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Histopathological Lesions Associated with Hyperlipidaemia Induced by Cholesterol and Groundnut Oil in Some Tissues of Albino Rats

Olufunke A. Sodipo, Halima I. Gambo, Hassan Abdulsalam, Fanna I. Abdulrahman, and Umar K. Sandabe

[1]Professor of Pharmacology from the Department of Clinical Pharmacology and Therapeutics, College of Medical Sciences, University of Maiduguri, P.M.B. 1069, Maiduguri, NIGERIA
[2]Reader and consultant Diagnostic Pathologist with Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, NIGERIA
[3]University of Maiduguri, Borno State, NIGERIA
[4]Professor, Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B. 1069, Maiduguri, NIGERIA
[5]Professor, Department Department of Veterinary Physiology and Biochemistry, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, NIGERIA

*Corresponding Author: abdulsalamh@unimaid.edu.ng

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Abstract

The heart, kidney, brain and intestine are tissues associated with hyperlipidaemia, atherosclerosis, ischemia and infarcts. Other tissues may not be so severely affected but may show dysfunctions which can only be seen at histopathology. The effect of oral administration of cholesterol and groundnut oil on some tissues (Heart, lungs, liver, kidney, intestine, spleen and brain) of albino rats was investigated. Ten (10) male albino rats weighing between 155 to 255 g were procured and allowed to acclimatized for 14 days before commencement of the experiment. Rats were fed commercial prepared feed and water ad libitum throughout the experiment. Hyperlipidaemia was induced in the 10 rats by feeding them orally with 1% cholesterol and groundnut (mixed in standard rat feeds) oil for a period of 3 weeks. Thereafter, the rats were humanely sacrificed; tissues were harvested, processed and examined microscopically. The tissue changes observed included interstitial vacuolated mononuclear cell infiltration and marked congestion in the lungs, marked vacuolar degeneration of hepatocytes, mild gliosis and degenerate neuron in the cerebellum, marked hydropic degeneration and necrosis of renal tubular epithelium, marked erythrophagocytosis in the spleen and severe villous matting and mononuclear infiltrates in the small intestine. Thrombosis was evident in coronary vessels. These findings suggested that orally administration of 1% cholesterol and groundnut induced hyperlipidaemia with resultant tissue architectural alterations.

Keywords: Albino Rats, Cholesterol, Groundnut Oil, Hyperlipidaemia.

Introduction

It is widely known that hyperlipidemia, particularly hypercholesterolemia, is a notable risk factor for the development of cardiovascular disease (CVD), which is the most common cause of mortality worldwide (Huang *et al.,* 2018). The role of lipids and oils in the aetiology of obesity and cardiovascular diseases has been of concern for decades (Kubow, 1996; Kris-Etherton *et al.,* 1999). Hyperlipidemia refers to elevated levels of lipids and cholesterol in the blood; It is also known as dyslipidemia which describes the manifestations of different disorder associated with lipoprotein metabolism (Karam *et al.,* 2018). It is established that hyperlipidaemia commonly arising from high lipid diets represents a major risk factor for the development of atherosclerosis and its cardiovascular complications. Atherosclerosis is usually associated with four vital organs namely the heart, brain, intestine and kidneys where it causes ischemia and infarction which in the heart is known as coronary heart disease (CHD), a major cause of heart failure (Navar-Boggan *et al.,* 2015). In the brain, it leads to haemorrhages and hemiplegia or stroke while in kidneys and the intestines, infarcts due to atherosclerosis can lead to the failure of these organs with fatal consequences (Kumar *et al.,* 2003; Gopichandchinta *et al.,* 2009). In addition, several studies demonstrated that hyperlipidaemia, obesity and disorders of lipid metabolism are associated with overproduction of oxygen free radicals (Rehman *et al.,* 2003). The enhanced accumulation of these radicals and dysfunction of antioxidant defense system results in oxidative stress (Giao *et al.,* 2008). These radicals can bind covalently to macromolecules and induce peroxidative degradation of cell membrane lipids rich in polyunsaturated fatty acids, leading to the formation of lipid peroxides, followed by multiple pathological changes (Shyamala *et al.,* 2003). It is therefore important to assess the lesions associated with hyperlipidaemia, a common problem of man and animals in industrialized countries that is now becoming increasingly important in developing nations (Abdul Kareem *et al.,* 2009). Hence, this study therefore tries to look at the histopathological changes induced by experimental feeding of Wistar albino rats to cholesterol and groundnut oil on some tissues.

Materials and Methods

Experimental Animals

A total of ten (10) male Wistar albino rats weighing between 155 and 255g were used in the study. The animals were obtained from the Animal House of the Department of Veterinary Physiology, Pharmacology and Biochemistry, University of Maiduguri. They were housed in standard plastic cages and fed with commercial grower's mash (ECWA, Feeds, Jos, Nigeria) and water *ad libitum* before the start of the experiment. All the animals were handled according to the International Guiding Principles for Biomedical Research Involving Animals (CIOMS, 1985) as certified by the Animal Ethics Committee of the Faculty of Veterinary Medicine, University of Maiduguri, Nigeria. The rats were made hyperlipidaemic by feeding them orally with 1% cholesterol (BDH Biochemical Ltd: Poole, England) and groundnut oil for 3 weeks according to Odetola *et al.* (2004). Thereafter, all the animals were humanely sacrificed by cervical dislocation and tissue samples of the lungs, liver, kidney, spleen, heart, intestine and brain were harvested and fixed in 10% buffered formalin.

Histopathological Evaluation

The 10% buffered formalin fixed lungs were dehydrated in graded alcohol (70, 80, 90 and 100 %); while Xylene and Paraffin wax were used for clearing and embedding respectively. Serial sections of 5 µ thick were obtained using a rotator microtome. Deparafinised sections were stained with haematoxylin and eosin as described by Bancroft and Gamble, (2002). Slides were examined using light microscope at different magnifications. Photomicrographs of lesions were taken using Amscope digital camera for microscope version (3.0 China)

Results

The result of histopathological examination of the tissues revealed the following lesions: The lungs showed moderate to severe interstitial vacuolated macrophages infiltrations with congestion and bronchial exudates (Plate I a & b). Visible lesions seen on the spleen include prominent sinusoids filled with heavily vacuolated macrophages. Large numbers of erythrocytes have been engulfed by macrophages in erythrophagocytosis (Plate II). The kidneys showed marked hydrophic degeneration of renal tubular epithelium and necrosis (Plate III). There was marked vacuolar degeneration of hepatocytes and kupfer cells on the liver tissue (Plate IV); while the small intestine showed severe villous stunting, matting and mononuclear cell infiltration (Plate V). The cerebellum of the brain tissue

showed degenerate neurons and mild gliosis (Plate VI); the heart showed thrombosis in the coronary vessel of the heart (Plate VII).

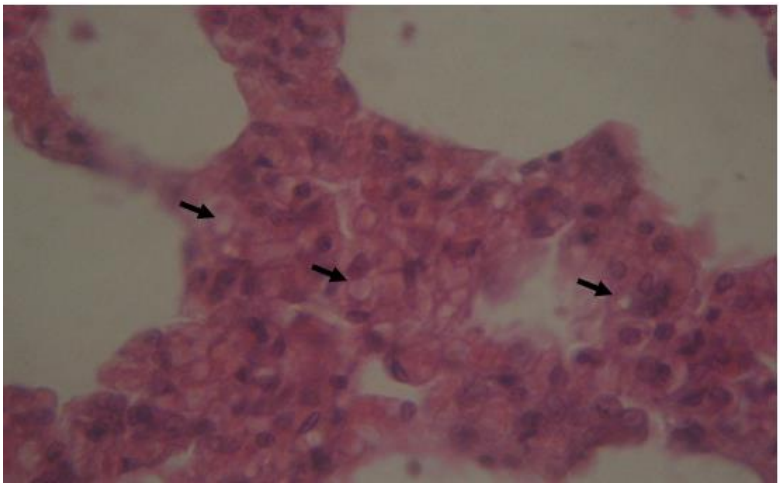

Plate 1a: Photomicrograph of the lung of an albino rat (Wister strain) fed with 1% cholesterol and 1% groundnut oil showing moderate interstitial vacuolated mononuclear cell infiltrations (arrows). H&E x800.

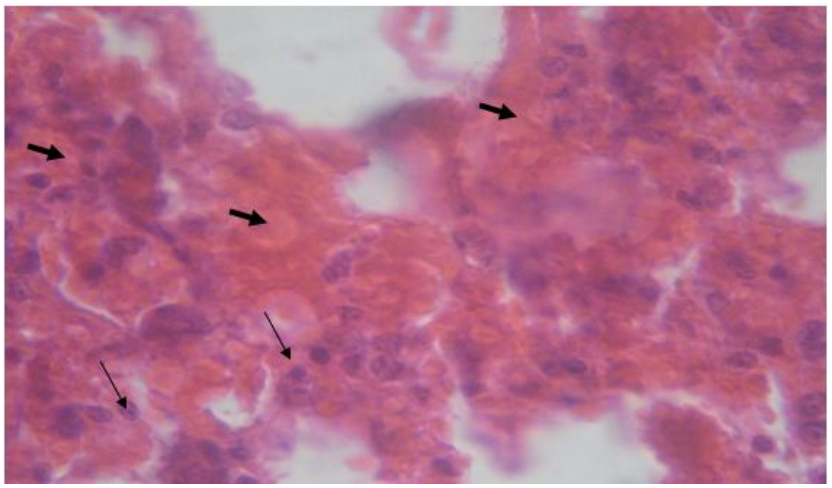

Plate Ib: Photomicrograph of the lung of an albino rat (Wister strain) fed with 1% cholesterol and 1% groundnut oil. Note the marked congestion (thick short arrows) and interstitial mononuclear cell infiltrations (thin arrows). H&E x1600.

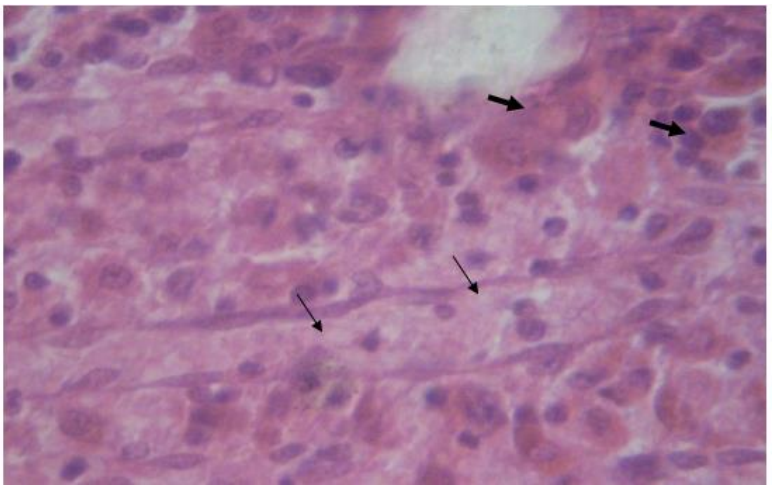

Plate II: Photomicrograph of the spleen of an albino rat (Wister strain) fed with 1% cholesterol and 1% groundnut oil. Note the prominent sinusoids filled with vacuolated macrophages (thin arrows) and marked erythrophagocytosis (thick arrows). H&E 2000

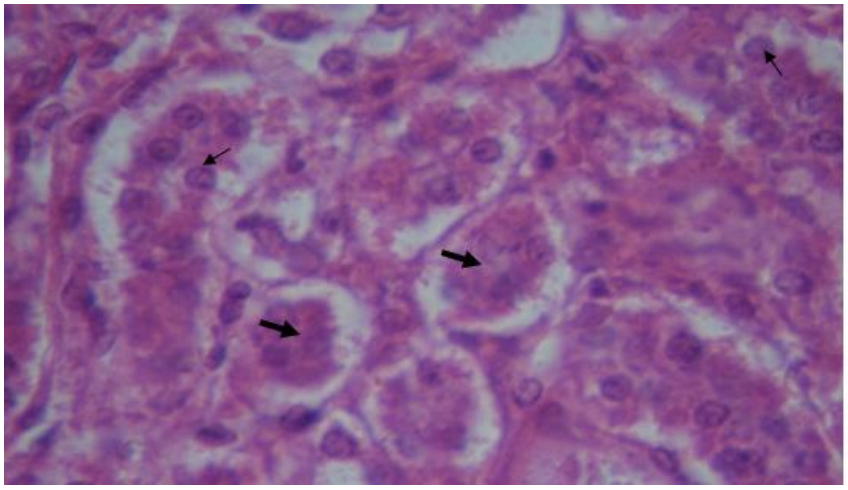

Plate III: Photomicrograph of the kidney of an albino rat (Wister strain) fed 1% cholesterol and 1% groundnut oil. Note the marked hydrophic degeneration of renal tubular epithelium (thin arrows) and necrosis (thick arrows). H&E x1600.

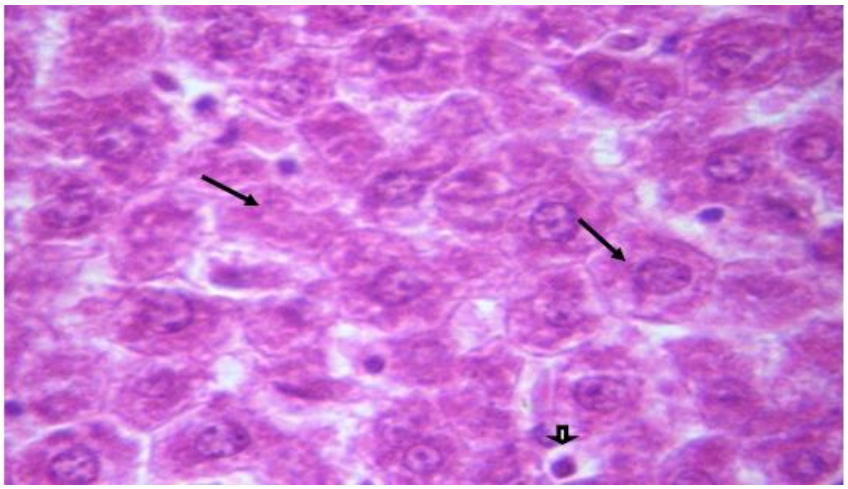

Plate IV: Photomicrograph of the liver of albino rat fed with 1% cholesterol and groundnut oil. Note the marked vacuolar degeneration and necrosis of hepatocytes (arrows) and Kupfer cell (short thick arrow). H&E X 1600.

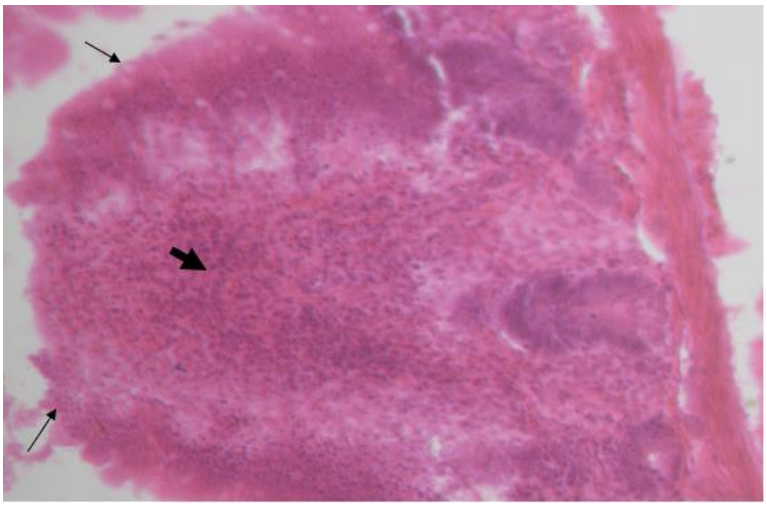

Plate V: Photomicrograph of the small intestine of an albino rat (Wister strain) fed with 1% cholesterol and 1% groundnut oil. Note villus matting (thin arrows) and mononuclear cellular infiltrations (thick arrow). H and E X200

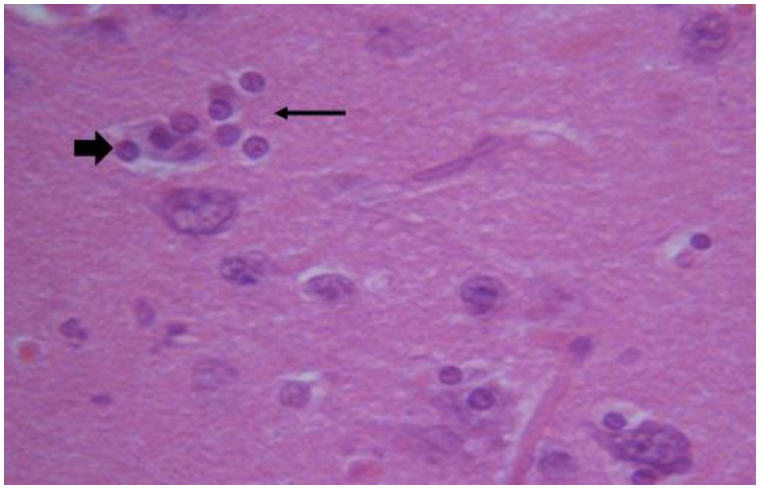

Plate VI: Photomicrograph of the cerebrum of an albino rat (Wister strain) fed with 1% cholesterol and 1% groundnut oil. Note degenerate neuron (thick arrow) and mild gliosis satelitosis (thin arrow.) H&E x1600.

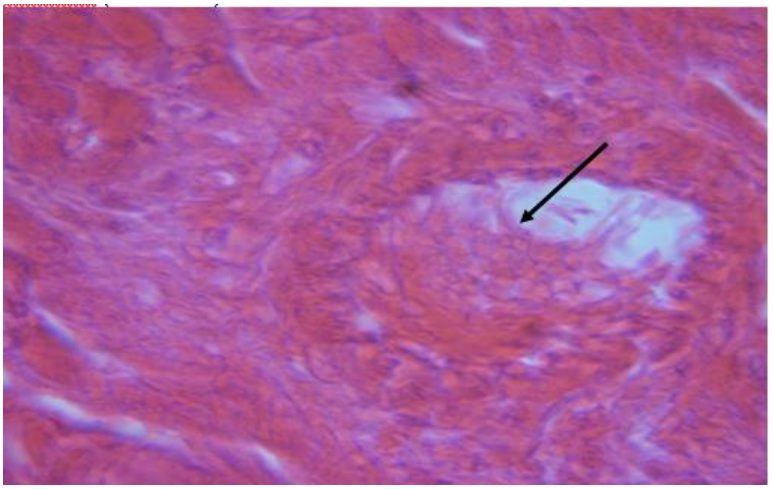

Plate VII: Photomicrograph of coronary vessel of an albino rat (Wister strain) fed with 1%; Cholesterol and 1% groundnut oil showing thrombosis (arrow). H&E x1600

Discussion

The lack of clear visible evidence of atherosclerosis in this study could probably be due to the comparatively short duration of the experiment (three weeks). However, coronary thrombosis was evident and other important lesions observed in the different organs were in themselves significant and consistent with hyperlipidaemia.

In the liver, which is a central organ of lipid metabolism, fatty infiltration was pronounced with most cells having fat vacuoles. This is consistent with the finding of Karam *et al.* (2018). Hepatic lipidosis is commonly caused by hypoxia, defective metabolism of fatty acids, toxins such as carbon tetrachloride (CCL4), breakdown of adipose tissue (Cotran *et al.*, 1999) and as in this experiment excess dietary lipid. Mild cases of lipidosis may not have much impact on hepatic function but on the scale seen in this experiment, a profound impairment of hepatic function will probably ensue with complete failure unless the condition is reversed. The presence of fat vacuoles is an indication of defective beta oxidative of fatty acids including mitochondrial cytopathies (Hassan *et al.*, 2018).

The lungs were similarly affected and an interstitial pneumonia with severe congestion and large numbers of lipid laden macrophages were indicative of the severity of the condition that impairs pulmonary function with the potential of leading to congestive heart failure.

The heart itself though not showing any evidence of coronary problems had degenerate and necrotic myocytes with fat laden macrophages, further adding to the cardiac burden. Rajadhurai and Prince (2005) stated that, lipids play an important role in CVD, not only by way of hyperlipidaemia and the development of atherosclerosis, but also by

modifying the composition, structure and stability of cellular membranes.

Attempts to remove the excess lipid burden was clearly shown by large numbers of macrophages in splenic sinusoids full of fat droplets displacing most erythrocytes. In addition, erythrophagocytosis was prominent and have been triggered by lipids coating red blood cell surfaces. A severe anaemia will probably be the result further complicating the problem of hyperlipidaemia (Ola *et al.,* 2011).

The villous matting and massive mononuclear cell infiltration observed will certainly interfere with digestive processes and lead to poor nutrient absorption (Curran and Crocker, 2000; Jones *et al*. 2006).

Also, the kidneys with marked degenerative and necrotic changes in tubular epithelia as well as presence of fat laden macrophages clogging the glomeruli cannot be expected to carry out their normal functions of urine formation with resultant salt, water and acid/base imbalance and the stimulation of the bone marrow to produce more erythrocytes will also be impeded.

In the brain, a few neurons were degenerate with satelitosis, indicating the possibility of neuronal necrosis. This probably arose from systemic hypoxia evidenced by all the lesions discussed above (especially those in the lungs).

In conclusion, on the whole, it can be inferred from this work that hyperlipidaemia even when it has not yet induced atherosclerosis places a very heavy burden on most organ systems which may lead to their complete failure or have crippling secondary consequences. Therefore, excessive lipids should be avoided even for relatively short periods.

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Contribution by Authors

Equal contribution. All authors declared that ‘written informed’ consent was obtained from the approved parties for the publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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