

A POSTMORTEM STUDY ON THE VOLUME OF THE HUMAN KIDNEY

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Abstract:

Context: Kidney volume is a sensitive index of kidney size for the detection of renal abnormalities. It is also excellent predictor of renal function and correlates very well with body indexes. The present study was done on cadaveric specimens to see the age related changes in the volume of the kidney in a Bangladeshi population and to compare with the previous local and foreign studies.

Methods: This cross-sectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, from July 2008 to June 2009, based on collection of 140 post mortem human kidneys from 70 unclaimed dead bodies which were in the morgue under examination in the Department of Forensic Medicine, Dhaka Medical College, Dhaka. All the samples were divided into three age groups including A (10-19 years), B (20-39 years) and C (40-59 years). The length, breadth and thickness of each kidney were measured by using a slide calipers and recorded. Then the volume was determined by using prolate ellipsoid formula i.e. length × breadth × thickness × 0.52.

Results: The volume of the right and left kidneys were found 54.46±4.02 cm³ and 53.15±1.98 cm³ in group A, 78.31±10.41 cm³ and 75.90±8.32 cm³ in group B, 74.47±6.22 cm³ and 73.34±6.80 cm³ in group C. No statistically significant difference was found between the right and the left kidney in any group. However, statistically significant differences were evident between A & B and A & C (P<0.001).

Conclusion: No difference was found in volume between the right and the left kidney in any group. However, kidney volume was found to increase with advancing age in apparently healthy Bangladeshi people.

Key words: Human kidney, volume of kidney.

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Introduction:

The determination of kidney size is important in clinical field, because it can facilitate to make decisions on the management strategy¹. Kidney volume is a more sensitive index of kidney size for the detection of renal abnormalities². It is also excellent predictor of renal function and correlates very well with body indexes³. Furthermore, pre-transplant kidney volume is an independent determinant of the prognosis of the graft kidney⁴. Assessment of the kidney size or volume with advancing age can be performed with autopsy,

ultrasound and computed tomography, in apparently healthy individuals. As with autopsy studies, imaging studies in populations that exclude persons with comorbidity show less decline in the kidney volume with age than the studies that do not have this exclusion⁵. Due to the complexity in kidney shape⁶, the calculation by using ellipsoid formula, however, sometimes tends to underestimate kidney volume^{7,8}. Still we proposed prolate ellipsoid formula for measurement of kidney volume, as it is more convenient and widely used. Moreover, no data are available on volume of

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the kidney in healthy adult Bangladeshi people. Evidence showed that the morphological dimensions of different organs in Bangladeshi population have got variations from those of the western population⁹. Based on collection of cadaveric specimens, the aim of the present study was to see the variation in kidney volume with advancing age in a Bangladeshi population (who were not suffering from known kidney disease) and to compare with previous records of both local and foreign studies.

Methods:

This cross-sectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, from July 2008 to June 2009, based on collection of 140 post mortem human kidneys from 70 unclaimed dead bodies which were in the morgue under examination in the Department of Forensic Medicine, Dhaka Medical College, Dhaka. All the samples were collected from medicolegal cases excluding poisoning, any cutting or crushing injury to the kidneys, kidney found in one side or grossly abnormal in shape/size and from patients suffering from any kidney disease. For convenient description of changes in weight of the kidney in relation to age, the collected samples were divided into three age-groups including A (10-19 years), B (20-39 years) and C (40-59 years), according to Darmady et al.¹⁰ (table-I). The kidney was taken and its outer surface was dried with blotting paper. Then its length, breadth and thickness were measured by using a slide calipers and recorded. Then the volume was determined by using prolate ellipsoid formula i.e. length × breadth × thickness × 0.52 (according to Emamian et al.)¹¹. All data were recorded and processed. The comparison between right and left side was done by unpaired Student's 't' test and the comparison between different groups was done by One-way ANOVA. All the statistical analyses were done by using the SPSS 13.0 version. This study was approved by the Ethical Review Committee of Dhaka Medical College, Dhaka.

Table-I

Age distribution of the samples of the present study (n=140)

Age group	Age limit in years	Number of samples	
		Right Kidney	Left kidney
A	10-19	12	12
B	20-39	43	43
C	40-59	15	15

Results:

The volume of the right and left kidneys were found 54.46±4.02 cm³ and 53.15±1.98 cm³ in group A (10-19 years), 78.31±10.41 cm³ and 75.90±8.32 cm³ in group B (20-39 years), 74.47±6.22 cm³ and 73.34±6.80 cm³ in group C (40-59 years) (table-II, fig. 1). No statistically significant difference was found between the right and left kidneys in any group. However, statistically significant differences were evident between A & B and A & C (P<0.001) (table-II).

Table-II

Volume of right and left kidney in different age group

Age Group	Volume in cm ³		P value
	Right Kidney Mean±SD	Left Kidney Mean±SD	
A (n=12)	54.46±4.02 (45.40-58.12)	53.15±1.98 (48.50-54.90)	>0.10 ^{ns}
B (n=43)	78.31±10.41 (53.60-96.50)	75.90±8.32 (59.10-98.20)	>0.10 ^{ns}
C (n=15)	74.47±6.22 (61.40-87.60)	73.34±6.80 (59.40-87.03)	>0.50 ^{ns}
	P value	P value	
A vs B	<0.001 ^{***}	<0.001 ^{***}	
A vs C	<0.001 ^{***}	<0.001 ^{***}	
B vs C	>0.10 ^{ns}	>0.10 ^{ns}	

Figures in the parentheses indicate range. Comparison between right and left side done by unpaired Student's 't' test and comparison between different age groups done by One-way ANOVA (PostHoc), ns = not significant, *** = significant.

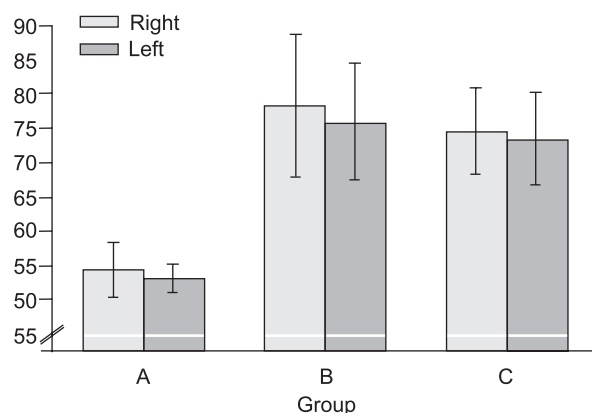


Fig. 1: Volume of right and left kidney in different age group.

Discussion:

Dunnill & Halley¹² examined 68 pair of kidneys aged from birth to 90 years and found the combined volume of the both kidneys at birth about 20 ml. In healthy adults aged 20-25 years it was about 250 ml and in old age the volume declines. According to Rasmussen et al.¹³, there was no demonstrable difference between volumes of right and left kidneys, and no difference in relation to sex. Total renal volume was most accurate when correlated with the body weight and normal values of total renal volume in relation to body weight were found 4.3 to 8.0 ml/kg. Emamian et al.¹¹ examined 665 kidneys of both sexes, aged from 30 to 70 years, in Denmark, and found median renal volume 134 cm³ in the right and 146 cm³ in the left kidney. Besides, they concluded that renal size decreased with age, almost entirely because of parenchymal reduction; however, renal volume correlated best with total body area. Buchholz et al.¹⁴ performed ultrasonographic kidney measurements on 194 adult patients without known kidney lesions (98 male and 96 female) in Pakistan. The mean age was 44.7±14 years (age range 13-80 years) and mean kidney size (*length × width × cortical thickness*) was 76.16±21.7 cm³ (ranging from 36.8 to 138 cm³). They found the average size of the kidneys 70±22 cm³ (right kidney) and 82±24 cm³ (left kidney), with the right kidney being significantly smaller than the left. They also reported that the average size of the right kidneys were 77±22.6 cm³ in male and 63±18.1

cm³ in female, while the average size of the left kidneys were found 90±25.7 cm³ in male and 74±20.3 cm³ in female, where female kidneys were significantly smaller than the male kidneys. Nomasa¹⁵ calculated the volume of the kidney in 442 kidneys in 221 normal children (15 neonates, 45 infants, 82 boys and 79 girls between 1 and 15 years of age) by using three-dimensional ultrasonography in Japan. The renal size ranged from 34.08±5.92 cm³ (right) and 34.58±3.70 cm³ (left) to 119.23±31.07 cm³ (right) and 120.77±25.25 cm³ (left). Cheong et al.⁸ performed a retrospective study on 150 subjects; as measured by MRI, kidney volumes were 202±36 ml for men and 154±33 ml for women. Shin et al.¹⁶ retrospectively reviewed and evaluated the normal kidney volume in 113 young Korean men by using multi-detector computed tomography (MDCT) data; the mean kidney volume was 205.29±36.81 cm³. Raza et al.¹⁷ studied on 4,035 adult Pakistani subjects with normal serum creatinine and without any known renal disease and found the mean renal volume on right 99.8±37.2 cm³ and on left 124.4±41.3 cm³, as left renal size was significantly larger than right in both genders. The values of the present study were more or less similar to Buchholz¹⁴; however, much lower than that of others^{8,11-13,15-17}.

The main disadvantage of autopsy studies for studying normal aging is that the underlying renal pathology may have contributed to the cause of death⁵. Another limitation of the cadaveric study is that measurements obtained from cadavers cannot be considered equivalent to those of living kidneys, because a large volume of blood circulates through a kidney¹⁵.

There is both increased volume of functional glomeruli and decreased glomerular density with aging, as thought to be responsible for shrinkage of kidney size with aging process¹⁸⁻²¹. Unlike, our study revealed that kidney volume increases with advancing age. A compensatory increase of the volume of unaffected nephrons in response to loss of nephrons affected by glomerulosclerosis and tubular atrophy has been suggested²². Besides, an increase in renal sinus fat with age may compensate for the decrease in the kidney

parenchymal volume with age^{11,23}. The difference in size of the kidney i.e. volume of the kidney in different age group or different periods of life may attribute to difference in body surface area or size change in renal mass in relation to age in a specified population²⁴.

Conclusion:

No difference was found in volume between the right and the left kidney in any group. However, kidney volume was found to increase with advancing age in apparently healthy Bangladeshi people. The results of the present study can be used as a standard reference for the kidneys of Bangladeshi people and to determine the abnormal evidences in Forensic and Pathologic corpses. However, further studies with larger samples and comparison between sexes are recommended.

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