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Original Article

Anatomy Section

Relationship of Renal Length with Height and Weight of an Individual using Computed Tomography

LIPIKA PAUL[1], SHWETA S TALHAR[2], JWALANT E WAGHMARE[3], SUSHILKUMAR KALE[4], MORESHWAR R SHENDE[5]

ABSTRACT

Introduction: Variety of clinical disorders such as diabetes mellitus, chronic hypertension, renal artery stenosis, chronic renal failure affects the kidney and alters renal length. It also varies according to height, weight, age and ethnicity. So there should be standardised values for renal length to evaluate the pathological condition of kidney.

Aim: To determine the normal range of renal length and also to evaluate the relationship of renal length with body height and body weight of an individual.

Materials and Methods: Abdominal Computed Tomography (CT) scans of 70 individuals between the age of 21-79 years without any renal disease were reviewed and their anthropometric data like height, weight, age and sex were also recorded. Renal length was calculated as the maximum longitudinal length in coronal section parallel to the renal long axis by using CT scan images of abdomen.

Results: The mean renal length of the total study population group was 9.38±1.08 cm and 9.23±0.92 cm for left and right kidney respectively. Mean height for the study group was 158.53±9.64 cm and mean weight was 49.24±9.77 kg. We found significant relationship between renal length and height of an individual in combined group consisting of both males and females whereas, weight of an individual did not show any significant relationship with renal length when correlation was done in combined group. Moreover, renal length was in negative relationship with age which was statistically significant for total population group (Left kidney p=0.0001, Right kidney p=0.011).

Conclusion: Measurements of renal length plays a vital role in detecting renal abnormalities. Thus, the measurement of renal length is very useful for early diagnosis in urological and nephrological practices. In the present study, renal length has a direct positive relationship with height and significant inverse relationship with age. We also have formulated regression equations to predict the probable renal length with the help of body height and body weight which can be used in routine practices without imposing the patients to the toxic ionising radiation and to the financial stress.

Keywords: Body height, Body weight, Regression equation, Renal measurements

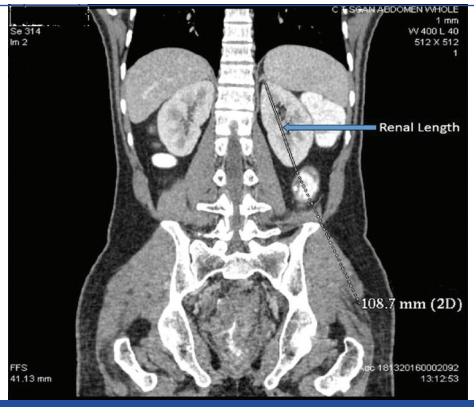
INTRODUCTION

Estimation of kidney size is an important criteria for assessment of renal disease [1,2]. A change in kidney size, either decrease or increase facilitates the evaluation of kidney disease [3]. Changes in renal dimensions between successive examinations are important parameter in evaluation and follow-up of patients with renal disease. Thus, renal dimensions are used for both diagnostic as well as prognostic purposes [4]. Renal volume and renal length estimation are two important measurements in evaluating kidney size [5,6]. Although, renal volume is the most precise parameter for measurement of kidney size, kidney length measurement is the most useful method for determination of kidney size as it is simple and practical to obtain, less inter-observer variations and easy to reproduce [3,7-9]. Renal length is the frequently used renal measurement for clinical evaluation of kidney disease in most of the standard literatures [10]. Renal length varies with various factors like age, gender, anthropometric measurements like height, weight and also with Body Mass Index (BMI) [11,12]. Moreover, racial differences can be a great influencing factor in measuring renal dimensions [13,14]. Renal length can be measured by using various newer imaging techniques such as USG, CT and MRI [12]. In most of the studies, measurement of renal dimensions is carried out by using ultrasonography as it is readily available and free from harmful radiation [15-17]. CT evaluation of renal length is more specific and accurate than any other radiological method, but it has got some limitations because of its ionising radiation [5,18]. Very few studies are available on renal length measurements by using MRI as it is not readily available in rural set up and is very costly [19,20]. Different studies had shown that anthropometric measurements like height, weight and BMI correlates very well with renal length and volume but there are limited Indian studies regarding renal length and its correlation with somatic parameters [11,14,18,21-23]. In the present study, we measured the renal length of individuals without any renal disease and evaluated the correlation of renal length with height, weight and age of an individual using CT to establish the standard renal length in the present study population as renal parameters vary according to different geographical locations. Also, we tried to develop simple equation to measure the renal length using height and age as somatic parameters of an individual.

MATERIALS AND METHODS

A prospective cross-sectional study involving total of 95 hospital attended individuals with age ranging from 21 to 79 years were included in the study. The present study was conducted in the Department of Anatomy, Mahatma Gandhi Institute of Medical sciences, Sewagram, in collaboration with the department of Radiodiagnosis, Mahatma Gandhi Institute of Medical Sciences, Sewagram, India from January 2016 to January 2017. Age, gender, height, weight of all the individuals of study group was recorded during examination. Study was conducted after obtaining ethical approval from the Institutional Ethical Committee and written informed consent was also taken from all participants. Initial screening of the patient was done on the basis of normotensive state (systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg). Individuals with underlying diseases like Diabetes Mellitus (DM), Hypertension (HTN), previously diagnosed renal disease by reviewing medical reports or any abnormal findings at CT examination such as renal stone, renal cysts, hydronephrosis were excluded. Age of the

patient ranging from 21 to 79 years without any known renal disease were included in the study whereas, patients found to have any renal disease on CT evaluation were excluded subsequently. These patients were referred to the radiodiagnosis department for abdominal CT scan from various other departments like surgery, radiotherapy and obstetrics and gynecology for evaluation of underlying diseases like hepatobiliary indication, gastrointestinal indication, genito-urinary indication etc. We had included only those patients without any known renal disease. Thus, after screening 95 hospital attended patients, 70 patients were included in the study without any renal disease. All patients underwent CT scan examination of abdomen using the same CT scan machine (8 slice CT). Renal length measured in coronal plane was considered as the maximum longitudinal length of the kidney parallel to the renal long axis [Table/Fig-1].



[Table/Fig-1]: Normal abdominal CT scan showing renal length (coronal section).

STATISTICAL ANALYSIS

Statistical analysis was done by using descriptive and inferential statistics using Student's unpaired t-test, Pearson's correlation coefficient and multiple regression analysis and software used in the analysis were SPSS 17.0 version and Graph Pad Prism 6.0 version and p<0.05 is considered as level of significance (p<0.05).

RESULTS

A total number of 95 patients from January 2016 to January 2017 without any known renal disease underwent abdominal CT scans at MGIMS, Sewagram, Maharastra, India. A total of 25 patients were excluded from the study owing to hydronephrosis, nephrolithiasis, renal cyst, renal mass and congenital renal variants. Here we are trying to evaluate the normatic values of renal length in the study population and also assessing the correlation between renal length with body parameters. These 95 hospital attended patients were referred to the radiodiagnosis department from various other departments for abdominal CT scan for hepato-biliary indications, gastric and pancreatic indication, uterine and ovarian indication and various other indications. Study group comprised of patients free from any known renal disease. Patients found to have any renal disease in CT scan report were excluded immediately. The study group was in between 21-79 years of age with the mean age of 47.01±16.73 year. Majority of individuals (91.44%) were between 21 to 70 years of age and only 8.57% of individuals were above 70 years of age and among them 37 (52.86%) were males and 33 (44.14%) were females. Mean body height for the total study group was observed to be 158.53±9.64 cm, whereas, mean body height for the male and female were 163.52±8.75 cm and 152.95±7.32 cm respectively. Thus mean body height of male was significantly higher than female (p<0.05, t=5.43). The body weight of the total study group was 49.24±9.77 kg, whereas the body weight of the male group was 51.48±9.77 kg and female group was 46.72±9.27 kg. The average body weight of the male was greater than female and it was statistically significant (p=0.041, t=0.041).

The mean left renal length of total population group was 9.38±1.08 cm and right renal length was 9.23±0.92 cm. The left kidney was found to be slightly longer than the right; but, was found to be statistically insignificant.

Right renal length was found to be significantly more in males than in females (p=0.008, t=2.74) while significant correlation was not observed on left side (p=0.34, t=0.94). Statistical analysis revealed that renal length of both sides (left and right) were in strong relationship with height, showing direct relationship in female (Left kidney r=0.44, p=0.009, Right kidney r=0.363, p=0.038). These relationships estimated a regression model in females taking renal length as dependent variable and height of an individual as independent variable which are as follows:

a) Left renal length (cm)=0.115+0.060×Height (cm)

b) Right renal length (cm)=2.206+0.044×Height (cm)

Similar findings were also observed in case of male group where only right renal length showed significant positive relationship with height (r=0.253, p=0.013).

Regression model was derived in males and these are as follows:

a) Left renal length=5.247+0.026×Height (cm)

b) Right renal length=3.205+0.039×Height (cm)

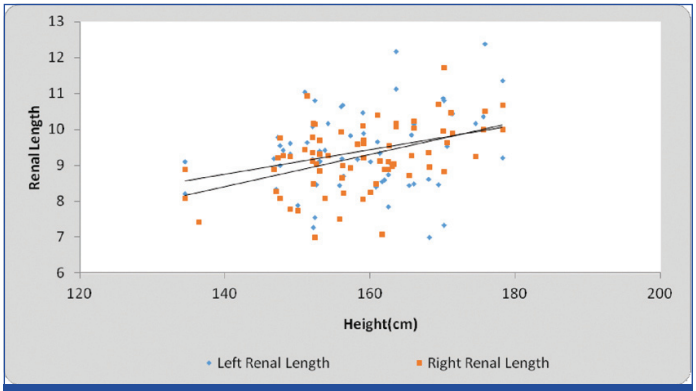
There was significant positive correlation between renal length (Left and Right) and height of an individual in combined study group consisting of both males and females [Table/Fig-2,3]. Regression equations were also derived which are as follows:

a) Left renal length=3.95+0.034×Height (cm)

b) Right renal length=2.102+0.045×Height (cm)

	Mean	Standard deviation	n	Correlation coefficient (r)	p-value
Height (cm)	158.53	9.64	70	-	-
Left renal length (cm)	9.38	1.08	70	0.304	0.011, S
Right renal length (cm)	9.23	0.92	70	0.469	0.0001, S

[Table/Fig-2]: Correlation of renal length with height (cm) of an individual in combined study group.
Cm: Centimetre; n: Total number of individuals; S: Significant



[Table/Fig-3]: Scatter diagram showing correlation of renal length (cm) with height (cm) of an individual in combined study group.

Further analysis of data was done showing relationship between renal lengths with age. Renal length showed statistically significant negative correlation with the age of females on both sides (Left kidney r=-0.393, p=0.024) (Right kidney r=-0.440, p=0.010).

Regression equations were derived for females as follows:

a) Left renal length (cm)=10.415–0.025×Age (years)

b) Right renal length (cm)=10.116–0.025×Age (years)

In males, renal length showed inverse relation with the age of a subject, but statistical significance was seen on left side only (r=–0.499, p=0.002). Following Regression Equations were derived in males.

Left renal length=11.035–0.033×Age (years)

Right renal length=10.032–0.011×Age (years)

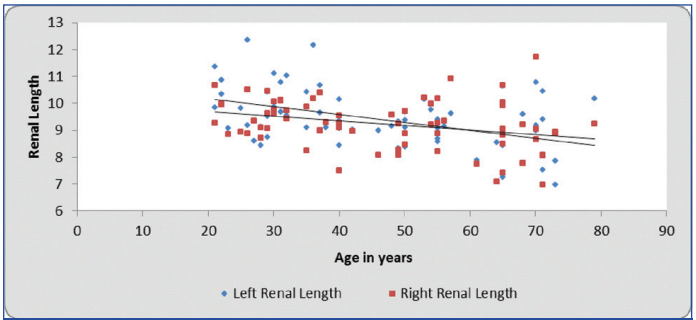
In case of combined group (both male and female), renal length showed statistically significant inverse relationship with age of an individual (Left kidney r=-0.455, p-value=0.0001 and Right kidney r=-0.304, p-value=0.011) [Table/Fig-4,5]. We have formulated regression equation for predicting dependent variable (renal length) using independent variable (age) as follows:

a) Left renal length=10.77–0.030×Age (years).

b) Right renal length=10.02–0.017×Age (years).

	Mean	Standard deviation	n	Correlation coefficient (r)	p-value
Age in years	47.01	16.73	70	-	-
Left renal length (cm)	9.38	1.08	70	-0.455	0.0001, S
Right renal length (cm)	9.23	0.92	70	-0.304	0.011, S

[Table/Fig-4]: Correlation of renal length with age of an individual in combined study group.
Cm: Centimetre; n: Total number of individuals; S: Significant



[Table/Fig-5]: Correlation of renal length with age (year) of an individual in combined study group.

Right renal length was found to be significantly more in males than in females (p=0.008, t=2.74) while significant difference of renal length was not observed on left side (p=0.34, t=0.94) [Table/Fig-6].

	Male	Female	t-value	p-value
Left renal length (cm)	9.49±1.18	9.25±0.97	0.94	0.34, NS
Right renal length (cm)	9.50±0.88	8.92±0.88	2.74	0.008, S

[Table/Fig-6]: Comparison of renal length in male and female.
Cm: Centimetre; S: Significant; NS: Non-significant

Moreover correlation of renal length with body weight of an individual in combined study group was observed to be insignificant [Table/Fig-7]. We have formulated regression equation for predicting dependent variable (renal length) using independent variable (body weight) as follows:

Left renal length=8.527+0.017×Weight (kg).

Right renal length=8.311+0.019×Weight (kg).

	Mean	Standard deviation	n	Correlation (r)	p-value
Weight (kg)	49.24	9.77	70	-	-
Left renal length (cm)	9.38	1.08	70	0.156	0.198, NS
Right renal length (cm)	9.23	0.92	70	0.198	0.100, NS

[Table/Fig-7]: Correlation of renal length with body weight (kg) of combined group in both sides.
Kg: Kilogram; Cm: Centimetre; NS:Non-significant

DISCUSSION

Renal length measurements are important in the evaluation of renal diseases as it reflects kidney function [21]. Renal length in normal subjects ranges from 10 cm to 12.4 cm among different population groups [18]. Moreover, renal length is affected by various factors like gender, age, ethnicity, body height and body weight of an individual [24]. Shin HS et al., reported the mean renal length of 10.08±0.69 cm and also mean left renal length greater than the right renal length [25]. In an ultrasonographic study conducted in Pakistan, mean renal length was observed to be 10.4±0.8 cm [22]. In an Indian study, mean left renal length was found to be 99.2±9.71 mm and right renal length was 95.3±8.47 mm with left kidney significantly larger than the right kidney [18]. In the present study, the mean length of the left kidney in total population group was 9.38±1.08 cm and the mean length of the right kidney was 9.23±0.92 cm. There was a marked but insignificant difference between right and left renal length with greater left renal length. Buchholz NP et al., also reported that there was no difference between right and left renal length [22]. Few authors did not find any significant differences in renal length of both sides. Thus the present finding of non-significant difference between right and left renal length with larger left renal length in study group is in concordance with the number of past studies [8,26,27]. Best possible explanations for relatively longer left renal length are the presence of liver on the right side of abdomen leading to comparatively less spatial growth of the right kidney and also shorter as well as straighter left renal artery delivering more blood flow to left kidney [23]. In contrast to the present study, Adeyekun AA et al., reported that right kidney was larger than the left one [16].

In the present study, significant increase in renal length with increasing body height was observed in both left and right kidney in case of total population group (left kidney, p=0.011 and in right kidney, p=0.0001). Moreover, statistically significant relationship was observed when renal length was compared with body height in female group. In short, both left and right renal lengths increases with increase in body height of an individual in case of female group (p-value was 0.009 and 0.038 for left and right kidney respectively). But in case of male, statistically strong positive relation was found in case of right renal length with body height (p-value was 0.383 and 0.013 for left and right kidney respectively). Abdullah MB et al., observed similar relationship between renal length and height of the patient [28]. They also established regression equation for easy prediction of renal length and these are as follows:

Left kidney length=0.038×height+3.940.

Right kidney length=0.028×height+5.202.

Another study conducted by Arooj A et al., also revealed that height of the patient is directly proportional to renal length which was statistically significant (p<0.001) [14]. Hence, the present observations are in accordance with other previous studies [21,25,28]. Okur A et al., in Turkish population observed significantly positive relationship with height (p=0.005) and the findings of the study conducted by Shin HS et al., in Korean population also coincides with Okur A et al [21,25]. However, another study from North Indian population by Srivastava A et al., revealed that there was statistically significant escalation in renal length with increasing body height which was applicable only in case of left side (p=0.013) whereas, a study from Kuwait, conducted by El-Reshaid W et al., did not observe any relationship between patient's height and renal length [18,29]. Abdoelrahman HAB et al., did not observe statistically significant variance among kidney length with patient's height [30].

In the present study, renal length was in direct negative relationship with age which was statistically significant in total population group (Left kidney p=0.0001, Right kidney p=0.011). Moreover, in the present study, significant negative relation was observed in between renal length with age in females (Left kidney p-value=0.024 and Right kidney p-value=0.010). Whereas, statistically significant inverse relationship was observed in between renal length with age in males only in case of left side (Left kidney p=0.002, Right kidney p=0.177). This observation can be enlightened by the fact that body height did not alter significantly with advancement of age once body has attended complete maturity [6,31]. As according to Arooj A et al., renal length is in direct relationship with body height

and body weight [14]. Buchholz NP et al., also postulated that taller and heavier individuals have greater renal length comparing to their shorter and lighter equivalents [22]. However, according to Melk A et al., a decrease in number of glomerulus by 30-50% at the age of 70 years may be accountable for decrease in renal size with advancing age [32]. Anderson S et al., had also concluded that Glomerular Filtration Rate (GFR) and renal blood perfusion reduces in a undeviating manner after 30 years of age [33]. Kidney length shrinkages roughly 0.5 cm per decade due to decrease in renal perfusion of about 1% per year after 5th decade of life [34,35]. Thus the finding of negative relationship between renal length and age is consistent with most of the previous studies [3,36]. Raza M et al., in Islamabad, observed that Absolute Renal Lengths (ARL) was in inverse relationship with age and this progressive decrease in renal length was more pronounced after middle age [36]. Hekmatia A et al., had shown that significant negative relationship between renal lengths with advancing age was more consistent after sixty years of age [3].

Furthermore, there was significantly larger right renal length in males than females in present study population. We also found greater left renal length in males as compared to females but it was statistically insignificant. Many studies conducted in different countries also reported larger renal length in males than females [3,7]. Best possible explanation given by the authors for gender differences in renal length was due to difference in gender related height or body size [22,27,36]. In the present study we have found that renal length in the study population was in positive relationship with weight but it was not statistically significant. Similar studies were conducted in the past showing significant positive relationship between renal length and body weight of an individual where it was observed that weight of a person is directly related to the renal length [23,29].

Thus renal length is the whole and most important renal parameter which was found to be correlated with body height and weight, but statistical significance was found for the body height. In the present study, we also found significant inverse correlation of renal length with age of an individual. Thus we conclude from the findings of present study that body habitus and built is one of the important predictor of renal length in normal healthy individual. Till date very few studies are available in India, where adult renal length estimation has been done by using CT [18]. Hence, it may be a fruitful attempt to derive easy reference in urological and nephrological practices.

LIMITATION

However, the limitation of the present study was that it involved a very small sample size to predict the most accurate renal length with the help of body height. Another important limitation of the current study was that we did not include the volumetric evaluation of kidney. Kidney length changes in chronic kidney disease patients as time passes and the changes are at a rate of ≈0.5 cm per decade and it is also dependent on the aetiology of renal diseases (Kariyanna SS et al.,) [37]. The changes in renal length are very minimal and are reliant on time. So, in practical renal length measurements alone is not applicable for diagnosing any renal disease in adult group but can be used as an adjunct tool. In contrast, according to Oh MS et al., renal length in children may simplify the diagnosis of CKD from the estimated reference values of renal length according to age and also the donor renal length can be predicted with the help of linear regression equation which is solely dependent on height [9]. Thus, next approach should be towards estimation of renal length depending on various age groups in adult population. As far as the diseases concern, kidney volume can better predict any renal disease if it is in progression or not. Hence, in future studies should be based on not only renal length estimation but also to the other measurements like renal width, cortical thickness and renal volume involving a large number of sample size.

CONCLUSION

The present study has attempted to establish the normal values of renal length in study population. The renal length was found to be influenced by somatic parameters such as body height, weight and also age of an individual. Renal length correlated best with body height. So, we can construct normogram of renal length with body height in the study population which can be used as a standard reference value for a specific population group in Indian scenario. As renal length is dependent on body height hence, we can have a rough idea about the probable renal length with the help of above mentioned regression equation by knowing the body height of that particular individual, without imposing an individual to the financial stress and also to the ionising radiation.

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PARTICULARS OF CONTRIBUTORS:
1. Resident, Department of Anatomy, Mahatma Gandhi Institute of Medical Sciences, Wardha, Maharashtra, India.
2. Assistant Professor, Department of Anatomy, Mahatma Gandhi Institute of Medical Sciences, Wardha, Maharashtra, India.
3. Associate Professor, Department of Anatomy, Mahatma Gandhi Institute of Medical Sciences, Wardha, Maharashtra, India.
4. Professor, Department of Radiodiagnosis, Mahatma Gandhi Institute of Medical Sciences, Wardha, Maharashtra, India.
5. Professor and Head, Department of Anatomy, Mahatma Gandhi Institute of Medical Sciences, Wardha, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Lipika Paul,
Resident, Department of Anatomy, Mahatma Gandhi Institute of Medical Sciences, Sevagram, Wardha-442102, Maharashtra, India.
E-mail: lipika@mgims.ac.in

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