

Normative Kidneys Measurements in Sudanese: A Morphometric CT Based Study

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Abstract :

Background: Normal values for kidney measurements are well established for many ethnic groups but very little is known about normal kidney measurements and its influencing factors in Sudanese. The objectives of this study were to establish a national reference for normal renal dimensions classified according to age and gender for Sudanese as well as to identify potential influencing factors, and to estimate their significance.

Methods: In multiphase thin-slice MDCTs of 200 kidneys in 100 Sudanese subjects, the kidney length and kidney width were registered. The renal parenchymal thickness (PT) including on CT scans was measured through upper calyx; renal pelvis; and lower calyx levels. PT was measured at four locations: anterior (a), posterior (p), medial (c), and lateral (d), at right angles to each other and oriented such that a-b paralleled the renal vessels. The possible influencing factors that can be visualized were recorded from a measurement data set. For measurements, axes were adjusted individually in axial planes. Analyses of distribution, T-tests, ANOVA, were performed.

Results: Kidney length was 96.75 mm for the right, and 95.73 mm for the left. The right kidneys width was 41.00 mm, less than the left 42.51mm at ($p = 0.041$). The cortex width was 5.21 mm for the right and 5.26 mm for the left. While the medulla was 10.82 mm for the right kidney and 11.21 mm for the left. Segments as anterior, posterior, medial and lateral segments were measured. Right upper calyx were found to be for 11.88mm, 16.21mm, 11.74mm and 15.56mm and the left were 2.00mm, 16.11mm, 12.99mm, 15.52 mm respectively. The RT renal pelvis segments measurements were found to be 0.00mm, 22.28mm, 13.41mm and 14.33 mm where the LT renal pelvis were 0.00mm, 22.37mm, 13.40mm and 14.02mm. The lower calyx segments were found to be 19.45 mm, 18.40 mm, 13.15mm and 13.35 mm for the right and 10.88mm, 18.85mm, 12.45mm and 12.29 mm for the left. The gender is not a predictor for changes in the renal measurements except for the medial and lateral renal pelvis segments for both right and left kidneys at ($P= 0.041, 0.040$ and $0.001, 0.040$). The age also is not a predictor for renal measurement except the renal pelvis lateral segment of the left kidney as well as lower calyx medial segment at $p=0.006$ and 0.026 . Sudanese kidneys measurements differs from other populations.

Conclusions: A new chart for renal character and measurement were established for Sudanese population aged from 10 years to 70 years

Keywords : - CTscan, renal parenchyma, Measurements, Ethnicity

I. Introduction

A normal human being has two kidneys. Kidneys filter the waste products from the blood and excrete them out in the form of urine. A normal functioning kidney should have normal renal volume specific for that particular gender and ethnicity. Evaluation of renal measurements such as length, width is an important parameter in the diagnosis and also management in many renal disorders as it is known that there is a close relationship between renal size and its function [1]. The evaluation of renal measurements is very important to the clinician as the results can be used to determine the health of the individuals and it can also visualize any abnormalities present in the kidneys. [2] Medical imaging has played an important role in helping physicians to make a medical diagnosis. These imaging included ultrasound and computed tomography (CT) scan. [3] CT scan is extensively used for diagnosing and evaluating kidney problems. One of the parameters which is measured and evaluated in CT scan reports is the kidney length. So, it is important to know the correct calculated length.[5]

One of the important factors in the evaluation of urogenital system is its size. Renal length measurement has a special place in the diagnosis and treatment of renal diseases. Studies conducted have shown that in various diseases, the kidney size changes, which are probably due to inflammation, diabetes and chronic diseases. [4] Symptom of chronic renal failure is increase in kidney size; also the first sign of diabetic nephropathy is the change in kidney size.[5] Kidney size increased in renal failure; furthermore, a kidney which has a double collecting system is usually long. [6,7] Renal ischemia also causes unilateral size change.[8] Therefore, controlling the size of kidneys and comparing them can be a major criterion in detection of renal damages.[6] In research conducted in 2009, Goldny *et al.* introduced the size of kidney as a criterion for the

health of adult kidneys.[9]Many studies have shown that the renal size and measurements is influenced by many factors such as age, ethnicity, gender, weight and height [10,11,12]. It is also known that the left kidney is larger than the right kidney, independent of gender [13, 14, 15]. Many studies also concluded that renal measurements variation occurs in nephropathies. [13,16]

One study found that the most important measurement of renal size is longitudinal length in subjects with normal renal function [3]. Thus, it is essential to establish the pattern of renal measurements for a more accurate diagnosis. Therefore, the kidney size can be suggested as a criterion for kidney health. So, obtaining the true measurements of kidney can be helpful in various diagnoses, and one of the main methods for finding the kidney size is through CT scan.

In practice, measurements of renal size of any age are compared with the measurements that are predicted by standard nomograms. However, to our best knowledge, the current nomograms which are widely used locally were derived from studies based on western population of relatively small sample sizes [17]. Since our currently used renal nomogram in Sudanese is based on the western database, it might lead to the false positive and false negative diagnosis of kidney condition. A wrong diagnosis on a normal kidney will end up with repeated unnecessary scans and patient's anxiety. Therefore, there is an urge to develop specific ethnic (for instance: Sudanese ethnic) population nomogram to provide a better accuracy of renal measurements in terms of making a proper medical diagnosis and also during monitoring the disease progress. Thus, this research is conducted as a first step in order to formulate a nomogram of renal measurements for Sudanese population.

II. Materials And Methods

2.1 Materials:

Neusoft multi-slice CT Scanner System Model: NeuViz 128, Volt: 3N-380/400v, Power: 90KVA (120 kV, 40MA) (5 mm slice) in complex of general Omer Sawi was performed, Antalya medical center (5 mm slice) and modern medical center.

2.2 Population of the study:

The population of this study consisted of normal kidneys free from any pathology, with normal renal function. The study includes both genders with their age ranged from 10 years to 70 years old.

2.3 Design of the study:

This study is analytic study of a case control type deals with CT scan.

2.4 Place and duration of the study:

The study population consisted of patients who referred to the CT scan department for CT abdomen; each patient was examined with CT (MDCT) scan by a qualified technologist. Between August 2014 to August 2016 in Sudan at (ALRabat National Hospital, Omdurman Hospital, Modern Medical Center, and Antalya Medical Center

2.5 Methods of data analysis:

Methods were used: axial, coronal single image, coronal multi image 100 patients referred for abdomen CT scans were included in the study. Patients both kidneys were investigated. Multi-slice CT was used in this research because by the obtained coronal and axial cuts, the actual length of kidney can be obtained easily. After that CT images were stored in computer disk were viewed by the Radiant, DICOM viewer Digital imaging and communication on medical in computer to selected the coronal images that suit the criteria of research population then uploaded into the computer based software Interactive Data Language (IDL) Then the image were read by IDL the first order were extracted from Multi-slice CT A non contrast to obtain coronal, Axial and sagittal cuts, to measure the renal parenchymal thickness (PT) on CT scans through A, upper calyx; B, renal pelvis; and C, lower calyx levels. PT was measured at four locations: anterior (a), posterior (b), medial (c), and lateral (d), at right angles to each other and oriented such that a-b paralleled the renal vessels. The length and the width of the kidneys, CT No of cortex and medulla, was also measured. And also Multi-slice CT with contrast was used to obtain Axial cuts, to measure the cortex and medulla.

2.6 Methods of data collection

2.6.1 Technique

CT scans were performed including protocol of axial images from the xiphoid process covers all abdominal area and pelvic down to pubic bone with patient in supine position, head first. The images were made at 100/120 kV and 60/80 MAs, with 5 mm slice thickness reformat 1.2mm. Reconstruction used 5mm to obtain coronal views. A light diet for 6 hr was preparation for patients. The simultaneous acquisition of multiple thin

collimated slices in combination with enhanced gantry rotation speed offers thin slice coverage of extended volumes without any loss in spatial resolution.

CT scans of the urinary tract were performed with and/or without intravenous iodinated contrast material depending on the indications. With rapid Scanning and contrast bolus timing, several sequential phases of pacification within the kidney was delineated .The corticomedullary phase was seen if scanning is performed during the first 20 to 90 seconds after contrast administration and represents the early preferential blood flow to the renal cortex . Subsequently, contrast begins to pass into the distal collecting tubules within the renal medulla, resulting in a more homogeneous opacification of the renal parenchyma, termed the CT nephrographic phase. This generally occurs around 2 to4 minutes after contrast medium injection. Finally, the excretory phase is seen when contrast opacifies the collecting system. Each different disease processes and thus various scanning protocols are used to evaluate the kidneys depending on the indication.

2.7 Ethical approval

The ethical approval was granted from the radiology departments; which include commitment of no disclose any information concerning the patient identification as well as consent from the patients. Informed consent was obtained from every patient prior to the examination.

III. Results

Table 1: Descriptive Statistics of kidneys characteristics data and CT (HU) for cortex and medulla for both right and left kidneys and T-Test.

	Side	N	Mean	Std. Deviation	P-value
Length Of Kidney	Left	100	95.73	11.40	0.495
	Right	100	96.75	9.61	
Width Of Kidney	Left	100	42.51	5.15	0.041
	Right	100	41.00	5.24	
Cortex(Axial)	Left	100	5.26	0.82	0.633
	Right	100	5.21	0.82	
Medulla(Axial)	Left	100	11.21	1.68	0.125
	Right	100	10.82	1.84	

Table2: Descriptive Statistics of the both kidneys measurements at the upper calyx, renal pelvis, Lower calyx measured at all directions and T-Test.

	Upper Calyx				Renal Pelvis			Lower Calyx		
	Side	Mean	Std. V	P-value	Mean	Std. V	P-value	Mean	Std. V	P-value
Anterior (a)	Left	12.00	2.60	0.771	0.00	0.00	-	10.88	2.44	0.357
	Right	11.88	3.14		0.00	0.00		19.45	92.32	
Posterior(p)	Left	16.11	3.95	0.847	22.37	3.63	0.859	18.85	3.85	0.431
	Right	16.21	4.09		22.28	3.65		18.40	4.10	
Medial (c)	Left	12.99	2.85	0.001	13.40	3.09	0.981	12.45	3.09	0.146
	Right	11.74	2.39		13.41	2.43		13.15	3.61	
Lateral (d)	Left	15.52	3.92	0.941	14.02	2.99	0.507	12.29	2.70	0.018
	Right	15.56	3.80		14.33	3.64		13.35	3.51	

Table 3: WE Statistics of the Kidneys length, width, cortex width and medulla width and CT(HU) and ANOVA Test

Kidney	Variable	Gender	N	Mean	Std. V	95% Confidence Interval for Mean	Min	Max	P-value	
Left	length of kidney	Male	42	95.00	11.28	91.49	98.52	71.30	117.80	.591
		Female	58	96.25	11.55	93.21	99.29	65.30	123.40	
		Total	100	95.73	11.40	93.47	97.99	65.30	123.40	
	width of kidney	Male	42	42.27	5.24	40.64	43.91	31.50	54.70	.696
		Female	58	42.68	5.11	41.34	44.03	33.20	57.60	
		Total	100	42.51	5.15	41.49	43.53	31.50	57.60	
	Cortex (axial)	Male	41	5.37	0.87	5.10	5.65	3.20	6.85	.282
		Female	58	5.19	0.79	4.98	5.40	3.10	6.70	
		Total	99	5.26	0.82	5.10	5.43	3.10	6.85	
	Medulla (axial)	Male	42	11.15	1.34	10.73	11.57	7.60	15.00	.762
		Female	58	11.25	1.90	10.75	11.75	6.80	17.60	

		Total	100	11.21	1.68	10.87	11.54	6.80	17.60	
Right	length of kidney	Male	42	95.11	8.61	92.43	97.79	79.60	113.40	.148
		Female	58	97.94	10.19	95.26	100.62	75.30	121.90	
		Total	100	96.75	9.61	94.8	98.66	75.30	121.90	
	width of kidney	Male	42	41.76	5.76	39.97	43.56	31.70	55.90	.219
		Female	58	40.45	4.81	39.19	41.72	30.00	51.90	
		Total	100	41.00	5.24	39.96	42.04	30.00	55.90	
	Cortex (axial)	Male	42	5.27	0.87	4.99	5.54	3.30	6.90	.554
		Female	57	5.17	0.7	4.95	5.38	3.20	6.70	
		Total	99	5.21	0.82	5.04	5.37	3.20	6.90	
	Medulla (axial)	Male	42	11.18	1.85	10.61	11.76	7.10	14.10	.093
		Female	58	10.55	1.80	10.07	11.03	5.40	14.80	
		Total	100	10.82	1.84	10.45	11.19	5.40	14.80	

Table 4: Descriptive Statistics of the Kidneys measurements at upper calyces distributed according to gender and ANOVA test

Kidney	Upper Calyx	Gender	N	Mean	Std. V	95% Confidence Interval for Mean	Min	Max	P-value	
Left	Anterior (a)	Male	42	12.05	2.83	11.16	12.93	4.70	20.00	.871
		Female	58	11.96	2.44	11.32	12.60	5.90	16.90	
		Total	100	12.00	2.60	11.48	12.51	4.70	20.00	
	Posterior (p)	Male	42	16.28	3.28	15.25	17.30	11.20	24.30	.715
		Female	58	15.98	4.40	14.82	17.14	8.60	24.60	
		Total	100	16.11	3.95	15.32	16.89	8.60	24.60	
	Medial (c)	Male	42	13.04	2.68	12.21	13.88	7.77	20.60	.883
		Female	58	12.96	2.98	12.17	13.74	4.70	23.40	
		Total	100	12.99	2.85	12.43	13.56	4.70	23.40	
	lateral (d)	Male	42	15.63	3.95	14.40	16.86	8.20	25.70	.814
		Female	58	15.44	3.94	14.41	16.48	7.31	26.10	
		Total	100	15.52	3.92	14.74	16.30	7.31	26.10	
Right	Anterior (a)	Male	42	12.04	2.91	11.13	12.95	7.00	16.70	.662
		Female	58	11.76	3.32	10.89	12.64	5.50	20.30	
		Total	100	11.88	3.14	11.25	12.50	5.50	20.30	
	Posterior (p)	Male	42	16.74	4.20	15.43	18.05	10.50	26.50	.277
		Female	58	15.83	3.99	14.78	16.89	8.30	24.90	
		Total	100	16.21	4.09	15.40	17.03	8.30	26.50	
	medial (c)	Male	42	12.02	2.51	11.24	12.81	7.50	18.00	.314
		Female	58	11.53	2.30	10.93	12.14	5.90	17.70	
		Total	100	11.74	2.39	11.26	12.21	5.90	18.00	
	lateral (d)	Male	42	16.28	4.25	14.95	17.60	9.60	30.60	.110
		Female	58	15.04	3.39	14.15	15.93	7.34	22.20	
		Total	100	15.56	3.80	14.81	16.32	7.34	30.60	

Table 5: Descriptive Statistics of the Kidneys measurements at renal pelvis distributed according to gender and ANOVA test

Kidney	Renal Pelvis	Gender	N	Mean	Std. V	95% Confidence Interval for Mean	Min	Max	P-value	
Left	Posterior (p)	Male	42	22.48	2.85	21.59	23.37	18.10	29.20	.789
		Female	58	22.28	4.13	21.20	23.37	12.90	32.90	
		Total	100	22.37	3.63	21.65	23.09	12.90	32.90	
	Medial (c)	Male	42	14.57	2.50	13.79	15.35	10.30	21.00	.001
		Female	58	12.54	3.21	11.70	13.39	1.16	18.90	
		Total	100	13.40	3.09	12.78	14.01	1.16	21.00	
	lateral (d)	Male	42	14.74	3.25	13.72	15.75	9.70	27.10	.040
		Female	58	13.50	2.69	12.79	14.21	7.20	19.10	

		Total	100	14.02	2.99	13.42	14.61	7.20	27.10	
Right	Posterior (p)	Male	42	23.22	3.48	22.14	24.31	17.10	32.50	.026
		Female	57	21.58	3.65	20.61	22.55	14.50	29.80	
		Total	99	22.28	3.65	21.55	23.01	14.50	32.50	
	Medial (c)	Male	42	13.99	2.38	13.24	14.73	8.84	18.80	.041
		Female	58	12.98	2.40	12.35	13.62	8.84	20.40	
		Total	100	13.41	2.43	12.92	13.89	8.84	20.40	
	lateral (d)	Male	42	15.21	3.61	14.08	16.34	10.10	24.60	.040
		Female	58	13.70	3.55	12.76	14.63	6.62	24.50	
		Total	100	14.33	3.64	13.61	15.05	6.62	24.60	

Table6: Descriptive Statistics of the Kidneys measurements at Lower Calyx distributed according to gender and ANOVA test

Kidney	lower calyx	Gender	N	Mean	Std. V	95% Confidence Interval for Mean		Min	Max	p-Value
Left	Anterior (a)	Male	41	10.86	2.58	10.04	11.67	4.40	15.80	.923
		Female	58	10.90	2.37	10.28	11.53	6.40	17.30	
		Total	99	10.88	2.44	10.40	11.37	4.40	17.30	
	Posterior (p)	Male	42	19.50	3.09	18.53	20.46	13.20	26.20	.152
		Female	58	18.37	4.28	17.25	19.50	8.80	28.80	
		Total	100	18.85	3.85	18.08	19.61	8.80	28.80	
	Medial (c)	Male	42	12.71	3.14	11.73	13.69	6.14	22.00	.479
		Female	57	12.26	3.06	11.45	13.08	6.50	23.40	
		Total	99	12.45	3.09	11.83	13.07	6.14	23.40	
	lateral (d)	Male	42	12.59	2.76	11.72	13.45	5.60	19.80	.357
		Female	58	12.08	2.65	11.38	12.78	6.78	22.00	
		Total	100	12.29	2.70	11.76	12.83	5.60	22.00	
Right	Anterior (a)	Male	42	32.26	142.40	12.11	76.63	2.60	933.00	.240
		Female	58	10.17	3.04	9.37	10.97	4.00	19.60	
		Total	100	19.45	92.32	1.13	37.76	2.60	933.00	
	Posterior (p)	Male	42	19.20	3.51	18.11	20.30	11.90	27.10	.097
		Female	58	17.82	4.42	16.66	18.98	10.00	33.30	
		Total	100	18.40	4.10	17.59	19.22	10.00	33.30	
	Medial (c)	Male	42	13.58	2.91	12.68	14.49	8.36	22.30	.307
		Female	58	12.83	4.04	11.77	13.90	7.28	27.30	
		Total	100	13.15	3.61	12.43	13.87	7.28	27.30	

	lateral (d)	Male	42	13.73	2.95	12.81	14.65	9.80	22.00	.353
		Female	58	13.07	3.87	12.05	14.08	7.68	25.70	
		Total	100	13.35	3.51	12.65	14.04	7.68	25.70	

Table7: Descriptive Statistics of the Kidneys measurements distributed according to age and ANOVA test

kidney	variable	Age class	N	Mean	Std. V	95% Confidence Interval for Mean		Min	Max	P-value
Left	Length Of Kidney	10-19	7	96.14	10.73	86.21	106.07	85.90	112.30	.702
		20-29	14	97.60	10.52	91.52	103.67	76.40	115.20	
		30-39	19	93.17	10.77	87.98	98.36	65.90	114.50	
		40-49	23	98.43	11.29	93.55	103.31	82.20	121.20	
		50-59	18	94.19	15.70	86.38	102.00	65.30	123.40	
		60-70	19	94.95	8.36	90.92	98.98	81.30	114.80	
		Total	100	95.73	11.40	93.47	97.99	65.30	123.40	
	Width Of Kidney	10-19	7	40.58	4.98	35.97	45.19	34.10	46.00	.315
		20-29	14	40.74	5.04	37.82	43.65	33.40	52.00	
		30-39	19	41.73	3.93	39.84	43.63	33.20	47.10	
		40-49	23	43.25	3.65	41.66	44.83	37.50	54.00	
		50-59	18	44.38	5.17	41.81	46.96	35.90	57.60	
		60-70	19	42.65	7.30	39.13	46.17	31.50	55.30	
		Total	100	42.51	5.15	41.49	43.53	31.50	57.60	
Right	Length Of Kidney	10-19	7	96.88	13.57	84.33	109.43	79.60	116.50	0.255
		20-29	14	94.50	10.80	88.27	100.74	75.70	111.70	
		30-39	18	94.35	8.09	90.32	98.38	79.70	110.00	
		40-49	23	99.95	8.37	96.32	103.57	83.10	118.40	
		50-59	19	99.04	9.64	94.39	103.69	75.30	121.90	
		60-70	19	94.46	9.41	89.92	99.00	76.30	113.40	
		Total	100	96.75	9.61	94.84	98.66	75.30	121.90	
	Width Of Kidney	10-19	7	39.48	4.72	35.11	43.85	34.20	47.70	0.254
		20-29	14	39.01	4.82	36.22	41.79	30.00	45.80	
		30-39	18	40.91	3.66	39.08	42.73	33.80	48.10	
		40-49	23	40.30	4.51	38.35	42.26	31.60	49.40	
		50-59	19	43.10	5.97	40.22	45.98	33.50	51.90	
		60-70	19	41.87	6.61	38.68	45.06	31.70	55.90	
		Total	100	41.00	5.24	39.96	42.04	30.00	55.90	

Table8: Descriptive Statistics of the Kidneys cortex and medulla measurements and CT (HU) distributed according to age and ANOVA test

Kidney	Variable	Age class	N	Mean	Std. V	95% Confidence Interval for Mean		Min	Max	P-value
Left	Cortex (axial)	10-19	7	5.16	.53	4.66	5.65	4.22	6.00	.400
		20-29	14	5.69	.73	5.26	6.11	4.45	6.70	
		30-39	19	5.19	.88	4.76	5.61	3.72	6.85	
		40-49	23	5.12	.83	4.76	5.48	3.20	6.60	
		50-59	18	5.15	.81	4.75	5.56	3.40	6.00	
		60-70	18	5.36	.91	4.90	5.81	3.10	6.10	
		Total	99	5.26	.82	5.10	5.43	3.10	6.85	
	Medulla (axial)	10-19	7	10.11	1.96	8.28	11.93	7.40	12.08	.318
		20-29	14	11.10	1.53	10.21	11.99	8.10	13.60	
		30-39	19	11.02	1.58	10.25	11.78	7.10	13.10	
		40-49	23	11.07	1.53	10.40	11.73	6.80	13.90	
		50-59	18	11.59	1.65	10.77	12.42	9.00	15.20	
		60-70	19	11.68	1.91	10.76	12.61	9.34	17.60	
		Total	100	11.21	1.68	10.87	11.54	6.80	17.60	
Right	Cortex (axial)	10-19	7	5.23	.82	4.46	5.99	4.09	6.70	.873
		20-29	14	5.45	.63	5.09	5.82	4.40	6.50	
		30-39	18	5.11	.84	4.69	5.53	3.67	6.60	

		40-49	23	5.15	.81	4.80	5.51	3.31	6.90	.109
		50-59	18	5.12	.82	4.71	5.53	3.30	6.30	
		60-70	19	5.26	1.00	4.78	5.75	3.20	6.50	
		Total	99	5.21	.82	5.04	5.37	3.20	6.90	
	Medulla (axial)	10-19	7	9.38	2.09	7.44	11.31	5.40	12.07	
		20-29	14	10.75	1.49	9.89	11.62	8.30	13.30	
		30-39	18	10.48	1.91	9.53	11.43	7.40	14.00	
		40-49	23	10.64	1.72	9.90	11.39	6.50	13.70	
		50-59	18	11.26	1.891	10.32	12.20	6.80	14.10	
		60-70	19	11.53	1.82	10.65	12.41	7.80	14.80	
		Total	99	10.82	1.84	10.45	11.19	5.40	14.80	
	Total	99	37.23	4.63	36.30	38.15	29.00	49.00		

Table9: Descriptive Statistics of both Kidneys upper calyx measurements at different sites distributed according to age and ANOVA test

Kidney	Upper Calyx	Age Class	N	Mean	Std. V	95% Confidence Interval for Mean		Min	Max	P-Value
Left	Anterior (a)	10-19	7	12.25	1.37	10.98	13.53	11.00	14.70	.959
		20-29	14	11.60	3.12	9.80	13.41	4.70	16.70	
		30-39	19	11.87	2.73	10.55	13.18	5.90	16.60	
		40-49	23	11.85	2.47	10.78	12.92	8.20	16.90	
		50-59	18	12.46	2.96	10.98	13.93	9.30	20.00	
		60-70	19	12.06	2.43	10.89	13.23	7.90	16.80	
		Total	100	12.00	2.60	11.48	12.51	4.70	20.00	
	posterior (p)	10-19	7	16.85	5.61	11.66	22.05	9.20	22.90	.689
		20-29	14	16.57	3.39	14.60	18.53	11.40	22.50	
		30-39	19	14.88	3.58	13.15	16.61	8.60	24.60	
		40-49	23	16.23	4.43	14.31	18.15	9.20	23.20	
		50-59	18	16.91	3.71	15.06	18.75	11.40	24.30	
		60-70	19	15.81	3.80	13.97	17.64	9.30	22.70	
		Total	100	16.11	3.95	15.32	16.89	8.60	24.60	
	medial (c)	10-19	7	13.36	5.20	8.54	18.18	7.77	23.40	.640
		20-29	14	12.94	2.53	11.47	14.40	10.00	18.00	
		30-39	19	12.05	3.15	10.53	13.57	4.70	17.70	
		40-49	23	12.86	1.91	12.03	13.69	9.50	16.20	
		50-59	18	13.46	2.26	12.33	14.58	8.50	16.70	
		60-70	19	13.56	3.19	12.02	15.10	8.00	20.60	
		Total	100	12.99	2.85	12.43	13.56	4.70	23.40	
	Lateral (d)	10-19	7	14.90	4.96	10.30	19.49	10.40	22.40	.930
		20-29	14	14.77	3.72	12.62	16.92	9.70	21.10	
		30-39	19	15.22	4.31	13.14	17.30	7.31	25.70	
40-49		23	16.06	4.02	14.31	17.80	9.58	26.10		
50-59		18	15.60	3.51	13.85	17.34	8.20	21.60		
60-70		19	15.88	3.90	14.00	17.77	9.10	20.70		
Total		100	15.52	3.92	14.74	16.30	7.31	26.10		
Right	Anterior (a)	10-19	7	13.37	3.46	10.16	16.58	9.20	19.50	.168
		20-29	14	11.67	3.73	9.52	13.83	5.50	17.40	
		30-39	18	12.73	3.30	11.08	14.37	7.36	20.30	
		40-49	23	12.29	2.92	11.02	13.56	7.50	18.40	
		50-59	19	10.37	2.94	8.95	11.79	6.27	18.20	
		60-70	19	11.69	2.58	10.44	12.94	7.33	16.50	
		Total	100	11.88	3.14	11.25	12.50	5.50	20.30	
	posterior (p)	10-19	7	18.10	2.07	16.18	20.01	14.70	20.70	.842
		20-29	14	16.27	4.93	13.42	19.12	8.30	23.70	
		30-39	18	16.38	3.53	14.62	18.13	9.30	24.90	
		40-49	23	15.92	4.30	14.06	17.78	9.07	23.20	
		50-59	19	16.3	3.76	14.51	18.14	11.90	25.30	
		60-70	19	15.57	4.74	13.29	17.86	10.50	26.50	
		Total	100	16.30	4.00	15.30	17.30	9.00	24.00	

	Medial (c)	Total	100	16.21	4.09	15.40	17.03	8.30	26.50	.715
		10-19	7	11.33	2.65	8.87	13.78	9.01	16.00	
		20-29	14	11.42	2.10	10.21	12.64	8.00	14.50	
		30-39	18	11.22	2.39	10.02	12.41	5.90	17.60	
		40-49	23	11.82	2.53	10.72	12.91	8.10	17.80	
		50-59	19	11.83	2.10	10.81	12.84	7.50	18.00	
		60-70	19	12.44	2.71	11.13	13.75	8.10	17.70	
	Total	100	11.74	2.39	11.26	12.21	5.90	18.00		
	lateral (d)	10-19	7	14.64	3.38	11.51	17.76	11.20	20.40	.440
		20-29	14	14.02	3.24	12.14	15.89	9.60	19.70	
		30-39	18	15.80	4.33	13.65	17.95	7.34	23.90	
		40-49	23	16.70	3.59	15.15	18.25	11.20	25.00	
		50-59	19	15.45	3.09	13.96	16.94	10.40	21.70	
		60-70	19	15.54	4.62	13.32	17.77	10.00	30.60	
Total		100	15.56	3.80	14.81	16.32	7.34	30.60		

Table10: Descriptive Statistics of both Kidneys renal pelvis measurements at different sites distributed according to age and ANOVA test

Kidney	Renal Pelvis	Age Class	N	Mean	Std. V	95% Confidence Interval For Mean	Min	Max	P-Value	
Left	Posterior (p)	10-19	7	20.57	2.58	18.18	22.95	17.80	26.10	.166
		20-29	14	23.66	4.30	21.17	26.15	19.90	32.90	
		30-39	19	21.08	3.52	19.39	22.78	13.60	26.30	
		40-49	23	23.41	2.53	22.31	24.51	19.20	29.00	
		50-59	18	22.21	4.34	20.04	24.37	13.50	31.50	
		60-70	19	22.25	3.64	20.50	24.01	12.90	27.10	
		Total	100	22.37	3.63	21.65	23.09	12.90	32.90	
	Medial (c)	10-19	7	12.28	3.21	9.31	15.26	10.30	18.70	.264
		20-29	14	12.27	3.53	10.22	14.31	6.80	18.90	
		30-39	19	13.16	2.59	11.91	14.41	9.50	19.80	
		40-49	23	13.14	3.44	11.65	14.63	1.16	20.70	
		50-59	18	14.12	2.24	13.01	15.24	8.90	17.90	
		60-70	19	14.50	3.26	12.93	16.07	6.60	21.00	
		Total	100	13.40	3.09	12.78	14.01	1.16	21.00	
	lateral (d)	10-19	7	13.70	2.25	11.61	15.78	10.50	15.60	.006
		20-29	14	12.13	3.15	10.30	13.95	7.20	19.10	
		30-39	19	14.78	3.15	13.26	16.31	7.60	20.00	
		40-49	23	13.26	1.98	12.41	14.12	10.10	17.70	
50-59		18	13.85	2.04	12.83	14.87	9.67	16.60		
60-70		19	15.84	3.74	14.03	17.64	11.50	27.10		
Total		100	14.02	2.99	13.42	14.61	7.20	27.10		
Right	Posterior (p)	10-19	7	22.80	3.35	19.70	25.89	20.20	28.40	.841
		20-29	14	22.32	3.57	20.25	24.38	19.00	29.80	
		30-39	18	22.20	3.35	20.53	23.87	15.50	28.80	
		40-49	23	21.74	2.67	20.58	22.89	16.00	25.60	
		50-59	19	21.87	4.71	19.60	24.14	14.50	32.50	
		60-70	18	23.23	4.21	21.14	25.33	14.80	28.90	
		Total	99	22.28	3.65	21.55	23.01	14.50	32.50	
	Medial (c)	10-19	7	11.86	2.33	9.71	14.02	8.84	14.70	.445
		20-29	14	12.93	2.27	11.62	14.25	9.30	18.50	
		30-39	18	13.37	2.43	12.16	14.58	9.43	17.30	
		40-49	23	13.94	2.44	12.89	15.00	10.30	18.80	
		50-59	19	13.74	3.03	12.27	15.20	9.00	20.40	
		60-70	19	13.37	1.83	12.49	14.26	10.20	17.40	
		Total	100	13.41	2.43	12.92	13.89	8.84	20.40	
	Lateral (d)	10-19	7	14.14	3.06	11.30	16.97	11.00	20.00	.416
		20-29	14	13.30	3.27	11.41	15.20	10.40	21.70	
		30-39	18	15.59	3.51	13.84	17.34	11.30	24.60	
		40-49	23	13.46	4.00	11.72	15.19	6.62	24.50	
50-59		19	14.51	4.02	12.58	16.45	9.76	21.80		
60-70		19	14.85	3.29	13.26	16.44	9.15	22.20		
Total		100	14.33	3.64	13.61	15.05	6.62	24.60		

Table11: Descriptive Statistics of both Kidneys lower calyex measurements at different sites distributed according to age and ANOVA test

Kidney	lower calyx	Age class	N	Mean	Std. V	95% Confidence Interval for Mean		Min	Max	P-Value
Left	Anterior (a)	10-19	7	10.14	1.77	8.51	11.78	8.70	13.80	.122
		20-29	14	10.33	2.59	8.83	11.83	4.40	14.40	
		30-39	19	12.30	2.41	11.14	13.46	8.05	17.30	
		40-49	23	10.64	2.36	9.61	11.66	6.90	16.30	
		50-59	17	10.39	2.33	9.19	11.59	7.00	15.80	
		60-70	19	10.89	2.53	9.67	12.11	6.11	15.60	
		Total	99	10.88	2.44	10.40	11.37	4.40	17.30	
	Posterior (p)	10-19	7	18.11	4.71	13.75	22.47	8.80	23.30	.589
		20-29	14	20.00	2.35	18.64	21.35	13.80	22.50	
		30-39	19	18.96	3.56	17.24	20.68	13.30	28.80	
		40-49	23	18.49	3.95	16.78	20.20	12.20	28.40	
		50-59	18	17.78	4.42	15.58	19.98	9.30	27.10	
		60-70	19	19.59	4.09	17.62	21.56	8.90	26.20	
		Total	100	18.85	3.85	18.08	19.61	8.80	28.80	
	Medial (c)	10-19	6	10.52	2.10	8.31	12.73	8.20	13.10	.026
		20-29	14	11.21	2.38	9.83	12.59	7.20	13.90	
		30-39	19	11.56	2.56	10.32	12.79	6.50	17.70	
		40-49	23	13.27	2.80	12.06	14.48	8.96	19.90	
		50-59	18	14.00	3.58	12.22	15.79	8.42	23.40	
		60-70	19	12.41	3.45	10.75	14.08	6.14	22.00	
		Total	99	12.45	3.09	11.83	13.07	6.14	23.40	
	lateral (d)	10-19	7	13.64	3.90	10.03	17.25	11.20	22.00	.154
		20-29	14	11.41	2.23	10.12	12.71	8.80	15.50	
		30-39	19	12.93	2.80	11.57	14.28	8.00	18.70	
		40-49	23	11.62	2.26	10.64	12.61	8.34	18.80	
		50-59	18	11.78	2.73	10.42	13.15	5.60	15.90	
		60-70	19	13.10	2.62	11.83	14.36	9.50	19.80	
		Total	100	12.29	2.70	11.76	12.83	5.60	22.00	
Right	Anterior (a)	10-19	7	12.20	2.58	9.81	14.59	9.44	16.50	.496
		20-29	14	9.73	2.66	8.19	11.27	4.80	13.60	
		30-39	18	60.95	217.65	47.27	169.19	2.60	933.00	
		40-49	23	9.78	3.38	8.32	11.25	4.00	19.60	
		50-59	19	10.61	2.71	9.30	11.92	5.73	15.30	
		60-70	19	10.49	3.07	9.00	11.97	5.12	17.50	
		Total	100	19.45	92.32	1.13	37.76	2.60	933.00	
	Posterior (p)	10-19	7	20.95	2.78	18.37	23.53	15.80	23.30	.347
		20-29	14	19.72	4.11	17.35	22.10	11.70	25.80	
		30-39	18	18.30	3.07	16.77	19.82	13.70	23.60	
		40-49	23	17.47	5.37	15.14	19.79	10.00	33.30	
		50-59	19	17.96	3.61	16.22	19.70	11.90	25.10	
		60-70	19	18.16	3.90	16.27	20.04	13.10	27.10	
		Total	100	18.40	4.10	17.59	19.22	10.00	33.30	

	Medial (c)	10-19	7	11.82	3.62	8.46	15.17	7.90	17.60	.292
		20-29	14	12.47	3.23	10.60	14.33	8.21	18.70	
		30-39	18	14.93	4.94	12.47	17.38	7.28	27.30	
		40-49	23	13.17	3.77	11.54	14.80	8.10	19.80	
		50-59	19	12.86	3.06	11.39	14.34	8.26	17.60	
		60-70	19	12.72	2.38	11.57	13.87	8.87	17.60	
		Total	100	13.15	3.61	12.43	13.87	7.28	27.30	
	Lateral (d)	10-19	7	14.78	2.48	12.48	17.08	11.70	18.90	.556
		20-29	14	13.20	2.31	11.87	14.54	10.40	18.70	
		30-39	18	14.12	4.41	11.92	16.32	7.68	25.70	
		40-49	23	13.33	4.46	11.39	15.26	7.97	24.40	
		50-59	19	12.22	2.70	10.92	13.53	7.74	17.20	
		60-70	19	13.34	3.01	11.88	14.79	8.50	22.00	
Total		100	13.35	3.51	12.65	14.04	7.68	25.70		

IV. Discussion

Normal renal measurements are an important issue in studying renal physiology and its disorders. It is also important in making a primary diagnosis as well as during the follow-up of patients with renal diseases, in order to monitor the diseases' development. [18]

Data that were obtained for both left and right kidney from all the participants were renal length, width and CT number as well as renal character in the upper pole, calyces and lower pole as well as renal pelvis. All measurements were taken in mm. When comparing the right and left kidneys the study showed that there is no significant difference between the two kidneys length where there were significant difference in kidneys width at $p \leq 0.041$, left kidney is greater than the right by 1.5cm (table1).

Our research agreed with previous studies done that left kidney is larger than the right [19-21] Table (1) shows the measurements of the kidneys as mean and standard deviation values. Both kidneys measurements at the upper calyx, renal pelvis, Lower calyx measured at all directions showed that the medial upper calyces for the left kidney measured in axial direction is larger significantly than the right kidney at $p=0.001$ as well as the lateral (d) of the lower calyx differs significantly between the two kidneys at $p=0.018$. Table (2). The likely justification is, due to the size of spleen which is smaller than the liver, thus the left kidney has more space for its growth. Another possible cause is that because of the left renal artery is shorter and straighter than the right one; this causes increased blood flow in the left artery which may result in relatively increased in measurements [22, 23]

The present data show that the kidney character including kidney length and width, cortex and medulla width were independent of gender; similar findings in other population have been mentioned. [24, 25] From the data obtained, we can also conclude that renal measurements in female population are relatively smaller compared to male population. However, the differences in renal measurements for upper and lower calyces found in this study are quite minimal and not significant

Except for the measurement of the renal pelvis measurement were significantly differ between both genders for medial, lateral measurements in both right and left kidneys at $p=0.001, 0.040$ and $0.041, 0.040$ respectively. The posterior measurement for the right kidney differed significantly between both genders at $p=0.026$. In all cases the males have greater measurements than females regarding renal pelvis measurements. Tables (3, 4, 5, 6)

The gender are not a predictor for changes in the renal measurements except for the medial and lateral renal pelvis segments for both right and left kidneys at ($P= 0.041, 0.040$ and $0.001, 0.040$). The age also is not a predictor for renal measurement except the renal pelvis lateral segment of the left kidney as well as lower calyx medial segment at $p=0.006$ and 0.026 . Tables (7-11). A new chart for renal character and measurement were established according to different age classes from 10 years to 70 years and for both gendered s for Sudanese population.

Our study showed that kidney length was 96.75 mm for the right, and 95.73 mm for the left. The right kidneys width was 41.00 mm, less than the left 42.51mm at ($p =0.041$) when compared to the study done by Emamian et al.[26] based on Denmark population which consist of different ranged of age had shown that the renal lengths were 11.2cm on the left side and 10.9cm on the right side. The mean renal length for Denmark differs from Sudanese. Another study from Mexican population by J. Oyuela- Carrasco et al. [27] had reported the renal length in Mexican adults differs as well as the gender has an impact in the kidneys measurements.

What we can say here is that all the differences in the previous studies were related to ethnic groups pointed that the results of this current study differ from other populations. Danish population left kidney length was found to be 11.2cm and the right kidney was 10.9cm, [26] In Mexicans; kidney length was 10.5cm for the left and 10.4cm for the right. [27] Nigerian population has kidney length of 10.6 cm for the left and 10.3cm for the right. [28] The Northwest Indian populations' measurements were 10.0cm for the left kidney length and 9.9cm for the right kidney [29] Japanese have left kidney length of 11.5cm, right of 11.3 cm and width of 5.7 cm, 5.5cm for left and right in respectively [30] Caucasians population have 12cm kidneys length and 6 cm kidneys width as mentioned by Williams et al. [31]

V. Conclusion

From what we can conclude from the comparison with other populations is that Sudanese renal characters differ from the other populations. A new chart for renal character and measurement were established for Sudanese population aged from 10 years to 70 years

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