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Advent of Nanomedicine–The Future Crux of the Health Sector

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Abstract

This review focuses on the field of nanomedicine as a translational science, which comprises of nanotechnological applications in medicine. In recent grounds, the aerial impact of nanoparticles & nanostructures and their potential therapeutic contributions to biological systems have led to an au courant era of nanotheranostics & nanodiagnosis. The significant augmentation of nanostructured devices brightens the opportunities in the field of Regenerative Medicine, Tissue Engineering & Stem Cell Technology. The novel usage of nano scaffold assemblies in stem cell therapy enhances stem cell commercialization. Encountering nanostructured collagen mimics contracts the troubles of graft rejection, thereby uplifting tissue transplantation & regeneration. Nanoplatforms are increasingly constructed to facilitate novel approaches to cancer treatment. The design of new nanocomposites for targeted drug delivery systems will provide better endeavors in molecular medicine. The green synthesis of metal nanoparticles from medicinal plants & their employment in nanomedicine unravels contemporary frontiers in the treatment of several diseases.

Keywords: Nanotheranostics, nanodiagnosis, regenerative medicine, tissue engineering, stem cell technology, nano scaffolds, nanoplatforms & nanocomposites.

Contents

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1. Introduction

Nanomedicine is the preservation and improvement of human health using molecular tools and molecular knowledge of the human body. The nanomedicine will have extraordinary and fair reaching implications in medicine for defining a disease, its diagnosis, its treatment and further improvement of human biological structure and function. The current applications of nanomedicine lies for the treatment of different types of cancers (prostrate, breast), heart diseases, rheumatoid arthritis, antitumour therapies. Recent advancements have exploited nanos in the field of tissue engineering and stem cell biology. The era of molecular medicine gradually transforms its face to nano medicine.

Nanoparticles for Biomedical Applications:

Nanoparticles range in the size of 1-100nm and can be composed of many base materials. Particles in the nanometer size do occur in nature and as a result of industrial processes. The most effectively studied nanoparticles today are those made from noble metals, in particular Ag,Au, Pt and Pd (Arangasamy Leela 2008). Gold and silver nanoparticles have been greatly employed for numerous potential biomedical applications.

Role of gold nanoparticles:

Therapeutic agents can also be coated onto surface of gold nanoparticles. The large surface areas – to – volume ratio of gold nanoparticles enable their surface to be coated with hundreds of molecules (including therapeutics, targeting agents and anti-fouling polymers). Gold nanoparticles are used to detect biomarkers in the diagnosis of heart diseases, cancer and infectious agents. A common household example, being the home pregnancy test. The successful application of colloidal gold in a patient with rheumatoid arthritis was first reported in 1997. Presently many recent advances are carried out using gold nanoparticles in rheumatoid arthritis. Gold nanoparticles coupled with specific targeting agents have the ability to track and eliminate breast cancer cells. By shining infrared light on specially designed gold-filled silicon wafers, scientists at the Methodist Hospital Research Institute have successfully targeted and burnt breast cancer cells. If the technology shown to work in human clinical traits, it could provide patience and non-invasive alternative to surgical ablation and could be used in conjunction with traditional cancer treatments such as chemotherapy, to make those treatments more effective. Shen and his team found that in presence of 808 nm light, the gold-filled silicon particles, heated up a surrounding solution by about 20°C in 7 minutes. These experiments showed that tumor cells growth was lowest in the presence of gold loaded silicon nanoparticle in three types of breast cancer cells – MDA-MB-231 and SK-BR-3 (human) and 4T-1 (mouse).

Role of silver nanoparticles:

AgNp's have been tested in various field of biological sciences, drug delivery, water treatment and antibacterial compounds against gram positive and gram negative bacteria. Most of the bacteria have yet developed resistance to antibiotics and in this view in future it is to need develop of antibiotics. AgNp's are attractive as those are non-toxic to human body at low concentration and having broad spectrum antibacterial nature. AgNPs inhibit bacterial growth at very low concentration than antibiotics and as of now, no side effects are reported.Silver nanoparticles synthesized from plant species have revealed numerous therapeutic efficacies. They are non toxic to human body thus facilitating various medical implications with no side effects so for.

Our Present Study

Determination of antimicrobial activity of silver nanoparticles (AgNp's) using various bacterial strains:

To test the antimicrobial activity of AgNp, we took six pathogenic bacterial species–Salmonella typhi, Enterococcus faecolis, Bacillus cereus, E.coli, Klebsiella pneumonia and Pseudomonas aeroginosa.

Methodology: We used agar gel diffusion method to test the antimicrobial activity of AgNp's. Two drugs streptomycin and gentamicin were used as reference 50µg/ml of AgNps along with the reference drugs were loaded in paper disks and tested on six culture plates. E.coli and Enterococcus faecalis were observed to exhibit high antimicrobial activity which conformed the antimicrobial efficacy of AgNps.

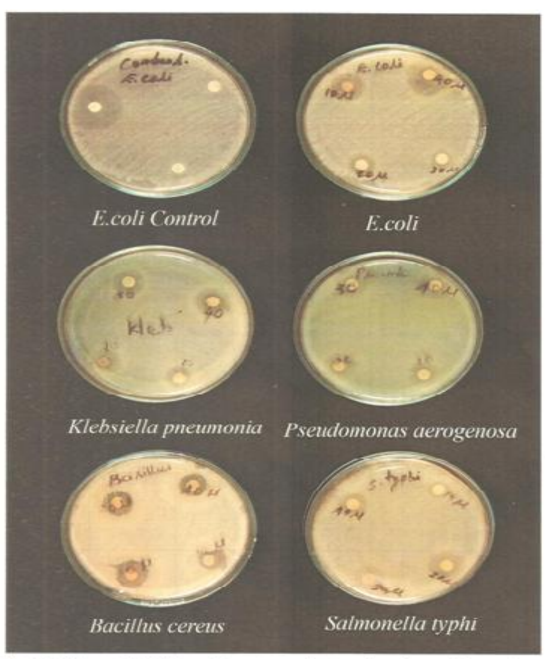


Fig 3.11 Zone of inhibition diameter against various bacterial species

Toxicity studies on silver nanoparticles- nanotoxicology:

Colloidal Ag has been consumed for decades for its perceived health benefits, but detailed studies on its effect on the environment have just begun. In all studies to date, AgNPs toxicity is much less than equivalent mass loading of Ag salts.

Nano diagnosis:

Nanotechnology that is incorporated in molecular diagnostics have potential applications in clinical diagnosis. Nano technology enable diagnosis at the single-cell molecule levels and some can be incorporated in current molecular diagnostic methods such as biochips.

Nano drug delivery system:

Core shell, zinc sulphide-cadmium telluride, quantum dots were studied by magnetic resonance and computed tomography phantoms. Quantum dots were also injected into rat brain as well ass intravenously, using convection enhanced delivery, prior to animal imaging.

CT studies suggest that current formulations of quantum dots might be imaged in vivo in animals. Used in conjunction with optical imaging techniques, quantum dots have the potential to function as a multi model imaging platforms in vivo. Ability to detect an optical nano particle pre operatively with clinical imaging modality offers distinct advantage to clinicians engaged in image guided surgical applications.

Nano Theronostics:

Theranostics is a concept that refers to the integration of imaging and therapy. Theranostic approaches include systems and strategies in which disease diagnosis and therapy was combined. Nanotheranostic systems are consequently considered to be highly suitable pre clinical implementations not only because they might assist in better understanding various important aspects of drug delivery process and in developing better drug delivery systems, but also because they might contribute to realising the potential of personalized medicine.

Tissue Engineering:

This field has evolved to be the most awakening technology since thousands die every year due to the lack of donor organs. There are three basic approaches for the engineering of tissues.

- Use of isolated cells or cell substitutes to replace the cell that supply a needed function.
- Delivery of tissue-inducing substances such as growth factors to a targeted location.
- Growing cells in a 3-D scaffold.
- Of these, the first two are used for small scale generation of tissues, while the third is used for producing large 3-D structures.

Nano fibrous scaffolds:

Basically three techniques are used for the fabrication of nano-fibrous scaffolds.

- Electrospinning
- Molecular self assembly
- Phase separation

Of these three techniques, the electrospinning and phase separation seems to be very effective. The principle of electrospinning is to use an electric field to draw a polymer solution from the orifice to a collector, producing fibres.

The phase separation methods uses a polymer solution like naphthalene, phenol or 1,4-dioxane to separate into polymer such phase and polymer lean phase. The temperature of polymer solution is controlled and then due to this, phase separation occurs. Then polymer rich phase solidifies and forms foam. By varying the types of polymers, different pore sizes can be achieved. The disadvantage of this method is the use of polymer solutions. Instead certain bioactive substances can be used for phase separation. Since polymer solutions present special problems, we suggest chitosan solution or fibrotin solution to be used as an alternative. Recently, nano-fibrous scaffolding has been shown to facilitate recovery from spinal cord injury in mice.

2. Stem Cell Research

Nanokicking

A new method has been developed that coaxes stem cells into growing new bone by nanokicking them 1000 times per second. They suggest the technique is cheaper and easier to implement than the current methods and opens the door to new ways of treating bone conditions like stress fractures, spinal traumas and osteoporosis.

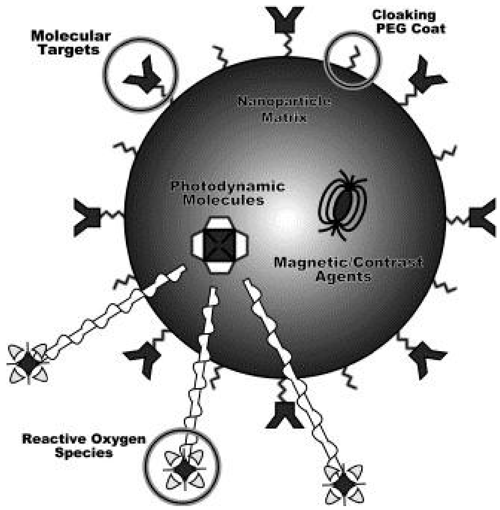
Nano hitchhikers

The new technique employs a trick that marks stem cells so they can be tracked by standard ultra sound, as they are squeezed out of the needle allowing their more precise guidance to the spot they are intended to go and then monitored by magnetic resonance imaging for week's afterward. To make this possible, a specialized imaging agent in the form of nanoparticles was designed and produced whose diameter clustered in the vicinity of just below 1/3 of a micron-less than one-thirtieth the diameter of an RBC. The acoustical characteristics of a nanoparticle's chief constituent silica allowed them to be visualized by ultra sound.

Mesenchymal stem cells- a class of cells often used in heart regeneration research- were able to ingest and store the nanoparticles without losing their ability to survive, replicate and differentiate into living heart cells. A novel delivery platform based on nanoghost produced from the membranes of mesenchymal stem cells has been reported. Encompassing MSC surface molecules, the MSC-NGs retained MSC-specific invitro and invivo tumour targeting capabilities and were cleared from blood filtering organs. MSC-NGs were found to be biocompatible and systemic administration of drug loaded MSC-NGs demonstrated 80% inhibition of human prostrate cancer.

Nanoplatforms:

Various nanoparticle platforms have been extensively developed for cancer diagnosis and therapeutics. Nanoparticle-based theranostic systems exploit diverse nanoplatforms. Examples include magnetic nanoparticles, carbon nanotubes, gold nano structures, polymeric nanoparticles and silver nano particles. The nanoplatforms are physically or chemically labeled with radionucleotides, MRI agents or optical imaging agents.



Nanocomposites:

A nanocomposite is a matrix to which nanoparticles have been added to improve a particular property of the material.

Speeding up the healing process for broken bones:

Researchers have shown that growth of replacement bone is speeded up when a nanotube-polymer nanocomposite is placed as a kind of scaffold which guides growth of replacement bone. The researchers are conducting studies to better understand how this nanocomposite increases bone growth. Dendrimer based nanocomposites1-5 are novel organic-inorganic hybrid nanoparticles synthesized by dispersing very small inorganic domains in nanoscopic size polymeric networks. Due to the molecular level mixing of their components they display unique material properties in addition to properties represented by their individual components. Dendrimers are often used as templates in making these particles because they can be made uniform, and using these well-controlled and uniform templates leads to well controlled and uniform composite particles.

Apart from obvious materials science applications, such as catalysis and photonic materials, dendrimer nanocomposites (DNC) have a great potential in biomedical applications due to their controlled composition, predetermined size, shape and optional surface functionalities. They may be used as drug delivery vehicles to deliver bioactive guests such as silver or for an incorporated radioactive isotope. Radioactive dendrimer nanocomposites can be delivered directly to the tumor by injecting nanoparticle solutions directly into the tumor microvasculature. If a short-lived isotope is used, a procedure like that may serve as an alternate method to direct irradiation. It has also been envisioned that if the surface of such a nanoparticle had been equipped by appropriate targeting moieties the nanoscopic device could find its way selectively to cancerous cells anywhere in the body.

Nanomedicince–Role In Future:

The ultimate tool of nanomedicine is the medical nanorobot – a robot the size of a bacterium, composed of many thousands of molecule-size mechanical parts perhaps resembling macroscale gears, bearings, and ratchets, possibly composed of a strong diamond-like material. A nanorobot will need motors to make things move, and manipulator arms or mechanical legs for dexterity and mobility. It will have a power supply for energy, sensors to guide its actions, and an onboard computer to control its behavior. But unlike a regular robot, a nanorobot will be very small. A nanorobot that would travel through the bloodstream must be smaller than the red cells in our blood – tiny enough to squeeze through even the narrowest capillaries in the human body. Medical nanorobotics holds the greatest promise for curing disease and extending the human health span. With diligent effort, the first fruits of this advanced nanomedicine could begin to appear in clinical treatment sometime during the 2020s.

Our future work – Installation of Nanomotors in Wind Mills:

Producing structural components with a high strength-to-weight ratio: For example an epoxy containing carbon nanotube can be used to produce nanotube-polymer composite wind mills. This results in a strong but lightweight blade, which makes longer windmill blades practical. These longer blades increase the amount of electricity generated by each windmill. Our future work on nano applications will investigate the use of nano motors in commercially operating wind mills.

3. Conclusion

Nanomedicine truely severs as the future cracks of the health sector due to the diverse technical promises them posses. The metal nanoparticles, nanoscaffolds, nanocomposites and nanoplatforms would play appreaciable roles in designating surgical processes and condensing biomedical complications.

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