COMPARATIVE ULTRASONOGRAPHIC MEASUREMENT OF RENAL SIZE AND ITS CORRELATION WITH AGE, GENDER, AND BODY MASS INDEX IN NORMAL SUBJECTS IN SULAIMANI REGION

Shilan Hussein Karim
MSc, Ph.D, Human Anatomy (Lecturer)
University of Sulaimani, School of Medicine, Department of Anatomy, Sulaimani, Iraq
Naser Abdullah Mohammed
FIBMS Radiology (Lecturer) University of Sulaimani, School of Medicine, Department of Surgery/Radiology, Sulaimani, Iraq
Ismaeel H.A.Aghaways
C.A.B.S, F.EB.U (Assistant Professor), University of Sulaimani, School of Medicine, Department of Surgery, Sulaimani, Iraq
Bryar Ali Muhammed, M.B.Ch.B
University of Sulaimani, School of Medicine, Department of Anatomy, Sulaimani, Iraq

Abstract

Background: The renal size of a population is a very useful diagnostic parameter in the practice of medicine. Since the renal size is affected by various factors, it is necessary to first determine the normal value.

Objective:The aim of this study is to provide an estimation of renal size in normal subjects in Sulaimani Teaching Hospital, and to study its relation with age, gender, and body mass index (BMI) using ultrasonography. Therefore, this provides a standard data for our locality as we are deficient of them. **Method:**A cross sectional descriptive study was conducted in Sulaimani Teaching Hospital during the period of June 2013 to February 2014. 450 random volunteer person were included in the study aging between 18 - 96 years, without any known renal diseases.The total sample of the study were 450 person. 239 person (53%) were females, while 211 person (47%) were males. The mean of the right renal size in males was 76553.9947 mm^3, while the mean of the left renal size was 94493.9mm^3. In

females, the mean of the right renal size was 68324.0292mm^3, while the mean of the left renal size was 84150.43264mm^3. Mean renal size for the right kidney was 72210.9842 mm^3,While the mean renal size for the left kidney was 89031.0296 mm^3. **Results**:There was a positive correlation between the size of the right and left kidney, with the left kidney size which is larger. There was also a positive correlation between renal size and age, as renal size increased with age till the 5^{th} decade of life. While the male renal size was greater than the female renal size with the same age group, there was a positive correlation between renal size and body mass index (BMI).

Keywords: Ultrasonography, Renal size, Body mass index

Introduction

Since the renal size is affected by various factors, it is necessary to first establish the normal values. The information available in the West may not be extrapolated to our population, since the renal size may differ between ethnic groups and according to body size (Odita JC *et al*., 1982; Emamian Sa *et al*., 1993). Therefore, background knowledge of normal renal dimensions may help in the diagnosis of kidney diseases. Renal dimensional variation occurs in nephropathies due to hypertrophic process and/or atrophy (Elkin M, 1980). Thus, it is imperative to establish the pattern of normal renal dimensions (Mario M.R. Fernandes *et al*., 2002). The kidney size of a patient is a valuable diagnostic parameter in urological and nephrologic practice.While the leading anatomy text describes the adult kidney as12 cm long, 6 cm wide and 3 cm deep, further review of the literature shows that renal size varies with age, gender, body mass index, pregnancy and co-morbid conditions. Renal size may be an indicator for the loss of kidney mass and kidney functions (Guzman RP *et al*., 1994). It is valuable for monitoring unilateral kidney disease through comparison with the other (Yamaguchi S *et al*.,1990) and discrimination between the upper and lower urinary tract infections (Dinkel E *et al*.,1986).

Estimation of renal size by sonography can be performed by measuring renal length, renal width, cortical volume or thickness. The most accurate of these is provided by the renal size (Emamian SA *et al*., 1995; Cheong B *et al*., 2007).

However, due to its low inter-observer variation and better reproducibility, renal length as measured in the longitudinal plane parallel to the longest renal axis, is the most clinically useful parameter (Emamian SA *et al*., 1995). Renal length as well as renal cortical thickness has been closely related to creatinine clearance in patients with chronic kidney disease (Sanusi AA *et al*., 2009). Similarly, medullary parenchymal thickness is pivotal for grading hydronephrosis especially in the pediatric age group and ultrasound,

which remains the mainstay for the diagnosis of hydronephrosis in adults (Webb JA., 1990). To recognize anatomical deviations in individuals with renal diseases, it is important to have a set of standard sonographic measurements for appropriate comparison (Aga Khan, 2012). 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 (E. Supriyanto *et al*., 2011).

Aim of the Study

The aim behind conducting this study is to provide an estimation of renal size in normal subjects in Sulaimani region, study its relation with age, gender and body mass index (BMI) using ultrasonography, and to provide a standard database for our locality because we lack them.

Subjects and Methods

Plan of the Study

A cross sectional descriptive study was conducted in the Sulaimani Teaching Hospital during the period of June 2013 to February 2014. 450 random volunteers were included, aging between 18 - 96 years, without any known renal diseases. Pregnant female, diabetic patient, hypertensive patient, patient who had history of previous surgical operation or trauma in their kidneys, and any renal congenital anomalies or pathologies and other systemic diseases observed during U/S examination, were excluded from the study.

Data Collection

Data collection begins by history taking and explanation, then the recording of their age, gender , weight (kg) , height (cm) using an electronic scale and tape measure to calculate body mass index (BMI) using the formular below:

BMI = $\frac{weight\ (kg)}{[height\ (m)\ ]^2}$) (Agenes Dominguez *et al*., 2001; Mujahid Raza *et al*., 2011; Zeb Saeed *et al*., 2012).

The subject lying in supine position and ultrasound (U/S) examination was prepared by Philips HD11 using lubricating jell and an abdominal probe (frequency C5-2). Curved array and ultrasound (U/S) was used to visualize the right kidney by the radiologist, and for checking if there is any abnormality. Thus, the measurements are taken in mm as follows:

1. Renal length (distance from pole to pole) (Fig. 2.1)
2. Renal width (distance between medial & lateral border of kidney) (Fig. 2.2)

3. Cortical thickness (distance between outer renal margin and renal sinus in transverse plane) (Fig. 2.3)

Statistical Analysis

The renal sizes of both kidneys are measured using the formula below:

Length x Width x Cortical thickness = Renal size $(\boldsymbol{mm})^{\boldsymbol{3}}$ (O.Bircan *et al*., 1993; Niels-Peter Buchholz *et al*., 2000; Wellington I. O. *et al*., 2010; Mujahid Raza *et al*., 2011).

Correlation of the size of the kidney with age, sex, and body mass index were done using the Statistical Package for Social Sciences (SPSS) program for statistical analysis using Pearson correlation .

Fig. (2.1). Sonogram shows measuring renal length.

(2.2) Sonogram shows measuring renal width

Fig. (2.3). Sonogram shows measuring renal cortex

Results

General Description

The study includes 450 person, out of which 239 (53%) were females and 211 (47%) were males at the Sulaimani Teaching Hospital. The whole subjects were volunteers ranging between 18-96 years old.

BMI is calculated by this formula: $\text{BMI} = \frac{weight\ (kg)}{[height\ (m)\ ]^2}$. However, renal length, width, and cortex of both kidneys for each individual were taken by ultrasound. Then, the renal size for each kidney were calculated using the equation below:

Renal size $(mm)^3$ **= Length x Width x Cortical thickness**

Table (3.1). General characteristics and kidney dimensions

	N	Minimum	Maximum	Mean	Std. Deviation
Age (year)	450	18.00	96.00	38.9845	13.75491
Height (m)	450	1.40	1.89	1.6413	0.10516
Weight(kg)	450	40.00	135.00	73.0622	15.45431
BMI (kg/m²)	450	16.11	45.31	27.1622	5.51293
RtKL (mm)	450	84.00	142.00	106.9967	8.73314
RtKW (mm)	450	28.00	61.00	42.2044	5.35243
RtKC (mm)	450	9.00	25.00	15.8024	2.56994
LtKL (mm)	450	86.00	139.00	108.5789	8.42423
LtKW (mm)	450	34.00	66.00	47.2111	6.18982
LtKC (mm)	450	11.00	26.00	17.2502	2.59801
RKSize $(mm)^3$	450	27846.00	165625.00	72210.9842	18681.46873
LKSize $(mm)^3$	450	43560.00	171741.00	89031.0296	22025.83057

3.2. Correlation Between the Right and Left Kidney Size

The mean of the left kidney size was 89031.0296 mm^3 with a standard deviation of 22025.83057, while the mean of the right kidney size was 72210.9842 mm^3 with a standard deviation of 18681.46873. Later on, finding the correlation coefficient between the right and left kidney was discovered using Pearson correlation. Thus, the results was a significant correlation between the right and left kidney, with the left kidney size greater than the right kidney size.

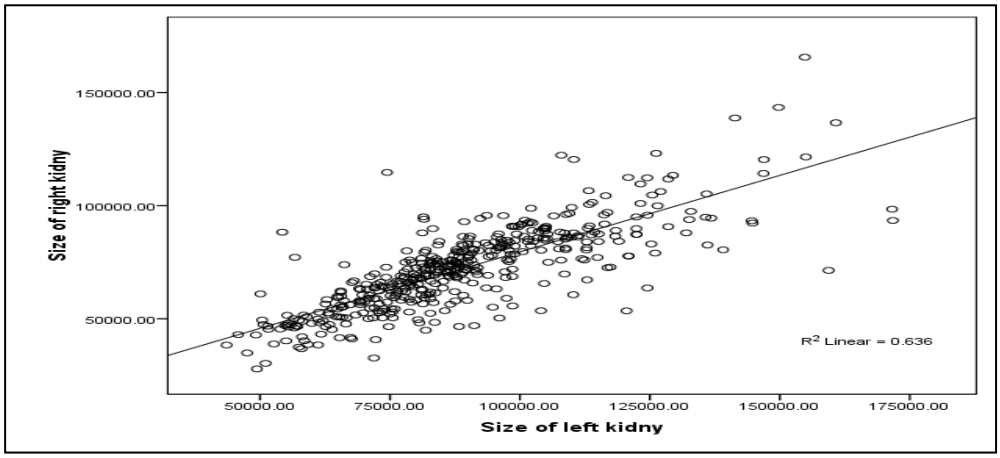


Fig. (3.2). Scatter graph shows (Correlation between Right and Left kidney size)

Correlation between Age and Kidney Size

The mean age of all subjects were 38.9845 years with a standard deviation of 13.75491. The mean of the right renal size was 72210.9842 mm^3 and that of the left kidney size was 89031.0296 mm^3. Then finding the correlation coefficient between age and the size of the right kidney by Pearson correlation, the result showed that there was a weak positive significant correlation between age and the size of the right kidney.

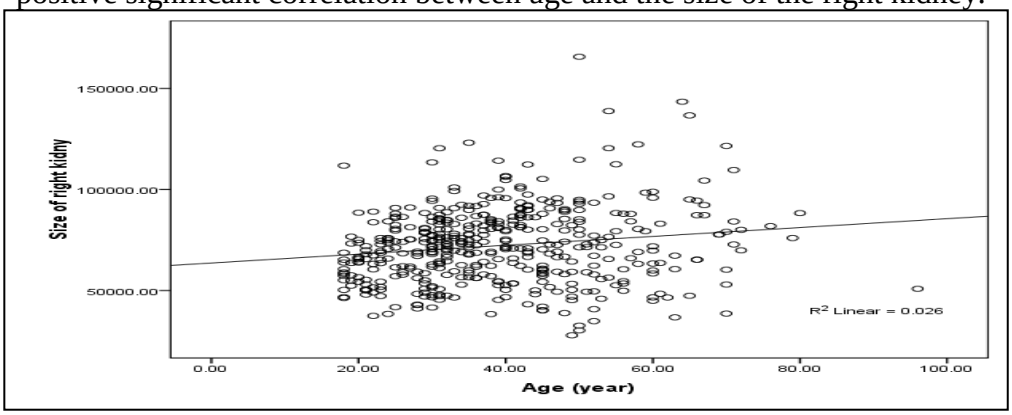


Fig (3.3). Correlation between age and the size of the Right kidney

Furthermore, in the same calculation done by SPSS on the relation between age and the left kidney size, the result showed that there was a weak positive significant correlation between age and the size of the left kidney.

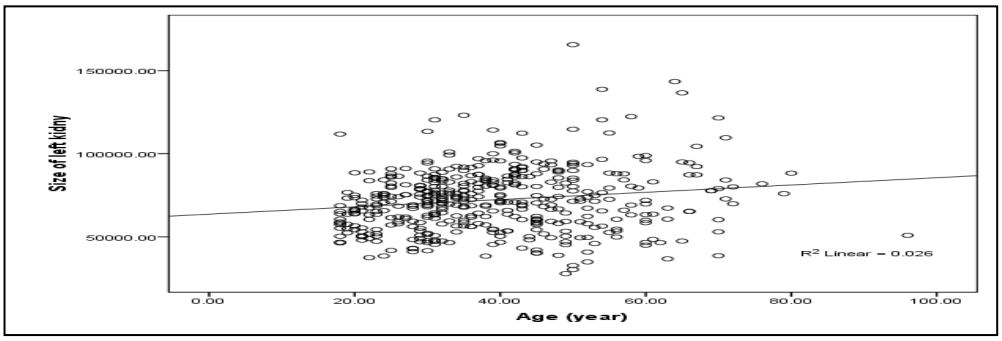


Fig .(3.4). Correlation between age and the size of the Left kidney

Correlation Between the Male and Female Kidney Size

The mean for both kidneys in both genders were calculated. The mean of the right renal size in male was 76553.9947mm^3, while the mean of the left renal size was 94493.9mm^3. In females, the mean of the right renal size was 68324.0292mm^3, while the mean of the left renal size was 84150.43264mm^3. The correlation coefficient between the right kidney size in males and the right kidney size in females were found by Pearson correlation. The results shows weak positive significant correlation, with the right kidney size greater in males than females.

Fig.(3.6). Correlation between male & female right kidney size

Furthermore, the same calculation was done to find the correlation coefficient between the left kidney size in males and the left kidney size in females by Pearson correlation. Thus, the result shows weak positive significant with the left kidney size greater in males than females.

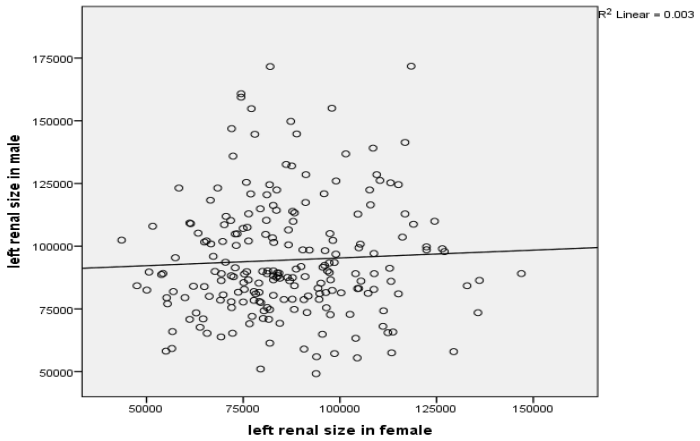


Fig.(3.7). Correlation between male & female left kidney size

Correlation Between Body Mass Index and Both Kidney Sizes

Mean BMI of all subjects are 27.1622 kg/m^2 with a standard deviation of 5.51293. The correlation coefficient between BMI and the size of the right kidney were found by Pearson correlation. However, the result showed that there was a strong positive significant correlation between BMI and the size of the right kidney.

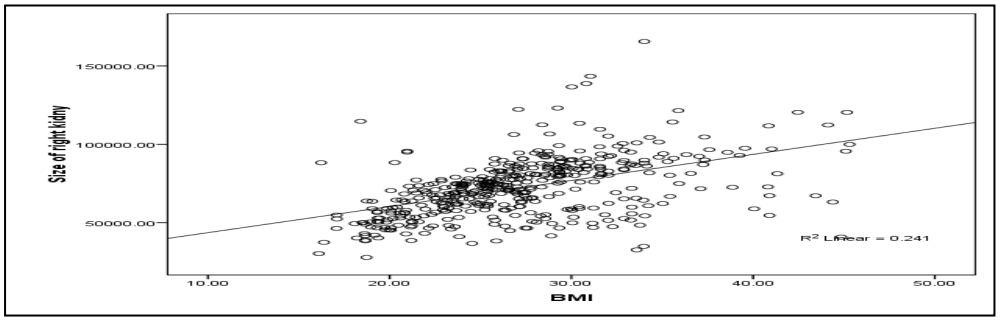
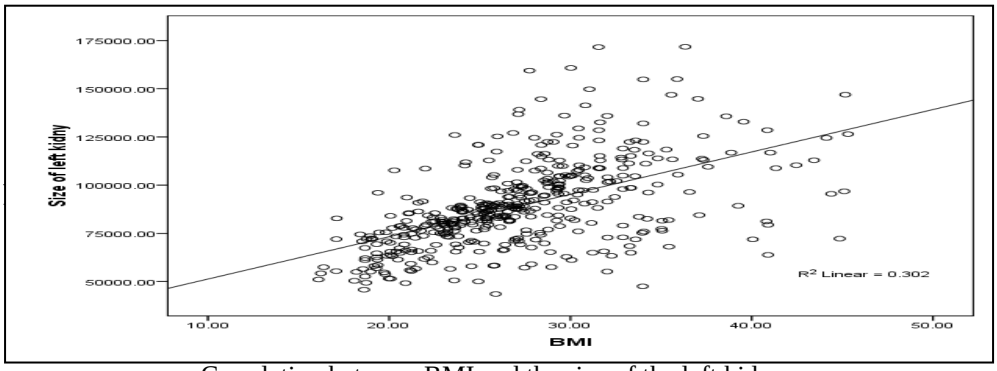


Fig.(3.9). Correlation between BMI and the size of the right kidney

The same calculation for finding the relation between body mass index and the size of the left kidney was done by Pearson correlation. However, the result shows that there was a strong positive significant correlation between BMI and the size of the left kidney.



Correlation between BMI and the size of the left kidney

Discussion

Fear of undergoing any invasive investigation makes the patient reluctant to undergo the test comfortably. Among all the imaging modalities, ultrasound has been regarded as an imaging technique of choice in most of the clinical survey for being non-invasive, safe, reliable, cost effective and easy availability, even though underestimation has been noted in calculated renal size by ultrasound (Mujahid Raza *et al*., 2011). Ultrasonography is one of the most common imaging methods used in routine practice for visualizing the normal anatomy. In addition, it is simple and reliable to visualize pathological changes in the abdominal organs (A.I. Udoaka *et al*., 2013). The objective of this study is to define the mean kidney dimensions in adult volunteers, correlating the measurements with age, BMI, and gender, and comparing the values with those of other nationals from earlier studies. Renal dimensional measurements is clinically relevant, serving as surrogates for renal functional reserve. However, it is used frequently as the basis for making clinical decisions. Serial measurements can also provide information regarding disease progression or stability. Renal disease can increase or decrease renal size, and may or may not be accompanied by changes in the normal organ structure (Sandeep Gupta *et al*., 2013).

Many studies in different countries have been done for renal dimensions including renal length, width, cortex, and renal size. Thus, those studies showed that the measurement vary between men and women, between people of different ethnic backgrounds, and even between kidneys of the same individual (Bakker J *et al.,* 1998). The normal size of a kidney is variable and is affected by age, gender, BMI, as well as the size. The size provides a rough indication of the renal function . Also, decrease of size and function are seen with chronic renal failure (Yamaguchi S *et al.,* 1990), renal arterial occlusion , renal artery stenosis (Paul S. Watson *et al*., 2000), and late stage renal venous thrombosis (Montague JP *et al.,* 1982). However, the kidney size seems to be related to a number of vascular diseases, and there is

no correlation with blood pressure (Raunan GV *et al.,* 1998*)*. On the other hand, there was an increase in kidney size in early stage renal venous thrombosis (Montague JP *et al.,* 1982), early stage diabetes mellitus , (Andrew S. O'Connor *et al*., 2005), and renal inflammation (Hiraoka M *et al.,* 1996). Thus, a physiological increase of the kidney size can be observed in pregnancy.

Correlation Between Right and Left Kidney Size

Renal size for both kidneys was measured. The mean renal size for the right kidney was 72210.9842 mm^3 and that of the left kidney was 89031.0296 mm^3**.** The correlation was significant with the left kidney larger than the right kidney regarding age and gender, as shown in Fig. (3.1). The renal size in this study was greater when compared with Saudian [right renal size =1032 ±0.69$(mm)^3$, left renal size=744680.88±0.18$(mm)^3$], and Pakistan [right renal size =6552±0.12$(mm)^3$, left renal size =8064±0.12$(mm)^3$]. When the data of the present study was compared with North-East India [right renal size =76500 ± 30.1$(mm)^3$, left renal size=80700 ± 26.0$(mm)^3$], it was found that the right renal size in the current study is smaller, while the left one is greater. Also, the renal size of Denmark [right renal size =8884.59±39$(mm)^3$, left renal size=9679.04 ±30$(mm)^3$] shows that the renal size of both kidneys are greater than our population. Hence, those differences reveals that the renal size is different among different ethnicities (Adeela Arooj *et al*., 2011).

There is an agreement with current results and the results of the study by Seyed Alireza Emamian1*et al*,(1993) , A. Hekmatnia *et al.,* (2004), A.I. Udoaka *et al.,* (2013), and Lina Fahmi Hammad (2012). Thus, there are differences between the right and left renal size according to most literatures. Also, the left renal size is larger than the right renal size. This may be due to the hepatic mass which does not allow comparable vertical growth of the right kidney to that which is attained by the left kidney.

Correlation Between Age and Kidney Size

The mean age of the current sample was 38.9845 years. Hence, both kidney sizes are shown in table (3.5). Calculation of correlation for both kidneys with age was done separately. The result showed that there was a weak positive significant correlation between age and kidney size, as shown in Fig. (3.2)(3.3). A fall in the renal length was observed with age, especially after 50 years. Comparing with international data presented by Agnes Dominguez-Mejia *et al.* (2001), Mujahid Raza *et al.* (2011), A.I. Udoaka *et al.* (2013), and Sandeep Gupta *et al,* (2013), the result showed that there were positive relation between age and renal size.

A fall in the renal size with age was noticed , especially after 50 years. The studies done by J. Oyuela-Carrasco *et al*. (2009) and Zeb Saeed *et al* . (2012), on Denmark, Mexican and Pakistan population respectively showed that a fall in the renal length was observed with age after 70 years.Other studies done by A. Hekmatnia *et al.* (2004), on Isfahani and Turkish population respectively showed that a fall in the renal length was observed with age after 60 years.Also, a study done by Niels-Peter Buchholz *et al.* (2000), in Karachi- Pakistan , showed that kidney size increases till the 3rd decade. However, it remains stable through the middle age and then declines.

Studies have shown that aging leads to a progressive decrease in kidney size after middle age (Fernandes MM *et al*., 2002; Akpinar IN *et al*., 2003) at the rate of 0.5 Cm per decade. This is especially due to the reduction of about 1% per year in blood flow after 3rd decade .According to these comparison, the fall in the renal size with age, differs according to ethnic groups and locality, which may be due to body built, environment, and other factors.

Correlation Between Male and Female Kidney Size

Renal size for both kidneys has been measured separately for both sexes. The mean of the right renal size in male was 76553.9947mm^3, while the mean of the left renal size was 94493.9mm^3. In females, the mean of the right renal size was 68324.0292mm^3, while the mean of the left renal size was 84150.43264mm^3. The mean of the right renal size in both sexes and also the mean of the left renal size in both genders were compared so as to find whether there is a difference in the size or not. Hence, the correlation was significant. The right and left kidney sizes were larger in males than the right and left kidney sizes in females as can be seen in Fig. (3.6)(3.7).

Probably because of the difference in height or body mass index , renal size have been found to be slightly larger in males in most studies (Emamian SA *et al*., 1995; Niels-Peter Buchholz *et al.,* 2000; Agnes Dominguez-Mejia *et al.*, 2001; Fernandes MM *et al*., 2002; Okoye IJ *et al*., 2005; Kang KY et al., 2007; Kiw-Yong Kang *et al*., 2007; Werner S Harmse, 2011; and Lina Fahmi Hammad, 2012) . The same is confirmed in the current study which shows a statistically significant larger kidney size in males. Consequently, some studies reported that there was no difference in renal size in the two genders (Tajima M ,1987).

This may be due to larger weight or body mass index in males than females, as renal size increases when body mass index increases.

Correlation Between Body Mass Index and the Size of Both Kidneys

Height and weight of every subject were taken using tape measure and bathroom scale to calculate body mass index, and in finding the correlation between the body mass index and both kidney size. However, the mean of the body mass index was 27.1622. The correlation coefficient between BMI and the size of both kidneys showed that there was a significant correlation between BMI and the size of both kidneys. Thus, this was shown in Fig. (3.4)(3.5).

Many studies have confirmed our results. Studies done by Niels-Peter Buchholz *et al.,* 2000; A. Hekmatnia *et al.,* 2004; Kiw-Yong Kang *et al*., 2007; J. Oyuela-Carrasco *et al*., 2009; Wellington Ivbolagbe Ohikhokhai *et al.,* 2010; Mujahid Raza *et al.,* 2011; Werner S Harmse, 2011; Zeb Saeed *et al* ., 2012; A.I. Udoaka *et al.,* 2013; and Sandeep Gupta *et al.,* 2013, shows a strong correlation between renal size and body mass index (BMI). Thus, the renal size increased correspondingly with an increasing BMI. So as all organs of the body, the renal size is changed according to the body mass index as shown by many studies which has been mentioned in the current study.

Comparison of the Data of Current Study with Data of Nearby Areas

The data of the current study was compared with renal dimensions of other countries and the differences was shown in table (4.1).After comparing the results of the current study with the results of studies conducted in other countries, it was found that the current study results were nearer or similar to those of nearby countries. There are results which are smaller or larger than ours, and this indicates that the variation in the body mass index, ethnic group and even environment, may affect the renal size. Furthermore, the limitations of this study were the unavailability of the data from different age groups (range store). The time of the study was limited, and most of the subject above the 5^{th} decade of life complained of either Diabetes mellitus (DM) or Hypertension (HT). Others complained of renal stone and urinary tract infection (severe one which causes hydronephrosis).

Table (4.1). Comparing Current Data with Nearby Areas Data

		Right kidney				Left kidney			
		Length (mm)	**Width (mm)**	**Cortex (mm)**	**Size $(mm)^3$**	**Length (mm)**	**Width (mm)**	**Cortex (mm)**	**Size $(mm)^3$**
Current data		106.9967	42.2044	15.8024	72210.9842	108.5789	47.2111	17.2502	89031.0296
Saudi's population		103.2 ±6.9	50.7± 6.8	12.3± 1.5	64356.552± 17	107.7 ±8.7	51.6 ±9	13.4± 2.3	74468.088±18
Malaysian population		97±7.9	38±5.2			99±9.6	44±5.9		
Korea		102±12				105±8			
Isfahanian Adults		109 ± 8.4				111 ± 9.8			
Nigerian adults	**Male**	107 ±10				110 ±9			
	Female	104 ±9				108 ±9			
Mexican adults	**Male**	105.74 ±5.74				107.16 ± 6.97			
	Female	102.99 ±6.85				104.6 ± 7.96			
Brazil		120.25±7	55.6± 4.6			126.5±7	60 ±4.2		
Turkish	**Male**	104.9125± 10.41				105.245± 10.25			
	Female	102.4425± 9.6				101.8825 ±10.37			
Pakistan		104 ±9	42±7	15±2	65520± 12	105±9	48±7	16±2	80640± 12
North-East India		89±9	47±8	18 ± 4	76500 ± 30.1	91±9	47±6	18 ± 3	80700 ± 26.0
Denmark		109±11	57±6	14.3± 6	88845.9 ±39	112±11	58±7	14.91 ± 4	96790.4 ±30

Conclusion

From the overall results, we conclude that :

1. Right renal size is smaller than left renal size.
2. There is weak positive correlation between age and renal size, up to the 5^{th} decade of the subject's life.
3. Renal length, width, cortex, and size are significantly larger in males than in females.
4. The renal size increased correspondingly with an increasing body mass index (BMI).
5. The renal size in the current study is larger than Saudian and Pakistanian population renal size. North-East Indians right renal size is greater and their left renal size is smaller than the current study renal size. Also, it is smaller than Denmark's population renal size.

Recommendation

However, the following points are recommended:

1. Increase the sample
2. Conduct the same study using CT and MRI.
3. Conduct the same study with infant and children.

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