

ULTRASONOGRAPHIC STUDY OF HUMAN RENAL VOLUME AND ITS CORRELATION WITH BODY MASS INDEX IN A TERTIARY TEACHING HOSPITAL.

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Abstract

Kidney is a paired organ whose functions include removing waste products from the blood and regulating the amount of fluid in the body. The basic units of the kidneys are called nephrons.

They are situated posteriorly behind the peritoneum on each side of the vertebral column and are surrounded by adipose tissue. Superiorly they are level with the upper border of the 12th thoracic vertebra, inferiorly with the third lumbar vertebra. The kidney continues to grow in size after birth and reaches the near adult size of 10 cm by 12 years of age. Renal size decreases with increasing age among patients older than 60 years. Decrease or increase in kidney size is an important sign of renal disease. Since the change in renal length may be an evidence of disease, it is important that we have normal reference values in relation to their age, gender, height, weight and body mass index and body surface area. In the present study the ultrasonographic assessment of left and right renal volume in different age groups and its relationship with body mass index of individuals was observed.

Keywords: ultrasonography, Renal volume, Body mass index

Introduction

Kidney is a paired organ whose functions include removing waste products from the blood and regulating the amount of fluid in the body. The basic units of the kidneys are called nephrons, which filter the blood and cause wastes to be removed in the form of urine. Together with the bladder, two ureters, and a single urethra, the kidneys make up the body's urinary system.

The kidneys are dark red in color and have a shape in which one side is convex, or rounded, and the other is concave, or indented.

They are situated posteriorly behind the peritoneum on each side of the vertebral column and are surrounded by adipose tissue. Superiorly they are level with the upper border of the 12th thoracic vertebra, inferiorly with the third lumbar vertebra. The right is usually slightly inferior to the left, reflecting its relationship to the liver. The left is a little longer and narrower than the right and lies nearer the median plane.¹

Each kidney on an average is 11 cm in length, 6 cm in breadth and 3 cm in antero-posterior dimension. The left kidney may be 1.5 cm longer than the right; it is rare for the right kidney to be more than 1 cm longer than the left. The average weight is 150 g in men and 135 g in women.

The kidney continues to grow in size after birth and reaches the near adult size of 10 cm by 12 years of age.²

renal size decreases with increasing age among patients older than 60 years³

Decrease or increase in kidney volume is an important sign of renal disease. It indicates loss of kidney mass and kidney function. Renal infections/inflammations, nephrologic disorders, diabetes mellitus and hypertension are the most important co-morbid conditions affecting renal volume. Since the change in renal length may be an evidence of disease, it is important that we have normal reference values in relation to their age, height, weight and body mass index.

Ultrasonography is a cheap, accessible, non-invasive, quicker, convenient, accurate, reliable, repeatable, reproducible investigation. It is an integral part of visualizing the kidney anatomy and estimating its dimensions and has largely replaced conventional radiography as an important tool in clinical evaluation of kidney diseases.

The purpose of this study is to establish a range of values for kidney dimensions on ultrasound and its comparison with anthropometric parameters and body mass index as well as body surface area in different age groups.

Materials and Method

This study was a prospective observational study conducted in MCI recognized private medical college in Western India. The patients who were referred for ultrasonography, both male and female were selected.

The patients following Parameters and anthropometric measures were taken:

Age, Height, Weight

Body mass index: Was calculated by using formula

Weight (kg) / Height (m.sq)

All ultrasounds were done in the department of radio – diagnosis using ACUSON X300 ultrasound machine with convex probe (2-5MHz) and linear probe (5-10MHz).

Selection of cases:

The study population included 1231 individuals who were referred from other departments to the Department of Radiodiagnosis for Ultrasonography.

Inclusion Criteria:

Both male and female, between 21 to 80 years of age

Exclusion Criteria:

Urinary tract infections, History of hypertension, diabetes, malignancy, renal surgeries, renal diseases, renal anomalies and Pregnant females. Patients were also excluded if a valid renal length could not be obtained in at least two of the three imaging planes for both kidneys. This was seen in cases where renal contour was partially obscured by bowel gas and when the renal size was longer than the field of view.

Methods:

Age: The subjects were divided into following groups based on their age:

Table I:

Classification	Age groups	Number of cases (%)
Group 1	21 – 30	169 (25.07)
Group 2	31 – 40	149 (22.10)
Group 3	41 – 50	102 (15.13)
Group 4	51 – 60	77 (11.42)
Group 5	61 – 70	30 (4.45)
Group 6	71 – 80	30 (4.45)

Weight: A portable weighing machine was used to record the weight of the subjects to the accuracy of 0.1 kg⁴. Checking the scale with a known weight was done

frequently. The subject was asked to stand on the platform bare feet without leaning against or holding anything.

Height: To assess the height of the subjects, methods used by Park et al⁴ and Singh R et al⁵ were followed. Subjects were asked to stand erect on a flat surface without shoes and back supported against clean and smooth wall. The subject was instructed to look straight with heel together and toes apart. The researcher stood on the subject's left side and firmly held the chin of the subject with the left hand with a ruler placed horizontally over head of the subject applying pressure to nullify thickness of the hair. This point was then marked on the wall with the help of a pencil.

Body Mass Index (BMI): BMI was calculated by using DeHoog's formula⁶

BMI is a simple index of weight for height that is commonly used to classify underweight, overweight and obesity in adults as per the WHO classification published in 2003⁷.

Renal Morphometry:

Length: Length was measured along the long axis parallel to the psoas major muscle.⁸ In order to provide an accurate long axis measurement of the kidney, both the upper and lower poles were carefully defined with the patient in supine oblique position⁹.

Width: Width was measured at the renal hilum in the transverse section.

Thickness: Thickness was measured as the antero-posterior dimension at the hilum perpendicular to the renal width.

Measurements were made on a freeze-frame image during the real-time examination by manually positioning electronic callipers in the image.

Renal Volume (RV): RV was estimated from 3 orthogonal measurements on the basis of the ellipsoid formula in cubic centimeters:

RV= Length x Width x Thickness x 0.523¹⁰.

Results and observations were tabulated and graphically represented for evaluation and statistical analysis of various parameters.

RESULTS

Table II: Association between BMI and renal volume

Age groups	BMI with left renal volume				BMI with right renal volume			
	Male		Female		Male		Female	
	r value	p value	r value	p value	r value	p value	r value	p value
Group 1	0.04	0.6156	0.19	0.0120	0.04	0.5709	0.15	0.0488
Group 2	0.26	0.0015	0.01	0.9517	0.18	0.0297	0.11	0.1712
Group 3	0.21	0.0336	0.03	0.7314	0.06	0.5720	0.15	0.1252
Group 4	0.07	0.5510	0.03	0.7665	0.11	0.3374	0.02	0.8656
Group 5	0.08	0.6909	0.45	0.0121	0.17	0.3643	0.51	0.0043
Group 6	0.03	0.8708	0.07	0.3698	0.02	0.9098	0.01	0.9732

Pearson's correlation (r) was calculated to see association between BMI with left renal volume and right renal volume. BMI when compared with left renal volume:

70. In group 1, the Pearson's correlation for males was 0.04 which was not statistically significant ($p=0.6156$) and for females, it was 0.19 which was **statistically significant ($p=0.0120$)**.

71. In group 2, the Pearson's correlation for males was 0.26 which was **statistically highly significant ($p=0.0015$)** and for females it was 0.01 which was statistically not significant ($p=0.9517$).

72. In group 3, the Pearson's correlation for males was 0.21 which was **statistically significant ($p=0.0336$)** and for females it was 0.03 which was statistically not significant ($p=0.7314$).

73. In group 4, the Pearson's correlation for males was 0.07 ($p=0.551$) and for females, it was 0.03 ($p=0.7665$) which were statistically not significant.

74. In group 5, the Pearson's correlation for males was 0.08 which was statistically not significant ($p=0.6909$) and for females, it was 0.45 which was **statistically highly significant ($p=0.0121$)**.

75. In group 6, the Pearson's correlation for males was 0.03 ($p=0.8708$) and for females, it was 0.07 ($p=0.3698$) which were statistically not significant.

BMI when compared with right renal volume:

1. In group 1, the Pearson's correlation for males was 0.04 ($p=0.5709$) which was statistically not significant and for females, it was 0.15 which were **statistically significant ($p=0.0488$)**.

2. In group 2, the Pearson's correlation for males was 0.18 which was **statistically significant ($p=0.0297$)** and for females, it was 0.11 which was statistically not significant ($p=0.1712$).

3. In group 3, the Pearson's correlation for males was 0.06 ($p=0.572$) and for females, it was 0.15 ($p=0.1252$) which were statistically not significant.

4. In group 4, the Pearson's correlation for males was 0.11 ($p=0.3374$) and for females, it was 0.02 ($p=0.8656$) which were statistically not significant.

5. In group 5, the Pearson's correlation for males was 0.17 which was not statistically significant ($p=0.3643$) and for females, it was 0.51 which was **statistically highly significant ($p=0.0043$)**.

6. In group 6, the Pearson's correlation for males was 0.02 ($p=0.9098$) and for females, it was 0.01 ($p=0.9732$) which were statistically not significant.

There is a positive correlation between BMI and left renal volume in 4th and 5th decades of life in males. In females positive correlation was seen in 3rd and 7th decades. Similarly a positive correlation between BMI and right renal volume was found in 4th decade in males and in 3rd and 7th decades in females.

Discussion

Emamian SA et al¹¹, Buchholz NP et al¹² and Wykretowicz M et al¹³ reported that BMI increases with increasing

volume. Safak AA et al¹⁴ reported weak correlation of BMI with dimensions.

In the present study there was a positive correlation between BMI and left renal volume in 4th and 5th decades of life in males. In females, positive correlation was seen in 3rd and 7th decades. Similarly, a positive correlation between BMI and right renal volume was found in 4th decade in males and in 3rd and 7th decade in females.

BMI is not used to measure body size because it is actually the definition of body adiposity level. BMI is used to determine whether an individual is obese and to define the level of obesity. BMI ≥ 25 kg/m² indicates tendency towards obesity. Obesity affects renal dimensions and is an independent risk factor for the occurrence of systemic hypertension as well as clinical and pathological progression of renal disease. The kidneys of obese subjects show significant focal glomerulonephrosis and other morphological changes, similar to those observed in patients with diabetic nephropathy. Due to obesity, adipose tissue accumulates around the kidney and the increase of renal matrix occurs, resulting in compression against medulla and the increase of intrarenal haemodynamics, which finally leads to hypertension.

Conclusion

Present study includes a prototype reference table of age and renal dimensions for both sides. There is no such information available for our population. However, validity of this data needs to be established through larger, population-based studies. Such a reference table can be useful for routine evaluations and monitoring of urological and nephrologic diseases. This would help the clinicians to decide the adequate line of treatment.

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