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SONOGRAPHIC EVALUATION OF ADULT RENAL VOLUME AND ITS CORRELATION WITH BODY SURFACE AREA

Hafizhalaila Ammar[1], Evo Elidar Harahap[1], Alwi Thamrin Nasution[2], Henny Maisara Sipahutar[1], Elvita Rahmi Daulay[1], Netty Delvrita Lubis[1], Putri Chairani Eyanoer[2]

[1]Radiology Department, Faculty of Medicine, Universitas Sumatera Utara, Indonesia
[2]Internal Medicine Department, Faculty of Medicine, Universitas Sumatera Utara,, Indonesia
[3]Departement of Community Medicine, Public Health, Faculty of Medicine, Universitas Sumatera Utara,, Indonesia
*Correspondence: hafizhalailaammar@gmail.com

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Abstract

Background: Renal size and volume play important roles in the diagnosis, treatment, and evaluation of renal pathology, and are excellent predictors of renal function. Renal size is associated with somatic growth parameters such as height, weight, and age, which are related to body mass index and body surface area. **Objective**: The aim of this study is to determine renal volume in the adult population using ultrasound and to analyze factors affecting the renal volume in patients. **Methods**: This was a case-series study of 35 renal in adult patients aged from >19 to 59 years without renal pathology. Renal length, width, depth, mean volume, and cortical thickness were sonographically measured. Patient age, gender, weight, height, and body surface area were recorded. **Results**: The mean body weight, body height, and body surface area were 69.8 ± 18.6 kg, 159.7 ± 8.1 cm, and 1.7 ± 0.2 m^2, respectively. There was a significant difference in mean renal volume between the right and left renal, with measurements of 107 ± 30,9 cm^3 and 125,5 ± 27,8 cm^3, respectively. The mean renal volume in male was 118,4 ± 37,2 cm^3 and 137,2 ± 32,6 cm^3 for the right and left sides, respectively, and was found to be larger than in females. Both renals had a mean cortical thickness of 1.3 ± 0.1 cm. There was a positive and significant correlation between renal volume and body surface area ($r=0.805$ for the right renal, and $r=0.604$ for the left renal) with $p<0.001$. **Conclusions**: Renal volume is positively and significantly correlated with body surface area. Body index, age, gender, and side should also be taken into consideration when reporting renal volume.

Keywords: ***Ultrasonography, Renal Volume, Body Surface Area***

INTRODUCTION

Multiple renal pathologies such as nephrolithiasis, hydronephrosis, chronic renal diseases, renal tumors, renal vascular disease, urinary tract disease, and end-stage renal disease alter renal size and shape, making variations in renal dimensions a diagnostic feature for these conditions.[1-3] Changes in renal size and volume are crucial for diagnosis, treatment, and evaluating renal pathology.[4] Alterations in renal size can indicate decreased in renal function and used to determine an individual's health, as well as identify renal abnormalities.[5] Renal dimensions can be assessed using radiological modalities, with ultrasound offering several advantages over others. It is non-ionizing, non-invasive, cost-effective, requires minimal or no patient preparation, and does not involve medications or contrast agents.[4,6,7] Ultrasound is a simple technique, that can be performed at the patient's bedside, providing detailed anatomical information with low interobserver variability of the renal. It is preferred for locating the renal, measuring their dimensions, detecting focal lesions, and is often the first choice for screening and follow-up in both patients and healthy individuals.[2,8,9] Renal volume is more sensitive in detecting pathologies compared to renal length and is considered an excellent predictor of renal function.[3,10,11] Renal dimensions are associated with somatic parameters like height, weight, age, body mass index (BMI), and body surface area (BSA).[2,12,13] Factors such as gender, pregnancy, body habitus, and comorbid conditions can also affect renal size.[5,14] Additionally, ethnicity and glomerular filtration rate (GFR) can influence renal parenchymal volume.[15]

Literature reviews show that an increased BMI is linked to larger renal size, highlighting the importance of considering anthropometric measurements when detecting renal pathologies.[2] Since renal size is influenced by various factors, and previously available information may not be applicable to all populations due to differences in ethnicity and body size, it is essential to establish normal renal measurement values for specific populations.[2,16]

MATERIALS AND METHOD

Patients and Clinical Assessment

A total of 35 consecutive adult patients between 19 to 59 years of age were includeded in this case-series study. Participants were referred for ultrasound examination at the Department of Radiology, Dr. Pirngadi Hospital, Medan, Sumatera Utara, Indonesia between November and December 2022. Institutional ethical approval was obtained for the study protocol, and written informed consent was taken from all participants. Study inclusion criteria were adult patients with no history of renal pathology and normal results of renal ultrasonography. Patients with underlying diseases such as hypertension, diabetes mellitus, symptoms suspicious for renal pathology, or a history of renal pathologies, such as acute or chronic kidney disease, prior renal surgery, renal trauma, or any abnormal findings on ultrasonography, such as renal stones, renal cysts, hydronephrosis, renal masses, and increased parenchymal echogenicity, pregnant women, and smoker or history of smoking were excluded from the study.

Patient age, gender, weight, height, and BSA were recorded. BSA was calculated using the D. Du Bois dan E. F. Du Bois formula:

$$\textbf{BSA (m}^2\textbf{) = weight (kg)}^{0.425} \times \textbf{height (cm)}^{0.725} \times \textbf{0.007184}$$

Sonographic Evaluation

Before proceeding with the ultrasound scanning, a brief history was taken, the procedure was explained to the respondents, and their consent was obtained. All renal scans were performed with a Siemens ACUSON S1000 ultrasound scanner using a 3-6 MHZ curvilinear probe. Images were obtained in transverse and longitudinal views in the supine position for the right renal and oblique position for the left renal. Both arms were raised behind the head to widen the intercostal space and the space between the lower border of the costae and the iliac crest.

Two examiners performed the ultrasonography examination to avoid any inter-observer variation. Renal length, width, depth, and cortical thickness of both renal were measured, and renal volume estimation was obtained using the ellipsoid formula:

$$\textbf{Renal Volume (cm}^3\textbf{) = length (cm) x width (cm) x depth (cm) x 0.523}$$

The renal length was determined by measuring the maximum bipolar dimension (the longest of the renal from superior to inferior pool) in a longitudinal plane, in centimeters (cm). The renal width was measured as the maximum distance between the medial and lateral renal borders of the renal, nearly perpendicular to the longitudinal axis, in cm. The renal depth was measured as the distance between the ventral and dorsal surfaces (from anterior to posterior) of the renal in the transverse plane at the level of renal hilum. Renal cortical thickness was measured from the outer border of the renal cortex to the outer border of the medullary pyramid, in cm.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) 26.0 software package. Parameters were expressed as mean ± Standard Deviation (SD). Pearson correlation coefficients, expressed as (r), were used to evaluate the strength of association between renal volume parameters with BSA parameters. Statistical significance was set at $p<0.05$.

Before conducting the inferential test analysis, a reliability test (Interclass Coefficient Correlation) was carried out to ensure the similarity between examiner results. The test showed a result of 99% for the two variables measured (right and left renal volume). Based on these results, the inferential analysis was continued using one of the measurement data sets.

RESULTS AND DISCUSSION

Result

Of the 35 patients, 16 were male (45,7%) and 19 were female (54,3%). The gender distribution was relatively balanced, aiming to minimize subject variability. The mean age was 34,5 ± 11,2 years, with the largest age group being 30 to 39 years (12 people, 34,3%) and the smallest age group being 50 to 59 years (4 people, 11,4%).

The mean weight, height, and BSA were 70 ± 18,8 kg, 159,6 ± 8,2 cm, and 1,7 ± 0,2 m^2, respectively. Overall, males had a greater body index than females, with a mean weight of 76,9 ± 18 kg, height of 165,9 ± 7,1 cm, and BSA 1,8 ± 0,2 m^2. The age range of 30 to 39 years had the largest BSA, with 1,7 ± 0,2 m^2 (Table 1).

Table 1. Demographic characteristics of subject

Characteristic		Frequency n	Frequency (%)	Mean ± Standard Deviation
Age (Years)				34,5 ± 11,2
19 – 29		11	31,4	
30 – 39		12	34,3	
40 – 49		8	22,9	
50 – 59		4	11,4	
Gender				
Male		16	45,7	
Female		19	54,3	
Body Index				
Weight (Kg)				70 ± 18,8
Height (cm)				159,6 ± 8,2
Body Surface Area (m^2)				1,7 ± 0,2
Renal Size Measurements				
Right Renal	Length (cm)			9,9 ± 0,7
	Width (cm)			4,4 ± 0,6
	Depth (cm)			4,5 ± 0,5
	Volume (cm^3)			107 ± 30,9
	Cortical Thickness (cm)			1,3 ± 0,1
Left Renal	Length (cm)			10 ± 0,7
	Width (cm)			4,9 ± 0,5
	Depth (cm)			4,7 ± 0,4
	Volume (cm^3)			125,5 ± 27,8
	Cortical Thickness (cm)			1,3 ± 0,1

n-sample size, Kg-Kilogram, cm-centimeter, m^2-square meter, cm^3-cubic centimeter.

Renal size was affected by side, with the left renal dimension being larger. The overall mean right renal length was 9,9 ± 0,7 cm, mean right renal width was 4,4 ± 0,6 cm, mean right renal depth was 4,5 ± 0,5 cm, and mean right renal cortical thickness was 1,3 ± 0,1 cm. The mean left renal length was 10 ± 0,7 cm, mean left renal width was 4,9 ± 0,5 cm, mean left renal depth was 4,7 ± 0,4 cm, and mean left renal cortical thickness was 1,3 ± 0,1 cm. Mean renal volume was 107 ± 30,9 cm^3 on the right side and 125,5 ± 27,8 cm^3 on the left side, indicating that the left renal volume was larger than the right (Table 1).

[redacted]

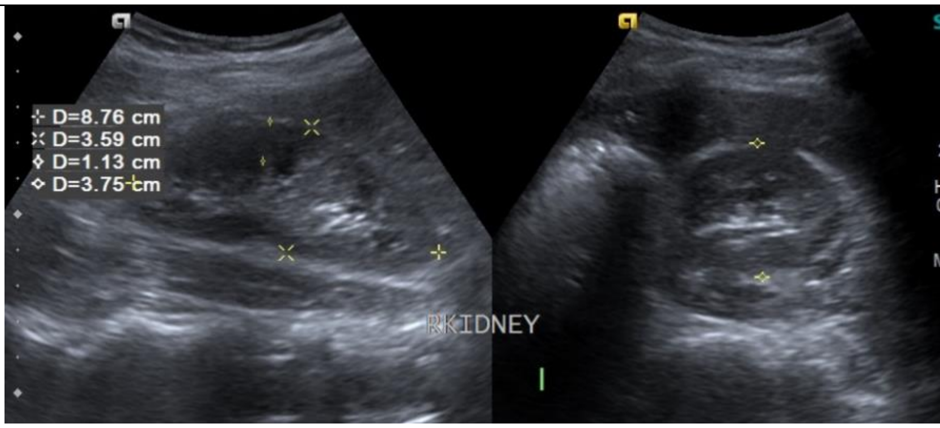

Figure 1. Measuring the smallest right renal volume of a female subject with a body surface area of 1.3 m^2. (a) Longitudinal axis measures of renal length, width, and cortical thickness, and (b) Transverse axis measures of renal depth.

[redacted]

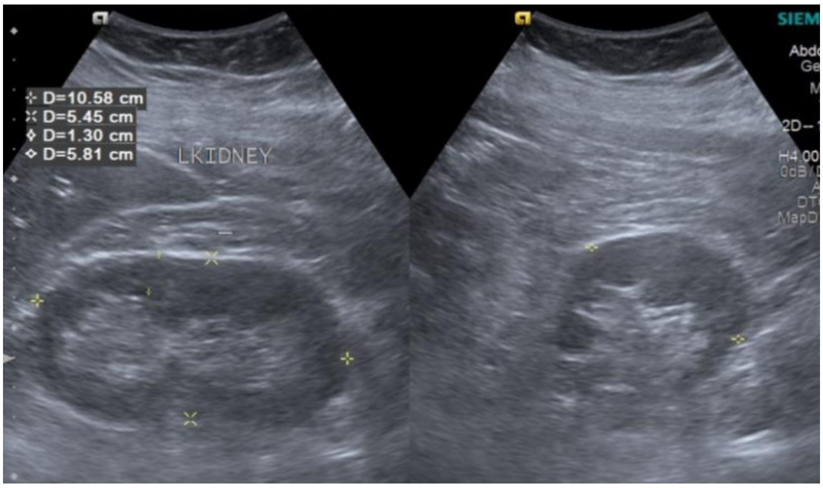

Figure 2. Measuring the largest left renal volume of male subject with a body surface area of 2.3 m^2. (a) Longitudinal axis measures of renal length, width, and cortical thickness, and (b) Transverse axis measures of renal depth.

In the male population, the mean right renal length, width, and depth were 10 ± 0,8 cm, 4,6 ± 0,7 cm, and 4,7 ± 0,6 cm, respectively, while the left renal dimensions were 10,3 ± 0,8 cm, 5,1 ± 0,5 cm, and 4,8 ± 0,5 cm, respectively. In the female population, the mean right renal length, width, and depth were 9,7 ± 0,7 cm, 4,2 ± 0,4 cm, and 4,3 ± 0,3 cm, respectively, with the left renal measurements being 9,8 ± 0,6 cm, 4,7 ± 0,4 cm, and 4,6 ± 0,4 cm, respectively. The mean renal volumes were 118,4 ± 37,2 cm^3 for the right and 137,2 ± 32,6 cm^3 for the left in males, and 97,4 ± 21,1 cm^3 for the right and 115,6 ± 18,7 cm^3 for the left in females. Overall, males exhibited larger renal dimensions than females, and the left renal was larger than the right in both genders (Table 2).

Table 2. Gender and mean renal dimensions

Parameters		Male	Female
Right Renal	Length (cm)	10 ± 0,8	9,7 ± 0,7
	Width (cm)	4,6 ± 0,7	4,2 ± 0,4
	Depth (cm)	4,7 ± 0,6	4,3 ± 0,3
	Volume (cm^3)	118,4 ± 37,2	97,4 ± 21,1
Left Renal	Length (cm)	10,3 ± 0,8	9,8 ± 0,6
	Width (cm)	5,1 ± 0,5	4,7 ± 0,4
	Depth (cm)	4,8 ± 0,5	4,6 ± 0,4
	Volume (cm^3)	137,2 ± 32,6	115,6 ± 18,7

Renal dimensions progressively increased with age, peaking between 18 and 39 years, before declining at age of 60. The 40 to 49 age group had the largest right renal volume (110.7 ± 17.5 cm³), while the 19 to 29 age group had the largest left renal volume (132.4 ± 37 cm³) (Table 3).

Table 3. Age distribution and mean renal dimensions

Parameter		19 - 29 Years	30 - 39 Years	40 - 49 Years	50 - 59 Years
Right Renal	Length (cm)	9,7 ± 0,8	10,2 ± 0,8	9,6 ± 0,5	9,8 ± 0,6
	Width (cm)	4,6 ± 0,9	4,4 ± 0,4	4,3 ± 0,4	4,3 ± 0,2
	Depth (cm)	4,3 ± 0,3	4,4 ± 0,6	4,8 ± 0,5	4,4 ± 0,5
	Volume (cm^3)	106,4 ± 38,7	108,7 ± 35,6	110,7 ± 17,5	96,6 ± 17,9
Left Renal	Length (cm)	9,9 ± 1,1	10,3 ± 0,7	9,7 ± 0,4	10,2
	Width (cm)	5,1 ± 0,6	4,7 ± 0,4	5,2 ± 0,3	4,5 ± 0,2
	Depth (cm)	4,8 ± 0,4	4,7 ± 0,4	5 ± 0,4	4,4 ± 0,2
	Volume (cm^3)	132,4 ± 37	122,5 ± 26,3	127,2 ± 21,3	112 ± 12,6

Body surface area has a positive correlation with renal volume (Pearson correlation (r) = 0.805 for the right renal and (r) = 0.604 for the left renal, Table 4). This relationship was statistically significant (P<0.05).

Table 4. Correlation of renal volume with Body Surface Area.

Parameters	Body Surface Area (BSA)	
	Correlation Coefficient (r)	P-value
Right Renal Volume	0,805	0,01
Left Renal Volume	0,604	0,01

Discussion

Renal dimension, including renal length and volume, are important diagnostic parameters in medical practice. These dimensions are influenced by various factors, necessitating the establishment of normative standard based on body index, age, gender, and ethnicity.[17] Ultrasonography is commonly used imaging method for visualizing normal renal anatomy, having largely replaced other modalities due to its simplicity and non-invasive nature in estimating renal size. Standard parameters used in routine renal ultrasonography include renal length, width, depth, and parenchymal thickness. Renal volume is regarded as the most precise indicator of renal size due to its strong correlation with renal mass.[3,17-20]

However, ultrasonography has some limitations, such as variations in observer skill and interpretation. It can be affected by the variability in subject cooperation, position, and hydration status.[21] Additionally, ultrasonography often underestimates actual renal size due to challenges in locating the maximum plane of bipolar renal length or movement during respiration. Being an operator-dependent procedure, there's a chance that some measurements may not align parallel to the renal axis. Moreover, factors such as overlying bowel gas, surrounding tissues, or obesity can hinder the clarity and accuracy of ultrasound visualization and renal demarcation.[3]

In this study, the left renal was consistently larger than the right in all dimensions, aligning with the findings of most other research.[3,6,16,17,22-25] This may be due to the smaller size of spleen compared to the liver, and the position of the liver in the upper right abdomen, which restricts the vertical growth of the right renal because of the lesser space.[6,17,22,25,26] Moreover, the left renal artery is shorter and straighter than the right, increasing blood flow and potentially resulting in a relatively larger renal volume.[6,17,22,25] Schoner's research also indicates that the left renal artery has a wider caliber than the right, which may contribute to the increased renal volume.[27]

The renal dimension recorded in this study, including renal length, width, and depth, are relatively similar to those found in a study by Arooj et al. in Malaysia. However, these values are lower than those reported by Maaji et al. in India and Rathore et al. in Nigeria.[21,25,28]

Renal volume is more effective in identifying renal pathologies than single linear measurements due to the significant variation in renal shape and its strong correlation with renal function and mass.[1,3] In an autopsy study by Widjaja, renal volume was found to correlate well with the number of functional nephrons, albeit observed indirectly.[20] The mean renal volume was 125.5 ± 27.8 cm³ for the left renal, higher than the right renal 107 ± 30.9 cm³. These values are relatively similar to those reported in Northwest Nigeria by Maaji et al. and in Pakistan by Raza et al. However, the values from this study are lower than those reported in North Central Nigeria (Kolade-Yunusa and Mamven), Turkey (Okur et al.), India (Rathore et al.), and Makassar, Indonesia (Zain et al.), and higher than those obtained in Saudi Arabia (Musa and Abukonna) and Malaysia (Arooj et al.).[6,17,21,25,26,28,29] A comparison of renal sizes based on previous studies is presented in Table 5.

Renal length is an effective predictor of renal size, exhibiting lower interobserver variation compared to renal volume, thus simplifying and streamlining the examination process.[3,18,23,24,28] The mean renal length recorded in this study was relatively similar to findings from studies in Jamaica by Barton et al., in Nepal by Yadav et al., and in Malaysia by Zaiki et al. However, it is lower than values reported in southeastern Nigeria by Okoye et al., in Taiwan by Su et al., and in Denmark by Emamian et al.[17,18,30-33] Arooj et al. compared renal sizes between the Malaysian population and the Caucasian population (studies by McMinn and Williams et al.) and found that the Caucasian population has larger renal lengths, up to 2 cm greater than those of the Malaysian population.[21]

Table 5. Comparison of renal parameters with other studies

Parameters	Population	n	Renal Side	Length (cm)	Width (cm)	Depth (cm)	Volume (cm³)
Kolade-Yunusa dan Mamven[17]	Nigeria	780	Right	10,1 ± 0,8	4,1 ± 0,6	6,4 ± 0,9	139 ± 34,2
			Left	10,7 ± 6,0	4,7 ± 0,8	6,5 ± 0,8	173,7 ± 13,5
Okur et al.[6]	Turki	152	Right	10,3 ± 7,8	-	-	158 ± 39
			Left	10,4 ± 9	-	-	168 ± 40
Kang et al.[3]	Korea Selatan	125		11,08 ± 0,96	6,25 ± 0,67	4,73 ± 0,65	158,7 ± 62,9
Rathore et al.[28]	India*	151	Right	10,86 ± 1,12	5,13 ± 0,77	4,73 ± 0,95	137,54 ± 34,48
			Left	11,02 ± 1,13	5,21 ± 0,75	4,65 ± 0,84	138,22 ± 29,81
Emamian et al.[22]	Denmark	665	Right	10,9	5,7	4,3	134
			Left	11,2	5,8	4,6	146
Hammad[34]	Arab Saudi	100	Right	10,32 ± 0,69	5,07 ± 0,68	4,94 ± 0,84	130,82 ± 36,6
			Left	10,77 ± 0,87	5,16 ± 0,90	4,46 ± 0,69	127,56 ± 32,4
Zain et al.[26]	Makassar, Indonesia	59	Right	-	-	-	120.07±33.74
			Left	-	-	-	126.4 ± 30.39
Present study	Medan, Indonesia	36	Right	9,9 ± 0,7	4,4 ± 0,6	4,5 ± 0,5	107 ± 30,9
			Left	10 ± 0,7	4,9 ± 0,5	4,7 ± 0,4	125,5 ± 27,8
Raza et al.[24]	Pakistan	4035	Right	10,16 ± 0,89	4,27 ± 0,71		99,8 ± 37,2
			Left	10,27 ± 0,92	4,76 ± 0,7		124,4 ± 41,3
Maaji et al.[25]	Nigeria	104	Right	11,3 ± 8,8	4,4 ± 0,71	4,7 ± 0,67	109,6 ± 29,3
			Left	11,6 ± 9,8	5,2 ± 5,26	4,5 ± 0,68	119,7 ± 32,8
Musa dan Abukonna[29]	Arab Saudi	125	Right	9,8 ± 0,9	4,9 ± 0,7	4 ± 0,7	90,84 ± 1,1
			Left	10,7 ± 0,3	3,5 ± 0,7	4,3 ± 0,7	93,35 ± 1,5
Arooj et al.[21]	Malaysia	100	Right	9,7 ± 0,79	3,8 ± 0,52	3,8 ± 0,57	71,5 ± 18,84
			Left	9,9 ± 0,96	4,4 ± 0,59	4,3 ± 0,79	93,6 ± 27,76

*meassuring the sample using CT scan

Variations in renal dimensions can be attributed to differences in the physical characteristics of diverse populations. In this study, the mean body index recorded were 70 ± 18.8 kg for weight, 159.6 ± 8.2 cm for height, and 1.7 ± 0.2 m² for BSA, which differ from those reported in other studies, such as in Nigeria by Kolade-Yunusa and Mamven, and in South Korea by Kang et al.[3,17] Renal dimension differences can also be attributed to environmental, genetic, and nutritional factors. Environmental conditions, nutrient availability, and food intake can influence growth rates, which are related to an individual's weight and height. Chao-Qiang Lai, a molecular biologist, noted in Arooj et al.'s study that genetic backgrounds and distinct environments (climates, dietary habits, and lifestyles) of ethnic groups are primary reasons for variations in height heritability.[3,17,21,25,31]

Previous studies have also shown that renal length varies by country and race. Data from European and American populations are not universally applicable due to their generally greater height and weight compared to other ethnicities, such as Asians. Therefore, it is essential to determine normal values for each region.[3,17,18,21,25] Renal cortical thickness was measured as the distance between the renal capsule and the outermost boundary of the medullary pyramid (base of the pyramid). While the thickness of the renal cortex can vary, it is typically greater than 1 cm, with a mean thickness ranging from 1 to 1.5 cm.[35,36,37,38,39,40] In this study, the mean renal cortical thickness was recorded at 1.3 ± 0.1 cm for both renals. This result is similar to Hammad's study in Saudi Arabia, which found mean cortical thicknesses of 1.23 ± 0.15 cm and 1.34 ± 0.23 cm for the right and left renal, respectively.[34] However, this value is lower compared to other studies. Renal cortical thickness decreases linearly with age, as aging causes cortical reduction and medullary enlargement, leading to renal cortex atrophy and a decline in renal function.[31,39,41]

Regarding of gender, male renal volume was found larger than that of female, consistent with previous studies.[16,17,23,25,28] Gender differences in renal size can be attributed to disparities in body index, with height and weight being independent factors of renal size.[17] Males generally have greater body index (height, weight, body surface area, and total body water), as well as larger renal size, weight, and volume compared to females.[3] Additionally, males generally participate in more physical activity, which leads to an increase in the diameter of the renal arteries and subsequently results in enhanced blood flow to the kidneys.[42,43] Age is also an important factor, as the anatomy and physiology of the human body change with aging, and influencing renal size. Earlier research has identified a significant correlation between renal volume and age (correlation coefficient 0.997, $p < 0.001$).[25] In this study, renal volume by age showed relatively consistent values in the age ranges of 19 to 49 years, and a decrease observed in the 50 to 59 years range. Similar findings have been reported in other studies.[16,17]

Raza et al. reported that the kidneys reach their mature size between the ages of 20 and 29 years and remain relatively unchanged until the sixth decade of life.[24] Essentially, renal dimensions remain stable between ages of 30 to 60, but a noticeable decrease in size is occurs in older age groups.[22.25] According to McLachlan and Wasserman, cited in the study of Kolade-Yunusa and Mamven, there is a decrease of about 0.5 cm per decade in renal size starting from the fifth decade of life. This reduction is due to a 1% decrease in blood flow per year after the third decade, leading to a progressive decrease in renal size with age.[17] Additionally, the diameter of renal arteries becomes smaller with age, associated with a reduction in blood vessel size and increased vascular stiffness.[42,43]

The reduction in renal volume with age can be linked to cellular aging, glomerulosclerosis, tubulointerstitial fibrosis, vascular collapse, and thickening. Additional contributing factors include oxidative stress and changes in cytokines and growth factors.[25] As age increases, the renal parenchyma decreases while renal sinus fat increases.[36] Melk and Halloran state that by the age of 70, there is a 30 to 50% atrophy of the glomerular cortex, leading to a progressive loss of renal mass.[44] Furthermore, aging increases the prevalence of comorbid diseases affecting renal conditions, such as diabetes mellitus and hypertension. According to Riskesdas 2018, the highest prevalence of diabetes mellitus diagnosis is found in the 55 to 64 years age range (6.3%). For hypertension, the prevalence increases with age, with the highest prevalence found in those over 75 years old (69.5%).[45]

This study demonstrated a strong positive correlation between renal volume and BSA. Similar findings were reported by Kolade-Yunusa and Mamven, with correlation coefficients of 0.72 for the right renal and 0.90 for the left renal).[17] A study in children by Mansour et al. also found a positive correlation with BSA with correlation coefficients of 0.605 for the right renal and 0.553 for the left renal.[46] Another study that compared the correlation of renal size with multipel body indices, such as height, weight, BSA, and body mass index, found that BSA had the strongest correlation (correlation coefficient 0.576; $p<0.001$).[47] According to Saeed et al., BSA proved to be the most accurate measure of renal size in their research, given that organ size is undoubtedly linked to body size. They also concluded that body habitus and physical characteristics are the main predictors of renal size in healthy adults. Anthropometric measurements can determine renal size in healthy individuals, although some parameters may have a greater impact than others.[47] BSA is positively related to both total glomerular volume and metabolic rate.[3]

Arooj et al. observed a strong positive correlation between both of weight and height with renal size, indicating that higher weight or height corresponds to larger renal size. It is a fact that the development of our organs, such as renal, progress linearly with the body. Their results also showed that renal size at the same weight and height can differ among different ethnicities.[21] Given that renal size correlates with body index, it is proposed that body index is the most practical and straightforward method for estimating renal size, aiding in treatment decisions concerning renal disease.[3]

CLOSING

Conclusion

In conclusion, we have determined the normal values for renal dimensions in our adult population, with key parameters being age, gender, side, and body index, such as height, weight, and BSA. Our results indicated that renal dimensions were larger on the left side, larger in males, and tended to decrease with age. A significant positive correlation was found between renal volume and body surface area.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

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