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Normal Ultrasonographic Renal Length In Relation to Age, Sex, BMI and Serum Creatinine Level Among Students in University Malaysia Sabah

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Abstract: *Variation in kidney size occurs in many renal diseases and considered as important indicator in evaluation of these problems. Our study aims to set a normal range of kidney lengths among healthy young adult University students in Uinversiti Malaysia Sabah (UMS) by using cross-sectional prospective study design. UMS students, 321 numbers from different programs participated in this study after obtaining informed consent. The age ranged from 19 to 25 year. Both male (34%) and female (66%) were included. The Chinese 32.7%, Malay 24%, Kadazan 10.9 %, Indian 3.7% were in this study. The mean Body Mass Index (BMI) of 320 students is 21.35 ± S.D 3.58. Ultrasonographic renal measurements revealed the mean length of kidneys of the students, the right was 9.81±0.75 cm and the left was 9.85±0.58 cm respectively.*
This study will act as an input for further research to establish a normal range in people in Sabah states. It will also exclude kidney pathology detected by ultrasonography despite the normal findings of physical examination and laboratory function tests.Thus it will improve awareness of possibilities in kidney diseases which can be present in apparently normal healthy adults.

Keywords: *normal ultrasonographic renal length, BMI, Serum creatinine*

I. Introduction

Renal length has traditionally taken and used as a predictor of chronic renal disease. The kidney size of apatient is a valuable diagnostic parameter in urological and nephrologic practice. While the leading anatomy text describes the adult kidney as 12 cm long, 6 cm wide and 3 cm deep [2]. Further review of the literature shows that renal size varies with age, gender, body mass index, pregnancy and co-morbid conditions[3,4,5]. Renal size may be an indicator for the loss of kidney mass and kidney function[6]. It is valuable in monitoring unilateral kidney disease through comparison with the other, compensatorily increased side [4] and for the discrimination between upper and lower urinary tract infections [9]. Renal infections/inflammations, nephrologic disorders, diabetes mellitus and hypertension are the most important co-morbid conditions affecting renalsize[8,9,10]. Since the renal size is affected by various factors, it is necessary to firstly establish the normal values. The information available in the West may not be extrapolated to our population since the renal size may differ between ethnic groups and body size[11,17]. While population-based studies are needed to establish the normal values for Malaysian individuals, in this study we determined the ultrasonographic renal size in a group of apparently healthy individuals without known renal disease and assessed the age, gender, size and BMI. In addition, we assessed correlation between renal size and renal function and compared our findings with the literature. Measurement of GFR (Glomerular Filtration rate) is considered the standard for estimating renal function. However, standardized accurate GFR methodology is expensive and cubercome; therefore,estimates of GFR based on serum creatinine concentration have been employed. The purpose of this study is to estimate normal sonographic renal lengths in relation to age,sex, BMI and serum creatinine among students in UMS.

II. Material And Method

This study was a cross-sectional prospective study. Study population were the University students of UMS who were apparently healthy individuals without known real disease.

Sampling and sample size

Sampling method is a simple random sampling.

Sample size determination: According to the study done in 1989, the normal renal length in healthy Malaysian adults was 105mm for males and 100 mm for females.

Supposing that the deviation from the average normal renal length among students in UMS is about 1% and if the worst acceptable limit is set at 2%, the calculated sample size for 955 Confidence Interval (CI) is 369. A total of 418 subjects were collected initially and those who have one of the following criteria were excluded from the study.

Exclusion criteria:

a. Those with past history suggestive of renal problems.
b. Those with abnormal sonographic morphology of the kidneys
c. Solitary or ectopic kidney

Informed consent was obtained from all the students in keeping with the guidelines of SPU, UMS ethic committee has approved the study design. Total 323 students were recruited. The data was incomplete in 2 students and one student has solitary kidney. These students were excluded from the study. Anthropometric measurement were done in the remaining students and they underwent ultrasound measurement of renal dimensions (Length, thickness and cortical thickness in both sides). Ultrasound was performed on Aloka SSD-1000 by a consultant ultrasonographist .

Serum creatinine was done on Dimension (R) clinical chemistry system (Autoanalyzer) at Gribbles laboratory.

III. Results

This study focuses on 321 students from UMS. Among 321 students, the age ranged from 19 to 25 year. The highest percentage (32.4 %) belongs to 21 year old and lowest age group (1.2%) is 25 year. Both male and female are included. However the number of female participants (66%) are greater than male (34%) students. Regarding different races, the largest group was Chinese (32.7%) and Malay (27%). The lower race groups were Indian, Kadazan, Dusun, Bajau,Brunei, Iban, Rungus, Sunnai and Parkistanese. On estimating BMI, there were normal BMI 64.3%, and Underweight 15%, overweight 12.9% and obese 7.8%.

Among them 20.7 % of students were overweight and obese according to BMI and male students were significantly higher in overweight and obese (35.1%) than female students (13.3%). The mean BMI of 320 students was 21.35 ± S.D 3.58 (as shown in histogram). BMI (weight in Kg/height in meter^2) was measured on students who were divided into 3 groups: BMI 10-20, 21-30 and 31-40. The mean renal size correlated with BMI and the size was correspondingly increased with BMI.

Ultrasonographic renal measurements revealed, the mean length in cm of right and left kidneys of the students are almost the same i.e., 9.81±0.75 cm and 9.85±0.58 cm respectively. The mean thickness (width) in cm of right and left kidneys of the students are not much different i.e., 3.82±0.56 cm and 4.05±0.58 cm respectively. The mean parenchymal thickness in cm of right and left kidneys of the students are nearly the same i.e., 1.27±0.18 cm and 1.32±0.20 cm respectively.

Mean serum creatinine level was 63.62 mmol/L (0.72mg/dl). Morphology of the kidneys were normal (84.10 %), presence of calcification in 9.2%, presence of stone in 2.8% and others (cysts) in 1.2% were noted. Fatty liver in 2.4% was found and one student showed a single kidney in right side.

Regarding correlation between bipolar renal length and serum creatinine, in the right side Pearson correlation of - 0.101 shows that there is no correlation between Bipolar length of right kidney (cm) and serum creatinine level although it is significant at $p<0.05$ level at one tailed.in left side, Pearson correlation of - 0.001 shows that there is no correlation between Bipolar length of left kidney (cm) and serum creatinine level. It is not significant as $p>0.05$ level at one tailed.

Regarding average bipolar length of kidney, Pearson correlation of - 0.064 shows that there is no correlation between average Bipolar length of kidneys (cm) and serum creatinine level. It is also not significant as $p>0.05$ level at one tailed.

IV. Research Findings

Table 1.Age (yrs.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	19	10	3.1	3.1	3.1
	20	62	19.3	19.3	22.4
	21	104	32.4	32.4	54.8
	22	60	18.7	18.7	73.5
	23	62	19.3	19.3	92.8
	24	19	5.9	5.9	98.8
	25	4	1.2	1.2	100.0
	Total	**321**	**100.0**	**100.0**	

Among 321 students the ages range from 19 to 25 year. The highest percentage (32.4 %) belongs to 21 year old and lowest age group (1.2%) is 25 year.

Table 2. Gender

Frequency	Percent	Valid Percent	Cumulative Percent
212	66.0	66.0	66.0
109	34.0	34.0	100.0
321	**100.0**	**100.0**	

Out of 321 students, 66% is female and 34% is male students.

3. Body Mass Index (BMI)

Normal BMI is (21-30)64.3%, Under underweight (10-20)is 15%, Over weight (31-40) is 12.9% and obese (>40)is 7.8%

20.7 % of students are overweight and obese according to BMI and male students are significantly higher overweight and obese (35.1%) than female students (13.3%). And the mean BMI of 320 students is 21.35 ± S.D 3.58 (as shown in histogram).

Renal size and effect of body mass index:

Information on body mass index (BM1) (weight [meter] 2) was available in 321study students who were then divided into 3 groups, i.e., BMI 10-20, 21-30 and 31-40. The mean renal size correlated well with BMI and correspondingly increased with BMI.

Table 3. Ultrasonographic renal measurement by side and gender

Measurement	**Male (n= 33.96) Mean +/- SD**	**Female (66.04) Mean +/- SD**	**P value**
Length cm			
Right	9.86+/-0.8	9.84+/-0.8	0.037
Left	9.88+/-0.7	9.86+/-0.7	0.024
Width cm			
Right	3.92+/-0.8	3.65+/-0.8	0.004
Left	4.01+/-0.8	4.01+/-0.8	0.005
Cortical thickness cm			
Right	1.25+/-0.6	1.21+/-0.8	0.002
Left	1.42+/-0.7	1.38+/-0.8	0.00

The mean length in cm of right and left kidneys of the students are almost the same i.e., 9.81±0.75 cm and 9.85±0.58 cm respectively. The mean thickness (width) in cm of right and left kidneys of the students are not much different i.e., 3.82±0.56 cm and 4.05±0.58 cm respectively. The mean parenchymal thickness in cm of right and left kidneys of the students are nearly the same i.e., 1.27±0.18 cm and 1.32±0.20 cm respectively.

Table 4. Statistics of serum creatinine

		Serum creatinine level (mmol/L)	**Serum creatinine level (mg/dL)**
N	Valid	317	317
	Missing	4	4
Mean		63.62	.7194
Median		61.00	.6900
Mode		57	.64
Std. Deviation		9.914	.11221

Mean serum creatinine level of 317 students are shown in mmol/L and mg/dL viz. 63.62mmol/L and 0.72 mg/dL

Table 5. Ultrasonographic findings (n= 321)

		Frequency	**Percent**
	Normal	270	84.1
	Calcification in kidney	30	9.3
	Stone in kidney	9	2.8
	Fatty liver	8	2.5
	Other abnormalities in kidney (e,g, cyst, duplex kidney etc.)	4	1.2
	Total	**321**	**100.0**

There are 9.3% calcification and 2.8% stone formation in kidneys seen in ultrasonogrphic findings of 321 students. Some fatty liver (2.5%) and other abnormalities in kidney of subjects (1.2%) are also seen.

Correlation between bipolar renal length and serum creatinine

Table6. Descriptive Statistics

	Mean	Std. Deviation	N
Average bipolar length of kidneys (cm)	9.8298	.52646	315
Serum creatinine	63.65	9.860	319

Table 7. Correlations

		Average bipolar length of kidneys (cm)	Serum creatinine
Average bipolar length of kidneys (cm)	Pearson Correlation	1	-.064
	Sig. (1-tailed)		.131
	N	315	314
Serum creatinine	Pearson Correlation	-.064	1
	Sig. (1-tailed)	.131	
	N	314	319

Pearson correlation of - 0.064 shows that there is no correlation between average Bipolar length of kidneys (cm) and serum creatinine level. It is also not significant as p>0.05 level at one tailed.

V. Discussion

We determined the ultrasonographic kidney dimensions in individuals without known renal disease. We assessed whether age, sex, side, body mass index (BMI) and presence or absence of renal disorder affect the renal size. This study provide a normal range of renal lengths among the healthy young adult University students with different demographic background in UMS in relation to their renal function and anthropometric parameters. The normal size of a kidney is variable and is affected by age, gender, BMI, as well as the side [17,18]. The size provides a rough indication of the renal function. The minimal size of a fully functional kidney is 9 cm in length [3]. In order to estimate aberrations of kidney size, normal values must be established first. Not many studies have been done on this issue. There are, as far as we know, no reliable reference tables because the measurements vary between men and women, between people of different ethnic backgrounds and even between kidneys of the same individual. Also, it has to be borne in mind that kidney size measurements with ultrasound (US), as well as with CT and MRI result in a 24% underestimation of the renal value [22]. Commonly, US is used to screen and measure the kidney. In comparison with an intravenous pyelogram, US is more accurate and suffers neither from the geometric magnification of X-raying, nor from a possible increase in kidney size by osmotic diuresis through iodinated contrast material [5]. It has been analyzed as a reliable, repeatable (inter-observer variation) and reproducible (intra-observer variation) method [9]. In our study, a single senior radiologist carried out the measurements at predetermined fixed points, to minimize the inter-observer and intra-observer variation. We believe that US is the tool of first choice due to its ubiquitous availability, its easy handling and its cost-effectiveness. Most studies have looked at kidney length. Ultrasonic kidney length measurement (bi-polar measurement) is the most commonly used and most practical measurement in clinical practice [3] and is correlated to renal function [24]. Normal renal length varies from 9.8 to 12.4 cm in different populations' [20, 21] dependent on ethnic background, side and sex. While population-based studies are needed to establish the normal values for Malaysian individuals, our pilot study group showed a mean kidney length of 9.8 cm. This is at the lower end of the scale and together with a Pakistanis study population [1,31]is probably a reflection of the relatively small body size of most Indo-Asians. Organ size is unquestionably related to the body size. Accordingly, Africans figured in the upper range 17 and Caucasians somewhere in the middle [31].

In our study, the kidney length, width, cortical thickness and size were significantly larger in males than in females. This has been reported by other investigators [15,18] and has been related to differences in body size [26]. We found this difference significant even in the multivariate analysis. Throughout all studies, there is a marked but not significant difference of kidney length between the right and left side, with the left side being on an average 5% larger[3,11,18]. We feel it could be related to the hepatic mass which does not allow comparable vertical growth of the right kidney to that which is attained by the left kidney. In our study, all renal dimensions were significantly larger on the left than on the right side. We thus feel that instead of renal length the renal size or volume as assessed may be used as the most useful parameter for evaluation and comparison. The age of an individual has an important bearing on the kidney size. The kidney size increases till the 3rd decade, remains stable through the middle age and then declines .But there is no such information available for our population as we studied only in young adults with very narrow limited age range.

Our data shows a strong correlation between renal size and BMI (Figure 2). The renal size increased correspondingly with an increasing BMI, except for the right kidney in the group of obese individuals (BMI: 3 1-40). In these patients, the body mass increase may surpass the renal growth capacity. Also, it has to be considered that gross obesity can be one of the limitations of ultrasound examination. Other investigators have also shown a strong correlation of renal volume with height, weight and BMI [3,11,18]

In our study , Morphology of the kidneys are normal (84.10 %), presence of calcification in 9.2%, presence of stone in 2.8% and others (cysts) in 1.2%. Fatty liver in 2.4%.renal calcification cane be progress to renal stone. The incidence of urolithiasis per 100,000 population over the IS-year period (1962-1976) in the various states of mainland Malaysia were studied. The highest incidence in the state of Negri Sembilan (

39.6/100,000 population) and the lowest incidence was in Kedah state (12.0/100,000 population). State of of Sabah was not included in the study.[25].

Regarding correlation between renal size and serum creatinine, in our study, in the right side Pearson correlation of - 0.101 shows that there is no correlation between Bipolar length of right kidney (cm) and serum creatinine level although it is significant at $p<0.05$ level at one tailed.in left side, Pearson correlation of - 0.001 shows that there is no correlation between Bipolar length of left kidney (cm) and serum creatinine level. It is not significant as $p>0.05$ level at one tailed. Correlation with average bipolar length of kidney, Pearson correlation of - 0.064 shows that there is no correlation between average Bipolar length of kidneys (cm) and serum creatinine level. It is also not significant as $p>0.05$ level at one tailed.

However Adibi A et al [26] from Isfahan University of Medical Sciences,Iran study showed there was correlation between ultrasonographic kidney sizes and glomerular filtration rate (GFR) in 116 healthy children. . The mean age of the children was 8.4+/-3.4. The GFR mean was 108+/-30 (mL/min per 1.73 m2). GFR correlated to total renal volume ($r=0.52$, $P<0.001$), total net volume ($r=0.53$, $P<0.001$) and total kidney length ($r=0.59$, $P<0.001$). Ultrasonographic kidney sizes, especially the kidney length, correlate to GFR in healthy children. This study had done among children between 3-10 year old. In our study we estimated ultrasonographic kidney sizes on health young adult University students. There were no significant differences in sizes and only slight enlargement in female than male. Further more we excluded all the student with kidney abnormalities such as renal stone in our study .All the kidneys are healthy and functionally normal although there were minor differences in size. The ages range from 19 to 25 year.

In clinical study of D.Z Giamo in Clinical Journal of American Society of Nephrology (CJASN) [27] found that there was a significant correlation between kidney size and serum creatinine ($P < 0.0001$) and between kidney size and serum blood urea nitrogen ($P < 0.002$). However in this study the chirdren are 6 month and above old who are admitted to paediatric ward. There can be a significant differnces in kidney sizes related to their ages.

VI. Conclusion

A few limitations were experienced during this study and need to be noted. The accuracy of ultrasound measurements is influenced by intra- and interobserver variability . Therefore performing ultrasound for renal measurements has to be considered by two radiologists or sonologists at the same time.

A second limitation of this study is related to the fact that we assessed renal function using serum creatinine levels. We also performed the analyses using GFR calculated with the Schwartz formula and obtained the same results as with serum creatinine (data not shown). Because measurements of creatinine clearance allow reducing the variance related to differences in body muscle mass, it is likely that our analysis has underestimated the relationship between renal function and renal mass by using serum creatinine levels. Therefore no correlation was found between renal size and serum creatinine level. Accurate measurement of renal size by two Radiologists at the same time and GFR estimation assessed by creatinine clearance in larger population of adult Malaysian in Sabah state should be done in further study.

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