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APPLICATION OF NANOTECHNOLOGY FOR CANCER TREATMENT: WITH AN EMPHASIS ON DRUG DELIVERY

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ABSTRACT

Nanotechnology at a molecular level has a multidisciplinary scientific potential that demonstrates exclusive and dynamic promise capacity to introduce revolutionary advantages in the medical sector through means of medicine, packaging of medicine, genome, and robotics. The motive of the research is to comprehensively explore the potential and implementation mechanism of nanoparticles in treatment of carcinoma through effective drug delivery approach. The review paper tries to highlight all the prominent components of the drug delivery approach opt by nanoparticles for the medication of carcinoma. The paper also highlights the nanoparticle carriers like liposome, dendrimers, micelles, gold nanoparticles, among others. Additionally, it describes the challenges, role and future perspective of the nano particle and its utilization in effective drug delivery mechanisms. The outcome demonstrated the capability of nanoparticle technology for drug delivery mechanisms to provide an anticancer therapeutic approach. It was explored that the nanoparticles approach is widely getting attention because of its specialty toward carcinoma targeting sites and deficiency of different intrusive toxicity potency due to the restricted pattern of drug packed nanoparticles in another organ.

KEYWORD: Nanoparticles, drug delivery, carcinoma.

INTRODUCTION

Nano is a Greek terminology that means dwarf and application of dwarf size particles on engineering and constructing at a micro or molecular level called nanotechnology. Nanotechnology is the element of matter consisting of material less than 100 nanometers (nm) to construct materials with elementary novel characteristics and functioning.[1] Nanotechnology at a molecular level has a multidisciplinary scientific potential that demonstrates exclusive and dynamic promise capacity to introduce revolutionary advantages in the medical sector through means of medicine, packaging of medicine, genome, and robotics. On the surface, miniaturization provides cost-effective, most frequent functioning mechanisms based on mechanical, chemical, and biological determinants.[2]

Nanomedicine depends on several overlapping molecular technologies which are themselves subsumed with evolutionary, progressive, and developing fields comprising[3]:

- For the manufacturing of nanosized structures for diagnostic, monitoring, detection, biosensing, drug sensing, and drug delivery mechanisms.
- For expanding and boosting the revolution in genomics, gene delivery, proteomics, and nanoengineering microbes.
- For manufacturing of molecular mechanisms for medical robots that hold the capability to determine and eliminate host pathogens, replacing cell or cellular compounds in vivo.

Implications of Nanotechnology in Drug Delivery

The efficiency of nanotechnology to efficiently deliver medications is broadly expected to modify the aspect of the drug and biotechnology area for the foreseeable doom.[4] By executing nanotechnology in drug delivery mechanisms, it can be plausible to accomplish -

- It can enhance the transportation of indisposed water-dissolvable medication.
- Expertly direct the transmission of medications in an organism or tissue-selective manner.
- Transcytosis of medications beyond mesenchymal and monocyte macrophage obstructions.
- Delivery of comprehensive microorganism medication to the intermolecular place of operation.
- Displaying sides of drug transmission by synthesizing medical factors with graphics arrangements.

Multifarious determinants perform a prominent role in the effective growth and manufacturing of targeted drug delivery vehicles: bio-compatible substance with manageable strengthening processing for biomaterial accumulation and refinement layers.[5] The inclination to optimize in correspondence the myriad of bio-physicochemical indicators of pointing medication transportation vehicles.[6] The physicochemical nature of the Nano drug transmission medium encompassed dimension and imposed surface hydrophilicity. The character and the frequency of the polydentate on their covering can all affect the regulating semi-life of the components and their bioconcentration.[7] The availability of activating polydentate can intensify the cooperation of the medication transmission mechanism with a sublayer of tissues in the targeting prosenchyma, which can dramatically augment multicellular adoption.

Role of Nanotechnology in Carcinoma Medication

The utility of the nanoscale substance for the medication of melanoma confirms its functionality and dynamic activity[8], which is ready to perform effortlessly and conveniently as it is cautiously to address and serve as the curative symptomatic, acquired at the appropriate neoplasm segment, to target particular microorganisms of malignancy actively, abandon physiological limitations in the material like dense stromal membranes of the pancreas of the blood-brain fence, and central nervous system.[9]

- An appropriate carcinoma medication transmission tool proves the potential and promising approach to accomplish high accommodation in neoplasm and forbear the encompassing healthy membranes. The scientist is utilizing the EPR effect for passive tumor-targeting drug delivery for solid tumor treatment.
- Enhanced permeability and retention (EPR) have the aptitude to stimulate targeting of carcinoma cells by appropriating Nanomedicine accumulation, strengthening their proposed cell uptake during receptor-mediated endocytosis.
- Nano-Drug delivery mechanisms work on the membrane wall before the medication arrives at the cancer position. Tissue barrier for active conveying of nanomedicine to carcinoma locality holding neoplasm stroma and neoplasm endothelium bars.[10]

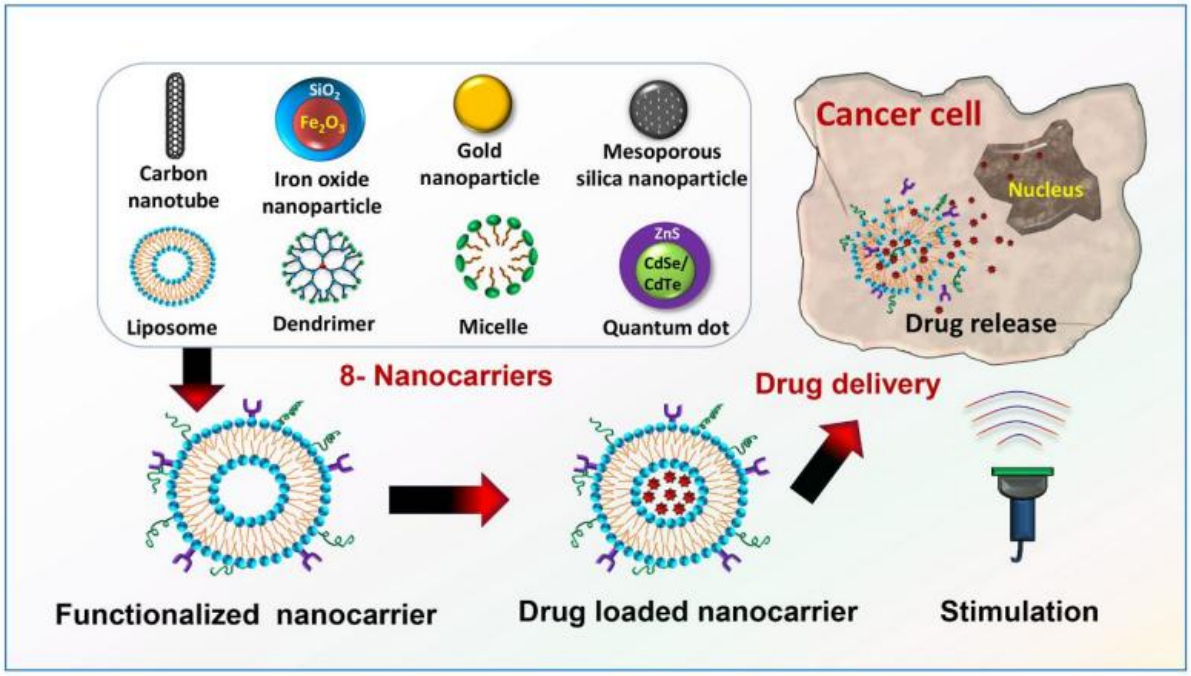

Figure 1: Multiple Nanocarriers used as drug delivery framework for carcinoma treatments.[29]

Challenges in Drug delivery system

The purpose of nanotechnology in the therapeutic sector is demonstrated by sharpening the hydrophobic medication to enhance solubility, organizing the dimension and their coverage area to mass ratio. Although these characteristics are enclosed to specific ingredients and in recession, it enhances their permeability, and ADME characteristics also intensify the toxicity of various constituents.[10] Subsequently, macromolecular and phospholipids are suitably utilized to consolidate the hydrophobic drug in the nanoparticles that concentrate on significantly intensifying the bioavailability aspects of the medication and reducing the cytotoxicity of that segment. Moreover, diverse studies exhibit that nanotechnology does not inscribe all the beneficial effectiveness as they are virulent, which was originally promulgated as Nanotoxicology.[12] In contemporary circumstances, the latest performance approach encompassing nano rely vehicles is being incorporated with more significance on the biochemical and inherent character of the transportation vehicle rather than much-restricted compromise associated with the medication or drug. Henceforth it is essential to enhance the consciousness concerning the methodology that can enhance the transmission of the medication to the target through several deliverance mechanisms.

DISCUSSION

Nanoparticles and their classifications used for drug delivery

Nanoparticles can be broadly categorized based on their dimension morphology, tractor and chemical composition.[8] Based on the studies, the material their size can be impacted rely on the psycho-chemical, optical characteristics of the material, such as gold, platinum, silver, palladium nanoparticles embedded with significant features as red panchromatic, yellowish-grey black and dim black panchromatic appropriately. Nanoparticles are embedded by three functional frameworks in which the foremost layer was bedrock layer which functionalized with a diver minute substance, metallic ions and polymers.[10] Unlike the bedrock, this framework is chemically based on multi-functioning material in the middle layer, and the third strata are the core. This layer performs a nucleus role in the nanoparticle and itself is termed as a nanoparticle.[9] Based on the biochemical functionality of nanoparticles can be classified into organic, inorganic and carbon-based. Under the organic nanoparticle, they rely on known convent fundamental interaction for the self-assemblage and designing of particles that functionalities the changing organic nanomaterial into desired structure encompasses dendrimer, phospholipid, and ferritin copolymers.

These nanomaterials are specifically termed nanocapsules which are very responsive to thermoelectric and electrostatic radiation.[13] Inorganic nanoparticles specifically constructed with metallic ions like gold, silver, platinum, zinc, cadmium, cobalt, copper, and metal oxide also construct inorganic nanoparticles. This material can be formulated by two specific methods termed constructive and destructive methodology.[14] The salient characteristic of these types of Nanomaterial is their bioavailability which offers then extremely activeness and more particular coverage area that can be specifically transformed by multiple biochemical activity like chain reaction, coupling agent, doping and so on[15] under the classification of carbon-based nanomaterials, which demonstrate a significant and inevitable role in the nanotechnology world. Carbon-based Nanomaterial exhibits various specific chemical-physical and mechanical characteristics in biochemical sustainability conductivity and thermoelectric properties. These characteristics make them more suitable and attractive for diverse utilization.[16] Carbon-based nanoparticles are specifically categorized into numerous forms encompassing carbon nanotube, carbon nanofiber, fullerenes (C60) and carbon black.

Nanotechnology based drug delivery system: Carcinoma Medication

Chemotherapy prominently targets and destroys all the frequently dividing tissues; the challenge in this therapy is that it harms and affects the body proliferating cells, for instance, intestinal epithelium and hair follicles.[17] With advanced nanotechnology, targeted drug delivery methodology can eliminate the adverse effect of other tissues. Some of the prominent nanoparticles like liposomes and micelles provide various characteristics for delivering chemotherapeutic factors.[18] Moreover, micelles also have characteristics to form unresolved medications solvable because of their hydrophobic nucleus and hydrophilic cell. Suppose the surface of the micelles is PEGylated. In that case, it enhances the capability of nanoparticles to get through the fenestrated vascular membrane of carcinoma and irritated prosenchyma through submissive carrying, subsequently occurring in extensive medication absorption in carcinoma. Presently various polymeric micelles have an anticancer drug characteristic such as NK012, NK105, NK911, NC-6004 are under therapeutic trial[19], and Genexol-PM demonstrates its significance to appropriately treat breast carcinoma.

Antibodies and aptamers encompass the outer surface of the liposome filled with anticancer drug characteristics that can effectively target carcinoma cells.[20] The most frequently utilized chemotherapeutic drugs of the liposome are doxorubicin and daunorubicin.[21] Abraxis is an albumin incorporated Nanomaterial for Doxil and paclitaxel highly utilized as a liposome therapeutic ultrasound delivery system for carcinoma medication specifically for metastatic breast cancer.[22]

Dendrimers are extremely branched macromolecules with various characteristics and multi-functioning groups to be attached with drug targeting and effectively influencing agents.[23] Their ADME profile is highly reliant on various framework characteristics.[24] A poly functioning dendrimers system has been reported for delivery of anticancer drug methotrexate. Nanomaterial methodology is highly influenced by dendrimers that can enhance the medication index of cyto-virulent medications by implementing bio-agreeable ingredients and covering derivation with PEGylation, acetylation glycosylation, and other amino acids.[25]

The carbon nanotube is an allotropic form of carbon with a barrel-shaped composition with various strata in concentric solids categorised as individual-fortified carbon nanotubes and multi-walled carbon nanotubes. Because of the characteristic hydrophobic hollow interior, they can easily carry water-insoluble drugs with them.[26,27] Another characteristic of carbon

nanotubes is that their extensive coverage area provides an effective external coverage that can be utilized for specific carcinoma receptors and contrast agents.[26] Buckminsterfullerene C60 and its derivatives are appropriately utilized for the medication of carcinoma. Fullerene nanocrystal Nano (C60) has immense properties to intensify the cytotoxicity of chemotherapeutic agents and effectively adjunct chemotherapy. Nanoparticles have dynamic potential and unequal intrinsic features, making them neutral for their wide prospective utilisation in the carcinoma section.

Several types of research have demonstrated the capability of nanoparticle technology for drug delivery mechanisms to provide an anticancer therapeutic approach. It was explored that the nanoparticles approach is widely getting attention because of its specialty toward carcinoma targeting sites and deficiency of different intrusive toxicity potency due to the restricted pattern of drug packed nanoparticles in another organ. Because of ongoing research, material eventually meets the desired expectations to leverage the technology and provide practical benefits to the sufferer in a suitable manner. The advanced technology has the vital capability to strive and enhance the overall medication procedure of drug delivery with immense favourable characteristics such as extended circulation in particular timely delivery and nominal toxicity.

RELATED STUDIES

This segment of the research demonstrates related studies and appropriate functioning of Nanocarrier and its effectiveness as a drug delivery mechanism for various types of carcinoma medication.

Nanocarrier	Drug	Carcinoma	Functioning	References
Liposome	Doxorubicin, Doxil	Breast, Lungs and Colon	It intensifies the anti-cancer drug efficiency.	[20,21,22]
Micelles	DKR like NK012, NK911	Breast, Pancreatic	Enhance the anti-cancer characteristics.	[18,19]
Dendrimers	Doxorubicin, methotrexate, 5-FU	Breast, Skin, Lungs.	It intensifies the anti-cancer drug efficiency.	[24,25]
Nano (C-60)	Dox	Breast, Skin, Lungs.	Intensify the cytotoxicity of chemotherapeutic agents	[26,27]

RESULTS AND FINDINGS

Nanocarriers are utilized as targeting agents for carcinoma medication involving anticancer drugs, targeting moieties, and polymers. There are multiple nanocarriers, for instance, liposomes, dendrimers, micelles, carbon nanotubes, nanocapsules, and so on. Medication factors can be entrapped, covalent bond, encapsulated, or adsorbed to the nanoparticles. Both active and passive targeting can be accomplished with proper drug delivery. The addition of ligands or antibodies can alter the coverage of these nanomaterials. The physicochemical nature of the Nano drug transmission medium encompassed dimension and imposed surface hydrophilicity. The character and the frequency of the polydentate on their covering can all affect the regulating semi-life of the components and their bioconcentration.

An appropriate carcinoma medication transmission tool proves the potential and promising approach to accomplish high accommodation in neoplasm and forbear the encompassing healthy membranes. The scientist is utilizing the EPR effect for passive tumor-targeting drug delivery for solid tumor treatment. Enhanced permeability and retention (EPR) have the aptitude to stimulate targeting of carcinoma cells by appropriating Nanomedicine accumulation, strengthening their proposed cell uptake during receptor-mediated endocytosis. Multifarious determinants perform a prominent role in the effective growth and manufacturing of targeted drug delivery vehicles: bio-compatible substance with manageable strengthening processing for biomaterial accumulation and refinement layers.

The inclination to optimize in correspondence the myriad of bio-physicochemical indicators of pointing medication transportation vehicles. The contribution of nanotechnology is to resize medication by avoiding the life-threatening effect and can potentially contribute to a positive movement in clinical practice for a life-saving approach.

Future Perspective-

- One of the prominent challenges of advanced nanotechnology is adequately utilising various carcinoma medications and their expansion toward new generation nanocarrier drugs.
- The toxicity of Nanocarriers rely on their dimensions along with coverage charge and the presence of the shell. The toxicity and the dimension of Nanoparticles are reciprocally correlated. The smaller the size the higher the toxicity level.
- Cost-effectiveness of the procedure, its diversity and heterogeneity to appropriately deal with carcinoma.

- Lack of specific regulatory guidelines and inappropriate expertise also act as a barrier to its growth.
- Nanocarriers also face several physical challenges, such as accelerated blood clearance and RES, among others.

CONCLUSION

With advanced nanotechnology, targeted drug delivery methodology can eliminate the adverse effect of other tissues. Based on the biochemical functionality of nanoparticles can be classified into organic, inorganic and carbon-based. Under the organic nanoparticle, they rely on known convent fundamental interaction for the self-assemblage and designing of particles that functionalities the changing organic nanomaterial into desired structure encompasses dendrimer, phospholipid, and ferritin copolymers. Nano-Drug delivery mechanisms work on the principal impeded membrane wall before the medication arrives at the cancer position. Tissue barrier for active conveying of nanomedicine to carcinoma locality holding neoplasm stroma and neoplasm endothelium bars.

By executing nanotechnology in drug delivery mechanisms, it can be plausible to accomplish as it can enhance the transportation of indisposed water-dissolvable medication as well as expertly direct the transmission of medications in an organism or tissue-selective manner. Delivery of comprehensive microorganism medication to the intermolecular place of operation. It displays sides of drug transmission by synthesizing medical factors with graphics arrangements.

Some of the prominent nanoparticles like liposomes and micelles provide various characteristics for delivering chemotherapeutic factors. It was explored that the nanoparticles approach is widely getting attention because of its specialty toward carcinoma targeting sites and deficiency of different intrusive toxicity potency due to the restricted pattern of drug packed nanoparticles in another organ. The challenges that came in front of the drug delivery procedure can be illustrated: the toxicity of Nanocarriers rely on their dimensions along with coverage charge and the presence of the shell. The toxicity and the dimension of Nanoparticles are reciprocally correlated. The smaller the size the higher the toxicity level. Cost-effectiveness of the procedure, its diversity and heterogeneity to appropriately deal with carcinoma.

Subsequently, advanced technology has the vital capability to strive and enhance the overall medication procedure of drug delivery with immense favourable characteristics such as extended circulation in particular timely delivery and nominal toxicity.

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