The Effects of High Fat Diet on Kidney and Lung Histopathology in Experimental Rats

Conference Paper · April 2020

DOI: 10.31580/ojst.v3i1.1357

3 authors, including:

Rawaa Salim Al-Mayyahi
University of Basrah
22 PUBLICATIONS **23** CITATIONS
SEE PROFILE

Rawaa Hraishawi
University of Basrah
11 PUBLICATIONS **13** CITATIONS
SEE PROFILE

Readers Insight
Publisher of open access books and journals

OJST
ISSN: 2664-7974

Journal Article
Doi: 10.31580/ojst.v3i1.1357
Volume 3 Issue 1 – April 2020
Submission: February 20, 2020 Revised: April 05, 2020 Published: April 30, 2020

Open Journal of Science and Technology.

The Effects of High Fat Diet on Kidney and Lung Histopathology in Experimental Rats

Manal Nasser Al-Hayder[1], Rawaa S. Al-Mayyahi[2*], Rawaa M.O. Hraishawi[3]

[1]***Department of Pharmacology and Toxicology,*** *College of Pharmacy, University of Basrah, Basrah, Iraq*
[2,3]***Department of Clinical Laboratory Science,*** *College of Pharmacy, University of Basrah, Basrah, Iraq*

***Corresponding Author:** Rawaa S. Al-Mayyahi, Department of Clinical Laboratory Science, College of Pharmacy, University of Basrah, Basrah, Iraq, r.s.h.almayyahi@gmail.com*

Abstract

High fat diet and obesity have been considered as a main risk factor for various diseases such heart disease, chronic kidney disease and respiratory diseases. However, the precise effect of high fat diet on lung and kidney histopathology is limited. The present study examined the effects of high fat diet on rat histopathology. Female albino Wistar rats of four-week-old were fed either a basic diet or a high-fat diet (20% of fat). After one month of feeding, the histopathological analysis of kidney and lung was investigated. The kidney tissue of rats fed with high-fat diet presented several alterations including variable size of glomeruli, bleeding and congested blood vessels and deformations of several tubular structures compared with those that fed a basic diet. While the lung parenchyma of rats fed with high fat diet showed collapsed alveoli separated by thick inter-alveolar septa, infiltration of inflammatory cells and congested blood vessels were also observed. In conclusion, the high fat diet is responsible for detectable changes in kidney and lung in female rat and this type of diet may lead to renal and respiratory deformities as a result of its histopathological effects.

Keywords: *High Fat Diet; Besity; Histopathology; Kidney; Lung*

INTRODUCTION

The obesity and dietary fat are major causes of several health isusses such as dyslipidemia, type II diabetes, heart, renal and respiratory diseases (Ge et al., 2013; Kovesdy, Furth, & Zoccali, 2017; Shirai et al., 2016). Previous studies in humans and in rodent models have suggested a connection between obesity and dietary fat with several health problems such as hypertension, liver, kidney and heart diseases and also several types of cancer (Fricke et al., 2018; Nguyen & Hsu, 2007; Shirai et al., 2016; Watanabe, Hojo, & Nagahara, 2007). It was found that the administrations of animal fat enriched-diet can develop abdominal obesity and dyslipidaemia (Innis SM, 2007). Among the problems related to the pathological features of disease, renal diseases are important issues and their pathophysiological mechanisms are uncertain (Kramer & Lukea, 2007). For instance, insulin resistance, hypertension and hyperlipidaemia impact renal system in a different way (Liu et al., 2007). Also, several previous researches in human and mice models have been demonstrated that obesity due to the high fat intake is a major resean for asthma, airway hyperresponsiveness and other respiratory diseases (Sharma, Tailor,

Warrington, & Cheang, 2008). Interestingly, the researchers observed that the weight loss in obese patients with asthma aid in recover respiratory signs (Dixon et al., 2011; Maniscalco et al., 2008). Taken together, all previous results suggest that obesity is associated with the administration of diet rich with fat and despite the linked between the diet rich in fat and obesity is well established. However, the impacts of diet rich in animal fat on kidney and lung histopathology remains conflicted. Therefore, the present study aims to investigate the infunces of diet rich in animal fat on the kidney and lung of rats. Histopathological features of all samples were analysed under the light microscopic.

MATERIALS AND METHODS

ANIMALS

All animals were approved by the Animal Research Ethical Committee of Basrah University. Female albino Kyoto rats aged four weeks, were purchased from animal house at Basrah University (Basrah, Iraq). The animals were housed in the animal facility where photoperiod (12 light: 12 dark) and temperature (25°C) were controlled.

EXPERIMENTAL DESIGN AND DIETS PREPARATION

Fifteen animals were assinged into two groups (five in each group). The control group fed a basic diet (AIN-76) which was demonstrated by the American Institute of Nutrition and well accepted as a basic nutrition for rodents in the scientific laboratory. The carbohydrate content of AIN-76 diet was 64.9% , protein 17.7%, and fat 5.2% (Anonymous, 1977). While the experimental group fed a high fat diet (20% of fat) which was prepared by adding 20 mg per 100 gm of beef tallow to the same ingredients of AIN-76 diet (Mercer & Trayhurn, 1987). Each diet was freshly prepared every day throughout the experimental time. The rats were free to eat and drink and they were meal-fed the diet for 30 days.

HISTOPATHOLOGICAL EVALUATION

After euthanasia, the whole kidney and lung were carefully removed and they were fixed with 10% neutral formalin. The kidney and lung of rats were dissected, embedded in paraffin and 5µm sections were cut by using a rotary microtome and the samples were then stained with haematoxylin and eosin (H&E) for microscopic examination (Junqueira & Mescher, 2013).

RESULTS

HIGH FAT DIET EFFECTS ON KIDNEY HISTOPATHOLOGY

The kidney tissue of rats that fed basic diets showed normal glomeruli, tubules and vessels (Fig. 1A). Light microscopy examinations of H&E stained slides of control group showed both proximal and distal tubules with very little interstitium between the tubular structures in the cortex (Fig. 1B and C). Normal cellularity of the glomerli and normak capillary walls thickness were observed in control group (Fig. 1C). However, light microscopic evaluations of kidney sections from rats that given a diet with20% of fat detected bleeding and congestion in the blood vessels and dilatation in glomerular capillaries (Fig. 2A and inset). Also, the Bowman's space was enlarged and several tubular structures were defected in experimental group compared with control group (Fig. 2B and inset).

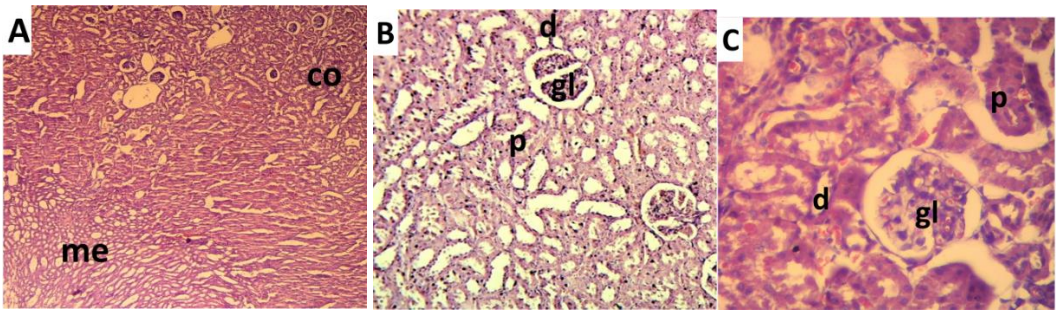

Fig. 1. Light micrographs of kidney tissue in rats fed basic diet. (A) Photomicrograph showing normal cortex (co) and medulla (me) in kidney tissues; (B) and (C) Photomicrographs showing proximal tubule (p), distal tubule (d) and glomerulus (gl). Sections were stained with H&E and the magnifications of images: 100x, 200x & 400x.

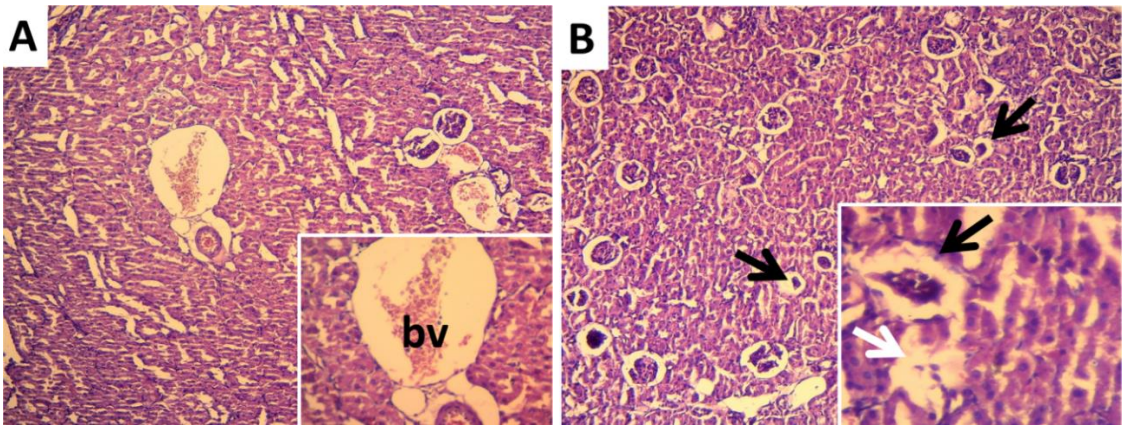

Fig. 2. Light micrographs of kidney tissue in rats fed high fat diet. (A) Photomicrograph shows dilated and congested blood vessels (bv). (B) Photomicrograph shows enlarged Bowman's space (black arrow) and tubules defects (white arrow). Samples with H&E staining and the magnifications of main and inset images: 100x and 400x, respectively.

HIGH FAT DIET EFFECTS ON KIDNEY HISTOPATHOLOGY

The histopathological study of the lung parenchyma in rats fed basic diet showed normal architecture of lung tissue. Normal alveoli structure with thin inter-alveolar septa and normal bronchiole with minimal collagen fibres around (Fig. 3A-C). However, H&E-stained slides of lung tissue in rats fed with diet rich in beef tallow showed collapsed alveoli separated by thick walled. Also, marked inflammatory cellular infiltration and congested blood vessels were noticed in animals eat diet rich in fat compared to those that eat normal diet (Fig. 4A-C).

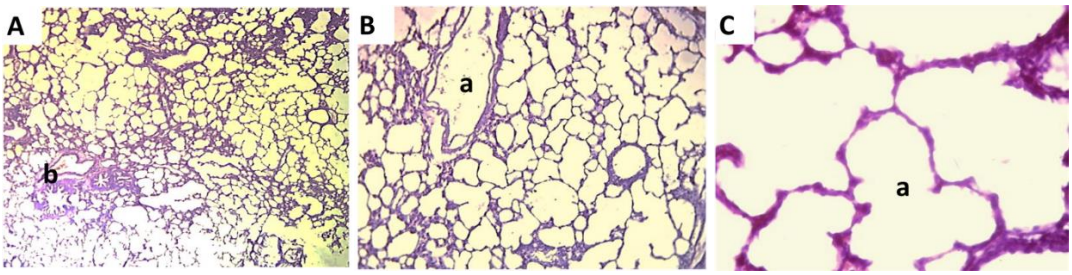

Fig. 3. Light micrographs of lung tissue in rats fed basic diet. (A) Photomicrograph displays normal bronchiole (b) with minimal collagen fibres around. (B) and (C) Photomicrographs show normal alveolar spaces (a) surrounded by thin inter-alveolar septa. Tissue sample were stained with H&E and magnifications of images: 100x, 200x & 400x.

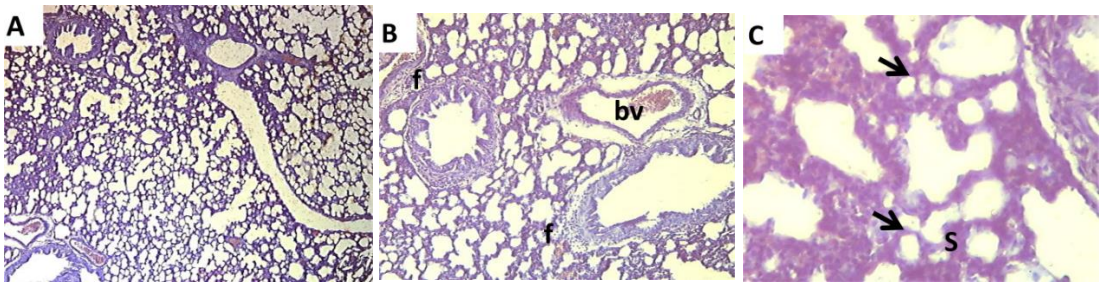

Fig. 4. Light photomicrographs of lung parenchyma of rats fed high fat diet. (A) Photomicrograph shows collapsed alveoli and congested blood vessels. (B) Photomicrograph show inflammatory cellular infiltration (f) and congested blood vessels (bv). (C) Photomicrograph shows collapsed alveoli (arrows) separated by thick inter-alveolar septa (s). Tissue samples were stained with H&E and magnifications of images: 100x, 200x & 400x.

DISCUSSION

Obesity is one of the main risk factor that impacts on about 30% of the adult people in developed countries. It was demonstrated that obesity is connected with increases in fat diet intake and a sedentary lifestyle (Kramer & Lukea, 2007). The previous researches have been reported that obese patients are linked to several health problems such asthma, hypercholesterolaemia, dislipidaemia, liver and cardiovascular diseases (Altunkaynak et al., 2008; Kovesdy et al., 2017; Shirai et al., 2016). Dietray fat and obesity effects on kidney and respiratory functions are receiving more attention (Altunkaynak et al., 2008; Fricke et al., 2018). They were observed that dietary fat leads to abdominal obesity and causes significant changes in kidney (Aguila & Mandarim-De-Lacerda, 2003; Armitage et al., 2005) and lungs tissues (Fricke et al., 2018; Ge et al., 2013). However, the effects of beef tallow on kidney and lung histopathology still conflicted therefore; the current study was performed to evaluate the histopathological alterations in kidney and lung of experimental rats following 30 days of high-fat diet intake. The histopathological investigation showed large and congested blood vessels. Dilatation glomerular capillaries and deformations of several tubular structures were also noticed in animals that given dietary fat compared with control group. The present results are in line with several previous researches, they were observed that a diet with 30% of fat caused several histopathological alterations such as dilatation and tubular defects, of rats kidney (Altunkaynak et al., 2008). Also, it was demonstrated that the administration of diet rich in saturated fatty acids caused diabetes and sever glomerulosclerosis in hamsters (Popov, Simionescu, & Shepherd, 2003). Importantly, it was well known the important role of the kidney proximal tubule is in the blood filtration and recirculation to the system. Therefore, any deformities and damage in these types of kidney tubules will lead to nutrients and electrolytes loss. Also, the researches reported that the increases hypercholesterolemia can impact on the renal tubule structures and cause tubular damage and lipid droplets accumulation in tubular cells (Abdel-Hamid, 2014; Curthoys & Moe, 2014; Zoja, Abbate, & Remuzzi, 2015). Moreover, the previous experimental studies observed that high levels of fat in renal tissue can cause damage in the mitochondria of all cell types of kidney. The high fat diet intake can cause mitochondrial dysfunction then resulted in damage kidney cells and lost the glomerular endothelial cells (Szeto et al., 2016). The current study is in agreement with several past reports in which diet rich in fat showed a notable increase in the inflammation cells in addition to several histopathological alterations in the kidney of experimental rats. They were found that the increases of inflammation cells may be associated with fat accumulation in the kidney (Salim, Kurnia, Bintarti, & Handayani, 2018). Moreover, several experiments have demonstrated that obesity or high weight gain due to exposure to dietary fat may cause asthma, develop airway hyperresponsiveness and affect lung functions in both humans and animals researches (Beuther, 2009; Johnston et al., 2007; Sharma et al., 2008; Shore & Fredberg, 2005). It was showed that high-fat diet induces lung fibrosis and reduces airway eosinophilia after cockroach allergen treatment in mice (Ge et al., 2013). Interestingly, they were demonstrated that the maternal high-fat diet changes lung development by disrupting the signalling pathways and

participates in lung dysfunction in the offspring. Further, they were observed that maternal or adult high-fat diet reduces the alveoli in the offspring (Heyob et al., 2019).

CONCLUSION

The findings of the current work show that there is a notable connection between high fat diet adminstartion and histological alteration in both kidney and lung in experimental rats. Several histopathological changes were observed in kidney and lung tissue of animals that given a diet rich in animal fat compared to those that given basic diet. These alterations were included bleeding and congestion in the blood vessels and dilatation in glomerular capillaries. The Bowman's space was enlarged and several tubular structures were defected. These detectable histopathological changes on rat kidney and lung may cause deformities and dysfunctions in renal and respiratory systems, respectivley.

Reference:

Abdel-Hamid, G. A. (2014). Effect of Red Grape Juice on Renal Glomeruli in Hypercholestremic Rats. *Life Science Journal*, *11*(May), 234–245.

Aguila, M. B., & Mandarim-De-Lacerda, C. A. (2003). Effects of chronic high fat diets on renal function and cortical structure in rats. *Experimental and Toxicologic Pathology*, *55*(2–3), 187–195. https://doi.org/10.1078/0940-2993-00313

Altunkaynak, M. E., Özbek, E., Altunkaynak, B. Z., Can, I., Unal, D., & Unal, B. (2008). The effects of high-fat diet on the renal structure and morphometric parametric of kidneys in rats. *Journal of Anatomy*, *212*(6), 845–852. https://doi.org/10.1111/j.1469-7580.2008.00902.x

Anonymous. (1977). Report of the American Institute of Nutrition Ad Hoc Committee on Standards for Nutritional Studies. *Journal of Nutrition*, *107*(7), 1340–1348. https://doi.org/10.1093/jn/107.7.1340

Armitage, J. A., Lakasing, L., Taylor, P. D., Balachandran, A. A., Jensen, R. I., Dekou, V., … Poston, L. (2005). Developmental programming of aortic and renal structure in offspring of rats fed fat-rich diets in pregnancy. *Journal of Physiology*, *565*(1), 171–184. https://doi.org/10.1113/jphysiol.2005.084947

Beuther, D. A. (2009). Obesity and Asthma. *Clinics in Chest Medicine*, *30*(3), 479–488. https://doi.org/10.1016/j.ccm.2009.05.002

Curthoys, N. P., & Moe, O. W. (2014). Proximal tubule function and response to acidosis. *Clinical Journal of the American Society of Nephrology*, *9*(9), 1627–1638. https://doi.org/10.2215/CJN.10391012

Dixon, A. E., Pratley, R. E., Forgione, P. M., Kaminsky, D. A., Whittaker-Leclair, L. A., Griffes, L. A., … Irvin, C. G. (2011). Effects of obesity and bariatric surgery on airway hyperresponsiveness, asthma control, and inflammation. *Journal of Allergy and Clinical Immunology*, *128*(3), 508-515.e2. https://doi.org/10.1016/j.jaci.2011.06.009

Fricke, K., Vieira, M., Younas, H., Shin, M. K., Bevans-Fonti, S., Berger, S., … Polotsky, V. Y. (2018). High fat diet induces airway hyperresponsiveness in mice. *Scientific Reports*, *8*(1), 1–6. https://doi.org/10.1038/s41598-018-24759-4

Ge, X. N., Greenberg, Y., Reza Hosseinkhani, M., Long, E. K., Bahaie, N. S., Rao, A., … Sriramarao, P. (2013). High-fat diet promotes lung fibrosis and attenuates airway eosinophilia after exposure to cockroach allergen in mice. *Experimental Lung Research*, *39*(9), 365–378. https://doi.org/10.3109/01902148.2013.829537

Heyob, K. M., Mieth, S., Sugar, S. S., Graf, A. E., Lallier, S. W., Britt, R. D., & Rogers, L. K. (2019). Maternal high-fat diet alters lung development and function in the offspring. *American Journal of Physiology - Lung Cellular and Molecular Physiology*, *317*(2), L167–L174. https://doi.org/10.1152/ajplung.00331.2018

Innis SM. (2007). Dietary lipids in early development: relevance to obesity, immune and inflammatory disorders. *Current Opinion in Endocrinology, Diabetes and Obesity*, *14*(5), 359–364.

Johnston, R. A., Zhu, M., Rivera-sanchez, Y. M., Lu, F. L., Theman, T. A., Flynt, L., & Shore, S. A. (2007). Allergic Airway Responses in Obese Mice. *Am J Respir Crit Care Med*, *176*, 650–658. https://doi.org/10.1164/rccm.200702-323OC

Junqueira, L. C., & Mescher, A. L. (2013). *Jonquiere's Basic Histology Text and Atlas*. *Journal of Chemical Information and Modeling* (Vol. 53). https://doi.org/10.1017/CBO9781107415324.004

Kovesdy, C. P., Furth, S. L., & Zoccali, C. (2017). Obesity and kidney disease: Hidden consequences of the epidemic. *American Journal of Hypertension*, *30*(3), 328–336. https://doi.org/10.1093/ajh/hpw151

Kramer, H., & Lukea, A. (2007). Obesity and kidney diseasee: a big dilemma. *Current Opinion in Nephrology and Hypertension*, *16*(3), 237–241. https://doi.org/10.1177/2054358117698669

Liu, Y., Wang, Z., Yin, W., Li, Q., Cai, M., Zhang, C., … Zu, X. (2007). Severe insulin resistance and moderate glomerulosclerosis in a minipig model induced by high-fat/high-sucrose/high-cholesterol diet. *Experimental Animals*, *56*(1), 11–20. https://doi.org/10.1538/expanim.56.11

Maniscalco, M., Zedda, A., Faraone, S., Cerbone, M. R., Cristiano, S., Giardiello, C., & Sofia, M. (2008). Weight loss and asthma control in severely obese asthmatic females. *Respiratory Medicine*, *102*(1), 102–108. https://doi.org/10.1016/j.rmed.2007.07.029

Mercer, S. W., & Trayhurn, P. (1987). Effect of high fat diets on energy balance and thermogenesis in brown adipose tissue of lean and genetically obese ob/ob mice. *Journal of Nutrition*, *117*(12), 2147–2153. https://doi.org/10.1093/jn/117.12.2147

Nguyen, S., & Hsu, C. Y. (2007). Excess weight as a risk factor for kidney failure. *Current Opinion in Nephrology and Hypertension*, *16*(2), 71–76. https://doi.org/10.1097/MNH.0b013e32802ef4b6

Popov, D., Simionescu, M., & Shepherd, P. R. (2003). Saturated-fat diet induces moderate diabetes and severe glomerulosclerosis in hamsters. *Diabetologia*, *46*(10), 1408–1418. https://doi.org/10.1007/s00125-003-1185-6

Salim, H. M., Kurnia, L. F., Bintarti, T. W., & Handayani, H. (2018). The Effects of High-fat Diet on Histological Changes of Kidneys in Rats. *Biomolecular and Health Science Journal*, *1*(2), 109. https://doi.org/10.20473/bhsj.v1i2.9675

Sharma, S., Tailor, A., Warrington, R., & Cheang, M. (2008). Is obesity associated with an increased risk for airway hyperresponsiveness and development of asthma? *Allergy, Asthma and Clinical Immunology*, *4*(2), 51–58. https://doi.org/10.2310/7480.2008.00008

Shirai, T., Shichi, Y., Sato, M., Tanioka, Y., Furusho, T., Ota, T., … Yamamoto, Y. (2016). High dietary fat-induced obesity in Wistar rats and type 2 diabetes in nonobese Goto-Kakizaki rats differentially affect retinol binding protein 4 expression and vitamin A metabolism. *Nutrition Research*, *36*(3), 262–270. https://doi.org/10.1016/j.nutres.2015.11.018

Shore, S. A., & Fredberg, J. J. (2005). Obesity , smooth muscle , and airway hyperresponsiveness. *J ALLERGY CLIN IMMUNOL*, *115*(5), 925–927. https://doi.org/10.1016/j.jaci.2005.01.064

Szeto, H. H., Liu, S., Soong, Y., Alam, N., Prusky, G. T., & Seshan, S. V. (2016). Protection of mitochondria prevents high-fat diet–induced glomerulopathy and proximal tubular injury. *Kidney International*, *90*(5), 997–1011. https://doi.org/10.1016/j.kint.2016.06.013

Watanabe, S., Hojo, M., & Nagahara, A. (2007). Metabolic syndrome and gastrointestinal diseases. *Journal of Gastroenterology*, *42*(4), 267–274. https://doi.org/10.1007/s00535-007-2033-0

Zoja, C., Abbate, M., & Remuzzi, G. (2015). Progression of renal injury toward interstitial inflammation and glomerular sclerosis is dependent on abnormal protein filtration. *Nephrology Dialysis Transplantation*, *30*(5), 706–712. https://doi.org/10.1093/ndt/gfu261