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Cross-Sectional Study of Ultrasonographic Assessment of Renal Volume and Its Correlation with Basal Metabolic Index

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ABSTRACT

Objective: To find the relationship between BMI and renal volumes in patients in a private tertiary care hospital who have no prior history of renal disease.

Methodology: This six-month cross-sectional study, conducted at the Department of Diagnostic Radiology, Shifa International Hospital in Islamabad, involved 310 participants in total. In this study, participants between 18 and 70 years of age with no history of renal disease were chosen. Using ultrasonography, the volumes of both kidneys were measured and correlated with BMI.

Results: The mean value of the right renal volume was 88.7 cm3 with 15.7 SD, while the left renal volume had a mean value of 95.3 cm3 with 16.5 SD. The calculated correlation coefficients between the right renal volume and BMI were 0.947 (P=0.001) and the left renal volume and BMI was 0.911 (P=0.001), suggesting a strong and statistically significant positive correlation between the renal volumes obtained by ultrasonography and BMI.

Conclusion: This study found a strong statistically significant positive correlation between BMI and renal volumes as determined by ultrasonography.

Keywords: Renal Volume, Basal Metabolic Index, Metabolism, BMI, Ultrasonography

Authors' Contribution:
[1,2]Conception; Literature research; manuscript design and drafting; [3,4] Critical analysis and manuscript review; [5,6]Data analysis; Manuscript Editing.

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Introduction

One of the most important factors in the diagnosis, management, and assessment of renal disease is the measurement of renal size. Renal length, renal volume, and cortical thickness are the most often used parameters for estimating renal size.[1] Ultrasonography (USG) is frequently used to evaluate renal dimensions due to its accessibility, non-invasiveness, and ease of repeatability. For the clinical assessment of disorders such as diabetes mellitus, renal artery stenosis, and chronic kidney diseases, kidney volume is a crucial measure.[2] It is also a crucial clinical criterion for kidney transplant follow-up patients. Compared to other measures, renal volume is thought to be a more sensitive indicator of renal mass. In addition, anthropometric measures (weight and height), sex, body size, basal metablic index (BMI), and ethnicity all affect renal capacity.[3,4]

In a study conducted by Karim SH, et al. It was found that the average right renal size in men was 76553.9947mm3, while in women it was 68324.029mm.[3] The right kidney's volume and BMI were shown to be positively and significantly

correlated (r=0.241, P<0.05) . In males, the mean left renal volume measured 94493.9 mm3, while in females it was 84150.43264 mm3. The left kidney's volume and BMI were shown to be positively and significantly correlated (r=0.302, P<0.05). Renal volume may serve as a marker for declining kidney mass and function.[5] Renal volume measurements help in distinguishing upper from lower urinary tract infections and are valuable for monitoring unilateral kidney disease by allowing comparison with the other kidney. Normal renal volume changes with BMI, and in order to distinguish between pathological and normal causes of volume variations, it must be measured in accordance with BMI. Since renal sizes can vary among ethnic groups and geographical regions, it may not be possible to extrapolate data from other geographic regions to our population.[6,7] The purpose of this study is to evaluate the relationship between kidney volumes and BMI in the local community. In a private tertiary care hospital in Islamabad, Pakistan, the main goal is to ascertain the relationship between renal volumes and BMI in patients without a history of renal illness. This will assist medical professionals in discerning between volume differences caused by healthy processes and those caused by diseases.

Methodology

This cross-sectional study was performed over the course of six months (12-6-2020 to 11-12-2021). For this purpose, a total of 310 patients were recruited via non-probability consecutive sampling at the Department of Diagnostic Radiology, Shifa International Hospital, Islamabad. Before conducting the study, ethical approval letter was obtained from the Institutional Review Board and Ethics Committee, Shifa International Hospital. An informed consent was obtained from the patients before enrollment. The sample size was calculated via WHO sample size calculator using the following parameters: Level of significance 5%, Power of the test 99%, Estimated sample correlation (r) 0.241%[8]. The inclusion and exclusion criteria for enrolling patients is given in Table I.

Table I. Inclusion and Exclusion criteria for selection of participants in the study

Inclusion criteria	Exclusion criteria
• Individuals without any history of known renal disease (No H/O of pain in lumbar region, normal RFTs, Normal kidneys on USG) • Individuals within age (chronological) range 18 to 70 years • Both gender	• Individuals who are diabetics and on anti-diabetic medication • Individuals who are hypertensive and on anti-hypertensive medication • Individuals who had history of any renal surgery • Individuals with H/O any other chronic ailment. • Individuals with H/O taking nephrotoxic medicines for any previous ailment • Individuals with H/O urolithiasis • Individuals with H/O renal congenital anomalies • Individuals with H/O of bladder outlet obstruction • Males with H/O benign prostate hypertrophy • Pregnant females

Individuals fulfilling the inclusion criteria were included in the study and were taken from the outpatient department of Hospital. Informed consent was obtained. After enrolling the individuals age, height and weight was recorded and BMI was calculated. All individuals underwent ultrasonographic measurements of renal volumes of both kidneys in supine position.

Data was analyzed via SPSS version 26. Quantitative variables like age, weight, height, BMI and renal volumes were expressed as mean ± standard deviation. Qualitative variables like gender were expressed in frequency and percentages.

Correlation between BMI and right and left renal volumes was measured by calculating Pearson correlation coefficient (r). *P*-value ≤ 0.05 was considered as significant. Effect modifiers like patient's age and gender were controlled by stratification. Post stratification correlations were calculated. *P*-value ≤ 0.05 was considered as significant.

Results

The age range of patents was 18 to 70 years old. The patients' mean age was 40.6±11.9 years. 135 females (43.5%), and 175 males (56.5%) were present. Majority of the patients belonged to 18-45 years of age (70.3%) whereas 29.7% belonged to 46-70 years of age. The mean BMI was calculated as 27.7±6.2 Kg/m^2. The mean right renal volume was 88.7±15.7 cm^3 and the mean left renal volume was calculated as 95.3±16.5 cm^3. The mean values of quantitative variables are summarized in Table II.

Table II. Mean of weight (kg), height (m), BMI (kg/m^2), left renal volume (cm3) and right renal volume (cm3).

	MEAN	STD. DEVIATION	p-value
Age (years)	40.6	11.9	<0.001
WEIGHT (Kg)	72.9	14.1	
HEIGHT (m)	1.62	0.08	
BMI (Kg/m^2)	27.7	6.2	
Right Renal Volume (cm^3)	88.7	15.7	
Left Renal Volume (cm^3)	95.3	16.5	

Renal volumes and BMI were correlated using the Bivariate Correlations procedure, assuming both variables followed an approximate normal distribution. Pairwise associations were then calculated for each set of variables and Pearson correlation coefficient (r) was calculated.

Table III. Correlation between BMI and right renal volume.

Correlations

		BMI	Right Renal Volume
BMI	**Pearson Correlation**	1	.947**
	Sig.		0.001
		310	310
Right Renal Volume	**Pearson Correlation**	.947**	1
	Sig.	0.001	
		310	310

**. Correlation is significant at the 0.001 level.

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Table IV. Correlation between BMI and left renal volume.

Correlations

		BMI	Left Renal Volume
BMI	**Pearson Correlation**	1	.911**
	Sig.		.000
		310	310
Left Renal Volume	**Pearson Correlation**	.911**	1
	Sig.	.000	
		310	310

**. Correlation is significant at the 0.001 level.

The correlation coefficient calculated was 0.947 (P<0.001) between right renal volume and BMI (Table III) and it was 0.911 between left renal volume and BMI (P<0.001), as shown in Table IV, implying that there is a significant and strong

positive correlation between renal volumes measured through Ultrasonography and BMI.

Discussion

A total of 310 participants between the ages of 18 and 70 who had no prior history of renal disease were included in the study. Using ultrasonography, the volumes of both kidneys were measured and associated with BMI. According to our findings, the mean value of the right renal volume was 88.7 cm3 with 15.7 SD, while the mean value of the left renal volume was 95.3 cm3 with 16.5 SD. The estimated correlation coefficients between the right renal volume and BMI were 0.947 (P=0.001) and the left renal volume and BMI was 0.911 (P=0.001), suggesting a strong and statistically significant positive association between the renal volumes obtained by ultrasonography and BMI. Our findings are consistent with previously released studies on the topic. In research by Maaji et al., 104 adult volunteers who were free of renal disease received renal ultrasonography measures. Renal measures comprised renal volume, thickness, breadth, and length. The average kidney volumes were 109.6 ± 29.3 cm3 for the right kidney and 119.7 ± 32.8 cm3 for the left kidney. The subject group's average weight was 70.9 ± 11.2 kg, and their average height was 1.67 ± 0.85 m. For both genders, the average BMI was determined to be 26.0 ± 5.36 kg/m2 and 25.1 ± 3.96 kg/m2, respectively.[9] Renal volume and BMI were shown to be positively correlated when the Pearson correlation test was used to examine the association between renal measures and body indexes. In order to quantify the renal volume and link it with various body indexes, Rathore et al. studied 84 renal donors. Their findings showed a significant correlation between BMI and renal volumes.[10] A total of 194 patients, aged 13 to 80 without renal disease, were recruited by Buchholz et al. and ultrasonographically examined to ascertain the renal dimensions and their relationship to age, sex, and BMI. Renal dimensions comprised cortical thickness, renal breadth (transverse axis), and renal length (distance between poles). The kidney's dimensions were calculated using the length-width-cortical thickness formula. The kidneys measured 76.16 ± 21.7 cm3 on average. A recent study demonstrated a significant relationship between renal size and BMI as well as a proportional rise in renal size with rising BMI in obese children.[11] Tatar et al. examined the connection between BMI and renal volume in kidney donors who were either obese or not. Utilizing computed tomography, renal volume was investigated in 82 kidney donors; the study group's mean renal volume was 196 ± 36 cm3. The study group's average body mass index (BMI) was 28 ± 4.2 kg/m2, with 32.9% of them being obese. Renal volume and BMI were shown to be highly linked [12]. In an additional investigation, Karim SH, et al. found that the average right renal size in men was 76553.9947mm, while in women it was 68324.029mm3. The right kidney's volume and BMI were shown to be positively and significantly correlated ($r=0.241$, $P<0.05$). In males, the mean left renal volume measured 94493.9 mm3, while in females it was 84150.43264 mm3. The left kidney's volume and BMI were shown to be positively and significantly correlated ($r=0.302$, $P<0.05$).[8]

In a different study, Uchenwa and colleagures determined the relationship between renal dimension and body mass index in a population of 450 children (6-12 years of age) in Nigeria. They reported a significant positive association between BMI and renal dimensions, indicating that renal length and volume increased annually by 1.372 mm and 1.951 cm^3, respectively. Furthermore, for each percentile increase in BMI, renal length and volume were found to grow by 0.067 mm and 0.176 cm^3, respectively.[13] However, there are studies that have demonstrated that BMI is not an excellent indicator of body composition and sometimes have found to have very little effect in relation to renal volume. A study conducted in Taiwan comprising over 7357 patients between the ages of 20 and 85 years of age

investigated the relationship between BMI categories and renal function deterioration. A higher prevalence of male sex, diabetes mellitus (DM), and hypertension was observed among overweight and obese chronic kidney disease (CKD) patients, whereas underweight CKD patients showed a greater prevalence of cancer. Additionally, individuals with a BMI less than 18.5 kg/m² demonstrated a non-significant trend toward higher rates of eGFR decline across both early and late stages of CKD compared to other BMI categories. They concluded that BMI alone was not able to sufficiently predict renal deterioration and proposed that new appropriate definition of obesity should be established as BMI is not an accurate predictor of body composition.[14] This study is limited to a single centre in Pakistan. Thus, the results produced may not be generalized to the entire population. Moreover, in this study BMI is used as a measure of body composition, however, recently it is being established that BMI does not accurately reflect body fat percentages and individual variations in the body.

Conclusion

In conclusion, the current study found a high correlation between renal volume and BMI, which is consistent with the majority of earlier research. The studies mentioned above made it abundantly evident that there is a substantial correlation between a patient's BMI and kidney volume.

We advise more investigation into the relationship between BMI and renal volumes in patients with diabetes, hypertension, and obesity.

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