

# Estimation of Splenic Volume in Sudanese Adult Population Using Abdominal Computed Tomography Scan

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**Abstract:** Spleen is enlarged in a variety of clinical conditions including infectious, infiltrative, immunologic and malignant states. Evaluation of splenic size is important in every physical examination of the abdomen by a physician. The accurate diagnosis of splenic enlargement is a matter of considerable importance as it is a useful guide for arriving at a diagnosis of the disease. It is therefore of utmost importance to resort to a mechanism that will give us an accurate estimation of the size of spleen. Objectives: of this work was to Estimation of Standard Splenic Volume in Sudanese Adult Population Using Abdominal CT scan and compare it with the published data. Methods: 110 CT scans of consecutive adult patients (55 male and 55 female) aged between 20 - 80 years, having no splenic disorders, The patient's body weight and height were recorded at the time of the Computed tomography (CT) examination. The volume of spleen was calculated manually by using the standard clinical prolate ellipsoid formula. Results: The average splenic volume of the all population was  $165.5 \pm 23 \text{ cm}^3$ . The average splenic volume in adult males was  $182.4 \pm 25.8 \text{ cm}^3$  and that in adult females  $148.5 \pm 37.9 \text{ cm}^3$ . Conclusions: These results provide normative data for evaluating patients with splenomegaly.

**Keywords:** Splenomegaly, Spleen, Computed Tomography, Reconstruction Index

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## 1. Introduction

Evaluation of splenic size is important in every physical examination of the abdomen by a physician. It is enlarged in a variety of clinical conditions including infectious, hematological, infiltrative, immunologic and malignant states [1].

Among infections, viral illnesses such as infectious mononucleosis are by far the most common cause in the young population. Others include malaria, kalaazar (leishmaniasis), brucellosis, salmonellosis, tuberculosis and bacterial endocarditis [1]. Hematological disorders include lymphomas and lymphatic leukemias, hemolytic anemia, chronic anemia, congenital spherocytosis and myeloproliferative diseases

such as polycythemia vera and myelofibrosis. Among immunological states are rheumatoid arthritis and systemic lupus erythematosus. Other important causes include cirrhosis of liver, portal hypertension, congestive heart failure, glycogen storage disorders, lymphoid tissue and hematological malignancies, Sarcoidosis and Amyloidosis. Hypersplenism is a pancytopenia (low platelet count, white cell count and hemoglobin concentration) caused by splenic enlargement. Hematological disorders causing splenomegaly commonly, but not invariably, also cause enlargement of the liver. Hemolytic anemia causes mild splenomegaly without hepatomegaly. The spleen has to increase in size three fold before it becomes palpable, so a palpable spleen always indicates splenomegaly [1].

## 2. Anatomy of the Spleen

The spleen starts to develop in the fourth week of gestation as a mesenchymal condensation in the dorsal mesogastrium of the lesser sac. In the following weeks these early mesenchymal cells differentiate to a vascular lymphatic pedicle that eventually forms the spleen. Smaller condensations that develop near the hilum of the spleen form accessory spleens. When the embryo is about 10 cm in length the dorsal mesogastrium can be divided into a posterior part and an anterior part. The posterior part, from the posterior abdominal wall to the spleen, is eventually invaded by the pancreatic bud, which grows as far as the hilum and later fuses with the peritoneum of the posterior abdominal wall ventral to the left kidney to the splenorenal ligament. In this dorsal structure the splenic artery and vein develop. The anterior part of the dorsal mesogastrium develops into the gastro splenic ligament and contains the short gastric vessels. It is now clear that the spleen is of mesenchymal origin and does not originate from the embryonic endodermal gut.

The splenic condensation forms a trabecular structure resulting in a mesh and ending up in the connective supportive structure of the spleen. The isolated free cells in this network differentiate into hematopoietic cells in the next months of gestation. Other cells derived from the sinusoids of the splenic artery specialize to participate in the reticulo-endothelial system [2].

The spleen is located in the left hypochondria between the fundus of the stomach and the diaphragm, behind the maxillary line opposite the 9th, 10th, and 11th ribs. Its long axis lies parallel to the long axis of the 10th rib. It moves a bit in living during respiration [12].

The spleen is a wedge-shaped soft organ with purple color. The size of the spleen roughly corresponds to the first of the subject.

Normal Measurements of the spleen are 1 inch Thickness, 3 inches width, 5 inches Length and about 7 oz Weight. The spleen is marked on the surface on the left side of the back of the trunk. Its long axis corresponds to that of the 10th rib. Its upper border corresponds to the upper border of the 9th rib, and its lower border corresponds to the lower border of the 11th rib. Its medial end lies about 5 cm from the posterior midline of the body at the level of spine of T10 vertebra and lateral end at the mid axillary line [12].

Various studies were done by sonography to study the linear dimension of spleen length, width, and thickness. dimensions determined by 2-D ultrasound are limited predominantly by the variable, irregular contour of spleen but also by the difficulty in completely scanning the entire organ or visualizing complete contours as because of the presence of overlying structures such as bone, bowel gas or kidney, CT imaging is more accurate than ultrasonography because this drawback is not seen with computed tomography [3].

## 3. Materials and Methods

The data used in this study were collected from cases

admitted to various hospitals in Khartoum state (Al-Zytouna specialist hospital, Royal care international hospital and royal scan diagnostic center) during the period from October 2015 to January 2016, 110 CT scans of consecutive adult patients (55 male and 55 female) aged between 20 - 80 years, having no splenic disorders, The patient's body weight and height were recorded at the time of the Computed tomography (CT) examination. Computed tomography (CT) examinations was done by using CT machine Toshiba- aquilion 64 slices.

The technical parameters were 120 kvp, 200 mAs, and 5 mm slice width with identical reconstruction index and rotation time of 0.6 secs.

### 3.1. Inclusion Criteria

The study included all adult patients ranged from 20 years to 80 years old and having no splenic disorders.

### 3.2. Exclusion Criteria

Patients whose spleen appeared abnormal on Computed tomography

(CT) scans were excluded. Following subjects were also excluded from study:

Subjects with pathologies potentially involving the spleen.

Subjects with hemoglobinopathies.

Subjects with skin infections at the area of the spleen.

Subjects with lymphoproliferative disorders such as lymphomas, leukemias, etc.

### 3.3. Measurements

CT-scan DICOM images of each patient were observed in radiant DICOM Viewer software. Spleen was identified in each cross section and longitudinal section of CT-scan images. The maximum length of spleen was recorded in longitudinal section along 10th rib from superior border of the spleen. The maximum Width of spleen was also recorded as the greatest overall dimension on transverse images and the maximum thickness as the distance between the hilum and the outer convex surface of the spleen [Figure 1]. All dimensions were recorded maximum appreciated in sections for better accuracy.

The volume of spleen was calculated manually by using the standard clinical prolate ellipsoid equation for spleen [ $0.524 \times$  splenic index (max. length  $\times$  max. width  $\times$  max. thickness)]

### 3.4. Data Collection and Analysis

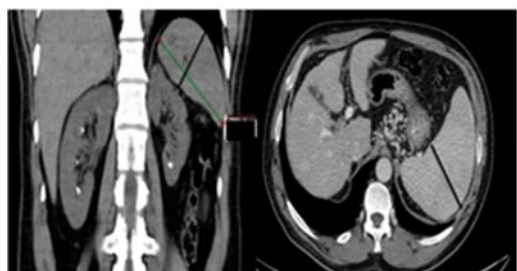
Data were collected by using a sheet for all patients in order to maintain consistency of the information from display. The data collection sheet was designed to obtain patient gender, age, spleen length, spleen thickness, spleen width, patient Weight and height.

Microsoft excel 2013 was used for data analysis.

## 4. Results

In this study the age and gender related random sample of 110 patients including 55 males and 55 females and Age of the

subjects included in this study ranged between 20 to 80 years (Table 1), The average age of the participants was  $49.1 \pm 3.2$  years. The mean age of male subjects was  $51.4 \pm 14$  years and that of female subjects  $46.8 \pm 13$  years.



**Figure 1.** Method of spleen measurements.

The mean splenic dimensions were in  $\text{cm}^3$  for volume

**Table 1.** Physical data of patients.

Gender	Age (years)	Weight (Kg)	Height (cm)	BMI ( $\text{Kg}/\text{cm}^2$ )	No of Patient
Male	$51.4 \pm 14$	$74.6 \pm 13.1$	$170.7 \pm 9.7$	$25.3 \pm 3.9$	55
Female	$46.8 \pm 13.9$	$74.3 \pm 16$	$166.6 \pm 8.3$	$26.3 \pm 4.6$	55

**Table 2.** The mean splenic volume and standard deviation.

	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)	Total (Mean $\pm$ SD)
Spleen Volume ( $\text{cm}^3$ )	$182.4 \pm 25.8$	$148.5 \pm 37.9$	$165.45 \pm 23$

Various studies were analyzed and their data compared with our study.

Siddiqui et al (2014) [8] measured splenic volume using prolate ellipsoid formula in 34 patients who underwent CT scan for various reasons. They reported splenic volume in Saudi Arabian people to be  $254.94 \pm 71.74 \text{ cm}^3$  in all subjects.

We found the volume to be  $165.45 \pm 23 \text{ cm}^3$  in all Sudanese subjects by using the same technique.

AdilAsghar et al. (2011) [11] measured splenic volume using volumetric software in north Indian adult population and found it out to be  $192 \pm 54.91 \text{ cm}^3$  in males,  $118.39 \pm 47.7 \text{ cm}^3$  in females and over all  $161.57 \pm 90.2 \text{ cm}^3$ . We found the splenic size in males to be  $182.4 \pm 25.8 \text{ cm}^3$  and in females to be  $148.5 \pm 37.9 \text{ cm}^3$ . They found a significant difference in two sexes. We have also found a significant difference in two sexes

Mustapha et al. (2010) [9] examined 374 adult African people by using ultrasonography and found the mean splenic volume to be  $120 \text{ cm}^3$  and they found a Men had a larger mean spleen volume than women. We have also found a male had a larger mean spleen volume than female

Hoefs et al. (1999) [10] calculated splenic volume in healthy volunteers to be  $201 \pm 77 \text{ cm}^3$  through liver-spleen scan by CT and MRI.

## 6. Conclusion

These results provide normative data for evaluating patients with splenomegaly. We have provided the normative data of normal splenic volume in Sudanese adults which can be used in Diagnosis of spleen enlargement and comparisons with standard of normal splenic volume would be useful.

[Table 2]. The average splenic volume of the participants was  $165.5 \pm 23 \text{ cm}^3$ . The mean splenic volume in adult males was  $182.4 \pm 25.8 \text{ cm}^3$  and that in adult females  $148.5 \pm 37.9 \text{ cm}^3$ .

## 5. Discussion

Splenomegaly is a well-known manifestation of several diseases that may involve the liver, immune system, and hematopoietic system. Accurate noninvasive assessment of splenic volume is used in the clinical treatment of patients with these diseases. Previously described techniques for measuring the spleen have relied on nuclear scintigraphy [4], sonography [5], and CT [6-7]. CT is known to be a reliable and accurate method for assessing the volume of the spleen and other intra-abdominal organs [6].

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