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Sonographic measurement of the renal size in a normal adult population in Erbil, Kurdistan Region- Iraq

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Abstract---Background: Renal parameters have an important role in the anatomical, pathological and clinical fields and many factors can have a role in determining the renal parameters hence, making normal renal parameter references are essential. Objectives: To find out the renal size and volume of a sample of Kurdish people and to assess their association with age, sex, and body mass index (BMI) to make a reference for measurement of renal size in Kurdish population. Methods: A descriptive cross-sectional study was conducted on 350 subjects who were selected through a purposive sampling method in Erbil city from April 2021 to April 2022. Almost all of the candidates were received in a private clinic. The sample was composed of 161(46%) males and 189(54%) females between the ages of 18-72years normal adults. Sonographic Renal parameters were estimated and BMI index was calculated. Significant differences were found among renal size and volume and sex, age, and BMI. Results: Significant factors associated with renal size and volumes were age, sex, and BMI. Apart from no significant differences in the means of the renal lengths between males and females, other renal parameters are larger in the left kidney and among males. Renal size and volume had an inconsistent relationship with age, the renal size and volume are decreased at the age of 60 and older. Conclusion: there was a discrepancy in the study sample renal size and volume data in comparison with that of the Kurdish populations in other areas and different populations of other countries. Age, sex and BMI are significant factors.

Keywords---renal size, sonographic measurement, adult population, erbil, kurdistan region.

Introduction

Since the kidney size and volume can be affected by many urological and nephrological diseases and, they have a valuable role in the diagnosis and estimation of the severity of renal diseases, normal kidney dimensions and parameters should be established. Despite significant variations of normal kidney parameters among different ethnic groups, ages, gender, and body mass index (BMI). (1, 2, 3). Kurdistan region hospitals are practicing common established normal kidney standards in the USA like The Radiological Society of North America (RSNA), and in European countries like the International Society of Nephrology (ISN). Only a few studies are conducted about normal kidney dimensions in adult Kurdish people. The most feasible modality for renal dimensions measurement is ultrasound. It is an easy, achievable, and inexpensive tool and there is a small difference compared with CT scan and MRI for the assessment of renal dimensions (4) as well as it has no magnification and no radiation hazards compared with radiography. The importance of this study is to provide an estimation of renal size and volume for normal adult people in the Kurdistan region to be used in medical practice and to find out if there is a significant difference between local normal kidney measurements and that of other countries, furthermore, it will help to put guidelines to make a standard reference for normal renal dimensions of Kurdish people. The objectives of the present study were to measure renal parameters of normal adult Kurdish people who are living in Erbil city including renal volume and size and to find out the association between the size and volume of both kidneys of the study sample with their age, gender, and BMI.

Subjects and Methods

A descriptive cross-sectional study on 385 subjects who were selected through the purposive convenience sampling method in Erbil city from April 2021 to April 2022. For the sample size, Sample Size Calculator was used which was online software and we entered data of a 95% confidence interval, 5% margin of error, and 50% of the population proportion, a sample size of 385 subjects was calculated (5). Some subjects are excluded because of missed data or the subject refused to be included in the study. All of the candidates were received by the researcher in a private clinic. The final sample (350 subjects) was composed of 161(46%) males and 189(54%) females between the ages of 18-72 years.

Inclusion criteria

- Normal adult people of both sexes with normal renal function test older than 18 years old.
- The kidneys with few and small simple renal cysts that do not affect renal size and dimensions.

Exclusion criteria

- Any congenital or acquired renal disorders like single kidney, previous operation, and insult.
- Systemic diseases like hypertension, DM, and autoimmune diseases.

- Multiple renal cysts or large solitary renal cysts.
- Pregnant ladies
- Significant renal diseases were observed during sonographic examinations.
- Other ethnicities and races were excluded.

The study conducted after approval from the Research Ethics Committee of the College of Medicine/Hawler Medical University. Data collected after obtaining verbal consent of all participants after a full explanation of the purpose and procedures of the examination and history taking. Variables included race, age, sex, height, weight, and body mass index (BMI) were recorded. For calculating BMI the used formula was $\text{Weight (kg)} / (\text{Height m})^2$. A tape and an electronic scale were used to measure the height (m) and weight (Kg) of each subject. Examination began with a hospital-type sonography machine having a 2D high resolution (Chison 64Qbit) by using a convex sonography probe (3.5-5Mhz) and renal system preset software. The subject was lying down on supine and lateral decubitus, both kidneys were thoroughly examined and the required data were recorded. In some cases, the prone position was also used. An ample of gel was been used. A questionnaire was filled with acquired data, composed of two parts as follows:

- Part one was for sociodemographic data of the study sample.
- Part two was for body weight, body height, and both kidney parameters, which include.
 - Renal length (the distance between far renal borders of lower and upper poles).
 - Renal width (the distance between the lateral and medial renal borders on coronal projection perpendicular to the renal length)
 - Renal thickness (the distance between anterior and posterior renal borders on transverse projection).
 - Renal cortical thickness (the distance between the outer renal border and renal sinus including renal column, on coronal projection at the mid-portion. In the case of a prominent column of Bertin or irregular cortical thickness, the average upper or lower renal pole distance was used.
 - Renal volume ($\text{Length in mm} \times \text{Width in mm} \times \text{renal thickness in mm} \times 0.523 = \text{renal volume (ml)}$).
 - Renal size ($\text{Length in mm} \times \text{Width in mm} \times \text{cortical thickness in mm} = \text{renal size (mm)}^3$). Renal size reflects the renal function.
 - Renal function test (blood urea and serum creatinine)

Data were entered managed and analyzed using the statistical package for social sciences (SPSS) software. Data presented as frequency, percentage mean , standard deviation, standard error, median, range, and confidence intervals, accordingly, Mann-Whitney test, Kruskal Wallis test, and Dunn-Bonferroni test were applied to compare the parameters across different variables.

Results

Three hundred fifty persons were included in the study. Their mean age (\pm SD) was 38.1 (13.0) years, ranging from 18 to 72 years, and the median was 38 years. More than half (57.7%) of the sample were aged < 40 years as presented in Table

1, which shows also that 54% of the sample were females (Table 1). The descriptive statistics of the studied renal variables are presented in Table 2. No significant differences were detected between males and females in the mean ranks of the right renal length ($p = 0.382$), and the left renal length ($p = 0.767$). Table 3 shows that all the means (and mean ranks) of the following parameters were significantly higher among males than females: right and left renal width ($p < 0.001$), right and left renal thickness ($p < 0.001$), right cortical thickness ($p < 0.001$), left cortical thickness ($p = 0.035$), right and left renal size ($p < 0.001$), and right and left renal volume ($p < 0.001$) (Table 3).

In general, the more the body mass index, the more the mean of the renal measurements, and the differences were significant between the categories of body mass index for all the renal variables. Most of the differences between every two groups (as studied by the post-hoc test) were significant (Table 4). It is evident in (Table 5) that there were significant differences between the age groups in the means of the right renal length ($p = 0.007$) and the left renal length ($p = 0.021$), but the relationship was not consistent through the age categories, as the means start to increase with age, and then decrease at the age of 60 and above. The means of the right renal width and the left renal width significantly differ between the age categories ($p < 0.001$ and $p = 0.001$ respectively), but according to the post-hoc test, this significant difference is attributed to the increase in the mean renal width in the age group 40-49 years compared to the mean of the age group of less than 40 years. All the other differences were not significant. It is worth mentioning that the mean of the left renal width of all ages was 49 mm while that of the right renal width was 41.9 mm.

The lowest mean of the right renal thickness (40.5 mm) was among those aged less than 40 years, then it starts to increase, and then decrease at the age of 60 and higher ($p = 0.001$). No significant differences were detected between the age groups in the mean of the left renal thickness ($p = 0.060$). Significant differences were detected between the age groups in the means of right cortical thickness but these differences were not consistent through the age groups ($p = 0.014$). No significant difference was detected regarding the left cortical thickness ($p = 0.159$). Significant differences were detected in the right and left renal size ($p < 0.001$, and $p = 0.015$ respectively), again the size start to increase and then decrease at 60 years and higher. The same pattern is observed for the right and left renal volume, where the mean was less at those aged less than 40 years, then increase, and then decrease at the age of 60 years and above.

Table 1
Age and gender distribution of the studied group

Variable	No.	%
Age (years)		
18-40	202	57.7
40-49	84	24.0
50-59	37	10.6
≥ 60	27	7.7
Mean (SD)	38.1 (13.0)	
Gender		

Male	161	46.0
Female	189	54.0
Total	350	100.0

SD: standard deviation of mean

Table 2
Descriptive statistics of the renal parameters

Parameter	Mean	SD	SE	Median	Minimum	Maximum	95%CI	
							Lower	Upper
Right Renal Length (mm)	108.1	8.7	0.5	107.5	85.4	140	107.2	109
Left Renal Length (mm)	109.9	9.7	0.5	109.9	77.1	140	108.9	110.9
Right Renal Width (mm)	41.9	6.5	0.3	41.3	27	61.2	41.2	42.6
Left Renal Width (mm)	49	7	0.4	48.7	26	74.8	48.2	49.7
Right Renal Thickness (mm)	41.6	6.3	0.3	41	27.6	64.2	41	42.3
Left Renal Thickness	44.5	5.9	0.3	44.5	22.2	63.7	43.9	45.1
Right Cortical Thickness (mm)	14.7	2.5	0.1	14.5	9.4	23	14.5	15
Left Cortical Thickness (mm)	16.2	2.8	0.2	16	8.8	28	15.9	16.5
Right Renal Size (mm)	68206	22650	1211	64641	28215	151634	65825	70587
Left Renal Size (mm)	88863	28479	1522	85324	25626	192786	85869	91857
Right Renal Volume (mm ³)	100826	32019	1711	93981	43695	206656	97460	104192
Left Renal Volume (mm ³)	127480	36242	1937	123380	41425	252624	123670	131290

SD: standard deviation of mean, SE: standard error of mean, CI: Confidence interval

Table 3
Comparison of renal parameters according to gender

Parameter	Male		Female		P. value
	Mean	SD	Mean	SD	
Right Renal Length (mm)	107.6	8.6	108.5	8.7	0.382
Left Renal Length (mm)	110.1	8.9	109.8	10.3	0.767
Right Renal Width (mm)	44.8	6.2	39.4	5.7	< 0.001
Left Renal Width (mm)	51.5	6.6	46.8	6.6	< 0.001
Right Renal Thickness (mm)	43.9	6.3	39.7	5.6	< 0.001
Left Renal Thickness (mm)	45.9	5.6	43.2	5.8	< 0.001
Right Cortical Thickness (mm)	15.4	2.4	14.1	2.5	< 0.001
Left Cortical Thickness (mm)	16.6	3.1	15.8	2.5	0.035
Right Renal Size (mm ³)	75589	21908	61916	21388	< 0.001
Left Renal Size (mm ³)	95877	29878	82888	25842	< 0.001
Right Renal Volume (ml)	112813	32499	90615	27865	< 0.001
Left Renal Volume (ml)	138015	34669	118505	35205	< 0.001

Table 4
Renal parameters by body mass index

Parameter	statistic	BMI			Pairwise multiple comparisons P. values		
		Normal (n= 83)	Overweigh t (n=117)	Obese (n=150)	*P1	*P2	*P3
Right Renal Length (mm)	Mean	104.5	106.8	111.1	0.162	<0.001	< 0.001
	SD	8.2	8.1	8.4			
Left Renal Length (mm)	Mean	105.5	109.6	112.7	0.011	<0.001	0.029
	SD	9.2	9.3	9.3			
Right Renal Width (mm)	Mean	37.6	41.8	44.3	<0.001	<0.001	0.014
	SD	5.5	5.9	6.3			
Left Renal Width (mm)	Mean	44.5	49	51.4	<0.001	<0.001	0.019
	SD	5.8	6.7	6.8			
Right Renal Thickness (mm)	Mean	38.4	41.8	43.3	0.001	<0.001	0.063
	SD	5.4	6.6	5.9			
Left Renal Thickness (mm)	Mean	40.9	44.3	46.6	<0.001	<0.001	0.004
	SD	5.1	5.4	5.7			
Right Cortical Thickness	Mean	13.7	14.7	15.3	0.029	<0.001	0.084
	SD	2.3	2.4	2.5			
Left Cortical Thickness	Mean	15.4	16.1	16.6	0.398	0.002	0.108
	SD	2.4	2.9	2.8			
Right Renal Size (mm ³)	Mean	54947	66592	76801	<0.001	<0.001	0.002
	SD	17541	20180	23258			
Left Renal size (mm ³)	Mean	73733	87628	98198	0.002	<0.001	0.007

	<i>SD</i>	20702	27212	29510			
Right Renal Volume (ml)	<i>Mean</i>	80148	99470	113326	<0.001	<0.001	0.001
	<i>SD</i>	23030	30175	31681			
Left Renal Volume (ml)	<i>Mean</i>	101638	125990	142941	<0.001	<0.001	0.001
	<i>SD</i>	25120	32529	35932			

*Kruskal Wallis test. And Bonferroni post hoc tests are used in comparison.
P. values ; P1: Normal vs. overweight, P2: Normal vs. obese, P3: overweight vs. obese

Table 5
Renal parameters by age

Parameter	Age (years)	N	Mean	SD	Pairwise multiple comparisons	
					Subgroup	P. value
Rt. Renal Length (mm)	A) <40	202	107.5	8.8	A x B	0.011
	B) 40-49	84	110.6	8.3	A x C	1.000
	C) 50-59	37	108.1	7.7	A x D	1.000
	D) ≥ 60	27	105	8.6	B x C	0.830
					B x D	0.040
				C x D	1.000	
Lt. Renal Length (mm)	A) <40	202	109.4	10.2	A x B	0.719
	B) 40-49	84	111.3	8.9	A X C	0.373
	C) 50-59	37	112.5	9.5	A x D	0.537
	D) ≥ 60	27	106.4	6.6	B x C	1.000
					B x D	0.078
				C x D	0.042	
Rt. Renal Width (mm)	A) <40	202	40.5	6.2	A x B	< 0.001
	B) 40-49	84	44	6	A x C	0.063
	C) 50-59	37	43.9	7.2	A X D	0.509
	D) ≥ 60	27	42.9	6.5	B X C	1.000
					B X D	1.000
				C x D	1.000	
Lt. Renal Width (mm)	A) <40	202	47.8	6.9	A x B	0.002
	B) 40-49	84	51.1	6.7	A x C	0.098
	C) 50-59	37	50.5	8.2	A x D	1.000
	D) ≥ 60	27	48.8	5.6	B x C	1.000
					B x D	1.000
				C x D	1.000	
Rt. Renal Thickness (mm)	A) <40	202	40.5	6	A X B	0.004
	B) 40-49	84	43.2	5.8	A x C	0.022
	C) 50-59	37	44.3	7.7	A x D	1.000
	D) ≥ 60	27	41.8	6.2	B x C	1.000
					B x D	1.000
				C x D	1.000	
Lt. Renal Thickness	A) <40	202	43.9	5.9	A x B	NA
	B) 40-49	84	45.7	5.7	A x C	NA

(mm)	C) 50-59	37	45.5	6.5	A x D	NA
	D) ≥ 60	27	43.3	5.1	B x C	NA
					B x D	NA
					C x D	NA

*By Kruskal Wallis test. **By Dunn-Bonferroni test.

Table 5
Continued: Renal parameters by age

Parameter	Age (years)	N	Mean	SD	Pairwise multiple comparisons P. values	
Rt. Cortical Thickness (mm)	A) <40	202	14.5	2.6	A x B	0.011
	B) 40-49	84	15.5	2.3	A x C	1.000
	C) 50-59	37	14.5	2.7	A x D	1.000
	D) ≥ 60	27	14.4	2.2	B x C	0.253
				B x D	0.281	
				C x D	1.000	
Lt. Cortical Thickness (mm)	A) <40	202	16	2.6	A x B	NA
	B) 40-49	84	16.8	3.1	A x C	NA
	C) 50-59	37	16	3.1	A x D	NA
	D) ≥ 60	27	15.7	3.1	B x C	NA
				B x D	NA	
				C x D	NA	
Rt. Renal Size (mm ³)	A) <40	202	64703	22391	A x B	<0.001
	B) 40-49	84	76253	20955	A x C	0.815
	C) 50-59	37	70659	24672	A x D	1.000
	D) ≥ 60	27	66016	21163	B x C	0.636
				B x D	0.186	
				C x D	1.000	
Lt. Renal size (mm ³)	A) <40	202	85504	26919	A x B	0.027
	B) 40-49	84	96930	30110	A x C	0.722
	C) 50-59	37	93461	32563	A x D	1.000
	D) ≥ 60	27	82596	23530	B x C	1.000
				B x D	0.170	
				C x D	0.719	
Rt. Renal Volume (ml)	A) <40	202	94166	30061	A x B	<0.001
	B) 40-49	84	111419	29295	A x C	0.024
	C) 50-59	37	113226	39160	A x D	1.000
	D) ≥ 60	27	100698	31413	B x C	1.000
				B x D	0.422	
				C x D	1.000	
Lt. Renal Volume (ml)	A) <40	202	122657	36769	A x B	0.004
	B) 40-49	84	137440	33584	A x C	0.066
	C) 50-59	37	137867	39690	A x D	1.000
	D) ≥ 60	27	118339	25612	B x C	1.000
				B x D	0.069	

					C x D	0.151
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Discussion

Ultrasonography is a noninvasive cost-effective diagnostic radiology modality that is easily available and widely used in daily practice for the kidney anatomy, diagnosis, and follow-up of renal diseases. Despite underestimation has been seen in sonographic kidney measurements (4), there is a similarity in the variation of sonographic kidney dimension measurements in normal adults in the obtained inter-observer and intra-observer variation results hence, there is reasonable reliability regarding sonographic renal dimensions. (2). Many studies have concluded that there is a correlation between kidney dimensions and age, sex, BMI, ethnicity, and environmental factors (6,7). Kidney size and volume can be indicators of renal function. Many diseases can cause a decrease in renal size and volume like chronic kidney disease, renal artery stenosis, and chronic infections, on the other hand, some diseases can cause an increase in renal size or volumes like DM and renal parenchymal inflammation (8). In this study, we tried to find kidney dimensions and the correlation of renal size and volume with age, sex, and BMI in Kurdish people as few studies have been done in the population which may be the reason for the absence of an established standard of normal kidney dimension in this area.

Correlation between right and left kidney parameters

In the present study, the whole sample mean (\pm SD) renal size is 68206 (22650 mm³) for the right kidney and 88863 (28479mm³) for the left kidney. The comparison of the current results with the results of Karim et al. (2015) (8) who examined the kidney size of Kurdish people in Sulaimani, showed that the Mean (\pm SD) of the current right renal size is almost equal to that of the right renal size of the Sulaimani population [72210 (18681mm³)], while the mean (\pm SD) of the current left renal size is larger than that of the Mean (\pm SD) of the left renal size in Sulaimani population [890321(22025mm³)]. This may be due to the normal physiological adaptation of kidneys to environmental factors like living at high altitudes (3). Meanwhile, the current study renal parameters are larger than the renal parameters of Kuwait populations (9) [right renal length is 10.68 (\pm 1.4cm) and left renal length is 10.71 (\pm 1cm)], Iranian (2) [right renal Length is 104 (\pm 6.6mm) and the left renal length is 106.22 (\pm 6.16mm)], and Thai population (10) [right renal length is 10.09 (\pm 0.68cm) and left renal length is 10.24 (\pm 0.7cm)]. When the current renal data are smaller in comparison with Turkish populations (11) [right renal volume is 158 (\pm 39cm³) and left renal volume is 168 (\pm 40cm³)], Pakistanian population (12) [right renal volume is 99.8 (\pm 37.2cm³) and left renal volume is 124 (\pm 41.3cm³)], and Central Europe (13) [renal volume is 59 – 230 (cm³)]. The difference in renal parameters of different populations showed that ethnicity may be an important factor in renal size and volume. There was an overall agreement between the current study renal parameters and renal parameters of the studies done by Barton et al. (2000) (14), Muthusami et al. (2014) (10), Udoaka et al. (2013) (15), Hammad (2012) (17), Elsayed, MD (2012) (18), and Oyuela -Carrasco et al. (2009)(19), they showed that there was a significant difference between the right and left renal parameters. The renal site and space in the body may be factors that affect renal size.

Correlation between male and female kidney size and volume

The current study results showed that there were no significant differences between males and females in the mean ranks of the right and left renal length. Significant differences were detected among the means of all other renal parameters; the right and left renal width, the right and left renal thickness, the right and left renal size, and the right and left renal size and volume. The means of all right and left renal parameters among males are higher than in females. There is an agreement with the study results on the renal size of both sexes and the study done by Karim et al. (2015) (8), which showed a significant correlation between the right and left renal size in both sexes and the mean of the right and left renal sizes were larger among males than females. Kalucki et al. (2020) (21), Noel Bairey Merz et al. (2020) (22), EL-Reshaid et al. (2014) (9), and Hammad, (2012) (17) also confirmed the significant difference between the right and left renal volume, and sex. They also confirmed that the right and left renal volumes are larger in males than those in female adults.

Correlation of the body mass index with the size and volume of both kidneys

Body mass index was calculated using the metric BMI formula by measuring the body weight by an electronic scale and the body height with a tape. The BMI of the subjects was categorized into normal, overweight, and obese, then differences were found between all renal variables and BMI. The results showed the more the body mass index, the more the mean renal measurements involving the renal size and volume. Significant differences were also found between all renal variables and the categories of body mass index. Karim et al. (2015) (8) results confirmed the significant difference between renal size and BMI. There is disagreement with the study results and Amirkhanlou et al. (2018) (23) results which showed no significant association between the renal length, cortical thickness, and BMI. Okur et al. (2014) (11) also did not find a strong correlation between renal volume and BMI. Other studies like Mollazade et al. (2016) (2), Maaji et al. (2015) (24), Mujahid Raza et al. (2011)(12), and Glodny et al. (2009) (25) confirmed the significant difference between the renal volume and BMI. Hence, the positive proportional association between the renal volume and BMI is similar to the positive proportion of other organs of the body with BMI.

Correlation between age, renal size, and renal volume

The mean age (\pm SD) of the study sample was 30.1 years (\pm 13.0), and 57.7% were younger than 40 years. The current results showed significant differences in the right and left renal sizes but, compared with the results of Karim et al. (2015) (8), a weak positive significant correlation between age and kidney size was detected. In comparison with international data presented by Hsuan-An Su et al. (2019) (1) and Mujahid et al. (2011) (12) and Udoaka et al. (2013) (16), they showed a positive correlation between age and size. There is a fall in both kidney sizes starting at 60 years and older compared to the results of Karim et al. (2019) (8) who detected a fall in the renal length at 50 years and higher. Other studies by Hsuan-An Su et al. (2019) (1) decrease the renal size starting from the 4th decade of age. And a study by Zeb et al. (2012) (20), stated decrease in kidney size starts

after 70 years. This difference may be contributed to the sample size in the older age groups, ethnicity, and environmental factors.

Conclusion

There is a discrepancy between the normal renal parameters in adult Kurdish population and those of different ethnicities. Sex, age, and BMI are significant factors. Environmental factors like Geographic distribution are may be significant factors. Ultrasonography is a useful tool for renal parameters measurement. Hence we recommend the related Kurdistan region authorities to establish a standard reference for the normal renal parameters for the Kurdish population by conducting a larger sample size studies of the Kurdish population of different ages, sex, BMI, and geographic area.

Ethical approval

The All ethical issues and approval were ascertained by the authors, the study protocol was approved by the Research Ethics Committee of the College of Medicine/Hawler Medical University. Verbal consents obtained from all participants with full explanation of the purpose and procedures of the examination before data collection. Collection of data and participants privacy was assured in accordance with the World Medical Association (WMA) Declaration of Helsinki 2013, the ethical principles for medical research involving human subjects

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