

Local Reference of Splenic Volume in Healthy Sudanese Subjects Sonographically

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ABSTRACT

This study was carried out to estimate normal linear dimensions and volume of the spleen in Sudanese using ultrasonography, and to keep it as standards reference for diagnostic purposes.

This prospective study was done at Radiology Department, National Ribat University Hospital, Khartoum, Sudan, conducted on 108 volunteers (72 males and 36 females). All linear dimensions of spleen were measured, and splenic volume was calculated using ultrasonography. The splenic volume was then analyzed with age and body parameters using the Pearson's correlation coefficient. Results of this study revealed that the mean values of the age, height, weight of subjects, spleen length (SL), spleen width (SW), spleen thickness (ST) and spleen volume were calculated were found to be 38.74 ± 18.898 years, 163.11 ± 17.747 mm, 65.33 ± 15.431 kg, 91.07 ± 11.330 mm, 37.59 ± 7.440 mm, 37.78 ± 8.085 mm and 70.63 ± 31.924 cm³ respectively. Age had no significant effect on spleen volume ($p=0.684$). There was a significant positive correlation, using Pearson's correlation coefficient, between the spleen volume, and other parameters (height $p=0.000$, and weight $p=0.002$). The present study concluded that a local reference of spleen dimensions was established with a different range of values reported previously.

Keywords: Spleen Size, ultrasound, Local Reference

1 Introduction:

The spleen is the largest organ in the reticulo endothelial system^[1] Spleen size is important in the evaluation of gastrointestinal and hematological diseases for both radiologists and clinicians.^[2] A normal spleen weighs 150-200 g, and is 10.9 ± 1.4 cm long, 4.0 ± 0.45 cm deep, and 6.8 ± 0.71 cm in diameter. The spleen volume can be measured by various techniques such as radiography, scintigraphy, CT, MRI, and ultrasonography.^[3,4] Ultrasonography is the first imaging method to assess splenomegaly.^[5,6]

There are several studies about normal internal organs character^[7, 8]. All of these are from the populations of Caucasoid and from the populations of Asian, Japan, China, Korea, and India. In the past, Thailand normally used references from American or European references. The problem is that the

differences of these factors make the indicators different: race, body structure, genetic, environment, living condition, life style, and food. ^[9,10].Spleen size varies widely according to age also many diseases can affect their size, including infections and malignancy ^[11, 12].Radiography and radionuclide studies expose the patient to gamma radiation ^[13,14,15].

Ultrasound is considered as one of the first lines of diagnosis of many abdominal organs, for its various facilities in detection and measurement; many of splenic disease may associate with incrimination of its volume and sometimes without causing and morbidity of the patient, therefore the measurement of normal spleen volume may assist in early diagnosis of its pathological condition as well as providence of reference standard for spleen volume.

This study was carried out to estimate normal linear dimensions and volume of the spleen in Sudanese using ultrasonography, to correlate splenic volume with age and body parameters: age, height, and weight, in order to keep it as standards reference for diagnostic purposes.

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2 Material and method

2.1 Subjects

The study was performed at the Radiology Department, National Ribat University Hospital, Khartoum, Sudan, between December 2016 and April 2017, conducted on 108 volunteers (72 males and 36 females) not known to have any conditions likely to be associated with splenomegaly, and verbal informed consent was taken for each case. Ethical approval was obtained from the Research Council of the college of Medical Radiological science.

2.2 Exclusion criteria

Subjects underwent a physical examination and completed a short standardized interview questionnaire to exclude any previous or current conditions that might involve the size of the spleen.

2.3 Methods of the Study

Baseline data including age, gender, height, and weight were recorded for all participants. All ultrasonographic examinations were performed by experienced senior sinologists. The examinations were performed using Siemens Aplio MX ultrasound machine equipped with 3.5 MHz curvilinear probes (Erlangen, Germany).The subjects were placed and examined in the supine and right posterior oblique positions, and the spleen was scanned during suspended respiration. Splenic length, thickness and width measurement methods used in this study. D1= Splenic length D2= Splenic width, D3= Splenic thickness, Fig. (1)



**Figure 1. Splenic length, thickness and width measurement methods used in this study. D1= Splenic length
D2= Splenic width, D3= Splenic thickness,**

2.4 Statistical analysis

The data was entered into a spread sheet and analyzed using the SPSS Statistics for Windows, version 16. The means (\pm standard deviation), ranges, were all calculated.

The relationship between the splenic index and each of the variables (age, height, and weight) was assessed with the Pearson's correlation coefficient.

The significance threshold was set at 0.05. The XY scatter plots were generated by Microsoft Excel 2010.

3 Results

This prospective study conducted on 108 volunteers (72 males and 36 females). All linear dimensions of spleen were measured, and splenic volume was calculated using ultrasonography. The splenic volume was then analyzed with age and body parameters using the Pearson's correlation coefficient. The mean values of the age, height, weight of subjects, spleen length (SL), spleen width (SW), spleen thickness (ST) and spleen volume were calculated were found to be 38.74 ± 18.898 years, 163.11 ± 17.747 mm, 65.33 ± 15.431 kg, 91.07 ± 11.330 mm, 37.59 ± 7.440 mm, 37.78 ± 8.085 mm and 70.63 ± 31.924 cm³ respectively. Age had no significant effect on spleen volume ($p=0.684$). There was a significant positive correlation, using Pearson's correlation coefficient, between the spleen volume, and other parameters (height $p=0.000$, and weight $p=0.002$). The present study concluded that a local reference of spleen dimensions was established with a different range of values reported previously

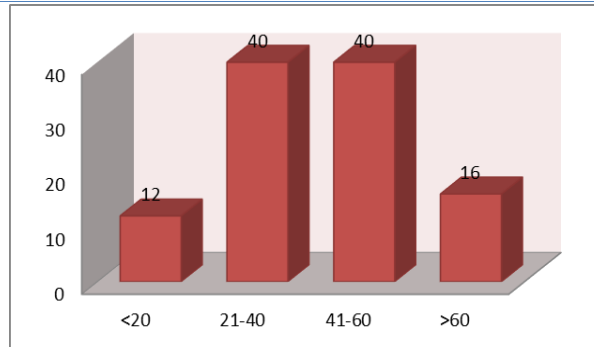


Figure 2 shows the distribution of the subject's age groups

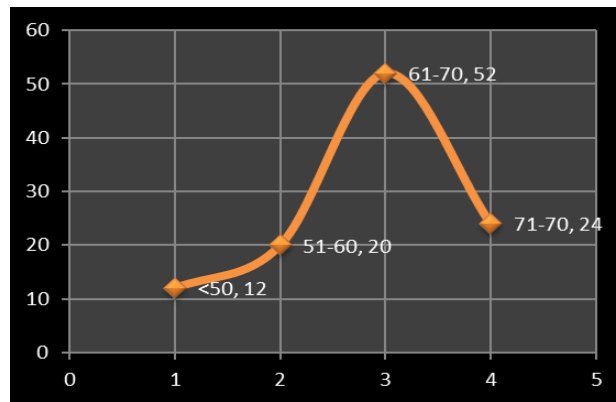


Figure 3 shows the distribution of the subject's weight (in Kgs)

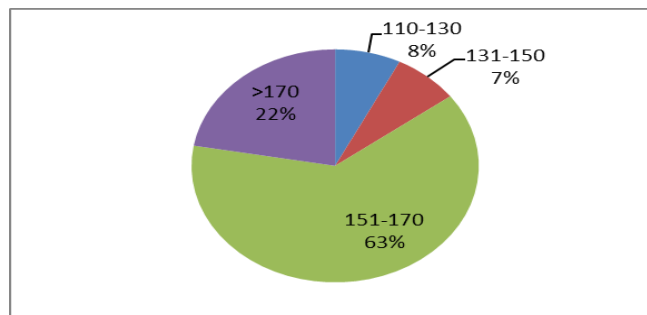


Figure 4 shows the distribution of the subject's height (in cm)

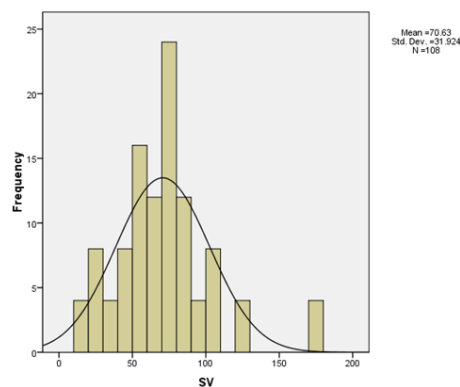


Figure 5 shows the distribution of spleen volume (mm³) in all participants. The x-axis shows measurement of spleen length, and the y-axis shows the number of subjects

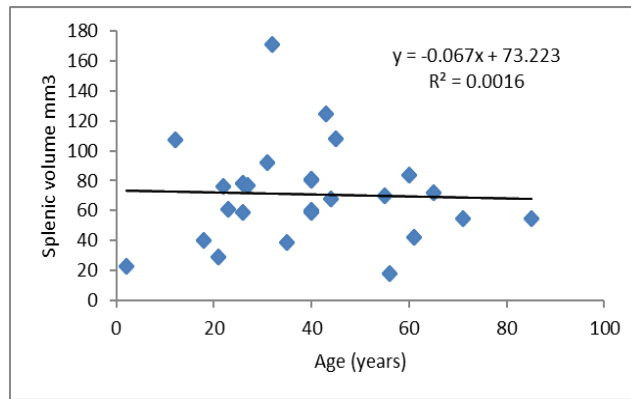


Figure 6 shows the correlation between age groups and spleen volume

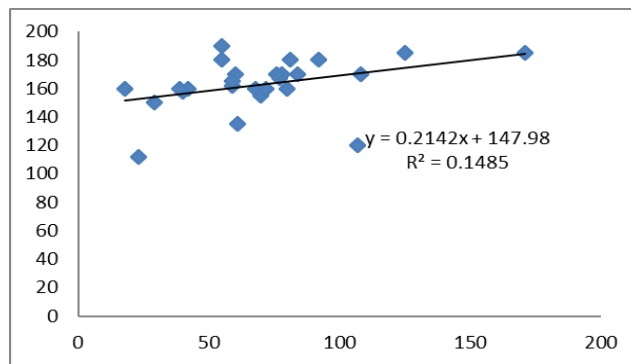


Figure 7 shows the relation between body height and spleen volume.

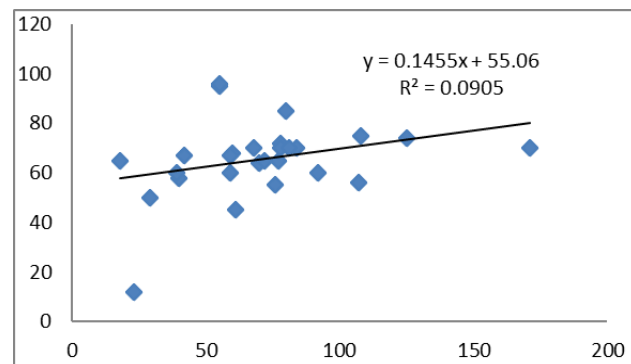


Figure 8 shows the relation between body weight and spleen volume.

Table 1. Characteristics of spleen from 108 subjects (72 males and 36 females' ages 2–85 years).

		Age (years)	Spleen length mm	Spleen width-mm	Spleen depth-mm	Splenic volume mm3	Subjects height(M)	Subjects Weight (Kg)
N	Valid	108	108	108	108	108	108	108
	Missing	0	0	0	0	0	0	0
Mean		38.74	91.07	37.59	37.78	70.63	163.11	65.33
Std. Deviation		18.898	11.330	7.440	8.085	31.924	17.747	15.431
Range		83	48	30	36	153	78	84
Minimum		2	74	22	17	18	112	12
Maximum		85	122	52	53	171	190	96

Table 2 illustrates Proximity Matrix of correlation between variables.

		Age (years)	Spleen length (mm)	Spleen width-(mm)	Spleen depth-mm	Splenic volume mm3	Subjects height(M)	Subjects Weight (Kg)
Age (years)	Pearson Correlation	1	.178	-.082	-.009	-.040	.538**	.733**
	Sig. (2-tailed)		.065	.398	.925	.684	.000	.000
	N	108	108	108	108	108	108	108
Spleen length (mm)	Pearson Correlation	.178	1	.576**	.454**	.735**	.609**	.487**
	Sig. (2-tailed)	.065		.000	.000	.000	.000	.000
	N	108	108	108	108	108	108	108
Spleen width-(mm)	Pearson Correlation	-.082	.576**	1	.661**	.880**	.394**	.281**
	Sig. (2-tailed)	.398	.000		.000	.000	.000	.003
	N	108	108	108	108	108	108	108
Spleen depth-mm	Pearson Correlation	-.009	.454**	.661**	1	.838**	.181	.261**
	Sig. (2-tailed)	.925	.000	.000		.000	.061	.006
	N	108	108	108	108	108	108	108
Splenic volume mm3	Pearson Correlation	-.040	.735**	.880**	.838**	1	.385**	.301**
	Sig. (2-tailed)	.684	.000	.000	.000		.000	.002
	N	108	108	108	108	108	108	108
Subjects height(M)	Pearson Correlation	.538**	.609**	.394**	.181	.385**	1	.766**
	Sig. (2-tailed)	.000	.000	.000	.061	.000		.000
	N	108	108	108	108	108	108	108
Subjects Weight (Kg)	Pearson Correlation	.733**	.487**	.281**	.261**	.301**	.766**	1
	Sig. (2-tailed)	.000	.000	.003	.006	.002	.000	
	N	108	108	108	108	108	108	108
**. Correlation is significant at the 0.01 level (2-tailed).								

4 Discussion

The wide range of normal spleen size values reported in the literature makes the establishment of normal ranges more difficult. The Sudanese's population is a cosmopolitan society of approximately 40 million people where the vast majority is Sudanese, and the rest are refugees and immigrants from nearby countries. Only Sudanese were included in this study. In this study population,

The majority of the sample under study was male 72 patients (81%) and female 36 patients forming the (19%). In this study the average age of the patients studied was 38.74 years. The majority of patients studied were from Khartoum state (81%), Central Sudan (7%), and Western Sudan (7%), and Eastern Sudan (5%). The subjects' characteristic data were comparable to the mean values reported in the literature (Table 1)

Table 3 illustrates the subjects characteristic data comparable to the mean values reported in the literature

Authors	N	Age.range(years)	L±SD	W±SD	T±SD	V±SD	country
current study	108	2–85	9.107±1.133	3.759±.744	3.778±8.09	70.63±31.92	Sudan
Nouri et al , 2013 ^[16]	215	7–13	NR	NR	NR	9.0 ± 1.2	Sudan
Ezeofor1 et al ,2014 ^[17]	1315	5 - 17	10.1±1.4	NR	NR	NR	Nigeria
Badran, et al, 2015 ^[18]	205	NR	10.72±1.37	7.40±1.52	4.40±1.47	184.15±79.56	Jordan
Çeliktaş et al 2015 ^[19]	150	18- 76	9.87±1.28	7.58±1.56	3.34±0.79	136.05±61.14	Turkey
Tanna et al , 2012 ^[20]	80	NR	9.70±0.15	NR	NR	NR	India
Mustapha et al 2010 ^[21]	375	NR	8.9±1.3	4.9±1.2	5±0.9	119.5±55.7	Nigeria
Serter et al 2010 ^[22]	2179	17-42	10,76±1,8	NR	NR	NR	Turkey
Singh and Kumari, 2016 ^[23]	NR	NR	2.5 ± 0.3	1.7 ± 0.1	1 ± 0.1	NR	India
Chakraborti et al in 2016 ^[24]	146	17- 95	8.85±1.54	NR	NR	NR	India

The means of splenic dimensions were fairly similar to those recorded by Turkish and Nigerian populations^[19,20] and less than the data from Jordan ^[18] implicating that ethnicity could be attributed in part to the wide ranges of normative data registered by different populations this recent study performed on Jordan adults. To estimate normal linear dimensions and volume of the spleen in Jordanians using ultrasonography, and to correlate splenic volume with age and body parameters: height, weight, body surface area (BSA), and body mass index (BMI). ^[18]. Splenomegaly is considered as moderate if the biggest dimension is 11-20 cm, and severe if the biggest dimension is greater than 20 cm. ¹⁸ However, this study recorded a the mean of spleen length of normality in Sudanese is 9.107cm. Therefore, caution is required in defining splenomegaly in our population.

A likely decrease in the size of the spleen due to aging reported in the previous literature was not evident in this study ^[25], Arora et al. 2010). However, our findings were in agreement with the results described in Africans and Indians studies ^[22]. Moderate positive relationships between splenic volume and height, weight were observed; this was similar to the data from spleen sonography and autopsy ^[26, 27]. Graphic representation of the data showed some variability of the spleen volume by height; weight (**Figs (7,8)**), it also showed the unmistakable trend for spleen volume to increase in parallel with the increase in the body parameters. So the variations of body parameters could be attributed to different splenic measurements in different areas. Previous studies showed that the longitudinal measurements of the spleen were best correlated only with body height ^[28]. On the other hand, studies of African adults and Turkish males found no correlation between spleen volume and body parameters ^[21,22]. From a physiological perspective, our findings would make more sense; as patients with a bigger body habitus will have a larger blood volume requiring larger spleens for filtration. As there is a positive correlation between the body parameters and the splenic volume.

This study measured the splenic length, width, thickness and volume among Sudanese and the results were compared to other populations. The mean values of splenic length and width were 9.107cm and 3.759cm

The Africans, Rajasthan population and Thai population having lower, and Nigerians having greater values than this study. The study results are different from those of these investigations, except the Thai population when comparing splenic width results.

Moreover, mean values of splenic thickness were reported between 3.33 cm and 6 cm in Thai population, Indians, Africans, Americans and Nigerians ^[21, 28,29] In this study this value was 3.778cm. According to this data of the present result is similar to Thai population.

Splenic volume was calculated in males and 136.05 cm³ in females. In a studying consisting of Nigerians, in males mean value of splenic volume were 202.7 cm³ and in females 153.7 cm³ respectively (Ehimwenma & Tagbo, 2011).

Moreover, the same value was 119.5 cm³ in African population ^[21, 29] determined that the splenic volumes were 288.36 cm³ and 217.44 cm³ in males and females respectively. Furthermore, the mean volume of the spleen was 132 cm³ and 113 cm³ respectively in Japanese males and females whereas; same dimensions were 134.2 cm³ and 115.6 cm³ in males and females respectively in Thai adults ^[29]. However, same value was 344 cm³ in the USA ^[30].

Due to these data, this study found differences in the mean values of the splenic volume of Sudanese, Nigerians, Japanese population.

We consider that these discrepancies could be a result of such factors like race, genetic variables, nutritional status, socioeconomic status and demographic variables including age, weight, and height. Moreover, we found that all dimensions were greater in males than females and splenic length decreased with increase in age in both genders. As we mentioned before, there were no differences in the mean values of the spleen volume between two calculation methods.

Among the different techniques employed for assessment of normal or otherwise spleen size, ultrasonographic measurements have been considered to be the most feasible and accurate. Ultrasonography can be a useful technique as it is noninvasive and does not involve any risk of radiation. Ultrasound, therefore, has become the most common practice to differentiate pathologically enlarged or reduced spleen in patients.

5 Conclusion

The precise knowledge of the spleen morphology with USG may be essential for safe and accurate diagnose of many disorders such as infections, splenomegaly, malignant conditions and viral illnesses for surgeons and radiologist. Therefore, the observations presented in this study have defined anatomic parameters that need to be taken into consideration for evaluating splenic problems and guidelines to determine the reference values.

The data obtained in this study can provide crucial information for surgeons and radiologists about spleen, and they can be used as reference values for evaluating pathologic changes in the spleen region.

A local reference of spleen dimensions was established in this study with a different range of values reported previously. Setting a higher cutoff point for defining splenomegaly in Sudanese should be considered.

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