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Renal Length and Its Relationship with the Height of an Individual: A Review

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Abstract: *Kidney plays an important role in our body such as excretes metabolic wastes, maintaining the equilibrium between fluid and electrolyte, control of blood pressure, erythropoiesis etc. Loss of kidney mass and kidney function alters the length and size of kidney. Many diseases adversely affect the kidney leading to its enlargement or reduction. Renal dimensions are also greatly affected by age, gender and body mass index. The methods of assessment of changes in the dimensions of visceral organs by using clinical methods are difficult and unreliable and there may occur subjective errors. Thus now-a-days, there are several newer techniques like x-rays, USG, CT, and MRI etc to detect renal pathology. Thus measurement of renal length and to establish its normal range serves as a baseline tool for early diagnosis and intervention. We tried to present a comprehensive account of the research conducted so far to establish relationship between renal length and one of the anthropometric parameter, height of an individual.*

Key words*: Renal length, Kidney, Height, Ultrasonography, Renal dimensions.*

I. Introduction

The kidneys are the paired abdominal organ measures about 9 to 15 cm long, 4-5 cm wide and its thickness is about 3 cm. It lies on either side of vertebral column between the parietal peritoneum and fascia covering the musculature of posterior abdominal wall. Right kidney is slightly lower than the left kidney [1].Renal dimensions and its functions reflect the health status of the kidney [2].Changes in renal dimensions between successive examinations are an important parameter in evaluation and follow up of patients with renal diseases. Thus renal dimensions are used for both diagnostic as well as prognostic purposes.

There are several modalities and techniques such as radiography i.e x-rays, intravenous pyelography, ultrasonography, computed tomography, magnetic resonance imaging etc available for the evaluation of renal diseases. Among them, now-a-day, USG, CT scan, MRI remains the methods of choice in urological as well as nephrological practices [3]. Present review of literature attempts to sequentially encompass significance of height of an individual with renal length using various imaging techniques. Such type of sequential analysis of literature on this topic may provide better research opportunities and diagnostic criteria in urological and nephrological practices.

1.1 Height and kidney length relationship in healthy adults

A Hekmatia et al (2004) estimated sonographic measurements of absolute and relative renal length in healthy 400 Isfahani adult volunteers. Data included in the study was height, age, sex and sonographic renal length. Mean height for men and women was 171±6 cm and 159±5 cm respectively. Longest longitudinal diameter of kidney was considered as renal length. The mean renal length (absolute length) for left and right kidney was 111±9.8 mm and 109±8.4mm, respectively. Relative renal length for each kidney was considered as Kidney body-height ratio (KBR) = Absolute renal length (in millimeters)/Subjects body height (in centimeters). KBR (kidney body-height ratio) was considered a good index for estimating renal length. They found that mean KBR for left kidney was significantly higher than that for the right kidney. They concluded that there was a positive correlation between absolute renal length and subject's height which was significant [4].

An ultrasonographical study was conducted by Arooj A et al (2011) on 100 adult normal Malaysian populations to estimate the relationship between renal dimensions with anthropometric measurements. Renal dimensions included renal length as the maximal longitudinal distance in sagittal view, width as the

perpendicular distance to the longitudinal length and thickness as maximum length in cross section. Ultrasonographic images were taken in two postures, in supine and lateral decubitus position in respective side after holding breath for a while. Mean left renal length for male was 10.04±0.88 cm and right renal length was 9.67±0.77 cm. In case of female, the mean left renal length was 9.8±1.03 cm and right renal length was 9.7±0.84 cm. The average height of the study group was 163.34±9.13cm. This study revealed that height of the patient was directly proportional to renal length, width and thickness [5].

To establish relationship between renal length and height, 514 adult patients without any renal disease underwent oblique coronal 8-slice CT scan to measure renal length. Anthropometric measurements like height, weight and age, gender and race were recorded. For each patient, the average kidney size (kidney length) was considered between right and left kidney and it ranged from 80-134mm. The average body habitus constant for male and female were 61.0 and 57.7 respectively. By regression analysis it was observed that 0.39868 units increase in kidney size (kidney length) was strongly associated with a unit increase in patient's height. A strong significant correlation was established between the anthropometric data like height and weight of the patient along with kidney size (kidney length) by the following formula:

Kidney size (mm) = 49.18109+0.2065×weight (kg) +0.27360× height (cm).

He also commented that a bigger body height would have a larger blood volume to flow in kidneys and thus make it larger [6].

Hammad L.F et al (2012) established relationship between anthropometric measurements and renal dimensions in young Saudi population of age group 19-28 years without any known clinical disease. all participants underwent ultrasonography examination in empty bladder, so that an increase in renal length caused by oral hydration can be avoided. Renal length was taken as the longest longitudinal diameter and renal width, thickness and cortical thickness were measured in longest absolute term. The mean renal length for right and left side was 10.32 cm and 10.77 cm respectively. The mean height for male and female was 1.72m and 1.57m respectively. Renal volume was measured by using ellipsoid formula: renal volume= length×width×thickness×0.5. Pearson correlation test was used to examine the relationship of renal dimensions with anthropometric measurements. They observed that both kidney lengths in young Saudi population were smaller than the same aged European population. They explained by giving reason that mean height of the young Saudi population was lower than the European population [7].

Relationship between renal length and height was established by Abdullah MB et al (2014) by carrying out a study on normal adult Sudanese using MRI disc summation method. 98 subjects aged 20-45 years underwent MRI for indications other than renal disease. Renal length was calculated as -Renal length= number of slices (in which kidney appeared) x slice thickness (cm). Correlation value (0.007) showed the linear relationship between the height and right kidney length and similar findings were also observed in relation to left kidney with height, where correlation coefficient was significant (0.000) in Scatter plot diagram. The mean renal length was10.18±0.46 cm for right kidney and 10.67±0.47 cm for left kidney. Following equations were derived from their study for easy reference in clinical practice:

Left kidney length= 0.038x height+3.940.

Right kidney length= 0.028x height + 5.202.

They also commented a significant relationship between renal length and height of the patient [8].

Sonographic values of mean renal dimensions were compared with mean height in 252 patients aged 18-80 years without any renal disease, in Kuwait. Renal dimensions included the longest longitudinal diameter as renal length and the interval between the outer border of the renal cortex and the outer border of the medullary pyramid as renal cortical thickness. The mean renal length of the right kidney was 10.68±1.4cm and the left kidney was 10.71±1.0cm. Mean height of the male was 172±6.5cm and a female was 158±6.5cm. The Pearson correlation coefficient was used to assay the significance of linear association among different variables. They did not find any relationship between patient's height and renal length [9].

A study was carried out with aim of correlating renal length with the height of an individual among 77 healthy participants. Renal length was measured using ultrasonography as the maximum bipolar dimension in longitudinal plane after fasting for 6 hours prior to the test, in order to reduce bowel gas, and height was measured in meters (m). The average renal length for right side was 10.15 cm and for left side was 10.33 cm. It was observed by the authors that renal length did not correlate with patient's height .While right renal parenchymal thickness showed strong positive relationship with height of patient but it failed to establish such relation on left side [10]

1.2 Height and kidney length relationship in healthy children

Weisenbach J et al (2001) estimated relationship between percentiles of kidney size with anthropometric measurements in healthy Hungarian children. 330 children underwent ultrasonography for measurement of kidney size (renal length and parenchymal thickness) and their body heights were also recorded. They measured length of kidney and parenchymal thickness at upper pole, middle pole and lower pole

in each of the 330 children. They also prepared the normograms showing 10^{th}, $50^{th}$and 90^{th} centiles for body height and renal length/parenchymal thickness. It was observed that there was a strong association between renal length and body height (r= 0.93) which can be used as a diagnostic tool for renal disease [11].

Ultrasonographycally derived maximal renal lengths and heights were measured in 474 children between 3 months-18.5 years without any renal disease to derive the relationship between them. Ultrasound examination was done in supine decubitus position. Left kidney showed a correlation of 0.911 with height by regression analysis. Similar analysis showed a correlation of 0.921 with height for right kidney. Taking into consideration the kidney length as dependent variable (Y) and height as the independent variable (X), regression equation for both the kidneys were derived as follows:

Left kidney, Y= 2.5372+0.0479X, where determination coefficient is 0.8304.

Right kidney, Y= 2.5815+0.0464X, where determination coefficient is 0.8478.

It was concluded from the study that renal length correlates significantly with height of the patient. They also found that height measures for 83% of variability in left kidney length and 85% for right kidney length [12].

R. Ganesh et al (2010) found significant correlation of renal length with anthropometric variables in 230 Indian children. Parameters included in the study were height, weight, age, head circumference, femur length and renal length. Longest dimension of each kidney in ultrasound image was considered as renal length after being averaged. It was observed by the authors that the mean renal length significantly correlated with patient's height (correlation value=0.94) and considerably related with chest circumference, upper thigh length and weight. By multiple regression analysis they formulated the following equation to calculate the mean kidney length as:

Mean kidney length (cm) =2.736+ 0.021x femur length +0.029 X height+ 0.008x head circumference+ 0.014x chest circumference [13].

Renal dimensions were estimated by Eze C et al (2014) using a prospective cross-sectional study among 947 apparently healthy children sonographycally [14]. The association between kidney dimensions and anthropometric measurements were assessed with Pearson's correlation coefficient. Non- linear regression analysis performed to know the exact relationship between them. During deep inspiration, with the subject in supine or lateral decubitus position kidney size (renal length and width) were obtained in coronal plane, passing through the renal hilum. The mean renal length for right was 79.56± 8.10 mm and for left kidney was 81.61±8.32 mm. The mean height of the study group was 140.24±17.93 cm. It was observed that height correlated best with kidney length. The equations derived from their study of normal kidney size estimation in relation to height were:

Right kidney length (mm) = 0.406x height (cm) + 22.61.

Left kidney length (mm) = 0.407x height (cm) +23.41.

A study was conducted to evaluate 150 healthy children aged 1 month to 14 years old to determine standard normal values for renal dimensions using USG. Renal lengths were obtained in sagittal view with children in supine or in the contralateral decubitus position without any preparation or sedation during ultrasound examination. The mean right kidney length in both male and female were 7.45cm and 6.9 cm and the mean left kidney length in male and female were 7.6 cm and 6.8cm respectively. Taking height/ length as independent variable and kidney length as dependent variable, regression analysis for right kidney was 0.424 and for left kidney, it was 0.443. It was observed by the authors that both right and left kidney lengths moderately and significantly correlated with height of the children [15].

Relationship between renal length and height was established sonographycally among 331 children without any renal diseases from both the sex, aged 0-14 years. The maximum bipolar length of both the kidneys was obtained from sagittal view in supine or in a contralateral decubitus position. ANOVA test was used to compare the correlation between kidney length and height of the children. A linear increase was observed in renal length of 4.6 cm and 9.4 cm in two different age group, 0-3 months and 12-14 year age group respectively. A statistically significant correlation was found between kidney length and height. They explained it as organ-growth in children dependent on somatic parameters [16].

1.3 Height and kidney length relationship in renal disorders

Dustan H.P (1974) concluded that there was an inverse relationship between height of an individual and kidney size in ischaemic nephropathy due to higher arterial pressure in taller individual that resulted from height of the hydrostatic column of blood. He also mentioned that size of kidney was directly associated to individuals height for all disease except ischaemic nephropathy and obstructive nephropathy. In case of vascular disease, greater arterial pressure gets reflected to the renal circulation leading to greater damage of kidney. Thus it leads to more shrinkage of kidney in taller individual [17].

Ultrasonographic study was conducted on 178 kidneys of 93 patients with chronic kidney disease to see the correlation between kidney size and height of an individual. Kidney size was determined by reviewing the renal ultrasound images of maximum bipolar length of both the kidneys. Relationship of kidney size with

height was related as coefficient value equal to 0.116, a bivariate analysis. Final conclusion by the authors was height of the patient directly related to the kidney size in all chronic kidney diseases except ischaemic and obstructive nephropathy as there was larger height of the hydrostatic column of blood leading to a greater arterial pressure in taller people. It was also observed that in chronic kidney diseases, an average decline in kidney size was about ~ 0.5 cm/decade which was independent on height and aetiology of kidney diseases [18].

Another study was conducted to evaluate relationship between renal length and somatic parameters such as height and weight and analyzed the growth affecting reasons of renal size in children aged 12.9±15.6 months with the impression of urinary tract infection. Renal lengths of 66 children were measured using ultrasonography and Dimercaptosuccinic acid (DMSA) scan. In ultrasonography, renal length was measured as the longest axis from upper pole to lower pole of the kidneys in prone position and DMSA scan revealed renal length as the maximum pixel length which was then converted to centimeters. Average renal length in left kidney was 6.47±0.89cm and in right kidney was 6.22±0.85cm, measured by DMSA scan. Average renal length in left kidney was 6.01±0.84cm and in right kidney was 5.88±0.81cm, measured by USG. Mean height of the sample group (in both sexes) was 72.91±12.80 cm. T-test was used to compare the difference between two renal length measurement methods and it was found that left renal length measured by DMSA scan had higher correlation- coefficient than right. The most reliable finding observed by Pearson correlation test was that height of the subject had significant correlation with renal length. They finally concluded that in growing children, height seems to be the most vital parameter associated with organ growth [19].

Kruszka PS et al (2013) evaluated kidney normograms among 50 patients aged 2.2-36.3 years with methylmalonicaciddemia (MMA), an inborn error of metabolism [20]. Renal length was measured as longest longitudinal axis. Correlation of renal length with height was assessed using linear regression analysis. 325 children aged 3 days to 16 years without any renal pathology were compared as control group for this linear model. Considering height as the independent variable and renal length as the dependent variable the following equations were established:

For control group, equations for left kidney length (cm) =0.051× height (cm) +1.8 and right kidney length (cm) =0.050×height (cm) +1.8.

For MMA patients, equations for left kidney length (cm) =0.033×height (cm) +4.0 and right kidney length (cm) =0.037×height+3.0.

Kokoris J C et al (2015) evaluated the significance of absolute and relative renal length in relation to chronic kidney disease (CKD) patients. The study sample were 181 patients including 35 with Balkan endemic nephropathy (BEN), 31 with diabetic nephropathy (DN),30 with primary glomerular disease (GN), 30 with autosomal recessive polycystic kidney disease (ADPKD) and 58 healthy controls (C). Absolute renal length was the maximum distance between two poles measured by ultrasonography. Relative renal length was calculated as the ratio of renal length and body height (kidney length/ body height, KBR). Anova test was used to analyze the differences in absolute lengths and KBR. The measured result of absolute renal length explained that the mean length of both right and left kidney were maximum in ADPKD patients and minimum in BEN group. Similar result was demonstrated in the average values of KBR of both right and left kidney in all groups except GN and DN group. It was concluded by the authors that there was no significant difference between correlation coefficient of absolute and relative length of both kidneys [21]

II. Conclusion

Most of the studies showed that normal renal dimensions vary according to patient's body habitus, height of an individual. This variation can be represented by a normograms and thus it enlightens the clinicians for easy reference in urological and nephrological practices. Thus the knowledge of normal renal dimensions enables them for easy comparison in situations where renal diseases come into questions.

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