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Nanomedicine: Promise Of The Future In Disease Management

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Abstract

Nanomedicine was born as a combined result of the numerous researches done pain staking by thousands of scientists across the globe. Soon after its inception it became one of the hottest research areas and also the most debated one. When the scientists became aware of its innumerous applications in medicine, its importance reached newer heights. Now the entire medical community all over the world is looking forward eagerly for the miracles of nano medicine. Starting from targeted drug delivery in cancer treatment, biotechnology, disease diagnosis to nanostructure implants, the areas that nanomedicine covers is astounding. The main attraction of this novel technology is its flexibility for innovations. Another important aspect of this is that unlike many other hi-fi technologies which the ordinary man cannot afford to use, nanomedicine can easily extend its application to every sections of the society. With nanotechnology cancer therapy is going to be made much simpler and painless which itself is a boon to millions of cancer patients around the world. Critical organ transplantations are to be made easier with much reduced chances of incompatibility and thereby rejection, with the help of nanostructure implants. Diseases can be diagnosed more effectively and easily with the assistance of nanomedicine. Nanomedicine has triggered the wind of revolution in medicine, which in turn is going to be a new lease of life for the suffering.

INTRODUCTION

Nanomedicine is the medical use of molecular-sized particles to deliver drugs, heat, light or other substances to specific cells in the human body. Engineering particles to be used in this way allows detection and/or treatment of diseases or injuries within the targeted cells, thereby minimizing the damage to healthy cells in the body. Nanomedicine, just as the word suggests it is the innovative combination of nanotechnology and medicine providing us with the most modern cutting edge tool in the field of medicine. It has triggered a whirlwind of medical revolution across the globe. Even now researchers around the world are scrutinizing the limitless possibilities offered by nanomedicine. What makes it so special is that unlike the conventional methods of medication, in this method the drug is adsorbed or entrapped in carriers which enables it to act more efficiently, accurately and with fewer side effects. Another important aspect of this method is that it can be incorporated in almost all fields like treatment, research, production of drugs, analysis and other related medical areas. The process of disease diagnosis can be simplified greatly with nanomedicine. The applications of nanotechnology in the fields of cancer therapy, disease diagnosing, drug delivery etc makes up just the tip of the ice berg of what nanotechnology is going to offer us. 1

SCOPE AND FUTURE IN DISEASE MANAGEMENT

Our medical field is going to witness the greatest revolution in the annals of medical history, the revolution of nanotechnology. With nanotechnology at our fingertips nothing is going to be impossible, everything is made so simple. Doctors will be able to search out and destroy the very first cancer cells that may have transformed into a tumor poised to kill us, broken parts of cells can be removed or replaced with miniature biological machines, life saving drugs can be delivered precisely when and where they are needed with the assistance of miniature nanopumps.2

The approaches to nanomedicine range from the medical use of nanomaterials to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology. The basic aim of molecular nanotechnology would be to conduct balanced chemical reactions in positional controlled locations and orientations and then to build systems by assembling the byproducts of these reactions. Nanomedicine is a large industry, with nanomedicine sales reaching 6.8 billion dollars in 2004, and with over 200 companies and 38 products worldwide. Moreover a minimum of 3.8 billion dollars in nanotechnology R&D is being invested every year. As nanomedical industry shooting up at a fast pace it is expected to have a great impact on our economy.3

NANOTECHNOLOGY AND MEDICINE AT CROSS ROADS

Nanomedicine, a byproduct of nanotechnology, refers to highly specific medical application of nanoscale particles at the molecular scale for curing diseases or repairing damaged tissues, such as bone, muscle, or nerve. A nanometer is one-billionth of a meter, too small to be seen with a conventional lab microscope. It is at this incredibly small size scale (less than 100 nanometers) that biological molecules and structures inside living cells operate. Many nanomedicine systems are being constructed as self sufficient and automated machines with sophisticated targeting, sensing, and feedback control systems. It is basically the concept of nanomedicine that distinguishes it from the conventional methods of treatment. The concept of nanomedicine is not to just kill all aberrant cells by surgery, radiation therapy, or chemotherapy. Rather it is to fix cells, appropriately, one cell-at-a-time, to preserve and re-build organ systems. The ultimate aim of nanomedicine is to combine diagnostics and therapeutics into real-time medicine, thereby radically changing the basic approach towards medication and therapy.1, 2

APPLICATION OF NANOTECHNOLOGY IN MEDICINE

1. Nanostructural implants in drug delivery
2. Nanostructured scaffolds for tissue engineering.
3. Nanostructuring for cell expansion.
4. Disease diagnosing by targeted nano particles.
5. Nanoparticle for efficient, highly sensitive, and high throughput bio assays.
6. Improving efficacy, reduction in dose and side effects by formulating into nano drug form
7. Nanofibrils in development of rapid wound healing dressings.

MEDICAL NANOROBOTS

The most promising and futuristic product of cutting edge nanotechnology will be the designing of nanorobots. Imagine thousands of nanorobots as sentinels patrolling our body day and night and fighting any foreign body that is likely to infect our body. We can start imagining a day when we no longer have to worry about visiting our doctor. Medical nanodevices would first be injected into a human body, and would then go to work in a specific organ or tissue mass. The doctor will monitor the progress, and make certain that the nanodevices have gotten to the correct target treatment region. 4

The typical size of a blood born medical nanorobot will be 0.5-3 micrometers as it is the maximum size that can be permitted due to capillary passage requirement. Carbon would be the primary element used to build these nanorobots due to their inherent strength and other characteristics. These nanorobots would be fabricated in desktop nanofactories specialized for this purpose. The capacity to design, build, and deploy large numbers of medical nanorobots into the human body would, make possible the rapid elimination of disease and the effective and relatively painless recovery from physical trauma. Medical nanorobots can be of great importance in easy and accurate correction of genetic defects, and help to ensure a greatly expanded health span. More controversially, medical nanorobots might be used to enhance natural human capabilities. However, mechanical medical nanodevices would not be allowed to self-replicate inside the human body, nor would there be any need for self-replication or repair inside the human body since these nanobugs are manufactured exclusively in carefully regulated nanofactories with outmost precision. 4

NANOPARTICLES

Nanospheres and nanocapsules,that can be either amorphous or crystalline are the most widely used nanoparticles. They are specially designed to adsorb or encapsulate a drug, thereby protecting it against chemical and enzymatic degradation. The drug is confined in a cavity lined by a polymer membrane in nanocapsules while, there is a matrix system wherein the drug is physically and uniformly dispersed in nanospheres. In recent years, biodegradable polymeric nanoparticles have attracted the attention of numerous researchers around the world in the controlled release of drugs due to its inherent capacity in targeting particular organs/tissues and also as carriers of DNA in gene therapy and in their unique ability to deliver proteins, peptides and genes by the oral route. Nanoparticles are used for parenteral, oral, ocular and transdermal applications as well as used in cosmetics and hair care technologies, sustained release formulations and as a carrier for radio nucleotides in nuclear medicines.5

NANOPARTICLE DRUG DELIVERY SYSTEMS

With nanotechnology industry booming out of limits, the entire systems of delivering the drugs is to be rewritten. Safe, effective, without side effects, no wastage, and increased bioavailability are going to be the mantras of future drug delivery. The focus of nanomedical approach to drug delivery is in the production of nanoscale particles or molecules to enhance the bio availability of a drug. Bioavailability refers to the presence of drug molecules (in the right concentration) where they are needed in the body and that too where they will do the outmost good. Drug delivery focuses on maximizing bioavailability at specific places in the body and for prolonged period of time.The ability to alter the pharmacokinetics and biodistribution of the drug in the body determines the strength of the drug. The advantage of nanoparticles over other conventional drug delivery systems lies in the size, when larger particles would have been cleared from the body; cells take up these nanoparticles because of their incredibly small size. For example, biodegradable nanoparticle drug delivery systems can be used for targeting drugs to the lungs, which has advantages such as avoidance of macrophage clearance mechanisms and long resistance times.2

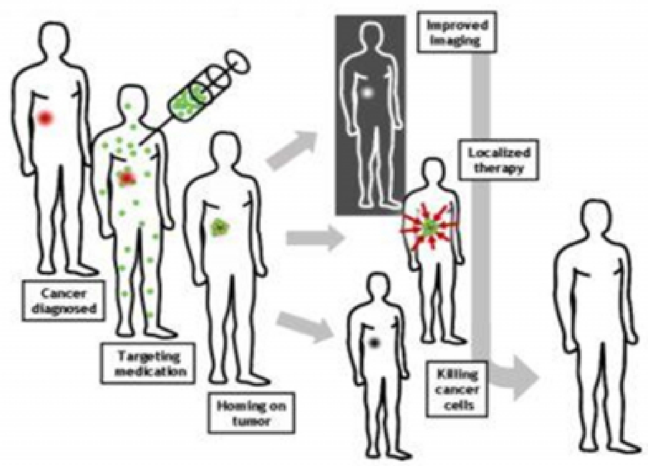
Triggered response is one way for drug molecules to be put to use more efficiently. In this method drugs which are placed in the body gets activated only on encountering a particular signal. For example, a drug with poor solubility can be replaced with a drug delivery system where both hydrophilic and hydrophobic environments exist, thereby increasing the solubility. Also, a drug may cause tissue damage, but with targeted drug delivery, regulated drug release can eliminate the problem. When a drug is cleared too quickly from the body even before the body could assimilate it, it can cause the patient to use high doses to make up the bio availability, but with targeted drug delivery systems elimination can be avoided by altering the Pharmacokinetics of the drug. Poor bio distribution is a problem that can affect normal tissues (non target tissues) adversely through unwanted widespread distribution, but the particulates from targeted drug delivery systems reduce the rate of distribution and reduce the effect on non-target tissue thereby drastically reducing the side effects.

APPLICATION IN CANCER THERAPY

As cancer grinding away the lives of a large section of the society, the importance of nanomedicine is gaining new heights. Novel nanomedical anticancer therapies with much lesser pain and side effects are becoming the ultimate anticancer solutions (See Fig 1). The incredibly small size of nanoparticles empowers them with properties that can be very useful in oncology, particularly in imaging. Quantum dots, which are nanoscale particles with confinement capacity, when used in combination with MRI (magnetic resonance imaging), can produce exceptionably sharp images of tumor sites. Unlike the conventional organic dyes these nanoparticles are much brighter and only need one light source for excitation. This implies that the use of fluorescent quantum dots could produce a higher contrast image and in a cost effective way than today's organic dyes used as contrast media. Another specialty of nanoparticles, the high surface area to volume ratio empowers a large number of functional groups to attach to a single nanoparticle, which can then seek out and bind to highly targeted tumor cells. Moreover the small size of nanoparticles enables them to accumulate at tumor sites as tumors lack an effective lymphatic drainage system. 6

Figure 1

Figure 1: Shows how nano-drug particles work in human body for cancer treatment



NOVEL CANCER TREATMENT METHODS

1. The kanzius radio frequency therapy is a promising cancer treatment method that is edging closer to human trials. The method has the potential to replace the radiation and chemotherapy used today. Here microscopic nano particles are attached to cancer cells and then literally ‘cooks' the tumors inside the body with the help of radio frequency waves that heats only the nanoparticle attached tumor cells, thereby causing no harm to the adjacent normal tissues.

2. Sensor Test chips embedded with thousands of Nanowires, designed to detect proteins and other

biomarkers left behind by cancer cells, could enable the detection and diagnosis of cancer in the initial stages from a few drops of a patient's blood.

3. Researchers at Rice University have demonstrated the destruction of cancerous tumors in mice with the help of 120 nm diameter nanoshells coated with gold . The nanoshells can be targeted to bond to cancerous cells by conjugating antibodies or peptides to the surface of the nanoshell. By irradiating the tumer area with an infrared laser, which can easily pass through flesh without heating it, the gold is heated sufficiently to cause death to the cancer cells.
4. Dr John Kanzius has invented a novel radio machine which uses a combination of radio waves and carbon or gold nanoparticles to destroy cancer cells.
5. Dr Bing xu and colleagues working for a honkong based multinational institute claims to have created an anticancer nanocrystal .The structure has an outer shell that encloses a "yolk" just like that of a chickens egg, and the structure can release the yolk when needed. A yolk consisting of two metals gold and platinum responsible for the activity of the widely acclaimed anticancer drug cisplatin was used. The nanostructures which released their yolks were readily taken up by the human cancer cell cultures which proved surprisingly extremely toxic for the cancer cell cultures. The researchers are confident that this new break through can go a long way in developing novel anticancer nanomedicine .Researchers have also developed state of the art nanostructures that can be coated with antibodies that can specifically target cancerous tissues and hence effectively reduce the side effects associated with the age old chemotherapy's.
6. Nanoparticles of cadmium selinide when injected into tumor sites glows under infra red radiation which the surgeon can use to accurately remove the tumor.

NANOVACCINES

Another application of cutting edge nano technology is the formulation of nanovaccines. Scientists have already created nanovaccines which are in reality specialized nanoemulsions made up of tiny soybean oil droplets suspended in water and studded with bits of pathogenic organisms. These special nanovaccines can be ingested by swabbing into the nose. Nanoemulsion vaccines have proved to be effective against a wide variety of microorganisms. The technology is borrowed from the cosmetic industry where nanoemulsions have been used to incorporate into skin creams to ease the penetration of the drug through the skin through pores and down the shaft. Since these vaccines are administered through the nose they produce immunity not only in the blood stream but also in the mucosal lining making them relevant for a wide variety of diseases. Especially concerning incurable diseases like HIV, researches have shown that virus replicates itself in the genital mucosa, so a strong mucosal response can effectively hinder or completely stop the virus before it enters the blood stream. The new technology also has the potential to radically change the process of small pox vaccination by obleviating the concern in using a live virus. More importantly nano emulsions are uniquely suited to the needs of the developing and tropical countries as the constituent proteins are stabilized, require no needles or inhalers, and can survive high temperatures.

NANOTOXICOLOGY

Even though nanomedicine has several applications in the health sector, more attention is needed towards its safety concern. A preclinical study at the University of Rochester revealed that when rates breathed in nanoparticles, the particles deposited in the lungs and brain. That led to significant increases in biomarkers for inflammation and cell injury. Researchers have found that silver nanoparticles used in socks to reduce foot odour are being released in the wash with possible negative consequences. Silver nanoparticles, which are bacteriostatic, may then destroy beneficial bacteria which are important for breaking down organic matter in waste treatment plants or farms. A major study published more recently in Nature nanotechnology suggests some forms of carbon nanotubes could be as harmful as asbestos if inhaled in sufficient quantities.7

CONCLUSION

Nanomedicine is a new age phenomenon which the international medical community is eagerly looking forward to come into full swing. The ever increasing demands and challenges that the present medicine field is posing can be met by nanomedicine. The stakes are high and the need is ours, so all we need is to embrace innovations. This technology can revolutionize the entire medical field if given proper attention and importance, with proper government intervention in aspects like funding. Attracting young talents to the research field can also boost its growth. Let us hope that nanomedicine is going to be put to the maximum use and its benefits reach every sections of the society thereby alleviating the pains of millions of people around the world.

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