



**SAINT PAUL HOSPITAL MILLENNIUM MEDICAL COLLEGE**

**DEPARTMENT OF RADIOLOGY**

**Assessment of renal size and its correlates in patients  
without known renal disease determined using Ultrasound at  
SPHMMC, Addis Ababa.**

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**A research submitted to the department of radiology, Saint Paul's millennium medical  
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**A research on the Assessment of renal size and its correlates in patients without known renal disease determined using Ultrasound at SPHMMC, Addis Ababa.**

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## List of Abbreviation/ acronyms

SPHMMC .....Saint Paul Hospital Millennium Medical College

ESRD----- End stage renal disease

CT----- Computed tomography

MRI ----- Magnetic resonance imaging

## Abstract

**Background:** Many renal diseases can manifest with unilateral or bilateral changes in kidney size. To evaluate abnormalities in renal size, knowledge of standardized values for normal renal dimensions is essential as it shows variability in the values of normal renal size depending on body size, age. Ultrasound, being an easily available, noninvasive, safe and less expensive modality, is widely used for evaluation of renal dimensions and repeated follow-ups.

**Objective:** - Our primary aim was to determine a normal range of values for renal dimensions in patients who came for abdominal ultrasound, having normal abdominal ultrasound study, no known renal disease and to correlate other parameters

**Methods:** Facility based cross sectional Study was conducted at St. Paul Hospital Millennium Medical College, radiology department from Jun 2019 July 2019 in adult subjects with normal abdominal ultrasound and without any known renal disease. Renal length, width, depth and volume were obtained. Mean renal length, width, depth and volume were correlated with body mass index and other factors like age, gender, weight and height of the subjects.

**Result:-** Total number of subjects included in this study was 438. Out of them 14 subjects had abnormal creatinine value and left the study. There were 240 females (56.6 %) and 184 were males (43.4%). The average renal length for the study group was  $11.7 \pm 1.5$  cm and  $11.7 \pm 1.4$  cm for right and left kidney respectively. The mean width of the right kidney was  $3.8 \pm 0.58$  cm and left kidney was  $3.8 \pm 0.6$  cm. The average right renal depth was  $3.7 \pm 0.47$  cm and left renal depth was  $3.81 \pm 0.52$  cm. Mean right kidney volume was  $89.7 \pm 30.5$  cm<sup>3</sup> and left kidney volume was  $91.2 \pm 31.8$  cm<sup>3</sup>.

**Conclusion:-** we can concluded that renal length, width, depth and volume has direct association with individuals' height, weight and BMI as seen in most other studies.

Left kidney is slightly larger than Right and larger renal sizes are seen bilaterally in males as compared to females as seen in most other studies.

## 1. Introduction

### 1.1. Background

The normal adult kidney is bean shaped with a smooth, convex contour anteriorly, posteriorly, and laterally. Medially, the surface is concave; the medial surface is known as the renal hilum. The renal hilum is continuous with a central cavity called the renal sinus. Renal length correlates best with body height, and renal size decreases with advancing age because of parenchymal reduction. Right kidney is smaller than that of the left kidney, possibly because of a relatively larger potential space for left renal growth (growth of right kidney inhibited by liver) or relatively increased left renal blood flow (left renal artery typically shorter than right renal artery). The left kidney usually lies 1 to 2 cm higher than the right kidney. The kidneys are mobile and will move depending on body position. In the supine position, the superior pole of the left kidney is at the level of the 12<sup>th</sup> thoracic vertebra, and the inferior pole is at the level of the third lumbar vertebra.

Renal ultrasound is simple, inexpensive and can be done at the bedside to provide the clinician with important anatomical details of the kidneys with a low inter-observer variability. The safety of the diagnostic procedure using ultrasound is well established. Few studies have shown that computed tomography (CT) can acquire renal dimensions more accurately than ultra-sonography. But the use of ionizing radiation and contrast media for measurement of renal dimensions limits its place as a non-invasive procedure on daily basis. On the other hand, MRI (magnetic resonance imaging) can also predict 3-dimensional data without any ionizing radiation but very little data is available regarding renal dimensions, as it is very expensive and not readily available. Renal size estimation most commonly includes renal length, renal volume and cortical thickness. For everyday practice, renal length measurements are more reliable because of its easy reproducibility but most accurate being the renal volume measurement. Systemic diseases like diabetes mellitus and hypertension rising globally and are the leading cause of end stage renal disease (ESRD). Serial measurements can also provide information regarding disease progression or stability. Measurement of renal size by ultrasound is essential when evaluating patients with possible renal disease. However, it requires prior knowledge of actual normal renal size in the population being studied.

## 1.2. Statement of the problem

Currently in all health facilities of Ethiopia including SPHMMC the incidence of patients with chronic kidney disease is increasing however the diagnosis is without prior knowledge of the actual size of normal kidney size in this population which negatively affect the proper diagnosis process. As kidney size abnormalities are reflective of many renal diseases, it is valuable to have a set of standard US measurements for use when these patients are examined. The presence of close relationship between kidney sizes and functions has stimulated the research related to renal sizes for different ethnic groups and body sizes, which are known to be helpful in diagnosis of kidney diseases. Knowing the normal size will help early detection of the kidney injury sometimes even prior to biochemical derangement

To recognize anatomical deviations in individuals with renal diseases, it is important to have a set of standard sonographic measurements for appropriate comparison.

Renal size may be an indicator for the loss of kidney mass and therefore, kidney function

## 1.3. Significance of the study

Multiple renal diseases like nephrolithiasis, hydronephrosis, chronic renal diseases, and renal tumors along with end stage renal disease alters renal dimensions leading to changes in the size and shape of kidney. Renal length and volume measurements are clinically relevant, serving as surrogates for renal functional reserve, and are used frequently as the basis for making clinical decisions. Thus estimation of renal volume which is obtained from in this study will be used as a base line in the diagnosis, treatment and evaluation of renal disease in different departments in SPHMMC.

## 2. Literature Review

A study in Nigeria showed mean bipolar length in left kidney was  $(10.31 \pm 1.10)$  cm and in right kidney was  $(10.02 \pm 0.97)$  cm. It was concluded by the author that BMI has strongest correlation with renal dimensions. [1]

A study conducted by Maaji, et al. 104 adult volunteers. The average renal length for the study group was  $11.3 \pm 8.8$  cm and  $11.6 \pm 9.8$  cm for right and left kidney respectively. The mean width of the right kidney was  $4.4 \pm 0.71$  cm and left kidney was  $5.2 \pm 5.26$  cm. The average right renal thickness was  $4.7 \pm 0.67$  cm and left renal thickness was  $4.5 \pm 0.68$  cm. Mean right kidney volume was  $109.6 \pm 29.3$  cm<sup>3</sup> and left kidney volume was  $119.7 \pm 32.8$  cm<sup>3</sup>. The average height of the subject group was  $1.67 \pm 0.85$  m and average weight was  $70.9 \pm 11.2$  kg. The average BMI calculated were  $25.1 \pm 3.96$  kg/m<sup>2</sup> and  $26.0 \pm 5.36$  kg/m<sup>2</sup> for female and male respectively. Pearson correlation test was applied to assess the relationship between renal measurements and body indexes and it showed that there was positive relation between renal volume and BMI. [2]

A study conducted in Pakistan Mean kidney lengths were 9.85cm (95% CI: 9.74-9.95 cm) on right side and 10.0 cm (9.85-10.1 cm) on left. The mean width was 4.61cm (95%CI: 4.53 – 4.68cm), cortical thickness 1.46 cm (CI 1.43-1.49cm). Males had larger kidney sizes than females ( $p < 0.001$ ); age however was only associated with a decrease in renal length after ages 70 and above. ( $p=0.001$ ) Renal length best correlated with body weight (correlation coefficient 0.384). eGFR, representative of renal function also positively correlated with renal length (Coefficient 0.415). A multivariate analysis showed male gender (OR 1.60), age (OR 0.89), weight (OR 1.02) and height (OR 7.77) to be significant independent predictors of renal length. [3]

In a research done on 194 adult patients without known kidney lesions. The mean kidney length was  $10.4 \pm 0.8$  cm, mean width  $4.5 \pm 0.6$  cm and mean cortical thickness  $1.6 \pm 0.2$  cm. Kidney length did not significantly differ between right and left, however, kidney width, cortical thickness and size did ( $p < 0.05$ ). Right kidneys were smaller than the left ones. [4]

A study done in Pakistan, The Mean renal length on right side was  $101.6 \pm 8.9$  mm, renal width  $42.7 \pm 7.1$  mm, and parenchymal thickness  $14.4 \pm 2.9$  mm. On left side, mean renal length was  $102.7 \pm 9.2$  mm, width  $47.6 \pm 7.0$  mm, and parenchymal thickness  $15.1 \pm 3.1$  mm. Left renal size was significantly larger than right in both genders. Relationship of mean renal length was significant

when correlated with age, gender, height and weight, and body mass index. Renal volumes also showed a similar relationship with gender, height and weight, and body mass index; but with age such a relationship was seen only for left kidney. [5]

A study done in 153 healthy Mexican adults; Average left renal length (LRL) in male and female group was  $107.16 \pm 6.97$  mm and  $104.6 \pm 7.96$  mm respectively. The average right renal length (RRL) in male and female group was  $105.74 \pm 5.74$  mm and  $102.99 \pm 6.85$  mm respectively. Mean weight of the study group was  $68.87 \pm 11.69$  kg. The average height of the study group was  $160 \pm 8.62$  cm and average BMI (body mass index) was  $26.7 \pm 3.82$  kg/m<sup>2</sup>. The correlation coefficient of LRL (left renal length) with BMI was  $r=0.408$  and for RRL (right renal length) was  $r=0.363$ , using Pearson correlation assessment. It showed a significant positive correlation between both renal lengths with body mass index (BMI). [6]

A study on 100 adults Saudi volunteers to establish the relationship between kidney length and body mass index with the help of ultrasonography . Average renal lengths of both the kidneys were  $9.91 \pm 0.85$  cm for right kidney and  $10.17 \pm 0.89$  cm left kidney. Average height for male and female were 174 cm and 164 cm respectively. Statistical analysis was done using SPSS programme and it revealed that significant increase of right and left renal lengths were associated with increased BMI with  $p=0.0000$ . [7]

A study in Kuwait on 252 patients aged 18-80 without any renal disease. Renal length was measured as the longest longitudinal diameter. Anthropometric data like height and weight were also recorded. The mean renal lengths of the study group were  $10.68 \pm 1.4$  cm and  $10.71 \pm 1.0$  cm for right and left kidney respectively. Mean height and weight of the study group were (143-193) cm and (37-124) kg respectively. The renal length showed strongest correlation with BMI (where  $p$  value  $p<0.01$ ) and weight of the patient ( $p<0.01$ ). Pearson correlation test also showed that renal length increased by 0.23 cm for each 10 kg increase in body weight within the range of 60-120 kg.[8]

A study conducted in Malaysia on 321 students with age ranges of 19-25. According to BMI the sample size was divided into four categories and these are normal BMI (64.3%), underweight (15%), overweight (12.9%) and obese (7.8%). Mean renal length was  $9.81 \pm 0.75$  cm in case of

right side and  $9.85 \pm 0.58$  cm in case of left side. Statistical analysis of the study revealed that renal length significantly correlated with BMI and correspondingly increased with increased BM. [9]

A study done by Buchholz, et al on 194 subjects between 13-80 years of age, without any renal disease were evaluated ultrasonographically. Mean kidney size was  $76.16 \pm 21.7$  cm<sup>3</sup>. Statistical analysis revealed a strong correlation between renal size and BMI and it also showed that renal size increased correspondingly with increased BMI, only in case of left kidney. [10]

A study by Hammad, et al established relationship between anthropometric measurements and renal dimensions in young Saudi population of age group 19-28 year without any known renal disease. Renal length was taken as the longest longitudinal diameter and renal width, thickness and cortical thickness were measured in longest absolute terms. Renal volume was measured using the formula,  $RV = \text{renal length} \times \text{width} \times \text{thickness} \times 0.5$  Pearson correlation test was used to examine the relationship between renal dimensions with anthropometric measurements. It was concluded that, in case of female there was a moderate positive correlation between right kidney volume and BMI. [11]

A study of correlation between anthropometric measurements and renal dimensions using ultrasonography was carried out by Kim, et al. A total number of 794 Korean children underwent sonographic evaluation without any renal disease. Anthropometric measurements like height, weight and BMI were recorded. Renal dimensions included renal length, width, depth and renal volume. Renal volume was measured by using the ellipsoid formula,  $\text{renal volume} = \text{length} \times \text{width} \times \text{depth} \times 0.523$  Statistical evaluation by Multivariate analysis showed that renal volume had no relation with BMI. [12]

A study by Okur et al evaluate the relationship between kidney volume and body parameters of 152 patients, Mean right kidney length was  $10.3 \pm 7.8$  cm and left kidney length was  $10.4 \pm 9$  cm. Mean right kidney volume was  $158 \pm 39$  cm<sup>3</sup> and left kidney volume was  $168 \pm 40$  cm<sup>3</sup>. BMI for women was  $27 \pm 6$  kg/m<sup>2</sup> and for men was  $28 \pm 5$  kg/m<sup>2</sup>. Pearson correlation co-efficient were used to evaluate the relationship between renal dimensions with other parameters. They observed a weak correlation between left kidney volume and BMI. [13]

### 3. OBJECTIVES

#### 3.1. General Objective

- Assessment of renal volume and its correlates in patients without known renal disease was determined using Ultrasound at SPHMMC, Addis Ababa

#### 3.2. Specific Objective

- To assess renal volume in patients with no known renal disease
- To determine factors associated with renal volume

### 4. METHODS

#### 4.1. Study area and Study period

The study was conducted at SPHMMC, which is found in Addis Ababa and is the 2<sup>nd</sup> largest hospital in the country. It was built by Emperor Haile Selassie I in 1969 with the help of the German Evangelical Church. It is the training center for undergraduate and a wide spectrum of postgraduate. The hospital has 700 beds it sees an average of 1200 emergency and outpatient clients daily. It has a catchment population of more than 5 million. The radiology department has 11 consultants, 57 residents and 20 radiology technicians.

The study was conducted from June 2019 to July 2019.

#### 4.2 Study design

The study design is a facility based cross sectional study.

#### 4.3 Source Population

All patients who came for abdominal ultrasound at SPMMHC from June 2019 to July 2019 were the source population.

#### 4.4 Study Population

All patients who came for abdominal ultrasound in SPHMMC from June 2019 to July 2019 and having normal abdominal u/s and no known renal disease.

#### 4.5 Operational definition

**Known renal disease:** - known acute or chronic renal failure, any known parenchymal disease like renal cyst, renal mass and ectopia, agenesis etc.

**Normal abdominal ultrasound:** - normal echotexture, size and Doppler study findings of abdominal organs

#### 4.6. Inclusion and exclusion criteria

##### 4.6.1 Inclusion

All patients with normal abdominal ultra sound study and have no known renal disease were included.

##### 4.6.2. Exclusion

Patients who are not willing to participate in the research

Patients who are unconscious

#### 4.7. Sampling procedures

Sample size determination for large population and Single population proportion method is used.

Simple random sampling technique was used to select the study participant from the daily examined patients with ultra sound in SPHMMC.

The sample size is calculated based on a P value of 50% at a 95% confidence level and margin of error of 5 %, with a 10% non-response rate, the desired sample size is calculated to be 424

Given- confidence interval = 95%  $Z = 1.96$ ,  $P = 0.5$ ,  $W = 0.05$

$N = Z^2 P (1-P) / D^2$

$N = (1.96)^2 0.5 (1-0.5) / (0.05)^2$

$N = 385$

Non-response rate (10%) = 39

The total sample size of the study is **424**

#### 4.8. Data Collection and data quality

Structured questionnaire was developed based on study objectives and available literature. Data was collected by the principal investigator using the questionnaire. Renal ultra sound were performed in volunteers who came for abdominal ultra sound in the study period with no known renal disease. All patients who have normal abdominal ultra sound were send for creatinine determination. Clear gel was applied on the patient skin over the area to be scan. Images were obtained in supine, left and right lateral positions with the patients holding their breath during image accusation. All renal scans were done using real time dynamic ultra sound scanner using a 3.5 MHZ curvilinear probe. Once the kidney was located, the transducer was rotated slightly to determine the longest renal axis and renal length was measured as the maximum bipolar dimension in longitudinal plane which showed central sinus echoes the best with the renal parenchyma evenly distributed all around the central sinus. The transducer was then rotated 90 degrees to the longitudinal axis and the transverse section was obtained at the level of the renal helium. Renal width was measured as the maximum distance between medial and lateral borders of kidney. In the same plane, renal thickness or depth was also measured as the distance between ventral and dorsal surfaces of the kidney. The parenchymal thickness was measured as the distance between outer renal margin and renal sinus in transverse plane. Mean of three readings was taken for each of them.

Renal volume (cm<sup>3</sup>) was calculated as:  $0.523 \times \text{length (cm)} \times \text{width (cm)} \times \text{depth (cm)}$ .

Correlation of renal volume with BMI and also with age, gender, height and weight of the subjects were determined.

#### 4.9. Data Processing and Analysis

Data entry and analysis were performed using SPSS version 21. Simple tabulation and descriptive statistics using cross tab and frequency table was used to look for the renal size. Correlation was used to look for the association of renal volume with other variables. Variables having p value less than 0.2 in descriptive analysis were added to the final analytic process. Independent variables

having a p value less than 0.05 in the analytical statistics were considered as a significant association to the renal size.

#### 4.10. Ethical Consideration

Before conducting the study, permission and approval letter from Saint Paul were obtained. Informed consent were obtained before the imaging. The participants of the study were told they can discontinue whenever they want. During the data collection procedure, the patient privacy and confidentiality were kept to the maximum.

#### 4.11. Dissemination of the Result

After accomplishing the study, the results will be presented to department of Radiology. The result will be distributed to the library and department of nephrology. Subsequently, attempts will be made to present it on scientific conferences and publish it on scientific journals.

## 5. RESULTS

Total number of subjects included in this study was 438. Out of them 14 subjects had abnormal creatinine value and left the study. There were 240 females (56.6 %) and 184 were males (43.4%).

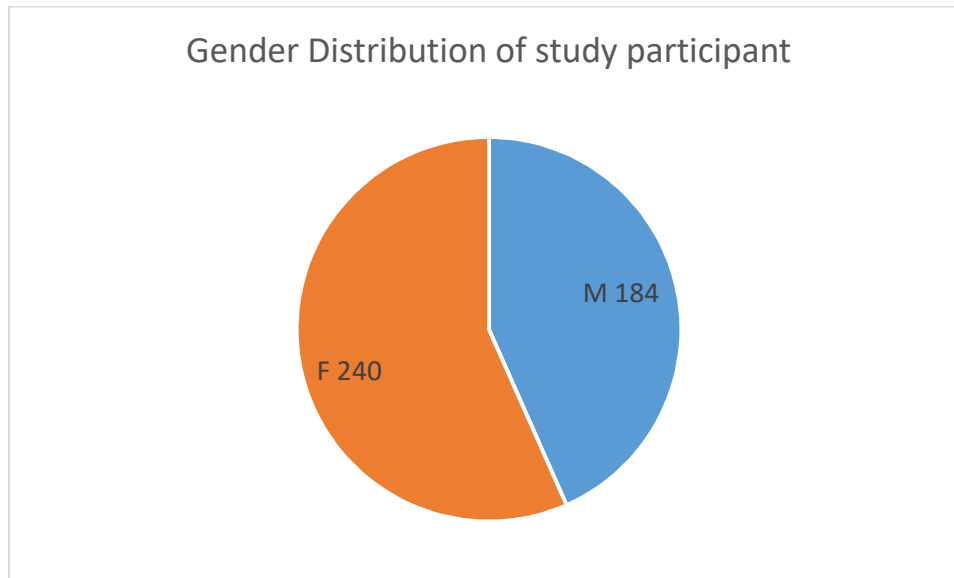


Figure 1 Gender distribution of study participant

Average age of females and males are 36.1 and 47.4 respectively with Mean age of  $41.1 \pm 13.4$  years, with the majority lying between the 35 and 49 yrs. of age. Height of the subjects ranged from 145 – 189 cm with a mean of  $169 \pm 7.9$  Cm for men and  $159.4 \pm 8.7$  Cm for women. Similarly, weights ranged from 4203–96 Kg with a mean of  $67.1 \pm 9.7$  Kg for men and  $57.3 \pm 8.9$  Kg for women. The average BMI calculated were  $23.5 \pm 2.7$  kg/m<sup>2</sup> and  $22.5 \pm 2.8$  kg/m<sup>2</sup> for male and female respectively. The average renal length for the study group was  $11.7 \pm 1.5$  cm and  $11.7 \pm 1.4$  cm for right and left kidney respectively. The mean width of the right kidney was  $3.8 \pm 0.58$  cm and left kidney was  $3.8 \pm 0.6$  cm. The average right renal depth was  $3.7 \pm 0.47$  cm and left renal depth was  $3.81 \pm 0.52$  cm. Mean right kidney volume was  $89.7 \pm 30.5$  cm<sup>3</sup> and left kidney volume was  $91.2 \pm 31.8$  cm<sup>3</sup>.

Table 1: Renal dimension in males and females

| parameters        | males (184)  |            |             |            | females (240) |          |             |            |
|-------------------|--------------|------------|-------------|------------|---------------|----------|-------------|------------|
|                   | right kidney |            | left kidney |            | right kidney  |          | left kidney |            |
|                   | Mean±SD      | Range      | Mean±SD     | Range      | Mean±SD       | Range    | Mean±SD     | Range      |
| renal length (cm) | 11.7±1.4     | 8.6-15.1   | 12.1±1.5    | 9.2-15.1   | 11.4±1.3      | 8.4-15.0 | 11.4±1.2    | 8.6-15.1   |
| renal width (cm)  | 3.8±0.58     | 2.5-5.1    | 4.02±0.59   | 2.6-5.2    | 3.7±0.58      | 2.5-5.1  | 3.6±0.54    | 2.6-5.2    |
| renal depth (cm)  | 3.7±0.47     | 2.5-5.08   | 3.8±0.52    | 2.4-5.1    | 3.5±0.45      | 2.4-5.1  | 3.8±0.52    | 2.4-5.1    |
| renal volume (cm) | 101.7±34.9   | 58.9-188.7 | 104±31.7    | 61.5-188.9 | 80.5±22.7     | 29-172.2 | 79.6±23.7   | 32.5-188.8 |

Table 2:- Correlation coefficients between BMI and renal lengths, volume and renal width (n=424)

| parameters   | Pearson correlation coefficient |             |
|--------------|---------------------------------|-------------|
|              | Right kidney                    | left kidney |
| Renal length | 0.73                            | 0.77        |
| renal width  | 0.72                            | 0.77        |
| Renal volume | 0.82                            | 0.81        |

## 6. DISCUSSION

Among all the imaging modalities, US has been regarded and preferred as an imaging technique of choice in most of the clinical surveys for being non invasive, safe, reliable, cost effective and easy availability, even though underestimation has been noted in calculated renal volumes by US. One of the very important and easily reproducible parameter as an indicator of renal function is renal size that shows variations with age, gender, ethnic backgrounds, height, weight and BMI. Many congenital and acquired diseases directly or indirectly significantly affect renal dimensions in all age groups, thus when considering renal size as an indicator for renal function in an individual we have to keep in mind not only the effect of diseases on kidneys but also the relationship of normal renal size of an individual with different factors as mentioned above. Standard parameters used in routine US renal examinations are longitudinal renal length, renal width and renal depth mm or cm. Additional measurement acquired using these three parameters include renal volume, based upon their correlation with subject's height, weight, BMI, age etc. Even the most precise assessment of abnormalities in renal size would require measurement of renal volume in relation to sex, weight, or total body area, but such calculations are not clinically practical. It is rarely included as an indication for intervention due to high inter-observer variation and difficulty in measuring renal volume but it has shown to be a more sensitive method of detecting renal abnormality than any single linear measurement and correlated better with renal mass. In autopsy studies, kidney volume has been shown to correlate well, although indirectly, with the number of functioning nephrons. In contrast to renal length, renal volume has received little attention in the literature as a parameter for clinical follow-up because measurement of renal length is easy. For everyday situations, measurement of renal length is therefore recommended. The small difference and acceptable standard deviation indicate that renal length can be measured with the subject either supine or prone. Thus renal length measurement should be preferred to renal volume estimation because of lower observer variation; more over it is reliable, simple, practical, reproducible measurement of renal size. We calculated these measurements to find normal values for our population to help standardize a criteria to be used in clinical assessment of certain disease processes largely relying on renal dimensions and thus to reduce any missed or over-diagnosis of a disease in practice. Secondly, aim was to show that BMI had direct relationship with renal size.

Pearson correlation test was applied to assess the relationship between renal measurements and body indexes and it showed that there was positive relation between renal volume and BMI (2).

Mild difference was found between dimensions of right and left kidneys, with left being slightly larger than right in renal length, renal width, renal depth, and renal volume ( $p < 0.01$ ). All these parameters were statistically higher in males as compared to females ( $p < 0.01$ ).

As the height of subjects increased a significant increase in renal length and renal volume was seen, showing a positive strong linear relationship for the renal volume both for the right and left kidney with  $r$  value 0.72 for the left and 0.7 for the right. The renal length shows moderate linear relationship for both right and left kidneys with  $r$  value being 0.57 for the left and 0.56 for the right.

As seen between height and renal size, a similar significant positive relationship was found on correlation of subject's weight with renal length and renal volume ( $p < 0.01$ ). Value of  $r$  was 0.55 and 0.66 on right and left side respectively for renal volume and it was 0.66 and 0.625 for renal length on Right and Left respectively.

With increase in subject's BMI, a significant increase in renal length and renal volume was also seen. Mean BMI was  $22.9 \pm 2.7$  Kg/m<sup>2</sup> (range: 17.2–30.8). A significantly positive and strong linear relationship was found when renal length and BMI were correlated for both kidneys. Value of ' $r$ ' was 0.82 and 0.73 for right and left side respectively. Renal volume showed a similar relationship with BMI. Calculated ' $r$ ' was 0.73 and 0.77 for right and left side respectively.

Normal renal length ranges from 97–112 mm in different populations dependent upon their age groups, gender, height, weight and ethnic backgrounds (5, 11, 14–18). Our study showed the mean renal length of study population was  $117 \pm 15$  mm, which lies in almost the same range as that of Nigerians (16) Jamaicans (17) and Malaysians (18) but is relatively shorter as compared to population residing in Denmark, Croatia and USA (5,14,15). We observed that LT kidney was significantly larger than RT in length, width, parenchymal thickness and volumes. The same has been reported by other workers,(5,14,17–19). While (11) there was observed no significant difference between RT and LT renal length; however RT kidney was shorter in cortical thickness, width and volume as compared to LT. Similarly no demonstrable difference was seen between RT and LT renal volumes (20). Larger value for RRL on left kidney was also reported (14) as in our study. Probably because of difference in height or body size, renal sizes have been found slightly larger in males in most of the studies (4, 5, 11, 14, 16, 18, 19, and 21). The same was observed in

current study, which showed a statistically significant larger kidney sizes including volume, renal length, width and renal depth in males found a lower in males as compared to females (21).

Kidney reaches its mature size at age 20–29 years and remains relatively unchanged until the 6th decade of life. Studies have shown that aging leads to progressive decrease in kidney size, after middle age (11, 14, 19, and 21) at rate of 0.5 Cm per decade, especially due to a reduction of about 1% per year in blood flow after the third decade (24). We also noticed a significant negative, but relatively weak, linear relationship between renal lengths with increasing age in both genders. This decrease in renal size became more consistent from 6th decade onwards. In normal subjects, the smallest kidney's volume should not be less than 37% of the total renal volume (20). Studies shows significant correlation was seen between renal length and height bilaterally; while some authors concluded that renal length is not associated with body's height, but with subject's weight (16) while some others believed that lengths and widths of kidneys were not associated with height in either genders (17). Our data showed a significant positive relationship when subject's height and weight were correlated with renal volume and length in both genders. This correlation was comparatively stronger between renal volume and subject's height and weight. This finding has been supported by many workers.(5,11,19) The renal length and renal volume have been found to show a good accordance with BMI.(11) This was shown in our study as well where renal length showed a stronger correlation than renal volume.

## 7. CONCLUSION

From our research we can concluded that renal length, width, depth and volume has direct association with individuals' height, weight and BMI as seen in most other studies.

Left kidney is slightly larger than Right and larger renal sizes are seen bilaterally in males as compared to females as seen in most other studies.

## 8. REFERENCES

1. Bax L, Van der Graaf Y, Rabelink AJ, Algra A, Beutler JJ, Mali WP; SMART Study Group. Influence of atherosclerosis on age-related changes in renal size and function. *Eur J Clin Invest* 2003;33(1):34–40.
2. Weisenbach J, Horvath M, Jeges S, Adamovich K, Huszar T. Normal percentiles of kidney size in children as measured by ultrasonography. *Orv Hetil* 2001;142:71–4.
3. Segal MC, Lecky JW, Slasky BS. Diabetes mellitus: The predominant cause of bilateral renal enlargement. *Radiology* 1984;153:341–2.
4. Kang KY, Lee YJ, Park SC, Yang CW, Kim YS, Moon IS, *et al.* A comparative study of methods of estimating kidney length in kidney transplantation donors. *Nephrol Dial Transplant* 2007;22:2322–7.
5. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Sonographic evaluation of renal appearance in 665 adult volunteers. Correlation with age and obesity. *Acta Radiol* 1993;34:482–5.
6. Radermacher J. Ultrasonography of the kidney and renal vessels. I. Normal findings, inherited and parenchymal diseases. *Urologe A* 2005;44:1351–63. (Article in German)
7. Rafique M. Value of routine renal and abdominal ultrasonography in patients undergoing prostatectomy. *Int Urol Nephrol* 2006;38:153–6.
8. Mehmood T. Experience of intraoperative ultrasound compared to CT, MR and percutaneous ultrasound. *J Surg Pak* 2003;8:35–8.
9. Widjaja E, Oxtoby JW, Hale TL, Jones PW, Harden PN, McCall IW. Ultrasound measured renal length versus low dose CT volume in predicting single kidney glomerular filtration rate. *Br J Radiol* 2004;77:759–64.
10. Bakker J, Olree M, Kaatee R, Lange de EE, Beek FJ. In vitro measurement of kidney size: Comparison of ultrasonography and MRI. *Ultrasound Med Biol* 1998;24:683–8.
11. Buchholz NP, Abbas F, Biyabani SR, Afzal M, Javed Q, Rizvi I, *et al.* Ultrasonographic renal size in individuals without known renal disease. *J Pak Med Assoc* 2000;50:12–6.
12. Cheong B, Muthupillai R, Rubin MF, Flamm SD. Normal values for renal length and volume as measured by magnetic resonance imaging. *Clin J Am Soc Nephrol* 2007;2:38–45.
13. Mazzotta L, Sarteschi LM, Carlini A, Antonelli A. Comparison of renal ultrasonographic and functional biometry in healthy patients and in patients with chronic renal failure. *Arch Ital Urol Androl* 2002;74:206–9.

14. Miletić D, Fuckar Z, Sustić A, Mozetic V, Stimac D, Zauhar G. Sonographic measurement of absolute and relative renal length in adults. *J Clin Ultrasound* 1998;26:185–9.
15. Brandt TD, Neiman HL, Dragowski MJ, Bulawa W, ClaykampG. Ultrasound assessment of normal renal dimensions. *J Ultrasound Med* 1982;1:49–52.
16. Okoye IJ, Agwu KK, Idigo FU. Normal sonographic renal length in adult southeast Nigerians. *Afr J Med Med Sci* 2005;34:129–31.
17. Barton EN, West WM, Sargeant LA, Lindo JF, Iheonunekwu NC. A sonographic study of kidney dimensions in a sample of healthy Jamaicans. *West Indian Med J* 2000;49:154–7.
18. Wang F, Cheok SP, Kuan BB. Renal size in healthy Malaysian adults by ultrasonography. *Med J Malaysia* 1989;44:45–51.
19. Fernandes MM, Lemos CC, Lopes GS, Madeira EP, Santos OR, Dorigo D, *et al.* Normal renal dimensions in a specific population. *Int Braz J Urol* 2002;28:510–5.
20. Rasmussen SN, Haase L, Kjeldsen H, Hancke S. Determination of renal volume by ultrasound scanning. *J Clin Ultrasound* 1978;6:160–4.
21. Akpınar IN, Altun E, Avcu S, Tüney D, Ekinçi G, Biren T. Sonographic measurement of kidney size in geriatric patients. *J Clin Ultrasound* 2003;31:315–8.
22. Tajima M. Ultrasonic kidney size measurement. 2. In normal adolescents. *Hinyokika Kiyo* 1987;33:1742–8.
23. Ameer S, Anjum MN, Rehman M, Haider SI, Farooq L, Ijaz MZ. Sonographic assessment of renal length in normal Pakistani children. *Mother Child* 1999;37:45–50.
24. McLachlan M, Wasserman P. Changes in sizes and distensibility of the aging kidney. *Br J Radiol* 1981;54:488–91.