Role of Oats in ameliorating hepatic and renal toxicity induced by acuteLead nanoparticlesin male rats

ABSTRACT

Aims: Lead is well known environmental pollutant, which can cause toxic effects in multiple organ systems. Lead originates from various industrial and/or household sources, and enters the body through food and fluid intakes, as well as by inhalation. No sufficient information present about the toxic effect of acute lead nanoparticles on kidney and liver. Accordingly, current study was performed to study the therapeutic effects of Oats extract towards the injection of lead nanoparticles (PbNPs) in rat induced kidney and liver damage by increasing kidney and liver functions, and electrolytes.
Study design:A total of 40 male adult albino rats were equally divided into four groups (Control group, Oats group, Pb NPs group as acute toxicity and last group isPb NPs +Oats).
Results: Current results revealed that; a significant increase in the levels of serum aspartate transaminase (AST) and alanine transaminase (ALT), alkaline phosphatase (ALP), urea, creatinine, potassium and chloride ions after injection with Pb NPs as compared to control group. In contrast; a significant decrease in serum albumin, total proteins, and sodium ions in Pb NPs as compared to control groups. Treatment of Pb NPs with Oats improved this change in liver and kidney functions as compared to Pb NPs group.
Conclusion: These findings suggested that; lead nanoparticles injection induced hepatic and renal damage. This shows that the desired dose of Pb NPs can safely be used with Oats in improving hepatic and renal damage in toxic group in young rats.

Key words: Lead nanoparticles; Oats; Rats; Liver and kidney functions.

1. INTRODUCTION

During recent decade, major researchers focused their research towards nanotechnology and its applications all over the globe. Metal nanoparticles have gained more attention and play a major role in day by day due to its vast of area of application like development of biosensors etc [1,2,3].Nanoparticles had found a number of applications in everyday life. Despite of many benefits that nanomaterials, including nanoparticles (NPs), bring to the society, e.g. in drug delivery systems, medical devices, food products, cosmetics, etc. their increasing usage raises concern about the consequences and health threats that it might bring to humans. The risk of dermal, inhalation and ingestion exposure to NPs exist at many stages of NPs life cycle [1,3].

Lead is well known environmental pollutant, which can cause toxic effects in multiple organ systems [4]. Lead continues to remain a persistent environmental health threat today. Exposure to lead can result in significant adverse health effects in multiple organ systems. Leads have toxic effects on the nervous, hematological, renal and reproductive systems have been studied extensively and have been documented in detail [5].Lead originates from various industrial and/or household sources, and enters the body through food and fluid intakes, as well as by inhalation [6,7].
Children have been shown to be at greatest risk because of their enhanced gastrointestinal absorption of lead (40–50% vs. 10–15% in adults) and an incompletely developed blood-brain barrier [4]. Lead exposure increases the risk of diminished intelligence, attention deficit, hyperactivity disorder, school failure and criminal behavior, thus, there is no known safe level of exposure to lead [8].Absorbed lead, which is not excreted out of body, is deposited primarily in

mineralizing tissues (bones and teeth), which typically store the majority of the body burden of lead, and in soft tissue organs such as the liver, kidneys, lungs, brain, spleen, muscles and heart [4]. At a steady state, about 90% of lead in the human body was found in the skeleton of adults [5] and 73% in children, respectively [7]. The half-life of lead in adult human blood has been estimated to range between 28 and 36 days [4]. Lead is excreted via the kidneys with a half-life of about 30 days under normal kidney function.

Recently, there is a marked increase in the use of complementary and alternative medicine[10-15]. Kidney and liver diseases is accompanying with extraordinary morbidity and mortality, and these diseases are associated with elevation oxidative damage, and endogenous and synthetic antioxidants [16-19].
Oats (Avena sativa L.) is an annual 1.5-m-high grass widely cultivated in cool and moistregion of Northern Europe and North America. Oatsare distinct among cereals due to their considerably higher protein concentration. Oat is mainly eaten as porridge, breakfast cereals, and baked goods (oatcakes, oat cookies, and oat bread)[20].At the same timeouts possess a protein quality of high nutritional value and a special protein composition. Most cereals like wheat, barley, and rye have a high percentage of prolamins, the alcohol-soluble fraction, which usually contains most of the storage proteins, but oats are an exception [20]. Their major storage proteins belong to the salt-water soluble globulin fraction, whereas oats prolamins are a minor component. During oats great development, most obvious is the fairly linear increase in the globulin fraction [21]. No sufficient information present about the toxic effect of acute lead nanoparticles on kidney and liver. Accordingly, current study was performed to study the therapeutic effects of Oats extract towards the injection of Lead Nanoparticles (Pb NPs) in rat induced kidney and liver damage by increasing kidney and liver functions, and electrolytes.

2. MATERIAL AND METHODS

2.1. Lead nanoparticles

Lead nano powder with a particle size less than 100 nm and a 99.9% trace metals basis was purchased from Sigma-Aldrich Chemicals, Cairo, Egypt.

2.1 Experimental Animals

The experiment was performed on 40 male albino rats (*Rattusnorvigicus*) weighing 150 g (±10) and of 9-10 weeks' age. They were obtained from the animal house of the National Research Center (Dokki, Giza, Egypt). The rats were housed in suitable plastic cages for one week before the experimental work for acclimation with a new room conditions and maintained on a standard rodent diet, with water available ad libitum. Animal maintenance and treatments were conducted by the Faculty of Science, Tanta University guide for the animal, as approved by the Institutional Animal Care and Use Committee (IACUC-SCI-TU-0185).

2.2 Experimental Design

A total of 40 male adult's rats were equally divided into four groups. Group 1, control includes animals that not given any drug; group 2, includes rats that receive Oats (intragastrically, 5 g/Kg body weight/ day); group 3, (PbNps) include animals that treated with PbNps (50 mg/Kg body weight/ day) for 1 weeks. In contrast; group 4, (PbNps+Oats) include animals that treated PbNps for one week and then with Oats for another 2 weeks.

2.3 Determination of Serum Enzymes

At the end of the experimental period, animals fasted overnight and blood samples were individually collected from the eyes by retroorbital puncture using blood capillary tubes without heparin as per requirement under mild ether anaesthesia for clinical chemistry examinations. Blood samples were incubated at room temperature for 10 minutes and left to clot then centrifuged at 3000 r.p.m for 10 min and the serum was collected, serum was separated and kept in clean stopper plastic vial at –80ºC until the analysis of serum parameters [22].

2.3.1 Serum liver functions enzymes

Serum aspartate transaminase (AST) and alanine transaminase (ALT) activities were assessed in the sera as per [23, 24]respectively while serum alkaline phosphatase (ALP) levels were evaluated by [25]. Serum albumin were assessed by [22] while serum total proteins level was evaluated by [26].

2.3.2 Electrolytes and kidney functions biomarkers

Serum urea and creatinine were determined in the mouse sera according to [27]. The approach proposed by [28] was followed to measure the levels of serum electrolytes (Potassium, sodium, calcium and chloride ions) using commercial kits (Sensa core electrolyte, India).

2.4 Statistical Analysis

Data were expressed as mean values ± SE and statistical analysis was performed using the unpaired t-test to assess significant differences among treatment groups. The criterion for statistical significance was set at $p<0.05$ for the biochemical data. All statistical analyses were performed using SPSS statistical version 21 software package (SPSS® Inc., USA).

3. RESULTS

3.1 Liver function:

Figures (1) revealed that; a significant increase in the level of ALT, AST and ALP in the injected rats with lead nanoparticles (PbNps) as compared control group. In contrast; Figures (2) revealed a significant decrease in the levels of albumin and total proteins in the injected rats with lead nanoparticles (PbNps) as compared control group. On the other hand; treatment of lead nanoparticles with oats (PbNps+Oats) revealed a significant decrease in the levels of ALT, AST, ALP and a significant increase in the levels of albumin and total proteins as compared to injected rats with lead nanoparticles (Figures 1&2).

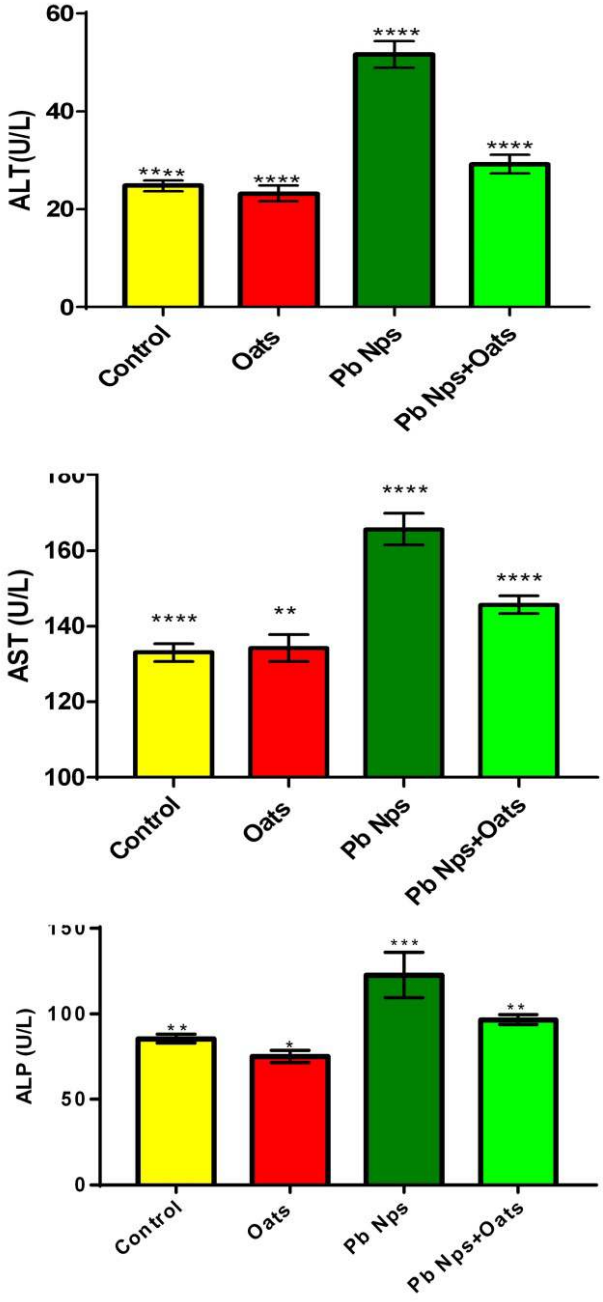

Figure 1: Changes in liver function as serum aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) levels in different groups. Data are expressed as mean ± SE of 10 observations. The significance of difference was analyzed by one – way ANOVA and Dunnett test (compare all vs. PbNps group) using computer program. Values are expressed as means ± SEM. one – way ANOVA was significant at $P < 0.05$. Dunnett test was significant from corresponding PbNps group value at*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$ and ****$P < 0.0001$.

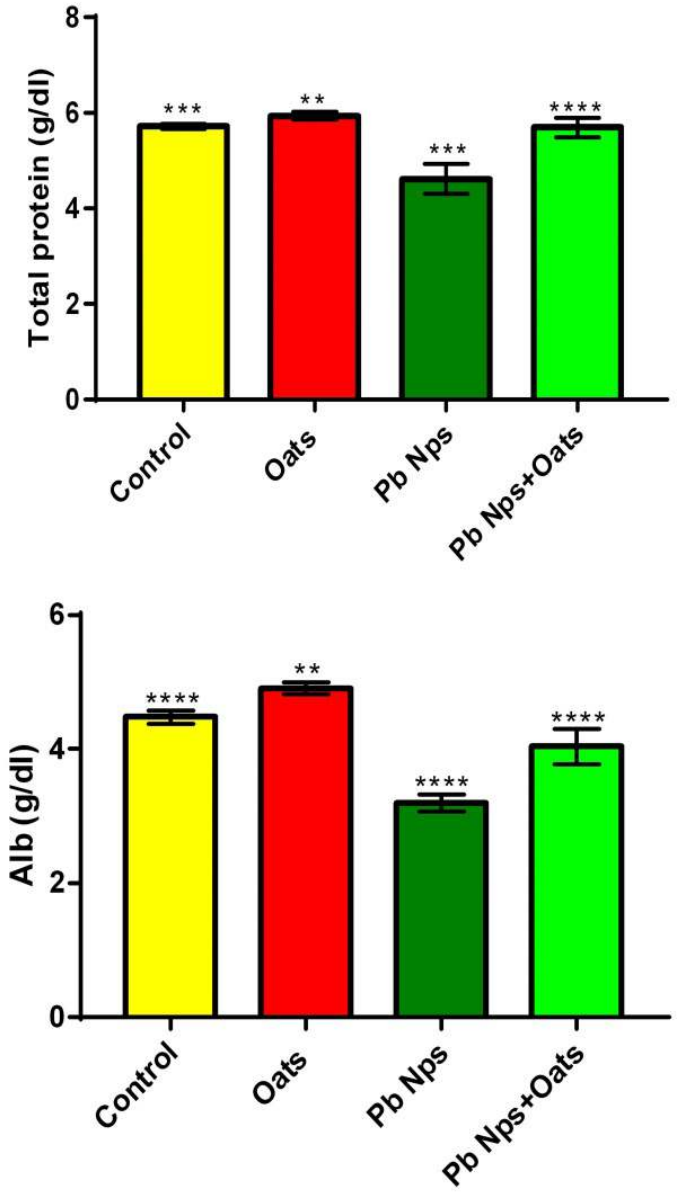

Figure 2: Changes in liver function as albumin (Alb) and total proteins levels in different groups. Data are expressed as mean ± SE of 10 observations. The significance of difference was analyzed by one – way ANOVA and Dunnett test (compare all vs. PbNps group) using computer program. Values are expressed as means ± SEM. one – way ANOVA was significant at $P < 0.05$. Dunnett test was significant from corresponding PbNps group value at*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$ and ****$P < 0.0001$.

3.2 Kidney function:

Table (1) revealed that; a significant increase in the level of urea, creatinine, potassium and chloride ions in the injected rats with lead nanoparticles (PbNps) as compared control group. In contrast; a significant decrease in the levels of sodium and calcium ions in the injected rats with lead nanoparticles (PbNps) as compared control group (Table 1). On the other hand; treatment of lead nanoparticles with oats (PbNps+Oats) revealed a significant decrease in the levels of the level of urea, creatinine, potassium and chloride ions and a significant increase in the levels of sodium and calcium ions as compared to injected rats with lead nanoparticles (Table 1). Serum uric acid levels showed insignificant changes between different groups (Table 1).

Table 1: Variations in the serum kidney function (urea, creatinine, uric acid) and electrolytes as potassium (K+), chloride (Cl^-), calcium and sodium ions(Na+) levels in different groups.

	Control	Oats	PbNps	PbNps+Oats
Urea (mg/dl)	31.6±1.691*	34.2±1.772*	39.8±0.860**	35.2±2.154**
Creatinine (mg/dl)	0.492±0.052**	0.492±0.051**	0.8±0.030***	0.584±0.020*
Uric acid (mg/dl)	3.618±0.065	3.59±0.0532	3.614±0.095	3.54±0.066
K^+ (mEq/L)	4.118±0.090**	4.002±0.059*	5.462±0.104****	4.916±0.217***
Na^+ (mEq/L)	135.4±0.32****	135.8±0.664***	122.2±0.522**	130±0.745**
Ca^{++} (mEq/L)	1.248±0.021***	1.272±0.017***	1.118±0.016**	1.164±0.025**
Cl^- (mEq/L)	101.6±0.585**	100.7±0.372*	106±1.116****	104.2±0.937****

*Data are expressed as mean ± SE of 10 observations. The significance of difference was analyzed by one – way ANOVA and Dunnett test (compare all vs. PbNps group) using computer program. Values are expressed as means ± SEM. one – way ANOVA was significant at P < 0.05. Dunnett test was significant from corresponding PbNps group value at*P < 0.05, **P < 0.01, ***P < 0.001 and ****P < 0.0001.*

4. DISCUSSION

Lead is an environmental pollutant with the largest toxicological database [8]. Exposure to lead can result in significant adverse health effects in multiple organ systems. Lead originates from various industrial and/or household sources, and enters the body through food and fluid intakes, as well as by inhalation[6,7]. Children have been shown to be at greatest risk because of their enhanced gastrointestinal absorption of lead (40–50% vs. 10–15% in adults) and an incompletely developed blood-brain barrier [6]. Lead exposure increases the risk of diminished intelligence, attention deficit, hyperactivity disorder, school failure and criminal behavior, thus, there is no known safe level of exposure to lead [8]. Acute lead poisoning is characterized by non-specific symptoms such as abdominal pain (lead colic), joint pain, constipation, anorexia, muscle aches, headaches, decreased libido, sleep disturbance, irritability, fatigue, anemia, nephropathy, confusion, encephalopathy and seizures [8]. The current study was performed to study the therapeutic effects of Oats extract towards the injection of lead nanoparticles (PbNPs) in rat induced kidney and liver damage by increasing kidney and liver functions, and electrolytes.

Liver enzymes (AST, ALT, ALP, albumin and total proteins) are considered as an important biomarker for the detection of lead hepatotoxicity. According to our results, lead caused a significant increase in AST, ALT and ALP levels versus the control group. In contrast; a significant decrease in albumin and total proteins. The changes in serum albumin provide valuable indices of severity, progress and prognosis in hepatic disease and this indicates hepatocellular origin of liver disease [25]. Decrease in albumin has been observed in serum of patients with tissue inflammation and damages [29]. Our results agree with [30] who studied the hepatotoxic effects of lead acetate in rats. Also [31] confirm our result and studied the ameliorative effect of curcumin against lead acetate–induced hemato-biochemical alterations, hepatotoxicity, and testicular oxidative damage in rats.

Urea is a waste item framed from the breakdown of proteins while creatinine is a waste item made by the muscles [17,32]. Serum urea and creatinine are helpful records for assessing the status of renal capacity and the creatinine levels is typically a more exact marker of kidney work than urea [18]. The elevation serum urea levels may suggest debilitated renal discharge [33]. [34]who reported that; nanoparticles induced renal toxicity. Current results revealed that; treated rats with lead nanoparticles (PbNPs) induced significant elevation in the levels of creatinine, urea, potassium ions and chloride ions, (P < 0.01) by comparison to the control and Oats groups. In contrast; decline in serum sodium ions were observed after the treatments of rats with PbNPs. Post treatments of rats with PbNPs andOats extract (PbNPs+Oats), improved the kidney functions and structure. This elevation in kidney functions is due tothe abnormalities in kidney histological structure (data not shown). Our results align with [35] who stated that hydroxyapatite nanoparticles induced renal toxicity in male rats. Our results agree with [36] who reported that administration of Pb significantly increased the levels of renal function as creatinine, urea and uric acid. Our results in line of [37,38]who find that; treatments with TiO2NPs induced elevations in the levels of urea creatinine and uric acid. This increase in potassium ions and the decrease in sodium ions levels may be due to kidney injury.

The current results indicate that administering Oats extract led to hepatic and renal structures being close to normal and very similar to the kidneys and livers retrieved from control animals. The reduction in the activities of ALT. AST, ALP,

creatinine, urea, potassium and chlorides by Oats point to the compound exerting a hepato- and renal protective effect by stimulating antioxidativedefence mechanisms, in addition to performing scavenging and or antioxidant properties [39,40,41,20].

5. CONCLUSION

These findings suggested that the misuse of lead nanoparticles may contribute to continuous hepatic and renal damage. This shows that the desired dose of PbNPs can safely be used with Oats in improving hepatic and renal damage in toxic group in young rats.

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