

# Ultrasound assessment of normal splenic length and spleen to left kidney ratio in sample of Iraqi population

Qays A. Al-timimy M.B.CH.B., D.M.R.D., C.A.B.M.S\*, Mahjoob N. Al-Naddawi MRCP, FRCP, FRCP, FRCP CH\*\*, Salam M. Joori M.B.CH.B., D.M.R.D., F.J.M.C\*

## ABSTRACT

**Background:** Spleen is a hemopoietic organ which is capable of supporting elements of different systems. It is affected by several groups of diseases; inflammatory, hematopoietic, reticuloendothelial proliferation, portal hypertension and storage diseases. 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. 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.

**Objectives:** To measure the normal values of splenic length in Iraqi subjects and compare the results with western, Chinese and Jordanian data; to determine whether there is a constant ratio of the length of the spleen to the left kidney, which could be used to diagnose splenomegaly without reference to a nomogram.

**Methods:** This is a cross-sectional study conducted among a total of 280 subjects ranging in age from birth to 20 years (159 males and 121 females). US was used to measure maximum splenic and left kidney lengths to obtain normal values for splenic length and to determine spleen to left

kidney ratio. The subjects were divided into the same age groups as those used by other similar international studies in order that comparisons with their results could be made.

**Results:** Splenic lengths in Iraqi subjects are similar to those in American, Chinese and Jordanian subjects up to the age of 15 years. The spleen to left kidney ratio 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.

**Conclusion:** Splenomegaly should be suspected in children if the spleen is more than 1.25 times longer than the adjacent kidney.

**Key words:** Spleen, subjects, ultrasound

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\* Department of surgery, Al-Kindy College of Medicine, University of Baghdad.

\*\* Chairman of the scientific council of pediatrics  
Received 6<sup>th</sup> Feb 2014, accepted in final 28<sup>th</sup> July 2014  
Corresponding to Dr Qays Ahmed AL-timimy  
e-mail: qtimeme@yahoo.com

The spleen is the largest organ in the reticuloendothelial system. A number of disorders are accompanied by altered spleen size including: infestation, infective, infiltrative, immunological and malignant disorders<sup>1</sup>.

Normal dimensions of the spleen at adulthood: length <110 mm, thickness <50mm, width <70mm<sup>2</sup>. Spleen size in childhood has logarithmic increase in length with increase age<sup>3</sup>. Spleen size varies with age, nutrition, and hydration. The spleen is relatively larger in children, reaching adult size by age of 15 year<sup>4</sup>. The spleen weighted 15 g at birth, while at adulthood range between 100-265 g<sup>3</sup>. No sex-based differences in splenic sizes have been found<sup>3</sup>.

Splenomegaly in childhood is generally first suspected upon physical examination. It may be difficult to palpate an enlarged spleen in the setting of obesity, muscular abdominal wall, or the inability to sufficiently relax the abdominal musculature, so the clinical examination is far from accurate to detect a small increase in size<sup>5</sup>. The spleen may be palpable in 15 - 17 % of healthy neonates<sup>5,6</sup> and 10 % of healthy children; However in most children, it must be two to three times its normal size before it is palpable<sup>7</sup>. The tip of the normal, palpable spleen is soft, smooth, non tender and less than 1 - 2 cm below the left costal margin. A pathological enlarged spleen is often firm, may have an abnormal surface and is frequently associated with signs and symptoms of the underlying disease. When any of these features are noted, or if the tip of the spleen is enlarged more than 1 - 2 cm below the costal margin, further evaluation should be considered<sup>8</sup>.

The aim of the study was to establish upper limits for normal splenic lengths in Iraqi population and compare the results of the normal value of splenic length in our subjects with those of USA, Chinese and Jordanian subjects and to determine

whether there is a constant ratio of the length of the spleen to the length of the left kidney which could be used to diagnose splenomegaly without reference to a nomogram.

**Methods.** This is a cross-sectional study conducted among subjects from age 1 day (full-term neonate) up to 20 years at X-ray institute, pediatric welfare hospital and Al-Shahid Ghazi Al-Hariri hospital in medical city complex from May 2011 through December 2011. These subjects came to our hospitals as outpatients for either a follow up examination or routine check up. The parent's informed consent was obtained for all selected children.

A total of 280 subjects (159 males, 121 females) underwent abdominal US examination and measurement of splenic length and left kidney length were obtained. We used high resolution real time US scanners (Philips HD 11 XE). We used 3.5 MHZ curvilinear transducer for most cases; alternatively we used a 7.5 MHZ linear array transducer for some cases in neonates and small infants.

The subject was asked to lie supine on the couch, with the arms away from the chest wall and instructed to take shallow breaths as possible. While necessary, scanning with the subject in deep inspiration was done 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. The intercostals spaces were used as scan widow for proper visualization of the entire spleen.

All measurements were made on sections through the splenic hilum in order to create a constant reference point for repeating measurements according to the guidelines of the American institute of US In medicine<sup>9</sup> and as described by Lamb et al.<sup>10</sup>. The splenic length (the

maximum distance between the dome of the spleen and the splenic tip) was measured on longitudinal coronal view. We also measured the maximum length of the left kidney to allow calculation of the ratio of the spleen length to left kidney length (figure 1 and 2). In most cases, we obtained three sequential measurements and calculated the mean; thus, we ensured minimum intra observer variation and greater accuracy and reliability of measurements. In the remaining cases, that are restless infants and young children, we were satisfied with two measurements. Neither preparation nor sedation was needed.

In all subjects, the spleen was not examined clinically and any child known to have renal disease was excluded. Also the following subjects were excluded from the study: 1. Subjects with hemoglobinopathies 3. Subjects with lymphoproliferative disorders such as lymphoma, leukemia, etc. 4. Subjects with focal splenic lesions and non-uniform parenchyma. 5. Subjects who had fever at time of scan. 6. Subjects in whom the entire length of the spleen could not be properly documented. 7. Gravid women.

Statistical Analysis was done using SPSS 18 (Statistical Package for Social Sciences version 18) used for data analysis. Continuous variables presented as mean (M) and standard deviation (SD). T test for two independent variables used to test the significance of difference between two normally distributed continuous variables<sup>11</sup>. The significance of the extrapolated means is supported by absence of zero from the 95% confidence interval (95%CI)<sup>11</sup>. Findings with P value less than 0.05 were considered significant. The advantage of the median as a measure for central tendency is that it is unaffected by extreme values<sup>12</sup>.

**Results.** Among 280 subjects, 159 (56.8 %) of the study's subjects were males and the rest 121 (43.2 %) were females, figure 3. We grouped the subjects into 11 definite age groups, figure 4.

Our results showed a steady, progressive increase in splenic length up to the age of 15 years. Above 15 years, no

increase in splenic length was noted in females, figure 5.

Males significantly were found to have longer spleen in ages 1- < 2 years, 4- < 6 years and in 15-20 years while females significantly were found to have longer spleen in ages 2-< 4 years (  $P < 0.05$  , table 1) . There was no significant difference in splenic length between males and females in ages up to 1 year and in ages between 10-15 years ( $P > 0.05$ , table 1). Our results showed that the spleen to the left kidney length ratio is around 1 for all age groups (table2). Using 2 SD above the mean as a guide, the upper limit of normal for the spleen to left kidney length ratio is 1.25.

**Discussion.** Various methods are defined for the evaluation of the spleen size in the literature. However, sonography is a simple, practical, low cost and accurate method.

In the literature, the normal splenic size in different age groups has been reported. In 1970, Deland<sup>13</sup> stated that the size of the spleen in 440 adult autopsy specimens shows variation according to the sex and age. He reported that splenic size in female was smaller than male in all age groups. In 1983, Niederau et al.<sup>14</sup> in their sonographic study found that the spleen size decreased with increased age. Dittrich et al.<sup>15</sup> reported the first splenic size nomogram with sonographically determined volume estimation in 194 healthy children , but this method is considered very time - consuming and not reproducible by Rosenberg et al.<sup>16</sup>

In 1991, Rosenberg et al.<sup>16</sup> used data from 230 healthy American subjects in the first and 2nd decades of life and suggested upper- limits guidelines for splenic length in 11 definite age groups without mention of somatometric factors. Rosenberg et al. reported that the difference between the two sexes emerges after 15 years; also found that measurement of splenic length was an easier technique. When we compared the median splenic lengths according to the age groups, our finding roughly seemed to agree with theirs except age group 15 - 20 year, where our splenic lengths were shorter.

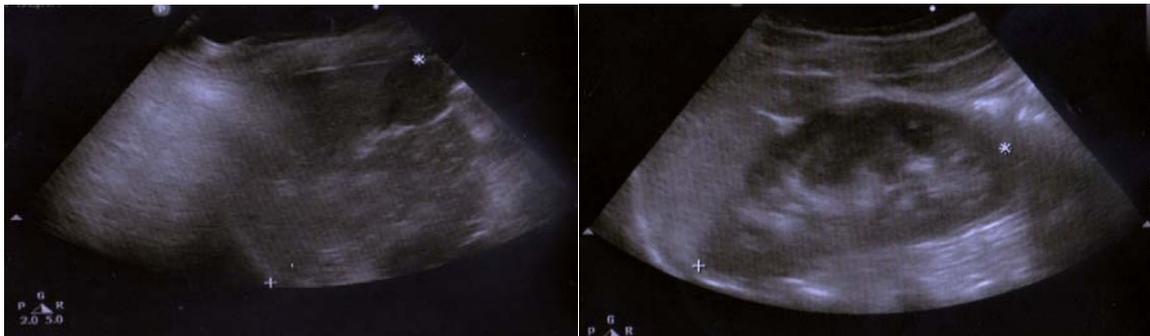


Figure 1: 10 years male, splenic length and left kidney length were measured.



Figure 2: 15 years male, splenic length and left kidney length were measured.

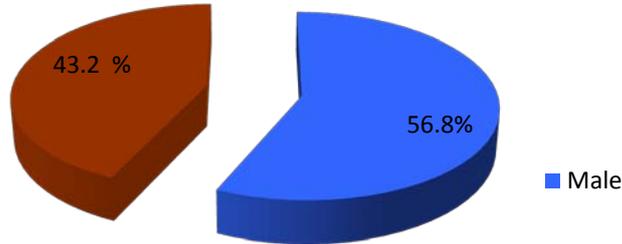


Figure 3: Pie chart depicting the relative percentages of male and female in the study.

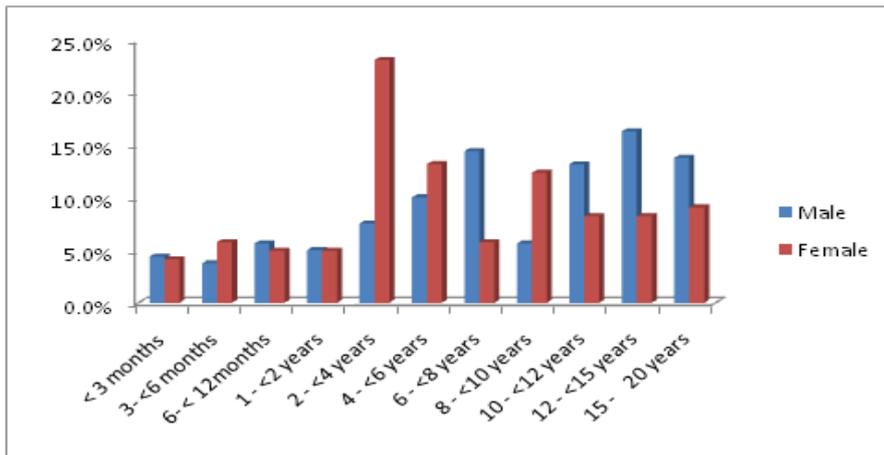


Figure 4: Distribution of the study sample according to age and to sex.

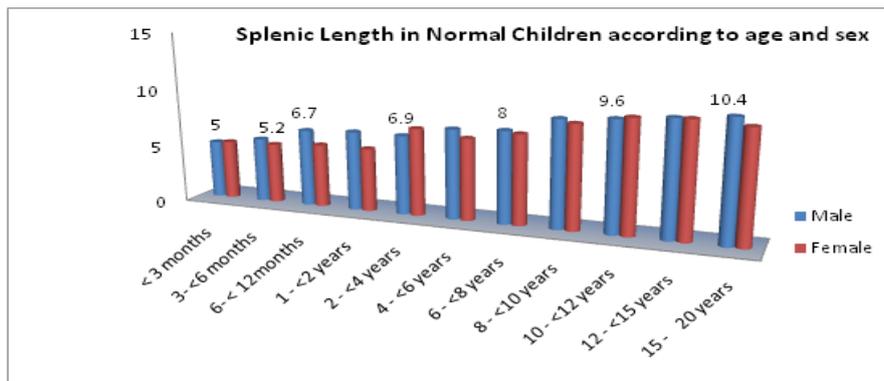


Figure 5: Median Splenic length (cm) in the study sample.

**Table 1:** Descriptive statistics for splenic length(cm) in normal subjects according to each age group and sex.

Age Group	Sex	N	Median	Mean	SD	95%CI	P value
<b>&lt; 3 months</b>	Male	7	5.0	5.0	0.0	5.0;5.1	0.220
	Female	5	5.1	5.1	0.2	4.9;5.3	
<b>3- &lt;6 months</b>	Male	6	5.6	5.5	0.3	5.1;5.8	0.079
	Female	7	5.2	5.2	0.2	5.0;5.4	
<b>6- &lt; 12months</b>	Male	9	6.7	6.1	1.1	5.2;7.0	0.154
	Female	6	5.5	5.4	0.4	4.9;5.8	
<b>1 - &lt;2 years</b>	Male	8	6.9	6.7	0.4	6.4;7.0	0.002
	Female	6	5.5	5.7	0.6	5.1;6.3	
<b>2 - &lt;4 years</b>	Male	12	6.9	6.9	0.5	6.5;7.2	0.045
	Female	28	7.6	7.3	0.7	7.1;7.6	
<b>4 - &lt;6 years</b>	Male	16	7.8	7.8	0.6	7.4;8.1	0.006
	Female	16	7.1	7.2	0.6	6.8;7.5	
<b>6 - &lt;8 years</b>	Male	23	8.0	8.0	0.7	7.7;8.3	0.785
	Female	7	7.8	7.9	0.4	7.6;8.2	
<b>8 - &lt;10 years</b>	Male	9	9.3	9.3	0.3	9.1;9.5	0.038
	Female	15	9.0	8.7	0.7	8.4;9.1	
<b>10 - &lt;12 years</b>	Male	21	9.6	9.5	0.9	9.0;9.9	0.847
	Female	10	9.8	9.6	0.9	8.9;10.2	
<b>12 - &lt;15 years</b>	Male	26	10.0	10.0	0.9	9.6;10.4	0.771
	Female	10	10.0	9.9	1.0	9.2;10.6	
<b>15 - 20 years</b>	Male	22	10.4	10.6	0.5	10.4;10.8	0.000
	Female	11	9.7	9.7	0.6	9.3;10.2	

**Table 2:** Splenic length to left kidney length ratio in the study sample.

	Ratio
<b>&lt; 3 months</b>	1.00
<b>3- &lt;6 months</b>	0.94
<b>6- &lt; 12months</b>	0.99
<b>1 - &lt;2 years</b>	1.01
<b>2 - &lt;4 years</b>	1.00
<b>4 - &lt;6 years</b>	0.98
<b>6 - &lt;8 years</b>	1.00
<b>8 - &lt;10 years</b>	1.00
<b>10 - &lt;12 years</b>	0.99
<b>12 - &lt;15 years</b>	0.99
<b>15 - 20 years; Males</b>	1.02
<b>15 - 20 years: Females</b>	0.91

**Table 3:** Splenic length in normal subjects in this study compared to similar international studies.

Age Group	Median Splenic Length (cm)			
	Iraq	USA <sup>A</sup>	Hong Kong <sup>B</sup>	Jordan <sup>C</sup>
< 3 months	5.1	4.5	4.8	4.7
3- <6 months	5.2	5.3	5.8	5.4
6- < 12months	5.6	6.2	6.1	6.2
1 - <2 years	6.5	6.9	6.2	6.9
2 - <4 years	7.3	7.4	6.7	7.1
4 - <6 years	7.4	7.8	7.2	7.8
6 - <8 years	8.0	8.2	7.7	8.0
8 - <10 years	9.1	9.2	8.0	9.3
10 - <12 years	9.7	9.9	8.4	9.5
12 - <15 years	10.0	10.1	9.5	10.4
15 -20 years; Males	10.4	11.2	9.8	10.5
15 - 20 years: Females	9.7	10.0	8.8	9.8

A (16), B (17), C(19)

In 1998 , Loftus and Metreweli<sup>17</sup> sonographically measured both spleen length and kidney length in 256 healthy Chinese subjects and they compared splenic lengths with the results of the study of Rosenberg et al<sup>16</sup>, they found that splenic length in Chinese subjects to the age of 15 year , was similar to that of western subjects . They also suggested that splenomegaly should be suspected in children if the spleen is more than 1.25 times larger than the adjacent kidney. When we compared the median splenic lengths according to age groups and spleen to kidney ratio, our findings roughly seemed to agree with theirs except age group 15 - 20 year, where our splenic lengths were taller.

Also in 1998, konus et al.<sup>18</sup> examined 299 healthy subjects by using sonography and provided results for both spleen length and transverse spleen dimensions (in coronal sections). Unfortunately, the age groups used in their study were no identical to those in ours, but we can make an approximate comparison by taking into account the differences in the age ranges. This reveals that their results were also not very different from ours.

In 2000, O. Al.Imam et al.<sup>19</sup> examined 184 normal Jordanian subjects by using sonography and provided results for both splenic length and spleen to left kidney ratio. Also they compared splenic lengths with the results of the studies of Rosenberg et al<sup>16</sup> and Loftus and Metreweli<sup>17</sup>; they found that splenic length in Jordanian subjects up to age 15 years was similar to that of subjects from USA and Hong Kong. However, they reported that in Jordanian males over 15 years, the splenic lengths were shorter and they didn't mention cause for this. Also they reported that spleen to left kidney lengths ratio was constant at around 1 and splenomegaly is highly probable in ratios > 1.25. When we compared the median splenic lengths according to age

groups and spleen to kidney ratio, our findings roughly seemed to agree with theirs.

In our study, a total of 280 subjects (159 males, 121 females) underwent abdominal US examination and measurement of splenic length and left kidney length were obtained.

We grouped the subjects into 11 definite age groups as those used by Rosenberg et al<sup>16</sup>, Loftus and Metreweli<sup>17</sup> and O. Al-Imam et al.<sup>19</sup> in order that comparisons with their results could be made . We found no increase in splenic length in Iraqi females above the age of 15 years. This is probably because the age of puberty in Iraq is usually between 11 and 14 years for girls<sup>20</sup>.

We found no obvious differences between the median splenic lengths of western, Chinese and Jordanian subjects and those of our subjects till to the age of 15 year and they can be applied to the same age groups. However for subjects over 15 years, splenic lengths in Iraqi subjects were found to be shorter in comparison with that of subjects from USA and taller in comparison with that for subjects from Hong Kong, but still nearly similar to that of Jordanian subjects. No cause for this is known and it is intended to carry out a similar comparison in the future using adults. Also we found that spleen to left kidney ratio is another easy and reliable way to exclude splenic enlargement. Splenomegaly is highly probable if the spleen to left kidney ratio is > 1.25 in the absence of renal disease.

We believe that by collecting the largest series so far, to our knowledge, of US-determined pediatric spleen length measurements, we have estimated more accurately its normal values in childhood. Our aim was to provide a more objective assessment of mild splenomegaly during routine abdominal US. Our results could be used as a practical and

comprehensive guide to indicate the normal spleen length range for every child according to his age.

In conclusion, up to age of 15 year, little variation in splenic length between Iraqi subjects and western, Chinese and Jordanian subjects was observed, but over 15 years, splenic length was slightly lower in Iraqi subjects in comparison to that of western subjects. Spleen to left kidney ratio was constant at around 1; and splenomegaly should be suspected in children if the spleen is more than 1.25 times longer than the adjacent kidney. We hope that this study contribute to daily practice in sonographic clinics.

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