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Nanotechnology: Boon in cancer diagnosis

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Abstract

Nanotechnology is quickly developing part of technology affecting many fields. Medicine is also greatly influenced by nanotechnology. Nanotechnology can be used in cancer treatment and can assist to have better diagnosis with less harmful substance. The use of optical nanoparticles can provide efficient drug delivery to tumor cells with liposomes and nanotubes. Nanotechnology can be also used in molecular imaging with tomography and photoacoustic imaging of tumors and therapy of cancer. Nanotechnology is a next generation technique and has many advantages to treat cancer patients from diagnosis to treatment.

Keywords: Cancer, Nanoparticles, Therapeutics, Nanotechnology, Diagnosis

Introduction

Oral cancer is the sixth most common malignancy worldwide with 5-year survival rate of approximately 50% [1]. This disease tends to spread rapidly and is often capable of invading adjacent tissue and metastasis. Oral cancer could cause chronic pain, altered facial appearance, paranesthesia, dysfunction in speech, and dysphagia, as well as social isolation and psychological distress [2]. Oral cancer occurs because of genetic mutations that control cell cycles and is usually associated with excessive alcohol intake and tobacco use [2]. Lengthy and expensive diagnostic strategies often lack the ability to efficiently differentiate between normal and tumor tissue, which could delay the initiation of treatment. In addition, the traditional treatment of oral cancer, such as surgery, radiotherapy, and chemotherapy, has certain limitations and side effects [3]. Thus, it is crucial to increase the effectiveness of diagnosis and reduce the side effects of treatment.

Since long past the word “nano” has its applications and paved way into the world’s day to day performance. Nanotechnology is science of manipulating matter at the atomic, molecular, or macromolecular levels. [3] The prefix ‘‘nano’’ is defined as a unit of measurement in one billionth of a meter and is derived from greek word meaning Dwarf. Nanotechnology has vast applications. In human life which includes cancer nanotechnology. Cancer Nanotechnology is new technology that has the ability of diagnosing cancer, targeting therapeutic drugs to specific sites in the body using submicron nanoparticles (NP). [4]

Concept of nanotechnology was elaborated by Richard P Feynman in 1959 and popularized by K. Eric Drexler. The term was first defined by Norio Taniguchi of Tokyo Science University in 1974 as consists of processing of, separation, consolidation and deformation of materials by one atom or more molecules. [4, 5]

Application of nanotechnology is revolutionizing biomedical engineering by allowing new type of drug delivery, synthesis of modules, biofiltration system and robotic assembly. [3]

Nanomaterials

Nanomaterials in one dimension are termed as sheets, in two dimensions as nanotubes and nanowires, and quantum dots in three dimensions. [6] Properties vary from other materials due to 2 reasons: quantum effects and increased surface area. They have a much-increased surface area per unit mass compared to bigger particles. [3,4]

Nano diagnostics in oral cancer detection oral cancer is the most aggressive and common cancer-causing metastasis and has high mortality rate. Head and neck carcinoma ranks 6th most common cancer in world and survival rate has not improved despite countless studies on this malignancy.[5]

Nano diagnostics is the use of nanotechnology for clinical diagnostic purpose in order to meet demand of increased sensitivity and early disease detection. It has capacity to detect in vivo a single cancerous cell and deliver drugs directly to it. Nano shell, quantum dots, nanowires, dendrimers and nano sponges are some materials used for cancer detection. [7] Nanoparticles selectively target cancer cells and cancer biomarkers, early detection using minimal amount of tissue, monitoring the progress of therapy and destruction of solely cancer cells. [2]

Nanomaterials for cancer diagnosis

Different kinds of nanoparticles are suitable for drug and gene delivery including Liposomes, solid lipid particles, nanocrystals, nanospheres and nano capsules. [7] Gold nanoparticles target and illuminate cancer cells under reflectance based optical imaging system, they provide an optical contrast to discriminate between cancerous and normal cell.[6]

Gold Nanoparticles

Subtypes of gold nanoparticles such as gold nanosphere, gold nanocages, gold nanorods and surface enhanced raman spectroscopy (SERS) nanoparticles are widely available. [4]

Gold nanoparticles have a unique optical response to scatter light when excited at their surface plasmon resonance frequency. The epidermal growth factor receptor is a cell surface receptor biomarker over expressed in epithelial cancer. The anti-epidermal growth factor receptor antibody conjugated nanoparticles specifically bind to the surface of cancer type cells greater affinity than to non-cancerous cell. [3,4] The successful conjugation of antibodies on gold nanoparticles is ascertained by adding 10% common salt leading to aggregation of gold nanoparticles and results in visible color change from red to purple or gray. [5]

Gold nanoshells can enhance the contrast of blood vessels in vivo suggesting their potential use in magnetic resonance angiography as blood pool agents. [4]

SERS is an optical technique offering many advantages over traditional technologies, such as fluorescence and chemiluminescence, better sensitivity, robustness and superior performance in blood and other biological environment. [4]

Quantam Dots (QDs)

Qds are semiconductor nanostructures which are 25 billionths of a meter in diameter and confine electrons in three dimensions emitting light when exposed to ultraviolet radiation. [2,3] They are fluorescent nanoparticles measuring 2-10 nm with a core of 100s-1000s atoms of group II and VI elements (cadmium, technetium, zinc and selenide) or group III (tantalum) and V elements (indium). They can produce reactive oxygen species and can be lethal to the target cells. [1,4] They contain a core of cadmium selenide and shell of zinc sulfide, surrounded by ligand and an amphiphilic polymer coating. Qds can emit between 450 nm and 850 nm (from ultraviolet to near infrared) by changing the size or chemical composition of the nanoparticle. Disadvantage includes the toxic effect of metal core. [4]

Nanocapsule

It is now possible to engineer tiny containers the size of a virus to deliver drugs and other materials with almost 100% efficiency to targeted cells in the bloodstream. [7] Drug targeting by nano capsules offers the following advantages: Reduces dosage and minimal side effects, ensures the better pharmaceutical effects, protects drug degradation and enhances drug stability. [6]

Single walled Carbon nanotubes (SWNTs)

They move into cells through the process of endocytosis enabling them to enter the cytoplasm and nucleus. [7] In order to fight cancer, functionalized SWNTs are targeted specifically to the malignant cells, ensuring that healthy cells are not adversely affected by the treatment. The cancer cells are distinguished by locating alterations on them that are not on healthy cells.[5] Coating functionalized SWNTs with peptides and cell-binding ligands like monoclonal antibodies allows them to target specific cancerous cells. Once inside the radiofrequency field, SWNTs can effectively convert radiofrequency energy into heat. They absorb the arriving waves of radiation causing them to vibrate. [1] The vibrational movement causes heat to be produced and thermal properties to activate transferring heat to the length of nanotube. [2] Heat is then dispersed inside the tumor from the entire surface area of the SWNTs causing overheating, protein denaturation and eventually malignant cell death. [2]

Liposomes

Nanocarriers encounter numerous barriers en route to their target. Liposome molecules are easily diffusible into the cells. Their structures and cell membrane structure can interact very well while drug uptake process. [8]

Advantages of Nanoparticles

Nanoparticles provide accuracy, precise treatment of diseases and drug delivery. Other uses of nanoparticles in field of medicine and cancer are fluorescent biological labels, bio detection of proteins and pathogens, drug and gene delivery, probing of DNA structure, tissue engineering, tumor destruction through hyperthermia, separation and purification of biological molecules and cells. [7,9]

Disadvantages of nanoparticles

Dependency on surface chemistry, biocompatibility, availability and cost of nano treatment are the major limitations of nanoparticles. [8,9]

Recent advances

Cancer nanovaccines

It is under development. The first is prophylactic type which triggers humoral and cellular immunity and administering into healthy individuals prevent them from getting cancer, eg. Human papilloma virus vaccine. Second vaccine called as nanovaccine is for thosw already suffering from cancer. [9,10]

Nanomedicine heat therapy

A laser optic probe is used, which ensures that the infrared radiation is directed at the tumor and allows the treatment through the skin. [6,10] this new heat treatment is similar to the current method of radiation therapy, but the nanoparticles cause minimal damage to the healthy tissue. [8]

Conclusion

Nanoparticles are as means for earlier detection and better treatment of cancer. Imagine a future where nanoparticles can detect cancer before it manifests and selectively destroy cancer cells leaving the normal cells unharmed. Cancer then could become a highly manageable condition. Nanoparticles may offer a new avenue to tackle these challenges.

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