بسم الله الرحمن الرحيم

Sudan University of Science and Technology

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Measurement of Normal Spleen Volume in adult Sudanese Population using Ultrasonography

قياس حجم الطحال الطبيعي لدى السودانيين البالغين باستخدام التصوير بالموجات فوق الصوتية

A Thesis Submitted for Partial Fulfillment of M.Sc. Degree in Medical Diagnostic Ultrasound

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الآيـة

قال تعالي:

﴿الحمد لله رب العالمين الرحمن الرحيم مالك يوم الدين اياك نعبد واياك نستعين اهدنا الصراط المستقيم صراط الذين انعمت عليهم غير المغضوب عليهم ولا الضالين ﴾. صدق الله العظيم

(سورة الفاتحة)

Dedication

To :

Soil of my father, asking Allah to mercy him.

My mother

My wife

My son

My daughter

Acknowledgment

First of all, I thank Allah the Almighty for helping me complete this study. I thank Dr. Mohammed Elfadil Mohamed Gar-elnabi, my supervisor, for his help, advising and guidance.

I thank my wife for her inspire me to doing this study.

Also I would like to thank all staff of Alhilal Alahmer Diagnostic complex in Sennar state for their great help and support.

I am greatly indebted to all for bearing with me during the past several months.

Finally I would like to thank everybody who helped me to prepare, perform and finish this study.

Abstract

Spleen ultrasound is one of the modality of choice to assess and evaluate the pathological condition of this organ and together with its measurement. This was an analytical study aimed to assess the spleen volume in adult Sudanese population using ultrasound measurement in order to provide the reference marker of its volume. A 121 patients (34 men; mean age, 30 years [range, 20-45years]) and (87 women ; mean age, 30 years [range, 20-52 years]) who presented with normal spleen although may have any abnormality rather than the spleen itself, underwent abdominal US scan and the measurement was performed in both transvers and longitudinal section, using a high resolution Mind-Ray DC-N6 US unit with 3-5 MHz curved array transducer.; this study was conducted in Sennar city at Alhilal Alahmer diagnostic complex in period from July 2018- till December 2018, and patient demographic data was measured for all study population which include (Height, Weight, and BMI) having mean of 163.7±7.7, 57.5±11.9 and 21.4±3.9 respectively.the result showed that the Splenic volume calculated with minimum 19.2 ml and maximum 213 ml, the mean volume was 89.2±36.8 ml. Directly proportional to the body characteristics.

ملخص الدراسة

الموجات فوق الصوتية للطحال هي أحدى طرق الاختيار لتقييم الحالة المرضية لهذا العضو بالإضافة إلى قياسه. كانت هذه دراسة تحليلية تهدف إلى تقييم حجم الطحال في السكانالسودانيين البالغين باستخدام قياس الموجات فوق الصوتية من أجل توفير مرجعية لحجمها.12 1(34 رجلاً ؛ متوسط العمر ، 30 سنة [المدى ، 20-45 سنة]) و (87 امرأة ؛ متوسط العمر ، 30 سنة [المدى ، 20-52 سنة]) الذين قدموا مع الطحال الطبيعي على الرغم من أن لديهم أي خلل بالأحرى من الطحال نفسه ، خضع لفحص الموجات الصوتي في البطن وتم إجراء القياس في كل من الإتجاه العرضي والطولي ، وذلك باستخدام وحدة عالية الدقة جهاز مندري دي سي إن6عالية التردد.

أجريت هذه الدراسة في مدينة سنار في مجمع الهلال للأحمر التشخيصي في الفترة من يوليو 2018 حتى ديسمبر 2018 ، وتم قياس البيانات الديموغرافية للمرضى لجميع سكان الدراسة والتي تشمل (الطول ، الوزن ، ومؤشر كتلة الجسم) مع متوسط 163.7 ± 7.7 ، 57.5 ± 11.9 و 21.4 ± 3.9 على التوالي. وأظهرت النتائج أن حجم الطحال محسوب بحد أدنى 19.2 مل وأقصى 213 مل ، وكان متوسط الحجم 89.2 ± 36.8 مل. يتناسب طرديا مع خصائص الجسم.

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List of abbreviations

LUQ	Left Upper Quadrant
St	Stomach
DM	Dorsal ministry
CEUS	Contrast Enhanced Ultrasound
CT	Computed Tomography
RLD	Right Lateral Decubitus
2D	Two Dimensional
3D	Three Dimensional

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Chapter one
Introduction

Spleen ultrasound is an imaging test that used to examine the spleen, the spleen is an organ in the upper far left part of the abdomen, to the left of the stomach. The spleen varies in size and shape between people, but it’s commonly fist-shaped, purple, and about 4 inches long. Because the spleen is protected by the rib cage, you can’t easily feel it unless it’s abnormally enlarged. The spleen plays multiple supporting roles in the body. It acts as a filter for blood as part of the immune system. Old red blood cells are recycled in the spleen, and platelets and white blood cells are stored there. The spleen also helps fight certain kinds of bacteria that cause pneumonia and meningitis.Ultrasound imaging of spleen is the primary imaging method used to evaluate the volume of the spleen.There is an international standards value of the normal spleen volume, any increase over that value will be an indicator of a sort of an abnormality of the spleen or related organs that affects the spleen, 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.Ultrasonography is the method of first choice for the rational work-up of abdominal pathologies.The variations in the anthropometric features of various populations, races and regions are an established fact. The climate of the zone and the socio-economic status of the population of this region is special.Palpation and percussion are the standard bedside techniques to document the spleen size, but are far from accurate to detect the small increase in size. The spleen has to be enlarged two to three times its normal size to be clinically palpable.

There is no comprehensive anthropometric study on the normal measurements of the spleen by ultrasonography and therefore, it was thought pertinent to undertake the present study to evaluate the normal measurements of the spleen in order to estimate it‘s volume. Spleen volume varywidely according to age. Many diseases can affect the volume, ranging from infective processes to malignant disorders.Radiography and radionuclide studies expose the patient to x-ray and gamma radiation. Sonography is routinely used to determine the internal structures of the body because the examination is real time and independent of organ function. Ultrasonography is a non-invasive, established, safe, quick and accurate method for the measurement of spleen size and volume. It allows a doctor to see inside a patient without resorting to surgery. Kamaya et.al 2006.

The aims of this study are to assess and document the splenic volume in asymptomatic adults in this region and thereby serve as a baseline for comparison in cases of splenomegaly using trans-abdominal sonography. This study will also serve as a guide in management and follow up of such cases. The finding will be compared to what is obtained elsewhere, bearing in mind the peculiarity of our environment.

1.1. Problem of the Study:

There is no standard reference for splenic measurements in Sudan

So there is no spleen volume diagnostic background by ultrasound

1.2. The Study Objective:

1.2.1. General Objective:

The general aims of this study was to estimate the normal spleen volume in adult of the Sudanese population in order to keep it as standards reference for diagnostic purposes.

1.2.2. Specific Objective:

- To measure the spleen volume and establishment of its reference as standard.
- To correlate between splenic dimensions and volume patient demographic data
- To develop a linear equations that can be used for estimation purpose

1.3. Significance of the Study:

This study was highlighted on the estimation of the normal spleen volume in adult patients in western region in relation with the international standards of the spleen volume, and to keep it as a reference standards of normal spleen volume in the region to assist in the diagnostic purposes. Some types of diseases initially start silently without any symptoms or signs, but it affect the volume of the spleen, increase in spleen volume will be an earlier sign of such diseases so ultrasonic evaluation of the spleen will help in detecting of these diseases. Also because sonography is a rapid and relatively inexpensive means of assessment with no radiation exposure.

1.4. Overview of the Study:

This study was consist of five chapters, chapter one was an introduction introduce briefly this thesis and contained (general introduction, problem of study also)

Chapter two
Literature review

2.1. Theoretical Background:

Ultrasound is a very useful imaging modality to diagnose or exclude splenic abnormalities and is also extremely helpful in the follow-up of patients with known splenic abnormalities. Splenic lesions may be encountered in a variety of clinical settings, and the radiologist should be aware of the spectrum of processes that may involve the spleen as well as the clinical context in which they occur. (kamaya A, et.al 2006).

The spleen and left upper quadrant (LUQ) should be routinely evaluated on all abdominal investigations, especially in patients with suspected splenomegaly, LUQ pain, or trauma. In general, the spleen can be examined by ultrasound without difficulty. Because the normal spleen is uniform in echogenicity, focal abnormalities stand out clearly. Similarly, perisplenic abnormalities and fluid collections are usually easily identified. Inadequate assessment of the spleen and surrounding structures is therefore relatively rare. Occasionally, because the spleen is located high in the LUQ, difficulties can be encountered. Shadowing from ribs, overlying bowel gas, and overlying lung can obscure visualization of the deeper structures. Expertise and persistence may be required to overcome these obstacles.M. Vos, et.al 2011.

2.1.1. Embryology and anatomy:

The spleen arises from a mass of mesenchymal cells located between the layers of the dorsal mesentery, which connects the stomach to the posterior peritoneal surface over the aorta. These mesenchymal cells differentiate to form the splenic pulp, the supporting connective tissue structures, and the splenic capsule. The splenic artery penetrates the primitive spleen, and arterioles branch through the connective tissue into the splenic sinusoids. As the embryonic stomach rotates 90 degrees on its longitudinal axis, the spleen and dorsal mesentery are carried to the left along with the greater curvature of the stomach. The base of the dorsal mesentery fuses with the posterior peritoneum over the left kidney, giving rise to the splenorenal ligament. This explains why, although the spleen is intraperitoneal, the splenic artery enters from the retroperitoneum through the splenorenalligament. In most adults, a portion of the splenic capsule is firmly attached to the fused dorsal mesentery anterior to the upper left kidney, giving rise to the bare area of the spleen, (zhao Z, et.al 1970).The size of the splenic bare area varies but usually involves less than half the posterior splenic surface. This anatomic feature is analogous to the bare area of the liver and can be helpful in distinguishing intraperitoneal from pleural fluid collections.The normal adult spleen is convex superolaterally, is concave inferomedially, and has a homogeneous echo pattern. The spleen lies between the fundus of the stomach and the diaphragm, with its long axis in the line of the left 10th rib. The diaphragmatic surface is convex and is usually situated between the ninth and 11th ribs. The visceral or inferomedial surface has gentle indentations where it comes into contact withthe stomach, left kidney, pancreas, and splenic flexure. The spleen is suspended by the splenorenal ligament, which is in contact with the posterior peritoneal wall, the phrenicocolic ligament, and the gastrosplenic ligament. The gastrosplenic ligament is composed of the two layers of the dorsal mesentery that separate thelesser sac posteriorly from the greater sac anteriorly.M. Vos, et.al 2011.

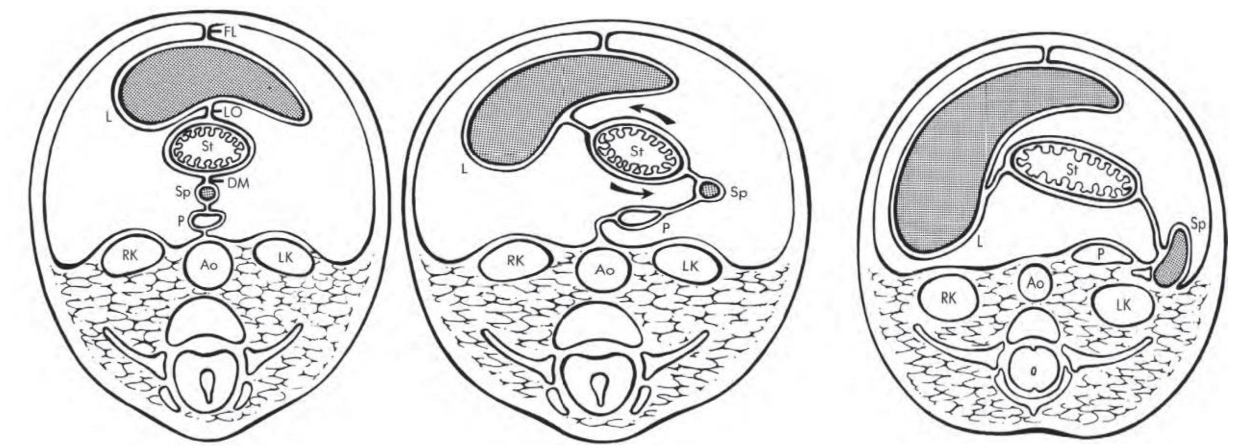

Figure 2.1. Embryologic development of the spleen.

Schematic axial drawings of the upper abdomen. A, Embryo: 4 to 5 weeks. The mesentery anterior to the stomach (St) is the ventral mesentery. The ventral mesentery is divided into two portions by the liver (L) into the falciform ligament (FL) anteriorly and the gastrohepatic ligament or lesser omentum (LO) posteriorly. Posterior to the stomach is the dorsal mesentery (DM), which contains the developing spleen (Sp) and pancreas (P). The dorsal mesentery is divided into two portions by the spleen: the splenogastric ligament anteriorly and the splenorenal ligament posteriorly. The pancreas (P) has not yet become retroperitoneal and remains within the dorsal mesentery. Ao, Aorta; RK, right kidney; LK, left kidney. B, Embryo: 8 weeks. The stomach rotates counterclockwise, displacing the liver to the right and the spleen to the left. The portion of the dorsal mesentery containing the pancreas, splenic vessels, and spleen begins to fuse to the anterior retroperitoneal surface, giving rise to the splenogastric ligament and the "bare area" of the spleen. If fusion is incomplete, the spleen will be attached to the retroperitoneum only by a long mesentery, giving rise to a mobile or "wandering" spleen. C, Newborn. Fusion of the dorsal mesentery is now complete. The pancreas is now completely retroperitoneal, and a portion of the spleen has fused with the retroperitoneum. Note the close relation of the pancreatic tail to the splenic hilum.

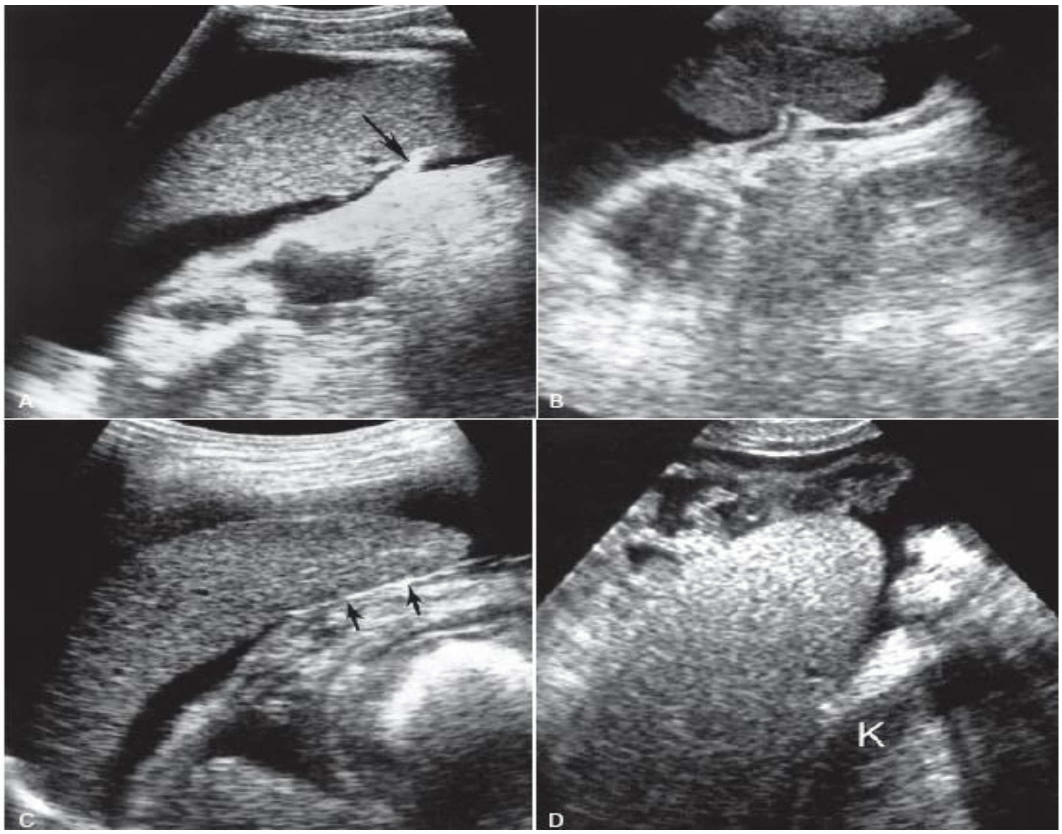

Figure 2-2. Bare area of the spleen.

Variability in the relationship of the spleen to the anterior retroperitoneal surface is demonstrated in patients with ascites. A, This spleen has no bare area. The splenorenal ligament (arrow) is outlined on both sides by ascetic fluid. B, Part of the lower pole of the spleen is fused posteriorly. C, Lower pole is fused to the retroperitoneum (arrows). D, Large proportion of this patient's spleen is fused posteriorly. Note the close relation of the spleen to the left kidney (K).

Its weight is related to the patient's age and gender; the spleen usually weighs less than 150 g on autopsy (range, 80-300 g). (Deland 1970).The spleen decreases in size and weight with advancing age and is smaller in women. It also increases slightly during digestion and can vary in size according to the nutritional status of the body.

Splenic functions: include phagocytosis, fetal hematopoiesis, adult lymphopoiesis, immune response, and erythrocyte storage. The spleen may be congenitally absent. Under a variety of conditions, including surgical misadventure, the spleen also may be removed. Currently, the surgical trend is toward preservation of the spleen whenever possible. (Gauer JM et.al 2008)A person can live fully without a spleen. However, particularly in childhood, the immune response may be impaired, especially to encapsulated bacteria. Overwhelming postsplenectomysepsisis a long-term risk in asplenic patients, and appropriate preventive measures should be taken to minimize this risk. (cadili and degara C 2008).

2.1.2. SonographicTechnique:

All routine abdominal sonographic examinations, regardless of the indications, should include at least one coronal viewof the spleen and the upper pole of the left kidney. The most common and easy approach to visualize the spleen is to maintain the patient in the supine position and place the transducer in the coronal plane of section posteriorly in one of the lower left intercostal spaces. The patient can then be examined in various degrees of inspiration to maximize the window to the spleen. Deep inspiration introduces air into the lung in the lateral costophrenic angle and may obscure visualization. A modest inspiration depresses the central portion of the left hemidiaphragm and spleen inferiorly so that they can be visualized. The plane of section should then be swept posteriorly and anteriorly to view the entire volume of the spleen. We generally find that a thorough examination in the coronal planeof section is highly accurate for excluding any lesion within or around the spleen and for documenting the spleen’s approximate size. If an abnormality is discovered within or around the spleen, other planes of section should be used. An oblique planeof section along the intercostal space can avoid rib shadowing. In some patients with narrow intercostal spaces, however, intercostal scanning can be difficult. A transverse planefrom a lateral, usually intercostal, approach may help to localize a lesion within the spleen anteriorly or posteriorly. In this regard, especially for beginners, it must be emphasized that the apex of the sector image is always placed at the top of the screen.However, on a left lateral intercostal transverse image, the top of the screenthe apex of the sectoris actually to the patient's left; the right side of the sector image is posterior, and the left side of the image is anterior. To look at the image appropriately, the clinician would have to rotate it 90 degrees clockwise.If the spleen is not enlarged and is not surrounded by a large mass, scanning from an anterior position as one would for imaging the liver is not helpful because of the interposition of gas within the stomach and the splenic flexure of the colon. However, if the patient has a relatively large liver, or spleen, the spleen may be visualized from an anterior approach. If there is free intraperitoneal fluid around the spleen or a left pleural effusion, the spleen may be better visualized from an anterolateral approach. Often, it is beneficial to have the patient roll onto the right side as much as 45 degrees, or even 90 degrees, so that a more posterior approach can be used to visualize the spleen. Generally, the same curvilinear transducers and technical settings are used for examination of the spleen as for the other abdominal organs. A high-frequency linear array transducer can be used for more detail. Advanced ultrasound imaging modalities such as harmonic and compound imaging are used to improve image quality and detect subtle lesions.The use of contrast-enhanced ultrasound (CEUS) is increasing both in research and clinical settings. Multiple reports have recently described CEUS of the spleen and its characterization of splenic lesions. (catalano, et.al 2006, and gorg 2007).However, its role in general practice is yet to be determined.

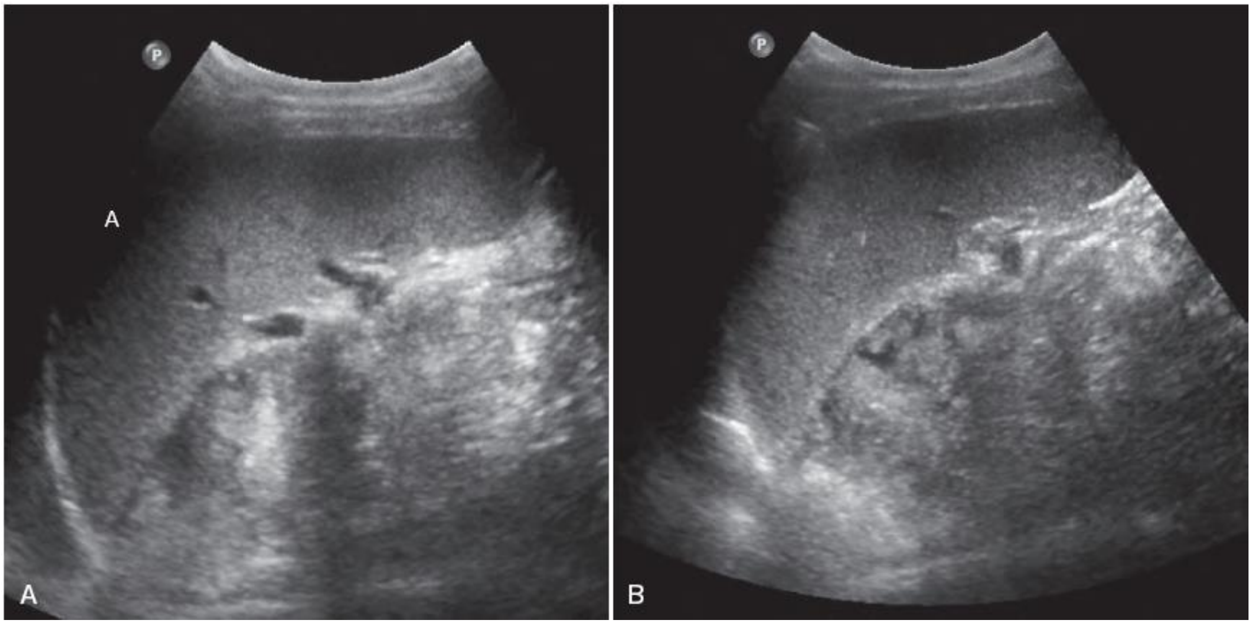

Figure 2-3. Importance of scan plane. A, Coronal ultrasound scan shows part of the spleen obscured by air in the lung. B, Improved visualization of the spleen on coronal oblique scan aligned with the 10th interspace between the ribs.

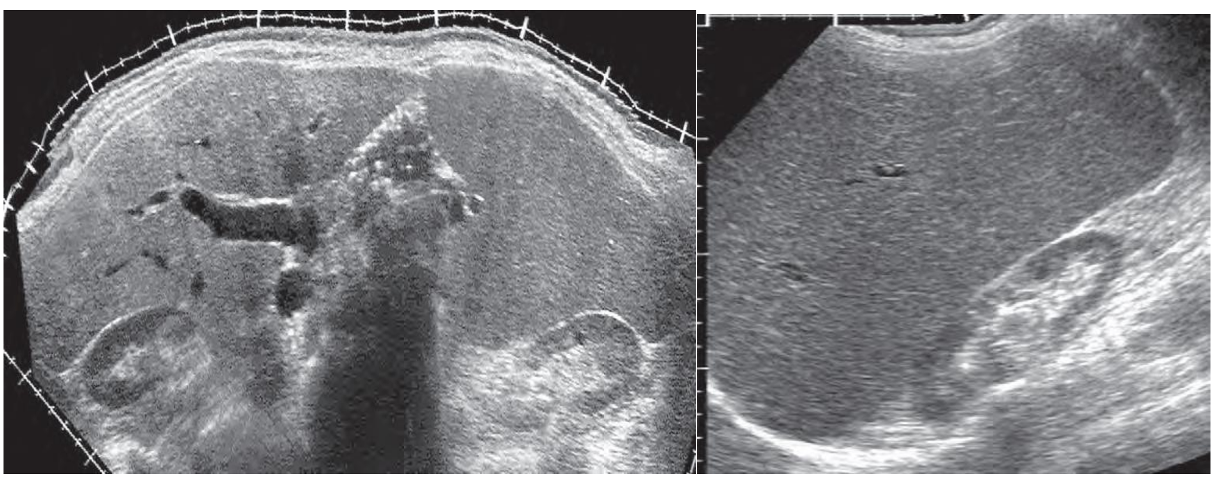

Figure 2-4. Showed US appearance of splenomegaly (left), and normal apperence in (right)

2.1.3. Sonographic appearance:

The shape of the normal spleen is variable. The spleen consists of two components joined at the hilum: a superior medial component and an inferior lateral component. More superiorly, on transverse scanning, the spleen has a typical fat, "inverted comma" shape, with a thin component extending anteriorly and another component extending medially, either superior to or adjacent to the upper pole of the kidney. This second component (superior medial) can be seen to indent the gastric fundus on plain films of the abdomen or in barium studies. As the scan plane moves inferiorly, only the inferior component of the spleen is seen. This component (inferior lateral) can be outlined by a thin rim of fat above the splenic flexure, as seen on a plain abdominal film. It may extend inferiorly to the costal margin and present clinically as a palpable spleen. However, either the superior medial or the inferior lateral component can enlarge independently, without enlargement of the other component.

It is important to recognize the normal structures that are related to the spleen. The diaphragm cradles the spleen posteriorly, superiorly, and laterally. The left liver lobe may extend into the left upper quadrant superior and lateral to the spleen. The fundus of the stomach and lesser sac are medial and anterior to the splenic hilum. The gastric fundus may contain gas or fluid, which should not be confused with a fluid collection. The tail of the pancreas lies posterior to the stomach and lesser sac. It approaches the hilum of the spleen, closely related to the splenic artery and vein. Consequently, the spleen can be used as a "window" to evaluate the pancreatic tail area. The left kidney generally lies inferior and medial to the spleen. A useful landmark in identifying the spleen and splenic hilum is the splenic vein, which generally can be demonstrated without difficulty. The normal splenic parenchyma is homogeneous. The liver is generally considered to be more echogenic than the spleen, but in fact the echogenicity of the parenchyma is higher in the spleen than in the liver. Using a dual-image setting, the operator may compare the echogenicity of these two organs. The impression that the liver has greater echogenicity results from its large number of reflective vessels.

As in measuring other body structures, it is helpful to have measurements that establish the upper limits of normal. The size of a normal spleen depends on gender, age, and body-height. The range of the “normal sized” adult spleen, combined with its complex threedimensional shape, makes it difficult to establish a normal range of sonographic measurements. Ideally, the clinician would assess splenic volume or weight. Techniques have been developed to measure serial sections of the spleen by planimetry and then compute the volume of the spleen by adding the values for each section.9 However, these techniques are cumbersome and not popular. The most frequently used method is “eyeballing” the size. Unfortunately, this method of assessment requires considerably more experience than is necessary for other imaging techniques and is relatively inaccurate. Various authors have used different methods to measure splenic size. The length of the spleen measured on a coronal or coronal oblique view that includes the hilum is the most common technique (Rosenberg 1991 and Lamb et.al 2002). This view can be obtained during deep inspiration or quiet breathing. Importantly, this method correlates well with the splenic volume, particularly when performed with the patient in the right lateral decubitus (RLD) position. (Lamb et.al 2002). Multiple studies have tried to establish nomograms of spleen size. In a study of 703 normal adults, the length of the spleen was less than 11 cm, the width (breadth) less than 7 cm, and the thickness less than 5 cm in 95% of patients.12 Rosenberg et al. 1991 established an upper limit of normal splenic length of 12 cm for girls and 13 cm for boys (≥15 years). Hosey et al. 2006, demonstrated a mean splenic length of 10.65 cm. In this study, menalso had larger spleens than women. Spielmann et al. 2005,showed that the length of the spleen correlates withheight and established nomograms for tall, healthy athletes.In women taller than 5 feet, 6 inches (168 cm), themean splenic length of 10 cm increased by 0.1 cm foreach 1-inch incremental increase in height. In men tallerthan 6 ft (180 cm), the mean splenic length of 11 cmincreased by 0.2 cm for each 1-inch incremental increasein height. Upper limits of normal in splenic length were14 cm in women 6 ft, 6 inches (198 cm) tall and 16.3 cmin men 7 ft (213 cm) tall. Finally, unlike patient height,Kaneko et al. 2009did not show correlation of splenicvolume with patient weight or body surface area inadults.

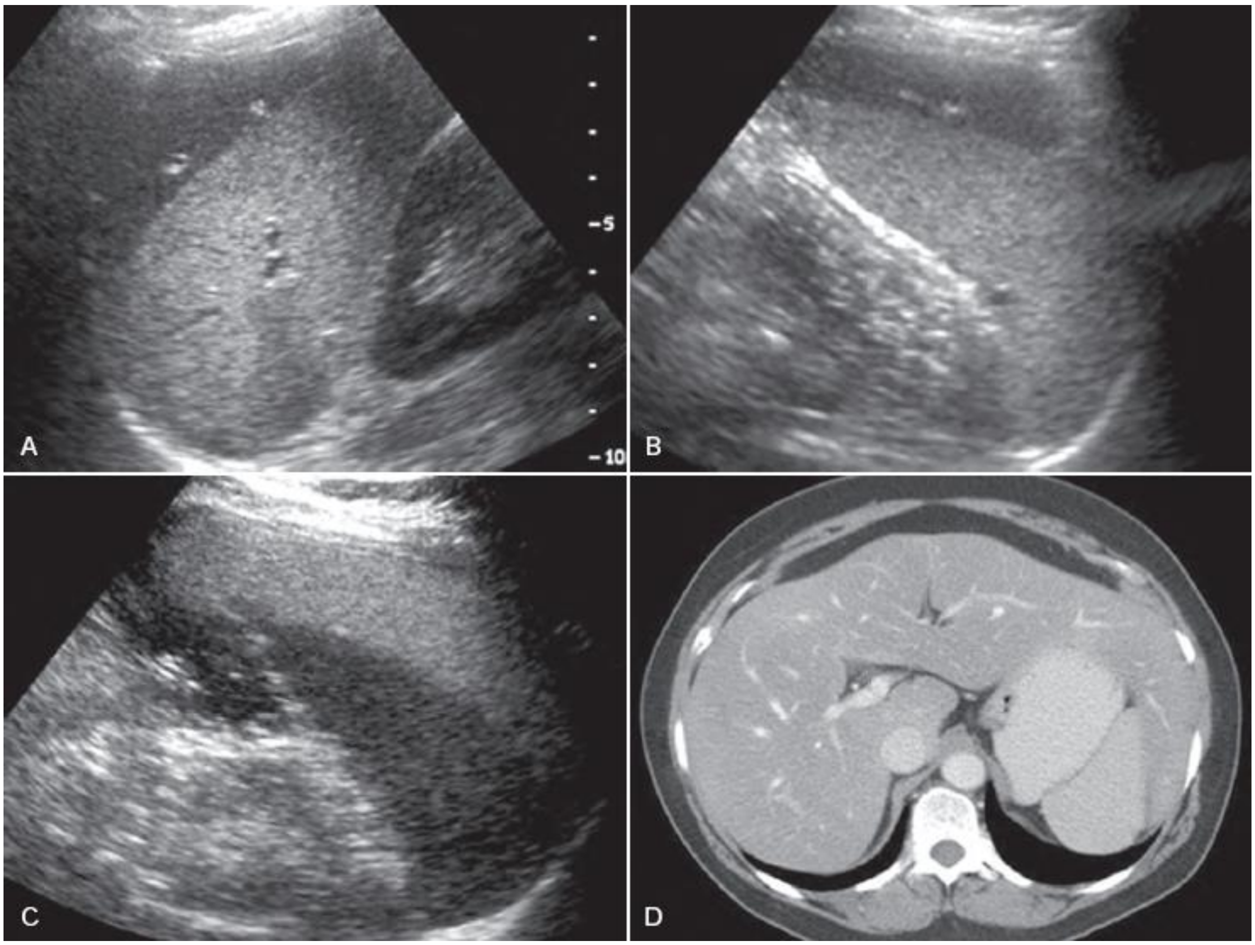

Figure 2-5. Relationship of spleen with surrounding structures. Left liver lobe extends into the left upper quadrant superior to the spleen. **A,** Coronal and **B,** transverse, sonograms demonstrate the left liver lobe superior to the spleen. The liver is hypoechoic compared with the spleen. **C** and **D,** Liver extends over spleen in a different patient with a fatty liver. **C,** Transverse sonogram shows an

echogenic liver and a relatively hypoechoic spleen**. D,** Axial CT image shows the left liver lobe draping around the spleen.

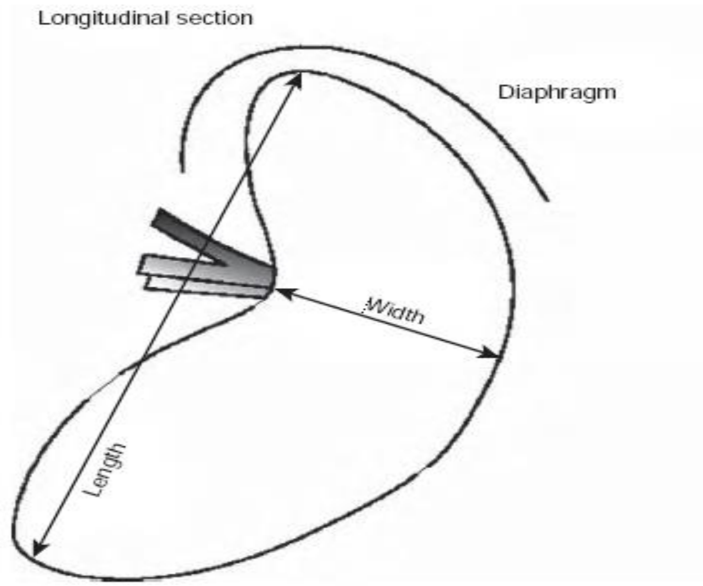

Figure 2-6. Splenic measurement. Diagram shows sonographic approach to measuring splenic length and width. Splenic size is best measured by obtaining a coronal view that includes the hilum. *(From Lamb PM, Lund A, Kanagasabay RR, et al. Spleen size: how well do linear ultrasound measurements correlate with three-dimensional CT volume assessments? Br J Radiol 2002;75:573-577.)*

2.1.4. Pathologic conditions:

Splenomegaly: The differential diagnosis of splenomegaly is exceedingly long. It includes infection (e.g., mononucleosis, tuberculosis, malaria), hematologic disorders (myelofibrosis, lymphoma, leukemia), congestion (portal hypertension, portal/splenic vein thrombosis, congestive heart failure), inflammation (sarcoidosis), neoplasia (hemangioma, metastases), and infiltration (e.g., Gaucher's disease).Frequency and etiology of splenomegaly vary between developing and developed countries and even between hospitals in the same region. (Swaroop J et.al 1999)Sonography is very helpful in determining the degree of enlargement. In "borderline" splenomegaly, however, diagnosis can be difficult. The spleen is capable of growing to an enormous size. It can extend inferiorly into the left iliac fossa, and it can cross the midline and appear as a mass inferior to the left lobe of the liver on longitudinal section. The degree of splenomegaly is generally not a reliable tool in providing a more concise differential diagnosis. The differential diagnosis of massive splenomegaly, defined as a spleen size greater than 18 cm, is less extensive and includes hematologic disorders and infections (Abramson JS et.al 2008).

Sonographic assessment of the splenic architecture is used to differentiate between focal lesions (single or multiple) causing splenomegaly and diffuse splenomegaly. The most common finding is diffuse enlargement; in these patients, imaging is typically not helpful in providing a specific diagnosis. When the spleen enlarges, it can become more echogenic, but the clinician cannot differentiate between the different types of splenomegaly on the basis of its echogenicity. Experimental studies have tried to quantify the degree of fibrosis in liver and spleen using the echotexture characteristics, but no clinical applications have been established to date. Jeong JW et.al 2007. Associated clinical and radiologic features can be helpful in establishing a differential diagnosis. Liver disease and evidence of portal venous collaterals can establish portal hypertension as the cause of splenomegaly. Focal lesions, multiorgan involvement, and lymphadenopathy may indicate lymphoma.However, in many patients, extensive radiologic and laboratory investigations will fail to yield a diagnosis. In these cases of “isolated” splenomegaly, the risks of serious underlying disease must be balanced against the risks of further invasive investigations, such as diagnostic splenic biopsy or splenectomy. In selected cases, ultrasound guided splenic biopsy of focal abnormalities can be helpful in establishing a diagnosis, with an acceptable complication rate and high accuracy. (Tam et.al 2008).

Complications of splenomegaly include hypersplenism and spontaneous splenic rupture. Spontaneous splenic rupture typically occurs in patients with an enlarged spleen after minimal trauma or insignificant events such as coughing. Wehbe et.al 2008.

Focal Abnormalities: Ultrasound is extremely helpful in finding and characterizing focal splenic lesions. However, because of the overlap in the appearance of splenic lesions, it is often not possible to make a specific diagnosis based on the sonographic findings alone. Splenic lesions can be solitary or multiple, diffuse, and infiltrative. Focal lesions can be cystic, complex cystic, or solid. Further, lesions can be categorized according to size as micronodular(<1 cm), nodular(1-3 cm), or focal (<3 cm) masses. (wehbe et.al 2008).Knowledge of past medical history, clinical presentation, and sonographic findings is required to provide an appropriate differential diagnosis and guide further management.Warshaur DM and hall 2008). Ultimately, percutaneous biopsy or splenectomy may berequired to obtain a definitive diagnosis.

Splenic Cysts: Splenic cysts, as with cysts elsewhere in the body, appear as anechoic lesions with posterior acoustic enhancement. Simple cysts are round to ovoid in shape and have a thin, sharply defined wall. Complex cystsdo not meet these criteria and may demonstrate septations, thick walls, calcifications, solid components, or internal echoes. Occasionally, cysts can grow to a very large size, becoming predominantly exophytic**.** It may then be difficult to appreciate their splenic origin. The most common splenic cystic lesions are primary congenital cysts, pseudocysts, and hydatid cysts. Uncommon splenic cystic lesions include pancreatic pseudocysts, lymphangiomas, hemangiomas, peliosis, hamartomas, angiosarcomas, and cystic metastases.Other lesions that can mimic cysts on ultrasound are abscesses, lymphoma, necrotic metastases and hematomas. Ishida et.al 2001.

Table (2-1): demonstrate type of splenic cyst:

Congenital cysts
Pseudocysts
Hydated{echinococcal}cysts
Pancreatic pseudocysts
Endothelial-lined cysts
Lymphoangiomas
Cystic hemangiomas
Peliosis
Cystic metastasis*
Abscess*
Hematomas*
*not true cysts

In the developed world, most splenic cysts are asymptomatic incidental findings discovered during routine imaging and generally represent congenital cysts or pseudocysts. These cysts may cause symptoms when large or when present with complications such as internal hemorrhage, infection, or rupture. Primary congenital cysts, also called epidermoid cysts or true cysts, are characterized by the presence of an epithelial lining on pathologic examination. (Urrutia et.al 1996).

Thought to arise from embryonic rests of primitive mesothelial cells within the spleen, typical epidermoid cysts present as well-defined, thin-walled anechoic lesions that do not change over time. Pseudocysts, also known as false cysts, have no cellular lining and are presumably secondary to trauma, infarct, or infection. Williams RJ et.al 1993. These cysts are more often complex, with wall calcifications and internal echoes. However, differentiation between both types of cysts is usually not possible because there is considerable overlap both on imaging and on pathologic examination (Mergensterm 2002). Furthermore, a history of significant trauma or infection is rarely established in patients with a pseudocyst.

Both types of cysts can be complex, with wall calcifications or increased echogenicity of the fluid caused by cholesterol crystals, inflammatory debris, or hemorrhage (Dachman AH et.al 1986).

Hydatid (or echinococcal) disease is the most common cause of splenic cysts in endemic areas. Isolated splenic involvement without liver and peritoneal disease is rare.Akhano et.al 2007).The appearance of a hydatid cyst depends on the stage of the disease and varies from simple to complex, with or without daughter cysts. The diagnosis is made by combining the appropriate history, geographic background, serologic testing, and imaging appearances. (Celebi. S et.al 2001).Percutaneous fine-needle aspiration can be diagnostic, provided the pathologist has been alerted to search for the scolices. Pseudocysts related to pancreatitis in or adjacent to the spleen are usually diagnosed by the associated features of pancreatitis. (hieder et.al 2001).Splenic peliosis is very rare and characterized by multiple blood-filled cystic spaces, sometimes involving the entire spleen. (Abbott RM et.al2004). On ultrasound, these lesions appear as multiple indistinct hypoechoic lesions. The lesions may be hyperechoic if thrombosis is present.Endothelial-lined cysts include lymphangiomas and cystic hemangiomas. (Willcox et.al 2000)Lymphangiomas have been described as multiple cysts of varying size, ranging from a few millimeters to several centimeters, divided by thin septa.Bezzi M et.al 2001).Hemangiomas with cystic spaces of variable size have been reported. Cystic metastases to the spleen are typically seen in patients with widespread metastatic disease, such as ovarian or colon carcinoma. Occasionally, necrotic metastases mimic a cystic lesion.The most common causes of splenic abscess are endocarditis, septicemia, and trauma. (Fotiadis M et.al 2008).Splenic pyogenic abscesses may have an appearance similar to that of simple cysts, but the diagnosis is typically made in conjunction with the clinical findings. The presence of gas indicates an infectious cause. Gas may cause a confusing picture if only a small, curvilinear or punctate hyperechoic focus is seen. The presence of a reverberation artifact (dirty shadowing) indicates the presence of gas. However, the sonographic findings of a pyogenic abscess are variable, and in indeterminate cases, aspiration is useful for diagnosis. (changchin CS et.al 2002).Percutaneous catheter drainage can be used as a safe and successful treatment option. (ferraioli G et.al 2009).

Nodular Splenic Lesions:Nodular lesions are often multiple and can be subdivided into micro-nodular (<1 cm) and nodular (1-3 cm). If splenic nodules are present in a patient with a known diagnosis such as lymphoma, tuberculosis, or sarcoidosis, these nodules likely represent the same disease. However, if no diagnosis has been established and the splenic nodules are an isolated finding, the diagnosis is rarely made on the imaging features alone. Most common etiologies of splenic nodules include infection (e.g., mycobacteria, histoplasmosis), sarcoidosis, and malignancy (e.g., lymphoma, metastases). Other, less common causes of splenic nodular lesions with similar imaging findings include Gamna-Gandy bodies, *Pneumocystis jir-oveci*(formerly known as *P*. cariniipneumonia) and cat-scratch disease.Kah DM et.al2003 and O' neal CB et.al 2008).

Active tuberculosis involving the spleen is typically seen in miliary dissemination and can occur with both tuberculosis and atypical mycobacterial infections. The typical sonographic findings are multiple hypoechoicnodules 0.2 to 1 cm in size. Sometimes the nodules are hyperechoic or present as larger, echo-poor or cystic lesions representing tuberculous abscesses. When the nodules or granulomas heal, they can be become calcified and appear as small, scattered, discrete, bright echogenic lesions with posterior shadowing in an otherwise normal spleen. These probably are the most frequently encountered nodular splenic lesions. Splenic artery calcifications are also common and should not be confused with a granuloma. Microabscesses are typically seen in immunocompromised patients with generalized infections. They often coexist in the liver and spleen and are similar in appearance. Microabscesses usually present as multiple hypoechoic nodules. In hepatosplenic candidiasis the two most common sonographic patterns are hypoechoic nodules and hyperechoic foci 2 to 5 mm in size, occasionally containing central calcification. Two other sonographic patterns have also been described. In the wheels-within-wheels appearance the outer hypoechoic "wheel" is thought to represent a ring of fibrosis surrounding the inner echogenic "wheel" of inflammatory cells and a central hypoechoic, necrotic area.The bull's-eye appearance consists of echogenic inflammatory cells in the center surrounded by a hypoechoic fibrotic outer rim. (Pastakia B et.al 1988).

Lymphoma and metastatic disease can also present with a small, diffuse nodular pattern, especially Hodgkin's disease and low-grade non-Hodgkin's lymphoma.

Table (2.2): containing the most causes of splenic nodules:

infectious	inflammatory	malignant	other
tuberculosis	sarcoidosis	lymphoma	Gamna-gandy bodies
Mycobacterium aviumintrcellulare complex		metstases	Gaucher's disease
Pyogenic abscesses			
histoplasmosis			
Candida abscesses			
Cat-scratch disease			
Pneumocystis jirovesi {formerly P.carinil pneumonia}			

Congenital anomalies: Accessory spleens,also known as splenunculi, are common normal variants found in up to 30% of autopsies. They are typically located near the splenic hilum and have similar echogenicity as the normal spleen. Splenunculi may be confused with enlarged lymph nodes around the spleen or with masses in the tail of the pancreas. When the spleen enlarges, the accessory spleens may also enlarge. Ectopic accessory spleens described in various locations, including the pancreas and scrotum, are typically confused with abnormal masses or may rarely undergo torsion and cause acute abdominal pain. Meyer–Rochow et.al 2007.

The vast majority of accessory spleens, however, are easy to recognize sonographically as small, rounded masses, usually less than 5 cm in diameter, with the same echogenicity as the spleen. CT, MRI or in challenging cases, scintigraphy with 99mTc-labeled heatdamaged red blood cells, can confirm the diagnosis. A "wandering spleen" (or mobile spleen) can be found in unusual locations and may be mistaken for a mass. It is caused by absence or extreme laxity of the supporting ligaments and a long, mobile mesentery. The mobile spleen may undergo torsion, resulting in acute or chronic abdominal pain. If the diagnosis of a wandering spleen is made in a patient with acute abdominal pain, the diagnosis of torsion may be supported by color flow Doppler imaging showing absence of blood flow. (Gayer G et.al 2006)

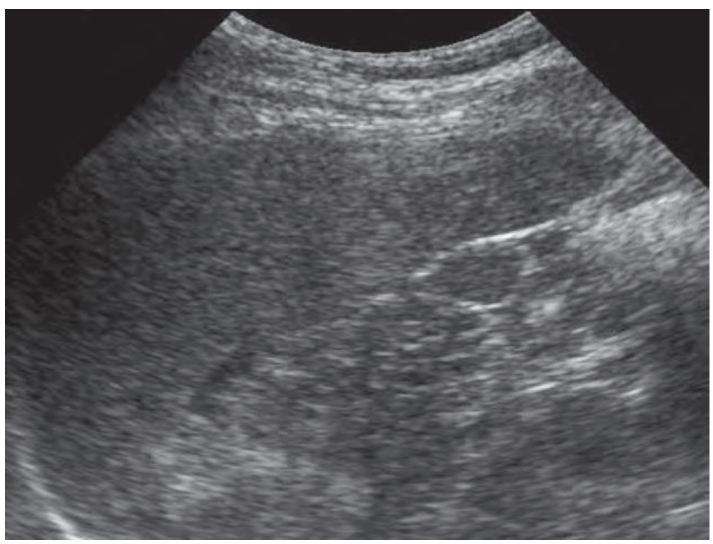

Figure 2-7. Accessory spleen. Coronal sonogram shows an accessory spleen (splenunculus) adjacent to the inferior medial portion of the spleen.

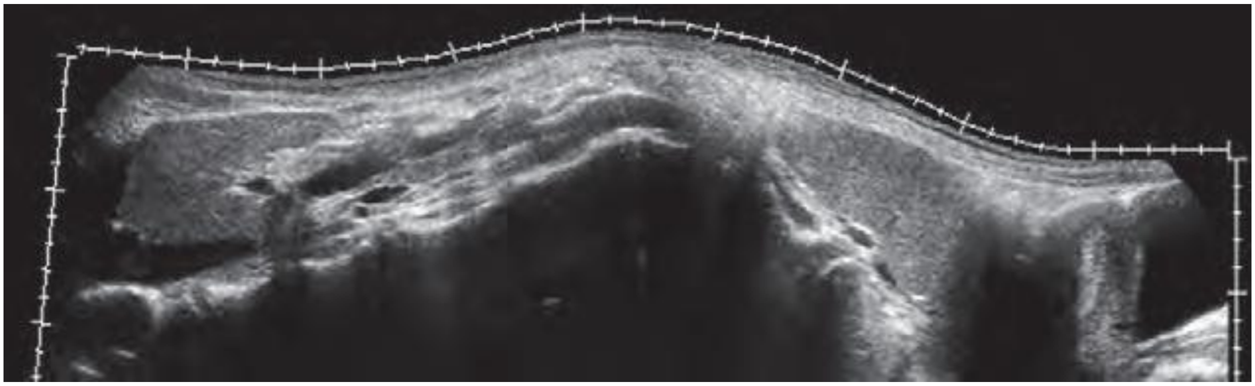

Figure 2-8. Wandering spleen.Sagittal extended- fov image of midline abdomen in asymptomatic young woman;*L,* liver, *s,* spleen; *u,* uterus; *b,* bladder.

The other two major congenital splenic anomalies are the asplenia and polysplenia syndromes. These conditions are best understood if viewed as part of the spectrum of anomalies known as visceral heterotaxy. A normal arrangement of asymmetrical body parts is known as situssolitus. The mirror image condition is called situsinversus. Between these two extremes is a wide spectrum of abnormalities called situsambiguus. Splenic abnormalities in patients with visceral heterotaxy consist of polysplenia and asplenia. Interestingly, patients with polysplenia have bilateral left-sidedness, or a dominance of left-sided over right-sided body structures. They may have two morphologically left lungs, left-sided azygous continuation of an interrupted inferior vena cava, biliary atresia, absence of the gallbladder, gastrointestinal malrotation, and frequently cardiovascular abnormalities. Conversely, patients with asplenia may have bilateral right-sidedness. They may have two morphologically right lungs, midline location of the liver, reversed position of the abdominal aorta and inferior vena cava, anomalous pulmonary venous return, and horseshoe kidneys. The wide range of possible anomalies accounts for the variety of presenting symptoms, but absence of the spleen itself causes impairment of the immune response, and such patients can present with serious infections, such as sepsis and bacterial meningitis. Spelman D et.al 2008.

Polysplenia must be differentiated from posttraumatic splenosis.[Gayer G et.al 2006] Splenosis is an acquired condition defined as autotransplantation of viable splenic tissue throughout different anatomic compartments of the body. It occurs after traumatic or iatrogenic rupture of the spleen.Nuclear medicine imaging, with technetium- labeled heat-damaged red blood cells, is the most sensitive study for both posttraumatic splenosis and congenital polysplenia. Accessory spleens as small as 1 cm can be demonstrated by this method.[Gayer G et.al 2006]

2.2. Previous Study:

Shah SH, et.al (1996) stated that splenomegaly is common in portal hypertension due to hepatic cirrhosis, but there are little data comparing different methods of spleen measurement. We have compared ultrasound with radionuclide imaging in measuring splenomegaly. The relation of splenomegaly to hypersplenism and portal hemodynamic factors was also studied. His main result was: Ultrasound and radionuclide measures of spleen volume gave comparable results ($r = 0.95$, $p < 0.0001$). Phagocytic activity of the spleen measured by radionuclide uptake increased as the volume of the spleen increased ($r = 0.46$, $p < 0.03$) but was not related to diminishing liver phagocytic activity. Spleen volume was correlated negatively with leukocyte counts ($r = 0.43$, $p < 0.05$) but not with hemoglobin or platelet counts. Spleen radionuclide uptake was negatively correlated with hemoglobin ($r = 0.48$, $p < 0.04$) and leukocyte counts ($r = 0.46$, $p < 0.04$) but not with platelet counts. Spleen volume was related to portal vein cross-sectional area ($r = 0.91$, $p < 0.0001$) and portal vein blood flow volume ($r = 0.57$, $p < 0.008$) but not to portal vein blood flow velocity, portal pressure gradient, or azygos blood flow. Finaly he conclude that the Spleen size measured by ultrasonography and radionuclide studies gives comparable results. Spleen phagocytic activity in cirrhosis increases as the spleen enlarges but not in relation to decreased hepatic phagocytic activity. Spleen phagocytic activity probably contributes to anemia and leukopenia in the splenomegaly of cirrhosis, but other factors must contribute to thrombocytopenia. Portal hemodynamics are probably important in the splenomegaly, but the interrelation is complex.

P M Lamb, et.al (2002) was aimed to measure the splenic length as standard practice using US, but it is not known how well this represents the true size of the spleen. Previous studies, using a combination of measurements from in vivo and resected spleens, were subject to error because of changes in splenic size. The aim of this study was to correlate the dimensions of the spleen measured by ultrasound with the splenic volume measured by helical CT. Ultrasound examination was performed on 50 adult patients at the time of their attendance for abdominal CT. Linear dimensions of the spleen were measured with the patient first in the supine and then in the right lateral decubitus (RLD) position. The splenic volume was calculated from a three-dimensional reconstruction of the CT images. There was good correlation, using Spearman's rank correlation, between ultrasound measurements and CT volumes with correlation coefficients exceeding 0.7 for all parameters except one. The linear measurement that correlated most closely with CT volume was the spleen width measured on a longitudinal section with the patient in the RLD position (correlation coefficient $(r)=0.89$, $p<0.001$). There was also good correlation between splenic length measured in the RLD position and CT volume ($r=0.86$, $p<0.001$). We conclude that a good correlation exists between in vivo ultrasound assessment of splenic size and true splenic volume. The most accurate single measurement is spleen width 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.

C Niederau, et.al (1983) stated that the Normal values and upper limits (95th percentile) of liver, spleen, pancreas, and portal vein size were determined prospectively with ultrasound in 915 healthy subjects. Sex, age, weight, height, and body surface area were determined in each case. Since correlation of longitudinal and transverse organ diameters with physical data was poor (r less than or equal to 0.3), the authors do not consider it necessary to correct the measurements accordingly. However, the liver is oriented longitudinally in slender subjects and transversely in heavy subjects; thus both longitudinal and anteroposterior diameters need to be measured, since the longitudinal diameter alone will give too high or too low a value, respectively.

O L Konuş, et.al (1998) he was aimed to determine the normal range of dimensions for the liver, spleen, and kidney in healthy neonates, infants, and children. This prospective study involved 307 pediatric subjects (169 girls and 138 boys) with normal physical or sonographic findings who were examined because of problems unrelated to the measured organs. The subjects were 5 days to 16 years old. All measured organs were sonographically normal. At least two dimensions were obtained for each liver, spleen, and kidney. Relationships of the dimensions of these organs with sex, age, body weight, height, and body surface area were investigated. Suggested limits of normal dimensions were defined. Dimensions of the measured organs were not statistically different in boys and girls. Longitudinal dimensions of all three organs showed the best correlation with age, body weight, height, and body surface area. Height showed the strongest correlation of all. This correlation was a polynomial correlation. Determination of pathologic changes in size of the liver, spleen, and kidney necessitates knowing the normal range of dimensions for these organs in healthy neonates, infants, and children. Presented data are applicable in daily routine sonography. Body height should be considered the best criteria to Picardi, et.al (2002) was assess the Spleen size in 73 patients with thrombocytosis and in 15 healthy subjects, comparing palpation with ultrasonography (US) measurement of longitudinal diameter and volume. Intraobserver and interobserver variability for volume on US, checked in 12 patients, was very low. Correlation between spleen volume measured by US and that measured by computed tomography was excellent. Splenomegaly was detected by palpation in 25% of patients, by US assessment of longitudinal diameter in 33%, and by US assessment of volume in 52%. After diagnostic work-up, 54 patients had a diagnosis of essential thrombocythemia (ET), 4 of idiopathic myelofibrosis (IMF), and 15 of secondary thrombocytosis (ST). Spleen volume in patients with ST was in the normal range (138 ± 47 mL) and was significantly lower than that in patients with ET or IMF (370 ± 210 mL;$P < .001$). Thus, US-measured volume was the most sensitive method for identifying nonpalpable splenomegaly in patients with primary myeloproliferative diseases, and it may help in distinguishing these diseases from reactive disorders.

RS Breiman, et.al (1982) stated that computed tomography potentially offers the most accurate noninvasive means of estimating in vivo volumes. Contiguous 1-cm-thick CT scans were obtained through phantoms, dog kidneys in vivo, and human spleens before splenectomy. Cross-sectional areas were calculated for each individual scan and volumes then determined with each of four mathematical integration techniques. Volume estimations were compared to volumes determined by water displacement. The simplest, most practical means of calculating volumes, using the summation-of-areas technique with scans obtained at 2 cm intervals, was similar in accuracy to more complex methods. The mean percentage error of volume calculations using the sum-of-areas technique was 4.95% for five immobile phantoms, 3.86% for eight dog kidneys, 3.59% for eight human spleens in vivo at 1 cm scan spacing, and 3.65% for the same human spleens at 2 cm scan spacings. Difficulties in visual recognition and manual tracking of object boundaries seem to be more significant sources of error than patient-related factors.

H K Rosenberg, et.al (1991) stated that the purpose of this study was to establish guidelines for normal splenic size at different ages by using a simple and reproducible sonographic method. Two hundred thirty patients, from neonate to 20-year-old, had sonography because of abdominal and/or pelvic problems unrelated to the spleen. Findings on sonograms of the liver and kidneys were normal in all cases. Splenic size was measured by obtaining a coronal view that included the hilum, while the patient was breathing quietly. The greatest longitudinal distance between the dome of the spleen and the tip (splenic length) was measured and correlated with age, height, and weight. The following guidelines are proposed for the upper limit of normal splenic length based on this simple, easy to use, one-measurement technique: splenic length no greater than 6.0 cm at 3 months, 6.5 cm at 6 months, and 7.0 cm at 12 months, 8.0 cm at 2 years, 9.0 at 4 years, 9.5 cm at 6 years, 10.0 cm at 8 years, 11.0 cm at 10 years, 11.5 cm at 12 years, 12.0 cm at 15 years or older for girls, and 13.0 cm at 15 years or older for boys. Twenty-two patients with known abnormalities of the spleen were randomly selected and their splenic lengths compared with the proposed guidelines; in each case, the length of the spleen exceeded the upper limit of normal for that age. Normal values of a single measurement of the greatest longitudinal diameter of the spleen, from the dome to the tip measured at the hilum in the coronal plane, were obtained in patients from newborn to 20 years old.

Chapter three
Methodology

3.1. Material:

All spleen US scans were performed by the same operator, who used high resolution Mind-Ray DC- N6 US unit with 3-5 MHz broadband curved array probe

3.2. Method:

An analytical study of 121 patients (34 men noted by number 1; mean age, 30 years [range, 20-45years]) and (87 women noted by number 2; mean age, 30 years [range, 20-52 years]) who presented with normal spleen although may have any abnormality rather than the spleen itself. Patients with overt spleen enlargement (i.e.3 cm from the costal border at palpation) or with a disease associated with splenomegaly (e.g. portal hypertension or thalassemia) were excluded from the study. Informed consent to participation was obtained from all subjects studied. And the research was approved by College of medical radiologic science council board.

All spleen US scans were performed by the same operator, who used high resolution Mind-Ray DC-N6 US unit with 3-5 MHz broadband curved array probe. The spleen was scanned in patients who were fasting, in the longitudinal and transverse planes by using an intercostal approach, a subcostal approach, or both. The patient was placed in a supine or right-sided position until complete organ visualization was achieved.8-10 Perimeter, longitudinal diameter, and area, defined as the maximum measurements with splenic borders and angles clearly defined, were measured, and volume (in milliliters) was calculated automatically. Reference values for volume were obtained from measurements in healthy subjects matched with the patients for sex, age, and body-surface area that was previously reported in literature. For each subject, the mean value of measurements repeated on the same occasion twice and the mean value from two measurement was calculated and recorded for final analysis.

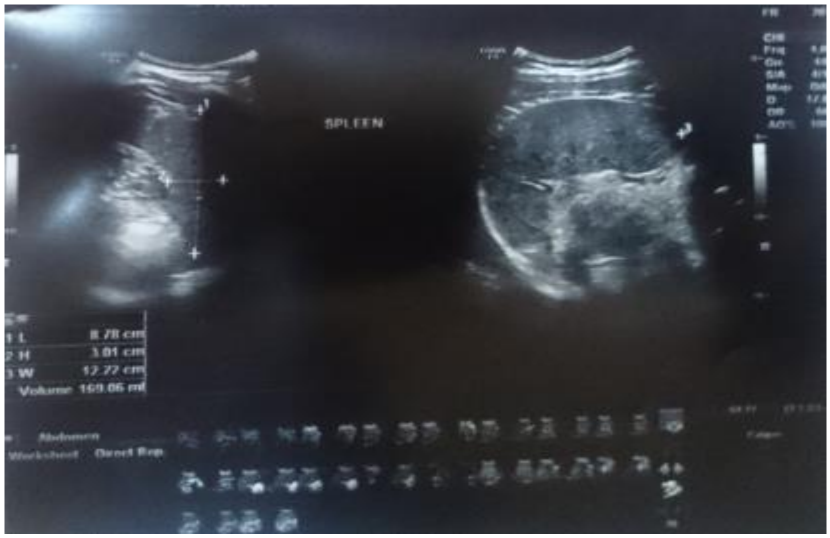

Figure (3.1) US measurement of the spleen

3.2.1. Study area:

This study was conducted at AlhilalAlahmer diagnostic complex, Sinnar state, Sinnar city.

3.2.2. Study duration:

This study was carried out from July 2018 to February 2019.

3.2.3. The study population:

The study sample was consisted of (121) patient with normal spleen examined by ultrasound.

3.2.4. Study sample:

The study sample was consist of 121 patients with normal spleen.

3.2.5. Inclusion criteria:

The study was include all male and female patients with normal spleen.

3.2.6. Exclusion criteria:

Any patient with suspected splenic problem were excluded from this study.

3.2.7. Statistical analysis:

All data were presented as mean±SD values. Data were analyzed by correlation analysis with the use of the SPSS(Inc., Chicago, Illinois version 21.0). A value of P<0.05 was considered significant.

3.2.8. Method of data collection:

The data were collected on master data sheet from the diagnostic stations which was include all parameters need for evaluations.

3.2.9. Variables of the study:

Splenic length, width, thickness and volume correlated with patient height, weight, gender and BMI.

3.2.9.1. Example of standard master data sheet which used in data collection

volume	length	width	thickness	sex	age	height	weight

3.2.10. Ethical issues:

There was official written permission to AlhilalAlahmer diagnostic complex, to take the data.

- No patient data were published also the data was kept in personal computer with personal password.

Chapter four
Result

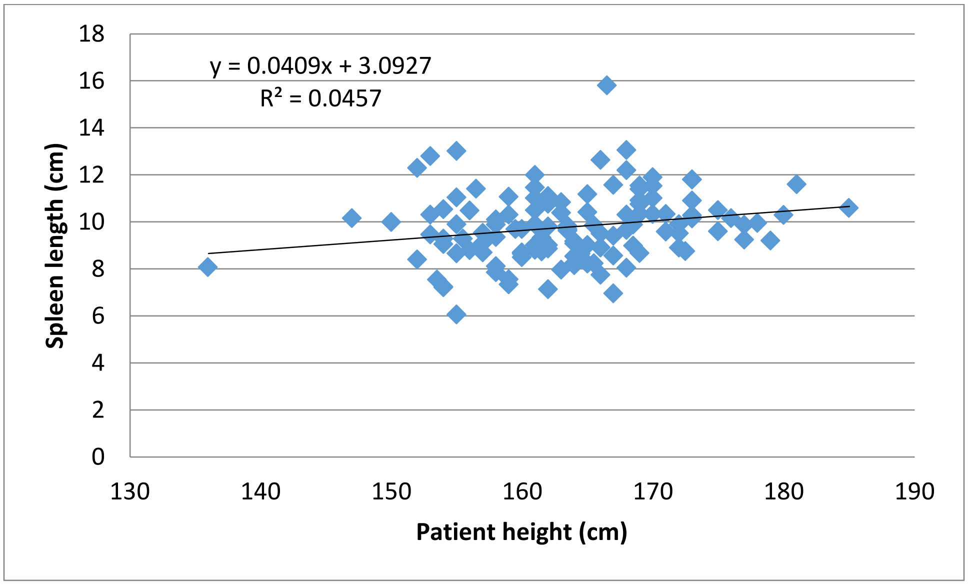

Figure 4-1 scatter plot show a direct linear relation of spleen length with body height 0.04cm of spleen length/cm of body height

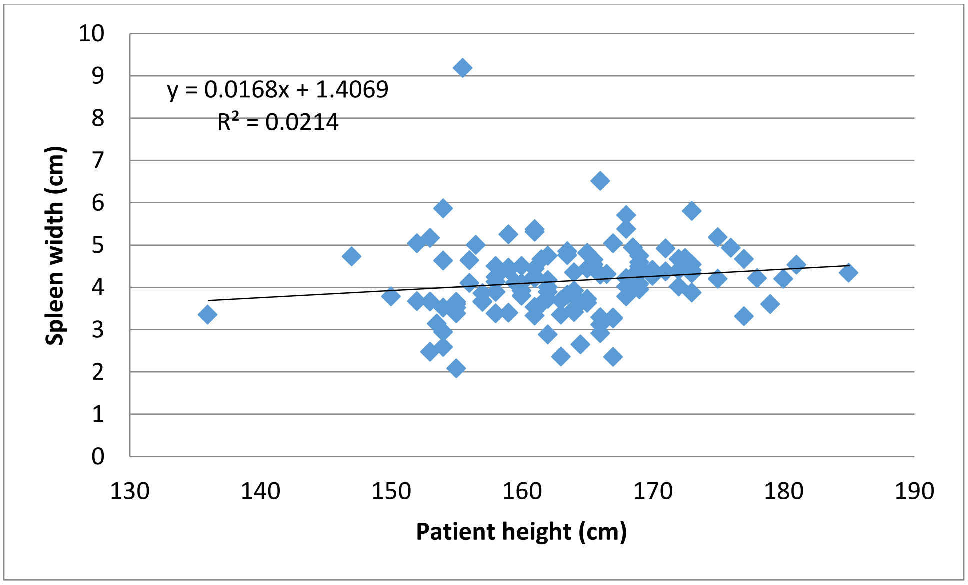

Figure 4-2 scatter plot show a direct linear relation of spleen width with body height 0.016cm of spleen width/cm of body height

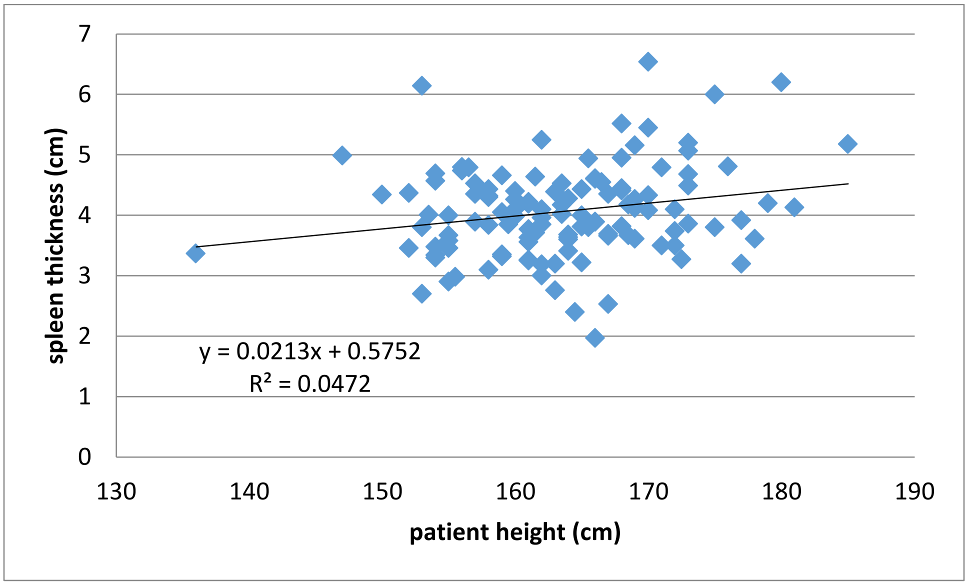

Figure 4-3 scatter plot show a direct linear relation of spleen thickness with body height 0.021cm of spleen thickness/cm of body height

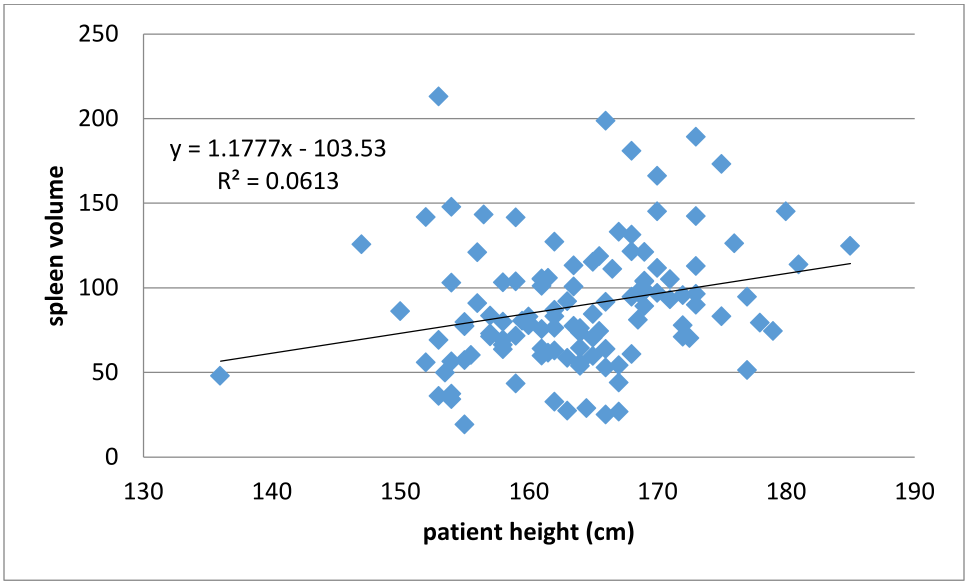

Figure 4-4 scatter plot show a direct linear relation of spleen volume with body height 1.177 ml of spleen volume/cm of body height

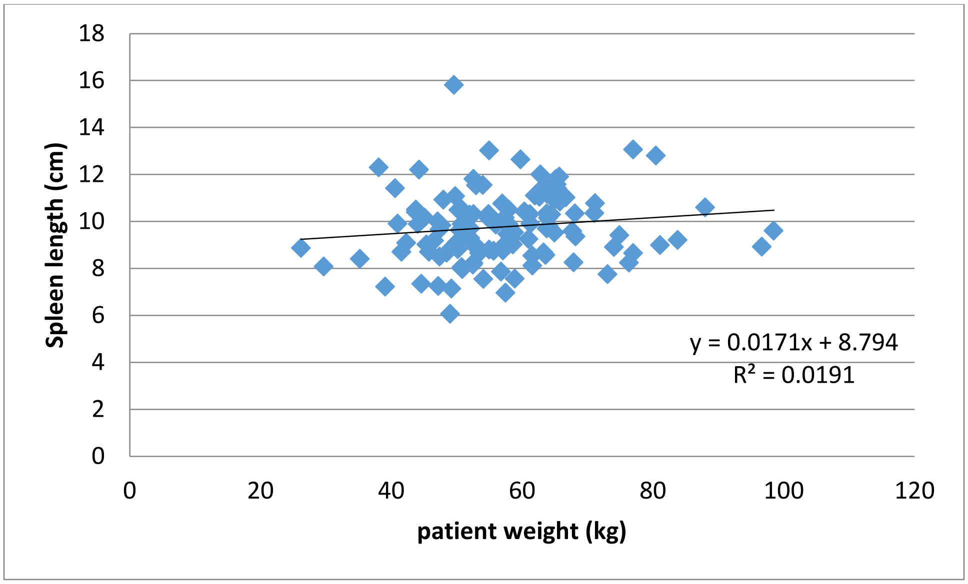

Figure 4-5 scatter plot show a direct linear relation of spleen length with body weight 0.017cm of spleen length/kg of body weight

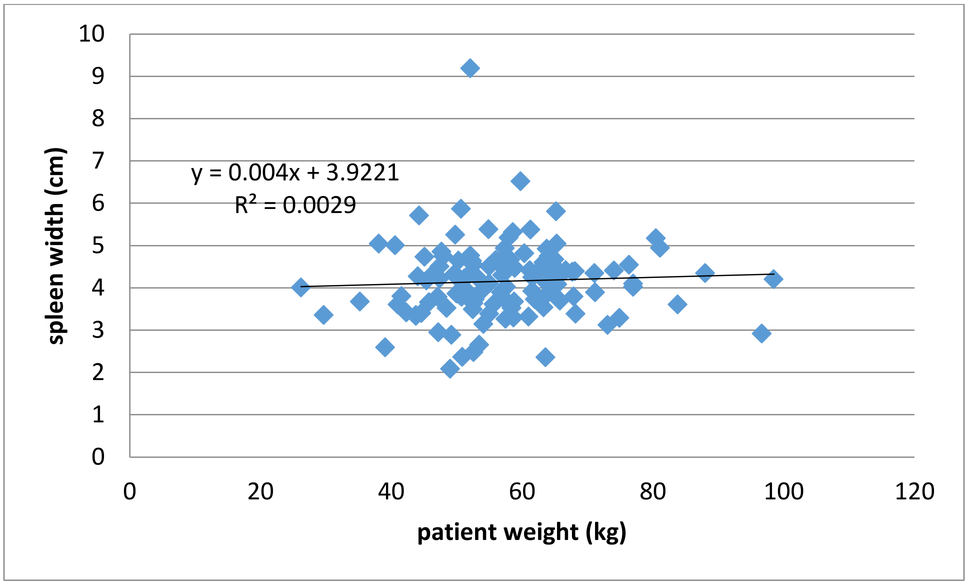

Figure 4-6 scatter plot show a direct linear relation of spleen length with body weight 0.004cm of spleen width/kg of body weight

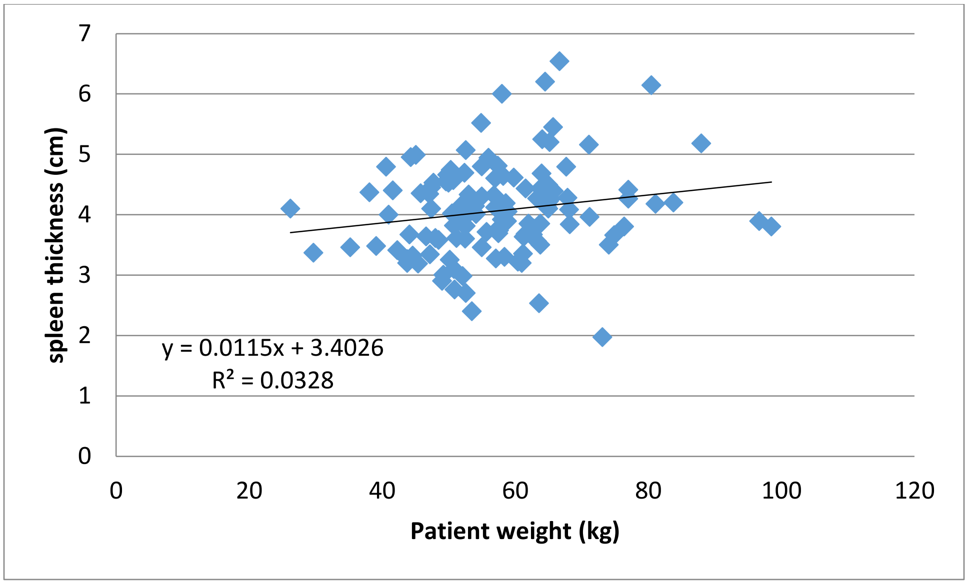

Figure 4-7 scatter plot show a direct linear relation of spleen thickness with body weight 0.012cm of spleen thickness/kg of body weight

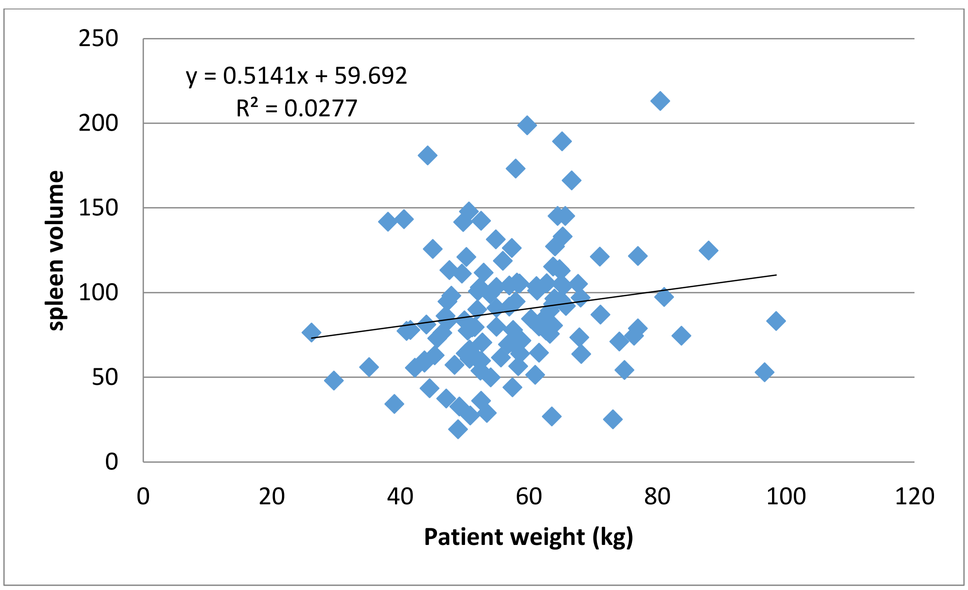

Figure 4-8 scatter plot show a direct linear relation of spleen volume with body weight 0.51 ml of spleen volume/kg of body weight

Table 4-1 the mean, standard deviation, min and max measurement of body characteristics and spleen dimension's

Measurement	mean	STD	Min	Max
Body height	163.7	7.7	136.0	185.0
Body weight	57.5	11.9	26.2	98.5
BMI	21.4	3.9	10.0	35.1
Spleen length	9.8	1.5	6.1	15.8
Spleen width	4.2	0.9	2.1	9.2
Spleen Thickness	4.1	0.8	2.0	6.5
volume	89.2	36.8	19.2	213.0

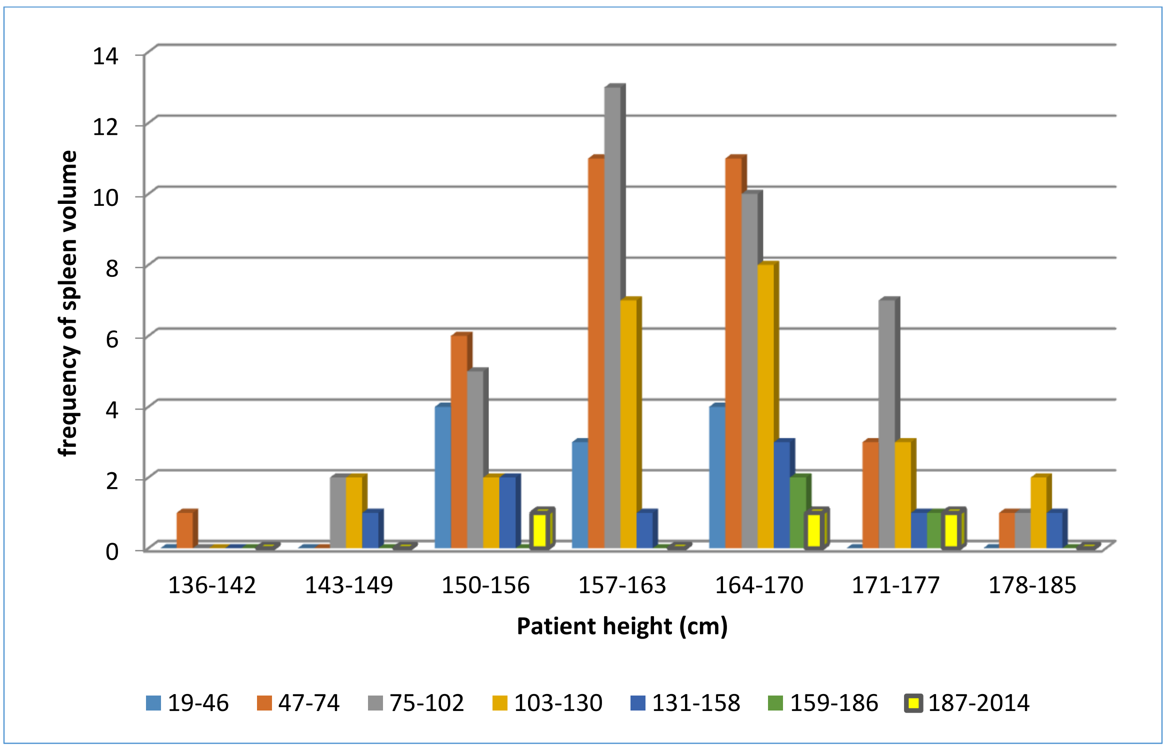

Figure 4-9 bar graph show cross tabulation frequencies of patient height and spleen volumes groups

Table 4-2 t-test between spleen dimension’s and patient gender

Independent Samples Test Gender		
	t-test for Equality of Means	
	t	Sig. (2-tailed)
Spleen length	2.114	.037
Spleen width	1.955	.053
Spleen Thickness	2.413	.017
Volume	2.682	.008

Chapter five

Discussion, conclusion and recommendation

5.1 Discussion

This study was done to evaluate measurement of normal spleen volume in adult Sudanese population using ultrasound.

The study consist of 121 patients (34 men noted by number 1; mean age, 30 years [range, 20-45years]) and (87 women noted by number 2; mean age, 30 years [range, 20-52 years]).

The study correlate between patient height and splenic length, it was found that there is a direct linear relationship of splenic length with body height, the splenic length increased by 0.04 centimeter per each centimeter of body height as described in figure 4.1.

The study also correlated between patient height and splenic width, it was found that there is a direct linear relationship of splenic width with body height, the splenic width increased by 0.016 centimeter per each centimeter of body height as described in figure 4.2.

The study also correlated between patient height and splenic thickness, it was found that there is a direct linear relationship of splenic thickness with body height, the splenic thickness increased by 0.021 centimeter per each centimeter of body height as described in figure 4-3.

The study also correlated between patient height and splenic volume, it was found that there is a direct linear relationship of splenic volume with body height, the splenic volume increased by 1.177 ml per each centimeter of body height as described in figure 4-4

The study also correlated between patient weight and splenic length, it was found that there is a direct linear relationship of splenic length with body weight, the splenic length increased by 0.017 centimeter per each Kg of body weight as described in figure 4-5.

The study also correlated between patient weight and splenic width, it was found that there is a direct linear relationship of splenic width with body weight, the splenic width increased by 0.004 centimeter per each Kg of body weight as described in figure 4-6.

The study also correlated between patient weight and splenic thickness, it was found that there is a direct linear relationship of splenic thickness with body weight, the splenic thickness increased by 0.012 centimeter per each Kg of body weight as described in figure 4-7.

The study also correlated between patient weight and splenic volume, it was found that there is a direct linear relationship of splenic volume with body weight, the splenic volume increased by 0.51 centimeter per each Kg of body weight as described in figure 4-8.

The study measured the body height weight and BMI with mean of 163.7±7.7, 57.5±11.9 and 21.4±3.9 respectively. The study also measured the splenic length width and thickness with mean of 9.8±1.5, 4.2±0.9 and 4.1±0.8 centimeter. Splenic volume calculated with minimum 19.2 Cm3 and maximum 213 ml, the mean volume was 89.2±36.8 ml as described in table 4-1.

Table 4-2 show t test between spleen dimensions and patient gender and it was found that there is a significant difference (P value =0.05), in more details splenic length P value 0.037, splenic width P value 0.053, splenic thickness P value 0.017 and splenic volume P value 0.008.

5.2 Conclusion

Spleen ultrasound is an imaging test that used to examine the spleen , the spleen is an organ in the upper far left part of the abdomen, to the left of the stomach. The spleen varies in size and shape between people, but it’s commonly fist-shaped, purple, and about 4 inches long. Ultrasound is the noninvasive procedure, not harmfull, available, low cost and easy to perform than other imaging procedures. Spleen ultrasound is one of the modality of choice to assess and evaluate the pathological conditions of this organ based on normal measurements.

An analytical study of 121 patients (34 men; mean age, 30 years [range, 20-45years]) and (87 women ; mean age, 30 years [range, 20-52 years]) who presented with normal spleen although may have any abnormality rather than the spleen itself. Patients with overt spleen enlargement (i.e. 3 cm from the costal border at palpation) or with a disease associated with splenomegaly (e.g. portal hypertension or thalassemia) were excluded from the study. And the research was approved by College of medical radiologic science council board.

All spleen US scans were performed by the same operator, who used high resolution Mind-Ray DC-N6 US unit with 3-5 MHz broadband curved array probe.

The study found that the splenic dimensions and splenic volume increased with patient height and weight.

Splenic dimensions measurements are valuable in studying sex investigations with high significant difference was observed between sexes. However, it should be noted that sex differences in the dimensions of the spleen and the variations should be taken in to concern during the performance of clinical and radiological diagnostics and during surgical approach.

Radiological and anatomical measurements indicated that the Sonographical assessment greatly help to organize preoperative preparation.

5.3 Recommendations:

- This study reveals that there is no available requests for spleen volume by ultrasound in Sudanese population, although it's important in evaluation of many disease related to its volume. So the documentation of spleen volume as routine should be considered.
- 2D US is not accurate in term of surface irregularity and spleen structures so 3D US should be considered.
- Initiation of ultrasound units with Doppler facilities can help a lot in detecting splenic problems.
- Study can also be done in depth for other types of medical images like CT and MRI.
- Due to work policy just adult patients was studied so pediatrics and geriatrics should be incorporated for future scope.
- We have to increase the number of patients to give more accurate study.

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Appendix

Master data sheet was used in data collection:

N	volume	length	width	Thickness	sex	age	height	weight
1								
2								
3								
4								
5								
6								
7								
8								