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Morpho-Metrical Profile of the Kidney and the BMI Correlation in Normal Adults Metropolitans of Port Harcourt City, Nigeria.

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ABSTRACT
The Morpho-metrical profile of the kidney and the BMI correlation in Normal Adult is a study which determines the normal range of values of kidney dimensions in 202 healthy Port Harcourt metropolitans (102 male; 100 female) who were 20 – 70 years of age. Mean age 46 ± 21.2 years; 46.3 ± 21.6 years (male), 45.7 ± 20.8 years (female). Mean height: t 1.6 ± 0.1; 1.6m ± 0.1m (male), 1.5 ± 0.1m (female). Mean weight: 70 ± 12.4kg; 72.8 ± 11.4kg (male); 67.4 ± 12.8kg (female). Mean body mass index (BMI [kg/m^2]) 29.1 ± 7.8; 29.9 ± 12 (male), 28.4 ± 5 (female). The renal dimensions measured were length × width × cortical thickness which was established as equal to renal size. The mean kidney length 9.6 ± 0.4cm (right); 9.6 ± 0.4cm (left), kidney width 4.2 ± 0.3cm (right); 4.6 ± 0.2cm (left), cortical thickness 1.4 ± 0.1cm; (right); 1.6 ± 0.2cm (left), kidney size 53 ± 9.9cm^3 (right); 69 ± 9.1cm^3 (left). Male kidney length were 9.8 ± 0.5cm (right); 9.9 ± 0.5cm (left), width 4.2 ± 0.4cm (right); 4.5 ± 0.4cm (left), cortical thickness 1.3 ± 0.2 (right); 1.6 ± 0.2cm (left) and kidney size 57 ± 12cm^3 (right); 72 ± 17cm^3 (left). Female kidney length was 9.7 ± 0.4cm (right); 9.7 ± 0.5cm (left), width 4.2 ± 0.2cm (right); 4.6 ± 0.2cm (left), cortical thickness 1.4 ± 0.1cm (right); 1.6 ± 0.1cm (left) and kidney size 55 ± 8cm^3 (right); 71 ± 8cm^3 (left). There was significant difference between kidney length in male and female (p= <0.01). Kidney dimension measurement with ultrasound (US) is regarded as the most precise indicator of clinical diagnosis of hydronephrosis, nephritis and other renal pathologies.

Keywords: renal length, renal dimension, sonography, cortical thickness, kidney width

INTRODUCTION
The length and volume of kidneys are considered very important parameters for clinical assessment of patients with diabetes, renal artery stenosis and for assessment of renal transplant candidates. The average size is 8-11cm in length and 4-6cm in width and 2-4cm in thickness. The minimal size of a fully functional kidney is 9cm in length, 3cm in width and 1cm in cortical thickness[1].

Renal size in ultrasound image is 2-3cm less than direct intravenous urogram measurement. The advantages of ultrasound (US) include the fact that it is noninvasive involves no radiation exposure, is widely available and importantly standard nomorgrams exist for comparison and the method for ultrasound (US) measurement of renal dimensions has been described[2].

It has been shown that body mass index (BMI) and age showed a weak correlation with organ dimensions[3], and that renal length is not only age dependent but also significantly correlated with other important demographical variables.

Sammy[4] carried out a renal histopathologic findings with sonography. The retrospectively compared sonographic parameters (length), qualitative echogenicity, cortical thickness and parenchymal thickness) to biopsy finindgs of glomerular sclerosis, tubular atrophy, intertital fibrosis, and intertital inflammation in 207 patients.

They reveled that, the echogenicity showed the strongest correlation with all 4 histologic parameters (r = 0.28 – 0.35). Renal size was significantly correlated with glomerular sclerosis (r = 0.26) and tubular atrophy (r = 0.20). parenchymal thickness, but not cortical thickness, correlated with tubular atrophy (r = 0.23). By multivariate analysis, tubular atrophy and interstitial fibrosis inflammation, but not interstitial fibrosis was significantly determinants of cortical echogenicity. Severe chronicdisease (> 50% sclerosed glomerula or a score of 3 out of 5 or greater for tubular atrophy or interstitial fibrosis) was present in 69% and 47% of patients with combined renal length < 20cm, respectively (p = <0.05). For cortical echogenicity > 1.0, (> liver echogenicity) and ⩽ 1.0, the proportions of severe disease were 66% and 30%, respectively (p < 0.001). Severe disease was present in 86% of patients with combined renal length < 20cm and cortical

echogenicity > 1.0.

Sonographically, the kidney is seen to consist of a central highly echogenic core called the renal sinus surrounded by a comparatively loss echogenic layer called the renal collecting systems, calyces, renal infundibulate arteries, virus, lymphatics.

The aim of the study is to establish a normative values of the kidney dimensions is adults (18-70years of age) in port Harcourt metropolis. It is also to evaluate the effect of body mass index (BMI) to kidney profile and investigate correlations between renal size body mass index (BMI) and changes in variation of renal dimensions with respect to gender.

MATERIALS AND METHODS

The research was a retrospective between 2013– 2015 with a population of 212. Consecutive patients (102 female; 110 male) with sonograms between 18 - 80 years of age, who underwent an abdominal diagnostic ultrasound at the department of radiology of Braithwaite Memorial Specialist Hospital Port-Harcourt (BMSH) and Military Hospital Port Harcourt (MHPH), for indications other than renal parenchyma disease were sampled.

Exclusion criteria includes

- Pregnant women were excluded from the analysis due to the fact that the uterus containing fetus tilted more on the left abdomen which causes the ultrasound inability to visualize the left kidney in pregnant women.
- Patients with kidney pathologies.

Patients with clinical history of symptoms of renal abnormality.Electronic calipers were used to measure the renal morphometric parameters.

Maximum renal depth (D), length (L), and with width (W) and the maximum length (C), depth (d), and with (w) of the echogenic central sinus were measured in cm. The volume of the entire kidney and that of the central sinus echoes were calculated using the prolate ellipsoid formula

$$V\,(ml) = L \times W \times \frac{D_1 \pm D_2}{2} \times 0.523$$

Where, D_1 maximum depth in longitudinal section. D_2 maximum depth in transverse section.The renal parenchyma volume (RPV) was calculated by subtracting the renal sinus volume form the renal volume.

Kidney dimension measured include length (distance pole to pole), width (transversal axis) and cortical thickness, in centimeters. The kidney size was estimated, defined as length x width x cortical thickness, which correlates closely to the renal volume. Additional data recorded include age, gender, height, body mass index (BMI [Weight, kg/height (m^2)]) and history of pathological conditions. The mean, SD, were calculated for the various dimensions.

Comparative analysis was done by means of a student's "t" test. A P – Value of <0.05 was regarded as statistically significant.

RESULTS

Table 1: Demographic data of Students' Age group and Percentage

Age group	2013	2014	2015	Tota1	Percentage									
	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)								
11-20	3(5.2)	3(6)	1(2.5)	3(8.6)	0 (0)	0 (0)	10	4.7%						
21-30	10(17.2)	6(12)	5(12.5)	5(14.3)	1(8.3)	5(29.4)	32	15.1%						
31-40	10(17.2)	8(16)	11(27.5)	9(25.7)	6 (50)	4(23.5)	48	22.6%						
41-50	15(28.9)	19(22)	10(25)	9(25.7)	0 (0)	2(11.8)	47	22.2%						
51-60	10(17.2)	7(14)	7(17.5)	4(11.4)	3 (25)	2(11.8)	33	15.6%						
61-70	6(10.3)	7(14)	5(12.5)	5(14.3)	2(16.7)	3(17.6)	28	13.2%						
Total	58(27.3)	50(23.6)	40(18.9)	35(16.5)	12(5.7)	17 (8)	212	100%						

Table 2. Age, height, weight and body mass index (BMI) of the study population

Characteristics	Overall mean ± SD	Male mean ± SD	Female mean ± SD
Age (years)	46 ± 21.2	46 ± 21.6	45 ± 20.8
Height (m)	1.6 ± 0.1	1.6 ± 0.1	1.5 ± 0.1
Weight (kg)	70 ± 12.4	72.8 ± 11.4	67.4 ± 12.8
Body mass index (kg/m^2)	29.1 ± 7.8	29.9 ± 12.0	28.4 ± 5.0

Of the total 212 patients studied with normal kidney, 110 were males and 102 were females. The mean age was 46 ± 21.2 years (16– 80); 46.3 ± 21.6 years (16 – 80) for males and 45.7 ± 20.8 years (16 –80) for females. Mean height was 1.6 ± 0.1 years; 1.6 ± 0.1 for males and 1.5 ± 0.1 for females. Mean weight was 70 ± 12.4; 72.8 ± 11.4 for male and 67.4 ± 12.8. Mean body mass index (BMI) was 29.1 ± 7.8; 29.9 ± 12.0 for male and 28.4 ± 5.0.

Renal Size And Gender

Table 3: Ultrasonographic kidney measurement and side differences in the whole study population (n = 212)

Measurements	Right kidney (mean ± SD)	Left kidney (mean ± SD)	P – Value
Length (cm)	9.6 ± 0.4	9.6 ± 0.5	≥ 0.05
Width (cm)	4.2 ± 0.3	4.6 ± 0.2	< 0.05
Cortical thickness (cm)	1.4 ± 0.1	1.6 ± 0.2	< 0.05
Size (cm^3)	53 ± 9.9	69 ± 9.1	< 0.01

The mean kidney length was 9.6 ± 0.4cm (right); 9.6 ± 0.5cm (left) 8.2 – 10.6, the mean kidney width 4.2 ± 0.3cm(right); 4.6 ± 0.2cm (left) 2.0 – 5.5, and the mean cortical thickness was 1.4 0.1cm (right); 1.6 ± 0.2cm (left) 1.0 – 2.5. Kidney size (length x width x cortical thickness) was 53 ± 9.9 cm^3 (right) 24.43 – 112.07; 69.86 ± 9.1 cm^3 (left) 37.14 – 128.9.

There was no significant difference in kidney length between right and left side (P 0.05). However, differences in width, cortical thickness and size were all significant (P < 0.05), with the right kidney being significantly smaller than the left.

Table 4: Ultrasonographic kidney measurement by side and gender

Measurements	Males (n = 170) mean ± SD	Females (n = 102) mean ± SD	P - Value
Length (cm)			
Right	9.8 ± 0.5	9.7 ± 0.4	< 0.01
Left	9.9 ± 0.5	9.7 ± 0.5	< 0.01
Width (cm)			
Right	4.2 ± 0.4	4.2 ± 0.2	< 0.01
Left	4.5 ± 0.4	4.6 ± 0.2	< 0.01
Cortical thickness (cm)			
Right	1.3 ± 0.2	1.4 ± 0.1	< 0.01
Left	1.6 ± 0.1	1.6 ± 0.1	0.00
Size (cm^3)			
Right	57 ± 12	55 ± 8	< 0.01
Left	72 ± 17	71 ± 8	< 0.01

As a group, male kidneys were significantly larger than female kidney. Male kidney length as provided in the table above measures 9.8 ± 0.5cm (right); 9.9 ± 0.5cm (left), kidney width 4.2 ± 0.4cm (right); 4.5 ± 0.4cm (left), cortical thickness 1.3 ± 0.2cm (right); 1.6 ± 0.1cm and kidney size 57 ± 12cm^3 (right); 72 ± 17cm^3. Female kidney length measures 9.7 ± 0.4cm (right); 9.7 ± 0.4cm (left), width 4.2 ± 0.2cm (right); 4.6 ± 0.2cm (left), cortical thickness 1.4 ± 0.1cm (right); 1.6 ± 0.1cm (left) and kidney size 55 ± 8cm^3 (right); 71 ± 8cm^3 (left).

Table 5: Ulstrasonographic determination of renal size according to age.

Age group	Right kidney (mean ± SD)				Left kidney (mean ± SD)							
	Length (cm)	Width (cm)	Cortical thickness (cm)	Size (cm^3)	Length (cm)	Width (cm)	Cortical thickness (cm)	Size (cm^3)				
11-20	9.3 ± 0.4	3.8 ± 0.4	1.2 ± 0.2	44 ± 12	9.3 ± 0.5	4.1 ± 0.3	1.5 ± 0.2	60 ± 15				
21-30	9.8 ± 0.5	4.2 ± 0.2	1.4 ± 0.1	56 ± 10	9.8 ± 0.4	4.5 ± 0.2	1.6 ± 0.1	68 ± 5				
31-40	9.9 ± 0.4	4.2 ± 0.3	1.4 ± 0.2	59 ± 6	10.0 ± 0.5	4.5 ± 0.4	1.6 ± 0.2	73 ± 8				
41-50	10.0 ± 0.5	4.5 ± 0.4	1.4 ± 0.1	66 ± 18	10.1 ± 0.6	4.8 ± 0.4	1.7 ± 0.2	83 ± 6				
51-60	9.8 ± 0.3	4.3 ± 0.2	1.4 ± 0.1	59 ± 6	9.8 ± 0.5	4.6 ± 0.2	1.6 ± 0.1	75 ± 16				
61-70	9.5 ± 0.4	4.1 ± 0.2	1.3 ± 0.1	53 ± 15	9.6 ± 0.4	4.4 ± 0.2	1.6 ± 0.1	69 ± 8				
71-80	8.8 ± 0.3	3.8 ± 0.2	1.2 ± 0.1	37 ± 16	8.8 ± 0.3	4.1 ± 0.2	1.5 ± 0.1	56 ± 18				

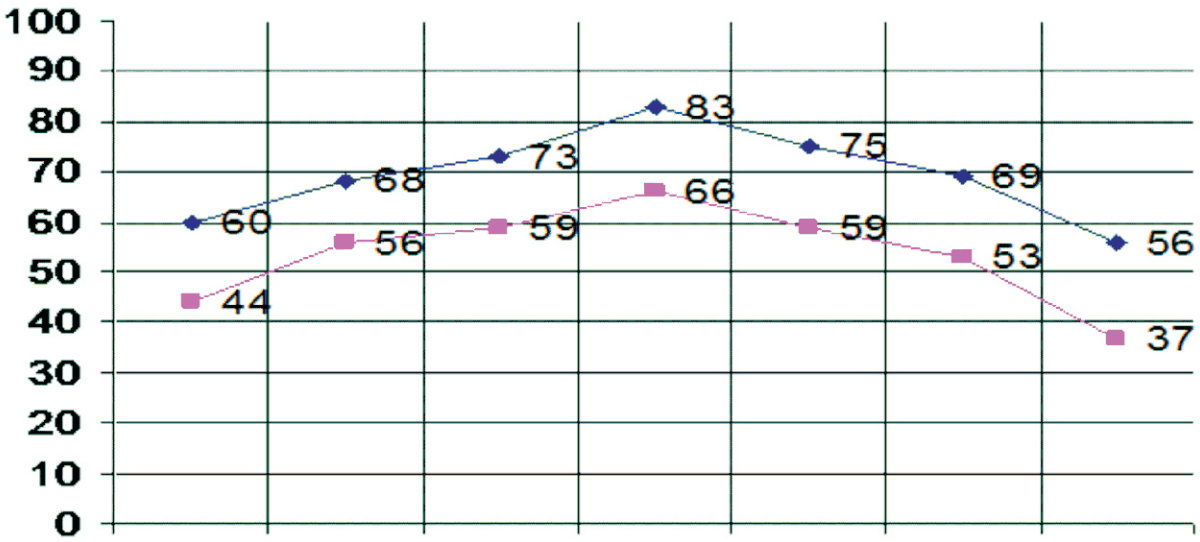

Figure 1: Change in dimensions of renal size

Table 6: Renal size and BMI according to group.

Body mass index (BMI [kg/m^2])	Right renal size (cm^3)	Left renal size (cm^3)
10 – 20	49.48	61.31
20 – 30	53.36	68.01
30 – 40	65.01	80.72

Information on body mass index (BMI [kg/m^2]) was available in 209 individual of the study population who were then divided into 3 groups, i.e. BMI 10 – 20, 21 – 30 and 31- 40. The mean renal size correlated well with BMI and correspondingly increased with BMI. This observation however, was made for both right and left kidney. In the BMI 10 – 20 group, renal size was 49.48cm^3 (right); 61.31cm^3 (left), 21 – 30 was 53.36cm^3 (right); 68.06cm^3 (left) and 31 - 40 was 64.01cm^3 (right); 80.72cm^3 (left). They all increase with BMI as shown in figure 6

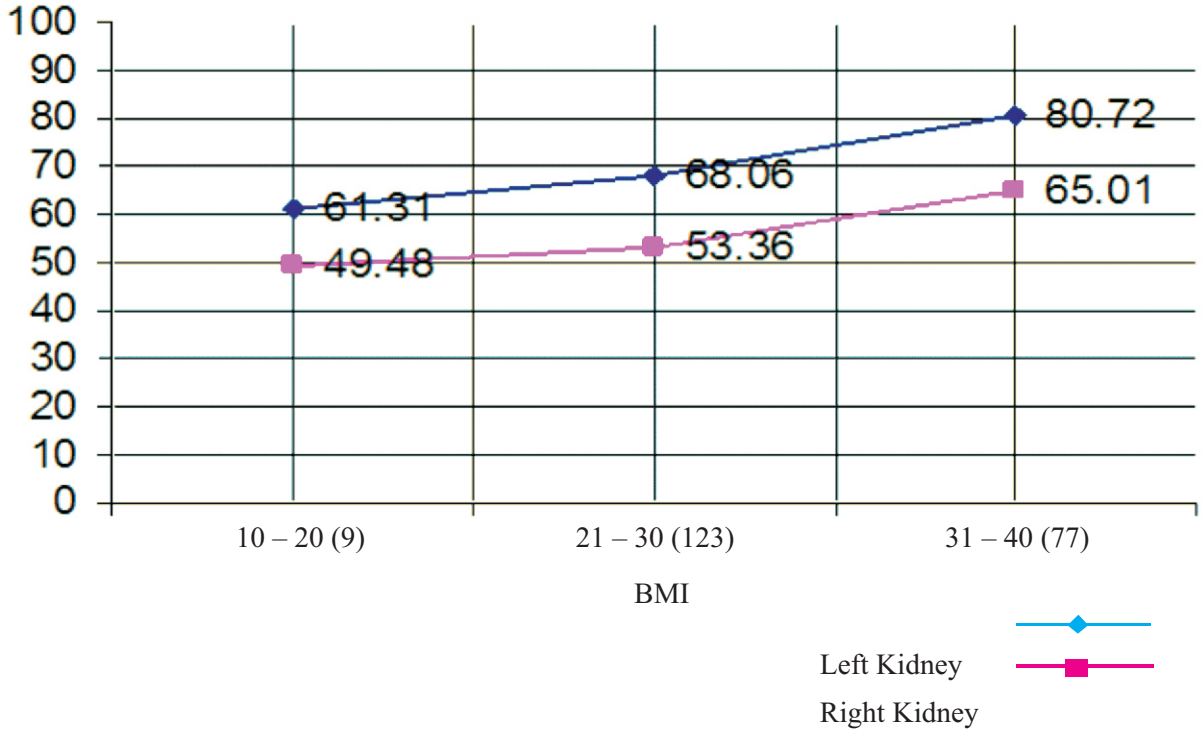

Figure 2: Correlation of renal size with BMI

DISCUSSION

The normal size of a kidney is variable and is affected by age, gender, body mass index, (BMI) as well as the side. The size provides a rough indication of the renal function. The mean renal size correlated well with BMI and correspondingly increased with BMI. This observation however, was made for both right and left kidney, with the left being on the higher size than right kidney.

Normal renal length varies from 100 to 124mm in different population, dependent on ethnic background, side and sex. While population – based studies are needed to establish the normal values for Port Harcourt residents, the study showed a mean kidney length 96mm. this is at the lower end of the scale and is probably a reflection of the relatively small body size of most individuals.

In this study, the kidney length, width, cortical thickness and size were significantly larger in males than in females, 9.9cm (male); 9.7 (female). This has been reported by other investigators such as the one done by Okida and Ugbodaga[5], male 12.4cm; female 12.0cm, Wang[6], male 10.5cm; female 10.0cm and Miletic[7], male 11.2cm; female 11.0cm on renal length measurement, and has been related to differences in body size, but different from work[8], on 665 adults volunteers using renal lengths were 11.2cm on the left side and 10.9cm on the right side. Median renal volumes were 146cm^3 in the right kidney. Renal size decreased with age, almost entirely because of parenchmal reduction. Kidneys become relatively wider and thicker with age.

Throughout this study, there is a marked but not significant difference of kidney length between the right and left side, with the left side being on an average 5% larger. This is no doubt, could be related to the hepatic mass which does not allow comparable vertical growth of the right kidney to that which is attained by the left kidney. The work[9], in their study measured the renal length, bipolar parenchymal thickness and anteriposterior pelvic diameter from serial sonograms of patients with hydronephrosis. Renal longitudinal parenchyma area and renal longitudinal pelvic caliceal area were also determined. They observed that normal parenchyma area correlated well with normal renal length ($r^2 = 0.2$). However in my study, except for the length, all other renal dimensions were significantly larger on the left side than on the right side. I feel thus, that instead of renal length, the renal size as determined by this project or volume as determined by others may be the most useful parameter for evaluation comparison.

The age of an individual has an important bearing on the kidney size. I found out that the kidney size increase till the 3rd decade remained stable through the middle age and then declines even as observed[8]. One possible explanation for this could be the relaxation of the abdominal wall with age, so that the kidney is squeezed less in older persons. This would also explain the broadening that becomes most pronounced for the right kidney, which has been squeezed more because of the liver.

My data shows a strong correlation between renal size and height, body weight and BMI (figure 4, 5, and 6). The renal size increased corresponding with an increasing height, body weight and BMI. Researchers[10], also reported a good correlation of renal parameters with body parameters, the height and BMI being the one having the best correlation.

Generally values obtained in this work are small with one of the reason being that of the modality. Infact, Moell H[11], showed that renal dimensions measured by using sonography were smaller than those obtained by using radiography because no geometric magnification and no osmotic diversis caused by intravenous contrast occurred in the former study. Also, it has to be borne in mind that kidney size measurement by Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) results in a 24% underestimation of the renal value according to work[12] in comparison with an intraverious pyelogram; even as Ultrasound (US) is more accurate and suffers neither from the geometric magnification of x – raying, nor from a possible increase in kidney size by osmotic dieresis through iodinated contrast material as noted[13].

Finally, of all the variables assess in my study, the most significant factors associated with the kidney size were sex (P = 0.01), BMI (P = 0.01).

REFERENCES

1. Shcherbak. *Angiographic Criteria in the determination of indications for organ preserving surgery in renal artery occlusion*. Ajlin, Khir.1989; 2:5.
2. Dixit PK, Sahai SB, Rath B, Garg A, Chowdhury V. *Norms for renal parenchymal volume in Indian children*. Indian pediatric. 1994; 31:1059-64.
3. Chen JJ, Pugach J, Patel M, Luisiri A, Steinhadt GF. *The renal length nomogram: multivariable approach.* Jurology. 2002; 168:2149 – 52.
4. Sammy M, Edria J, Jill S, Kraisith A, William M, Randolph AH, Charles WO. *Correlation of renal histopathology with sonographic findings.* J clin nephrology. 2005; 67:1515 – 20.
5. Okita J, Ugbodage C. *Roentgenologic estimation of kidney size in adult Nigerians.* Trop. Geogr – Med. 1982; 2:34:177 – 79.
6. Wang F, Cheok S, Kuan B. *Renal size in healthy Malaysian adults by ultrasonography*. Med .J. Malaysia. 1989; 44:45 – 46.
7. Miletic D, Fuckar, Stistic A. *Sonographic measurement and relative renal length in adults*. J. Clin. Ultrasound. 1998; 26:185 – 87.
8. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. *Kidney dimensions at sonography: correlation with age, sex and habitus in 665 adult volunteers*. AJR AM J Roentgenology. 1993; 160:83 – 6.
9. Cost GA, Merguenan PA, Cheerasarn SP, Shortlife LM. *Sonographic renal parenchymal and pelvicaliceal areas:* New quantitative parameters for renal sonographic follow – up. J Urology. 1996; 156:725 – 9.
10. Gavela T, Sanchez Bayle J, Gomez Mardones G, Gallego S, Martinez – Perez J, Moya MT. *Ultrasonographic study of kidney size in children*. Netrologia. 2006; 26:325 – 9.
11. Moell H. *Kidney size and its deviation from normal in acute renal failure.* Acta Radiology Supply. 1961; 206:1 – 74.
12. Bakker J, Olree M, Kaatee R. *Lit vitro measurement of kidney size. Comparison of ultrasonography and MRI.* Ultrasound Med. Biol. 1998; 24:683 – 84.
13. Brandt T, Neiman H, Diagowski M. *Ultrasound assessment of normal renal dimensions* .J. Ultrasound Med. 1982; 2:1:49 – 51.