APPLICATIONS OF NANO PARTICLES IN RESPIRATORY DISEASES

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Abstract

With time the blow of respiratory disorders are increasing, which is leading to the shortage of conventional drugs. To overcome this shortage new nanomedicine are discovered with the use of nanoparticles. Therefore, it is necessary to discuss the effects of drugs that are based on Nano particles, on various respiratory diseases. Nano particles proved to be very effective in treating pulmonary diseases on the basis of its intrinsic characteristics and the basic composition it had. Different kinds of nano materials like carbon nanotubes, polymeric nano particles, dendrimers, liposomes etc. reveal therapeutic effects on respiratory diseases. This can lead to new feasible remedies for different illness related to the respiratory system with an intention of increasing efficacy of the drug and reducing the side effects.

Keywords: *respiratory disorders, nanoparticles, nanomedicine, asthma, chronic obstructive pulmonary disease*

1.1 Introduction

The most widespread respiratory disorders include low respiratory infections like bronchitis, laryngitis, pharyngitis, pneumonia, common cold and obstructive lung disorders like chronic obstructive pulmonary disease (COPD), asthma and lung cancer. The primary root of these diseases are genetic attributes, pollution of air and the infections as a result of bacteria and viruses. Airborne diseases and infections can easily infect the lower respiratory airways that provide a route to acute respiratory infections. Severe respiratory infections can be caused by new corona virus (COVID-19) which is a recent acute infection; and by severe acute respiratory syndrome corona virus (SARS-Cov), avian influenza A (H7N9) and Middle East respiratory syndrome corona virus (MERS-Cov) which are the older ones. Chronic respiratory diseases like lung cancer, asthma, hay fever, cystic fibrosis and COPD are caused as a result of air pollution and certain genetic disorders. The main aim of this treatment is to improve the quality of life of patients either by restoring or by repairing the functions of respiratory system.

The utilization of nano based drugs may be justified as it is a contemporary treatment method that get control of barriers including drug resistance, side effects, low drug efficiency and costs. As a result of their nano scale dimensions, nano particles have exceptionally high surface to volume ratio. This attribute allows the attachment of several ligands on to the surface and the proneness to build multiple covalent bond increases. Nano particles have a likelihood to form a bond with hydrophobic as well as hydrophilic drugs, the potential to be prescribed through injection or inhalation, and also has an increased chemico-biological and all of these characteristics completely rely on the nano carrier's physicochemical characteristics and the chemical structure that the reagent has. Amongst many drug delivery system, Aerosol drug delivery is a well-received one, which can be used for both respiratory and non-respiratory disorders. The deposition spot in the respiratory tract would be regulated by the size of the nano particles.

Compared to conventional drugs, higher efficacy is seen in nano systems as they are put into operation for targeted delivery and an increased biocompatibility is observed in them with reduced unfavorable effects.

1.2 Nano particles for biomedicine applications

The goal of nano scale platforms is to enhance the efficacy of treatment and localize drug delivery. Through this, the dosage is reduced, controlled biodistribution and fewer systemic side effects are observed, pharmacokinetics is modulated and the patient's compliance is improved. In simple terms, nano particles are tiny packages that carries drugs and deliver them to specific locations in the body. Many different types of nano particle drugs are used to treat various respiratory disorders. Some of them are listed below.

1.2.1 Carbon based nano materials.

In the progress of material science, carbon based materials have always played a crucial role. Macroscopic carbon materials have a deficiency of satisfactory band gap, which makes it a problem to represent itself as an efficient fluorescent material. In spite of this they are used generally in the interdisciplinary fields along with primary investigation. The nano diamonds and nano tubes of carbon are strong, versatile and highly conductive because of which it can be operationalized to draw up robust diagnostic tools as a drug delivery system. Although the nano tubes are inhalable they cause health risks like inflammation and lung fibrosis. This is why they are not acceptable as a treatment for respiratory diseases. Considerable traits of various newly generated carbon based nano materials are evolved and altered to be employed in pharmacology, medicine and biology in recent years.

Dendrimers - Dendrimer is derived from a Greek word *Dendron*, meaning a tree because the structure of dendrimer is branched resembling with a tree. The structure of dendrimer has dendrons. Dendrons are arm like structure that begins from the central core and they are classified according to their physicochemical characteristics. Dendrimers are highly versatile hyper branched structures or architectures that can be used for medical purposes.

Dendrimers are widely used in drug delivery. There are various dendrimers like polylysine and polyethylene glycol which are extensively utilized as nano carriers in the treatment of diseases. To prevent the cationic toxicity of dendrimers the nano carriers are run along with biomolecules. This is easily operated as dendrimers have more number of amino groups.

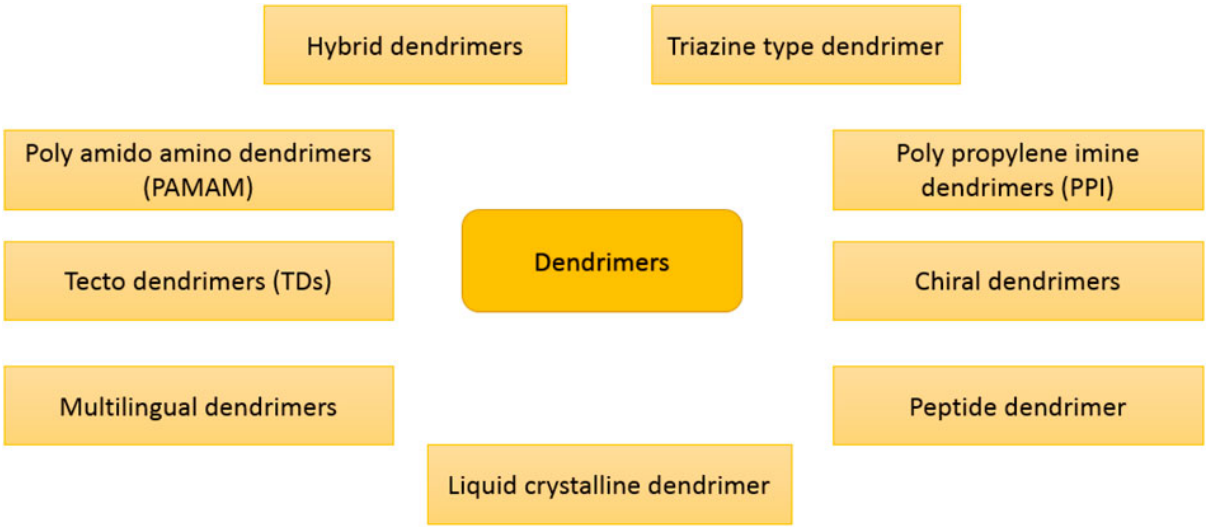

Fig 1: classification of dendrimers

1.2.2 Polymeric nano particles

These are solid colloidal particles ideally formed from polymers that are achieved either from synthetic or from natural basis Hydrogels, nanocapsules and nanospheres are classes in which polymeric nanoparticles can be segregated into. Hydrogels are polymeric materials that has a notable aggregate of hydrophilic groups attached to it and exhibits a three dimensional network which support them to take up water or drugs dissolved physically or chemically in a considerable amount. There are two kinds of polymeric nanoparticles. The one in which the remedial element is enveloped inside a polymeric capsule shell are nanocapsule polymeric nanoparticles. Nanosphere polymeric nanoparticles are those that has drugs or solid particles embedded in a polymeric matrix. The drug delivery of polymeric nanoparticles is site specific and delivery is in a specific amount. This trait is helpful in treating various diseases.

1.3 Methods for nano particles establishment for lung delivery

A number of formal methods have been reported for the inflation of particulate material for specific delivery to the lungs. However there are restraints such as shape, size and delivery. The physicochemical property of any particle are the key agents to describe its flow activity, which effect the particle convey and deposition on the structure. Although, the impact of inhaled nanoparticles are clearly far for the treatment of non – lung disorders, mainly the cardiovascular structure and other most vascularized organs, such as brain diseases.

Inhaled powders found in various nano particle types, similar to polymeric nanoparticles, liposomes, mesoporous silica and solid lipid nanoparticles, were deliberate for the respiratory system but mainly for the polymeric and lipid nanoparticle types of nanoparticles.

1.4 The effect of nano particles on respiratory diseases

1.4.1 Asthma

Asthma is a provocative disorder of the lungs distinguished by reversible airway obstruction, bronchial hyper responsiveness and chronic airway inflammation. Enduring liability to irritants causes an inflammatory reaction in the lungs, emerging in tapering the small airways and lung tissue damage. Anti-inflammatory effect of nanoparticles were visible in several inflammatory disorders earlier on. Nanoparticles expand the therapeutic product by facilitating the distribution of the drug to the target tissue, thus enhancing the deposition of the drug in the lungs. In multiple in vitro and in vivo studies, the consequences of nanoparticles on asthma were reported.

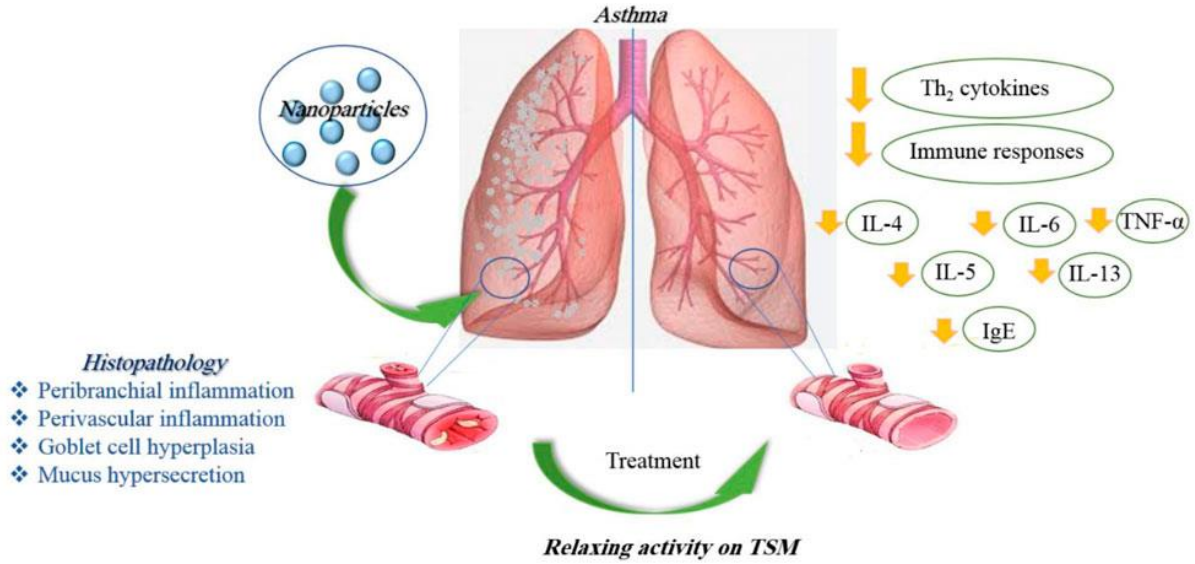

Fig 2 : Effects of nanoparticles on asthma

1.4.2 Chronic obstructive pulmonary disease and chronic bronchitis

It is a chronic inflammation in the lungs that causes the obstruction of airways. The patient with COPD will have increased secretion of mucus, difficulty in breathing and coughing as symptoms. The cause of this disease is a long term exposure to exasperating or airborne particles which mostly occur due to cigarette smoke. In COPD, the air is trapped inside the lungs since the airways become narrower and their flexibility is decreased. Nano material drugs are needed in small quantities and they can be effectually targeted to diseased tissue microenvironment. Hence they portray therapeutic potentials against respiratory disorders with very less side effects. Different effects of nano particles were revealed from in vitro and in vivo studies.

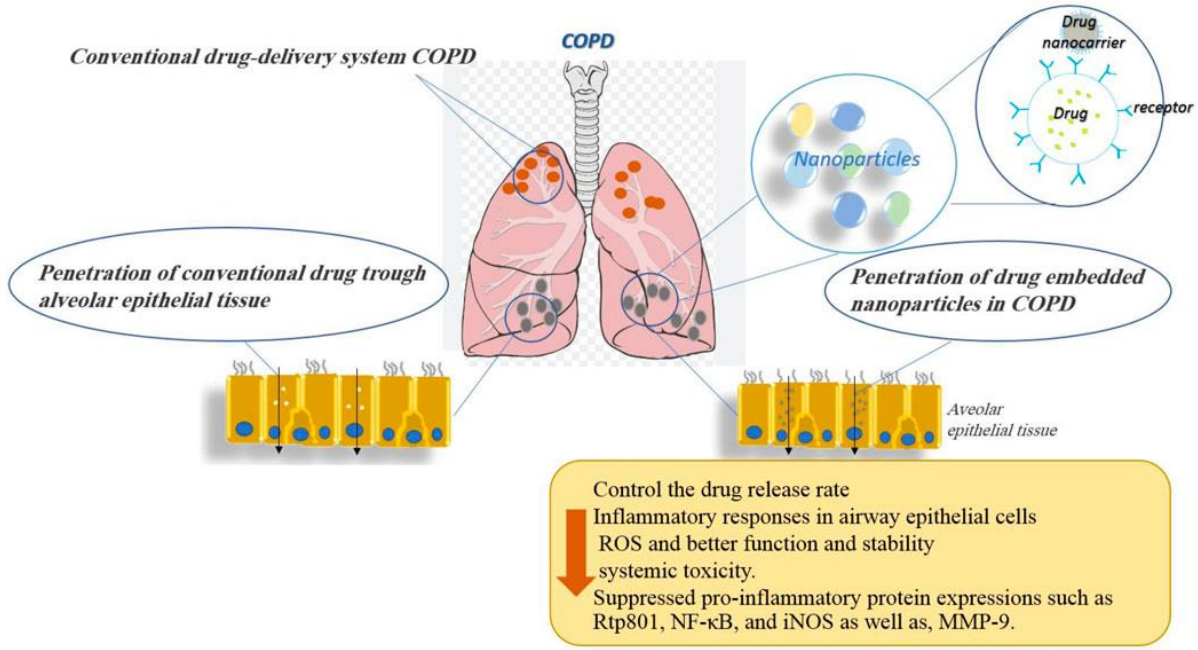

Fig 3: Effects of nanoparticles on COPD

1.4.3 Lung cancers

The most common type of cancer in the world is lung cancer and for its therapy nano materials play a very crucial role. Lung cancer is a very considerable and disturbing genesis of deaths and diseases within the planet. It is an unchecked growth of cells in the tissue of lungs. Various studies reveals the effects of nano particles on lung cancer. In fact, for treating lung disorders, nano therapies and regenerative medicines are continued to be developed.

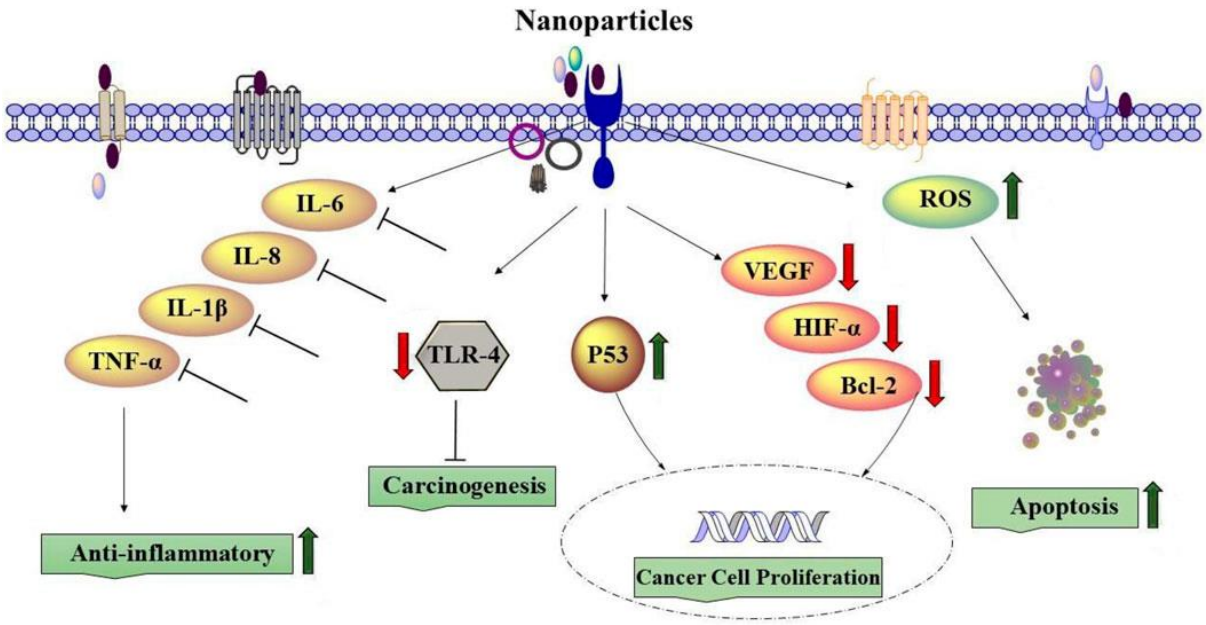

Fig 4 : Effects of nanoparticles on lung cancer

1.5 Discussion

Nano particles used different mechanisms like immunomodulatory, antioxidant, anti-inflammatory, apoptosis, and necrosis mechanisms and resulted in displaying therapeutic effects on respiratory disorders.

- Anti-inflammatory, antioxidant and immunomodulatory effects

The most crucial elements of nanoparticles that can alter lung disease are its size and structural properties. Certain proinflammatory mediators like IL-6, IL-8, IL-1Beta and TNF-Alpha were getting suppressed by the nanoparticles. This was revealed through experiments of nano particles on lung disorders like lung cancer, COPD and asthma. Also, their capacity to produce proinflammatory cytokines was reduced along with deactivation of CD4 and CD8 T cells in lung tissues. Effect of apoptosis and necrosis

The characteristic feature of tumor cells is their potential to evade apoptosis which can be used as a signal for targeted cell treatment in cancer therapy. Apoptosis is induce in MCF-7 cells by selenium nanoparticles which are green synthesized by epigenin (SeNP-epigenin) treatment. This causes permanent damage to the DNA and leads to cell killing of MCF-7 cells.

1.6 Effects of dosage of nanoparticles on respiratory disorders

Nanoparticle	Dose	Duration
AgNPs: silver nanoparticles	8–128 μg/ml	1, 6, 24 h
AuNPs: gold nanoparticles	20, 100 μg/ml–5.00 mg/ml	24, 48, 72 h
Al_2O_3 NPs	0.4, 2 mg/ml	24 h
Carbon nanotubes	0.4–20 μg/ml	24 h
CdO NPs: cadmium oxide nanoparticles	1 μg/ml	24 h
CdSe: cadmium selenide	330 μl	24 h
CS: chitosan	5 μg/m–2.5 mg/ml	6 and 24 h
LCN: liquid crystalline NPs	10–50 μg/ml	12, 24, and 48 h
LPB: liposome-in-bacteria	0.62–5 μmol/L	24 h
NiO NPs: nickel oxide NPs	5 μg/ml–0.24 mg/kg	6 weeks
ONP-302-NPs	1 mg	
QDs: quantum dots	5–20 μg/ml and 6 μg/kg	24 h
SBS: salbutamol sulfate	200 μg aerosolized	14 h
siRNA: small interfering RNA	5 μg–2.5 mg/kg	24 h and 3 days
SLN: solid lipid nanoparticles	30 μg/25 g/kg	1, 2, 3, and 6 days
TAC: tacrolimus	60 μg/mouse	
ZnO: zinc oxide nanoparticle	10, 20, and 40 μg/ml	

References were provided in the main text.

Table 1 : Shows the effect of various nanoparticles on respiratory disorders.

1.7 Future trends and prospects

Further studies and investigation along with in vivo studies and clinical trials can be performed on certain areas of subject to check how nanoparticles can be used to treat respiratory disorders.

They are:

- More precise assessment of effects of nanoparticles
- To determine the perfect time period in which nano particles show their effect
- More particular and effective doses of nano particles
- Examining the possible routes for the conduction of nano particles especially for inhaler nano particles
- Evaluation of different nano particles along with their clinical trials

1.8 Conclusion

In this article, we have discussed the functioning of various nano particles on different lung disorders that included efficacy, drug delivery and drug safety. It is based on the in vitro and in vivo studies. In asthma and in COPD, the nano particles enhanced lung pathological changes and lung oxidative stress in in vivo studies by reducing the inflammatory cells and markers. Effects of nano based medicine has emerged as a promising tool in treating lung infections through local antibiotic properties where both doses and side effects were reduced. This was revealed in the in vivo and in vitro studies. When the drug delivery was increased on some specific lung cancer and locations off lung metastases, the efficacy of the treatment enhanced in both primary and metastatic lung cancer.

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