

Nanotechnology in cancer therapy

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ABSTRACT

Cancer is one of the primary causes of death. Every year, millions of people are diagnosed with cancer. Many cancer cells contain a protein all over their surface, whereas healthy cells usually do not have as much protein expression. The researchers were able to connect gold nanoparticles to cancer cells by conjugating, or attaching, the nanoparticles to an antibody, which may help us understand the inner workings of a cancer cell and develop better treatments. Nano particles enable novel methods to cancer treatment in terms of drug delivery systems. A vast variety of nanoparticles deli-

-very systems for cancer therapy have been created and are now in the preclinical stages of research. A vast variety of nanoparticle delivery systems for cancer therapy have been created and are now in the preclinical stages of research. Recently created nanoparticles are exhibiting the potential sophistication of these delivery systems by adding multifunctional capabilities and targeting tactics in an effort to boost their efficacy against the most tough cancer issues.

Key Words: *Radiotherapy; Chemotherapy; Nanoparticles; Nano medicine*

INTRODUCTION

Many liposomal, polymer-drug conjugates, and micellar formulations are now on the market, and an even larger number of nanoparticle platforms are in the preclinical phases of development. Recently developed nanoparticles are demonstrating the potential sophistication of these delivery systems by incorporating multifunctional capabilities and targeting strategies in an effort to increase their efficacy against the most difficult cancer challenges, such as drug resistance and metastatic disease [1]. The primary goal of most nano carrier uses has been to preserve the drug from rapid degradation following systemic distribution and to allow it to reach tumour sites at therapeutic concentrations while avoiding drug delivery to normal sites as much as possible to limit side effects. These nano carriers are designed to carry medications either passively through leaky tumour vasculature or actively through ligands that promote tumoral absorption, potentially resulting in greater antitumor activity and a net improvement in therapeutic index. In most cases, treatment failure is caused by medication resistance, pharmacological difficulties, or toxicity. On the contrary, the use of nano carriers increases the therapeutic index and tumour tissue concentrations of the drugs, and can improve the efficacy of currently used regimens by providing superior pharmacokinetic features, such as extended blood circulation time, cellular uptake, volume of distribution, and half-life, all of which are important factors for an improved therapeutic window and subsequent clinical success. Nanotechnology advancements are also expected to lay the groundwork for the development of innovative therapies and the broad application of diagnostic tools in cancer [2].

Biocompatibility, biodegradability, safety, and simplicity of assembly in structures with the appropriate properties are important considerations when selecting biomaterials. Biomaterials and nanotechnology, when combined, offer a once-in-a-lifetime opportunity to increase cancer patient survival. In this study, we will concentrate on nanoparticle design methodologies and highlight the most recent advances in cancer nano medicine. Despite the benefits of passive targeting systems, there are some limitations that must be addressed in the future. Because certain cancers are difficult to deliver due to a lack of EPR effect, blood vascular permeability may not be uniform throughout the same tumour. To overcome these constraints, nanoparticles are programmed to bind to specific targets (active targeting) by ligands that identify specific receptors in target cells [3].

Several receptors on the tumour cell surface have been investigated as potential sites for selective administration. A variety of conjugation chemistries can be used to modify the surface of nanoparticles in order to attach certain receptor ligands. Nanoparticles recognise and bind to their targets, followed by uptake via receptor-mediated endocytosis. The medicine or payload is released in the cytoplasm or nucleus once it has been absorbed. Peptides, vitamins, antibodies, carbohydrates, and other chemical structures are examples of receptor ligands. For example, the overexpression of transferrin and folate in some cancers has been used to deliver nanoparticles conjugated with these ligands of these receptors. Another example is the $\alpha_5\beta_1$ integrin, which is overexpressed in a variety of malignancies and angiogenic tumor-associated endothelial cells but is mostly lacking in normal tissues.

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Han and colleagues recently found that chitosan nanoparticles coupled with cyclic Arg-Gly-Asp (RGD) boosted tumour delivery and anti-tumor efficacy in ovarian cancer mice. To improve tumoral uptake of nanoparticles, a number of targeted agents such as Monoclonal Antibodies (mAbs) and nucleic acids (aptamers) are utilized [4].

NANOPARTICLES

Polymer-based delivery methods have considerable potential for biomedical applications due to their excellent biocompatibility and flexibility in terms of engineering multifunctional nanoparticles with desired shape, size, internal and exterior morphology, and surface changes. Polymers can be used during the nanoparticle manufacturing stage by isolating them from their natural sources, such as chitosan, which is made from chitin, or by synthesising them in the appropriate structure, such as Poly-Lactic-Co-Glycolic Acid (PLGA). PLGA, arginine, chitosan, human serum albumin, alginate, and hyaluronic acid have been widely used in preclinical studies for drug delivery [5]. In preclinical research, polymer-based nanoparticles show significant potential. Preclinical Drug Delivery materials such as PLGA, arginine, chitosan, human serum albumin, alginate, and hyaluronic acid have been widely employed. Preclinical research on polymer-based nanoparticles has shown significant promise. Chitosan nanoparticles, for example, are a popular polymeric delivery method.

Nanoparticle Characteristics

Physical and chemical aspects of nanoparticles, such as size, charge, shape, and surface qualities, all play important roles in the *in vivo* bio distribution and cellular uptake of these drug carriers. In this section, we will concentrate on the important characteristics that influence the lifetime and delivery of nanoparticles.

Size

One of the most important major elements in regulating the circulation period of nanoparticles is particle size. Following systemic delivery, nanoparticles concentrate in the spleen due to mechanical filtration and are eliminated by the Reticulo-Endothelial System (RES).

Nanomedicine, which has ushered in multiple recognized drug delivery platforms, is an emerging field with enormous potential for improving cancer treatment. Liposomes, for example, are commonly utilised in clinics, and polymer micelles are in advanced stages of clinical studies in various countries. The discipline of nano medicine is currently developing a new generation of nanoscale drug delivery techniques, embracing advances that entail the functionalization of these constructs with moieties that improve site-specific delivery and tailored release [6]. In this paper, we discuss several advancements in established nanoparticle technologies, such as liposomes, polymer micelles, and dendrimers, in terms of tumour targeting and controlled release strategies, which are being incorporated into their design in the hopes of producing a more robust and efficacious nontherapeutic modality. Nano medicine advancements provide new chances to strengthen the anticancer arsenal. Targeted and non-targeted nanoparticles are currently in preclinical and clinical trials, demonstrating the impact of delivery mechanisms on the sector. Further research in nano medicine will broaden the therapeutic window of medications while drastically reducing side effects, resulting in better patient results.

Long-lasting and target-specific nanoparticle

The fast detection of intravenously injected colloidal carriers such as liposomes and polymeric Nano spheres from the circulation by Kupffer cells has sparked an explosion of development for "Kupffer cell-avoiding" or long-circulating particles. These carriers have uses in vascular medication delivery and release, site-specific targeting (both passive and active), and transfusion medicine.

We have critically analysed and assessed the rational ways to design as well as the biological performance of such constructions in this study. We took inspiration from nature for the engineering and design of long-circulating carriers [7]. We investigated the surface mechanisms that allow red blood cells to circulate for lengthy periods of time, as well as the capacity of specific bacteria to avoid macrophage detection. Our investigation then focuses on how such methodologies have been translated and manufactured in order to create a diverse variety of particulate carriers (e.g., Nano spheres, liposomes, micelles, oil-in-water emulsions) with prolonged circulation and/or target selectivity. Over the years, nanotechnology has showed a lot of promise in cancer therapy. Nanomaterials have helped to improve cancer detection and treatment by improving pharmacokinetic and pharmacodynamics qualities. Because of their specificity, nanotechnology enables targeted medicine delivery in damaged tissues with minimal systemic toxicity. However, as with other therapeutic approaches, nanotechnology is not without toxicity and comes with a few obstacles with its use, such as systemic and specific organ toxicities, creating setbacks in clinical applications. Given the limitations of nanotechnology, further progress must be made to optimize medicine delivery and increase efficacy while minimizing drawbacks.

By enhancing the interactions between the physicochemical properties of the nanomaterials used, safer and more effective derivatives for cancer diagnosis and therapy can be made available. To summarise, we attempted to emphasise the fundamental benefits of nanotechnology as well as the gaps in its application to satisfy therapeutic needs for cancer. Furthermore, the therapeutic benefits of nanotechnology, as well as future improvements, may make them a therapeutic possibility for use in various medical situations. Ischemic stroke and rheumatoid arthritis are two examples of conditions that would necessitate the targeted delivery of a suitable pharmacologic treatment at the affected spot. Nanotechnology is being utilised to search for cancer biomarkers.

Cancer biomarkers are biological traits whose presence or absence signals the presence or status of a tumour. These markers are used to research cellular processes, as well as to monitor or identify changes in cancer cells, and the data may eventually lead to a better knowledge of tumours. Proteins, protein fragments, and DNA can all be used as biomarkers. Tumor biomarkers, which are signs of a tumour, are among them and can be evaluated to confirm the presence of specific cancers. Tumor biomarkers should preferably have a high sensitivity (>75%) and specificity (99.6%) [32]. Biomarkers derived from blood, urine, or saliva samples are now utilised to test people for cancer risk [8]. As a result, some researchers have turned to the investigation of extract patterns of improperly produced proteins, peptide fragments, glycan's, and autoantibodies from cancer patients' blood, urine, ascites, or tissue samples [33-35]. Protein biomarkers for several tumours have been found as a result of the advancement of proteomics technology. Quantum Dots in the Near Infrared (NIR) Spectrum. The inability of visible spectrum imaging to penetrate things restricts its application. Quantum dots that emit fluorescence in the near-infrared region (700nm-1000nm) have been developed to circumvent this limitation, making them more appropriate for imaging colorectal cancer, liver cancer, pancreatic cancer, and lymphoma. To improve cancer imaging, a second Near-Infrared (NIR) window (NIR-ii, 900nm-1700nm) with greater tissue penetration depth and superior spatial and temporal resolution has been developed [9]. In addition, the synthesis of silver-rich Ag₂Te Quantum dots (QDs) incorporating a Sulphur source has been claimed to enable for the observation of higher spatial resolution pictures across a broad infrared range. The usage of Nano shells is another frequent nanotechnology application. Nanoshells are dielectric cores ranging in size from 10 nm to 300 nm, typically const-

-ructed of silicon and covered with a thin metal shell (commonly gold).

CONCLUSION

Genetic mutations can alter the production of specific macromolecules, resulting in unregulated cell growth and, eventually, malignant tissues. Cancers are categorized as benign or malignant. Benign tumours are limited to the site of the cancer's development, whereas malignant tumours actively shed cells that infiltrate neighboring tissues and distant organs. Cancer diagnostic and treatment procedures are aimed at detecting and inhibiting malignant cell development and spread as early as possible. The use of Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and ultrasound as early diagnostic techniques for malignancies is notable. These imaging techniques, however, are hampered by their inability to provide important clinical information regarding various cancer kinds and stages.

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