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Update of Usefulness and Adverse Effects of Nanoparticles on Animals and Human Health

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Abstract

Nanotechnology has a potential application and a great biological role in veterinary diagnosis and in animal reproductive biotechnologies beside great impact on diagnosis in animal diseases. There is also a great interest from toxicologist for research on safety of different nanoparticles that used in cure of diseases. Nanoparticles reported to have various adverse effects in different animal tissue and also in human health. Various nanoparticles have toxic effect on liver, lung, skin, eye, reproductive disturbance and blood cells. The key mechanism of toxicity of nanoparticle is due to increase its concentration in non-target tissue of therapy through genotoxicity, oxidative stress or hemotoxic effects. On other word, nanoparticles could have adverse effects on healthy rather than diseased tissue.

Keywords: Nanoparticles; Animals; Toxicity

Introduction

Nanotechnology is defined as an application of scientific knowledge for manipulation and control in nanometric scale (1-100 nm) with specific function at the cellular, atomic and molecular levels [1]. Nanostructures may be a new physical and chemical characteristic, demonstrating high solubility levels, reactivity and better stability than its original compound [2]. The application of the novel nanoparticles generated the new research field of Nano biotechnology, which plays a central role in disease diagnosis, drug design and delivery [3]. It holds a major promise for animal health, veterinary medicine and animal production and also has a key role in treatment of diseases by development of smart drug delivery systems which providing targeted time controlled self-regulated, pre-programmed and effective dosage of drug to site of disease. Moreover, Nano medicine includes the use of nanoparticles for diagnosis and treatment of a variety of diseases, as well as in regenerative medicine [4]. Currently, employing nanoparticles in medicine as a drug delivery, heat, light or other substances to a specific types of cells such as cancer cells [5]. Nanoparticles are also used in reduction of FMD which is controlling disease of cattle and other ruminants that had severe consequences in United Kingdom, as nanotechnology is the key enabling sensitive detection in a very small scale by a rapid sensitive test of virus prior to disease symptoms (nanomaterial are bound as hand-held detector) and its application poses little to risk and great social benefits [6].

Silver nanoparticles (Ag NPs) could be used as coating of the device. Nano-silver coating has been applied to several medical catheters, drains and wound dressings are the most prominent as it leading to reduce colonization, infection rate, and hospitalization days, wound healing and show economic benefits. The efficiency of silver to improve clinical outcome depend on application and device. Wound dressing used for treatment of burns and non-healing wound with silver sulfadiazine crème or with other silver compound or salts [7]. Key mechanisms of toxicity of Silver nanoparticles include oxidative stress and genotoxicity, disruption of actin cytoskeleton, activation of lysosomal AcP activity, and stimulation of phagocytosis in blood cells and increase of MXR transport activity and inhibition of Na-K-ATPase in gill cells of fish [8].

Silver nanoparticles had the ability to inhibit the activities of interferon gamma and tumor necrosis factor alpha which involved in inflammation. The study proved that silver nanoparticles had anti-inflammatory action which can be used in many therapies. Also Silver nanoparticles (AgNPs) are widely used because of their anti-bacterial and anti-inflammatory properties; however, the adverse health effects of these nanoparticles, especially to the lungs [9]. Silver nanoparticles are also shown toxic effect on male reproductive system as it could pass blood-testis barrier and deposited in testes and adversely affect the sperm [10].

Additionally, the aquatic animals affected by silver nanoparticles, as silver nanoparticles could interact with gills of fish and inhibit basolateral Na+-K+-ATPase activity which inhibits osmoregulation in the fish [11]. Additionally, a combination of a low level of the NPs in the chitosan matrix improved their antimicrobial benefit. However, aqueous exposure to these materials still had hazardous effects on fish health [12].

Prostate cancer in dog was considered a highly dangerous disease but scientists at university of Missouri developed a new formulation of gold nanoparticles for treatment of dog prostate cancer. This new treatment doses that thousands times smaller than used in chemotherapy and didn't travel through body so not cause damage to the healthy tissues [13]. Notably, gum arabic-coated radioactive gold nanoparticles therapy had no toxicity in the treatment of natural occurring prostatic cancer in dog [14].

Mastitis is a disease of high milk yielding animals and causing high economic loss include decreased milk yield and increased use of drugs and veterinary services which caused by *Staphylococcus*, *Streptococcus*

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Figure 1: Show major non target toxicity of nanoparticles as recorded in literature.
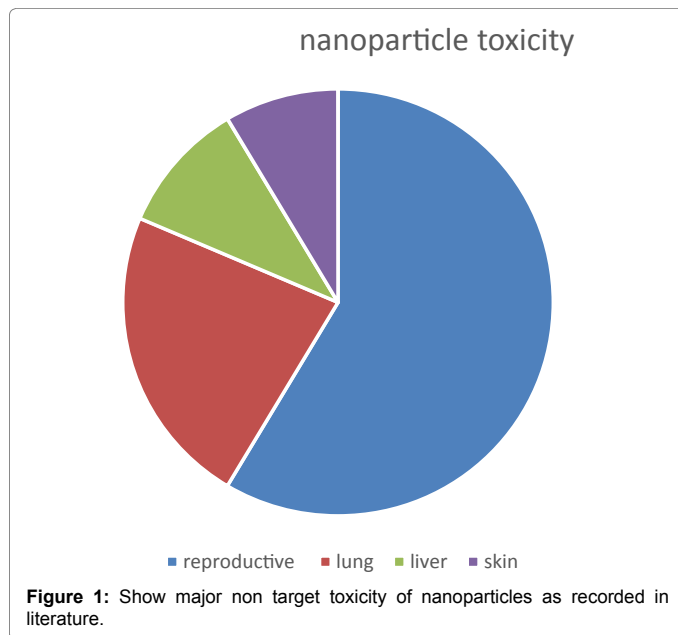
and *E. coli* could be treated by zinc oxide nanoparticles (ZnONPS), where they could reach the target organism generally inaccessible to antibiotics [15].

Titanium dioxide, due to its spherical shape with zero dimensionality had a large specific surface area, it used in a higher rate of photo catalytic decomposition of organic pollutants [16]. Although the unique physical and chemical properties of silver, an excellent anti-microbial and anti-inflammatory action it has adverse effect on environment and human. Titanium in many studies causes pulmonary toxicity of acute exposure to anatase form of titanium in terms of bronco-alveolar lavage (BAL) inflammation [17]. Also, mixtures of anatase and rutile particles of Tio_2 were able to induce increase in BAL fluid inflammatory parameters and lung histopathological alteration by inhalation in rat's sub acutely [18].

The trace mineral elements in brain were altered after the exposure to Tio_2 NP which may responsible of the spatial recognition memory impairments reported in treated mice due to the disrupted homeostasis of trace elements, neurotransmitters and enzymes in the brain [19,20]. Also Titanium dioxide (TiO_2) has been recorded to induce diverse pulmonary responses in exposed animals (Figure 1) [21].

In human exposed to free silver ions caused permanent bluish-grey discoloration of skin (argyria) or argyrosis due to silver ions in aqueous phase as a result from industrial wastes but the exposure to soluble silver caused toxic effect on liver and kidney and damage of eye, skin, respiratory tract and intestinal tract irritation and disturbances of blood cells [22].

Results

It was notice from analysis of previous literature that different nanoparticles used in veterinary fields for diagnosis, treatment of natural occurring disease especially cancer in valuable breeds of dog and cat. Also nanoparticles used in domestic animals for treatment of diseases as mastitis and used frequently in fish and treatment and safe of zoo or wild animals in captive protected area. The key mechanism of toxicity of nanoparticles in veterinary is due to increase in its leakage of nanoparticles in non-target tissue of therapy through genotoxicity, oxidative stress or hemotoxic effects. On other word, nanoparticles could have adverse effects on healthy rather than diseased tissue.

Discussion

Nanoparticles is promising tools in future medicine even there were toxic for reproductive organ [10,15], lung [9], liver and skin [22]. Toxicity of nanoparticles used in veterinary due to increase its accumulation of nanoparticles in non-target tissue of therapy [13,14] through genotoxicity, oxidative stress or hemotoxic effects [8]. On other word, nanoparticles could have adverse effects on healthy rather than diseased tissue. While adverse effect of nanoparticles includes liver, kidney and eye damage, skin, respiratory tract and intestinal tract irritation and disturbances of blood cells [22].

Finally, nanoparticles are hopeful agent in veterinary and human cure of diseases but still have adverse effects and need more investigation to reduce its toxicity.

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