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Study of Measurement of Cortical and Medulla Thickness in 200 Sudanese Diabetic Patients 2021 - 2023

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Abstract: ***The study was to evaluate the renal changes in diabetic patient using ultrasound scan. This cross - sectional study was done in Khartoum State from the period from December 2021 to January 2023, for 200 diabetic patients (96 males and 104 females), all of them had type 2, their age ranged between 30 - 90 years old. patient with renal congenital anomalies, renal tract obstruction, malignant tumor and renal failure were excluded, all patients had been scanned with ultrasound for measuring renal dimensions, renal length was also been calculated and echogenicity was evaluated, The study revealed that increase in duration of diabetes has direct impact on kidney texture. The study showed the renal changed associated with increase of Diabetes period. It was also observed that the both cortical and medulla thickness are affected with severity of diabetes that showed the import ants of ultrasound as a useful tool to measure renal volume and detecting renal changes in diabetic patient. The study showed the significant relation between the right medulla thickness and duration of diabetics, the result is significant at p = 0.03 (if Value is <0.05 considered significant) also study confirmed that the significant relation between the left medulla thickness and duration of diabetics also the result was significant at p = 0.048 (if Value is <0.05 considered significant).***

Keywords: Measurement, Cortical, Medulla, Thickness, Sudanese, Diabetic Patients

1. Introduction

Kidneys are paired retroperitoneal organs situated in the posterior part of the abdomen on each side of the vertebral column, the upper pole of each kidney lies opposite the twelfth thoracic vertebra and the lower pole lies opposite the third lumbar vertebra. The right kidney is usually slightly more caudal in position. The weight of each kidney ranges from 125 g to 170 g in the adult male and from 115 g to 155 g in the adult female. The kidney is approximately 11 cm to 12 cm in length, 5.0 cm to 7.5 cm in width, and 2.5 cm to 3.0 cm in thickness. Located on the medial or concave surface of each kidney is a slit, called the hilus through which the renal pelvis, the renal artery and vein, the lymphatic's, and a nerve plexus pass into the sinus of the kidney. The organ is surrounded by a tough fibrous capsule, which is smooth and easily removable under normal conditions. The kidneys receive blood from the renal arteries, left and right, which branch directly from the abdominal aorta. Despite their relatively small size, the kidneys receive approximately 20% of the cardiac output. each kidney is supplied normally by a single renal artery, although the presence of one or more accessory renal arteries is not uncommon. The renal artery enters the hila region and usually divides to form an anterior and a posterior branch. Three segmental or lobar arteries arise from the anterior branch and supply the upper, middle, and lower thirds of the anterior surface of the kidney. The posterior branch supplies more than half of the posterior surface and occasionally gives rise to a small apical segmental branch. However, the apical segmental or lobar branch arises most commonly from the anterior division. No collateral circulation has been demonstrated between individual segmental or lobar arteries or their subdivisions. Not uncommonly, the kidneys receive aberrant arteries from the superior mesenteric, suprarenal, testicular, or ovarian arteries. True accessory arteries that arise from the abdominal aorta usually supply the lower pole of the kidney. (1, 2, 3, 4, 5)

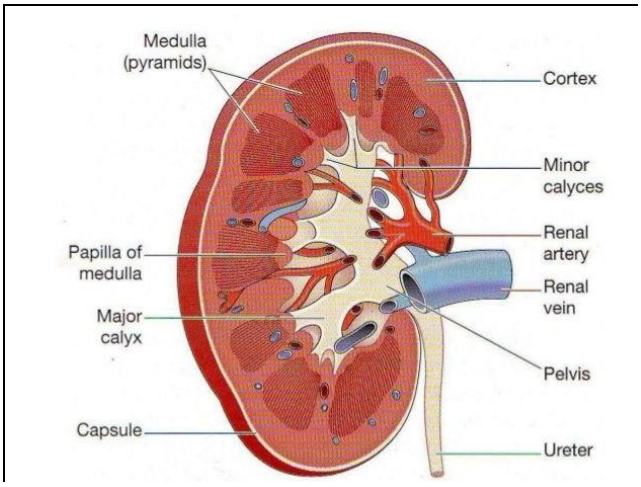

Figure 1: Anatomy of The kidney

The functional unit of the kidney is the nephron. Each human kidney contains about 0.6 × 10 to 1.4 × 10nephrons, which contrasts with the approximately 30, 000 nephrons in each adult kidney. The essential components of the nephron include the renal or Malpighian corpuscle (glomerulus and Bowman's capsule), the proximal tubule, the thin limbs, the distal tubule, and the connecting tubule. The origin of the nephron is the metanephricblastema. Although there has not been universal agreement on the origin of the connecting tubule, it is now generally believed to derive from the metanephricblastema. The collecting duct system, which

includes the initial collecting tubule, the cortical collecting duct (CCD) in the medullary ray, the outer medullary collecting duct (OMCD), and the inner medullary collecting duct (IMCD), is not, strictly speaking, considered part of the nephron because embryologically it arises from the ureteric bud. However, all of the components of the nephron and the collecting duct system are interrelated functionally. [5] Two main populations of nephrons are recognizable in the kidney: those possessing a short loop of Henle and those with a long loop of Henle. The loop of Henle is composed of the straight portion of the proximal tubule (pars recta), the thin limb segments, and the straight portion of the distal tubule (thick ascending limb, or pars recta). The length of the loop of Henle is generally related to the position of its parent glomerulus in the cortex. most nephrons originating from superficial and mid cortical locations have short loops of Henle that bend within the inner stripe of the outer medulla close to the inner medulla. A few species, including humans, also possess cortical nephrons with extremely short loops that never enter the medulla but turn back within the cortex. Nephrons originating from the Juxtamedullary region near the corticomedullary boundary have long loops of Henle with long descending and ascending thin limb segments that enter the inner medulla. many variations exist, however, between the two basic types of nephrons, depending on their relative position in the cortex. The ratio between long and short loops varies among species. Humans and most rodents have a larger number of short - looped than long - looped nephrons. (5, 6)

Ultrasound Technique of kidney:

The examination begins with the patient in the supine position. Scans are performed in the sagittal and transverse planes from the anterior approach using the liver and spleen as acoustic windows. Various maneuvers may enhance demonstration of the kidneys: left lateral decubitus or lateral oblique positions for the right kidney and right lateral decubitus or lateral oblique positions for the left kidney. Coronal longitudinal and transverse scans may also be obtained and are recommended for evaluating the renal pelvis and proximal ureter on hydronephrotic patients. The highest frequency transducer permitting adequate penetration is used. This is usually in the 3 to 5 MHz range. A phased array sector probe with its small footprint permits subcostal and intercostal scanning. (7, 8, 9)

Normal Sonographic Appearances of Kidney:

The kidney is an ellipsoid structure when demonstrated in its long axis as (figure 2 - 30) which demonstrate right kidney. The capsule is an echogenic white boundary separating the kidney from adjacent structures anteriorly and the musculature posteriorly, the renal cortex is homogeneous, fine textured and poorly echogenic, the cortex is equal to, or less echogenic than the normal liver, the medulla consists of pyramids which are anechoic structures with their bases adjacent to the renal cortex and their apices directed towards the renal sinus; the renal sinus is the most echogenic portion of the adult kidney. This echogenic area is called the central echo complex. In the non - hydrated state, the renal pelvis is collapsed. (7.8.9)

Figure 2: Sonographic Appearance of Normal Right kidney

Normal Renal Measurements:

The size of the kidneys is affected by age, sex (greater in men than in women), and body size; furthermore, the left kidney is slightly larger than the right in most individuals. (The normal renal length in females ranges from 9.5 to 12.1 cm and in males from 10.1 to 12.6 cm. Therefore, the normal adult kidney should measure 9 - 13 cm in length, 2.5 to 3.5 cm3, 4 in thickness and 4 to 5 cm in width3, 4. These are good average measurements for exam purposes. Body habitus and age should be considered since a single measurement could misrepresent the patient's condition. A 10 cm long kidney is a normal renal length; however, it is likely to be abnormal in a 20 - year - old male who is 6 feet tall and weighs 200 pounds. Parenchymal thickness is 11 - 18 mm in the male and 11 - 16 mm in the female. (8, 9, 10)

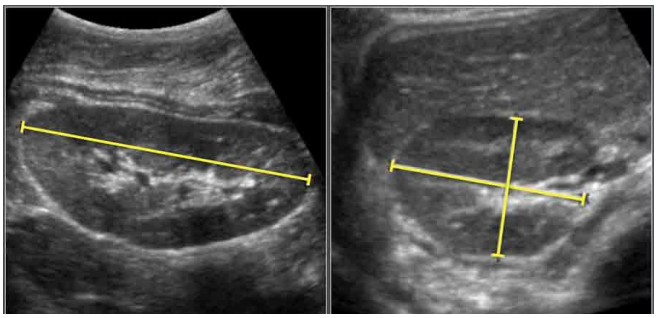

Figure 3: Sonographic normal renal measurements

Diabetic nephropathy:

Diabetic nephropathy (nephropatiadiabetica), also known as Kimmelstiel - Wilson syndrome, or nodular diabetic glomerulosclerosis and intercapillary glomerulonephritis, is a progressive kidney disease caused by angiopathy of capillaries in the kidney glomeruli. It is characterized by nephrotic syndrome and diffuse glomerulosclerosis. It is due to longstanding diabetes mellitus, and is a prime indication for dialysis in many Western countries. (11, 12)

The syndrome can be seen in patients with chronic diabetes (usually less than 15 years after onset) after about 5 years in type 1 diabetes. Clinical nephropathy secondary to glomerular disease usually manifests 15–25 years after diagnosis of diabetes and affects 25 - 35% of patients under the age of 30 years. It is the leading cause of premature death in young diabetic patients. (between 50 and 70 years old) The disease is progressive and may cause death two or three years after the initial lesions, and is more frequent in

men. Diabetic nephropathy is the most common cause of chronic kidney failure and end - stage kidney disease in the United States. People with both type 1 and type 2 diabetes are at risk. The risk is higher if blood glucose levels are poorly controlled. Furthermore, once nephropathy develops, the greatest rate of progression is seen in patients with poor control of their blood pressure. Also, people with high cholesterol level in their blood have much more risk than others. (11, 13)

The word diabetes means "passing through", referring to the polyuria (abnormal increase of urine production), a symptom historically present in those affected by the disease. When the level of blood glucose rises beyond the kidney's capacity to reabsorb glucose from the renal ultrafiltrate, glucose remains diluted in the fluid, raising its osmotic pressure and causing more water to be carried out, thus, increasing the excreted urine volume. The increased volume dilutes the sodium chloride in the urine, signaling the macula dense to release more renin, causing vasoconstriction, a survival mechanism to retain water by passing less blood through the kidneys. Because the kidney is nurtured exclusively by the blood it filtrates, the vasoconstriction also reduces the nutrients supplied to it, causing infarct of its tissues and reduction of renal function. (The earliest detectable change in the course of diabetic nephropathy is a thickening in the glomerulus. At this stage, the kidney may leak more serum albumin (plasma protein) than normal in the urine (albuminuria), and this can be detected by sensitive medical tests for albumin. This stage is called “microalbuminuria”. As diabetic nephropathy progresses, increasing numbers of glomeruli are destroyed by progressive nodular glomerulosclerosis. Consequently, urine albumin increases to the point that it may be detected by ordinary urinalysis techniques. At this stage, a kidney biopsy generally clearly shows diabetic nephropathy. Diabetic nephropathy continues to get gradually worse. Complications of chronic kidney failure are more likely to occur earlier, and progress more rapidly, when it caused by diabetes than other causes. Even after initiation of dialysis or after transplantation, people with diabetes tend to do worse than those without diabetesPossible complications include: hypoglycemia (from decreased excretion of insulin) (insulin isn’t secreted by the kidneys) (decreased excretion of insulin would cause hyperglycemia), rapidly progressing chronic kidney failure, end - stage kidney disease, hyperkalemia, severe hypertension, complications of hemodialysis, complications of kidney transplant, coexistence of other diabetes complications, peritonitis (if peritoneal dialysis used) and increased infections. Omer et. al (2014) describes the Ultrasonographic Characteristics of Diabetes Impacts in Kidneys’ Morphology. A total sample size consisting of 150 Diabetic male patients to assess the impact of diabetes in kidney morphology. The result showed that the diabetes has been as endemic disease in central Sudan (Khartoum & Jazeera) representing 55% and in the west of Sudan representing 38%. The BMI of diabetic patients has been significantly (R2 = 0.6) decreasing following aging. The impact of duration was a reduction in size significantly. In late case of Diabetes, the kidney is more echogenic, atrophied size with loss of corticomedullary differentiation. Somia Mohamed salih (2013) Studied the characterization of diabetic kidney and her result showed that the mean volume of Rt kidney was 131.4 cm3, Lt kidney 140.6 cm3, and the mean of C/M ratio was (0.76) for Rt kidney and (0.72) for the Lt one, there was decrease in the renal volume related to duration of diabetes. There was no difference in echogenicity Saud butt (2010) published a paper and found in the early stages of diabetic nephropathy kidney size may be enlarged from hyper filtration with progressive kidney disease from diabetes the kidneys diminish in size from glomerulosclosclerosis. In addition, renal ultrasound can assess for hyper echogenicity that suggest chronic renal disease. (Jastaniah. S. D, et al 2013). renal ultrasound is typically obtained to measure the renal size, volume and echogenicity. Renal enlargement may be seen early in diabetes due to hyper filtration, while in late stages the kidneys diminish in size from glomerulosclerosis. In addition, renal cortical hyper echogenicity is seen suggesting deteriorated renal function. Ultrasound is also used to exclude non - diabetes - related renal disorders, e. g., renal stones, masses or hydronephrosis. (Ultrasonographic Renal Size in Individuals with Known Diabetes Mellitus, this study assumed that the renal changes in diabetic patients are detectable by conventional ultrasound only in very advanced stages of the disease. Pathologic resistive indices, however, may be detected in the earlier stages. Even later in life, combined lifestyle factors are associated with a markedly lower incidence of newonset diabetes mellitus. Intensive therapy effectively delays the onset and slows the progression of diabetic retinopathy, nephropathy, and neuropathy inpatients with IDDM. Diabetes is the most prevalent diseases in the world WHO expects that the number of infected will increase from 200 million to 2.5 million by 2010, despite the seriousness of this disease and rapidly spread it ranks seventh in the list of causes of death and is responsible for one third of cases leading to renal failure and cardiovascular disease are known to most people with diabetes die from heart attacks. (14.15.16.17)

2. Methodology

The data were collected using Ultrasound machine made in China, and (Samsung, medical system) ultrasound machine made in Coria, each with curve linear array 2.5 - 5 MHz, using coupling gel. Method: provided informed consent before entering the study. U/S examination of the kidney will be performed using (Mindary& Samsung machines with 3.5MHz TA convex probe). Subject ages, duration of diabetes, and gender of patients were recorded in the clinical data sheet, the examination began with the patient in the supine position. Scans are performed in the sagittal and transverse planes from the anterior approach using the liver and spleen as acoustic windows, and evaluated kidney size, Echogenicity, cortical and medullary thickness.

The renal medulla thickness:
Measuring the length from the renal capsule to medulla and subtract the length of cortical thickness of each kidney.

Method of evaluation the Echogenicity:
Evaluated the echogenicity of right kidney compared with the liver echogenicity, while the echogenicity of the left kidney was compared with spleen all measurement were done by one sonographer. The population: The study sample consisted of (200 patients) underwent ultrasound

examination of the abdomen at Khartoum state. Study designed for this study was analytic cross - sectional study where all volunteers are diabetic Data collection variables Kidney size, echogenicity, cortical thickness and CMD of both kidneys, Age, gender and medication status, diabetic duration and the presence of other chronic illness. Method of data collection the data used master data sheet n collection of the variable that used to achieved the result of this study.

3. Result

Table 1: Age distribution

Age	Frequency	Percent%
Less than 40	14	7
40 - 50	50	25
50 - 60	70	35
60 - 70	58	29
70 - 80	6	3
More than 80	2	1
Total	200	100

Table 2: Gender

Gender	Frequency	Percent%
Male	96	48
Female	104	52
Total	200	100

Table 3: Duration of diabetes

Duration	Frequency	Percent%
Less than 5 Years	56	28
05-Oct	78	39
Oct-15	40	20
15 - 20	20	10
20 - 25	2	1
More than 25	4	2
Total	200	100

Table 4: Relation between Right medulla Thickness and Duration of Diabetes

		Right Medulla Thickness					Chi - Value	Sig - Value
		Less than 0.4cm	0.4 - 0.6	0.6 - 0.8	0.8 - 1.0	1.0 - 1.2		
Duration	Less than 5 Years	0	6	13	8	1	31.027	0.03
	5- 10	3	8	16	10	2		
	10- 15	5	1	6	5	1		
	15 - 20	0	2	2	6	0		
	20 - 25	0	0	1	0	0		
	More than 25	0	0	2	0	0		
Total		8	17	40	29	4		

The table above shows the significant relation between the right medulla thickness and duration of diabetes, the result is significant at p = 0.03 (if Value is <0.05 considered significant)

Table 5: Relation between Left medulla Thickness and Duration of Diabetes

			Left Medulla Thickness				Chi - Value	Sig -Value
		Less than 0.4cm	0.4 - 0.6	0.6 -0.8	0.8 -.0	1.0 -1.2		
Duration	Less than 5 Years	1	3	15	8	1	24.627	0.048
	5 - 10	2	3	18	13	2		
	10 - 15	5	1	3	7	3		
	15 - 20	1	1	4	4	0		
	20 - 25	0	0	1	0	0		
	More than 25	0	1	0	1	0		
Total		9	9	41	33	6		

The table above shows the significant relation between the left medulla thickness and duration of diabetes, the result is significant at p = 0.048.

The study had been done to evaluate characterization of renal parenchyma in diabetic patients using sonography among Sudanese population and it was done to 200 diabetic patients 48% male (96of 200), female 52% (104 of 200) diabetes affect both male and female in near percentage according to this study the frequency of distribution for male and female showed in (table2). This study done for different age group from less than 40 range to more than 80 years, the age less than 40 years 7% and age from 40 - 50 years 25%, age 50 - 60 35%, age 60 - 70 29%, age 70 - 80 3% and only 1% over 80 years old, represent that most of cases in this study was in age group between 40 to 70 years old (table1). This study showed that there were many changes in kidney parameters, length, cortical and medulla thickness which were measures using ultrasound and it showed their relation to duration of diabetes. most of cases had duration of diabetes less than 25 years in distribution of less than 5 years 28%, 5 - 10 39%, 10 - 15 20%, 15 - 20 10%, 20 to 25 1% and only 1%more than 25 years as shown in table (3). The relationship between right and left kidneys echogenicity to the duration of diabetes showed significant relationship with p value of 0.04 and 0.39 respectively (less than 0.05). Also the relation between both kidneys and the duration of diabetes showed significant relationship with p value of 0.03 for the right cortical thickness and 0.05 for left one (both less than 0.05). Both of the medulla thickness showed significant relation related to the duration of diabetes with p value of 0.03 for the right side and p value of 0.048 for the

left kidney (both less than 0.05).

4. Conclusion

The study concluded that diabetes can affect both genders, according to this no significant difference between male and female gender regarding the presence of associated renal changes (females were slightly more affected than males). There was significant relation with diabetes duration with parenchyma changes in forms of both cortical and medulla thickness in both kidneys. The type of medication and hypertension had no significant relation to parenchyma changes as seen in this study. The study revealed that renal volume inversely related to the duration of diabetes mellitus, these finding provided a basis for using of conventional renal ultrasound among diabetic patients in evaluation of renal morphology in order to predict diabetes complication progression and in exclusion of obstruction and other complications that diabetic patients might had.

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