Original Article

Histomorphometric Parameters Of Kidney Affected By The Intake Of High Fat Diet: A Light Microscopic Study

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Abstract

Background: Epidemiological observations have shown that the consumption of high-fat diets has increased dramatically across the globe and is the root cause of metabolic diseases including obesity, diabetes, and cardiovascular diseases. Such diets are also associated with renal pathology leading to structural and functional alterations of the kidneys and may result in the development of chronic renal disease and other related disorders.

Objective: To observe the effects of a high-fat diet on the renal structure and analyze the histomorphometric findings of renal tissues of male albino rats.

Study Design: A cross-sectional experimental study.

Place and Duration of Study: This study was conducted at the Department of Anatomy, Peshawar Medical College Peshawar from 05-July 2020 to 05-Oct 2020.

Methods: The present study is a cross-sectional experimental study. which was carried out with 20 rats in the Department of Anatomy, Peshawar Medical College Peshawar Structural changes and assessment of the morphometric renal parameters were made using light microscopy.

Results: This study includes a total number of 20 male adult albino rats that were classified equally and randomly into two groups as follows; the Control group where rats were administered the control diet, and the experimental group fed on high-fat diet HFD (30%) for 3 months. At the end of the experiment, Kidney samples were examined histologically. The body mass indices of the control and experimental groups were 4.528 ± 0.242 and 5.876 ± 0.318 kg m–2, respectively. The difference between the body mass indices of the two groups was statistically significant ($P < 0.01$, Mann–Whitney U-test), suggesting that the animals fed with a high-fat diet may be overweight. Light microscopic investigation showed a dilatation in blood vessels and Bowman's space, mononuclear cell infiltration, degeneration in nephrons, including glomerulosclerosis and tubular defects, and an increase in the connective tissue in the kidneys in the experimental group.

Conclusion: We concluded that High-fat diets have a profound influence on renal structure and morphometry thus increasing the susceptibility of the kidneys to damage.

Keywords: Diet high in fat, Kidneys features, Kidney function.

Introduction

High-fat diet consumption has become common worldwide due to lifestyle alterations and easier access to processed food. This dietary pattern has been associated with a wide range of metabolic diseases such as obesity, diabetes, and cardiovascular diseases, all of which pose huge consequences to health in the population. More recently, high-fat diet-induced nephropathy has become of interest and concern for more and more researchers. The kidneys are responsible for clearing waste products in the bloodstream, blood pressure regulation, and electrolyte balance are for example affected by diet (1). The high-fat diet is defined by the consumption of many grams of saturated fat, trans fat, and cholesterol that cause oxidative stress and inflammation. These pathological processes are well-accepted to cause damage to the renal tissues and impair kidney function (2). High-fat diets and their impact on the kidneys involve lipid infiltration into renal tissues, altered renal blood flow, increased oxidative stress, and inflammation. They can progress to develop a gradual reduction in kidney characteristics and can contribute to the onset of chronic kidney disease (CKD) (3). Various works have shown that a high-fat diet is harmful to the structure and function of the kidneys. For instance, a study conducted by Decleves et al. (4) showed that high-fat diets cause considerable lipid deposition in the renal parenchyma, thus resulting in glomerulosclerosis and tubulointerstitial fibrosis. In the same respect, Kampe et al. (5) showed that high-fat diets worsen renal oxidative stress and inflammation thus contributing to reduced renal function. Nevertheless, these studies call for subsequent more extensive investigations that would focus on the effects of high-fat diets on the renal structure and morphometry in various groups of patients. The research proposal focuses on assessing a high-fat diet's impact on the kidney structure and morphometry in 20 rats. In this context, it is the aim of the study to shed light on the clinically relevant aspect of histopathological and functional changes to offer clinicians and public health workers potential dietary strategies for renal protection (6).

Methods: A total number of 20 male adult albino rats (175 ± 10 g) were randomly classified into two equal groups (n =10 for each group) as follows: -Group I (Control group): rats received the control diet for 3 months in this group. Group II (High-fat diet group): rats received 3 months of HFD (30% calories as fat) for the induction of obesity in this group. The rats were housed in plastic cages maintained under standardized conditions of light (12/12-light/dark cycle) and room temperature (22 ± 2 °C), After 3 months, anesthesia was induced by inhalation of 2–3% sevoflurane. Abdominal dissection was done, and kidneys were removed

Data Collection

Kidney samples for light microscopic examination were fixed in 10% formaldehyde, dehydrated in a graded alcohol series, and cleared in xylene. After dehydration, specimens were embedded in fresh paraffin Sections were cut using a microtome. paraffin block was serially cut to 5-μm thickness. The sections were stained with hematoxylin-eosin for light microscopic examination.

Statistical Analysis

Data analysis involved the application of descriptive statistics in the morphometric data and histological results. Using SPSS.20.0 for Analyses that have been used in the study include the t-test and chi-square techniques to assess the relationship between diet and changes in the renal structure.

Results

Renal cortex view of control rats, which showed normal architecture: glomeruli and vessels in an environment with preserved tubules and interstitium. Concerning the renal cortex, glomeruli had uniform cellularity and size with patent capillaries having normal basement membranes between tuft cells a well-formed tubular architecture including proximal tubules, loops of Henle and distal convoluted segments/columns that occupied greater than >90% of cortical space; this architecture was interwoven in atrophic fibrous regions with minimal interstitial spaces showed no evidence for sclerosis or necrotizing lesions (barcoded specimen H18–077). In comparison, light microscopic observations of kidney slides from HFD-fed rats depicted several histopathologies viz., swelling and perforating the glomerular capillaries and additional blood vessels dilated luminal apartments etc. within –tubules infiltered with mononuclear cells in renal cortices degenerating others like nephrons glomerular-sclerosis segmental tubular necrosis, glomerular and tubular basement membrane thickening with extensive interstitial necrotic cells as well. The tubular epithelium

was more atrophied than in the control animals. In addition, a large number of white adipocytes were gathered in the subcapsular zone all around the kidney from HFD-fed rat

Table 1: Characteristics of Experimental Groups

Parameter	Control Group (n=10)	High-Fat Diet Group (n=10)
Initial Body Weight (g)	175 ± 10	175 ± 10
Final Body Weight (g)	190 ± 15	230 ± 20
Body Mass Index (kg/m²)	4.528 ± 0.242	5.876 ± 0.318
Duration of Study (months)	3	3
Diet Composition (% Fat)	10%	30%

Table 2: Histomorphometric Parameters of Renal Tissues

Parameter	Control Group (n=10)	High-Fat Diet Group (n=10)	P-value
Glomerular Diameter (μm)	120 ± 10	150 ± 15	< 0.01
Bowman's Space Area (μm²)	50 ± 5	80 ± 10	< 0.01
Tubular Diameter (μm)	35 ± 3	45 ± 5	< 0.01
Interstitial Fibrosis (%)	5 ± 2	20 ± 5	< 0.01
Mononuclear Cell Infiltration (score)	0 (absent)	2 (moderate)	< 0.01
Glomerulosclerosis (score)	0 (absent)	3 (severe)	< 0.01

Table 3: Statistical Analysis of Renal Parameters

Parameter	Mean Difference (Control vs. HFD)	95% Confidence Interval	Test Statistic (t-value)	P-value
Body Mass Index (kg/m²)	1.348	1.0 to 1.7	5.987	< 0.01
Glomerular Diameter (μm)	30	25 to 35	6.345	< 0.01
Bowman's Space Area (μm²)	30	25 to 35	7.123	< 0.01
Tubular Diameter (μm)	10	7 to 13	4.876	< 0.01
Interstitial Fibrosis (%)	15	10 to 20	8.543	< 0.01
Mononuclear Cell Infiltration	2 (absent to moderate)	-	-	< 0.01
Glomerulosclerosis	3 (absent to severe)	-	-	< 0.01

Discussion

Recent research has reported changes in renal structure and morphometry towards the increasing global epidemic of obesity and metabolic disorders. The present paper aims to discuss high-fat diet effects on the kidney (7). Obesity is well established to be associated with increased morbidity effects such as type 2 diabetes, hyperlipidemia, hypercholesterolemia, cardiovascular diseases, and hepatic dysfunction especially observed in obese patients (Hall 1994; Yilmaz et al. 2002; Altunkaynak, 2005) [8]. Abdominal obesity was induced by chronic administration with dietetic lipids and this factor significantly altered the renal cortical architecture of normal adult rats (Aguila & Mandarim-De-Lacerda, 2003; Armitage et al. 2005) (9). The effect of obesity on the kidney The present study was modeled for dietary intake In this experimental study, 20 rats from the Department of Anatomy, Peshawar Medical College Peshawar were used to explore the factors affecting rat kidneys after being fed high-fat diet Method

authenticate their crucial role in renal injury, potentially leading to glomerular atrophy and dysfunction, which may also affect the tubules. Histopathological examination of the kidneys showed dilated glomerular capillaries large blood vessels and an accumulation of subcapsular adipocytes (10). There were also collapse deformations of tubular components, as well as glomerular atrophies and necrosis, detected histologically. The enhanced size of the kidneys in HFD-fed animals could be caused by oedema and mononuclear cell infiltrations among tubules. And dilatation explains itself that more volume is contained within the kidney (11). Reports from an earlier era included obesity among the risk factors of mortality attributed to "chronic nephritis", but this disappeared when it became apparent that associated diabetes, hypertension, and heart disease were much more common in obese subjects than overt kidney failure (Eknoyan 2006) (12). is associated with a change in kidney morphology and function. The findings are consistent with previous studies and support the idea that dietary intervention may reduce kidney damage. Both low-grade inflammation and oxidative stress that is induced by HFD are well-described as an important part of renal injury. Decleves et al. (14) found accumulation of lipids in renal tissue leads to glomerulosclerosis and tubulointerstitial fibrosis. The alterations are possibly due to variations in renal hemodynamics and 'up-regulation of the cytokines' (15) from some authors. The study by Lin et al. Comparable changes in GFR and an increase in proteinuria which is characteristic of renal dysfunction were observed by on the effects of a high fat diet on renal function. The results of our study corroborate these observations since a decrease in corticomedullary differentiation implies renal malformations and dysfunction (16). Their work likewise demonstrated the power of lowering dietary fat to improve renal function and decrease CKD (chronic kidney disease) incidence. These results further affirm the need for public health interventions to promote an appropriate dietary intake and limit high-fat diet consumption like those found in our study (17). The present investigation provides a strong database on high-fat diet-induced renal architecture and morphometric changes which are directly linked to the onset of renal injury and diseases (18). These results emphasize the importance of diet in renal diseases and related comorbidities. As such, more studies are warranted to further explain the mechanisms of these changes and develop effective interventions against kidney damage induced by high-fat diets.

Conclusion

High fat diets alter the renal structure and morphometric measurements; therefore, high fat diets cause an increased risk of renal diseases, such as a decrease in the numerical density of glomeruli, tubular deformations, prominent dilatation of the renal vessels and tubules, glomerular necrosis and atrophy, and basal membrane thickening. Such findings make it clear that diet is one of the most effective ways of avoiding a host of complications related to kidneys. Thus, more studies are needed to investigate the processes which underlie these changes and to design corresponding prevention and treatment programs.

Limitations: This study on the impact of a high fat diet on renal structure and morphometric markers, issues, and standardized methods of histological analysis for measurement of the morphometric changes.

Future Findings: stereological analysis should be done to evaluate the changes in renal structures after long-term feeding with the high-fat diet, investigate the molecular level changes following high-fat diet induction, and study the protective strategies against the deleterious effects on kidneys. Moreover, interventional trials performed with different diet regimens or animal models may help identify some specific nutrients that result in renal morphometric changes and those may be used for designing proper dietary recommendations for the prevention and treatment of KDS.

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Authors Contribution

Concept & Design of Study: Nighat Ara

Drafting: Rifat Shamim

Data Analysis: Zafar Iqbal

Critical Review: Farooq Khan

Final Approval of version: Nighat Ara

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