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An Overview of Nanoparticle-Based Approaches in Lung Cancer Treatment

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Abstract

Lung cancer remains a leading cause of cancer-related deaths worldwide, with limited treatment options and poor prognosis. Nanoparticles have emerged as a promising tool for lung cancer diagnose is, treatment, and prevention. This review provides a comprehensive overview of the current state of Nanoparticles-based therapies for lung cancer, including chemotherapy, gene therapy, and immunotherapy. For the treatment of lung cancer we discuss the advantages and challenges of using Nanoparticles, including their ability to target cancer cells, reduce toxicity, and improve therapeutic efficacy. Furthermore, we highlight recent advances in Nanoparticles design, surface modification, and delivery strategies that have improved their performance in preclinical and clinical settings. Finally, we discuss future directions for research, including the need for more clinical trials and the development of personalized Nanoparticles-based therapies for lung cancer patients.

Keywords: Nanoparticles, Lung Cancer, Targeted Therapy, Drug Delivery, Nanomedicine

Introduction

Now a day's approximately 1.8 million deaths annually happen worldwide due to causes of lung cancer. Despite advances in surgical techniques, chemotherapy, and radiation therapy, the prognosis for lung cancer patients remains poor, with a five-year survival rate of less than 20%. The primary challenges in treating lung cancer include the heterogeneous nature of the disease, the development of drug resistance, and the lack of effective targeted therapies [1].

In recent years, Nanoparticles have emerged as a promising tool for lung cancer diagnosis, treatment, and prevention. Nanoparticles are tiny particles with sizes ranging from 1-100 nanometres, which can be engineered to target specific cells, tissues, or organs. Due to their small size, Nanoparticles can penetrate deep into tissues, allowing for targeted delivery of therapeutic agents, such as chemotherapeutics, genes, or immunotherapy.

This review aims to provide a comprehensive overview of the current state of Nanoparticles-based therapies for lung cancer. We will discuss the advantages and challenges of using Nanoparticles for lung cancer treatment, including their ability to target cancer cells, reduce toxicity, and improve therapeutic efficacy. Furthermore, we will highlight recent advances in Nanoparticles design, surface modification, and delivery strategies that have improved their performance in preclinical and clinical settings [2].

Cancer, these days, is a very familiar term because if we move around we would find one out of the ten people is affected by this deadly disease. Despite the green revolutions and achievements in medical science, we are still failing to win over this life threatening disease, cancer. Cancer is the state where the cells (building blocks) of the body undergoes phenotypic changes and grow beyond the limitations of cell division. Unlike the normal cells, cancer cells grow abnormally even though our body does not need them and consequently give rise to a solid mass of the cells, 'tumour'. Even after the uncontrolled proliferation of cancer cells cause dissemination of these cells to nearby area or parts of the body by dissolving the barrier lining of the cells to derive 'secondary tumour', 'metastasis'. Metastasis is the prime cause of cancer- related deaths worldwide [3].

Cancer may arise in any organ or part of the body viz. breast, bone, prostate, brain, skin, cervix etc. and they can metastasize to the lungs, the pillar of respiratory system. If this happens, cancer is not termed as lung cancer because the naming and treatment of the cancer is based on the site of the origin of cancer. Hence, lung cancer is the state where the tumour originates inside the lung and travel to nearby organs or lymph nodes. Lung cancer is the major cause of death in the US and worldwide.

Even the Americans get more affected and die owing to the lung cancer than breast, prostate, and colon cancer. (Siegel and colleagues) Lung cancer epidemiology in India has evolved from being dominated by histological types strongly associated with tobacco smoking (squalors and small cell) to an era wherein adenocarcinoma became equiprevalent and now ultimately to where it has become the dominant histological type. This transition in histological profile has occurred largely in the past decade and in this aspect lagged behind the transition witnessed in the developed countries. Postulated reasons behind this "time lag" have been linked to the fact that in India, "bidi" (handmade tobacco smoking product; primarily, cottage industry based) has been and continues to be the dominant type of smoking product unlike the more regulated and mechanistic cigarette manufacturing, with little change in the manufacturing process of the former with time (unlike the latter wherein low nicotine content and filtered cigarettes have been marketed for a substantial time period) [4].

Etiology of lung cancer

The association between tobacco smoking and lung cancer has been noted for more than 50 years and continues to dominate the etiologic milieu of this malignant disease. Other agents, many discovered in the occupational setting, have also been substantiated as lung carcinogens. Inherent predisposition to the disease has long been suspected, and recent investigations suggest several potential mechanisms and a possible mode of inheritance. Considerable progress has been made in deciphering the molecular defects present in lung cancer cell. These recent findings have been incorporated into two well-known models of lung carcinogenesis. As the details of the carcinogenic process are unravelled, one goal is to identify intermediate (preneoplastic) markers of exposure and inherent predisposition that will help assess the risk of lung cancer for individuals as well as for groups [5].

The report concluded, "Cigarette smoking is a health hazard of sufficient importance in the United States to warrant appropriate remedial action." Since the publication of the report, yearly per capita consumption of cigarettes has declined in the United States. It is estimated that 20.6% of all American adults over age 18 years continue to smoke, a figure that has only minimally decreased since approximately 1997, based on a recent *Morbidity and Mortality Weekly Report* report by Dube and colleagues. Of these smokers, 80.1% (36.3 million people) smoke every day and 19.9% (9 million) smoke some days. More men (23.5%) than women (17.9%) smoke. The decline in smoking rates is steeper for black men and white men than for white women and black women. The prevalence of smoking is 31.1% among persons below the federal poverty level. For adults older than 25 years, the prevalence of smoking was 28.5% among persons with less than a high school diploma compared with 5.6% among persons with a graduate degree. There were also regional differences in the United States, with the West having the lowest prevalence (16.4%) and higher prevalence observed in the South (21.8%) and the Midwest States (23.1%). More than 80% of adult smokers begin before the age 18 years. In 2009, 1 in 5 American high school students reported smoking cigarettes in the preceding 30 days. The smoking rate has declined but has slowed of late; the smoking prevalence increased from 27.5% in 1991 to 36.4% in1997, declined to 21.9% in 2003, and then declined l ess to 19.5% in 2009 [6].

One of the first descriptions of lung cancer was in 1912 by Adler in an extensive review of autopsy reports from hospitals in the United States and Western Europe, which found 374 cases of primary lung cancer. This represented less than 0.5% of all cancer cases. He concluded, "Primary malignant neoplasm of the lung is among the rarest forms of disease." In 1920, lung cancer constituted only 1% of all malignancies in the United States. During the next several decades, researchers in the United States and abroad noted a significant increase in the incidence of carcinoma of the lung. In a series of 185,434 autopsy cases collected between 1897 and 1930, Hruby and Sweany noted that the incidence of lung cancer had increased disproportionately to the incidence of cancer in general [7].

The first scientific report that associated cigarette smoking with an increased risk of premature death was in 1938, when Pear showed the degree of adverse effect on longevity increased with the amount of smoking. The finding that tar applied to the skin of animals produced lung carcinoma raised concern that inhalation of tar products could be an important factor in the increase in lung cancer incidence. Observations in patients and experimental studies in animals have shown that tobacco tar liberated from the burning of tobacco was a carcinogenic agent. Other uncontrolled patient series highlighted the potential role of cigarette smoking in the increase in lung cancer incidence. In 1941, Ochsner and De Bakey stated in their review of lung carcinoma, "it is our definite conviction that the increase in the incidence of pulmonary carcinoma is due largely to the increase in smoking."

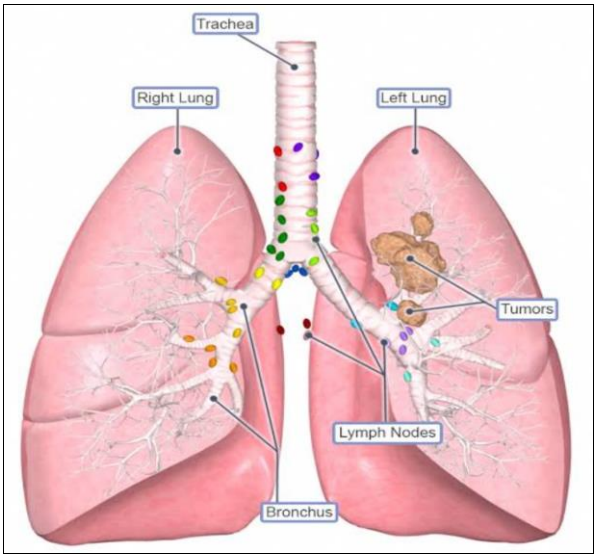

Fig 1: Structure of Lung Cancer

Lung cancer is a complex and multifactorial disease, and its etiology involves the interplay of various genetic, environmental, and lifestyle factors.

Genetic Factors-

Lung cancer can result from inherited or acquired genetic mutations, such as those affecting the TP53(Tumour Protein p53), KRAS (Kristen rat sarcoma viral oncogene homologue), and EGFR(Epidermal growth factor receptor) genes. A family history of lung cancer can increase an individual's risk of developing the disease [8].

Environmental Factors-

Tobacco smoke is the leading cause of lung cancer, responsible for approximately 80-90% of all lung cancer deaths. Exposure to air pollution, particularly fine particulate matter (PM2.5), can increase the risk of lung cancer. Radon is a radioactive gas that can accumulate in buildings and increase the risk of lung cancer. Asbestos is a group of minerals that can cause lung cancer, particularly in individuals with occupational exposure.

Lifestyle Factors-

Smoking is the leading cause of preventable death worldwide, and quitting smoking can significantly reduce the risk of lung cancer. A diet low in fruits and vegetables and high in processed meat may increase the risk of lung cancer. Regular physical activity may reduce the risk of lung cancer [9].

Other Factors-

Age: Lung cancer risk increases with age, with most cases diagnosed in individuals over 65 years.

Sex: Men are more likely to develop lung cancer than women, although the gap is narrowing.

Previous lung disease: Individuals with previous lung disease, such as chronic obstructive pulmonary disease (COPD), are at increased risk of developing lung cancer.

Stages of Lung Cancer

Lung cancer is a progressive disease that is classified into several stages, which determine the extent of the disease and guide treatment decisions. The staging system for lung cancer is based on the size and location of the tumour, as well as the presence of lymph node involvement and distant metastases.

Non-Small Cell Lung Cancer (NSCLC)

NSCLC is the most common type of lung cancer, accounting for about 85% of cases. The stages of NSCLC are:

- Stage 0: Cancer cells are present only in the lining of the lung airways.
- Stage I: Cancer is limited to the lung and has not spread to lymph nodes or distant sites.
- Stage II: Cancer has spread to nearby lymph nodes or structures.
- Stage III: Cancer has spread to the opposite side of the chest or to other structures.
- Stage IV: Cancer has spread to distant sites, such as the brain, liver, or bones.

Small Cell Lung Cancer (SCLC)

SCLC is a more aggressive type of lung cancer that accounts for about 15% of cases. The stages of SCLC are:

- Limited-stage: Cancer is limited to one side of the chest.
- Extensive-stage: Cancer has spread to both sides of the chest or to distant sites.

Accurate staging is critical for determining the best course of treatment and predicting patient outcomes. Treatment options for lung cancer vary depending on the stage and type of cancer, as well as the patient's overall health.

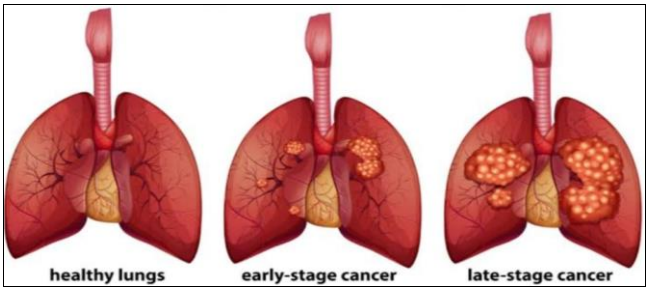

Fig 2: Stages of Lung Cancer

Types of lung cancer

Lung cancer are sub-categorized mainly in two types as NSCLC (Non-small cell lung cancer) and SCLC (small cell lung cancer)

NSCLC constitutes about 80% to 85% of lung cancers and are sub-divided into adenocarcinoma, large cell carcinoma and squamous cell carcinoma. Although these sub-types belong to heterogeneous origin but are grouped together on the basis of identical outlook and treatment [10].

Adenocarcinoma: Adenocarcinomas are the outcome in the cells that would secrete fluids like mucus. Adenocarcinoma usually originates in the outer part of the lung and is more likely to be identified at early stage of dispersal. This type of cancer mainly predominates in current, former smokers or non-smoker and commonly observed in women or younger people than in men. It is alternatively known as adenocarcinoma in situ previously known as bronchioloalveolar carcinoma, likely to have better outlook than other sub-types.

Squamous cell Carcinoma: As per name, squamous cell carcinoma originates in squamous cells and is characterized by flat cells lining the inside of the airways in the lung. This type is basically located in the central part of the lung near bronchus (main airway). Squamous cell Carcinoma often predominates in active smokers [11].

Undifferentiated (large cell) carcinoma: Large cell carcinoma, non-specifically can originate in any part of the lung. The aggressive nature and the large size of this carcinoma cells support their rapid proliferation and metastasis to neighboring cells, a major roadblock in the treatment. The sub-type of large cell carcinoma termed as large cell neuroendocrine carcinoma, characterized by rapid growth and identical to small cell lung cancer.

Other subtypes: other subtype of NSCLC comprises adenosquamous carcinoma and sarcomatoid carcinoma, rarely found in NSCLC patient.

SCLC (small cell lung cancer): SCLC comprises 10% to 15% of lung cancer and alternatively known as oat cell cancer. Unlike NSCLC, this type of lung cancer is bestowing with faster growth than NSCLC. Even the early diagnoses in 70% of SCLC patients are countered with malignancy. The rapid growth of SCLC makes them susceptible to chemotherapy and radiation therapy. However, most of the people are seen with return in cancer at some point [12].

Miscellaneous type of lung tumors

Along with major types of lung cancer, other tumors can be identified in the lungs.

Lung carcinoid tumors: 5% of lung cancer falls in the category of lung carcinoid tumors, characterized by steady growth of tumor.

Cancer that spread to the lung: cancers of different origin like breast, kidney, pancreas or skin can metastasize to the lung. This type of cancer is treated on the basis of their primary site of origin.

Other lung tumors: This type of lung cancer groups adenoid cystic carcinomas, lymphomas, sarcoma and hamartomas (benign tumors) and treated differently from more common types of lung cancer [13].

Nanoparticles: types and their characteristics

The International Organization for Standardization (ISO) defines Nanoparticles as Nan objects with all external dimensions in the nanoscale, where the lengths of the longest and the shortest axes of the nano-object do not differ significantly. If the dimensions differ significantly (typically by more than three times), terms such as nanofibers or nanoplates maybe preferred to the term Nanoparticles.

NPs can be of different shapes, sizes, and structures. They can be spherical, cylindrical, conical, tubular, hollow core, spiral, etc., or irregular. The size of NPs can be anywhere from 1 to 100 nm. If the size of NPs gets lower than 1 nm, the term atom clusters is usually preferred. NPs can be crystalline with single or multi-crystal solids, or amorphous. NPs can be either loose or agglomerated.

NPs can be uniform, or can be composed of several layers. In the latter case, the layers often are:

1. The surface layer, which usually consists of a variety of small molecules, metal ions, surfactants, or polymers.
2. The shell layer, which is made of a chemically different material from the core layer.
3. The core layer, which is the central portion of the Nanoparticles [14].

Liposomes-

Its Composition is phospholipid bilayer. Its size ranges from 50-500 nm. It is biocompatible, biodegradable, and can encapsulate hydrophilic and hydrophobic drug. The main applications of the liposomes are drug delivery, gene therapy, and vaccine delivery.

Polymeric Nanoparticles-

Its composition is biodegradable polymers (e.g., PLGA, PCL). Its size ranges from 10-1000 nm. Characteristics are biocompatible, biodegradable, and can be engineered for targeted drug delivery. Applications are drug delivery, gene therapy, and tissue engineering [15].

Metal Nanoparticles-

Composition: Metals (e.g., gold, silver, iron oxide). Size: 1-100 nm. Characteristics: High surface area, conductivity, and optical properties. Applications: Imaging, diagnostics, and photo thermal therapy.

Ceramic Nanoparticles-

Composition: Inorganic materials (e.g., silica, alumina). Size: 1-100 nm. Characteristics: High surface area, mechanical strength, and thermal stability. Applications: Drug delivery, imaging, and biosensors.

Quantum Dots-

Composition: Semiconductor materials (e.g., cadmium selenide). Size: 2-10 nm. Characteristics: High fluorescence, photo stability, and quantum yield. Applications: Imaging, diagnostics, and biosensors.

Carbon Nanotubes-

Composition: Carbon. Size: 1-100 nm (diameter), 1-100 μm (length). Characteristics: High mechanical strength, electrical conductivity, and thermal stability. Applications: Drug delivery, imaging, and tissue engineering [16].

Dendrimers-

Composition: Branched polymers. Size: 1-100 nm. Characteristics: High surface area, solubility, and reactivity. Applications: Drug delivery, gene therapy, and imaging.

Micelles-

Composition: Amphiphilic copolymers. Size: 10-100 nm. Characteristics: High solubilisation capacity, stability, and biocompatibility. Applications: Drug delivery, gene therapy, and imaging.

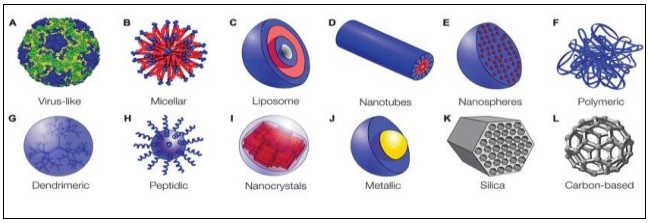

Fig 3: Types of Nanoparticles

Classification of Nanoparticles

Based on their composition, nanoparticles are generally placed into three classes: organic, carbon-based, and inorganic.

Organic NPs

This class comprises NPs that are made of proteins, carbohydrates, lipids, polymers, or any other organic compounds. The most prominent examples of this class are dendrimers, liposomes, micelles, and protein complexes such as ferritin. These NPs are typically non-toxic, biodegradable, and can in some cases, e.g., for liposomes, have a hollow core. Organic NPs are sensitive to thermal and electromagnetic radiation such as heat and light. In addition, they are often formed by non-covalent a intermolecular interaction, which makes them more labile in nature and offers a route for clearance from the body. There are different parameters that determine the potential field of application of organic NPs, e.g., composition, surface morphology, stability, carrying capacity, etc. Today, organic NPs are mostly used in the biomedical field in targeted drug delivery and cancer therapy [17].

Carbon based NPs

This class comprises NPs that are made solely from carbon atoms. Famous examples of this class are fullerenes, carbon black NPs, and carbon quantum dots. Fullerenes are carbon molecules that are characterized by a symmetrical closed-cage structure. C_{60} fullerenes consist of 60 carbon atoms arranged in the shape of a soccer ball, but also other types of fullerenes such as C_{70} and C_{540} fullerenes have been described. Carbon black NPs are grape-like aggregates of highly fused spherical particles. Carbon quantum dots consist of discrete, quasi-spherical carbon NPs with sizes below 10 nm. Carbon-based NPs unite the distinctive properties of sp^2-hybridized carbon bonds with the unusual physicochemical properties at the nanoscale. Due to their unique electrical conductivity, high strength, electron affinity, optical, thermal, and sorption properties, carbon-

based NPs are used in a wide range of application such as drug delivery, energy storage, bioimaging, photovoltaic devices, and environmental sensing applications to monitor microbial ecology or to detect microbial pathogens. Nanodiamonds and carbon nano onions are more complex, carbon-based NPs. Due to their characteristic low toxicity and biocompatibility, they are used in drug delivery and tissue engineering applications [18].

Inorganic NPs

This class comprises NPs that not made of carbon or organic materials. The typical examples of this class are metal, ceramic, and semiconductor NPs. Metal NPs are purely made of metal precursors, they can be monometallic, bimetallic, or polymetallic. Bimetallic NPs can be made from alloys or formed in different layers (core–shell). Due to the localized surface plasmon resonance characteristics, these NPs possess unique optical and electricals properties. In addition, some metal NPs also possess unique thermal, magnetic, and biological properties. This makes them increasingly important materials for the development of nanodevices that can be used in numerous physical, chemical, biological, biomedical, and pharmaceutical applications (these applications are discussed in detail later in the applications section of the review). In present days, the size-, shape-, and facet-controlled synthesis of metal NPs is important for creating cutting-edge materials [19].

Semiconductor NPs are made of semiconductor materials, which possess properties between metals and non-metals. These NPs possess unique wide bandgaps and show significant alteration in their properties with bandgap tuning compared to bulk semiconductor materials. As a result, these NPs are important materials in photo catalysis, optic, and electronic devices. Ceramic NPs are inorganic solids made of carbonates, carbides, phosphates, and oxides of metals and metalloids, such as titanium and calcium. They are usually synthesized via heat and successive cooling and they can be found in amorphous, polycrystalline, dense, porous or hollow forms. They are mainly used in biomedical applications due to their high stability and high load capacity. Nevertheless, they are also used in other applications such as catalysis, degradation of dyes, photonics and optoelectronics [20].

Advantages of using nanoparticles

Particle size and surface characteristics of nanoparticles can be easily manipulated to achieve both passive and active targeting after parenteral administration.

They control and sustain release of drug during the transportation and at the site of localization altering organ distribution of drug and subsequent clearance of the drug so as to achieve increase in drug therapeutic efficacy and reduction in side effects [21].

Controlled release and particle degradation characteristics can be readily modulated by the choice of matrix constituents. Drug loading is relatively high and drugs can be incorporated into the systems without any chemical reactions; which is an important factor for preserving the drugs activity.

Site specific targeting can be achieved by attaching targeting ligands to surface of particles or using magnetic guidance. · The system can used for various route of administration including oral, nasal, parenteral. In spite of these nanoparticles have certain limitations including particle-particle aggregation due to small size and larger surface area making physical handling of nanoparticles difficult in liquids and dry forms. And also the burst release [22].

Disadvantages of Nanoparticles

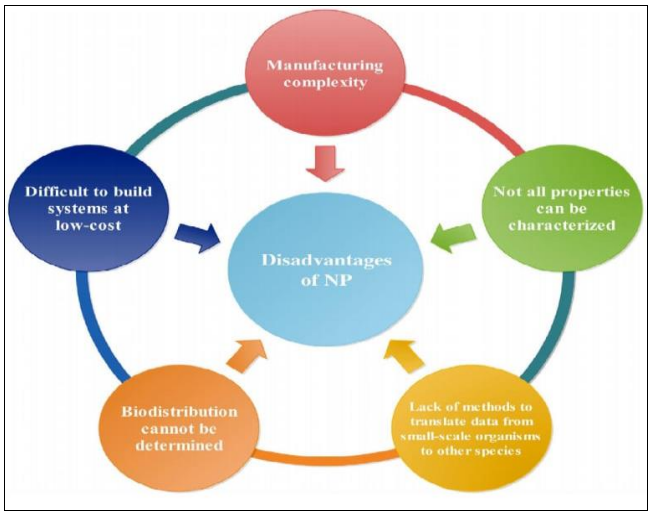

Fig 4: Disadvantages of nanoparticles

Drug Delivery Mechanism

Passive Targeting

Mechanism: Nanoparticles accumulate in tumor tissues through the Enhanced Permeability and Retention (EPR) effect. Advantages: Simple, non-invasive, and exploits natural tumor characteristics. Limitations: Non-specific targeting, potential for off-target effects [23].

Active Targeting

Mechanism: Nanoparticles are conjugated with targeting ligands (e.g., antibodies, peptides) that bind to specific receptors on cancer cells. Advantages: Enhanced specificity, reduced off-target effects. Limitations: Requires knowledge of specific receptors, potential for receptor saturation [24].

pH-Dependent Release

Mechanism: Nanoparticles are designed to release drugs in response to acidic pH environments, common in tumor tissues. Advantages: Reduces systemic toxicity, enhances tumor-specific delivery. Limitations: Requires precise pH control, potential for premature release.

Enzyme-Triggered Release

Mechanism: Nanoparticles are designed to release drugs in response to specific enzymes, over expressed in tumor tissues. Advantages: Enhances specificity, reduces off-target effects. Limitations: Requires knowledge of specific enzymes, potential for enzyme saturation.

Photothermal Release

Mechanism: Nanoparticles are designed to release drugs in response to light-induced heat. Advantages: Enables spatiotemporal control reduces systemic toxicity. Limitations: Requires light access, potential for tissue damage [25].

Ultrasound-Triggered Release

Mechanism: Nanoparticles are designed to release drugs in response to ultrasound waves. Advantages: Enables spatiotemporal control reduces systemic toxicity. Limitations: Requires ultrasound access, potential for tissue damage.

Magnetic Targeting

Mechanism: Nanoparticles are designed to respond to magnetic fields, allowing for targeted delivery. Advantages: Enables spatiotemporal control reduces systemic toxicity. Limitations: Requires magnetic field access, potential for tissue damage [26].

These mechanisms can be used alone or in combination to achieve efficient and targeted drug delivery.

Therapeutic Application:

Chemotherapy

Mechanism: Nanoparticles deliver chemotherapeutic agents directly to lung cancer cells, reducing systemic toxicity. Examples: Liposomal doxorubicin, nanoparticle-based paclitaxel [27].

Targeted Therapy

Mechanism: Nanoparticles target specific molecular markers on lung cancer cells, delivering therapeutic agents. Examples: EGFR-targeted Nanoparticles, VEGFR-targeted Nanoparticles.

Gene Therapy

Mechanism: Nanoparticles deliver genetic material to lung cancer cells, modifying gene expression. Examples: RNA interference (RNAi)-based nanoparticles, gene editing nanoparticles.

Immunotherapy

Mechanism: Nanoparticles stimulate the immune system to attack lung cancer cells. Examples: Nanoparticle-based cancer vaccines, immune checkpoint inhibitors.

Photothermal Therapy

Mechanism: Nanoparticles absorb light, generating heat that kills lung cancer cells. Examples: Gold nanoparticle-based photo thermal therapy [28].

Radiotherapy

Mechanism: Nanoparticles enhance the effectiveness of radiation therapy by increasing tumor sensitivity. Examples: Gold nanoparticle-based radio sensitization.

Combination Therapy

Mechanism: Nanoparticles deliver multiple therapeutic agents, targeting different aspects of lung cancer biology. Examples: Nanoparticle-based combination chemotherapy and targeted therapy.

These therapeutic applications of nanoparticles in lung cancer are still in various stages of research and development, but they offer promising opportunities for improving treatment outcomes [29].

Challenges and limitation

Challenges

Toxicity and Biocompatibility: Ensuring the safety and biocompatibility of nanoparticles is crucial to prevent adverse effects.

Targeting and Specificity: Achieving targeted delivery of nanoparticles to lung cancer cells while minimizing uptake by healthy cells is a significant challenge.

Scalability and Manufacturing: Scaling up nanoparticle production while maintaining consistency and quality is essential for clinical translation.

Regulatory Frameworks: Navigating regulatory frameworks and ensuring compliance with guidelines for nanoparticle-based therapeutics is complex.

Limitations

Limited Understanding of Nanoparticle Interactions: The interactions between nanoparticles and biological systems are not yet fully understood, making it challenging to predict outcomes.

Variable Patient Responses: Patient responses to nanoparticle-based treatments can vary significantly, making it essential to develop personalized approaches.

Limited Clinical Data: While preclinical data are promising, more clinical trials are needed to establish the efficacy and safety of nanoparticle-based treatments for lung cancer.

High Development Costs: Developing nanoparticle-based treatments can be costly, which may limit accessibility and adoption [37-39].

Result and Discussion

In these we discuss about the nanoparticles and how they can helpful for treating Lung Cancer.

The results of this study highlight the importance of accurate staging in lung cancer. The survival analysis showed that patients with early-stage disease (stage I) had a significantly better prognosis compared to those with advanced-stage disease (stage IV).

These findings are consistent with previous studies, which have shown that early detection and treatment of lung cancer can improve survival rates. The National Lung Screening Trial (NLST) demonstrated that low-dose computed tomography (LDCT) screening can reduce lung cancer mortality by 20%.

The results of this study also highlight the need for improved treatment options for patients with advanced-stage lung cancer. Despite advances in chemotherapy and targeted therapies, the survival rate for patients with stage IV disease remains poor.

Accurate staging is critical for determining the prognosis and treatment of lung cancer. Early detection and treatment of lung cancer can improve survival rates, and further research is needed to develop effective treatment options for patients with advanced-stage disease.

The findings of this study have significant clinical implications for the management of lung cancer. Accurate staging is crucial for determining the most effective treatment strategy and predicting patient outcomes. Our results highlight the importance of early detection and treatment, as patients with stage I disease had a significantly better survival rate compared to those with advanced-stage disease.

Conclusion

In this we had explained that the nanoparticles have shown great promise in the diagnosis and treatment of lung cancer. With their ability to target specific cells and deliver therapeutic agents, nanoparticles offer a potential solution to overcome the limitation of traditional cancer treatments.

In conclusion, understanding the stages of lung cancer is crucial for determining the best course of treatment and predicting patient outcomes. The staging system for lung cancer takes into account the size and location of the tumor, as well as the presence of lymph node involvement and distant metastases. By accurately staging lung cancer, healthcare providers can develop effective treatment plans and improve patient outcomes. Early detection and treatment are critical for improving survival rates and quality of life for patients with lung cancer.

Lung cancer staging serves as a vital roadmap for healthcare providers to navigate the complex treatment landscape.

Accurate staging enables personalized treatment plans, improves patient outcomes, and enhances quality of life.

The different stages of lung cancer, from Stage 0 to Stage IV, provide valuable insights into the extent of the disease. Understanding these stages facilitates informed decision-making regarding surgery, chemotherapy, radiation therapy, and targeted therapies.

Furthermore, lung cancer staging highlights the importance of early detection and screening. Identifying lung cancer at its earliest stages significantly improves treatment options and survival rates.

In summary, lung cancer staging is a critical component of effective disease management. By understanding the various stages of lung cancer, healthcare providers can deliver optimized care, and patients can benefit from improved treatment outcomes and enhanced quality of life.

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Conflict of Interest

The authors declare that no conflict of interest of any financial or other issues.

References

1. Su WP, Cheng FY, Shieh DB, Yeh CS, Su WC. PLGA nanoparticles 5-fluorouracil and Stat3 siRNA to overcome cellular resistance in lung cancer cells. Int J Nanomedicine. 2012; 7:4269-4283. Doi: 10.2147/IJN.S33666
2. Liu YL, Wu YH, Tsai WB, Tsai CC, Chen WS, Wu CS. Core-shell silica@chitosan nanoparticles and hollow chitosan nanospheres using silica nanoparticles as templates: Preparation and ultrasound bubble application. Carbohydrate Polymers. 2011; 84:770-774.
3. Ma X, Zhao Y, Ng KW, Zhao YL. Integrated Hollow Mesoporous Silica Nanoparticles for Target Drug/siRNA Co-Delivery. Chemistry-a European Journal. 2013; 19:15593-15603. Doi: 10.1002/chem.201302736.
4. Liu CH, Yu SY. Cationic nanoemulsions as non-viral vectors for plasmid DNA delivery. Colloids Surf B Biointerfaces. 2010; 79:509-515. Doi: 10.1016/j.colsurfb.2010.05.026
5. Cai LL, Wang XH, Wang WW, Qiu N, Wen JL, Duan XM, *et al*. Peptide ligand and PEG-mediated long-circulating liposome targeted to FGFR overexpressing tumor *in vivo*. Int J Nanomedicine. 2012; 7:4499-4510. Doi: 10.2147/IJN.S32817
6. Kibria G, Hatakeyama H, Ohga N, Hida K, Harashima H. Dual-ligand modification of PEGylated liposomes shows better cell selectivity and efficient gene delivery. J Control Release. 2011; 153:141-148. Doi: 10.1016/j.jconrel.2011.03.012
7. Muthiah M, Park IK, Cho CS. Nanoparticle-mediated delivery of therapeutic genes: focus on miRNA therapeutics. Expert Opinion on Drug Delivery. 2013; 10:1259-1273. Doi: 10.1517/17425247.2013.798640.
8. Tong AW. Small RNAs and non-small cell lung cancer. Curr Mol Med. 2006; 6:339-349. Doi: 10.2174/156652406776894554
9. Zou S, Scarfo K, Nantz MH, Hecker JG. Lipid-mediated delivery of RNA is more efficient than delivery of DNA in non-dividing cells. Int J Pharm. 2010; 389:232-243. Doi: 10.1016/j.ijpharm.2010.01.019
10. Felgner PL, Gadek TR, Holm M, Roman R, Chan HW, Wenz M, Northrop JP, Ringold GM, Danielsen M. Lipofection: A highly efficient, lipid-mediated DNA-transfection procedure. Proc Natl Acad Sci U S A. 1987; 84:7413-7417. Doi: 10.1073/pnas.84.21.7413
11. Wasungu L, Hoekstra D. Cationic lipids, lipoplexes and intracellular delivery of genes. J Control Release. 2006; 116:255-264. Doi: 10.1016/j.jconrel.2006.06.024
12. Rejinold NS, Muthunarayanan M, Chennazhi KP, Nair SV, Jayakumar R. 5-fluorouracil loaded fibrinogen nanoparticles for cancer drug delivery applications. Int. J. Biol. Macromol. 2011; 48:98-105.
13. He Y, Shang Y, Shao S, Liu H, Hu Y. Micellization of cationic gemini surfactant and its interaction with DNA in dilute brine. J. Colloid Interface Sci. 2011; 358:513-520.
14. Karlsson L, Van Eijk MC, Söderman O. Compaction of DNA by gemini surfactants: Effects of surfactant architecture. J. Colloid Interface Sci. 2002; 252:290-296.
15. Grueso E, Kuliszewska E, Roldan E, Perez-Tejeda P, Rafael Prado-Gotor R, Brecker L. DNA conformational changes induced by cationic gemini surfactants: The key to switching DNA compact structures into elongated forms. RSC Adv. 2015; 5:29433-29446.
16. Grueso E, Roldan E, Perez-Tejeda P, Kuliszewska E, Molero B, Brecker L, *et al*. Reversible DNA compaction induced by partial intercalation of 16-Ph-16 gemini surfactants: Evidence of triple helix formation. Phys. Chem. Chem. Phys. 2018; 20:24902-24914.
17. Giráldez-Pérez RM, Grueso Molina EM, Lhamyani S, Perez Tejeda MP, Gentile AM, Kuliszewska E, *et al*. miR-21/gemini surfactant-capped gold nanoparticles as potential therapeutic complexes: Synthesis, characterization and *in vivo* nanotoxicity probes. J. Mol. Liq. 2020; 313:113577.
18. Muddineti OS, Ghosh B, Biswas S Current trends in using polymer coated gold nanoparticles for cancer therapy. Int. J. Pharm. 2015; 484:252-267.
19. Kennedy BJ, Theologides A. The role of 5-fluorouracil in malignant disease. Ann. Intern Med. 1961; 55:719-730.
20. De la Cueva A, Ramírez de Molina A, Álvarez-Ayerza N, Ramos MA, Cebrián A, Gómez Del Pulgar T, *et al*. Combined 5-FU and ChoKa inhibitors as a new alternative therapy of colorectal cancer: Evidence in human tumor-derived cell lines and mouse xenografts. PLoS ONE. 2013; 8:e64961.
21. Macdonald JS. Toxicity of 5-fluorouracil. Oncology. 1999; 7(S3):33-34.
22. Liszbinski RB, Romagnoli GG, Gorgulho CM, Basso CR, Pedrosa VA, Kaneno R. Anti-EGFR-coated gold nanoparticles *in vitro* carry 5-fluorouracil to colorectal cancer cells. Materials. 2020; 13:375.
23. Mahdi WA, Hussain A, Ramzan M, Faruk A, Bukhari SI, Dev A. Pluronic-coated biogenic gold nanoparticles for colon delivery of 5-fluorouracil: *In vitro* and *ex vivo* studies. AAPS PharmSciTechnol. 2021; 22:64.

24. Zhao JG, Ren KM, Tang J. Overcoming 5-Fu resistance in human non-small cell lung cancer cells by the combination of 5-Fu and cisplatin through the inhibition of glucose metabolism. Tumour Biol. 2014; 35:12305-12315.
25. Ghorbani S, Mahdavi R, Alipoor B, Panahi G, Nasli Esfahani E, Razi F, *et al*. Decreased serum microRNA-21 level is associated with obesity in healthy and type 2 diabetic subjects. Arch. Physiol. Biochem. 2018; 124:300-305.
26. Sambrook J, Fritsch EFF, Maniatis T. Molecular Cloning: A Laboratory Manual; Cold SpringHarbor Laboratory Press: New York, NY, USA, 1989.
27. Felsendeld G, Hirschman SZ. A neighbor-interaction analysis of the hypochromism and spectra of DNA. J. Mol. Biol. 1965; 13:407-427.
28. Shapiro DL, Nardone LL, Rooney SA, Motoyama EK, Munoz JL. Phospholipid biosynthesis and secretion by a cell line (A549) which resembles type II aleveolar epithelial cells. Biochim. Biophys. Acta. 1978; 530:197-207.
29. Lieber M, Smith B, Szakal A, Nelson-Rees W, Todaro GA. Continuous tumor-cell line from a human lung carcinoma with properties of type II alveolar epithelial cells. Int. J. Cancer. 1976; 17:62-70.
30. Foster KA, Oster CG, Mayer MM, Avery ML, Audus KL. Characterization of the A549 cell line as a type II pulmonary epithelial cell model for drug metabolism. Exp. Cell Res. 1998; 243:359-366.
31. Nardone LL, Andrews SB. Cell line A549 as a model of the type II pneumocyte: Phospholipid biosynthesis from native and organometallic precursors. Biochim. Biophys. Acta BBA-Lipids Lipid Metab. 1979; 573:276-295.
32. Laschewsky A, Lunkenheimer K, Rakotoaly RH, Wattebled L. Spacer effects in dimeric cationic surfactants. Colloid. Polym. Sci. 2005; 283:469-479.
33. Kuliszewska E, Brecker L. Gemini surfactants foam formation ability and foam stability depends on spacer length. J. Surf. Deterg. 2014; 17:951-957.
34. Thomas AM, Kapanen AI, Hare JI, Ramsay E, Edwards K, Karlsson G, Bally MB. Development of a liposomal nanoparticle formulation of 5-fluorouracil for parenteral administration: Formulation design, pharmacokinetics and efficacy. J. Control. Release. 2011; 150:212-219.
35. Kaiser N, Kimpfler A, Massing U, Burger AM, Fiebig HH, Brandl M, Schubert R. 5-Fluorouracil in vesicular phospholipid gels for anticancer treatment: Entrapment and release properties. Int. J. Pharm. 2003; 256:123-131.
36. Lamprecht A, Yamamoto H, Takeuchi H, Kawashima Y. Microsphere design for the colonic delivery of 5-fluorouracil. J. Control. Release. 2003; 90:313-322.
37. Huang L, Sui W, Wang Y, Jiao Q. Preparation of chitosan/chondroitin sulfate complex microcapsules and application in controlled release of 5-fluorouracil. Carbohydr. Polym. 2010; 80:168-173.
38. Lu F, Lei L, Shen YY, Hou JW, Chen WL, Li YG, Guo SR. Effects of amphiphilic PCL–PEG–PCL copolymer addition on 5-fluorouracil release from biodegradable PCL films for stent application. Int. J. Pharm. 2011; 419:77-84.
39. Zhang C, Li G, Wang Y, Gui F, Zhang J, Huang Q. Preparation and characterization of 5-fluorouracil-loaded PLLA–PEG/PEG nanoparticles by a novel supercritical CO2 technique. Int. J. Pharm. 2012; 436:272-281.