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Original Research

Biochemical and morphological alterations caused by silver nanoparticles in Wistar rats

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Abstract

Objective: This study evaluated the biochemical effect of the oral administration of silver nanoparticles on some biochemical parameters and tissue morphology.
Methods: Wistar rats of both sexes with an average weight of 160 ± 5 g were randomly assigned into four groups. Animals in Group 1 served as the control and received 0.5 mL of distilled water (drug vehicle). Those in Groups 2, 3, and 4 were administered with 10, 50, and 100 mg/kg body weight silver nanoparticles, respectively. The animals were sacrificed under slight anesthesia 24 hours after the last treatment.
Results: Silver nanoparticle exposure in rats elevated the level of rat serum total cholesterol, triacylglyceride, free glycerol, low density lipoprotein-cholesterol, and bilirubin ($p < 0.05$) when compared with the control. The level of high density lipoprotein-cholesterol was depleted by nanoparticle exposure, whereas the atherogenic index rose. The levels of albumin, urea, creatinine, as well as activities of aspartate transaminase and alkaline phosphatase were decreased by the nanoparticles, whereas the total protein and alanine transaminase were inconsistently altered relative to the control. Furthermore, the nanoparticle treatment caused morphological lesions in rat cardiac, renal, and hepatic tissues relative to the control.
Conclusion: We show evidence that silver nanoparticle potentiated biochemical changes predisposing to liver injury and cardiovascular disorder in rat.

Keywords: lipid profile; nanotoxicology; safety evaluation; tissue pathology

1. Introduction

Nanoparticles are simply defined as particles <100 nm in size.[1] Nanoparticles have unique properties that may be useful in a diverse range of applications, and consequently they have attracted significant interest. In the biomedical field, in particular, the use of nanovaccines and nanodrugs are being intensively researched. Nevertheless, our knowledge about the biocompatibility and risks of exposure to nanomaterials is limited.[2] Hence, there is an urgent need for studies that contribute to our understanding of the interaction between nanoparticles and living cells. Because of the large surface area/volume ratio and reactivity, nanoparticles can bind to and interact extensively with biomolecules within the cell, which leads to several consequences.[3] This factor has

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stimulated the various research efforts aimed at investigating the effects of nanoparticles or nanomaterials in living organisms.

Silver nanoparticles (AgNPs) are increasingly and widely being applied for biomedical purposes.[4] This hinges on the fact that AgNPs have been credited with broad antimicrobial potential. AgNP, as an arch product from the field of nanotechnology, has gained interest because of its distinctive properties, such as good conductivity, chemical stability, catalytic, antibacterial activity, antifungal, antiviral, and anti-inflammatory properties.[5–7] Silver-based medical products, ranging from topical ointments and bandages for wound healing to coated stents, have been proven to be effective in retarding and preventing bacterial infections.[8] However, the increasing usage of AgNP for biomedical purposes far exceeds the availability of safety evaluation studies of these nanoparticles. This research gap is being gradually filled.

The present study evaluated the effect of AgNPs on some serum biochemical indices and tissue morphology in Wistar rats.

2. Materials and Methods

2.1. Nanoparticles

The AgNPs were obtained from the Nanomedicine and Biomedical Target Laboratory, Department of Biochemistry, Microbiology and Biotechnology, Rhodes University, South Africa. The preparation procedures and the characterization are as previously demonstrated in our previous report.[4,9,10]

2.2. Experimental animals

Wistar rats of both sexes with an average weight of 160 ± 5 g were obtained from the animal unit of the Department of Biochemistry, University of Ilorin, Nigeria.

2.3. Chemicals and reagents

The assay kits for creatinine (CREA), urea, bilirubin (BIL), and albumin (ALB), total cholesterol (TC), triacylglyceride (TAG), high density lipoprotein-cholesterol (HDL-C), free glycerol (FG), alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were obtained from Randox Laboratory Limited (Crumlin, United Kingdom). All other reagents used were of analytical grade and supplied by Sigma Aldrich Inc. (St. Louis, MO, USA).

2.4. Animal groupings and treatments

The animals were housed in standard plastic cages and were acclimatized for 2 weeks. They were maintained under standard conditions of 12 hours light and dark cycle and had free access to standard rat chow and clean water *ad libitum*. Handling of animals was humane and consistent with relevant guidelines as approved by the institutional ethics committee on scientific study. The details of animal groupings are as shown below:

Group 1 served as control and was administered 0.5 mL distilled water.
Group 2 was administered 0.5 mL of 10 mg/kg body weight of Ag nanoparticles dissolved in distilled water.
Group 3 was administered 0.5 mL of 50 mg/kg body weight of Ag nanoparticles dissolved in distilled water.
Group 4 was administered 0.5 mL of 100 mg/kg body weight of Ag nanoparticles dissolved in distilled water.

Rats were given oral and daily treatments. The treatments lasted for 30 days. The selection of dosages used is premised on our previous report.[4]

2.5. Preparation of serum and tissue homogenates

The rats were sacrificed under slight anesthesia 24 hours after the end of the last treatment. The blood was collected into a clean and sterile sample bottle. The blood was centrifuged at 1500g for 15 minutes using a Uniscope Laboratory Centrifuge (Model SM800B). The serum was aspirated and stored frozen until required for analyses. The tissues including liver, kidney, and heart were removed, blotted, and weighed. The tissues were then homogenized in ice-cold 0.25M sucrose solution (1:5 w/v). Sections from the excised tissues were fixed in buffered neutral formalin and used for the histopathological examination.

2.6. Determination of biochemical parameters

The activities of AST (E.C. 2.6.1.1), ALT (E.C. 2.6.1.2), ALP (E.C.3.1.3.1), ALB, BIL, CREA, urea, serum TC concentration, HDL-C, and TAG was assayed using the Randox assay kits (Randox Laboratory Limited). The concentration of serum low density lipoprotein (LDL-C) was estimated using the Friedewald formula,[11] whereas the atherogenic index (AI) was estimated by finding the ratio of TC to HDL-C concentration. The protein content of the serum and homogenates was determined using the Biuret method as previously described by Sulaiman and Adeyemi.[12]

All measurements were done using a Spectronic 21 spectrophotometer (Bausch and Lomb, Rochester, NY, USA).

2.7. Histological examination

The procedures described by Adeyemi and Akanji[13] were used. Briefly, the heart, kidney, and liver were fixed in 10% (v/v) formaldehyde, dehydrated through ascending grades of ethanol (70%, 90%, and 95%, v/v), cleaned in xylene, and embedded in paraffin wax (melting point 56°C) and stained with hematoxylin and eosin. The photomicrographs were captured at $\times 100$ using the software Presto Image Folio package.