OPINION

Nanoparticles: Toxicological concerns

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ABSTRACT

One of the scientific developments in technology is nanotechnology. The size of Nanoparticles (NPs) ranges from 1 nm to 100 nm. The physiological reaction of the cells might vary greatly depending on how the given nanoparticles are shaped. The composition, surface chemistry, surface charge, and form of NPs are just a few of the features that can have a significant impact on how poisonous they are.

This opinion article covers specific topics that address the effects of NPs on nanomedicine.

Key Words: *Nanoparticles; Medical applications; Nanotoxicity*

INTRODUCTION

Few areas of human endeavour do not believe that nanotechnology can play a significant role. From "smart drug" packaging that can reach the central nervous system and accurately target tumur cells. to self-cleaning glass, from nano-gold embedded in odorous socks to the development of stealth fighter jets, artificial muscle to desalination plants, from safer nuclear energy to better clinical diagnosis. Amazing progress is being made in nanotechnology. The ongoing advancement of nanotechnology has resulted in the creation of nanoscale treatments for a variety of complicated ailments.

Several new nanomaterials and their composites, such as liposomes, polymer Nanoparticles (NPs), dendrimers, and nanostructured lipid carriers, have been commercialised as a result.

NPs effectively breach the membrane barrier, travel throughout the body through translocation into the bloodstream, and play a cellular and molecular role in the organs and tissues.

Nanotoxicity can result from NPs' interactions with cells. Nanomaterials may be used often. The high reward-risk ratio still governs those applications, though. Concern over the effects and potential effects of exposing ecosystems to these compounds grows as nanotechnology develops.

Routes of human body adsorption of nanoparticles

Hand-to-mouth contact between employees, engineers, and scientists working on cutting-edge goods in the lab is the main cause of extrinsic ingestion of artificial NPs. NPs, including AuNPs, may be exposed during synthesis or development. Additionally, it cannot rule out the effects of AuNP-composite attached to consumer goods in homes, markets, landfills, and other outdoor locations, as well as routes like dermal absorption inhalation, ingestion from implants, airborne adherence, surface materials, and results of AuNP-composite on skin. NPs can also be consumed directly through food, water, medications, or drug delivery systems. They can, however, be absorbed during applications through direct ingesting, intravenous injection, or waste disposal. Uncertainty surrounds the impact of the uptaken NPs. There aren't many similar studies in this field that used volunteers, though.

The intriguing study by Kuschner et al. found no evidence of pulmonary inflammation following exposure to small and ultrafine magnesium oxide particles. This is a potentially significant discovery since it challenges the idea that a particle's physical characteristics determine its response and demonstrates the significance of the particle's chemistry. It doesn't seem like this study has been followed up on or duplicated. Small enough to settle in the olfactory mucosa and go to the Central Nervous System (CNS), inhaled ultrafine particles can cause neurotoxicity. When NPs are inhaled or administered intravenously, the CNS can be a significant target for exposure.

Exacerbations of inflammation, asthma, and metal fume fever to fibrosis, chronic inflammatory pulmonary illness, and carcinogenesis are only a few of the acute and chronic impacts of NP exposure. Inhaled or infused NPs can reach the systemic circulation and go to various organs and tissues, according to numerous studies.

Nanotoxicology

There are several commercial and medical uses for NPs and other nanomaterials, but they are also associated with some toxicities. More people are paying attention than ever before to the risk posed by nanotoxics. For instance, NPs could enter the airway wall's dendritic cells. The main antigen-presenting cells, dendritic cells are crucial to the coordination of the innate and adaptive immune systems. Nanotechnology-based dendritic cell targeting is a promising approach for cancer treatment. Results, however, point to the possibility that these cells' ability to function can be harmed by NP absorption.

By affecting dendritic cells' roles in the maturation, homing,

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processing, and presentation of antigens processes, the physicochemical characteristics of NPs affect their interactions with dendritic cells. There are questions over whether these cell dysfunctions can be detected by conventional toxicological approaches or if they are really very slight. Such recommendations will undoubtedly be made as nanotechnology develops and humans are exposed to a greater range of NPs. The challenge of nanotoxicology includes deciding how to react to these recommendations.

EFFECT OF NANOPARTICLES IN DIFFERENT ORGANS

Nanoparticles on skin

Most nanotechnologies come into touch with skin first. As a result, it might be the first and most important target for nanotoxicity. Additionally, a variety of diseases that can be treated by applying medications topically to the site of action include those that impact the skin. The use of NPs in dermatology and cosmetology is a new field that is strongly tied to the theme of risk assessment. With the development of new, effective delivery systems for nanoparticles, it is still unknown how deeply these particles will penetrate living tissues. The ability to achieve a transdermal effect is made possible by the structural similarity between the lipid matrix of the nanosystem and the lipids of the skin.

Nanoparticles in brain

NPs have been demonstrated to reach the sensory cells of the olfactory epithelium before being delivered to the brain's olfactory lobe by way of the olfactory nerve. Metallic NPs can escape or cross the blood-brain barrier to enter the central nervous system and cause neurotoxicity. Inflammation, oxidative stress, DNA and/or mitochondrial damage, and cell death are the results. Microglial cell activation, inflammatory factor release, production of reactive oxygen species, glial cell death, and/or autophagy are some of the possible causes.

Nanoparticles in Eye

A lot of research has been done on nanoformulations as prospective substitutes for conventional ocular formulation techniques. The research into whether nanoparticles are safe for use in the eyes is still in its early stages. Human retinal pigment epithelial cells can undergo mitochondrial apoptosis when exposed to AgNPs. Mesoporous Silica Nanoparticles (MSiNPs) are among the best-researched inorganic NPs for medication and MRI contrast agent delivery; nonetheless, exposure to Ag^+ in combination with MSiNPs at a tolerable dose resulted in more substantial toxicity than the MSiNPs alone on the eye.

Nanoparticles in liver

The liver is a key test site for examining new nanomedicines and their therapeutic applications since it is the location where well-dispersed NPs passively collect. Numerous research have documented how CeO_2 NP protects against excessive ROS generation and inflammatory processes. Other research, however, has demonstrated how these NPs play a significant role in inducing oxidative stress by lowering cell viability through autophagy, apoptosis, and inflammation. According to studies by Zhao et al., mice given daily doses of $CeCl_3$ such as 2 mg/kg, 10 mg/kg, or 20 mg/kg body weight for two months may develop damaged hepatocytes due to ROS buildup, lipid peroxidation, and decreased defence.

Nanoparticles in reproductive system

Previous research has demonstrated that a variety of NP kinds can pass through specific biological barriers and have harmful effects on important organs such the kidneys, liver, and brain. The danger of nanoparticles to reproduction has only recently come to light. The blood-testis barrier is permeable, and MOxNPs can collect in the testis. Contradictory data suggest that MOxNPs reduce male fertility by interfering with spermatogenesis, despite the fact that some of these NPs have been demonstrated to have protective effects on male germ cells. Both in vitro and in vivo investigations have shown that exposure to MOxNP can cause an overproduction of ROSs. As a result, oxidative stress develops, which is a significant molecular process that may contribute to germ cell damage.