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Original Research Article

ESTIMATION OF RENAL LENGTH IN ADULT NORTH INDIAN POPULATION: A CT STUDY

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ABSTRACT

Introduction: Kidney size reflects the health of the kidney. It is affected in a variety of acute and chronic renal diseases. Renal length is used in daily clinical practice to estimate kidney size. It acts as a surrogate for renal size and correlates well with renal function. To recognise the anatomical deviations in renal length it is important to have standard normal values for comparison. Currently, the data used for comparison is based on studies conducted in western population and therefore it is an incorrect representation of adult Indian population. The aim of present study is to determine a normal range of values for renal length in North Indian adult population and its correlation with age, height and body weight.

Materials and Methods: CT scan of 100 normal adult (16 males and 84 females; mean age of 43.5±10.42 years), who were voluntary prospective kidney donors, were analysed. The CT images were taken in axial, coronal and sagittal sections and renal length was measured and it was correlated with age, height and body weight.

Results: It was observed that the mean length of left kidney side was 99.2±9.71 mm and the right side was 95.3±8.47 mm. The left kidney significantly longer than the right kidney (p= 0.0028). In males, the left kidney length was 103.5±7.09 mm and right kidney length was 98.9±7.09 mm (p=0.08). In females the left kidney length was 98.4±9.96 mm and right kidney length was 94.6±8.56 mm (p=0.009). Renal length showed a positive correlation with the height. No correlation was seen with age, body weight and BMI.

Conclusion: In present study it was observed that in North Indian population the renal length was smaller as compared to Western population and it had a positive correlation with only height. This study makes an attempt to define the standard reference values for renal length in Indian population.

KEY WORDS: Renal length, Kidney Size, Chronic renal failure, CT scan.

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INTRODUCTION

Kidney disease is emerging as an important chronic disease globally [1] In India, with a population of more than one billion, the rising incidence of kidney disease is likely to pose major problems for both healthcare and the economy in future years. The size of kidney reflects its health and varies with age, gender, body mass index and pregnancy [2]. Kidney size is affected in variety of clinical disorders such as diabetes, renal artery stenosis, chronic hypertension, and chronic renal failure [3]. Mazzota et al. have observed that most important measurement of renal size is longitudinal renal

length [4]. The knowledge of kidney length in normal population serves as reference for diagnosis of medical and surgical conditions affecting the kidney and to monitor their progress [5].

Ultrasound (USG) is the most frequently used imaging technique to estimate the kidney length as it is a simple and non-invasive method. However, USG tends to underestimate renal length as it observer dependent. Multi-detector computerized tomography (MDCT) has become the most preferred imaging technique to evaluate both kidney size as it is associated with least error compared to other imaging modalities [6].

MATERIALS AND METHODS

This prospective study was conducted in the department of anatomy, King George's medical university (KGMU), Lucknow in collaboration with the department of radio-diagnosis, Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS), Lucknow from August 2014 to July 2015. One hundred consecutive normal healthy adults (16 males and 84 females) who were voluntary kidney donors were the subject of the study. The inclusion criteria for the study were: serum creatinine level <1.5 mg/dl., normotensive at time of clinical evaluation (systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg), no acute or chronic illness which can affect the kidney and no known history of allergy to contrast media. Individuals with history of diabetes mellitus, hypertension and previous surgery for any renal pathology and pregnant women were excluded from the study.

The MDCT and CT angiography was performed in the department of radio-diagnosis, SGPGIMS, Lucknow in full agreement with institute ethical guidelines.

MDCT Protocol: The voluntary donors were given 1.0 to 1.5 litres of plain water to drink 45-60 minutes before the examination. Unenhanced CT acquisition extended from upper pole of the kidney to pubic symphysis. The enhanced CT acquisition extended from the diaphragm to the pubic symphysis with breath hold on inspiration. Thirty ml of non-ionic contrast medium (Omnipaque/ iohexol-350, GE Healthcare, 350 mg of Iodine/ml) was administered intravenously nously at the rate of 1 ml/s through a 18G cannula placed in the antecubital fossa, another 20 ml of contrast was given at 3 ml/s. After 25 seconds pause another 50 ml of contrast medium was given at rate of 5ml/s, then 30 ml saline chase was given at the rate of 3.5 ml/s using automatic injector (STELLANT-MEDRAD version 102.OSH). Region of interest was drawn on aorta at the level of the diaphragm. Monitoring scan was started 5 seconds after 3rd phase of contrast injection at the rate of 5 ml/s. Image acquisition was started manually, when high density contrast reached in abdominal aorta at the level of diaphragm. After 7-10 minutes another acquisition was acquired for excretory phase extending from above the kidney to pubic symphysis with breath hold in inspiration. Radiation dose was recorded for each patient.

All images obtained were independently analysed in random order using a workstation (Extended Brilliance workspace, Philips Medical Systems). Axial, coronal, sagittal, multi-planar reformatted image (MPR), and maximum intensity projections (MIP) were reviewed. Maximum intensity projection (MIPs) was obtained using various thicknesses (5-10 mm).

Cases with presence of renal or extra-renal pathological conditions were excluded from further analysis. The renal length was measured in axial, coronal and sagittal planes. In the axial plane the length was measured by subtracting the table position of the extremes of the kidney. In the coronal and sagittal plane the length was measured by electronic callipers (figure 1). The subjects' height (Ht.) and weight (Wt.) were measured. Body mass index (BMI) was calculated using the formula

$$BMI = Wt./Ht.^2$$

Statistical analysis: Descriptive statistics were used to analyse tendency and spread of the data. Comparative analysis between length of left and right kidney and renal length of males and females were done by means of t-test and the difference between the two groups were considered to be significant if $p < 0.05$. Variations in left and right renal dimensions between various groups of age, height and BMI were compared using a one way analysis of variance

(ANOVA) test. Pearson's co-efficient correlation test was used to assess the association between renal dimensions and anthropometric parameters.

RESULTS

The age of the subjects ranged between 21-66 years. Majority of subjects (63%) were between 31 and 50 years of age and only 2% of cases were above 60 years of age. The mean age was 43.5±10.4 years.

The mean length of the left kidney was 99.2±971 mm and the right kidney was 95.3±8.44 mm. The difference was statistically significant (p=0.003). In males, the length of left kidney was 103.5±7.09 mm and in females it was 98.4±9.96 mm (p=0.054). The mean length of right kidney in males was 98.9±7.09 mm and in females it was 94.6±8.56 mm (p=0.052) (Table1).

Table 1: Renal length by side and gender.

Renal Length (mm)	Male	Female	P value	Total
Left	103.5±7.09	98.4±9.96	0.054	99.2±9.71
Right	98.9±7.09	94.6±8.56	0.052	95.3±8.47
p value	0.08	0.009	-	0.003

In 69.5% of the subjects the length of the kidney was between 91.0 to 110.9 mm. In approximately 23% of the subjects the renal length was < 91.0 mm. The length of the right kidney was less than 91.0 mm in 27% of the subjects compared to 19% of the left kidney. Renal length >111.0 m was observed in 7.5% of cases. In 12% of subjects the left kidney length was more than 111.0 mm and in comparison only 3% of the right length was > 111.0 mm (Table 2).

Table 2: Distribution of kidney length according to side.

Kidney length (mm)	Left kidney (n=100) N (%)	Right Kidney (n=100) N (%)	Total (n=200) N (%)
< 91.0	19 (19.0)	27 (27.0)	46 (23.0)
91-100.9	36 (36.0)	48 (48.0)	84 (42.0)
101-110.9	33 (33.0)	22 (22.0)	55 (27.5)
> 111	12 (12.0)	3 (3.0)	15 (7.5)

The length of left and right kidney was compared with different age groups, body weight, height and BMI (table 2 to 6). It was observed that there was no significant difference in renal length among different age groups, body weight and BMI. A significant increase in kidney length was observed with increasing height for the left kidney (p <0.05). However, no significant difference was observed for the right kidney length among different height categories (Table 4).

Table 3: Renal length according to age.

Age Group (years)	Renal length (mm)	
	Left Kidney	Right Kidney
21-30 (n=12)	103±9.38	100.0±6.44
31-40 (n=28)	98.5±9.29	94.7±8.41
41-50 (n=35)	99.3±8.80	94.8±9.19
>50 (n=25)	98.0±11.48	94.3±8.06
F (ANOVA)	0.824	1.433
P	0.484	0.238

Table 4: Renal length according to height.

Height (cm)	Renal length (mm)	
	Left Kidney	Right Kidney
< 150.0 (n=6)	94.6±10.54	90.1±6.79
150.0-159.9 (n=57)	97.1±9.76	94.3±8.70
160.0-169.9 (n=34)	102.8±8.46	97.1±7.71
>170.0 (n=3)	106.6±7.11	103.1±1.70
F (ANOVA)	3.798	2.458
P	0.013	0.068

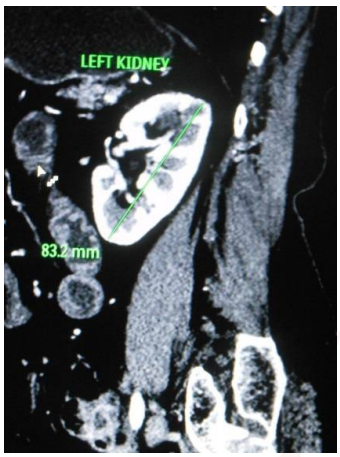
Table 5: Renal length according to body weight.

Body Weight (kg)	Renal length (mm)	
	Left Kidney	Right Kidney
<50.0 (n=5)	94.8±6.92	95.1±3.42
50.0-59.9 (n=51)	98.3±10.17	94.4±9.07
60.0-69.9 (n=39)	100.9±8.94	96.1±8.31
>70.0 (n=5)	99.1±12.82	97.5±0.36
F (ANOVA)	0.929	0.41
P	0.43	0.746

Table 6: Renal length according to BMI.

BMI (kg/m2)	Renal length (mm)	
	Left Kidney	Right Kidney
<20.0 (n=4)	110.9±5.64	102.3±7.98
20.1-24.0 (n=45)	99.0±9.00	96.4±6.92
24.1-28.0 (n=48)	98.7±9.98	93.6±9.53
>28.0 (n=3)	94.2±13.18	95.8±8.58
F (ANOVA)	2.347	1.82
P	0.078	0.149

Fig. 1: Saggital MIP CT imagen of left kidney showing the measurement of maximum renal length.



Correlation between renal length and age, height, body weight and BMI were assessed using Pearson's correlation coefficient. There was positive correlation between renal length and height (r=0.402 for left kidney and r=0.299 for right kidney (fig. 3). No correlation was seen with age, body weight and BMI (fig.2 and 4).

DISCUSSION

Kidney size reflects the kidney function. Renal length has been shown to be the most important measurement of renal size in persons with normal renal function [4]. Normal kidney length varies from 10.0 to 12.4 cm in different popula

Fig. 2: Correlation of renal length with age. A. Left kidney length with age. B. Right kidney length with age.

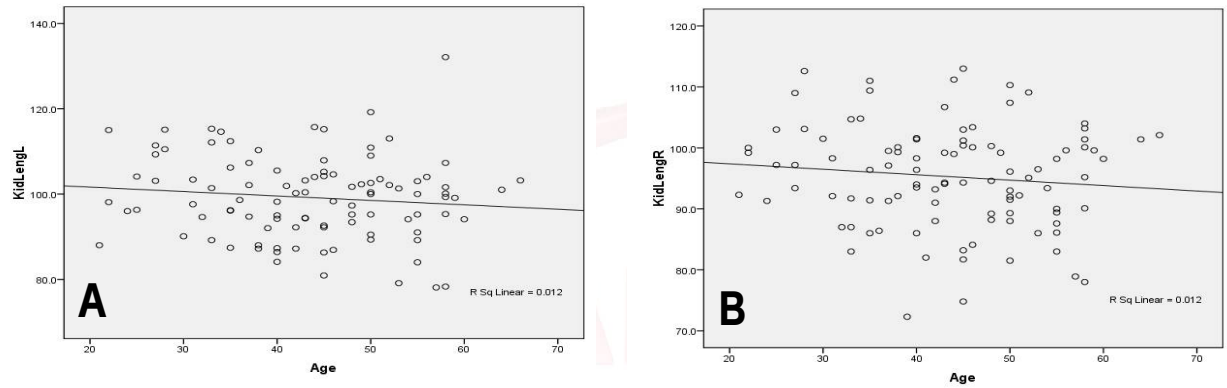


Fig. 3: Correlation of renal length with height. A. left kidney length with height. B. Right kidney length with height.

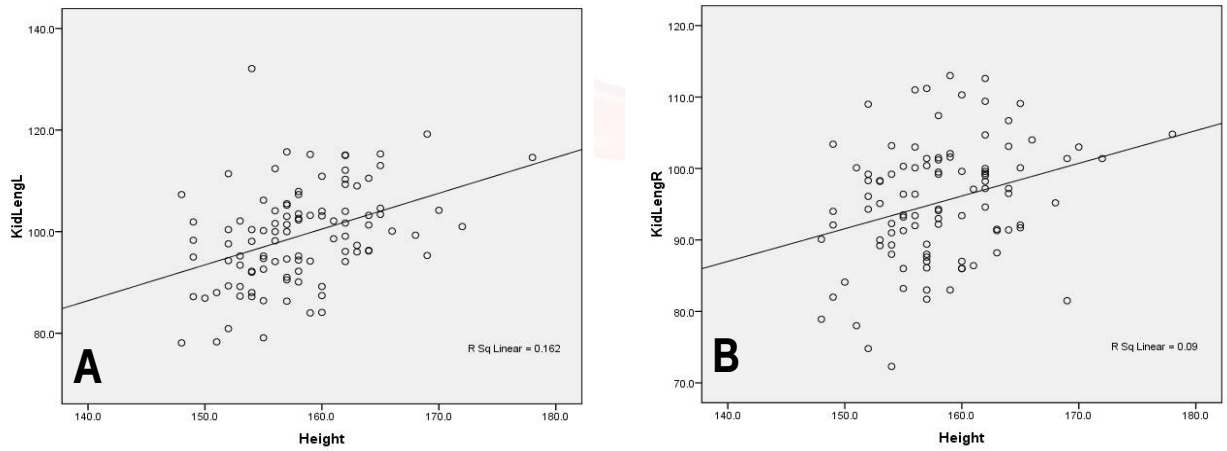
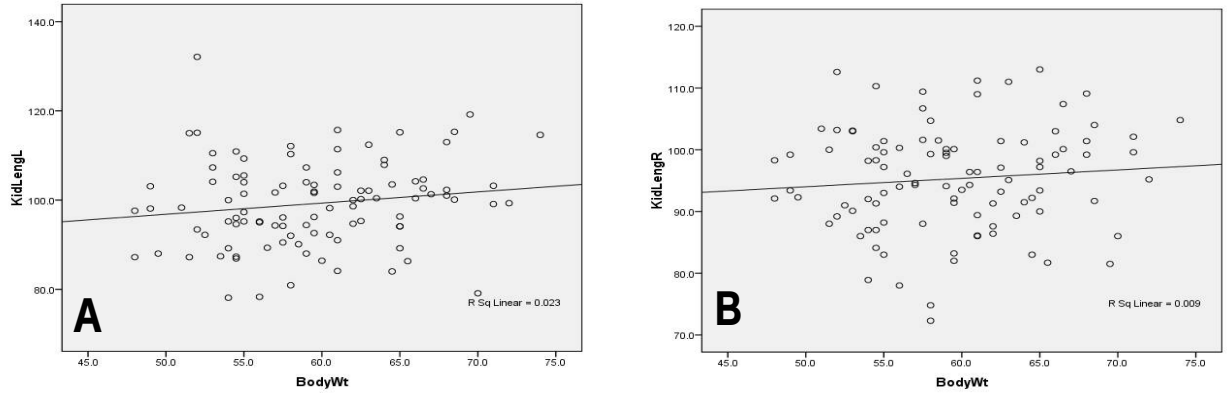


Fig. 4: Correlation of renal length with body weight.A. Left kidney length with body weight. B. Right kidney length with body weight.



tions and is influenced by several factors such as age, ethnicity, gender, weight and height. The left kidney is larger than right kidney independent of gender [4]. Renal length of 9 cm has been widely accepted as cut-off value to indicate irreversible renal disease [7,8].

The mean length of the left kidney was 98.91±9.7 mm in the present study and similar findings has been reported in other Indian study [5]. Similar findings have been observed in Jamaican, Malaysian, Pakistani and Northwest Indian population [9-12]**.** Ultrasonography studies in Caucasian population and CT scan studies in Austrian and Iranian population have shown a greater left kidney length as compared to present study [13-15].

Similar length of right kidney as observed in the present study (95.0±8.42 mm) has been reported in studies from other Asian countries [5, 9-12]. A greater right kidney length has been reported in Caucasian population & Iranian population [13-15].

In present study the left kidney was significantly larger than the right kidney. This observation is in concordance with other studies from Asia [9, 10]. However, in a study from Pakistan no difference between the length of left and right kidney was observed [8]. The relatively larger length of left kidney has been explained by the fact that, the left kidney is related to spleen, which is smaller in size compared to the liver and thus provides more space to grow than the right kidney. Another possible explanation that has been proposed is that the left renal artery is shorter and straighter than the right renal artery, which results in increased blood flow to the left kidney resulting in relatively increased volume of the respective viscera [13]**.**

Few studies have observed that the length of both the kidneys was significantly greater in males compared to females [6,13]. However, no gender difference in kidney length has been observed in other studies [5, 16,17]

In the present study it was observed that there was no statistically significant difference in renal length between different age groups for the left and right kidney. However, on comparing the left with the right kidney there was significant difference in all the three renal parameters between the two sides in the age groups 31-40 years. Renal length was not found to be affected by body weight and BMI. Significant increase in renal length with increasing height was observed for the left kidney only. Glodny et al observed that in both the sexes the renal length increased with age up to 50 years in both genders and then gradually decreased [14]. They also observed a strong relationship between renal length and BMI. Raza et al. observed the renal length to gradually decrease from sixth decades onwards and reported negative relationship between age and renal length. They also observed a positive relationship between height, BMI and renal length [18]. Emamian et al. reported that renal length correlated best with body height [13]. Barton et al. and Okoye IJ et al. did not observe any relation between renal length and height [9,19].

Majority of the studies related to measurement of renal size in Asian population is based on ultrasound [5, 8-11, 18]. Studies from India have also used ultrasound to measure renal size in their patients [5]. Very few studies have been done on CT scan to estimate renal length [14, 15]. There are no studies using CT scan to measure renal length in normal healthy individuals either from India or other Asian countries to the best of our knowledge. The main reason for this is that the use of MDCT scan is associated with radiation exposure and hence it is not ethically correct to evaluate normal persons by MDCT scan. All our subjects were normal voluntary kidney donors and evaluation of renal anatomy and its arterial supply by MDCT and CT arteriography is a universally accepted standard procedure for renal donor workup.

Ultrasound tends to underestimate the actual kidney size because of difficulty in locating the plane of maximum bipolar length and secondly it is operator dependant and thus there is a possibility that some measurement would not be made parallel to the axis of the kidney compared different radiological methods used for measuring kidney length [6,20]. It has also been observed that all radiological methods were associated with predictive errors, the least being with CT [6]. Therefore, the present study probably gives the near actual measurements

of the kidney in our Indian population.

Conflicts of Interests: None

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