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Zinc oxide nanoparticles hepatotoxicity: Histological and histochemical study

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ABSTRACT

Zinc oxide nanoparticles (ZnO NPs) are widely used in industry and cosmetic products with promising investment in medical diagnosis and treatment. However, these particles may reveal a high potential risk for human health with no information about hepatotoxicity that might be associated with their exposure. The present work was carried out to investigate the histological and histochemical alterations induced in the hepatic tissues by naked 35 nm ZnO NPs. Male Wistar albino rats were exposed to ZnO NPs at a daily dose of 2 mg/kg for 21 days. Liver biopsies from all rats under study were subjected to histopathological examinations. In comparison with the control rats, the following histological and histochemical alterations were demonstrated in the hepatic tissues of rats exposed to ZnO NPs: sinusoidal dilatation, Kupffer cells hyperplasia, lobular and portal triads inflammatory cells infiltration, necrosis, hydropic degeneration, hepatocytes apoptosis, anisokaryosis, karyolysis, nuclear membrane irregularity, glycogen content depletion and hemosidrosis. The findings of the present work might indicate that ZnO NPs have potential oxidative stress in the hepatic tissues that may affect the function of the liver. More work is needed to elucidate the toxicity and pathogenesis of zinc oxide nanoparticles on the vital organs.

1. Introduction

Nanoparticles (NPs) are biologically reactive due to their small size and larger surface area to volume ratio (Lanone and Boczkowski, 2006; Yu et al., 2011, 2012). The available information indicate that small size NPs have easier clearance from the site of injection, longer circulating residue and slower passage to the interstitial spaces than the large size ones (Hussain et al., 2005; Wang et al., 2010; Yu et al., 2011). In addition, NPs with all sizes can induce oxidative stress and generate free radicals that could cause damage to tissues, cells and macromolecules where smaller particles are more toxic than the larger ones (Abdelhalim and Jarrar, 2011, 2012).

Zinc oxide NPs are currently being produced in high tonnage and utilized in various cosmetic and makeup products. These particles are utilized in sunscreens, ointments, tooth pastes and in some coatings for protection from UV radiation (Xia et al., 2008; Zvyagin et al., 2008; Smijs and Pavel, 2011; Vanderiel and Jong 2012). Also, ZnO NPs have recently received much attention due to their possible applications in cancer therapy (Rasmussen et al., 2010). These fine particles exhibited selective apoptosis in some cancer cells via p53 pathway mediation (Hanley et al., 2008; Guo et al., 2008; Zhang et al., 2008; Nair et al., 2009; Hackenberg et al., 2010; Akhtar et al., 2012). In addition, ZnO NPs have important application in the industry of electronic devices and paint industry. Furthermore, these particles have been incorporated in polymeric matrices, packaging materials and food systems to provide antimicrobial activity (Vanderiel and Jong 2012; Tayel et al., 2011). Zinc oxide NPs have bactericidal effects on both Gram-positive and Gram-negative bacteria with activity against spores that are resistant to high temperature and high pressure (Arabi et al., 2012).

Zinc oxide NPs toxicity was found to be related to their solubility and ability to generate free radicals (Osmond and McCall, 2010). In addition, these particles have the ability to cross the cell membrane and some blood vital organs barrier. Moreover, some reports indicated that ZnO NPs could exhibit cytotoxicity, genotoxicity, oxidative stress, mitochondrial dysfunction, apoptosis, neurotoxicity and inflammatory response (Yang et al., 2009; Yuan et al., 2010;

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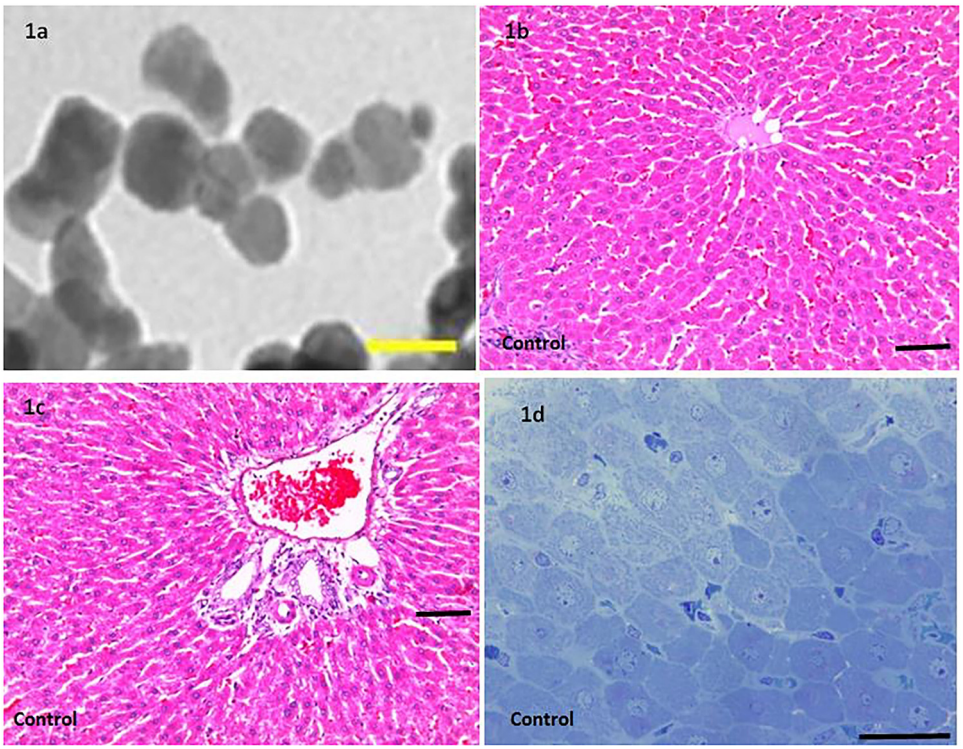

Fig. 1. (a–d) (a) Scanning electron micrograph demonstrating morphology and size of the used ZnO NPs, (Bar = 40 nm). (b) Section in the liver of control rats demonstrating normal hepatic architecture, hepatic strands and hepatocytes. H&E stain. (Bar = 40 μm). (c) Section in the liver of control rats demonstrating normal portal triads. H&E stain, (Bar = 40 μm). (d) Section in the liver of control rats demonstrating Normal sinusoids and Kupffer cells. Toluidine blue stain, (Bar = 15 μm).

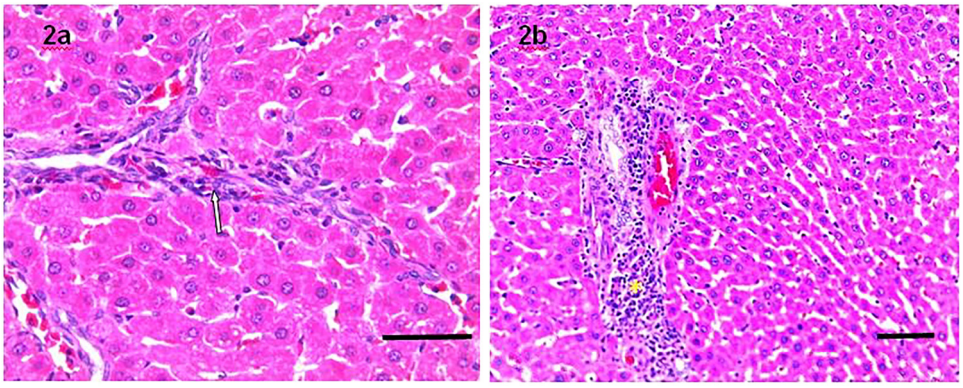

Fig. 2. (a–b) Light photographs of section in the liver of ZnO NPs treated rats demonstrating: (a) Lobular inflammatory cells infiltration (arrow). H&E stain. (Bar = 20 μm) (b) Microgranulomus inflammatory infiltration (star). H&E stain. (Bar = 40 μm).

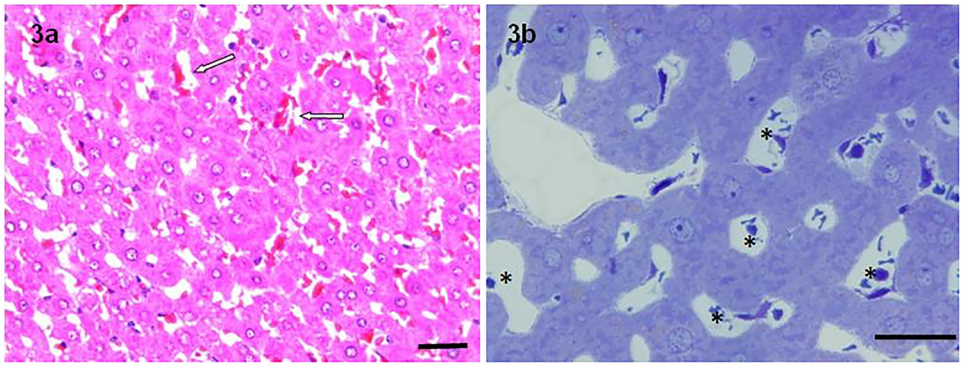

Fig. 3. (a–b) Light photographs of section in the liver of ZnO NPs treated rats demonstrating: (a) Sinusoidal dilation (arrows). H&E stain, (Bar = 30 μm) (b) Sinusoidal dilation (stars). Toluidine blue stain, (Bar = 10 μm).