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Effects of Aluminium Chloride Exposure on the Histology of Spleen of Wistar Rats

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Abstract: Human exposure to aluminium has been increasing over the last decades. Aluminium is presents in many manufactured foods, medicines and is also added to drinking water for purification purposes. The spleen is part of the lymphatic system and help in the production of lymphocytes. The objective of this study was to evaluate the effects that aluminium chloride exposure could have on the spleen of Wistar rats. Twenty adult wistar rats were used for this study. The Wistar rats were divided into five groups. Group I was the control that received distil water, groups II-V received various concentrations of aluminium chloride as follows: group II received 475 mg kg^{-1}, group III received 950 mg kg^{-1}, group IV received 1,425 mg kg^{-1} and group V received 1,900 mg kg^{-1} via oral intubation for duration of 8 weeks. The Wistar rats were humanely sacrificed, spleen removed and fixed in formalin. The spleen were processed and stained in Haematoxylin and Eosin (H&E). Photomicrographs of the stained section were taken using light microscope attached to digital camera and laptop. The results revealed that there was decreased cellularity of both red and white pulps of the spleen in the aluminium treated groups. Based on the observations, researchers therefore conclude that aluminium chloride exposure had deleterious effects on the spleen.

Key words: Effects, aluminium chloride, histology, spleen, Wistar rats

INTRODUCTION

The spleen is an organ found in virtually all vertebrate animals. Similar in structure to a large lymph node, the spleen acts primarily as a blood filter. As such, it is a non-vital organ with life possible after removal. The spleen plays important roles in regard to red blood cells (also referred to as erythrocytes) and the immune system (internet encyclopedia of science). In humans, it is located in the left upper quadrant of the abdomen. It removes old red blood cells and holds a reserve of blood in case of hemorrhagic shock while also recycling iron. As a part of the mononuclear phagocyte system, it metabolizes hemoglobin removed from senescent erythrocytes. The globin portion of hemoglobin is degraded to its constitutive amino acids and the heme portion is metabolized to bilirubin which is subsequently shuttled to the liver for removal. It synthesizes antibodies in its white pulp and removes antibody-coated bacteria along with antibody-coated blood cells by way of blood and lymph node circulation. The spleen is brownish (Mebius and Kraal, 2005; Fauci *et al*., 2008). It is an organ that is roughly the size and shape of a clenched fist. It lies in the abdomen in the shelter of the left 9th, 10th and 11th ribs with its long axis parallel with them. Its purple color is due to its great content of blood. Two kinds of pulp can be seen. The white pulp is distributed as tiny little firm gray islands, somewhat <1 mm in diameter, among the soft red pulp that fill all the remaining space. The basic frame work of the pulp is a network of reticular fibers (Arthur, 1974). It is an organ that is part of the lymph system and works as a drainage network that defends your body against infection. The white pulp is lymphatic tissue consisting mainly of lymphocytes around arteries. The red pulp consists of venous sinuses (cavities) filled with blood and cords of lymphatic cells such as lymphocytes and macrophages. The functions of spleen are centered on the systemic circulation which comprised of two functionally and morphological distinct compartments, the red pulp and white pulp. The spleen is also the largest secondary lymphoid organ containing about one-fourth of the body lymphocytes and initiates immune responses to blood-borne antigens (Kuper *et al*., 2002; Nolte *et al*., 2002; Balogh *et al*., 2004).

The spleen in healthy adult humans is approximately 11 cm (4.3 in) in length. It usually weighs between 150 g

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(5.3 oz) (David *et al*., 2009) and 200 g (7.1 oz) (Spielmann *et al*., 2005). Like the thymus, the spleen possesses only efferent lymphatic vessels. The spleen is part of the lymphatic system and help in the production of lymphocytes. Both the short gastric arteries and the splenic artery supply it with blood (Blackbourne, 2008).

Being a blood filter, it follows that the spleen is a highly vascular organ. Blood flow through the spleen is rather complex but is an important and sometimes controversial concept. Blood enters the spleen at the hilus via the splenic artery. The splenic artery divides into trabecular arteries located within the trabeculae entering the splenic parenchyma. Small arterioles branch from the trabecular arteries and enter the red pulp where they become central arterioles which are surrounded by lymphoid tissue. Smaller arterioles branch from the central arterioles and feed the white pulp capillary beds (Satodate *et al*., 1986; Valli *et al*., 2002). Some of these terminate in the marginal sinus at the junction of the white pulp and the marginal zone, others terminate within the marginal zone and a few extend beyond the white pulp to terminate in the red pulp (Dijkstra and Veerman, 1990; Schmidt *et al*., 1985). Located between the stomach, left kidney and diaphragm, the spleen is the largest lymphoid organ in the body, performing functions for the blood similar to those performed by the lymph nodes for the lymph. It is a soft organ, conforming to the contours of the organs and structures surrounding it. At the hilus on the visceral surface, the splenic artery brings blood into the spleen, the splenic vein takes blood from the spleen to the hepatic portal system and lymphatics drain lymph from the spleen. In some domestic species such as the horse and dog, the spleen functions as a reservoir from which blood can be mobilized when needed and in these species, smooth muscle is a prominent feature of the capsule and trabeculae of the spleen. Functions of the spleen include the following:

- Removal of abnormal blood cells and particulate matter via phagocytosis
- Storage of iron from recycled red blood cells
- Initiation of the immune responses by B cells and T cells in response to antigens circulating in the blood
- Hematopoiesis in fetus and sometimes in adult

Aluminium chloride has its derivation from purified chlorine with molten aluminium. It is composed of aluminium with molecular weight of 133.34 and formula (symbol) of $AlCl_3$. Other names (synonymous) for this compound include aluminium trichloride and trichloro aluminium. It is whitish powder with melting point of 194°C and specific gravity of 2.44 while its boiling point sublimes with vapour density of 4.5. It is not combustible but react violently (decomposes) with water and heat will contribute to instability (Laschkarew, 1930). Aluminium is a trivalent cation found in its ionic form in most kinds of animal and plant tissues and in natural waters everywhere. It is ubiquitous element and the third most prevalent (abundant) element in the earth's crust, comprising approximately 8% of the earth's crust exceeded only by oxygen (47%) and silicon (28%). The almost ubiquitous presence of this element has so heavily contaminated the environment that exposure to it is virtually inescapable.

Aluminium is also thought to be a causal agent in some cases of encephalopathy and osteomalacia observed in patients with chronic renal failure caused by long-term hemodialysis (Tahara, 2004). Aluminium toxicity in humans has been implicated in many neurodegenerative diseases such as Alzheimer's disease, amyotrophic lateral sclerosis and parkinsonism-dementia (Roberts, 1986; Garruto and Brown, 1994; Solomon *et al*., 2001). The mechanism of aluminium-inducted neurotoxicity and identification of effective treatment for such impairments is therefore, an important public and occupational health priority for industrial and developing nations. Aluminium contributes to a variety of cognitive impairments in mice, rabbits and rat pups (Muller *et al*., 1990; Yokel, 1985; Bilkei-Gorzo, 1993; Golub and Germann, 2001). Studies on workers exposed to aluminium dust in industrial environments demonstrate similar effects (Rifat *et al*., 1991; Bast-Pettersen *et al*., 1994; White *et al*., 1992; Akila *et al*., 1999). Many researchers have found elevated aluminium levels to be associated with a decline in visual memory, attention, concentration, frontal lobe function and lower vocabulary scores in hemodialysis patients (Bolla *et al*., 1992). He *et al*. (2003) demonstrated that exposure to electrolytic aluminium fumes adversely affects neurobehavioral performance in workers including motor coordination, mood and autonomic nervous function although other reports on occupational aluminium exposure and neurological impairments demonstrate mixed findings (Sim *et al*., 1997). The objective of this study was to evaluate the effects that aluminium chloride exposure could have on the histology of spleen of wistar rats.

MATERIALS AND METHODS

This research was conducted in the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Samaru, Zaria, Nigeria.

Experimental animals: Twenty adult Wistar rats were used for this study. The Wistar rats were housed in steel

cages in the animal house of Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, Nigeria; they were given sufficient food, water and kept under good ventilation. The Wistar rats were kept for 2 weeks before commencement of aluminium chloride administration. This was to enable the Wistar rats acclimatized to the environment.

Experimental design: The Wistar rats were divided into five groups; group I was the control that received distil water only while various concentrations of aluminium chloride were administered as follows: group II received 475 mg kg^{-1}, group III received 950 mg kg^{-1}; group IV received 1,425 mg kg^{-1} and group V received 1,900 mg kg^{-1} via oral intubation for duration of 8 weeks.

Tissue processing and staining: The Wistar rats were humanely sacrificed by anesthetizing them in a suffocating chamber using chloroform, after the end of 8 weeks of administrations of various concentrations of aluminium chloride except the control group I that received distil water only. The abdominal region was dissected and the spleen were removed and immediately fixed in 10% formalin. After fixation, the tissues were transferred into an automatic processor where they went through a process of dehydration in ascending grades of alcohol (ethanol) 70, 80 and 95% and absolute alcohol for 2 changes each. The tissues were then cleared in xylene and embedded in paraffin wax. Serial sections of 5 μ thick were obtained using a rotary microtome. The tissue sections were deparaffinised, hydrated and stained using the routine Haematoxylin and Eosin Staining Method (H&E). The stained sections were examined under the light microscope fitted to a digital camera and laptop.

RESULTS AND DISCUSSION

Aluminium has the potential to be neurotoxic in human and animals. It presents in many manufactured foods and medicines and is also added to drinking water for purification purposes (Newairy *et al*., 2009). Aluminium is widely used in antacid drugs as well as in food additives and tooth paste (Abbasali *et al*., 2005). Environmental pollution with different aluminium containing compounds, especially those in industrial waste expose people to higher than normal levels of aluminium (Kloppel *et al*., 1997). Particulate matters distributed by cement-producing factories contain, high amount of aluminium and populations residing in the vicinity are exposed to the pollution (Fatima *et al*., 2001). Evidence for the contribution of aluminium to Alzheimer's Disease (AD), remains contradictory (Flaten, 2001; Gupta *et al*., 2005). However, epidemiological studies have indicated a link between aluminium in drinking water and AD and a variety of human and animal studies have implicated learning and memory deficits after aluminium exposure (Buraimoh *et al*., 2011a; Exley, 2005; Schmidt *et al*., 2001; Yokel, 2000).

Animal studies in rats and case reports have implicated the use of oral aluminum-containing antacids during pregnancy as a possible cause for abnormal fetal neurologic development (Shuchang *et al*., 2008; Gilbert-Barness *et al*., 1998). Aluminium chloride was implicated to have negative effects on behavioural endpoints of wistar rats (i.e., alters behaviour) have negative effects on anxiety-related behaviour of Wistar rats as it increased the rate of anxiety in aluminium treated rats and was also said to have neurodegenerative effects on the histology of cerebral cortex of adult Wistar rats especially at higher dose (Buraimoh *et al*., 2011b; Buraimoh *et al*., 2011c; Buraimoh *et al*., 2012a). This was in contrast with another study that revealed that aluminium chloride exposure had no effects on the histology of the epididymis and hence storage of sperm cells (spermatozoa) by the epididymis could be safe (Buraimoh *et al*., 2012b). The effects of aluminium chloride exposure on the cerebral cortex of adult Wistar rats were said not to be transferable to the offspring (Buraimoh *et al*., 2012c).

In the present study, researchers observed that there was slight decreased cellularity of the red and white pulps in the group II that received 475 mg kg^{-1} of aluminium chloride (Fig. 1) when compared with the control group (Fig. 2) that received distil water only. The other treated groups III-V that received 950, 1,425 and 1,900 mg kg^{-1},

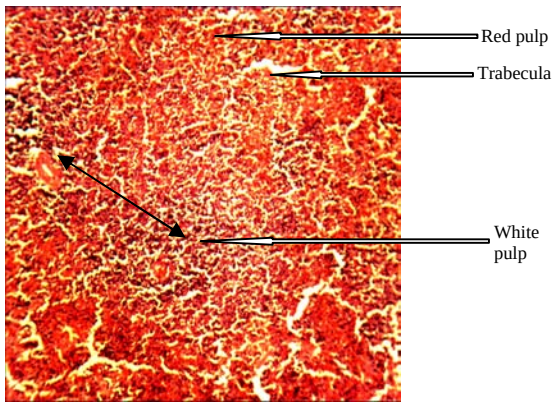

Fig. 1: Photomicrograph of spleen of group II showing the central artery (double arrow) as well as slight decreased cellularity of white and red pulps. x100 H&E

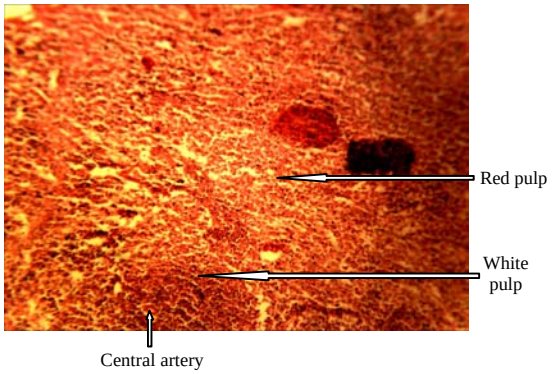

Fig. 2: Photomicrograph of spleen of group I (control) showing the central artery, white pulp and red pulp. x100 H&E

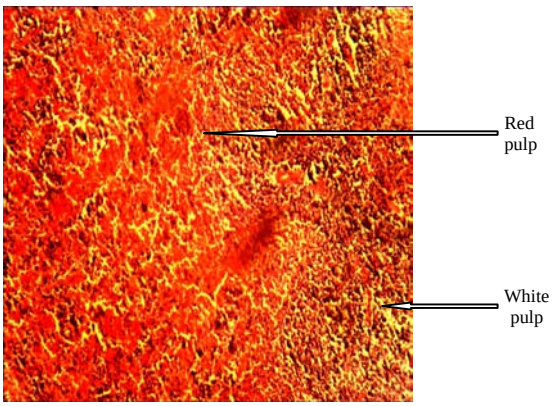

Fig. 3: Photomicrograph of spleen of group III showing decreased cellularity of white and red pulps. x100 H&E

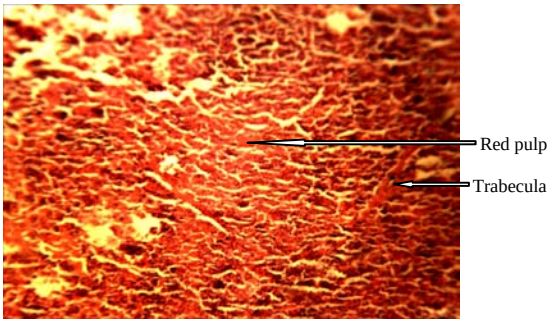

Fig. 4: Photomicrograph of spleen of group IV showing the trabecula as well as decreased cellularity of both red and white pulps. x100 H&E

respectively showed marked decreased cellularity of both the red and white pulps (Fig. 3-5) when compared with the control (Fig. 2).

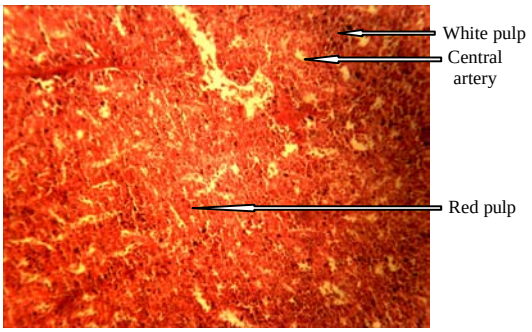

Fig. 5: Photomicrograph of spleen of group V showing the central artery as well as decreased cellularity of both red and white pulps. x100 H&E

CONCLUSION

Based on the observations, researchers therefore conclude that aluminium chloride exposure had deleterious effects on the spleen of Wistar rats as eminent in the decreased red and white pulps of the spleen of the treated groups when compared with the control.

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