Assessment of Application of Nanotechnology in the Treatment of Cancer

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Abstract

Cancer is one of the leading causes of death, affecting millions of people each year. But cancer treatment has not been very successful due to its limited drug access to cancer tissue, intolerable toxicity, and multiple drug resistance. In recent years, new methods of cancer treatment have been proposed to better identify tumor biology and advances in nanotechnology. Prevention, early diagnosis and treatment have been the main applications of nanotechnology in cancer, In this study, which was conducted in the form of a review through the collection and summary of research, the purpose of the application of nanotechnology in the treatment of cancer is discussed. Liposomes, nanoparticles, polymeric micelles, nanoparticles, magnetic nanoparticles, and gold nanoparticles have been the most important tools used to detect cancerous tumors through imaging and drug delivery systems. They have also helped minimize problems and damage to healthy cells as a result of radiotherapy and chemotherapy and other common cancer treatments. The results of this study show that despite the unique and special features of nanotechnology tools, it is possible to quickly diagnose and treat most cancers.

Keywords: Nanoparticles, Nano therapy, Nano magnetism, Chitosan, cancer treatment

INTRODUCTION

Cancer is a deadly disease with high mortality, which leads to many psychological and economic conflicts. Lifestyle is one of the most important and effective factors in the incidence of cancer. Environmental factors such as environmental pollutants, carcinogens and mutagenicity's, bacterial and viral infections, as well as genetic susceptibility are the most important factors influencing the incidence of cancer, depending on the type, progression of the cancer, the extent of the disease and the condition. The patient uses a combination of different methods such as surgery, radiotherapy and chemotherapy to fight and control cancer. The possibility of side effects in advanced cancers is not a positive result from these common methods, and the need for research and finding new ways to fight cancer is essential (Khatami, 2017).

Nowadays, nanoparticles have become very popular due to their wide range of applications in various fields of biology, medicine and medicine. Structurally, its size is in the range of 100 nanometers. A wide range of drugs, such as small hydrophobic and hydrophobic drugs, vaccines, and biological molecules, can be guided by these nanoparticles. Nanoparticles have a wide range of applications in the treatment and diagnosis of cancerous diseases. Nanoparticles in the form of Nano composites, cranial nanotubes, Nano fibers, Nano carriers have been widely used for drug carriers and cell scaffolding. Applications of nanoparticles in drug release include drug carriers in diseases such as cancer, cardiovascular disease, and Alzheimer's. Due to their small size, nanoparticles can also be used in brain cancers (Naserian, 2018).

Nanotechnology uses Nano bots that can easily drink a drinking cherry; They enter the human body and repair cells and tissues, Nano bots are so volatile that they can even be dissolved in water like a powdered sugar and drunk, or they can be injected into the body's arteries with a syringe. As robots, these robots can always be present in the human body as a soldier, and they can control the function of the organs of the body by controlling them with a Nano computer, or they can fight germs like white blood cells (Karimzadeh, 2005).

The main purpose in making nanoparticles as a drug release system

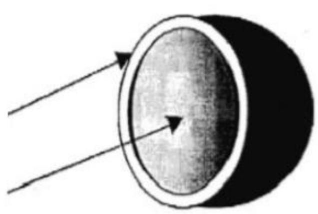
Particle size control, surface properties, and drug release are specific and effective at specific locations and time intervals for the drug to be as effective as possible. The nanoparticles used to release the drug must have biocompatibility, Drug Compatibility, biodegradability, as well as be released in proportion to time, and have optimal mechanical properties and easy manufacturing process. Nanoparticles can be categorized in different ways: they can vary in size, shape, and materials.

Nanoparticles are divided into the following types in terms of appearance:

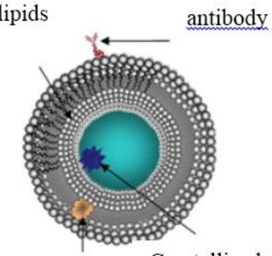
1- Dendrimers
2- Nano spheres
3- Nano capsules
4- Liposomes
5- Micelles
6- Fullerenes and nanotube (Naserian, 2018).

Dendrimers

The structure of a Nano sphere



The structure of Nano capsule



The structure of a Nano Liposomes

In other studies, nanoparticles are divided into organic and mineral categories in terms of their constituent material. In organic matter, organic molecules are the main constituent of nanoparticles, and in the mineral category, metals (iron). , Gold) and mineral elements play a major role in the nanoparticle structure. In another category, nanoparticles are made from macromolecular or polymeric materials, natural or synthetic, which are classified into two types of Nano spheres and Nano capsules according to their manufacturing method. Nano capsules are sac-like structures in which the drug is placed in a container in the center and surrounded by a layer of polymer. Nano spheres are cubic systems in which drugs and polymers are homogeneously distributed or absorbed on their surface. Polynomials used as nanoparticles are associated with drugs that have a specific therapeutic purpose for a specific disease, including cancer, which are associated with Nano carriers in two ways: (1) in Nano carriers. Encapsulated (trapped), (2) Drugs are absorbed or absorbed on the nanoparticle surface of the conjugate (chemical bond) (Naserian, 2018).

Table (1) Application of Nano scale in medicine, (Jen Jon, 2010)

Drug	Nano-scale carriers can (1) increase the therapeutic effect and reduce the negative effects of some drugs; (2) make new categories of treatment available; (3) Reinvestment in serious molecular institutions optimized and biologically active
Diagnosis	Nanotechnology-based sensors (such as Nano fibers, nanotubes, nanoparticles, micro- and Nano technological bases and rows) can provide high-speed, high-sensitivity operational capabilities to detect disease biomarkers with higher sensitivity and make it possible to consume less samples.
Intra-body imaging	Targeted imaging nanoparticles (such as magnetic nanoparticles, quantum dots, and carbon nanotubes) can provide faster, less harmful and more accurate ways to diagnose diseases (such as cancer). Present their early stages and monitor disease progression.
Biomaterials	Biocompatible Nano materials have optimal mechanical properties that can be used as medical implants as well as dental restorations and bone replacement. Nano-coatings with a nanostructure can enhance biocompatibility and biocompatibility.
Tissue Engineering	Nanotechnology can design and build biocompatible scaffolds at the Nano scale and space-time control of the release of biological factors, super cellular matrixes to guide cell behavior, and of course to achieve the construction of implantable tissues. Make.

Chitosan

It is an abundant natural polysaccharide that is known as a carrier of nanoparticles due to its very beneficial properties. Compared with synthetic polymers, chitosan obtained by chitin acetylation is suitable for the formation of Nano gels due to its biocompatibility, biodegradability and better stability and low toxicity. However, the low solubility of chitosan in alkaline and neutral environments, due to the large number of amino groups in its chain and the formation of strong hydrogen bonds and stable crystal structure, limits its use in pharmaceutical and biomedical applications. As a result, a significant number of different modifications of chitosan have been used. To overcome these problems, polyethylene glycol methyl ether is an excellent hydrophilic polymer that binds to the chitosan chain not only optimizing the biocompatibility of chitosan. But also avoids protein absorption and escape from the Reticuloendothelial system (Naserian, 2018).

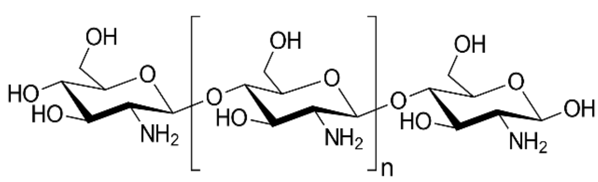


Figure (2): Chitosan construction formula

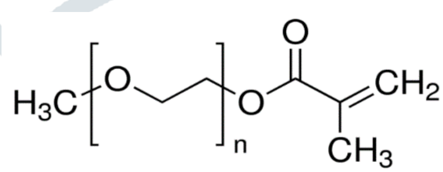


Figure (3): Polyethylene glycol Methyl ether

mPEG-Chitosan

A controlled release system was performed to load the FU-5 (5-Fluorouracil) drug (a cancer drug) in which chitosan was used as a cross linker and mPEG was designed as a hydrophilic commune mer. -Chitosan is fast, and these Nano gels are non-toxic and cell-compatible, so mPEG-Chitosan Nano gels have the potential to properly develop Nano carriers in cancer treatment (Naserian, 2018).

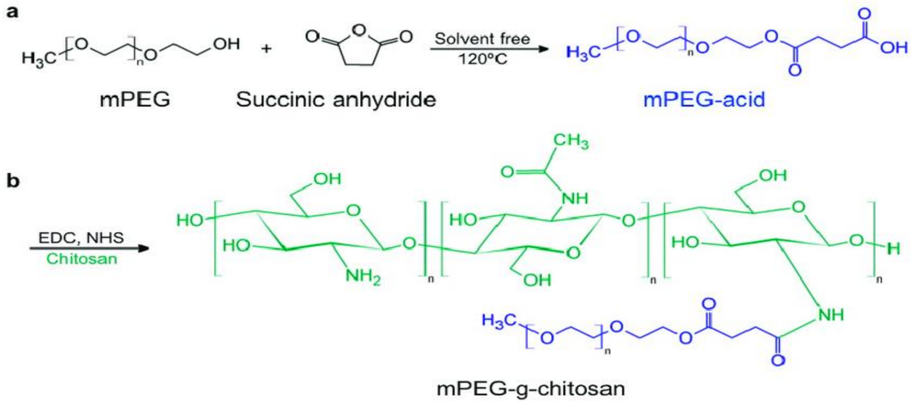


Figure (4): Synthetic-route-and-chemical-structure-of-a-mPEG-acid-and-b-mPEG-g-chitosan

Nano particle chitosan Pluronic

Pluronic chitosan nanoparticles were prepared by ionic gelation method, chitosan-pluronic nanoparticles were loaded with tamoxifen (C26H29NO molecular formula) and had good blood compatibility, and it was shown that these nanoparticles can be effective as a carrier for drug release. Use breast cancer treatment (Naserian, 2018).

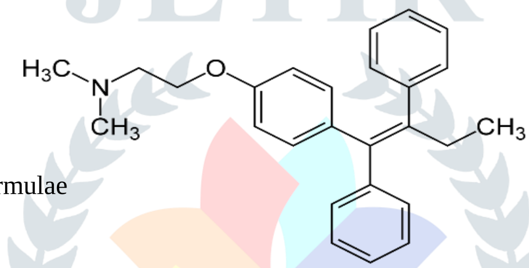


Figure (5): Tamoxifen Structural Formulae

Albumin nanoparticles with a coating of chitosan

Increased cellular uptake has been shown to be siRNA. The administration of siRNA in In vivo (intramuscularly) using chitosan-based nanoparticles reduced the expression of the target gene by 80%, resulting in the death of the cancer cell (Isfahani, 2016).

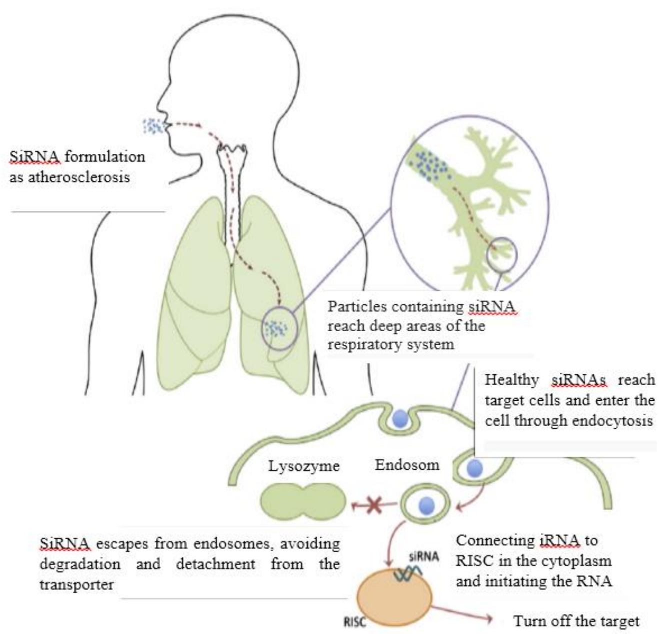


Figure (6) shows the stages of siRNA transfer to the lungs

DXT-DOX Nano Capsule

Doxorubicin has the molecular formula C27H29NO11, also known as DOX. It is another cancer drug used in studies with Dextran. The results showed a rapid release of DOX following a steady slow release that resulted in the release of 32% of the DOX entered within 15 days, which was a good result. It was also used in conjunction with the widely used polyethylene glycol polymer.

Doxorubicin is one of the most effective anti-tumor molecules in the treatment of metastatic breast cancer, which is produced together with colloidal carriers of biodegradable poly nanoparticles (butyl cyanoacrylate) (PBCA NP) (Naserian, 2018).

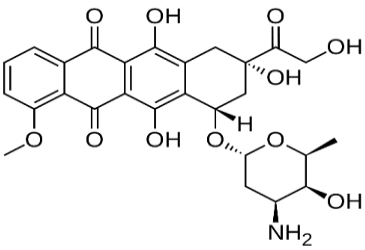


Figure (7): Skeletal formula doxorubicin

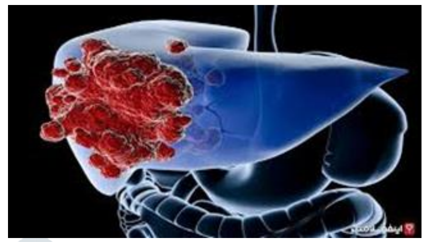


Figure (8): Metastatic breast cancer

Nano Particles

Nanoparticles attach to the surface receptors of cancer cells after binding to active chemical components such as antibodies and ligands, preventing their clearance by blood. Drug supply by nanoparticles using biodegradable polymers solves many problems. Two types of strategies for targeting cancer cells, including active and inactive, cause nanoparticles to be directed toward cancer cells (Shamsi, 2019).

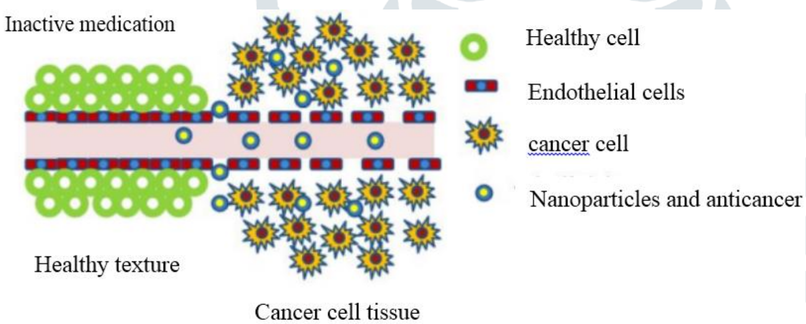


Figure (9): Passive targeting using leaky tumor capillary network in nanoparticles

The use of gold nanoparticles in cancer diagnosis

Gold is a very good material for absorbing and scattering light. Many cancer cells have a type of protein called EFGR on their surface that receives the epidermal growth factor, while healthy cells do not. By attaching anti-EFGR antibodies to gold nanoparticles, the researchers were able to bring the nanoparticles to cancer cells and attach them to them, and then use a microscope to see the dark background of the cancer spots brightly under a microscope. These nanoparticles are unable to bind to healthy cells; In this way, healthy cells look darker than cancer cells. Another potential use of gold nanoparticles in relation to cancer is the destruction of cancer cells. In studies, researchers have used these laser particles to heat up cancer cells by destroying them (Sadat Hosseinian, 2015).

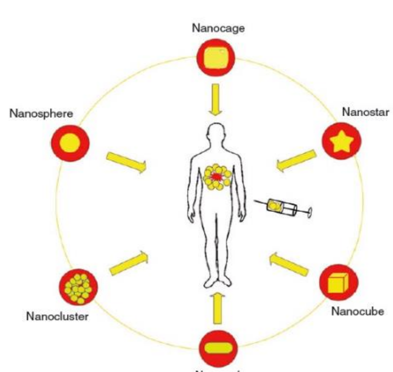


Figure (10) Different gold nanostructures used in biomedicine

Table (2) summarizes the intelligence and application of gold nanoparticles

NO	Factor group	Ligands / carrier molecules	Key features	Application
1	PEG	PEG with tulle ligands	Connection to the cell membrane	Cellular and intracellular targeting, biological studies
2	Amini Group	PEG	Sponsor siRNA	Useful in RNAi (RNA interference) technology and related matters
3	Carboxyl group	proteins	-	Depending on the type of protein
4	Peptide	Cellular surface receptors, antibody, inhibitory peptide, amyloid, sweet peptide, ectroid peptide	Displacement in the cytoplasm and nucleus, targeting cancer cells similar to somato statin	Cellular and intracellular targeting, imaging of cancer cells
5	DNA	Optamer, polyethylene glycol-poly beta amino ester gold, single-stranded DNA from the RNAi gene, allogeneic DNA anti-sensory DNA	Targeting prostate cancer cells, carrying siRNA, binding to the anti-sensory RNA	Bio imaging, delivery of RNAi gene regulation through gene expression, identification of certain specific genes, for example in microbial identification

(Sadat Hosseinian, 2015)

Cancer treatment with magnetic nanoparticles

Magnetic nanoparticles have a high practical importance in the diagnosis and treatment of cancer due to their special magnetic properties. Examining the numerous sources and studies conducted in this field, it can be concluded that loading anti-cancer drugs on magnetic nanoparticles has an effective role in enhancing drug performance and eliminating cancer cells. Research results show that Nano Magnetic particles enhance the function of anticancer drugs (such as doxorubicin and cis platinum) by killing cancer cells by enhancing the production of active oxygen species or other unknown mechanisms. In other words, magnetic nanoparticles increase the cellular toxicity of the anticancer drug and also play an important role in the transfer of the drug to tumor cells.

Magnetic resonance imaging is a common method used to diagnose and identify tumors and cancer. The use of magnetic nanoparticles in this method has made this method more sensitive and accurate in diagnosing cancer, so that cancer can be diagnosed in the early stages and effective treatment measures can be used for its definitive treatment. The special magnetic properties of magnetic nanoparticles can also be used in targeted drug delivery. These nanoparticles, especially iron oxide magnetic nanoparticles, can be used as Nano carriers in pharmaceutical nanoparticles due to their ability to encapsulate anti-cancer drugs and their high biocompatibility and low toxicity, as well as their ability to concentrate in tumors, Significantly reduced (Ghanbari, 2014).

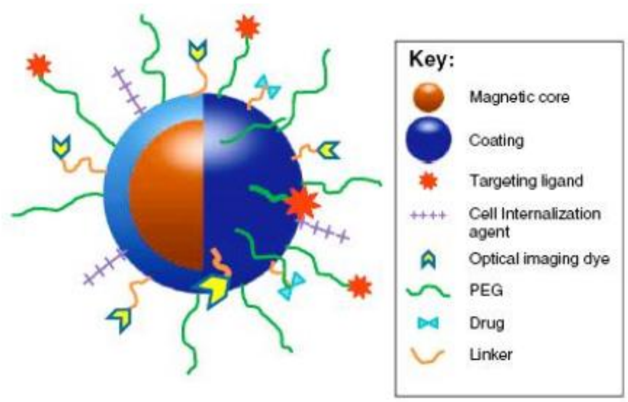


Figure (11): Image of the structure of the shell / core of magnetic nanoparticles and its surface decoration with different performance groups, These particles are composed of magnetic iron oxide nuclei and a coating of biocompatible materials such as polysaccharides, dextran, chitosan, poly ethylene glycol and polyvinyl alcohol Functional groups at the Nano-particle coating level have been used to bind ligands for molecular targeting, nanoparticle transfer to cancer cells and targeted drug delivery, and other therapeutic applications such as hyperthermia and magnetic resonance imaging.

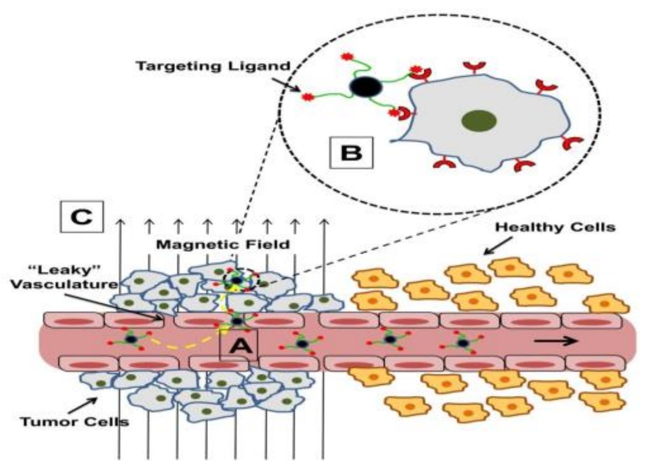


Figure (12): Image of different modes of targeting magnetic nanoparticles in tumors, passive targeting by EPR (A): Active targeting of magnetic nanoparticles with the help of molecular ligands, (B): Magnetic targeting, (C): This figure indicates that depending on the measures Used, each of these methods can be used together at the same time.

Destruction of cancer cells by frequency radio nanoparticles

The use of non-radiofrequency (RF) waves is one of the most common methods of heat treatment in oncology clinics. Non-ionizing radiation can be used as adjunctive therapy to enhance the toxic effects of chemotherapy and radiotherapy on cancer cells. In addition, thermal degradation of uncut tumors, such as hepatocellular carcinoma and colorectal metastasis, is possible by RF radiation.

Near-infrared (NIR) waves can be used to heat cancer cells, but only for superficial malignancies. Unlike NIR waves, RF waves can effectively penetrate the body, which is a positive point in the treatment of deep tumors (Pour Fallah, 2018).

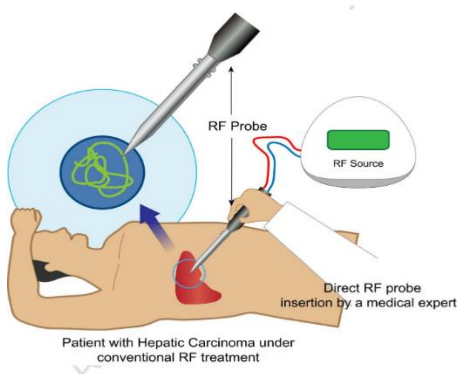


Figure (13): shows the schematic image of the RF beam inserted into the hepatic carcinoma to destroy the RFA electrode-based tumor to the RF regenerator. Heating is caused by ionic turbulence around.

Nano- Photo- thermal therapy

In Nano photo thermal therapy (NPTT), tumor elimination is performed selectively with the target of cancer cells sensitive to laser-sensitive nanoparticles and simultaneous laser light irradiation. With the invention of nanoparticles such as gold nanoparticles (AuNPs) and the modification of the photosynthetic properties of materials with the introduction of such nanoparticles in them, the conversion of laser light energy into heat increased and led to the development of local hyperthermia. In addition to AuNPs, other special nanostructures that respond to laser light have been developed for targeted photo thermal therapy. For example, carbon nanotubes such as carbon nanotubes, Fullerene, and Grapheme have recently created great potential for NPTT (Pour Fallah, 2018).

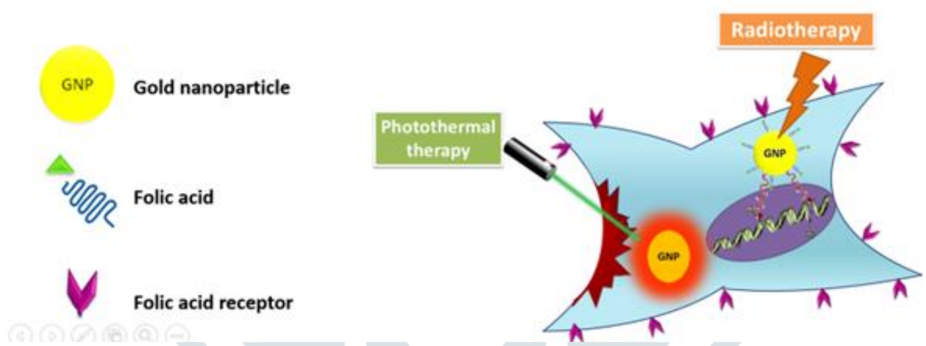


Figure (14) Increases the susceptibility to degeneration of cancer cells through folate conjugated gold nanoparticles as opposed to dehydration by Nano photo thermal hyperthermia.

Nanotubes

Recent advances in targeted cancer treatment have led to the invention of nanotube molecular machines. Nanotubes have revolutionized cancer diagnosis and treatment. Nanotubes are made of organic and intelligent materials that are programmed into units through the genetic embedding of their structure. Most Nano-robots can consist of one or more chemical strings from a single sensor factor, each of which is activated by a specific factor. The Nano-robot delivers the loaded cytotoxic agent to the target cell. In addition, the loaded agent may be composed of a drug or a single fluorescent depending on whether it is therapeutic or diagnostic (Salehzadeh, 2014).

Several classes of Nano-robots have recently been invented. Douglas et al has developed a DNA-based Nano bot that can be used to treat lymphoma and leukemia. These nanotubes are made up of a series of DNA strands that are arranged in two-dimensional chains and eventually become a three-dimensional structure that can be opened and closed selectively. Each robot has the capacity to load two molecules. The Nano-robot consists of a gold Nano cell and an antibody component. It is a molecular sensor that detects the surface antigens of certain cancer cells. After identifying the cancer cells, the contents are dissolved and the loaded material penetrates into the cancer cells and causes Destroys cancer cells (Shamsi, 2019).

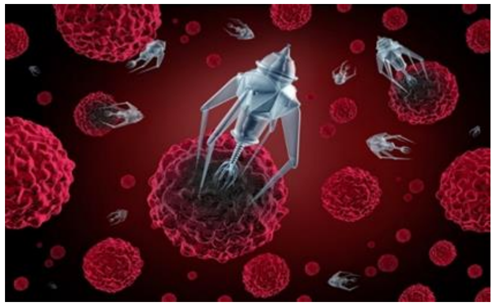


Figure (15) Nanotubes in the treatment of cancer

Emerging methods of cancer treatment

Thermal treatment

Thermal therapy, also known as hyperthermia, is known as a cancer treatment that uses heating the tumor tissue to sensitize cancer cells to the effects of radiation or chemical drugs or to kill them. Under this process, cell physiology changes in such a way that it eventually leads to their death.

The hyperthermia process consists of three periods:

1- Thermal removal: If the temperature of the tissue is raised to more than 46C°, the heated tissue is completely destroyed and undergoes the carbonization process.

2- Moderate hyperthermia: If cells are heated to a temperature between 41Co and 46Co, they undergo processes such as the interconnection of DNA strands or the destruction of proteins, leading to an inability to perform biological activities. This process will eventually lead to cell death. The increase in tissue temperature in this range is the cause of reversible destruction of normal cells and reversible destruction in cancer cells.

3- Diathermy: The use of low-temperature tissue heating at 41 Co has largely no therapeutic effect in cancer and is common for physiotherapy (Khafaji, 2016).

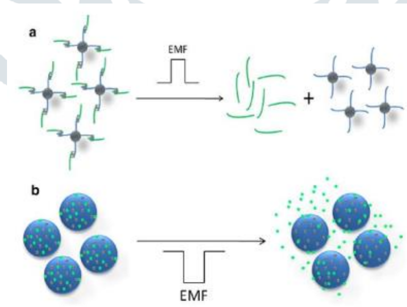


Figure (16) Chemistry of two drug delivery methods controlled through the hyperthermia process

Photodynamic therapy

PDT (Photo Dynamic Therapy) is a method in which a light-sensitive substance is activated by exposure to radiation and produces a unique oxygen. The active species produced will eventually kill the cells. There are three main mechanisms for tumor destruction: direct cell toxicity, vascular damage, and immune responses. In direct cell toxicity, short-lived toxic species are produced, And in a short time, they cause the cells to die. Profirines, chlorines, and bacteria chlorines are common light-sensitive materials.

Silica (Si) nanoparticles show significant performance in PDT by increasing solubility, stability of sensitive optical compounds, and drug aggregation in tumor tissue. The binding of light-sensitive substances to proteins such as albumin increases their accumulation in tissues such as the breast, ovary and uterus, which can be used to treat cancer in these areas with higher efficiency (Khafaji, 2016)..

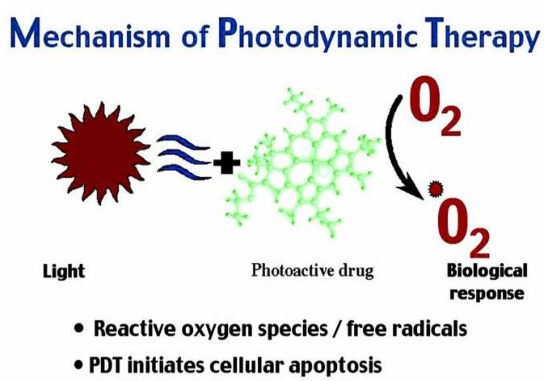


Figure (17): Using Photodynamic Therapy to Kill Hard-to-Reach Tumors

Conclusion

Diagnosis plays a major role in the treatment of cancer. Therefore, in recent years, the development of nanotechnology and the application of various nanoparticles in the field of medical sciences, efficient and low-risk techniques with greater impact than methods. Common in this area has been examined, Among them, nanoparticles have been widely used for a variety of applications, especially for drug delivery and diagnostic and imaging. Currently, a large number of drug delivery systems are made of nanoparticles. Different substances have been used as stimulants or enhancers to improve the effectiveness of treatment and to maintain stability, as well as the safety of anticancer drugs.

Magnetic nanoparticles in cancer cells are performed in two ways: active and inactive. In the active method, purposeful nanoparticles are transferred to the tumor using specific molecular ligands of tumor cells and by irradiating the external magnetic field to the tumor area. However, in the inactive method, they are enhanced by the permeability effect and the nanoparticles remain penetrating the tumor. Magnetic nanoparticles in medicine have led to the development of targeted and effective therapies for cancer treatment that can reduce the side effects and biological damage caused by chemotherapy in patients.

Mineral nanoparticles such as quantum particles, which have a central core with magnetic properties. Organic nanoparticle systems such as liposomes, solid lipid nanoparticles, and aptamers can be used for cancer diagnosis and imaging. Nano bodies are also antibody molecules that are widely used in the diagnosis and treatment of cancer.

Although there are still challenges and limitations to the use of nanoparticles in medicine, it is hoped that in the near future nanoparticles in medicine will create a great revolution, and all the diseases that exist in the world. Be treated with this nanotechnology.

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