

Sonographic measurements of Normal Spleen dimensions in Iraq: a sample from adults in Imamein Kadhimein Medical City

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ABSTRACT

INTRODUCTION: Many diseases can affect splenic dimension; assessment of splenic size is important in abdominal physical examination. It is difficult to detect splenic enlargement unless it is enlarged double or triple its own size.

OBJECTIVE: was to measure the normal splenic size in adults attending private ultrasonic department of Imamein Kadhimein Medical City and to establish correlation of splenic dimension with age, gender, height and weight.

METHODS: A cross-sectional study conducted on selected patients attending private ultrasonic department of Imamein Kadhimein Medical City within a period of three months. Splenic dimension took by Voluson-E6 Ultrasound machine, Splenic volume calculated using ellipsoid formula "length*width*thickness*0.52".

RESULTS: The mean $\pm$ SD of splenic volume was 97.58 ± 43.78 cm³. Splenic length, width, and thickness showed a strong correlation with volume ($r = 0.709, 0.756, 0.568$ respectively, $p < 0.0001$). No statistical significant correlations between the volume and gender, age, height, weight, or body mass index. Significant difference in splenic length between males and females, and correlated significantly with body height and weight ($r = 0.257, p < 0.01$), ($r = 0.248, p < 0.013$) respectively. For males, there was no significant correlation between anthropometric measurements and splenic dimension. For females, there was a significant correlation between height and splenic width ($r = 0.411, P < 0.006$), thickness ($r = 0.401, P < 0.007$), and volume ($r = 0.491, P < 0.001$).

CONCLUSION: A local standard reference with different ranges of splenic dimension was determined. Establishing a higher upper normal limit for diagnosing enlarged spleen in Iraqi population must be considered.

Key words: spleen, dimension, adult.

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INTRODUCTION

Spleen is the largest lymphatic organ in the human body.¹ Since Many diseases can affect splenic dimension, knowledge of normal splenic dimension by ultrasound is important in clinical practice to detect mild enlargement in the spleen as it may be difficult to detect mild enlargement by clinical examination.²

Ultrasonography affords a simple, non-invasive, accurate and reliable imaging modality for assessing splenic dimensions.³ Sonographically, the appearance of the spleen is that of a bean or of an orange slice, as only two axes are seen; longitudinal and transverse.⁴ as the outer ap-

pearance of the spleen is not constant because of its soft parenchyma and elastic capsule.^{3,4}

Several published studies have shown that the normal splenic dimensions vary among individual with age, gender, height, and weight.⁵ The variation in the biometric parameters of different population and regions were a well-known fact.⁶ normal splenic dimension has been reported in different age groups.⁷ In a study published in 2012 in which 111 human cadaveric spleens have been analysed, the average length of the spleens examined was 9.66 cm (ranging from 5 cm to 13 cm), the average width of 6.22 cm (values ranged between 3.5 cm and 9.5 cm) and the thickness varied between 1.5 cm and

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5.5 cm, with an average of 3.06 cm. Another study indicates that normal average dimensions of the spleen in a healthy male athlete with a height above 2 metres range between 13.2 cm and 16.2 cm. In female athletes taller than 2 metres the average dimensions of the spleen were found to be approximately 11.2 cm, with the maximum value recorded of 14 cm. The current clinical practice guidelines accept 11-12 cm (less than 13 cm) as the normal length of the spleen in a healthy adult, 3-4 cm in breadth. Ultrasonography study of adult spleen displayed that the spleen decreases in size in proportion to the aging process,⁴ and during autopsy in adult, it showed variation according to gender, as it is smaller in females than in males in all age groups.⁸

The standard normal range of splenic size in Iraqi population is required for correct interpretation. To our knowledge, there is no previous anthropometric study conducted on the normal dimensions of the spleen by ultrasonography in Iraqi adults, and we can not deny the well-known facts of anthropometric variations of various populations and regions. Thus, an anthropometric study of splenic dimensions based on a sample of Iraqi adults would provide be of values that would confidently detect minimal splenomegaly in this area. So, the purpose of this study was to measure normal splenic size in adult attending private ultrasonic department of Imamein Kadhimein Medical City by ultrasonography and to establish correlation of splenic dimensions with age, gender, height and weight for determination of mild splenomegaly.

METHODS

Settings and study design: This was a cross sectional study conducted on patients attending private ultrasonic department of the Imamein Kadhimein Medical City, Baghdad, Iraq within a period of three months from 1 April 2018 to 31 June, 2018.

Ethical issues: The study was conducted according to the ethical approval obtained from the hospital. Verbal informed consent obtained from all patients.

Definition of the cases and Inclusion and exclusion criteria: The study was conducted among 100 patients who attend the private ultrasonic

department of the Imamein Kadhimein Medical City for medical disorders unrelated to the spleen, mostly due to mild urinary tract infection, thyroid problem, or abdominal pain. A full medical history was obtained from them to exclude any medical conditions that might affect the spleen. Findings on US of the liver and kidneys were normal in all cases. The exclusion criteria included patients aged younger than 18 years, a history of haematologic or oncological disorders, collagen storage diseases, traumatic conditions, prolonged febrile illness more than 5 days, alcoholic drinker, and pregnancy.

Sampling: The Sample was taken from a single centre Imamein Kadhimein Medical City in convenient method, which included any patients with the inclusion criteria who came to the private US clinic on Tuesday of each week during the studied period.

Ultrasonographic Technique: A single skilled sonographer carried out the Ultrasonographic measurements of the spleen using Voluson-E6 Ultrasound machine with curvilinear 3.5 MHz transducer. Splenic measurement was taken with the patient lying in a right lateral decubitus position during sustained deep inspiration with the left arm elevated. Splenic length obtained by measuring the Maximum length of longitudinal axis then we took the cross-sectional image perpendicular on long axis from which we obtain two dimensions, Splenic width obtained on transverse scans by measuring the greatest dimension in a plane perpendicular to the length. Splenic depth obtained by measuring the greatest anteroposterior dimension on the transverse section as shown in figure 1. The splenic volume was estimated by using prolate ellipsoid formula " $0.52 \times \text{splenic length} \times \text{splenic width} \times \text{splenic thickness}$ " which is the standard clinical formula for calculation of splenic volume.¹

The anthropometric measurements including the age, gender, weight, and height were obtained from all patients, and body mass index (BMI) was calculated manually using the formula: $\text{weight (kg)} / \text{height}^2 \text{ (m)}$.

Statistical analysis: Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS) version 22.0. Volume was compared with the gender, height, weight, and BMI for all patients. Mean $\pm$ standard deviation was calculated. Correlation was assessed using the Pearson r correlation coefficient, and Inde-

Table 1: Characteristics of the patients and sonographic measurements of the spleen.

	Minimum	Maximum	Mean	SD
Age	18	84	41.58	15.52
Height (cm)	142	188	166.6	10.35
Weight (kg)	44	128	77.54	14.57
BMI (kg/cm ²)	16.63	41.79	27.92	4.73
Splenic Length (cm)	7.7	15.0	10.39	1.43
Splenic Width (cm)	2.2	9.0	5.0	1.28
Splenic Thickness (cm)	1.8	6.5	3.49	0.86
Splenic Volume (cm ³)	25.68	220.29	97.58	43.78

pendent sample t-test. The result was considered significant if p value was less than 0.05.

RESULTS

During the studied period, 100 patients who visited the private ultrasonic department of Imamein Kadhimein Medical City were selected to be included in the study. Of them 56 (56%) were male and 44 (44%) were female. The age of the patients ranged from 18 to 84 years with mean age $\pm$ SD was 41.58 $\pm$ 15.52 years. Characteristics of patients included in the sonographic study were summarized in **table 1**.

The measured splenic volume ranged from 25.68 to 220.29 cm³ with an average of 97.58 $\pm$ 43.78 cm³. Pearson's coefficient between splenic volume showed a negative relationship with age and a very weak positive relationship with patient's height, weight, and BMI, all of them were not statistically significant $p>0.05$. The mean volume of the spleen increased with age, reach its maximum size at the 4th decade in comparison with other age groups then start

to decrease after the age of forty years this is shown in **figure 1**, the study showed that the mean volume starts to increase with rising of BMI above the normal weight (25 kg/cm²) this is shown in **figure 2**.

Splenic length, width, and thickness displayed a strong correlation with splenic volume ($r= 0.709, 0.756, 0.568$ respectively, $p<0.0001$). Results showed that, in spite of the wide range of splenic measurements among Iraqi population, splenic length was correlated significantly with body height and weight ($r= 0.257, p<0.01$), ($r= 0.248, p<0.013$) respectively, and there is no significant correlation between splenic volume, width, or thickness with patient's age, height, weight, and BMI, this shown in **table 2**. Independent Sample t-test showed a significant difference in splenic length between males and females ($p<0.011$) but no statistical significant difference between splenic volume, width, or thickness and gender.

The study showed that the splenic length in 16% of males and 9% of the females exceed the upper normal limit 12 cm that implied in the literature. In 95% of the patients, the splenic length was <12.8 cm, the width was <7.2 cm, and the thickness was <5.1 cm.

The mean $\pm$ SD and range of Anthropometric data and splenic measurements among males and females of the study are summarized in **tables 3**. The mean splenic volume and length for males is higher than that for females. For the male patients, there was no significant correlation between Anthropometric measurements of the patients and measurements of the spleen. For the female patients Pearson's coefficient between splenic measurements showed

Table 2: statistical correlation between study parameters

Variable	Pearson r	p-value	Variable	Pearson r	p-value
Splenic length			Splenic thickness		
Age	-0.064	0.525	Age	-0.109	0.282
Height	0.257	0.010*	Height	0.113	0.261
Weight	0.248	0.013*	Weight	0.061	0.550
BMI	0.088	0.385	BMI	0.003	0.975
Splenic width			Splenic Volume		
Age	-0.063	0.533	Age	-0.116	0.580
Height	0.093	0.355	Height	0.145	0.204
Weight	0.066	0.515	Weight	0.128	0.150
BMI	0.016	0.872	BMI	0.056	0.249

* $p<0.05$ were significant.

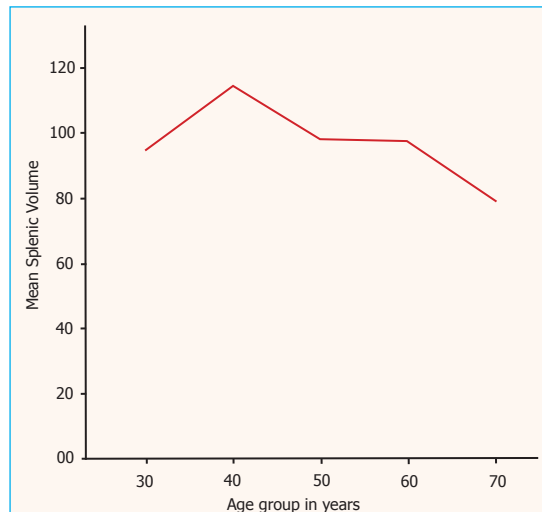


Figure 1: Correlation of spleen volume with age group

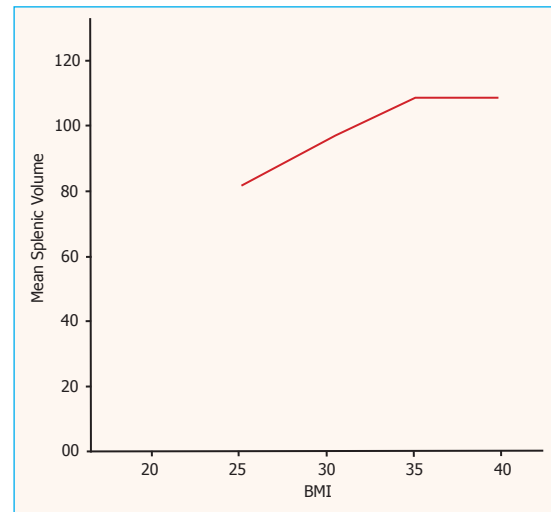


Figure 2: Correlation of spleen volume with BMI

a negative relationship with patient's age ($r = -0.087, -0.022, -0.142, \text{ and } -0.148$ for length, width, thickness, and volume, respectively), and a very weak positive relationship with BMI ($r = 0.12, 0.91, 0.95, \text{ and } 0.143$ for length, width, thickness, and volume, respectively), all of them were not statistically significant $p > 0.05$.

There was a significant correlation between height of the female patients and splenic width ($r = 0.411, P < 0.006$), thickness ($r = 0.401, P < 0.007$), and volume ($r = 0.491, P < 0.001$) and a weak positive correlation with splenic length ($r = 0.259$) but not statistically significant $p > 0.05$. There was a significant correlation between weight of the female patients and splenic width ($r = 0.324, P < 0.032$), and volume ($r = 0.399, P < 0.007$) and a very weak positive correlation with splenic length ($r = 0.153$), and thickness ($r = 0.281$) but not significant statistically $p > 0.05$.

DISCUSSION

The morphology of the spleen varies from person to person and in the same person under different conditions.^{9,10} In addition to wide range of normal splenic dimension in the literatures¹¹ combined with its outer inconstant appearance^{3,4} makes it difficult to establish a standard normal range of spleen dimension. Therefore, it is essential to determine the upper normal limit to diagnose splenic enlargement. It is found that splenomegaly by sonographic measurements was reported in 57% of patients with sarcoidosis and thrombocytosis. However clinically it is only palpable in 8% of those patients.^{12,13} Ultrasound is one of the most common imaging modalities in routine practice due to its diagnostic efficiency.⁸ Therefore, Ultrasound is suggested for the measurement of the splenic dimension in this study.

Table 3: Distribution of Anthropometric data and splenic measurements among males and females

Character	Male = 56				Female = 44			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
Age	18	80	38.84	15.3	22	84	45.07	15.19
Height (cm)	162	188	173.9	5.80	142	171	157.30	6.69
Weight (kg)	53	128	82.29	15.3	44	91	71.50	10.97
BMI (kg/cm ²)	16.63	41.79	27.23	5.07	20.0	41.18	28.80	4.16
Splenic Length (cm)	7.7	14.0	10.71	1.30	7.8	15.0	9.99	1.49
Splenic width (cm)	2.3	8.0	5.04	1.19	2.2	9.0	4.95	1.40
Splenic thickness (cm)	2.2	5.9	3.50	0.74	1.8	6.5	3.49	1.0
Splenic Volume (cm ³)	43.13	219.91	99.44	37.62	25.68	220.29	95.20	50.91

In this study, there is highly significant correlation between splenic volume and length ($r = 0.708$, $p < 0.0001$), this concordant with other studies, it had been shown in several studies that splenic length considered as an indicator of the actual size of the spleen as it has a strong correlation with the volume and can be used to diagnose splenomegaly in routine clinical practice.^{14,15,16,17}

The mean splenic volume for adults in this study $97.58 \pm 43.78 \text{ cm}^3$ (99.44 cm^3 in male and 95.2 cm^3 in female), ranged from 25.68 to 220.29 cm^3 . Same values were recorded in Jordanian population,¹⁸ as the mean splenic volume were 96.31 cm^3 . In comparison with this study, Saudi Arabian population (133.33 cm^3),¹⁹ Turkish population (115.42 cm^3 for males and 71.15 cm^3 for females),¹ in athletics of Unites state of America (174.47 cm^3),²⁰ and North Indian population (150.81 cm^3 for males and 113.72 cm^3 for females),² had a higher mean splenic volume. In comparison of this study with Africans (62.49 cm^3),¹⁶ Japanese adult (54.4 cm^3),²¹ and Thai population (70.18 cm^3 for males and 60.45 cm^3 for females).²² They had lower splenic volume than the current study. This observation probably may be due to different body habits in different area of the world. The higher splenic volume of athletics of Unites state of America might be due to the higher body height of those athletics as splenic length and volume were associated with body height as body height alone account for 17.3% of splenic length variability and 14.9% of splenic volume variability.²⁹ While the lowest splenic volume of Japanese population may be related to the average BMI (22.5) of that population is lower than Iraqi population average (25).³⁰

In this study, splenic volume had no statistical correlation with patient's age. These agreed with the findings of other studies,^{10,17,23,24,25} and disagree with some studies which showed a decrease of splenic size with aging.⁵ This agreed with Hosey et al study,¹⁰ Yahuza et al study,¹⁷ Okoye et al study,²³ Ehimwenma et al study in Nigerian Population,²⁴ and Khamis et al study in Sudan population,²⁵ and disagree with Kaneko et al study,⁵ who use CT scan for measurement of splenic size.

Furthermore, there were non-significant correlation between splenic volume and patient's weight or BMI, this agreed with the find-

ings of other studies.^{5,8,18,20,25,26} Moreover, this study showed non-significant correlation between splenic volume and patient's height. This corresponded with the findings of study African population,¹⁶ and mismatch the with other studies^{17,18,20,24,25} in which there is significant correlation between splenic volume and patient's height. In spite of non-significant correlation between splenic volume and patient' age, this study shows the splenic volume start to decrease slightly beyond the 4th decade and drop noticeably beyond the 6th decade. This agreed with other studies in Turkish and Tripura population.^{8,17} In the present study, the largest splenic volume was attained at the 4th decade, similar to Chakraborti et al study,^{8,23} while Yahuza et al study,¹⁷ the largest splenic volume was attained at the 5th decade. This may be due aging process as all visceral organs decrease in size. Additionally, there non-significant increases in splenic volume with increment of BMI above 25 kg/m^2 , there is no similar finding in other studies, this may need further study using larger sample size.

In this study, the mean length, width, and thickness of the spleen were $10.39 \pm 1.43 \text{ cm}$, $5.0 \pm 1.28 \text{ cm}$, and $3.49 \pm 0.86 \text{ cm}$ respectively. These agreed with the findings of studies in Jordanian and Turkish populations in splenic length 10.72 cm and 10.44 cm respectively and splenic thickness were 4.40 cm and 3.73 cm respectively, but differ in splenic width 7.40 cm and 8.16 cm respectively, which were higher than the current study.^{1,18} However, no reason was offered for this result. Moreover; the mean splenic length of 10.39 cm is concordance with normal values reported by Nigerian,²⁴ Italian population,²⁷ and Hosey et al study among collegiate athletes.¹⁰ Studies in Sudanese²⁵ and Rajasthani population²⁸ recorded lower value than that of the current study. Socioeconomic status and demographic variables including age, weight and height may contribute to this difference.

In this study, the mean splenic length of 16% of males and 9% of the females exceed the upper normal limit 12 cm that implied in the literature, and in 95% of the patients was less than 12.8 cm . This agreed with Turkish adult,²⁶ in which the mean splenic length of 95% of the patients was less than 12.8 cm and with Hosey et al. study¹⁰ in which the mean splenic length

Table 4: Showing the comparison of splenic volume between current study and various authors' studies

Study	Country	Adult	Male	Female
Çeliktas et al. (1)	Turkey		115.42 cm ³	71.15 cm ³
Asgar et al (2)	North India		150.81 cm ³	113.72 cm ³
Mustapha et al. (16)	Africa	62.49 cm ³		
Badran et al. (18)	Jordan	96.31 cm ³	107.94 cm ³	
Siddiqui et al. (19)	Saudi Arabia	133.33 cm ³		
Spielmann et al. (20)	United State	174.4 cm ³		
Srisajjakul et al. (21)	Thai		70.18 cm ³	60.45 cm ³
Ehimwenma et al (24)	Nigeria		106.01 cm ³	80.38 cm ³
Khamis MA (25)	Sudanese		73.29 cm ³	56.64 cm ³
Picardi et al. (31)	Europe	73.22 cm ³		
Hidaka et al. (32)	Japanese	54.4 cm ³		
Current study	Iraq	97.58 cm ³	99.44 cm ³	95.20 cm ³

of 93% of the athletes was less than 13 cm, but less than Spielman et al,²⁰ who records that the mean splenic length was more than 12.0 cm in 31.7% of males (mean 11.4) cm and in 12.8% of females (mean 10.3) cm. The current study shows that the splenic length had significant statistical difference with patient's gender. This agreed with other studies.^{8,18,24,25,29} Moreover, the splenic length had significant correlation with patient's height and weight. These agreed with the findings of other studies.^{17,24,25} Many studies found significant strong correlation between splenic length and patients height.^{13,17,20,23,24,25} The splenic length had no statistical correlation with patient's age and BMI. This concordance with many studies.^{24,25,26}

CONCLUSION

A local standard reference with different ranges of splenic dimension was determined. This may not represent the Iraqi population due to short study period and small sample size, and need further study to establish the normal dimensions of the spleen in Iraqi adult's population.

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Abbreviation list: Body mass index (BMI), Centimetre (cm), Kilogram (kg), Megahertz (MHz), Square centimetre (cm²), Standard Deviation (SD), Statistical Package for the Social Sciences (SPSS)

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