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Impacts of Acute Toxicity of Heavy Metals (Hg And Pb) On Liver Enzymes of Normal Albino Wistar Rats

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Abstract: *his study investigates the effects of acute toxicity from heavy metals (mercury chloride and lead nitrate) on the liver enzymes of normal albino Wistar rats. Sixteen male albino rats (292-297 g) were divided into four groups, with four rats in each group. Groups 1, 2, and 3 were exposed to 40% of the lethal dose (LD50) of lead nitrate, mercury chloride, and a combination of both metals, respectively. Group 4 served as the control group. All animals had access to commercial rat mash and water during the one-week experimental period. Animals in groups 2 and 3, treated with mercury chloride and the combination of the two metals, died within a day after exposure. The results showed no significant decrease (P > 0.05) in mean serum aspartate aminotransferase (AST) and alkaline phosphatase (ALP) levels in group 1 when compared to the control. The mean serum alanine transaminase (ALT) in group 1 also showed no significant difference (P > 0.05) compared to the control. The findings indicate that the toxicity of mercury chloride and the combination of mercury chloride and lead nitrate was lethal, leading to the death of the rats. Although lead nitrate alone altered liver enzyme levels, it did not cause fatality. Therefore, human exposure to these heavy metals should be avoided to prevent deleterious effects.*

Keywords*: Acute Toicity, Mercury Chloride, lead nitrate, liver enzymes, Albino Wistar rats*.

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1.0 Introduction

Heavy metals are a class of metals and metalloids known for their high density and potential toxicity, even at minute concentrations. These metals, including mercury (Hg) and lead (Pb), are introduced into the environment through both natural processes and anthropogenic activities such as industrial discharge, mining, and vehicular emissions (Jaishankar et al., 2014). Due to their non-biodegradable nature, heavy metals persist in the environment, leading to bioaccumulation in organisms, including humans (Wuana & Okieimen, 2011). This accumulation can cause severe health problems, as many heavy metals are associated with carcinogenic, neurotoxic, and nephrotoxic effects (Tchounwou et al., 2012). The liver, being a vital organ responsible for detoxification and metabolism, is particularly susceptible to damage caused by these metals. Lead and mercury are two of the most concerning heavy metals due to their widespread presence and highly toxic nature. Lead exposure has been shown to disrupt various biological processes, particularly in

children, where it can lead to developmental delays, reduced cognitive function, and damage to the nervous system (Sanders et al., 2009). Mercury, especially in its organic form, is also highly toxic, with its primary targets being the kidneys and central nervous system. Chronic mercury exposure has been linked to neurodegenerative diseases and other severe health conditions (Bose-O'Reilly et al., 2010).

In recent studies, mercury and lead have been reported to induce oxidative stress, leading to the overproduction of reactive oxygen species (ROS). This oxidative stress disrupts cellular integrity by enhancing lipid peroxidation, decreasing saturated fatty acids, and increasing unsaturated fatty acids within cell membranes (Gurer-Orhan et al., 2020). Such changes in the membrane composition impair cell function and contribute to the toxicity observed in exposed organisms. Both metals also disrupt normal enzymatic activities, including those related to liver function, which are critical indicators of systemic toxicity (Gupta et al., 2015).

Given the liver's role in metabolizing and detoxifying harmful substances, understanding the impact of heavy metals on liver enzymes is crucial for assessing the extent of toxicity. Previous studies have shown that the activities of liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) are often altered upon exposure to toxic metals (El-Tantawy et al., 2016). These enzymes serve as important biomarkers for liver damage, and their levels in the blood can provide insights into the health status of the liver.

This study aims to investigate the acute effects of mercury chloride (HgCl2) and lead nitrate (PbNO3) on the liver enzyme levels of normal albino Wistar rats. By assessing the serum levels of ALT, AST, and ALP, we aim to evaluate the extent of liver damage caused by these heavy metals. Understanding the acute toxicity of Hg and Pb is vital for informing public health policies and preventing human exposure to these hazardous substances.

2.0 Materials and Methods

2.1 Materials

The following materials were used for the experimental work 16 female albino Wistar rats, animal feed, cages, lead nitrate, mercuric chloride, analytical weighing balance, distilled water, dissecting sets, dissecting boards, sample plain bottles, syringes, needles, chloroform, beakers, centrifuge, spatula, cotton wool, hand gloves, face mask, masking tape, permanent markers, methylated spirit, sensitive weighing balance, laboratory coat, spectrophotometer.

The heavy metals used were lead nitrate and mercury chloride, which were bought from the Chemistry Laboratory, Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Akwa Ibom State. Forty (40) percent of the LD_{50} of lead nitrate was weighed with a sensitive electric balance and dissolved in 4ml of distilled water and based on the average body weight of group 1, 1ml was to be administered on each of the four animals in the group. The same was done to group 2 animals where 40% of the LD_{50} of mercury chloride was dissolved in 4ml of distilled water, then 1ml was to be treated on each rat in the group. Forty per cent of the LD_{50} of lead nitrate and mercury chloride were respectively weighed and mixed up, dissolved in 4ml of distilled water and 1ml of the mixture was to be treated on each of the rats in group 3. Group 4 animals were taken as control without treatment.

2.3 Experimental design, grouping and treatment

Sixteen (16) female albino Wistar rats were obtained from the Pharmacy Department University of Uyo, Akwa Ibom State. The animals were caged in a wooden cage with wire mesh covers under the standard conditions of temperature and natural light-dark cycle and were fed regularly with

commercial rat mash and distilled water. The animals were acclimatized for seven days after which they were randomly assigned four rats each for four groups. Groups 1, 2 and 3 were treated with 40% of the LD_{50} of lead nitrate, mercury chloride and a combination of the two metals.

2.2 Collection and preservation of blood sample

After 7 days of treatment with heavy metals, the albino Wistar rats were anaesthetized under chloroform and dissected heliocentrically. Blood samples were collected through cardiac puncture by syringe and needle into well-labelled sterile plain sample bottles. The samples were centrifuged at 3000rpm for 15 minutes using a benchtop centrifuge to separate serum from the red blood cells. The separated samples were pipetted into another sterile plain sample bottle with corresponding labelling for use in the determination of liver enzyme level parameters.

2.3 Method

The method used for the determination of liver enzyme level parameters was the spectrophotometric method.

3.0 Results and Discussion

The effects of acute toxicity induced by lead nitrate and mercury chloride on the liver enzyme levels in albino Wistar rats were analyzed by measuring the serum levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP). The results are presented in Table 1. Rats in Group 1, treated with lead nitrate, showed a non-significant decrease in serum AST levels (160.25 ± 21.46 IU/L) compared to the control group (207.75 ± 35.32 IU/L), while ALT levels (24.25 ± 6.37 IU/L) remained comparable to the control (24.25 ± 2.29 IU/L). Similarly, ALP levels in Group 1 showed a slight, non-significant increase (332.75 ± 32.18 IU/L) compared to the control group (169.50 ± 44.92 IU/L), indicating some degree of liver stress but without significant hepatic damage. In contrast, rats in Groups 2 and 3, which were treated with mercury chloride and a combination of lead nitrate and mercury chloride, respectively, experienced fatal outcomes within 24 hours of exposure. This acute lethality highlights the extreme toxicity of mercury chloride, which is known to cause rapid disruption of cellular function through direct inhibition of enzyme activity, alteration of mitochondrial function, and interference with antioxidant defence mechanisms (Bose-O'Reilly et al., 2010). The combined exposure to both metals in Group 3 may have exacerbated these toxic effects, overwhelming the liver's detoxification capacity and leading to the rapid demise of the animals.

Table 1: Effects of Lead Nitrate and Mercury Chloride on Liver Enzyme Levels in Albino Wistar Rats

	AST (IU/1)	ALT (IU/1)	ALP (IU/1)
Group 1	160.25±21.46	24.25 ± 6.37	332.75±32.18
Group 2	Dead	Dead	Dead
Group 3	Dead	Dead	Dead
Group 4	207.75 ± 35.32	24.25±2.29	169.50 ± 44.92

****Values are Expressed as Mean ± SEM, N=4; P<0.05 is considered Statistically Significant.**

The co-administration of lead nitrate and mercury chloride did not significantly prolong survival compared to exposure to mercury chloride alone, suggesting that the interaction between these metals may not mitigate their toxicities. Instead, likely, both metals contributed synergistically to liver damage, as

evidenced by the immediate mortality observed in both Groups 2 and 3. This aligns with research indicating that exposure to multiple heavy metals can result in cumulative toxic effects, particularly in organs like the liver, which are responsible for detoxifying these compounds (Jaishankar et al., 2014).

The serum enzyme levels observed in Group 1 are consistent with subclinical hepatic damage, as minor decreases in AST and increases in ALP are often indicative of hepatocellular stress or cholestasis (Gaskill et al., 2005). While ALT levels remained unchanged, which suggests that the structural integrity of hepatocytes was largely preserved, the overall enzyme profile suggests early stages of hepatic dysfunction. The absence of significant enzyme elevation indicates that the liver retained sufficient functional reserve to cope with the toxic insult, thus preventing overt liver failure.

Previous studies have reported similar findings in animals exposed to lead, showing that the metal causes oxidative damage to cellular membranes but does not immediately trigger massive hepatocyte necrosis at sublethal doses (Nabil et al., 2013). However, long-term exposure to lead, even at low doses, has been associated with cumulative liver damage, particularly through the disruption of mitochondrial function and the induction of lipid peroxidation (Wuana & Okieimen, 2011). Therefore, while acute exposure to lead nitrate did not cause immediate mortality in this study, prolonged exposure could potentially lead to more severe hepatic consequences.

The study reveals that acute exposure to mercury chloride, either alone or in combination with lead nitrate, is highly lethal due to its potent hepatotoxic effects, while exposure to lead nitrate alone results in mild, non-fatal alterations in liver enzyme levels. The findings underscore the need for strict regulation of heavy metal exposure to prevent deleterious health outcomes, particularly in environments where mercury and lead contamination are prevalent.

4.0 Conclusion

This study explored the acute toxicity effects of lead nitrate and mercury chloride on liver enzyme levels, including AST, ALT, and ALP, in albino Wistar rats. The rats were grouped into four, with Group 1 exposed to lead nitrate, Group 2 to mercury chloride,

Group 3 to a combination of both, and Group 4 as the control. The results showed that the rats in Group 1 experienced mild changes in enzyme levels, while those in Groups 2 and 3 died within 24 hours of exposure. This indicates that lead nitrate causes moderate hepatic stress without immediate fatality, while mercury chloride alone or in combination with lead nitrate results in severe liver toxicity and rapid death.

The findings demonstrate the varying toxic effects of these heavy metals on liver function. Mercury chloride exhibited far more potent toxicity than lead nitrate, with fatal consequences for the rats even after acute exposure. Lead nitrate, on the other hand, led to oxidative stress and some changes in liver enzyme levels, but did not result in acute liver failure within the short-term exposure period.

In conclusion, the study found that exposure to lead nitrate, at levels below its lethal dose, causes mild liver stress as shown by slight changes in enzyme levels. However, mercury chloride exposure, either alone or in combination with lead nitrate, was lethal, causing liver failure and death in the rats. Mercury chloride proved to be more toxic than lead nitrate in this acute exposure model, and the combination of both metals also led to fatal outcomes. While lead nitrate did not cause immediate death, prolonged exposure would likely lead to cumulative liver damage due to oxidative stress.

Based on these findings, it is recommended that environmental regulations be enforced to monitor and limit the presence of lead and

mercury in industrial waste and the broader environment to reduce exposure. Long-term studies are also advised to understand the cumulative impact of low-dose exposure to these heavy metals on liver function and overall health, as this could provide insights into the delayed effects of toxicity. Additionally, public awareness campaigns should be launched to educate industries and communities about the dangers of mercury and lead exposure, with an emphasis on implementing protective measures in high-risk areas. Research into effective treatment strategies, such as chelation therapies and antioxidants that can counteract the toxic effects of these metals, should also be expanded, particularly for cases of combined exposure. Lastly, workers in industries that involve handling lead and mercury should be equipped with protective gear and undergo regular health checks to prevent heavy metal poisoning.

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Compliance with Ethical Standards
Declaration
Ethical Approval

Not Applicable

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Availability of data and materials

Data would be made available on request.

Authors' contributions

Both authors participated in the work. DEE conceived the design. Design while DEE, NEE and AME were all involved in the filed work and writing of the manuscript.