

Original Research Article

Measurements of the normal size of spleen and spleen to left kidney ratio among sudanese children up to five years age using ultrasonography

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Received: 02 September 2019

Revised: 07 September 2019

Accepted: 27 September 2019

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ABSTRACT

Background: Knowledge of the normal range of spleen size in the population being examined is very important because there are many different pathological conditions that may alter in spleen size. Also, gender, height, weight and BMI of individual, affect the splenic length and could result in incorrect interpretation of splenic measurements, spleen to left kidney ratio is one of recent parameter mention in literature aid in diagnosis of splenomegaly in children.

Methods: The study was a cross-sectional study conducted in Khartoum state at Al-Buluk and Gaafar Ibauf Paediatric Tertiary Hospital during the period from March 2018 to August 2018. A total of 101 children (males and females) with aged ranged 1 month to 5 years included in study. A transabdominal scan was performed, and measurement of spleen and left kidney taken after an ethical verbal consent from their parents, then data analyzed by SPSS, Mean±SD. Deviation for study variables calculated then correlation between patients factors and ultrasound measurements done.

Results: The study found that the mean measurements of the normal size of the spleen and spleen to left kidney ratio for children up to five years of age, Splenic length was 7.24 ± 1.12 cm, width was 3.83 ± 0.81 cm, thickness 2.91 ± 0.55 cm and spleen to left kidney ratio was 1.04 ± 0.070 ranged (0.86-1.23). The male have larger spleen than female with no statistically significant differences in spleen sizes between the sexes. There was a strong significant correlation between age, weight, height spleen and left kidney length ($p < 0.01$) respectively and a moderate association with BMI ($p < 0.05$).

Conclusions: Spleen and left kidneys was growing rapidly and similarly in infant up to one year of life 1 mm\1 mm for each month and then decreasing growth rate of kidney in relate to spleen for 1 mm growth of spleen kidney grow 0.8 mm in up to five years of age. There was strong significant positive correlation between spleen and left kidney measurement with age, height, weight of individual. The spleen to left kidney ratio for children up to five years ranged (0.86-1.23) with mean 1.04, so if the ratio less or more than this ranged it should be considered in clinical context for diagnosis of splenomegaly or shrunken spleen in children up to five years of age.

Keywords: Left kidney length, Spleen length, Spleen to left kidney ratio, Ultrasound

INTRODUCTION

The spleen is part of the reticuloendothelial system and is rarely the site of primary disease. It is commonly involved in

metabolic, hematopoietic, and infectious disorders. The spleen is active in blood formation (hematopoiesis) during the initial part of fetal life. This function decreases gradually by the fifth or sixth month, when the spleen assumes its

adult characteristics and discontinues its hematopoietic (blood-producing) activities.¹

The spleen is of variable size and shape. The spleen is normally measured with ultrasound on a longitudinal image from the upper margin (near the diaphragm) to the inferior margin at the long axis. Normal measurements for the average adult should be 8-13 cm in length, 7 cm in width, and 3 to 4 cm in thickness. The spleen decreases slightly in size with advancing age. The size of the spleen may vary in size in accordance with the nutritional status of the body. In children, the formula for splenic length is $5.7+0.31 \times \text{age}$ (in years). The length of the spleen usually measures greater than the length of the kidney. Splenomegaly is diagnosed when the spleen measures more than 13 cm in the adult patient, or more than normal length in the respective child.¹

It has been the standard practice for many years to use splenic size as an indicator of disease activity in a variety of disorders of the reticuloendothelial system. Determination of spleen size is important in diagnosing small, infarcted, normal and enlarged spleens. Splenomegaly is an important clinical sign for diagnosis and serial follow-up of a variety of diseases, including portal hypertension, glycogen storage disease, leukemia, lymphoma, melanoma, celiac disease, schistosomiasis and other hematologic diseases.²

Enlargement of the spleen (splenomegaly) is associated with numerous conditions, including infections (subacute bacterial endocarditis, tuberculosis, infectious mononucleosis, and malaria), connective tissue disorders, neoplastic hematologic disorders (lymphoma and leukemia), hemolytic anemia and hemoglobinopathies, and portal hypertension (cirrhosis).³

"Ultrasound (US) may detect mild splenomegaly before it is clinically palpable. Knowledge of the normal range of spleen size in the population being examined is a prerequisite.⁴ Racial differences in splenic length could result in incorrect interpretation of splenic measurements and such differences would make it difficult to standardize expected splenic length and to determine non-palpable splenic enlargement".⁴

Spleen size in children has logarithmic increase in length with increase age. In infant less than 3 months less than 6 cm in length. Spleen size varies with age, nutrition, and hydration. The spleen weighed 15 g at birth and in adult 150 g range between 100-265 g (estimated weight = splenic index 0.55). No sex-based differences in splenic sizes have been found. The spleen is relatively larger in children, reaching adult size by age of 15 years. Splenic index = $0.524 \times \text{width} \times \text{thickness} \times (\text{ML} + \text{CCL})^2$, normal ranged 107-314 \ 480cm³.⁵⁻⁷

"Kidney size is an essential parameter for evaluating pediatric renal and genitourinary tract pathologies. Measurement of kidney size is important because many

current disorders with enlargement or kidney reduction, which means that renal size and function determined the health status of the kidney".⁸

Infantile kidneys are large compared to overall body size-typically 4 to 5 cm long at birth. The echogenicity of the renal cortex exceeds normal liver echogenicity usually for the first 3 years of life. The most commonly used measurement standard is renal length compared with chronological age.⁷ Normal renal length of the pediatric kidney may be determined using the following guide: Over one year - renal length in cm= $6.79+(0.22 \times \text{age in years})$ Less than one year - renal length in cm= $4.98+(0.155 \times \text{age in months})$. William K, Loftus, C. Mterweole state that the spleen to left kidney ratio in Chinese is strikingly constant with a mean value of 1. Using 2 SD above the mean as a guide, the upper limit of normal for spleen to left kidney ratio is 1.25. Splenomegaly should be suspected in children if the spleen is more than 1.25 times longer than the adjacent kidney.^{4,9} The aim of the study is to measure the normal size of spleen in Sudanese children up to five years using Ultrasonography and to determine the normal value of spleen to left kidney ratio.

METHODS

This was cross sectional study done to measure the normal size of spleen and spleen to left kidney length ratio among up to five years Sudanese children at Khartoum state in emergency department of Albuluk Pediatric Hospital and Jafar Ibn Ouf Referral Pediatric Hospital from March 2018 to June 2018.

The target populations was 101 children with age 1 month to five years age with normal spleen and kidneys, subjects with no history of malaria, typhoid fever, malnutrition, sickle cell disease or obesity and subjects with no evidence of splenic parenchymal mass lesions, abnormal echo texture of the spleen, accessory spleen and cysts were included as normal subjects. All children above five years old and under five years with tropical splenomegaly syndrome (malaria and typhoid fever), lymphadenopathy, sickle cell disease, obesity, splenic parenchymal mass lesions, accessory spleen and cysts were excluded from the study. The data was collected using data collection sheet designed specifically includes the following variables: Child's age, gender, height, weight, body mass index, spleen (length, width, depth), left kidney length, ethical approval granted from research world committee of Faculty of Radiology Science and Medical Imaging, Alzaiem Alazhari University and verbal consent taken from our parents (Figure 1).

The children exam using curve linear probe (3-5 MHz) lying in supine position on the couch, with the arms away from the chest wall and instructed to take deep breaths as possible. While necessary to move the spleen from under the ribs. The subject was lying in a supine position, but often (especially if there is a large amount of bowel

gases) the subject was examined in right lateral decubitus position, longitudinal and transverse views of spleen should be taken, splenic length and thickness measured from longitudinal section and width taken from transverse section, left kidney length measured from lateral decubitus longitudinal section also then spleen to left kidney ratio calculated by divided length of spleen\ length of left kidney.



Figure 1: Spleen measurements for pediatric 22 month; Length 5.93 cm, width 2.0cm, depth 5cm the length of left kidney 5.76, the ratio 1.03.

Statistical analysis

The data were analyzed by computer using Statistical Package for Social Science program (SPSS), version 16 and the results obtained was presented in tables and figures, then scatter plot and person correlation done to assess correlation between variables (p value <0.05) consider statistically significant. Independent sample t-test should be done to assess if there was significant difference in measurements in different gender.

RESULTS

The study was performed on 101 up to five years age children with normal spleen and kidneys. The mean age, height, weight, BMI respectively ranged (1-60 month) with mean 31.37±18.79 month, (50-110) mean 81.22±14.16 cm, (3-29) mean 12.66±4.99 kg, (9.8-36.36) mean 18.76±4.64 kg/cm².

The study found that the mean of splenic length was 7.24±1.12 cm (ranged 4.5-9.4 cm), width was 3.83±0.81 cm ranged (2.4-5.6 cm), thickness 2.91±0.55 cm (1.7-4.5 cm), left kidney length 6.97±1.09 cm (4.8-9.3 cm) and ratio of spleen length to left kidney length is 1.04±0.07 (0.85-1.23) (Table 1).

Table 1: Descriptive statistic (mean, minimum, maximum) for age, height, weight, and splenic measurements.

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Age\ month	101	1	60	31.37	18.79
Height\ cm	101	50	110	81.22	14.10
Weight\ kg	101	3	29	12.66	4.99
Bmi kg\ m ²	101	9.80	36.36	18.77	4.64
Spl\ cm	101	4.5	9.4	7.24	1.12
Spw\ cm	101	2.4	5.6	3.83	0.81
Spd\ cm	101	1.7	4.5	2.91	0.55
Left kidney length	101	4.8	9.3	6.97	1.09
Ratio spleen to left kidney length	101	0.86	1.23	1.04	0.070
Valid n (list wise)	101				

Table 2: Compare means for age splenic length, kidney length and ratio with age.

Age		LTK length	SPL length	Ratio(SPL\LTKL)
1 month to one years	Mean	5.92	6.12	1.03
	Std. Deviation	0.79	0.89	0.07
1.years 1 day - 2 years	Mean	7.03	7.12	1.01
	Std. Deviation	0.93	0.79	0.069
2 years 1 day to 3 years	Mean	6.95	7.39	1.06
	Std. Deviation	0.72	0.70	0.064
3 years 1d to 4 years	Mean	7.54	7.73	1.02
	Std. Deviation	0.59	0.79	0.07
4 years 1d -5 years	Mean	7.93	8.33	1.05
	Std. Deviation	0.92	0.75	0.059
p value		<0.01		>0.05

The age divided into five group, the study reveals that the mean length of left kidney increased steadily with age from (5.92±0.79 cm) at group one (month to 1 year) to (7.93±0.92 cm) at group five (4 years1day to 5 years), strong significance correlation with (p<0.01). The splenic length also had strong significant correlation with age (p<0.01), the mean splenic length in group one was 6.12±0.89 cm and in group five 8.33±0.75 cm. the ratio had no significant difference in different age group

(p>0.05) its mean 1.03±0.07 in group one and 1.05±0.06 in group five (Table 2). No significant difference found between spleen, left kidney length and spleen to left kidney length ratio in different gender (p>0.05) but these measurements is slightly more than in male than female, the mean measurements in male were 7.38±1.00 cm, 7.04±0.96 cm, 1.05±0.07 respectively while for female 7.05±1.22 cm, 6.88±1.23 cm, 1.03±0.07 respectively (Table 3).

Table 3: Independent sample t-test for compare means left kidney spleen measurements in both genders.

Variables	Gender	N	Mean	Std. Deviation	Std. Error mean	p value
Left kidney length	Male	55	7.04	0.96	0.1308	>0.05
	Female	46	6.88	1.22	0.1810	
Spleen length	Male	55	7.38	1.00	0.1358	
	Female	46	7.05	1.23	0.1817	
Ratio of spleen to kidney length	Male	55	1.05	0.067	0.00911	
	Female	46	1.03	0.07	0.01029	

Table 4: Correlation between age, height, weight, BMI and splenic measurements, ratio.

		SPL	SPLW	SPLD	Ratio
Age	Pearson correlation	0.720**	0.572**	0.625**	0.103
	Sig. (2-tailed)	0.000	0.000	0.000	0.307
	N	101	101	101	101
Height	Pearson correlation	0.663**	0.437**	0.431**	0.098
	SIG. (2-tailed)	0.000	0.000	0.000	0.328
	N	101	101	101	101
Weight	Pearson correlation	0.704**	0.516**	0.574**	0.112
	SIG. (2-tailed)	0.000	0.000	0.000	0.266
	N	101	101	101	101
BMI	Pearson correlation	0.252*	0.233*	0.298**	-0.12-
	SIG. (2-tailed)	0.011	0.019	0.002	0.902
	N	101	101	101	101

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Table 5: Correlation between age, height, weight, BMI and left kidney measurements.

		Left kidney length
Age/ month	Pearson correlation	0.674**
	Sig. (2-tailed)	0.000
	N	101
Height/cm	Pearson correlation	0.622**
	Sig. (2-tailed)	0.000
	N	101
Weight/cm	Pearson correlation	0.657**
	Sig. (2-tailed)	0.000
	N	101
BMI/ kg/ cm ²	Pearson correlation	0.259**
	Sig. (2-tailed)	0.009
	N	101

**Correlation is significant at the 0.01 level (2-tailed).

Table 6: Correlation Left kidney length, splenic length and ratio.

		Ratio	LTK length	Spleen length
Ratio	Pearson correlation	1	-0.219*	0.194
	Sig. (2-tailed)		0.028	0.052
	N	101	101	101
Left kidney length	Pearson correlation	-0.219*	1	0.913**
	Sig. (2-tailed)	0.028		0.000
	N	101	101	101
Spleen length	Pearson correlation	0.194	0.913**	1
	Sig. (2-tailed)	0.052	0.000	
	N	101	101	101

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Significant correlation found between age, height, weight, BMI with splenic length, AP, width ($p < 0.01$) as follows; ($r = 0.72$ for splenic length with age, $r = 0.66$ for body height and splenic length, $r = 0.704$ for body weight and splenic length, $r = 0.252$ for splenic length with BMI). The spleen\ kidney ratio shows no significant correlation with body parameters (age, weight, height and BMI) $p > 0.05$. Significant correlation also found between age, height, weight, BMI and left kidney length ($p < 0.01$) as follow: ($r = 0.67$ for age and left kidney length, $r = 0.65$ for weight and left kidney length, $r = 0.62$ for height and left kidney length and $r = 0.259$ for BMI and left kidney length) (Table 4, 5). Concerning the effect of splenic length and left kidney length on ratio the study demonstrate that no significant correlation between splenic length and ratio ($p > 0.05$), inverse weak correlation between ratio and left kidney length ($r = -2.19$, $p < 0.05$), but strong significant correlation between spleen and left kidney length measurements ($r = 0.913$, $p < 0.01$) (Table 6).

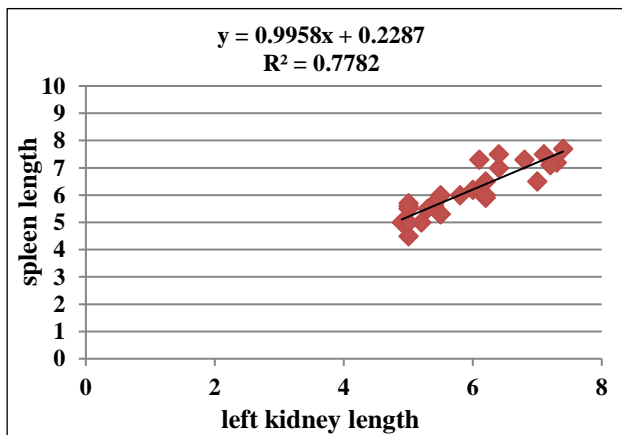


Figure 2: Scatterplot shows relationship between spleen lengths to left kidney length in 1 month to 1 year's age.

The study found that spleen length in one month to 1 years $= 0.99^* \text{ left kidney length} + 0.228$ ($R^2 = 0.7782$), and in 1 years 1 day to five years $= 0.84^* \text{ left kidney length}$

$+ 1.4612$ ($R^2 = 0.7375$), These result showed that the spleen and kidney was growing similarity during the first year of life, then than the growing rate of kidney decreased. (Figure 2, 3).

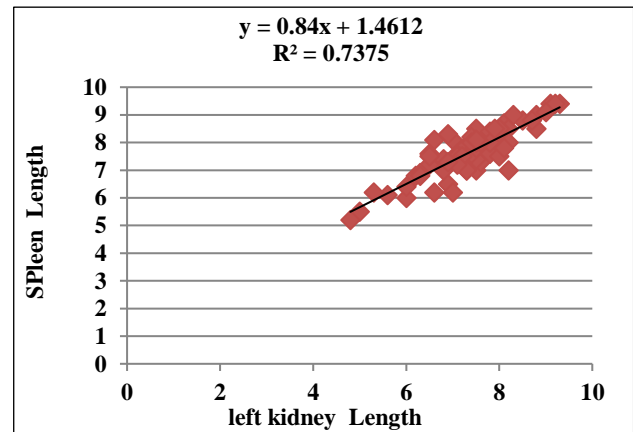


Figure 3: Scatterplot shows relationship between spleen lengths to LTK length in 1-year 1d to 5 years.

DISCUSSION

This was cross sectional study carried out in Khartoum state, the main objective of this study focused to measure the normal size of spleen and spleen length to left kidney length ratio performed on 101 under five age children with normal spleen and kidneys.

The study found that the mean splenic length was 7.23 ± 1.12 cm, width was 3.82 ± 0.80 cm, thickness 2.91 ± 0.55 cm, mean left kidney measurement was 6.97 ± 1.09 cm, 3.25 ± 0.65 cm, 2.73 ± 0.60 and 32.96 ± 18.03 ml for length, width and thickness. Spleen to left kidney ratio was 1.04 ± 0.07 (ranged 0.85-1.23), table (1) this mean that splenomegaly should be suspected if spleen is more than 1.23 times longer than left kidney in children up to five years age, this result similar to Qays Ahmed Al-timimy et al 2014 and others whom state that the spleen to left kidney ratio is strikingly constant with a mean value of 1. Using 2 SD above the mean as, the upper

limit of normal for spleen to left kidney ratio is 1.25. Splenomegaly should be suspected in children if the spleen is more than 1.25 times longer than the adjacent kidney, also little bit similar to Eze CU, Agwu KK, Ezeasor DN, Agwuna KK, Aronu 2014 whom state that the spleen to left kidney ratio according to age and somatometric parameters is constant at about 1.13 with 1.3 as the upper limit of normal in the studied population.^{5,10}

For comparing left kidney measurements, with age for five age group the study reveals that the mean length of left kidney increased steadily with age from (5.92±0.79 cm) at group one to (7.93±0.92 cm) at group, spleen length in group one 6.12±0.90 cm and in group five 8.33±0.75 cm, the left kidney length and spleen length increased with increasing age and there are strong significance correlation with (p<0.01) table 2, the present study agree also with study done by (A Otiv, K Mehta, U Ali, 2012),(Ravikumar Nalli, 2016) whose found that there was significant correlation of kidney length with age.^{11,12}

The study found that spleen to left kidney length has no significant difference in difference age group in group one 1.03±0.07 and in group five 1.05±0.05 (p>0.05)

The study found that no significant difference found in spleen, left kidney length and ratio in different gender, measurements is more in male than female (Table 3), this results go online with by Eze CU, Agwu KK, Ezeasor DN, Agwuna KK 2014, A Otiv, K Mehta, U Ali 2012, Ravi kumar Nalli, et al, and Oh M-S, et al, whom stated that there was no significant difference between the renal lengths of male and female.¹⁰⁻¹³

The study found that there was significant correlation between age, height, weight, BMI with splenic length, AP, width (p<0.01), this results go online with These results go online with Bhavna Dhingra, et al. 2010 whom state that there was significant correlation between spleen size age, weight and height.¹⁴ The study found that there was significant correlation between age, height, weight, BMI of participant and left kidney length, width and AP (p<0.01), these results agree Ravi kumar Nalli, et al. 2012-2013 whom state there was significant correlation between age, height and weight with kidneys length and volume.¹¹ No significant correlation between age, body height, BMI, body weight with spleen to left kidney ratio p>0.05 and study found that there was strong linear correlation between spleen length and left kidney (r=0.91, p<0.01) and there was no significant correlation between ratio (spleen\ left kidney length) with spleen length (p>0.05), but inversely correlated left kidney length (p<0.05) in children up to five years age. (Table 4, 5, 6).

Linear regression shows strong linear relationship between spleen length and left kidney length, in children up to one year age SPL (up to one years) =0.99* left kidney length +0.228(R²=0.78), for one year one day to five years SPL (1 years 1d to 5 years) =0.84* left kidney length +1.46 (R²=0.73). These results showed that the

kidney and spleen was growing similar in up the first year of life, while the growth rate of kidney slowed after one year age in relate to spleen, (Figure 2, 3).

CONCLUSION

The study found that the mean measurement of splenic length in children 1 month to five years was 7.23±1.12 cm, width was 3.82±0.80 cm, thickness 2.91±0.55 cm, the mean left kidney length is 6.97±1.09 cm, the mean ratio 1.04±0.70(0.86-1.23). The study found that strong significant correlation was found between splenic length, left kidney length with age, weight, height but weak linear correlation between spleen length and BMI. No significant correlation between age, height, weight, BMI with spleen to left kidney ratio, no significant difference in spleen, kidney length and ratio in different gender.

Recommendations

Beside that further researches advised with increases sample size including older children to obtain more precise results concerning spleen, kidneys length and spleen to left kidney ratio.

ACKNOWLEDGEMENTS

Authors would like to thank Al-Buluk and Gaafar Ibauf Paediatric Tertiary Hospital for granted an approval and helping in data collection in this study.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee of Alzaiem Alazhari faculty of Radiological Sciences and Medical Imaging Research Committee.

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Cite this article as: Sulima AG, Adam MA, Ahmed RY, Aburaida RA, Ebrahim AA. Measurements of the normal size of spleen and spleen to left kidney ratio among sudanese children up to five years age using ultrasonography. *Int J Res Med Sci* 2019;7:4349-55.