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Morphometric and Biochemical Evaluation of Aluminum Intoxicated Rats

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Abstract: *This research sought to evaluate the morphometric analysis on the visceral organs and mean body as well as serum proteins of aluminum intoxicated rats. A total of sixteen (16) rats of eight (8) each in a group were given 38mg/kg body weight of aluminum (treated) and 0.2ml normal saline (control) respectively for days 7 and 14. The results of this study showed that the aluminum-treated groups had significant reduction ($p<0.05$) in serum protein levels as compared to the control suggesting probably interference with protein synthesis. Similarly, the relative liver and brain weights of aluminum treated animals decreased significantly ($p<0.05$) when compared to the control after day 14. However, the relative kidneys weight decreased in the aluminum treated animals but were not statistically significant ($p>0.05$) when compared to the control both after 7 and 14 days of treatment. This result suggests that aluminum ingestion may predispose animals to signs and symptoms of toxicity like reduction in organ and body weights. Although, this result need to be further investigated using biochemical parameters.*

Keywords: *Aluminum, Visceral organs, Relative body weight, and Serum proteins.*

1. INTRODUCTION

Aluminum is an element with known toxicity in the human body, mainly in the central nervous system (Dominigo, 1995). Its toxic effects have been investigated for many years. Today, nearly 80% of those tested for heavy metal toxicity reveal excessively high aluminum levels in their system (Abbasali *et al.*, 2005). The toxic consequences in humans after aluminum exposure are now established (U.S. Public Health, 1992, and Nayak, 2002). Aluminum is known as a neurotoxin that can cause certain diseases such as Alzheimer's disease, dementia, Parkinsonism, and amyotropic Lateral Sclerosis (Alferey *et al.*, 1976, Wurtman, 1985, Piccardo *et al.*, 1988 and Biekei-Gorzo, 1993). The role of aluminum in these disorders is not clear, however, high concentration of aluminum is found in certain regions of the brains of patients with Alzheimer's disease (Crapper *et al.*, 1976, Perl and Brody, 1980 and Kellett *et al.*, 1986).

1.1. Sources

Aluminum is released to the environment both by natural processes and from anthropogenic sources. It is highly concentrated in the earth's crust (soil) and in particulate matter from coal combustion (WHO, 1997). Aluminum was discovered in 1825 by Hans Oversted of Denmark. It is a trivalent metallic element found in group three of the periodic table (Denniston *et al.*, 2001). Aluminum is ubiquitous being the third most prevalent element and the most abundant metal in the earth's surface mainly in the combined form – silicates, oxides, and hydroxides, and is considered to have no definite biological role (Devoto and Yokel, 1994).

1.2. Uses

Aluminum finds use in a variety of applications perhaps because it is light weight and cheap, combines easily with other elements and corrosion-free (Greger, 1992). Aluminum is widely used in:

Food Industries: as a packaging foil, drying agent (e.g. sodium silico-aluminate- a fine powder), used to dry cocoa, salt and other products. Baking powder, cake mixes, frozen dough, self-rising flour, grains, processed cheese, contain aluminum as in sodium aluminum phosphate as food additive and colouring. Aluminum is also used as a flocculating agent in most municipal water supply (Kandiah and Kies, 1994).

Pharmaceutical Industries: most antacids (antidiarrheal agents) contain significant amounts of aluminum as aluminum hydroxide ($Al(OH)_3$. Buffered aspirin compounds, such as ascriptin, contain aluminum. Aluminum functions in these preparations as an anticholinesterase agent to counteract the laxative properties of the magnesium hydroxide. Aluminum chlorohydrate is used as anti-perspirant to inhibit sweating, deodorants, lip-stick, skin creams, tooth paste, vaginal douches, baby wipes, etc. Significant amounts of aluminum can be absorbed through the skin (dermal absorption) when anti-perspirants are used daily.

1.3. Engineering Application

As in roofing of building, construction of vehicle, ship, aircraft parts and bridges.

In addition, beer and soft drink cans are made exclusively from aluminum and these beverages contain acid (as preservatives), even one beer or cola drink per day can lead to aluminum toxicity especially in susceptible individual over a period of time. Target tissues for aluminum burden are bone, brain, kidney and liver. Signs and symptoms include: colic, dementia, esophagities, gastro enteritis, kidney and liver damage (Rutter and Russel – Jones (eds), 1983, Yost, 1984, Pennington, 1987 and Greger, 1992). Despite the ample clinical and experimental data available, the mechanisms of aluminum toxicity remain poorly understood (Abubakar *et al.*, 2004). However, in spite of the known toxicity of aluminum, until recently, there was little concern about the effects of aluminum ingestion on visceral organ and body weight of rats. And this is the thrust of this study.

2. MATERIALS AND METHODS

Animals used for this study were male Wistar albino rats aged between 8-10 weeks with body weight range of 150-205g. They were obtained from the animal house of the Faculty of Veterinary Medicine, University of Nigeria, Nsukka (UNN). All Chemicals used in this study were of analytical grade and were obtained from reputable companies (Merck, Germany; BDH Chemicals Ltd, Proole, England and May and Baker Ltd England).

2.1. Experimental Design

Institutional Animal ethics: Permission from the institutional committee on animal ethics was sought and approval was given.

Sixteen male rats (16) were housed in two separate cages of eight rats each and acclimatized for five days. The two groups are: **Group A** is (Control) administered 0.2ml of normal saline whereas **Group B** is the test group administered 38mg/kg body weight of aluminum in the form of aluminum chloride. The route of administration was oral. All groups were fed with commercial feed (grower's mash) and water *ad libitum* for seven and fourteen (14) days respectively. The experiment was replicated and their results were pooled together. The rats were weighed at the beginning of the treatment i.e. at zero day, and on days 3, 7, 10 and 14 days of the experiment to observe weight gain/loss during the treatment period, with food and water intakes recorded. The animals were later sacrificed and dissected. Blood was collected from each group after 7 and 14 days through the median cantus vein in the eyes of the rats with the aid of capillary tubes and transferred into plastic tubes. This was later centrifuged at 2000 xg and serum collected into separate test tubes. The sera were used for analysis within 48 hours while the visceral organs: liver, brain, and Kidney were removed, weighed and washed with normal saline.

2.2. Relative Weight of Visceral Organs

The wet weight of the visceral organs; liver, kidney and brain of both control and test animals were weighed and calculated as percentages of their body weight

2.3. Statistical Analysis

Standard error mean (SEM) of replicate experiments with duplicate samples were taken for each analysis. Significant differences of results were established by one way analysis of variance (ANOVA) while differences between groups and within groups (7 and 14 days) were assessed by student's independent t-test. The acceptance level of significance was $p<0.05$ using a 2-tail distribution.

3. RESULTS AND DISCUSSION

The results from this study Table 1a below, show no significant difference ($p >0.05$) between the mean food intake of control group and those of the aluminum-treated groups after three days of aluminum exposure. However, after days 7, 10 and 14 of treatment, the test group showed a signifi-

cant decrease ($p<0.05$) in the mean food intake when compared to the control group. The results from this study Table 1b below, show no significant difference ($p>0.05$) between the body weight gain of control and the test animals. There was no significant difference ($P>0.05$) observed in the mean body weight of control and that of the aluminum-treated group. The mean water intake of rats after three, seven, ten and fourteen days of exposure to aluminum are shown in Table 1c. The results from this study show no significant difference ($P>0.05$) in the mean water intake of aluminum-treated groups relative to the control group after seven days of exposure while after fourteen days of treatment, the aluminum-treated groups were significantly lower ($P<0.05$) relative to the control group. From Table 2a below, the results show no significant difference ($p>0.05$) in the relative liver weight between the test groups and that of the control after seven days of treatment. However, the relative liver weight of aluminum-treated animals decreased significantly ($p<0.05$) when compared with the control after the fourteenth day of exposure. Results from Table 2b below, show that the relative brain weights of animals exposed to aluminum were non-significantly lower ($p>0.05$) than that of control group after the seventh day of exposure while after the fourteenth day, the relative brain weights of animals exposed to aluminum were significantly lower ($p<0.05$) than that of the control animals. From Table 2c below, the decrease in the relative kidney weight of the test groups given aluminum and that of the control group were not statistically significant ($p>0.05$) both after the seventh and fourteenth day of treatment respectively. Results in Table 2d, show significant decrease ($p<0.05$) in serum protein concentrations of the aluminum-treated group (38mg/kg) after seven and fourteen days when compared with the control group.

Table1a. *Mean Food Intake of Control and Test Animals after Aluminium Administration*

DAYS/GROUPS	3rd	7th	10th	14th
Control	29.43+5.34	36.47+6.00	22.80+6.35	29.70+3.41
38mg/kg	31.20+6.53	28.30+3.20*	14.80+2.00*	20.30+5.23*

Table1b. *Morphometric Analysis of Body Weight of Control and Test Animals after Aluminium Administration*

DAYS/GROUPS	3rd	7th	10th	14th
Control	18.23+5.85	35.72+4.22	44.60+6.07	41.43+8.6
38mg/kg	16.40+1.3	12.08+1.92*	9.80+3.5*	9.53+3.01*

Table1c. *Mean Water Intake of Control and Test Animals after Aluminium Administration*

DAYS/GROUPS	3rd	7th	10th	14th
Control	126.60+5.90	129.30+8.54	84.40+7.10	79.90+8.51
38mg/kg	120.70+7.25	127.50+8.04	53.00+12.5*	47.10+15.50*

** = Significant difference between the test and controls groups (P<0.05)*

Results are mean ± SD (N = 8)

Table2a. *Morphometric Analysis of Relative Liver Weight*

DAYS/GROUPS	Control	38mg/kg
7	3.85+0.31	3.80+0.06
14	4.27+0.13	3.04+0.14*

Table2b. *Morphometric Analysis of Relative Brain Weight*

DAYS/GROUPS	Control	38mg/kg
7	0.58+0.11	0.45+0.05
14	0.60+0.03	0.41+0.09*

Table2c. *Morphometric Analysis of Relative Kidney Weight*

DAYS/GROUPS	Control	38mg/kg
7	0.92+0.10	0.80+0.14
14	0.86+0.04	0.69+0.04

Table2d. *Serum protein*

DAYS/GROUPS	CONTROL	38mg/kg
7	0.96+0.03	0.86+0.05*
14	0.92+0.01	0.59+0.05*

** = Significant difference between the test and controls groups (P<0.05)*

Results are mean ± SD (N = 8)

3.1. Discussion

The results of this study show that administration of aluminum by oral intubation to rats produced some signs of toxicity such as reduction in the body serum protein,weight, food and water intake. The decrease in food and water intake after exposure to aluminum is supported by the work of van der Voet e*t al.,* (1992) who reported accumulation of aluminum in rat liver after, intraperitonal injection of $AlCl_3$. Nayak and Chatterjee (1998) reported a decrease in food intake in aluminum-treated rats but had a different response on body weight. The difference in the body weight in the two studies may be attributed to either the difference in the route of administration (i.p) or dose (5mg) of aluminum given to the rats. Paternain *et al.,* (1988) reported that administration of aluminum as $AlNO_3$ caused weight loss. The observed loss in weight for the rats exposed to aluminum thus suggests that aluminum probably interferes with normal metabolic (biosynthetic) processes. The growth of an organism integrates a range of physiological, biochemical and cellular processes. Thus, loss in body weight should be a sensitive indicator of a toxic impact. Body weights of the rats exposed to aluminum decreased with increase in concentration of aluminum. This is in line with the observation made by Donkin and Widdows, 1986, who stated that body weights of exposed organisms, decline in a predictable way with respect to the concentration of toxicant and duration. Aluminum ion (Al^{3+}) is a trivalent cation, and has a high affinity for negatively charged groups. It has been proposed that aluminum preferentially interacts with phosphate groups such as nucleic acids and phosphorylated proteins. In this way, aluminum remarkably decreases DNA synthesis (Nicholls *et al.,* 1995 and Yumoto *et al.,* 2001), and inhibits protein synthesis resulting in weight loss. Aluminum can also interfere with phosphate absorption and calcium deposition in the body, thus leading to phosphatemia and osteomalacia. Reports have shown an association between aluminum accumulation in the brain and antisocial behaviour in learning and development. and disruption of second messenger systems (Agrawal *et al.,* (1996).

4. CONCLUSION

On the basis of these findings, it is concluded that aluminum has potential effects. These effects may lead to some metabolic and tissue dysfunctions such as body weight loss, and oxidative stress. Animals human beings inclusive with daily intake of 38mg/kg body weight may be at a higher risk of aluminum intoxication. Results from this study show a significant decrease ($p<0.05$) in serum protein concentrations of the test groups given 38mg/kg body weight of $AlCl_3$ after seventh and fourteenth days respectively as compared to the control group. The reduction in serum proteins observed in this study is suggestive that aluminum administration may have interfered with protein synthesis. This interference may also have exposed proteins to a wide range of free radical species capable of oxidizing protein thiols, thus promoting the formation of disulphide bridges and even induction of protein fragmentation and catabolism. These will affect normal protein metabolism and growth, thus, leading to the observed body weight loss. In another work, Abubakar *et al.,* (2004), reported decreases in serum, liver and brain proteins during aluminum administration. However, this work is contrary to the report of Bondy e*t al.,*(1998) who reported an increase in protein after aluminum administration. He placed the rats on a special food, selenium supplement, however.

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