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Nanotechnology and it's therapeutic application – a review

Abstract

Cancer is a disease that involves abnormal cell growth; it can also invade the neighbouring cells and other parts of the body. Treatment of cancer involves radiation therapy, chemotherapy and surgery. New technologies and drug treatments are always under consideration to improve the symptoms and lifespan of cancer patients. Nano–technology is a branch of technology that deals with manipulation of atoms and molecules to nano sized products for various applications. Nano–technology has its application in various fields. Nanotechnology is creating astounding results in treatment of cancer by offering fast and sensitive detection of cancer even when it occurs on a small degree of cell and destroying tumours with least damage to surrounding non–cancer cells. This new research is providing exciting possibilities involving treatments, detection and control to cancer cells.

Keywords: cancer, nano–technology, nano–tubes, quantum dots

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Abbreviations: SWNT, single walled carbon nano tubes; MSH, melanocyte stimulating hormone; NIR, near infra red light rays; TNF, tumor necrosis factor; FISH, fluorescence in situ hybridization; FNAC, fine needle aspiration cytology; PET, positron emission tomography; CT, computerized tomography

Introduction

Globally, the major reason of death is Cancer.[1] Cancer is the second most common reason of death in United States (US), leading cause being the cardiovascular disorders.[2] The main goal of therapy for Cancer is about delivering high quantity of anti–cancer substances into sites of tumor to get uttermost efficacy and underrate the side effects to normal organs.[3]

Glimpse into nano–technology

Living systems are essentially comprised of building blocks which are Nano–scaled. The thickness of single unit of DNA is approx. 2.5nm,[4] Protein range is 1 to 20nm while cell membrane is 6–10nm.[5] Idea of nanotechnology introduced in 1959 by R. O. Feynman, a Physicist, who regarded Nanotech as the development which can't be avoided. The science of suppressing, identifying and managing diseases, traumatic injury, drug targeting, increasing bioavailability, analgesic effects,[6] controlled drug release,[7] improving human health,[6] by using Nano–scaled dimensions from 1.0 to 100.0nm[6] and taking benefits of exclusive properties of Nano scaled particles, is called NANO MEDICINE.

In all areas of today's science, the nano–science has recently started rapidly growing and becoming highly important offering improvements in human health, opportunities of creating money and providing incredible improvements in standards of living and well–being.[8] The field of medicine, in which nano–scaled particles having dimension range in–between 1–100nm are designed as biomedical tools for research, has been revolutionized by utilizing nanotechnology in different sections of therapeutics.[9] Structures, devices and materials made by nanotechnology show entirely different biological, chemical and physical properties from those produced on large scale.[10] Nano–probes gelatine, Fullerenes, quantum dots,[11] nanotubes, dendrimers, Nano–pores, liposomes,[12] magnetic, ceramic, micelles and radio controlled are being developed as different organic and inorganic platforms of nanotechnology(Table 1).[13,14]

Cancer treatments using nano–technology

As Nano–scaled dimensions have the ability to enhance delivery of molecule of drug and under rate the side effects of drug and drug carrier,[15] they are used as treatment of conditions like different stages of tumor, cancer, microbial infections, gene therapy and chronic hyperglycemia.[16] The main superiorities of this model of treatment are these particles act as contrast medium i.e. enhances the visibility of blood vessels for diagnostic purpose and biosensors, cell culture, magnetic nano–particles and enhance renewal and growth of tissue.[15] Nanostructures are being highly valued in the field of tumor imaging.[17] Small size of nano particles, due to their EPR (enhanced permeability and retention effects),[18] can invade tumors and leak into abnormal tumor blood vessels and accumulate in tumor tissues.[19] In Pharmaceutical development, nanotechnology proved to be the most important milestone. In human, Nano particles demonstrate superlative activity against cancer *in vitro*.

Nano–tubes

Nano–tubes possess great firmness and strength,[20] produce heat and destroy surrounding tumor cells by absorbing Near (IR) infra red light rays.[21] Indium–111 radio nucleus, a labeled carbon nano–tube has been inspected to destroy tumor cells.[22] The SWNT – (Single– Walled–Carbon Nano Tubes) have been investigated as new transporting agent *in vitro*.[23] SWNTs can efficiently transport various bimolecular substances inside human cells like therapeutic agents, amino acids, proteins, DNA and intervening RNA , by means of endocytosis.[24] Carbon nano–tubes have the intrinsic (NIR) near infra red light absorption property which is useful in destroying cancer slots[25] and Near–IR (infra–red) photoluminescence property which is used for cell visualizing and exploring, *in vitro*. Physicians can perform precise molecular and cellular intervention through nano–robotic devices. Medical Nano robots have been recommended for genetological applications[26] in pharmaceutical studies, clinical science, and in modern dentistry.[27] It can also be applied for reoccurring

atherosclerosis, boosting breathing ability, allowing near–immediate homeostasis, boosting immune system, substituting sequences of DNA in cells, healing brain damage and fixing gross cellular distress which may have occurred due to unchangeable process or by storage of biological tissues at low temperature. Active and passive are two models which are being used for targeting nano–scaled particles to specific site of tumor. Active is all about connecting the ligands to tumor specific nanoparticles.[28] The basic and characteristic mass of nanoparticles and the distinctive ability of tumor vascular system are the advantage of passive targeting.[29]

Quantum dots

Quantum dots are shiny new semiconductor nano–crystals,[30] their radiation is firm, solid, time–honored, and inextinguishable and they are being used in many different researches related to cancer cure and therapy.[31] A nano–particle with biomolecules attached to its surface or conjugation of the quantum dots is regulated to target many biological markers.[30]

Nano shells

The Gold Nano shells, developed by West and Halas, is an additional appealing way to detect and treat cancer.[30–32] These gold shells are intended to attack melanocytes by a film of melanocyte stimulating hormone (MSH). These Nano–spheres are made steady and then particularly absorbed by tumor cells via receptor–mediated endocytosis.[33] It was proclaimed through a model of subcutaneous colon cancer that organized administration of gold nano–particles of 33nm in size will initiate it's binding to tumor necrosis factor (TNF) gathered in tumors.[30]

Nano–bombs

Nano–bombs can destruct cancerous cells, tumor cells and vessel system around abnormal cells that nourish those diseased cells, but these bombs can be harmful for surrounding healthy cells if used in more than normal amount.[21] Contrast agent super paramagnetic nano–particles are used to enhance the contrast to characterize status of lymph node in medical imaging in humans like patients with fibro adenomas, cancer in respiratory tract, Prostate cancer, endometrial cancer and cervical cancer.[34] Iron oxide super paramagnetic are captivating as they have higher responsiveness to magnetism unlike gadolinium, a traditional MR contrast agent.

Liposomes

Lipid–based vehicles of this type have been put into service mainly for enhancing the dissolving capability of lipophilic drugs and for putting limit to toxicity caused by drug.[35] In mid 1960s, the discovered liposome was the actual version of Nano–scaled drug targeting tool. In ovarian cancer, folate receptors over exuberance occur by the tumor tissue. The conjugation of liposomal drug with folate can be made to direct the molecule to the tumor (Table 2).[36,37]

Table 1 Comparison of detection, imaging, diagnosis and drug delivery with and without use of nanotechnology.[14]

Applications	Without use of nanotechnology	With use of nanotechnology
Diagnosis	Fine needle aspiration cytology (FNAC), biopsy, Fluorescence in situ hybridization (FISH), immune histo chemistry used for diagnosis.	Quantum dots and Raman probe can be used for diagnosis.
	Early detection is not possible Only *in vitro* detection is possible.	Early detection is possible. *In vitro* and *in vivo* detection is possible.
	Real time detection is not possible	Real time detection is also possible
Imaging	X-ray, CT (Computerized tomography) scan, Magnetic resonance imaging (MRI), Positron emission tomography (PET scan) and Ultrasonography can be used.	Quantum dots can be used UCM (Ultrasound contrast medium) ultrasonography can be used. Very early detection of neo vascularization is possible. Imaging, targeting, delivering and monitoring is possible.
Early detection of cancer	Cytology, FNAC and biopsy are used.	Vital optical imaging is possible Inexpensive mass screening is possible
Drug delivery	Oral, intramuscular, intra venous, intra-arterial drug delivery is possible.	Targeted delivery is possible to deliver small dose, low systemic toxicity and better and faster responses.

Table 2 Nano- Particles used for treatment of Cancer.[37]

Product	Description	Use	Manufacturer
MRX 952	Nano-Particle Preparation - to Encapsulate Camptothecin Analogues	Tumors	IMA Rx Therapeutics
Targeted Nano Therapeutics (TNT)™ System	TNT with Polymer Coated Iron Oxide Magnetic Particle	Solid Tumors	Triton Biosystems
AuroLase™	Gold Nano-Shell	Head and Neck Cancer	Nano-Spectra Biosciences Inc
INGN 401	Nanoparticle Formulation of Tumor Suppression Gene FUS1	Lung Cancer	Introgen Therapeutics Inc
Abraxane	Albumin Bound Taxane Particles	Non-Small Cell Lung Cancer	Celgene
Doxil	Liposomal Doxorubicin	Ovarian Tumor	Ortho Biotech
Cyclosert-Camptothecin - IT 101	β-Cylcodextrin Polymer Drug Delivery System	Solid Tumors	Calando Pharmaceuticals

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Conclusion

Especial proposition and intensive advancement antagonistic towards cancer by timely detection, prognosis, prophylaxis, distinctive treatment and medicament is provided by Nanotechnology. The utilization of nanotechnology for the treatment of cancer has meet with appreciable consideration in recent times. In future, vast prosecution of cancer nanotechnology is expected. Nanotechnology is considered as medicine of tomorrow but still there is a lot of work that can be done in this.

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Conflict of interest

The author declares no conflict of interest.

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