain sized molecules tend to accumulate in tumor tissue much more than they do in normal tissues. Gold Nano Particles also exhibit Surface Plasmon Resonance. When light or energy waves hit Gold Nano-Particles, it makes the gold electrons resonate, causing them to heat up. This action heats the cancerous tumors they are attached to, ultimately terminating them, without harming the healthy tissues surrounding the tumor[20].

Alterations to surface nanotopography have been employed to stimulate a wide range of cell functions. Nanopillars and nanolines have been shown to effectively modify the dynamics of cell spreading in cancerous fibroblasts. Also cancer cells respond to nanoscale changes in surface topography at the polymer surface[24]. A nanoparticle-based targeted drug delivery system (DDS) contains cetuximab (C225) anti-epidermal growth factor receptor (EGFR) antibody as the targeting agent, gemcitabine as the anti-cancer drug, and gold nanoparticles as the delivery vehicle. The administration of this targeted delivery system resulted in the significant inhibition of pancreatic tumor cell proliferation in vitro and orthotropic pancreatic tumor growth in vivo. In the near future, this strategy could be used as a generalized approach for the treatment of a variety of cancers including pancreatic cancer[25].

Nanotubes bound to an antibody that is produced by chickens have been shown to be useful in lab tests to destroy breast cancer tumors. The antibody carrying nanotubes are attracted to proteins produced by a one type of breast cancer cell. Then the nanotubes absorb light from an infrared laser, incinerating the nanotubes and the tumor they are attached to. Improve the healing process for broken bones by providing a carbon nanotube scaffold for new bone material to grow on[26].
V. TISSUE ENGINEERING

Tissue engineering is a central tenet of regenerative medicine. The purpose of tissue engineering is not only to repair damaged organs and tissues, but also to grow healthy ones to replace their damaged counterparts in patients. The goal of tissue engineering is to build a natural tissue or organ for replacement of the damaged body part. This task could be done more effectively, if the spatiotemporal profile in expression of key molecules (e.g., proteins and polysaccharides) regulating cell behavior can be precisely controlled by means of nanotechnology. Nanoparticles are usually loaded with therapeutics and tagged with appropriate antibodies. These antibodies are specific to ligands in the diseased tissue so the nanoparticles circulate in the body for a long period and bind to the desired tissue.

Natural or synthetic scaffolds have been tested in order to produce a clinically useful tissue scaffold of a target tissue or organ. Examples of natural scaffolds that have been applied clinically include decellularized dermis to treat burn injuries, as well as decellularized small intestine, ureter, or xenogeneic vessels to restore vascular function[27]. To construct suitable synthetic bio-scaffolds, the most widely chosen technique is electrospinning. This method allows the production of nanofibrous scaffolds with specific and desired properties and functionality. Importantly, nanofibrous scaffolds possess an extremely high surface-to-volume ratio, tunable porosity, and malleability to conform to a wide variety of sizes and shapes with a desirable 3D pattern[28]. Nanomaterials have provided the potential to preferentially control the behavior and differentiation of cells by controlling nanoscale properties[29].

One of the largest causes of morbidity and mortality worldwide is ischemic tissue diseases. Therapeutic angiogenesis has emerged as a potential treatment plan because it enhances microvascular perfusion in ischemic tissue by delivering pro-angiogenic molecules. This treatment can be optimized through a better understanding of the nanoscale regulation of the process that involves both delivering growth factors and exerting complex signaling cascades. One of the most potent angiogenic factors that have been recognized is vascular endothelial growth factor (VEGF). Therefore, many pro-angiogenic treatments have attempted to utilize VEGF to enhance microvasculature in ischemic tissue[30].

VI. CONCLUSION

Nanotechnology is regarded as one of the greatest man-made engineering marvels. The technology has grown exponentially in recent years, and it arguably has had the most impact on human life. Nanotechnologists, cell biologists and medical doctors have begun to walk the path toward a personalized medicine with the hope of improving the treatment of many diseases. The advanced applications of this approach will definitely become an inevitable part of our life. Though many of the technologies involving nanoparticles for detection and treatment are mainly in preclinical stages, there is tremendous potential for nanotechnology to enable desperately needed detection of the abnormalities in its early stages.

REFERENCES