

Morphometric Study of Kidney in Normal Human Subjects by Using Ultrasonography

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Abstract: Kidneys are also called as renes or nephros from which we have the derivative renal or nephron are retroperitoneal by position. Study of normal anatomy with the aid of ultrasonography is reliable & cost effective.

Methods: 67 adult normal subjects ranging from 18-70 years were examined and parameters of kidney noted photographed and analysed statistically.

Keywords: kidney, length, width, renal size, renal volume, cortical thickness.

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I. Introduction

The present study Morphometric Study of Kidney by Ultrasonography method is most relevant in establishing the various parameters of kidneys playing a role in understanding technical complexities of modern treatment. In addition to diagnosis and treatment of illness, the scope of medicine has expanded to preventing of disease through measures such as screening by various techniques to foresee the impending health hazards to an individual. Although some tests provide qualitative results such as present or absent, the quantitative results as normal or abnormal, it is necessary to define normal range. By convention, the normal range is defined as those values which encompass 95% of population. However 2.5% of normal population will have values above and 2.5% will have values below the normal range, and it is precise to describe 'reference' rather than 'normal' ranges. No test is completely reliable and the diagnostic accuracy of a test can be expressed in term of sensitivity and its specificity. Renal ultrasound is a valuable non-invasive technique that is indicated to assess renal size and to investigate who are the victims of renal impairment.¹ Ultrasonography may show increased density of the renal cortex with loss of distinction between cortex and medulla which is characteristic of chronic kidney disease (CKD). Renal ultrasound is operator dependent. The stored images convey only a fraction of the dynamic information gained during the investigation, and the results are often less clear in obese patients. The present study is a sincere effort to review the literature on Morphometric Study of Kidney in Healthy Subjects using various parameters in relation to age, sex & side. Such study may find a place to correlate the difference between normal functioning kidney and the diseased kidney.

II. Materials And Methods:

The ultrasonographic measurement of renal length and width were taken in 67 healthy persons aged 15-80 years from 1st October 2016 to 31st October 2017 who were screened for normal renal dimensions in healthy subjects in the department of Radiology at Sri Venkateswara Institute of Medical Sciences and Hospital, Tirupati after taking consent from the subjects. Ethical clearance was obtained from the Institutional Review Committee of Sri Venkateswara Institute of Medical Sciences and Hospital. These subjects were screened by taking detailed clinical history and performing physical examination to exclude clinical conditions like hypertension, diabetes, renal cyst, renal calculi, acute and chronic kidney diseases, etc. The sonographic measurements of dimensions of the kidneys were collected from real time ultrasound images. All ultrasonographic assessments were carried out by radiologist trained in ultrasonography. Subjects selected for the study were evaluated sonographically for any other pathology unrelated to kidney. Liver, spleen and other organs were screened sonographically for normality in size, Position and echo texture in these subjects to qualify for inclusion in the study. In this study subject's demographic data such as age, gender, weight, height, and BMI were collected using designed questionnaire. This data is recorded by using weighing machine and stadiometer. Body Mass Index (BMI) was calculated as $BMI (kg/mt^2) = \text{weight (kg)} / \text{height (mt)}^2$.² Absolute Renal Size (cm)³ was calculated as: length (cm) width (cm) x cortical thickness (cm). Renal volume (cm)³ was calculated as: $0.523 \times \text{length (cm)} \times \text{width (cm)} \times \text{depth (cm)}$. The sonographic measurements were performed with a high-resolution real-time scanner (Philips iu22; Philips Medical Systems Co. Ltd. Nederland, USA.)

with a 3.5 MHz frequency curvilinear probe. The length, width and cortical thickness at all 3 poles of each kidney were measured for each subject. Images were obtained in supine, left, right lateral positions with subjects holding their breath during image accusation. The subject's hands were raised behind the head during the procedure to help enlarge the intercostal spaces and the space between lower costal margin and the iliac crest, thereby creating better access to the kidney. Then coupling gel is applied on abdominal wall in the epigastric, hypochondriac and lumbar regions in order to assure optimal transmission of energy between the subject and probe. The sonograms that displayed the elliptical kidney outline with central sinus echo complex and the poles were used for the measurement. The inter observer and intra observer variations in the measurements of the renal parameters were not evaluated in this study. All patients underwent an ultrasound of both kidneys, being carried out on the same ultrasound device. The curvilinear low frequency probe of 3 to 5 MHz was used for the whole study population.

Measurement techniques and parameters:

Once the kidney was located, the transducer was rotated slightly to determine the longest renal axis. The section which showed central sinus echoes are the best with the renal parenchyma evenly distributed all around the central sinus. The scanning was performed from posterior-lateral direction for obese patient and antero-lateral direction for thin patients. Renal length (L) was measured as the longest pole to pole distance representing the cranio-caudal dimension of the kidney in longitudinal plane.²The maximal longitudinal axis was evaluated with the ultrasound callipers placed on the outer edges of the caudal and cranial side in the sagittal plane to obtain the maximum longitudinal renal length. (Length = superior pole to inferior pole distance).^{3,4,2,5} At least three readings of the bipolar kidney length imaged on the longest axis were obtained by repeated readjustments of the probe. The average of these measurements was then taken as the true longitudinal length. The transducer was then rotated 90 degrees to the longitudinal axis and the transverse section was obtained at the level of the renal hilum.¹ Renal width (W) was defined as the maximum dimension in the transverse cross-section at the level of the renal hilum. The width was measured from the transverse ultrasonographic section of the kidney almost perpendicular to the longitudinal length. The level of this transverse section was intended to be placed quite close to the hilum of the kidney but at the same time free of the pelvis.⁶(Width = distance between medial border to lateral border at hilum).^{3, 4,2,5} Renal depth was measured from anterior to posterior aspect of kidney at its midpoint in the same image of transverse plane.^{4,2,5} Cortical thickness was defined as the thickness of the cortex measured at the each upper, middle and lower pole and then averaged for each kidney.⁷ True supine position was generally sufficient; however, slight elevation of the examined side was necessary in a few cases for optimal visualization. The data of all renal parameters are statistically analysed, MEAN±SD is presented for all renal parameters comparing with age, height, body weight and BMI of the subject. Frequencies and percentages are computed for gender, age groups, different height groups, weight groups, and different ranges of BMI.⁴Comparative analysis of mean values of all renal parameters between right and left kidney, males and females, and with age, height, weight and BMI of the subject are done by means of *t*-test and difference among the two groups are considered to be significant if P<0.05.

III. Observations:

Table. 1 Showing Total No. Of Male And Female Subjects In Our Study

S.NO	SEX	TOTAL NO. OF SUBJECTS	% OF SUBJECTS
1	MALE	41	61.19%
2	FEMALE	26	38.8%

Table. 2 Showing Mean, Sd And P Values Of Renal Measurements For Right And Left Kidney In All Subjects Of The Present Study

S.No	RENAL PARAMETERS	RIGHTKIDNEY MEAN (n=67)	SD	LEFTKIDNEY MEAN (n=67)	SD	P VALUE
1.	Length(cm)	9.709	0.715	9.923	0.74	0.015*
2.	Width(cm)	4.466	0.83	4.658	0.7	0.019*
3.	Cortical Thickness(cm)	1.493	0.47	1.56	0.47	0.59**
4.	Renal volume(cm) ³	107.4	35.92	113.1	29.9	0.076**
5.	Renal size(mm) ³	66.18	27.18	70.87	27.62	0.043*

Table. 3 Showing Mean, Sd And P Values Of Right And Left Kidney Dimensions In Males And Females Included In The Present Study

S.No	MEASUREMENTS	SIDE	MALE (n=41)	(MEAN±SD)	FEMALE (n=26)	(MEAN±SD)	P VALUE
1	Length(cm)	Right	9.71	0.72	9.7	0.72	0.93**
		Left	9.9	0.76	9.95	0.73	0.795**

Morphometric Study Of Kidney In Normal Human Subjects By Using Ultrasonography

2	Width(cm)	Right	4.6024	0.86	4.25	0.75	0.09**
		Left	4.8537	0.72	4.35	0.54	0.003*
3	Cortical Thickness(cm)	Right	1.486	0.47	1.473	0.47	0.76**
		Left	1.528	0.46	1.471	0.48	0.628**
4	Renal Size(cm) ³	Right	69.08	29.15	61.6	23.58	0.276**
		Left	74.66	28.57	64.89	25.46	0.16**
5	Renal Volume(mm) ³	Right	112.63	35.56	99.09	35.6	0.134**
		Left	116.74	29.26	107.38	30.55	0.214**

Table. 4 Showing Mean, Sd And P Values Of Males And Females Of Total Number Of Subjects In The Present Study

S.NO	MEASUREMENTS	MALES(n=41)		FEMALES(n=26)		P VALUE
		MEAN	SD	MEAN	SD	
1	Length(cm)	9.805	0.66	9.825	0.62	0.919**
2	Width(cm)	4.72805	0.73	4.3	0.53	0.013*
3	Cortical Thickness(cm)	1.507	0.46	1.472	0.46	0.685**
4	Renal Size(cm) ³	71.87	27.64	63.245	21.99	0.184**
5	Renal Volume(cm) ³	114.685	30.08	103.235	30.08	0.134**

Table. 5 Determination Of Renal Size Of Both Sides In Males And Females According To Age

S.No	AGE GROUP (years)	RENAL SIZE(mm) ³							MEAN
		MALES				FEMALES			
		No.	RIGHT	LEFT	MEAN	No.	RIGTH	LEFT	
1.	11 – 20	3	52.57	59.1	55.83	9	74.86	78.81	76.84
2.	21 – 30	25	65.76	72.21	68.99	11	54.5	56.51	55.51
3.	31 – 40	3	88.28	99.61	93.95	2	75.36	90.14	82.75
4.	41 – 50	6	77.02	80.98	79	4	44.4	43.98	44.19
5.	51 – 60	3	86.28	82.56	84.42	0	0	0	0
6.	61 – 70	1	43.97	46.13	45.05	0	0	0	0

Table.6 Comparison Of Renal Length With Age

S.NO.	AGE GROUP(YEARS)	RENAL LENGTH(CM)								MEAN
		MALES				FEMALES				
		No.	RIGHT	LEFT	MEAN	No.	RIGHT	LEFT	MEAN	
1	11 – 20	3	10	9.9	9.95	9	9.63	10.1	9.86	9.90
2	21 – 30	25	9.51	9.86	9.68	11	9.49	9.88	9.68	9.68
3	31 – 40	3	9.66	9.83	9.74	2	10.5	9.75	10.12	9.93
4	41 – 50	6	10.15	9.96	10.05	4	10.02	9.92	9.97	10.01
5	51 – 60	3	10.56	10.66	10.61	0	0	0	0	10.61
6	61 – 70	1	8.9	8.5	8.7	0	0	0	0	8.7

Table.7 Comparison Of Renal Width With Age

S.No	AGE GROUP (YEARS)	RENAL WIDTH(Cm)								MEAN
		MALES				FEMALES				
		No.	RIGHT	LEFT	MEAN	No.	RIGHT	LEFT	MEAN	
1	11-20	3	4.76	4.6	4.68	9	4.37	4.13	4.25	4.46
2	21-30	25	4.63	4.92	4.77	11	4.35	4.57	4.46	4.62
3	31-40	3	4.73	5.06	4.89	2	3.55	4.55	4.05	4.47
4	41-50	6	4.48	4.71	4.59	4	4.02	4.12	4.07	4.33
5	51-60	3	4.53	4.73	4.63	0	0	0	0	4.63
6	61-70	1	3.9	4.4	4.15	0	0	0	0	4.15

Table.8 Renal Volume With Age

S.No	AGE GROUP (YEARS)	RENAL VOLUME(Cm) ³								MEAN
		MALES				FEMALES				
		No.	RIGHT	LEFT	MEAN	No.	RIGHT	LEFT	MEAN	
1	11-20	3	120	104.4	112.2	9	108.8	116.7	112.8	112.48
2	21-30	25	109.2	116.8	113	11	104.8	109.5	107.1	110.07
3	31-40	3	135.5	128	131.8	2	74.7	103.4	89.04	110.4
4	41-50	6	116.4	115.3	115.8	4	73.84	82.46	78.15	96.985
5	51-60	3	122.6	129.6	126.1	0	0	0	0	126.08
6	61-70	1	78.06	89.98	84.02	0	0	0	0	84.02

IV. Discussion:

Medical imaging has played an important role in helping physicians to make a medical diagnosis. One such safe and easily available technique world-wide is ultrasound imaging. Ultrasound imaging also known as ultrasound scanning or sonography is a relatively inexpensive, fast, non - invasive and radiation free imaging modality.⁸ **Ultrasonography** is widely accepted and considered as the tool of choice especially where repeated examinations are required).⁹ In the present study a total of 67 adult subjects without any renal disease were investigated for the period of one year from May 2016 to May 2017. The data were collected from various age groups (11 – 20, 21 – 30, 31 – 40, 41 – 50, 51 – 60 and 61 – 70 years) in Rayalaseema region(A.P.). The mean age in this study is MEAN±SD: 28.81±11.48. The renal dimensions (length, width, cortical thickness, renal size and renal volume) are measured in the above mentioned age groups of 67 subjects at Radiology Department in SVIMS Hospital. The present study was undertaken to determine the normal renal dimensions which may help in the diagnosis of kidney diseases. The renal measurements play a vital role for the clinicians to determine the health status and to visualize any abnormalities present in the kidneys. Renal size may be an indicator of the loss of kidney mass and kidney function. Out of 67 subjects included, 41 subjects are from males and 26 subjects from females. The highest percentage noted among males (61.19%) compare to females (38.8%). Among 67 subjects of various age groups present in the study are categorised in relation to Height of 15 -25 age group individuals ranging from 151 – 155 cm, 156 –160 cm, 161 – 165 cm, 166 – 170 cm, 171 – 175 cm, 176 – 180 cm. the mean height is MEAN±SD: 165.81±8.51, in relation to weight of the total subjects ranging from 36 – 45kg, 46 – 55kg, 56 – 65kg, 66 – 75kg, 76 - 85kg. the mean weight is MEAN±SD: 61.87±10.82, and in relation to BMI of the total subjects ranging from 15.00 – 20.99 kg/m², 21.00 – 25.99 kg/m², 26.00 -30.99 kg/m², 31.00 – 35.99 kg/m². The mean BMI is MEAN±SD: 21.51±10.83. In this study measurements of renal dimensions length, width, cortical thickness, renal size and renal volume of right and left kidney has been taken and compared between both genders of various age groups.

LENGTH WITH AGE

The total mean length of the right and left kidney in different age groups (11 – 20, 21– 30, 31 – 40, 41 – 50, 51 – 60 and 61 – 70 years) are measured and the measurements are 9.908, 9.687, 9.937, 10.0125, 10.61, 8.7cms. These measurements confirmed that the total mean renal length of both kidneys increase with age as age advances up to 60 years. It gives an idea that in normal subjects of our population the age is a factor influencing the length of the kidney. This study is similar to that study of **Mário M. R. Fernandes, et al.³ in 2002, A. Hekmatnia MD*, et al.¹⁰ in 2004, Prakash Muthusami, et al.¹¹ in the year 2014, Zeb Saeed, et al.¹² in the year 2012** with a common statement that the renal length increases with age up to 60 years and decreases after 70 years of age. In the present study there is a slight significant difference in renal length with age with a P value of (0.055).

LENGTH WITH SIDE

In the present study there is a very significant difference noticed in total mean renal length measured in cm of right kidney is (MEAN±SD: 9.709±0.715), and of left kidney is (MEAN±SD: 9.923±0.74) with a P value of (0.015). This study is best correlated with the study of **Thomas D. Brandt, et al.¹³ in 1982, F. Wang, et al.¹⁴ in 1989, A. Hekmatnia MD*, et al.¹⁰ in 2004**, stated that the left kidney length is significantly larger than the right kidney.

LENGTH WITH SEX

The length of the right kidney in males is (MEAN±SD: 9.805±0.66), and in females it is (MEAN±SD: 9.825±0.62), and concluded that the length of the right and left kidney are larger in males than in females. This statement was also made by **F. Wang, et al.¹⁴ in 1989, A. Hekmatnia MD*, et al.¹⁰ in 2004** in their studies.

WIDTH WITH AGE

The total mean renal width of the both kidneys of the subjects included in the study increases with age of the subject till the fifth decade and then gradually decreases after fifth decade. The left mean renal width is more than the right one. There is no significant difference of renal width with various age groups of the subject with a P value of (0.702) unlike the length of the kidney. This study is similar to that of **A. Hekmatnia MD*, et al.¹⁰ in 2004, Prakash Muthusami, et al.¹¹ in the year 2014.**

WIDTH WITH SEX

The total mean renal width of the both kidneys in males and females is (MEAN±SD: 4.72805±0.73) and (MEAN±SD: 4.3±0.53). There is a significant difference of mean renal width in males and females with a P value of (0.013). **Niels-Peter Buchhol et al.⁹ in 2000** also stated that the female kidneys were significantly smaller than the right.

WIDTH WITH SIDE

The study done by **Niels-Peter Buchholz, et al.⁹ in 2000, Ohnmar Myint, et al.¹⁵ in the year 2016 in Pakistani population** concluded that there was significant difference in renal width between right and left

kidneys with a P value (<0.05) and the same is reflected in my study that the total mean renal width in both genders. In our present study the width of right kidney (MEAN \pm SD: 4.466 \pm 0.83), and of left kidney (MEAN \pm SD: 4.658 \pm 0.7) with a P value of (0.019) is observed.

RENAL SIZE WITH AGE

There is no significant difference in P value of (0.277) regarding total mean renal size with various age groups of the subjects included in the present study. **Shilan Hussein Karim, et al.¹⁶ in the year 2013-14** in his study said that the renal size increased till the fifth decade of life. This statement was same with the results obtained in the present study that the total Mean renal size of all the subjects in the study increases till the fifth decade and thereafter there is sudden decrease in renal size.

RENAL SIZE WITH SEX

The present study of total mean renal size in males is (MEAN \pm SD: 71.87 \pm 27.64), and in females (MEAN \pm SD: 63.245 \pm 21.09), shows that the males has larger kidney size compared to females and is similar to the study done by **Zeb Saeed, et al.¹² in the year 2012, Shilan Hussein Karim, et al.¹⁶ in the year 2013-14, Niels-Peter Buchholz, et al.⁹ in 2000**. But the p value (0.134) obtained in the study is not significant which is not correlating with the study of **Niels-Peter Buchholz, et al.⁹ in 2000** where it is significant.

RENAL SIZE WITH SIDE

In the present study the mean total renal size of right kidney (MEAN \pm SD: 66.18 \pm 27.18), and of left kidney (MEAN \pm SD: 70.87 \pm 27.62), the difference between these two is significant with a P value of (0.043) which is similar to the study of **Niels-Peter Buchholz, et al.⁹ in 2000, Mujahid Raza, et al.⁴ in the year 2011, Shilan Hussein Karim, et al.¹⁶ in the year 2013-14**.

RENAL VOLUME WITH AGE

The total mean renal volume obtained in the study is increases with age till the fifth decade of life and thereafter it reduces beyond the sixth decade with no significance in P value (0.759). The study is also similar to the observations made by **Sadisu Mohammed Maaji, et al.⁵ in the year 2015**.

RENAL VOLUME WITH SIDE

The total mean renal volume of the right and left kidney in the present study is (MEAN \pm SD: 107.4 \pm 35.92), and (MEAN \pm SD: 113.1 \pm 29.9), and it is inline with the study of **Aylin Okur, et al.¹⁰ in the year 2014** who made a common statement that left kidney mean renal volume is more than the right.

RENAL VOLUME WITH SEX

With reference to the total renal volume measurements in males (MEAN \pm SD: 114.685 \pm 30.08), and in females (MEAN \pm SD: 103.235 \pm 30.08), of the present study concurred that the volume of the kidney is more in males than in females. The study is best correlating with studies made by **Seyed Alireza Emamian, et al.⁶ in 1993, Ranjeet S. Rathore, et al.² in the year 2016**.

CORTICAL THICKNESS WITH AGE

The total mean cortical thickness values of the present study in all the subjects included in the study in relation to the age group ranging from (11 – 20, 21 – 30, 31 – 40, 41 – 50, 51 – 60 and 61 – 70 years), cortical thickness measurements 1.50515, 1.3639, 1.89735, 1.3409, 1.633, 1.245. These results concluded that the cortical thickness increases with age up to the age of 31 – 40 years and thereafter there is gradual decrease of cortical thickness as age advances. There is no significance in P value (0.114). This study is similar to that of the studies done by **A. Adibi MD, et al.¹⁷ in 2008, Prakash Muthusami, et al.¹¹ in the year 2014, Eze Charles, et al.⁷ in the year 2014, Abdoelrahman Hassan A. B., et al.¹⁸ in the year 2016**

CORTICAL THICKNESS WITH SEX

The mean cortical thickness in males is (MEAN \pm SD: 1.507 \pm 0.46) and in females is (MEAN \pm SD: 1.472 \pm 0.46), and it is observed that the males have larger cortical thickness than females which fall inline with the similar statement made by **Niels-Peter Buchholz, et al.⁹ in 2000, Abdoelrahman Hassan A. B., et al.¹⁸ in the year 2016, F. Wang, et al.¹⁴ in 1989** in their studies.

CORTICAL THICKNESS WITH SIDE

With reference to the mean cortical thickness of right and left kidney (MEAN \pm SD: 1.493 \pm 0.47), and (MEAN \pm SD: 1.56 \pm 0.47) it is observed that the left kidney cortical thickness is more than the right kidney, and there is no significant difference between the right and left with a P value (0.59). The studies of **Seyed Alireza**

Emamian, et al.⁶ in 1993, Ohnmar Myint, et al.¹⁵ in the year 2016, but not with the Prakash Muthusami, et al.¹¹ in the year 2014 and Niels-Peter Buchholz, et al.⁹ in 2000, indicated that there is a significant difference between right and left cortical thickness.

V. Conclusion:

The present study of Morphometric Dimensions of Kidney by Ultrasonography has lot of significance because of impounding renal pathologies causing alarming death rate. The ultrasonography method is chosen for the present study based on several advantages like cost-effective, non – invasive and advantage of repetitive studies. The ultrasonography method forms important tool for investigating renal pathologies and for which the normal renal data of various parameters is necessary. In the present study 67 normal subjects of both genders (Males: 41, and Females: 26) were chosen to observe various renal parameters. It is observed that the total mean renal length of both kidneys increase with age up - to 60 years and thereafter the decline is observed with a significant P value (0.05) is observed. The length of the left kidney is significantly more than the right kidney in both the genders with a significant P value (0.01). With relevance to the gender it is observed that the length of the right and left kidneys is more in males than in females. The data regarding the relationship between height of the subjects and the renal length indicate that the renal length increases up-to the height of 170 cm and a decline in the renal length is observed beyond the height of the 170 cm in both the genders. The renal width of both the kidneys in both the genders increases up-to fifth decade and a gradual decline is observed thereafter. It is observed that the mean renal width of both the kidneys is more in males than females with a significant P value (0.01).. The comparative study of renal size with reference to the gender shows that in the males the kidney size is larger than females. The data reveals that the renal size in both genders the renal size of left kidney is more than the right with a significant P value (0.04). The data reveals that the renal size increases up-to the height of 170 cm and decline thereafter. In general it is observed that the left kidney mean renal volume is more than the right. The parameter of cortical thickness increases up-to the age of 31 – 40 years and thereafter general decrease in cortical thickness is observed. It is also observed that the cortical thickness in males is more than the females, and regarding the side more on left side. In general, considering the available data it is observed that all the parameters are relatively more in males than females, and the data analysis reveal that all the parameters are more in relation to the left kidney than the right one.

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