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Nanoparticles based drug delivery system for cancer

Pratiksha Pawar *, Shruti Rajesh Pawar, Omkar Vaman Rupanawar *and* Suyog Chandrashekhar Rupanawar

Pharmaceutical Quality Assurance, Savitribai phule pune university, Pune, Maharashtra, India.

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Abstract

A medication delivery system based on nanoparticles is seen to be promising for the treatment of neoplasia. It demonstrates increased efficacy by prolonging the half-lives of the drug and proteins, improving the solubility of lipophilic medicines, and allowing for the precise and controlled release of the medication into the affected area. The main benefit of medication delivery systems based on nanoparticles is the treatment of tumors. It was also mentioned that tumors can be treated through angiogenesis. Patients using traditional medication therapy for tumor surfers may experience negative side effects from the chemotherapy medicines' non-selective activity on healthy cells.

Keyword: Nanoparticles; Effective; Angiogenesis; Less side effects

1. Introduction

Malignant tumor, another name for cancer, is defined as an enlargement or mass of cells. When a tumor is present, normal cells proliferate and disperse throughout the body [1].Thus, chemotherapy, radiation therapy, and surgery are the only available cancer treatments. Current issues with cancer therapy, such as inadequate drug concentrations reaching the tumor, nonspecific systemic distribution, lack of early disease identification, and inability to monitor therapeutic responses, lead to limitations in cancer treatment [2]. According to the World Health Organization (WHO), cancer is one of the worst diseases that kill about 7.6 million people globally, or 13% of all fatalities. In the next ten years, it is anticipated that there will be 13.1 million fatalities[3].Conventional chemotherapeutic medicines impact both diseased and normal cells because they are transported nonspecifically throughout the body. This limits the dose that can be administered inside the tumor and also leads to treatment that is not as effective because of excessive toxicities. One method to get around the traditional chemotherapeutic drugs' lack of specificity is molecularly targeted therapy[4].The field of nanomedicine holds gr potential in the development of targeted drug delivery systems for a range of disorders, including cancer cells. Due to cancer cells' high rates of proliferation and resistance to conventional treatment approaches, researchers are concentrating on lipid-based drug delivery, which uses nanoparticles to encapsulate and transport medications to certain cells or tissues [5].

In cancer treatment, nanoparticle (NP)-based drug delivery systems have demonstrated numerous benefits, including improved pharmacokinetics, specific targeting of tumor cells, decreased side effects, and decreased susceptibility to drug resistance. The size and features of nanoparticles (NPs) utilized in drug delivery systems are often selected or created in accordance with the malignancies' pathophysiology.

2. Drug delivery system based on Nanoparticles

Drug delivery methods based on nanoparticles have demonstrated potential in enhancing cancer treatment by delivering medications to cancer cells only while causing the least amount of harm to healthy tissues[6]. Additionally,

* Corresponding author: Pratiksha Pawar

medications can actively circumvent drug-resistant processes in cancer cells by using nanoparticles, which enables the pharmaceuticals to reach their specific targets and have therapeutic effects[7]. Furthermore, the intricate interplay between cancer cells and nanoparticles may result in unanticipated toxicities or side effects that could endanger healthy tissues and organs. It is crucial to keep in mind that the precise kind of cancer cells being treated can affect how effective nanoparticle-based therapies are[8].

2.1. Dimensions and Surface Properties of Nanoparticles

Nanoparticles need to be able to withstand prolonged circulation without being removed from the bloodstream in order to carry drugs to the specific tumor tissue. Depending on their size and surface properties, conventional surface-unmodified nanoparticles are typically engulfed in the bloodstream by the reticuloendothelial system, which includes the liver and spleen[9].

- Size: To travel through these two specific circulatory systems and reach tumor tissues, nanoparticles should have a maximum size of 100 nm.
- Surface characteristics: Apart from their dimensions, the surface features of nanoparticles play a crucial role in dictating their longevity and destiny in the bloodstream and their entrapment by macrophages. To avoid being engulfed by macrophages, nanoparticles should preferably have a hydrophilic surface[10].

3. Types of nanoparticles utilized in medication delivery systems:

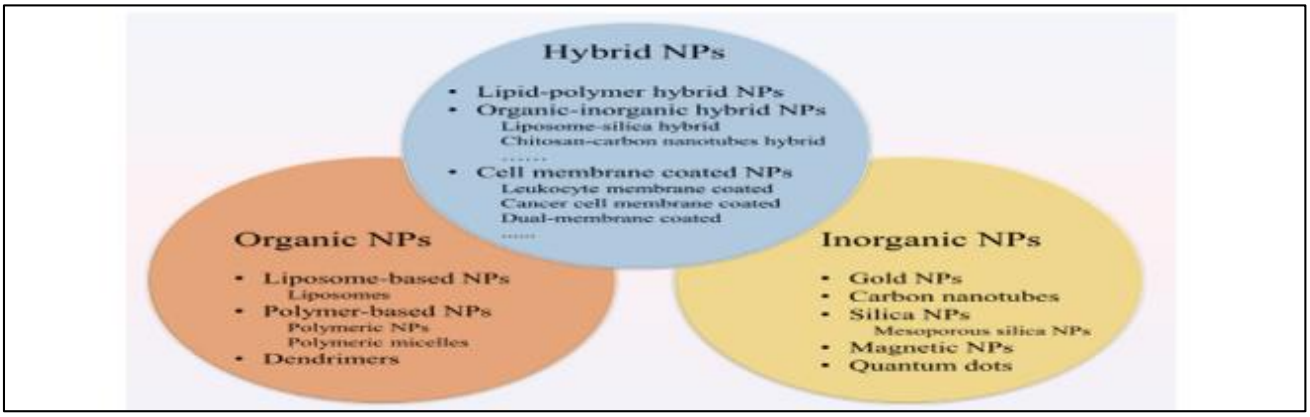

Figure 1 Different Types of Nanoparticles.

3.1. Routes of administration

There are two ways to deliver the drug: orally and intravenously (IV). By administering IVs, it is possible to direct medications away from harmful spots, concentrate NPs at the desired locations, and lengthen the half-lives of medications with short half-lives. Because several hospitalization events are necessary to complete multiple sessions of IV chemotherapy regimens, the main cause of discomfort, stress, and high expenses is IV delivery of chemotherapeutics. There has been a lot of research done recently on NPs as oral medication delivery systems[11].

3.2. Mechanisam of targeting

One essential feature of Nano-carriers for drug delivery is their ability to selectively target cancer cells, which increases therapeutic efficiency while shielding healthy cells from damage (figure 2).

3.3. Passive targeting

The purpose of passive targeting is to take advantage of the distinctions between normal and malignant tissue. When medications are successfully transported to the target site, they can function therapeutically. This is known as passive targeting[12].

3.4. Active targeting

By directly interacting between ligands and receptors, active targeting selectively targets cancer cells. In order to differentiate targeted cells from healthy cells, the ligands on the surface of NPs are specifically designed to target molecules that are overexpressed on the surface of cancer cells.[13]

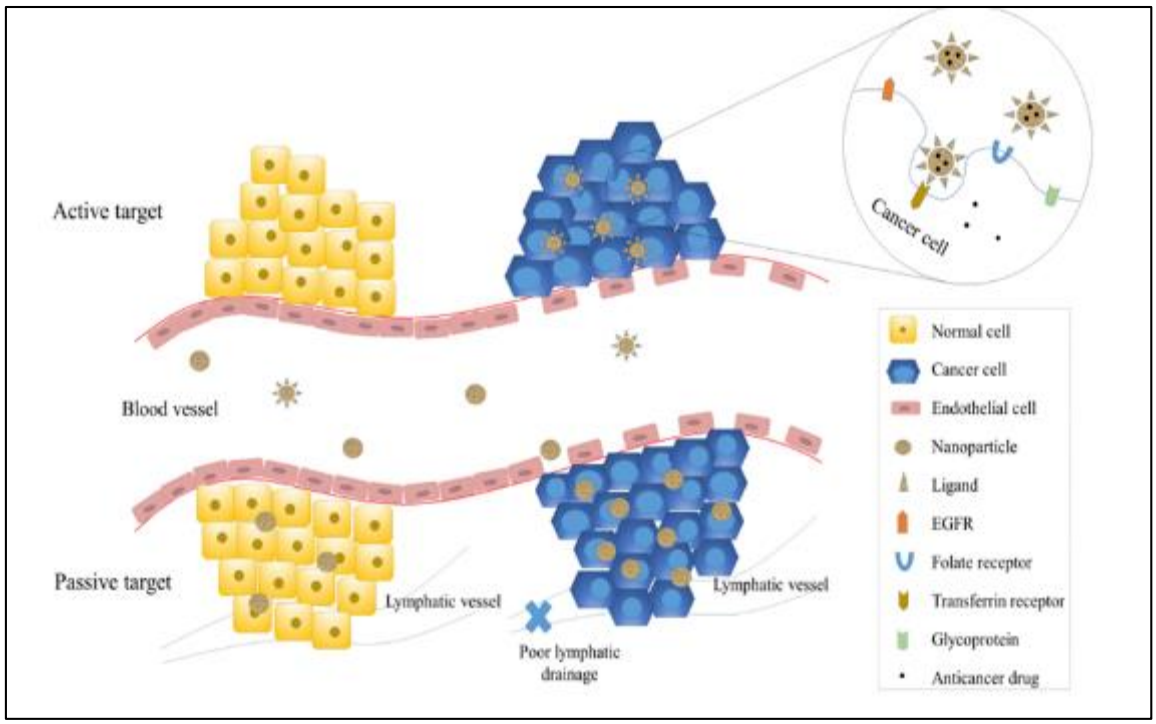

Figure 2 Passive and active targeting of NPs to cancer cells. Targeting of NPs enhance therapeutic efficiency and reduce systemic toxicity. Passive targeting of NPs is mainly achieved by the enhanced permeability and retention (EPR) effect, which exploits the increased vascular permeability and weakened lymphatic drainage of cancer cells and enables NPs to target cancer cells passively. Active targeting is achieved by the interaction between ligands and receptors. The receptors on cancer cells include transferrin receptors, folate receptors, glycoprotein (such as lectin) and epidermal growth factor receptors(EGFR).

3.4.1. Advantages of NPs

- A range of nanometer sizes appropriate for using the EPR effect to target tumors
- Insulating drug molecules with protective coatings to increase their stability and reduce systemic clearance
- The capacity to functionalize surfaces [14].

NP-based capsule coats can prevent drugs from being broken down. Because NPs are so minute, cancer cells can readily absorb them by breaking them into smaller capillaries. This facilitates drug absorption at the target spot. An additional benefit of the nanoscale system is its ability to effectively evade renal clearance, resulting in improved blood circulation for the medications they contain [15].

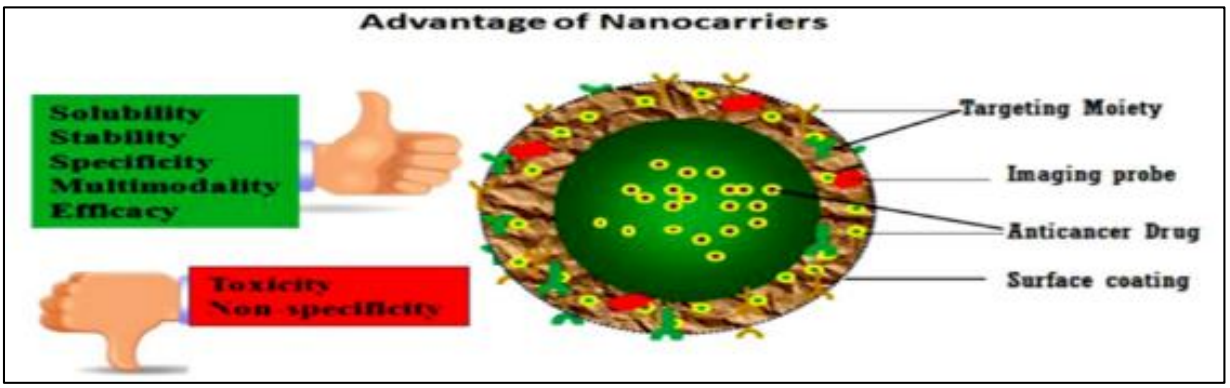

Figure 3 Advantage of nanomaterials, Nanomaterials as nano-carriers can improve solubility, stabilization, specificity, multimodality and efficiency, whereas decreasing toxic side effects also enhancing the non-specificity of traditional cancer therapies

4. Challenges facing nanoparticles in therapeutic settings

4.1. Growing problems

Chitosan is also quite sensitive to environmental conditions. For example, exposure to high relative humidity (>60%) will cause chitosan's water content to significantly increase, which will lower its mechanical properties[16, 17].

4.2. Biodistribution and toxicity

Compared to bulk materials, nanoparticles exhibit a variety of special qualities. As a result, the toxicological profile of the bulk components and the nanoparticles differ[18].

4.3. Inadequate oversight of medication loading and release

One of the main drawbacks for many polymeric nanoparticles is a low rate of drug loading[19,20].Less than 10% loading rate has been observed in numerous investigations [21, 22]. The nanoparticles' initial few minutes of interaction with the outside world are often when it occurs[23].

4.4. The future of drug delivery using nanoparticles

When compared to conventional medication delivery methods, nanoparticles provide numerous benefits. The increasing need for medical care is driving this profession. Nanoparticles are required for drug delivery, diagnostics, and medication monitoring during cancer treatment[24].

5. Conclusion

A new era in cancer treatments has been ushered in by the application of nanotechnology. NPs of all kinds, both organic and inorganic, have already been applied extensively in the clinical management of a number of cancer forms. When compared to conventional medications, NP-based drug delivery systems have better stability, pharmacokinetics, biocompatibility, and tumor targeting. They also significantly lessen systemic toxicity and overcome drug resistance.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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