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A CROSS-SECTIONAL STUDY ON RADIOLOGICAL MEASUREMENTS OF KIDNEY SIZES IN PATIENTS BETWEEN THE AGES OF 19 TO 50 YEARS PRESENTING TO THE RADIOLOGY DEPARTMENT, NATIONAL HOSPITAL OF SRI LANKA

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Introduction

Assessment of renal pathologies is recognized as a major entity in Radiology. Mostly for assessment of chronic kidney disease (CKD), acute renal injury, urinary tract infection &and obstructive uropathy.

CKD is a major disease burden in the world as well as in Sri Lanka, especially with the emergence of CKD of unknown origin (CKDU)[13]. There are multiple causes for CKD such as metabolic diseases, obstructive uropathy, and inflammatory diseases. They often cannot be differentiated radiologically. Though the diagnosis is mainly biochemical, radiological features like abnormal renal length and reduction in volume may be indicative of renal disease or progression of disease[3]. Radiological renal measurements such as Renal bipolar length (BPL) are commonly used for diagnosis and follow-up of these patients irrespective of the etiology. BPL reduces in most cases except in a few instances such as diabetic nephropathy and amyloidosis. In a patient with increased serum creatinine level, the renal size is one of the most valuable measures in differentiating acute versus chronic renal disease[15].

Radiological assessment plays a major role in urinary tract infection which is the commonest presentation in urology. Although acute pyelonephritis alone is not an indication for radiological assessment, it plays a vital role in assessing complications and possible etiology such as obstructive uropathy[16]. In pyelonephritis renal size often increases with changes in renal parenchyma and perirenal soft tissue[16].

Normal renal BPL is taken as 10-14 cm long in males and 9-13 cm long in females, with a transverse length of 3-5 cm wide and 3cm in anteroposterior thickness in reference to international datas[6]. The average weight of kidneys is 150-260 g and the left kidney is usually larger than the right [6].

Most of the reference values available for normal kidney sizes are derived from the western population. There is no enough national or at least regional data on renal sizes. Therefore, it is necessary to build a locally validated National reference for normal renal sizes in diagnosing renal pathologies. This study is aimed to establish a reference range for normal renal sizes of the national adult population

Still, the accuracy and reproducibility of measurement in renal sizes vary on the type of radiological imaging. Computed Tomography (CT) is more accurate for this purpose compared to other studies such as ultrasound imaging. Therefore CT scan was used in this study[14].

Material & methods

This was a single-center prospective cross-sectional study performed in the Main CT unit, Radiology Department, National Hospital, Sri Lanka. The study was done from 2021 January 31stt to 2022 February 01st.

Consented patients who were subjected to contrast or non-contrast CT abdomen for routine indications at NHSL were taken as the study population.

In the inclusion criteria, patients with normal renal serum creatinine values (0.84 to 1.21 milligrams per deciliter) and morphologically normal kidneys with no anatomical or pathological variations were taken as inclusion criteria. The age limit was considered from 19 years of age to 50 years of age. As only adult patients present to the radiology department and most studies referred lower age limit was 19 years, 19 years was considered as lower age limit. As studies show the decline of renal sizes after the age of 50 without derangement of serum creatinine, 50 years was taken as the upper age limit.

In the exclusion criteria, patients with any kind of congenital renal anomaly or renal disease which influence the renal size measurement (Ex: horseshoe kidney, hydronephrosis, urinary tract infection, renal injury, renal cyst, or a single kidney) were excluded from the study.

Patients with biochemical evidence of renal diseases such as proteinuria, gross hematuria, or renal failure were also excluded. Patients diagnosed with extra-renal diseases that can affect the urinary system and kidney mass, ureteral stones & splenomegaly, or abdominal or retroperitoneal masses around the kidney were also excluded.

Though the 136 patients were studied during the study period, only 104 were included. 21 were having a history of CKD, six having raised serum creatinine at the time of imaging, three having a duplex system, and one having horseshoe kidney were excluded from the study.

A pre-tested and validated interviewer administrated questionnaire was used for the collection of the data. The questionnaire was validated by a consultant radiologist (experienced in the field of general radiology of more than 10 years) and a consultant nephrologist (experienced in the field of more than 10 years). Each patient was provided an information sheet about the research, their involvement, and the effect of the research data on them. Data on the participant were collected from the patient and the height & weight were collected and BMI was calculated at the same time after consent. Serum creatine is done in every patient as a routine investigation before CT imaging, so was not an extra burden to the patient due to the study.

Anthropometric measurement

The Standing height was taken by using a stadiometer placed against a wall. Participants were asked to remove footwear and stand against the tape

measure with their feet together. Care was taken to make sure the heel touching the wall, arms by the side, and heel, buttock, and upper back were in contact with the wall. Participants were instructed to look straight away at eye level to maintain the head in Frankfort's horizontal plane. The maximum distance from the floor to the highest point of the head was measured in centimeters (cm).

A properly calibrated electronic digital scale was used to measure weight. The scale was in kilogram mode and had zero on the display before the procedure. Participants were asked to stand on the center of the scale after removing the shoes and their weight was recorded in kilograms (kg).

The body mass index (BMI) was calculated by the following calculation.

$BMI = weight\ (kg) / [height\ (m)]^2$

CT measurements

CT measurement taken from computer tomographic images done in Seimen multidetector 16 slices Computed tomographic machine at National Hospital, Sri Lanka. All the measurements were done on the same computer using the same viewer (Vitrea) to minimize intra-observational instrument-related bias. Bipolar length of the kidneys, the width of the kidneys, and cortical diameter of the kidney were taken as radiological measurements on both sides personally.

BPL was measured as the maximum pole-to-pole distance on the coronal plane of the CT image, and renal width was measured as the diameter from the renal hilum to the opposite side on the transverse plane at axial. Renal cortex anteroposterior length was taken in axial images. The measurements were taken separately by two different Radiologist who has experience of more than 10 years of in general radiology. This was done to reduce inter-observer measurement bias. All above values were measured three times and the mean value was taken to minimize intra-observational measurement bias and increase repeatability and reproducibility of data.

The renal cortical thickness was measured as the mediam of cortex thickness measured in upper, lower, and interpolar regions. These measurements were taken without looking at the anthropological measurement of each patient to reduce intra-observational bias.

Data collection and analysis

Data collection was done in the waiting area of the main CT machine at the Department of radiology in NHSL. Hard copies were used for the information sheet, consent form, and questionnaire, and the latter was filled as an interviewer-based one.

Data were analyzed using the newest version of Statistical Package for Social Sciences (SPSS statistics 27).

Ethical Consideration

Ethical permission was obtained from the ethical review committee, Postgraduate institute, Colombo. The official permission was obtained from the Director of the NHSL, Sri Lanka.

Results

Patient details

A total of 104 patients were included in the study (60 men and 44 women). Ages ranged from 27 to 59 years, with a mean age of 49.16 ± 2.96 years. The average weight of the enrolled group was 58.33 ± 10.8 kg (range: 38-81 kg), and the average height was 162.58± 13.2 cm (range: 145-198cm).

The mean BPL of the right kidney was 9.37 ± 1.03 cm & left was 9.85± 1.01. A paired t-test (T-test was applied as the data distribution was normal) indicated that the length of the left kidney was significantly greater than that of the right kidney ($P < 0.03$). But the rest of the renal parameters are not significant compared to the contralateral side (P-value for AP diameter-0.06, width-0.4 & for cortical thickness 0.2)

Variable	**Mean value (n-104)**	***P*-value**
Age, years	49.16 ± 2.96	
Sex, No (%)		
Male	**60 (57%)**	
Female	**44 (42%)**	
Height, cm	**162 ± 13.2**	
Weight, kg	**58.33 ± 10.8**	
Serum creatinine	**0.78 ± 0.22**	
Renal BPL		**0.03**
Right	**9.37 ± 1.03**	
Left	**9.85 ± 1.01**	

Table 01- Patient characteristics.

Mean renal size according to age & sex.

Linear regression analysis was used to assess the relationship of the bilateral renal BPL against the age (in the given age range). It showed the correlation in the scatter plot (figure 01) indicating the changes in BPL with the age are not statistically significant (p-value >0.05).

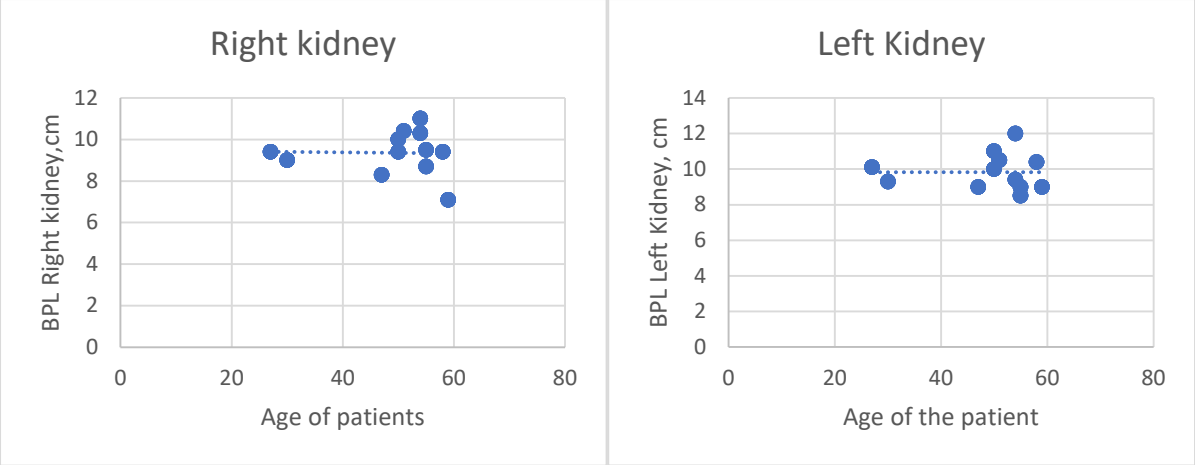

Figure 01. Scatter plot chart on renal length against the age

A paired T-test was used to analyze the relationship between renal length against sex. It showed that neither right nor left kidney length was showing a significant difference according to sex. The p-value of 0.1 & 0.4 for the right and left kidneys respectively.

Renal measurement according to serum creatinine

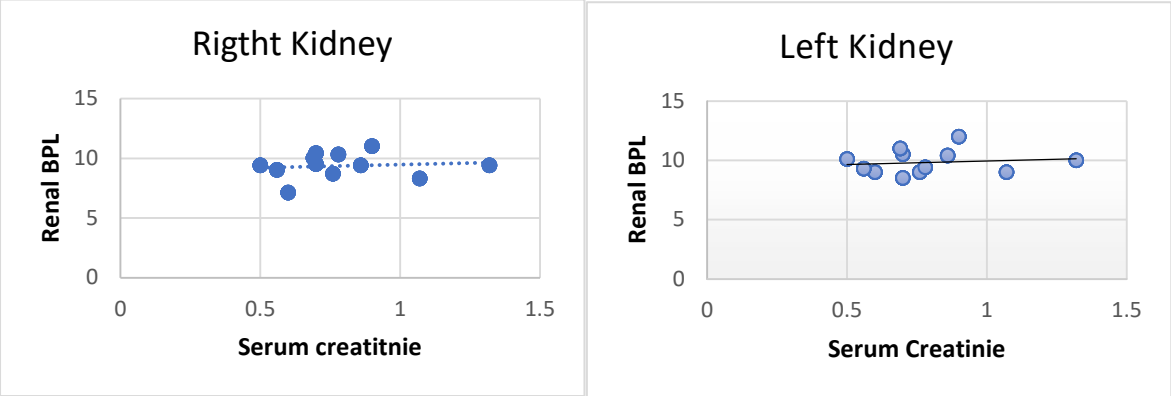

Figure 02. Scatter plot chart on renal length against serum creatinine value

Linear regression analysis of the bilateral renal BPL against the serum creatinine value showed no correlation in the scatter plot (figure 02) with a p-value of more than 0.005 indicating the absence of the changes in BPL according to the serum creatinine value. The main reason for this is the serum creatine values taken in this study are within normal limits & patients with abnormal serum creatinine values were excluded from the study.

Linear regression correlation of Renal size with BMI (Figure 03.)

Renal sizes with BMI showed a positive correlation in both kidneys with a p-value of 0.005 indicating the significance of the data set. The patient's weight also showed a positive correlation (<0.05 p-value), but the height shows no correlation with the bilateral renal length.

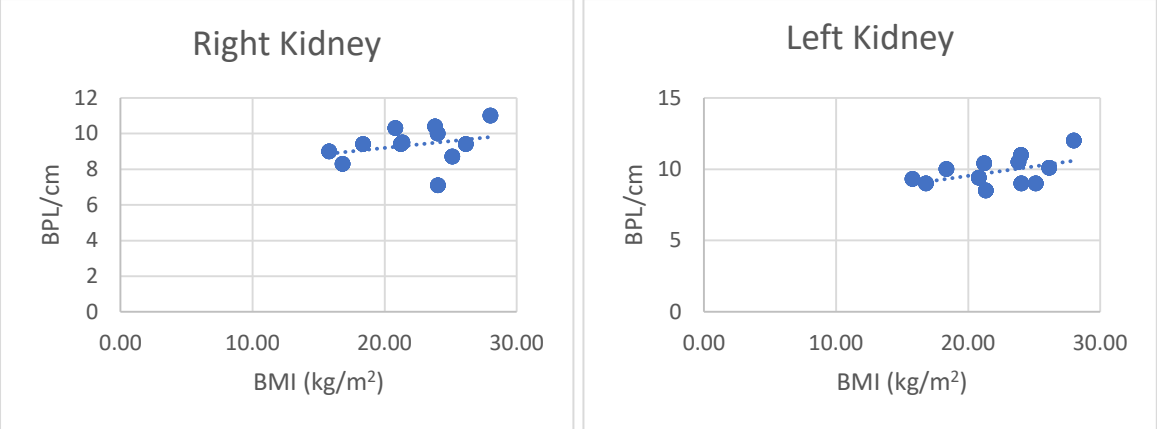

Figure 03. Scatter plot chart on renal length against the BMI of the patient.

Discussion

Assessment of kidney sizes plays a major role in radiological diagnosis and follow-up of most of the renal pathologies presented to the radiology department. So reference values for renal sizes are utterly important. But renal sizes may also vary due to age, sex, built, and geographic factors. So, reference values for normal renal sizes should be corrected according to those factors to get a validated National reference value.

Nevertheless, the total renal volume is the most useful measurement to assess the relative renal mass as it is a varying shape organ, the renal length is the most used measurement in assessing renal sizes radiologically in different modalities such as ultrasound imaging, Computed tomography, magnetic resonance imaging due to convenience of measurement[3,4,14].

There are studies done on renal sizes using various imaging modalities to build on reference values and to assess variations according to age, sex, build, and other factors. Most of them are done on western populations. Few studies are available on Asian populations and only a handful of published data is available data in Sri Lanka. Some studies done in Asian countries show a lower renal measurement compared to western population reference values which are using[18]. In our study, the right & left renal BPL showed 9.3 cm & 9.85cm respectively. This is similar to the BPL sizes seen in many Asian studies. But this was smaller compared to western studies [19].

Most studies have shown that renal volume & renal length are correlated with body anthropometric values [20,19]. Only the renal BPL was taken in our study. The volume was not measured as in most of the practical instances only the renal BPL is measured and is convenient. In our study, only the BMI showed a positive significant correlation with the renal BPL. But other factors such as sex, and age were not correlated with BPL in this study population.

Most studies have shown significantly longer left BPL than right, which is the same in this study[4], where the right and left kidney are 9.37cm & 9.85cm respectively (p values is 0.03). The left kidney is 5% longer than the right kidney. This is most probably the growth regression due to the mass effect of the bulk of the liver on the right side.

This study contains a few limitations. this study was performed only with a limited population, and only single centered. So

this is a major drawback to come to conclusion as a National reference value on the renal size and need large scale multicentered data on this subject. The renal measurements were taken only in either coronal or axial planes in CT. But the actual values can still differ. So the Multiplaner Reformated (MPR) images are still the ideal though malroatated kidneys were excluded from the study population.

In the conclusion, the mean renal BPL for the right kidney is 9.3 cm and 9.85cm for the left. It is smaller than the international value (formed based on the western population) we are currently using.

Renal length changes according to the BMI of the patient indicating consideration of the patient built in the interpretation of the renal BPL. Our study also shows left kidney is longer than the right.

But performing large-scale multicentered studies should be considered in subsequent studies to make a National reference value.

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