

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



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### Abstract

High fat diet and obesity have been considered as a main risk factor for various diseases such as 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 issues 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 reason 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 infunes 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.

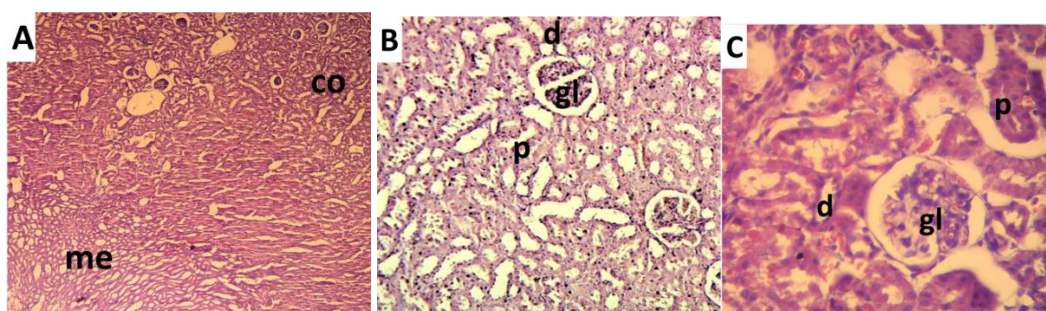
### HISTOPATHOLOGICAL EVALUATION

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).

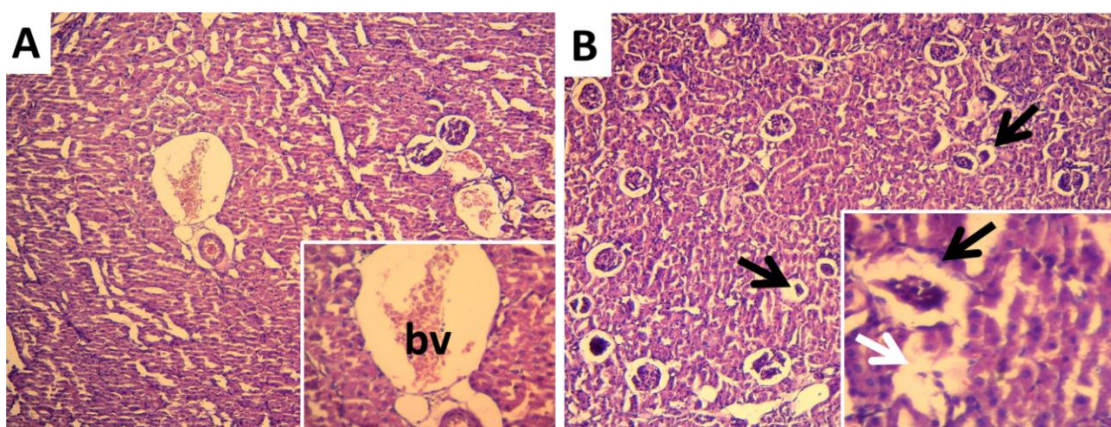
## RESULTS

### 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).



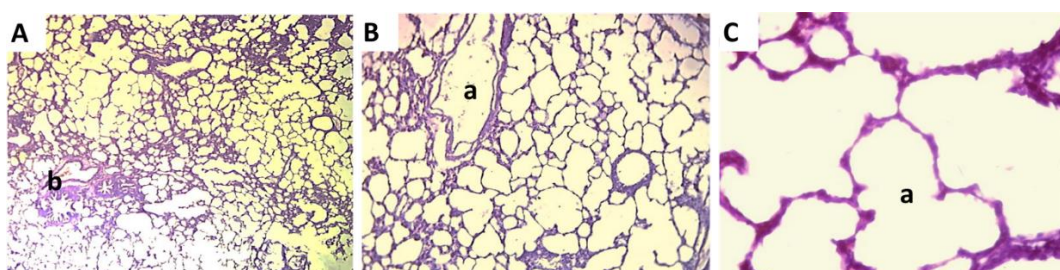
**Fig. 1.** Light micrographs of kidney tissue in rats fed basic diet. (A) Photomicrograph showing normal cortex (co) and medulla (me) in kidney tissues; (B) and (C) Photomicrographs showing proximal tubule (p), distal tubule (d) and glomerulus (gl). Sections were stained with H&E and the magnifications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



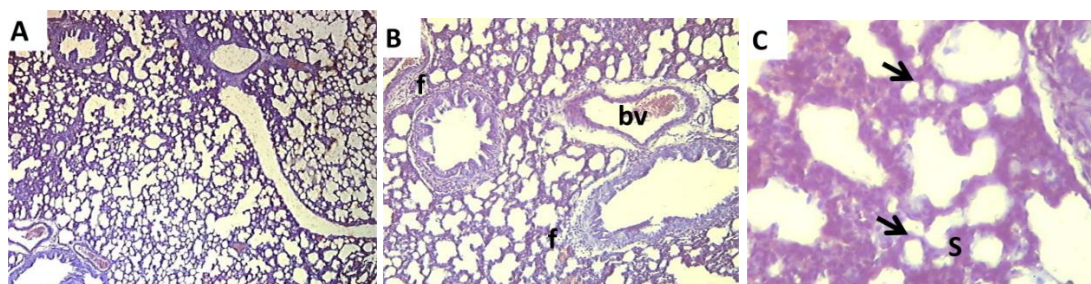
**Fig. 2.** Light micrographs of kidney tissue in rats fed high fat diet. (A) Photomicrograph shows dilated and congested blood vessels (bv). (B) Photomicrograph shows enlarged Bowman's space (black arrow) and tubules defects (white arrow). Samples with H&E staining and the magnifications of main and 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 as asthma, hypercholesterolaemia, dislipidaemia, liver and cardiovascular diseases (Altunkaynak et al., 2008; Kovesdy et al., 2017; Shirai et al., 2016). Dietary 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 & Mandarin-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 administration 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, respectively.

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