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Review Article

Theranostic Nanosystem for Targeting Cancer Cells

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Abstract

Nanoparticle offer several advantages Background for many applications due to its various properties like physical, chemical, biological. Nanotechnology have been use for many purposes like Imaging,Treatment and diagnosis. This multifunctional nano designs is used for targeting cancer therapy by their physiochemical properties they are delivered to target and activate by their internal and external stimuli.The review will focus on chemical design of stimuli response nano system to achieve a tumor targeting. Furthermore, it will enhance the cancer therapy. we will also summarize the smart nano system response to external stimuli like magnetic field, electric field, lightand internal stimuli for targeting tumor. The ranostic Nanosystems have potential for the future disease management. There has been a growing interest in the various kind of theranostic nanoparticle for cancer imaging and therapy in small animals. The ranostic nanoparticle use for diagnostic as well as therapeutic purposes.

Keywords: theranostic; nanoparticle,stimuli; magnetic field

Introduction

a.Theranostic : - Theranostic is a combination of the terms therapeutics and diagnostic. It permits us to diagnose disease in individual and then use identical or closely related agents to treat these diseases. [1-3]

b. Nanosystem_ Nanoparticle are targeted drug delivery and controlled release of therapeutic agents. This drug delivery system is a modern form which will minimise side effects and also reduce the dosage frequency with lowering the mass of nanoparticle.Thus achieving greater frequency .[2]

c.Theranostic Nanosystem: Theranostic nanoparticles are multifunctional nanosystems well designed for specific and personal Theranosticized disease management by virtue of their combining diagnostic and therapeutic capabilities into a single biocompatible, biodegradable particle .[1-3]

Theranostic nanoparticles must accumulate rapidly and selectively in target organ of interest, report biochemical and morphologic characteristics of disease, efficiently deliever sufficient drug on demand without damaging healthy organs, clear from the body within hour or be degraded into nontoxic by products.[3]

Cancer

Cancer caused by uncontrolled growth of abnormal cells. These cancerous cells called as malignant cells. Cancer occur when genetic material of cell will change which cause result in the growing out of control of the cells.Cancer is one of the disease which caused the level of complexity which demand for the multi-step diagnosis and treatment. Theranostic nanosystem having diagnostic as well as therapeutic activity having the multifunctional property which leads in the treatment of cancer cells and it will detect the cancer cells at the early stage which help to know the Physicianprogression of cancer cells. [7-12]

Advantage and disadvantage

Advantage

1.Nanotheranostics having advantage with the nanotechnology in order to diagnose and treat specific disease.

2.It is acting as a multifunctional nanoparticle in particular have been designed for targeted cancer therapy by the usage of various physical and biological stimuli.

3.It is relevant for personalized medicine, allowing detection of disease at early stage.

4.it also improve the safety profile of the given treatment.

5.Nanotheranostics are the agents which will treat the disease at the molecular and cellular level due to which it causes lesser side effects. (1-3)

Disadvantage

1.It is an expensive process.

2.Skill is required.

3.Nanotheranostics sometimes for the longer duration it will cause toxicity.

4.Nanotheranostics some of them only got approved some are still under pre-clinical and clinical trials.

5.Selection of the best nanoparticle for the treatment is still a challenging part. (7)

Preparation of Nano the ranostics

Theranostic is a combination of therapeutic and diagnostic agent in which nanoparticles is incorporated which show its therapeutic effect for the treatment of cancer. Nanoparticle are the agents used as a controlled drug release to reduce the side effects. Nanoparticles are prepared by several methods. The most commonly used methods are nanoprecipitation, salting out, solvent evaporation, desolvation method etc.

Theranostic is an emerging field of medicine whose name is combination of therapeutic and daignostic.The idea behind the theranostic is to combine drugs or techniques to simultaneously or sequentially daignose and treat medical conditions and also monitor response of the patient.Nanoparticle that units the daignostic molecules and drug into a single agent here the nanoparticle act as carrier molecule In the form of drug .A drug for the cancer treatment targeting specific biological pathway in the patient body avoiding damage to the healthy organs and tissues.Once at their target tissue , the nanoparticle produce daignostic images and dilevery their drug.(6)

Mechanism and it's classification

There is various mechanism for the Nanotheranostics delivery:

1.Stimuli responsive stratergies for nanotheranostics delivery:

Nanoscale particles have the ability to accumulate in tumors However, they are required to release the drug or trigger it at predetermined sites for the intended purpose. The nanosystems will enhance drug targeting delivery.It will also increase the local concerntration of drug with in the cancer cells.The stimuli-dependent nanotheranostics systems for cancer theranostics are targeted at cellular environments in a and also ensure the release of drug in a coordinate sequence.[1]

2.stimuli responsive nanotheranostics

2.1pH sensitive Nanotheranostics: -

This nanotheranostics is used for triggering the drug Carrier. When pH induced zno will generate O2 species in cellular medium where fluorescence imaging can be done. The green fluorescent nanowires which are used for targeting cancer cells in this study it was observed that signal of fluorescence zno nanowires was lower at third hour as compared with the first hour as it was showing possible dissolution of nanowire in acidic medium.

It was observed that dissolution of drug in the tumor changes gradually which is absorbed by green fluorescence.(1)

2.2Enzyme linked Nanotheranostics

Enzymes are the biological catalyst which is designed for the high specificity for therapy and diagnosis purposes.

Case study 1: - In this FRET (forester response energy transfer) combination with nanosystem was designed consist of lysine junction covalent linkage which involve combination of doxorubicin fluorescent Drug with response to lysosomal cat B which is efficient theranostic. It showed that nanosystem can be a promising candidate for Nanoscale enzyme-based delivery in the combination of cancer treatment and diagnosis. Therefore, enzyme based theranostics system can exhibit desirable technique to make better theranostic clinical candidate in the future.(1)

3. Magnetic Nanotheranostics

It is one of the most efficient ways of physical stimuli drug delivery system. It will work in the presence of magnetic field. Magnetic nanoparticles consist of multilayered which have ability to diagnose and imagine which further act as a drug carrier. It is layered with lactoferrin as a cap with mesoporous iron oxide nanoparticle which enhance deeper penetration to the tumour.

It consists of gas generated molecules perfluoro hexane anti-cancer drug paclitaxel the combination of lactoferrin magnetic iron oxide nanoparticle cause bursting generation of gas where drug delivery occurs upon magnetic field exposureIn vitro study showed that a short exposure of magnetic field can cause intense heat which cause increase in the local pressure and it will damage three dimensionally tumor to increase the drug localization.(1-6)

4. Novel material

Carbon nanotubes (CNTs) has gained much interest due to their efficiency in delivering theranostic load into cellular compartments, Various findings have speculated that the translocation of CNT-based systems through the cell membrane usually follows a pH-independent passive process. Theranostic prodrug which was based on multi-walled carbon nanotubes (MWCNTs), strategically decorated with a fluorochrome and anticancer agent (methotrexate, MTX). An independent cytoplasmic delivery of the theranostic prodrug via cellular pathway was observed.

CNT drug delivery systems can be used to deliver theranostic agents into the cytoplasm.Carbon nano-based theranostic delivery with surface functionalization to ensure specific targeting to tumor cells while relying on drug penetration effect the release of carbon nanomedicine will enhance delivery of theranostic system for cancer therapy (1-4)

5. Nanotheranostics for circulating tumor cells (CTCS):

It was estimated that 90% of cancer death occur due to circulating tumor cells. A novel strategy was developed for both diagnostic and therapeutic purposes where gold nanotube will coated with the peg and with folate.A spericalmagnetic nanoparticle is coated with peg and their amphiphilic polymer was conjugated with amino acid and fragment of Eurokinase plasminogen activator receptor is added a mixture of (ATFuPAR)and magnetic nanoparticle. This was injected IV into targeted circulating tumor and it was successfully targeted circulating tumor cells.(1)

Application

1. Theranostic nanomedicine

Theranostic nanomedicine is a combination of Diagnostic and therapy activity. Some popular nanomedicine example gold nanoparticle, magnetic or carbon nanotube are mostly used as a an advanced theranostatic system will recognize specific target bind and will give its action.[13]

2. Combinational delivery approaches

This delivery will enhance the effectiveness of cancer through IV it involved mainly multiple chemotherapeutic drugs and Co delivery of chemotherapeutic drug. (9-12)

3. Liposomal delivery system

Liposome are closed bilayer structure which consist of water insoluble polar lipid that is used to encapsulate the drugand target theabnormal cell by protected their bioactivity.Liposomal is a good choice for drug carrier system currently available liposomal formulation for drug carrier system. Currently available several liposomal formulations for cancer therapy are doxorubicin (doxil), daunorubicin. (8-13)

4. Ultrasonic image guided therapy

Nanobubble will enhance permeability of cell and cause increase in the drug delivery system the doxorubicin containgnanoemulsion which is made up from perflurocarbonnanodropeletsStabalize by biodegradable copolymer micelles.

This group showed that the release of encapsulated drugs can be achieved and can enhance tumor-specific drug uptake, along with the ability for real-time imaging using ultrasonography. These Nano agents showed both ultrasound and fluorine properties, allowing for multimodal monitoring of delivery and bio distribution through ultrasonography.(9-13)

5.Carbon nanotubes drug delivery:

CNTs can be single-walled or multi-walled, and can be used in multifunctional applications, including photoacoustic imaging, bio sensing and cancer cell detection, drug delivery, and photothermaltherapy.
In drug delivery applications, CNTs are able to enter cells and even cell nuclei thanks to their small size, and they can be functionalized with different moieties in their inner and outer surfaces for targeting and conjugation. The

single-walled CNTs conjugated to the chemotherapy drug paclitaxel showed 10 times higher tumor uptake than for the free drug in a breast cancer model. (10-13)

Challenging and future direction:

Theranostic Nano system can be a best approach for future as novel approach. But many major challenging must be overcome such as selection of best nanomedicine, efficacy, high reproducibility.It shows high sensitivity and quantification of PET imaging, radiolabeling where FDA approved therapeutic nanoparticle example liposomal doxorubicin which shows highly strategy to visualize and accurately biodistribution and pharmokinetic property of nanoparticle.

Nanoparticle with therapeutic and imaging such as gold nanoparticles will be another way to develop future theranostic nanosystem for active targeting tumor cells. Even research shows that a well-designed nanosystem in vivo to amplify cancer targeting efficacy. Such concept of vivo targeting hold a great potential for improving tumor targeting capability and may become one of the most interesting research directions for over next 5 years. This is the growing interest in developing theranosticnanosystem for even smarter cancer therapy.

Conclusion

Cancer is a lethal disease that is prevalent all over the world. The biology of cancer has largely been understood by advanced scientific practices. Conventional cancer diagnostic and therapeutic procedures have failed to eradicate cancerous cells effectively from the body. Moreover, From past years Nano therapy is solving many issues related to conventional chemotherapeutic.Nanotheranostics has been combined solution for all issues related to cancer imaging and treatment. Nanomedicine has come with advance nanosystem. It has huge potential to reduce multidrug resistance and enhance selectivity and solubility of nanoparticles. It is evident that the efficacy of nanoparticles depends on their size, surface charge, surface area, and multipotency. Nanoparticles for effective drug delivery need to be stable, easy to fabricate, biocompatible, biodegradable, and nontoxic and possess a capability to release the loaded drug to only targeted site with minimum side effects. Tumor heterogeneity is a major challenge in the development of nanomedicines for targeted delivery in the remedy of cancer. Nevertheless, many such Nano formulations are in clinical trial phase and there is need for more preclinical models so that their targeting effectiveness could be tested. Multiscale modeling and computational models should be used for designing of nanoparticles in order to escalate more advanced targeted drug delivery.

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