

Ultrasonographic Study of Splenic Dimensions

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Abstract: The spleen is a unique intraperitoneal organ belonging to both the hematopoietic and immune systems. The assessment of splenic size is essential in diagnosing small, normal and enlarged spleens. Splenomegaly is the result of various disease processes like inflammatory, infectious, infiltrative, metabolic, neoplastic, hematopoietic diseases and the other diseases like portal hypertension. Evaluation of splenic size by palpation is not reliable. Various clinical and radiological/imaging techniques are being used in the evaluation of splenic size or volume like clinical palpation, imaging modalities such as conventional radiography, ultrasonography, scintigraphy, computed tomography, and magnetic resonance imaging. Ultrasonography is a simple, safe and accurate method of assessing splenic size. The purpose of this study was to establish guidelines for normal splenic dimensions and volume in our healthy adults by using sonographic method and to compare our findings to other data.

Keywords: Splenic dimensions- length, width, and depth, ultrasonography.

INTRODUCTION

The spleen is a unique intraperitoneal organ belonging to both the hematopoietic and immune systems, having wide array of functions like phagocytosis, fetal hematopoiesis, adult lymphopoiesis, immune response, and erythrocyte storage [1, 19].

The assessment of splenic size is essential in diagnosing small, normal and enlarged spleens.

Splenomegaly is the result of various disease processes like inflammatory, infectious, infiltrative, metabolic, neoplastic, hematopoietic diseases and the other diseases like portal hypertension.

Evaluation of splenic size by palpation is not reliable because spleen is not palpable until it is enlarged 2 to 3 times its size [2]. The knowledge of spleen size, shape, volume or external features is essential to the clinicians and the radiologists as well [24].

Various clinical and radiological / imaging techniques are being used in the evaluation of splenic size or volume like clinical palpation, imaging modalities such as conventional radiography, ultrasonography, scintigraphy, computed tomography, and magnetic resonance imaging [1].

Although abdominal radiographs are not used as a primary imaging modality of the spleen,

abnormalities of the spleen such as splenomegaly or diseases that cause splenic calcifications may initially be discovered on radiography. The spleen is tucked beneath the lower left ribs, paralleling the posterior ribs. The normal spleen does not usually extend below the ribs. The entire spleen is usually not often visualized on an abdominal radiograph because of gas in the adjacent splenic flexure of the colon or in the stomach [1].

Volumetric measurements are most accurately obtained on CT and MRI [4, 9, 10]. Nevertheless routine CT for the diagnosis and serial follow-up of patients for suspected splenic enlargement is difficult to justify in view of the radiation exposure and the cost in our environment. The use of MRI is similarly hampered by the cost and limited availability in many areas of the world, particularly in developing countries. Scintigraphic examination of the spleen at present is helpful in localizing ectopic splenic tissue [5, 12].

Ultrasonography is a simple, safe and accurate method of assessing splenic size and patients with persistent splenomegaly should be followed up closely for development of complications which may necessitate splenectomy [4, 11]. Ultrasound scanning, apart from being non - ionizing, is painless, non-invasive, widely available, easy to use and less expensive than most other imaging methods [8]. However, its main limitation is being operator dependent. It can demonstrate existence and composition of splenic masses, changes in splenic echo texture and outline, progressive changes in masses and size of the spleen.

Current knowledge of spleen size is based on different populations or derived from autopsy studies [13, 14]. The ultrasound data from the previous studies demonstrated that racial differences could affect the splenic volume [14]. This necessitates the establishment of normative data of spleen dimensions for different areas [5-8].

Therefore, the purpose of this study was to establish guidelines for normal splenic dimensions and volume in our healthy adults by using sonographic method and to compare our findings to other data.

NORMAL ANATOMY

Spleen is a crescent shaped structure, with a convex outer margin, and indented inner margin [15]. It is situated in the left hypochondrium part of abdominal cavity, sandwiched between fundus of stomach and the diaphragm. Its long axis lies along the 10th rib obliquely, applied to 9th, 10th and 11th ribs behind mid axillary line. Its conventional dimensions are one inch thick, three inches broad and five inches long (2.5 × 7.5 × 12.5 cm) but its size varies considerably [15]. It has superior and inferior ends, anterior and posterior borders and diaphragmatic and visceral surfaces. The posterior border is rounded, but the anterior border is notched. The diaphragmatic surface is convexly curved to fit the concavity of the diaphragm while the visceral surface is related to stomach, left kidney, left suprarenal gland and left colic flexure [16]. Tail of pancreas is applied to the hilum that lies in the angle between stomach and left kidney [17]. The spleen is entirely surrounded by peritoneum except at the hilum, where the splenic branches of the splenic artery and vein enter and leave [16]. The spleen is supported by means of gastro-splenic ligament to stomach and to posterior abdominal wall by leino renal ligament. It sits on the left colic flexure and the fold of peritoneum that extends from left colic flexure to diaphragm, the phrenicocolic ligament. It is due to this ligament that the spleen when enlarges doesn't extend vertically downward but rather moves downwards and medially towards umbilicus. The spleen normally does not descend inferior to the costal margin unless it enlarges and is then identified by the presence of notch in the anterior border upon palpation. Although it is not a part

of digestive system, its venous blood is drained into portal vein and to the liver [15].

SPLENOMEGALY

Splenic enlargement is associated with a variety of clinical conditions. These can be infections, hematological disorders, and infiltrative states, immunological and malignant diseases. Among the infections the most common causes are infectious mononucleosis, malaria, kala azar (Lieshmaniasis), bacterial endocarditis, tuberculosis, brucellosis and salmonellosis [18]. In case of hematological disorders the causes of splenic involvement are lymphomas and lymphatic leukemias, hemolytic anemia, chronic anemia, congenital spherocytosis, myeloproliferative diseases such as polycythemia vera and myelofibrosis. Conditions causing portal hypertension such as cirrhosis or malignancy of liver invariably involve and cause enlargement of spleen. Congestive heart failure with ascites, glycogen storage disorders, sarcoidosis and amyloidosis are other important causes of splenic involvement. Therefore, it is important to assess spleen size when physicians evaluate patients with splenomegaly helping in the diagnosis of a disease process or determining its prognosis. A spleen must double its size before its anterior borders descends beyond left costal margin and is clinically palpable [15]. Early diagnosis of splenic enlargement before it becomes clinically palpable is important to a clinician for making diagnosis. Establishment of splenic enlargement by clinical examination is difficult and often inaccurate, particularly a mild enlargement. Therefore, objective diagnostic means have been sought and the imaging techniques have become necessary for the accurate determination of spleen size and its serial observation over the course of patient's illness.

MATERIALS AND METHODS

The splenic measurements and volume was measured in 205 consecutive patients who underwent ultrasound scans for various indications. Informed consent was obtained after explaining the procedure from all the subjects. To ensure adequate compliance with inclusion and exclusion criteria, brief clinical history and physical examination of the patient was undertaken. Patients with conditions that have known effect on the spleen size were not included in this study. Those with history of splenectomy, prolonged or chronic illness like liver disease, hematological disorders or malignancy which may compromise splenic size, were excluded from the study.

All ultrasonographic examinations were performed by experienced senior radiologists. The examinations were performed using Acuson S2000 Siemens ultrasound machine equipped with 3.5 MHz curvi-linear probe. The subjects were placed and examined in the supine and/or right posterior oblique positions, and the spleen was scanned during suspended respiration. However, it has been reported that the

presence of the colon, stomach and lung near the spleen makes the examination difficult. But, the intercostal approach permits a good examination [25]. The splenic length (in centimeters) is defined as the maximum distance between the most superomedial and the most inferolateral points on a longitudinal plane (Figure 1). The splenic width, defined as the maximum anteroposterior dimension, was measured on a transverse plane. The splenic depth is defined as the mediolateral distance from the hilum to the capsule, being measured on the same transverse plane (Figure 2). All measurements were taken on sections through the splenic hilum to create a constant reference point for

repeating measurements as described by Lamb *et al.* [4]. Each measurement was recorded to the nearest millimeter. An average reading was taken after three different measurements to avoid intraobserver variability. To express spleen volume, the splenic index was calculated using the standard prolate ellipsoid formula ($\text{length} \times \text{width} \times \text{depth} \times 0.523$); this formula is frequently used for estimating the volume of many irregularly shaped organs. All measurements showed excellent intra-observer and inter-observer reliability. For each subject, the mean value of 3 measurements repeated on the same occasion was calculated and recorded for final analysis.

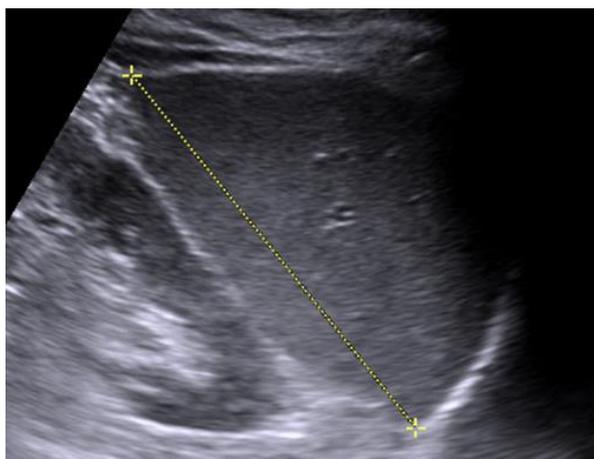


Fig-1: Method for measuring the splenic length in longitudinal plane

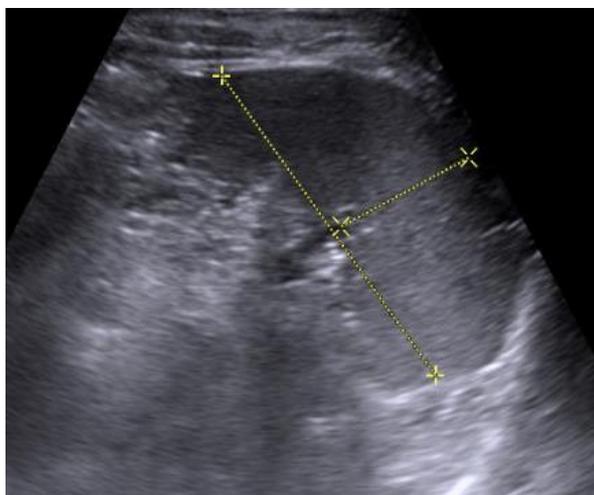


Fig-2: Method for measuring the splenic width and the depth in transverse plane

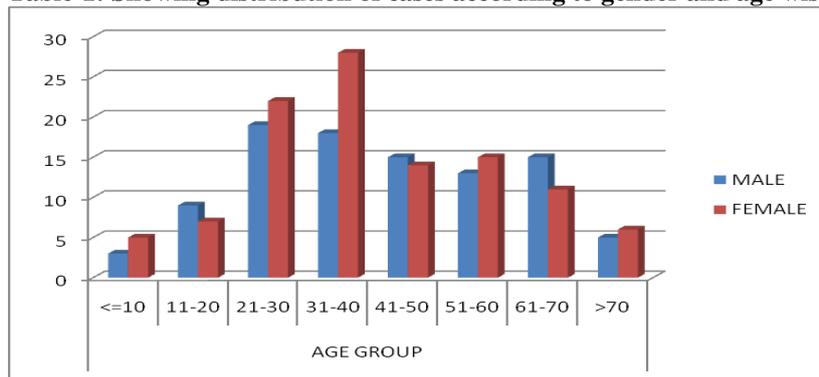
The most accurate single measurement is splenic length measured on a longitudinal section with the patient in the RLD position. However, measurement of splenic length, which is the most commonly used in clinical practice, also correlates well with splenic volume, particularly when performed with the patient in the RLD position. We conclude that a good correlation

exists between in vivo ultrasound assessment of splenic size and true splenic volume.

RESULTS

A total of 205 subjects comprising of 97 males and 108 females were recruited in this study. A chart showing subjects distribution according to sex is shown below [Table 1].

Table-1: Showing distribution of cases according to gender and age wise



For the overall subjects studied, the mean splenic length, width and depth and (\pm SD) were—9.2 cm (13.9mm), 3.7 (8.0 mm), and 8.2cm (13.6 mm),

respectively The maximum measurement obtained for the spleen length, width, and depth –15cm, 7.4cm, 13.6cm respectively.

Descriptive Statistics						
	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Spleen length	205	6.08	15.00	9.2176	.09746	1.39539
Spleen width	205	2.00	7.43	3.7942	.05638	.80731
Spleen breadth	205	3.400	14.000	8.22444	.095114	1.361822
Spleen volume	205	38.5451000	549.1500000	158.202091958	5.2705900556	75.4633653147
Valid N (list wise)	205					

Group Statistics					
SEX		N	Mean	Std. Deviation	Std. Error Mean
Spleen length (cm)	Male	97	9.6018	1.41833	.14401
	Female	108	8.8726	1.28587	.12373
Spleen width (cm)	Male	97	3.9970	.85766	.08708
	Female	108	3.6120	.71543	.06884
Spleen breadth(cm)	Male	97	8.57928	1.384290	.140553
	Female	108	7.90574	1.264862	.121711
Spleen volume (cc)	Male	97	180.818651842	86.9732037985	8.8307908946
	Female	108	137.889070581	56.4831566619	5.4350942839

The mean length of spleen for females and (\pm SD) was 8.8 cm (1.23 mm) and that of males was 9.6 cm(1.44 mm) indicating that the mean splenic length for females is lower/ higher than that for males.

The mean splenic width and depth for females were-3.6 cm (.06 mm) and -7.9 cm(1.26mm), respectively while that for males were -3.99 cm (.08 mm) and 8.5cm (1.4mm), respectively.

DISCUSSION

Spleen is a major component of reticuloendothelial system having a wide range of functions like fetal hematopoiesis, adult lymphopoiesis, immune responses, and erythrocyte sequestration [1, 19]. The splenic enlargement is an important clinical sign of various disorders of the reticuloendothelial system like infective, infestation, infiltrative, immunologic and malignant conditions .But the physical examination is not reliable to evaluate the

Splenomegaly [20]. Ultrasonography is routinely used for the diagnosis of the splenomegaly. Ultrasound scanning, apart from being non-ionising, is painless, non-invasive, widely available, easy to use and less expensive than most other imaging methods [8]. However, it has been reported that the presence of the colon, stomach and lung near the spleen makes the examination difficult. But, the intercostal approach permits a good examination [25]. Moreover, the spleen size is exposed to many variations at different periods of life, in different individuals, and in the same individual under different conditions. It can vary from individual, depending on the individual’s height, age and sex [25].

In this study, we measured the splenic length, width, breadth and volume (calculated with formula in adults and compared our results to other populations (Table – 1).

Table-I: Comparative study of splenic dimensions -various studies

S.NO	Studies	Length (Cm)		Width (Cm)		Breadth (Cm)		Volume(Cm3)	
		M	F	M	F	M	F	M	F
1	USA (TONELLI ETAL)	11.29	9.91	5.54	4.74			344 cm3	
2	NIGERIA (Ehimwenma & Tagbo; Hosey <i>et al.</i>)	11.1	10.1	4.4	2	-	-	202.7 cm3	153.7 cm3
3	Turkish adults	11.0	9.87	8.75	7.58			11.29	9.91
4	Okoye <i>et al</i>	11.5	9.9	4.5	4.0	7.5	6.0		
5	Spielman <i>et al.</i>	11.4	10.3						
6	THAI Asghar <i>et al.</i> , 2011b;	-	-	-	-	-	-	288.36 cm3	217.44 cm3
7	North indians	10.91	10.34	9.74	5.61				
8	Rajasthan (Mittal & Chowdhary).	9.4	9.34	3.45	3.45				
9	Our study	9.6	8.8	3.9	3.6	8.5	7.9	180.8	137.8

We compared our results with that of other studies done by various authors from other countries as well as from our own country in different states, the tabulations of which are given above (Table – I).

Some authors study only the length and width of the spleen, while some included breadth and volume measurement also. In the study done by Tonelli *et al.* USA, the mean values of splenic length and width were 9.91 cm and 4.74 cm in females and 11.29 cm and 5.54 cm in males in U.S.A. respectively.

In the study done in Nigerians by Ehimwenma & Tagbo; Hosey *et al.* the same values were 10.1 cm, 4.0 cm in females and 11.1 cm, 4.4 cm in males respectively.

In the study done by Okoye *et al* the mean values of splenic length, width and breadth were 11.5cm, 4.5cm, 7.5 cm in males and 9.9 cm, 4 cm, 6 cm in females respectively.

In India the study done by Mittal & Chowdhary in Rajasthan population the splenic length and width in females and males measure 9.34 cm and 3, 45 cm in females 9.40 cm and 3.45 cm in males respectively.

In another study done on north Indian population these dimensions were 10.34 cm and 5.61 in females and 10.91 cm and 9.74 cm in males.

In our study we have included all the parameters of spleen namely length, width, breadth as well as volume measurement for both females and males and found the values as 8.8 cm, 3.6, 7.9, 137.8 cc and 9.6 cm, 3.9 cm, 8.5 cm, 180 cc respectively

Splenic volume is calculated using with standard ellipsoid formula (0.524 x width x length x thickness). This formula is often used for predicting the

volume of many irregularly shaped organs (Asghar *et al.*, 2011b; Yetter *et al.*, 2003; Sonmez *et al.*, 2007). In literature findings, it was seen that ellipsoid formula was used. It was found to be 220.70 cm³ (measured with standard ellipsoid formula) in males and 136.05 cm³ in females. In a study consisting of Nigerians, in males mean value of splenic volume were 202.7 cm³ and in females 153.7 cm³ respectively (Ehimwenma & Tagbo). Moreover, the same value was 119.5 cm³ in African population (Mustapha *et al.*). Asghar *et al.* (2011a) determined that the splenic volume were 288.36 cm³ and 217.44 cm³ in males and females respectively. However, same value was 344 cm³ in USA (Tonelli *et al.*).

CONCLUSION

While comparing the literature findings with this study, we observe that there are differences between Nigerians, Africans, Chinese population, Rajasthani population, Indians and our population data.

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 was no differences in the mean values of the spleen volume between two calculation methods.

We conclude that the basic knowledge of ultrasonography of the spleen regarding its morphology and its disorders may be essential for the radiologists and surgeons. The observations made in this study have defined anatomic parameters that should be considered as guidelines or reference values in the assessment of spleen.

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