



بسم الله الرحمن الرحيم

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**Measurement of Normal Spleen Dimensions in Sudanese  
Adult using Ultrasonography**

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*A thesis Submitted for partial fulfillment for the requirement of M.Sc.  
degree in Medical Diagnostic Ultrasound*

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## الآية الكرمة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالى:

(قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا)

صدق الله العظيم

الايه (109) سورة الكهف

## **Dedication**

To my husband

To my Children

## **Acknowledgement**

I think Allah for helping me .

I think DR .AFRAA my supervisor for her help .

I think all teachers in different educational phases .

I would like to thank everybody who helped me .

## Abstract

This was cross section descriptive study was done during the period from December – February 2019 in Abuda Healthy Center – Elthaurah – Alharah 9 – Omduman – Khartoum state – Sudan.

The aim of the study to measure normal spleen (spleen length ,width ,thickness and volume ) and to find the relation between these measurements and subject variables (gender ,age ,height ,weight and BMI). Because we had no reference values of normal spleen measurements in adult Sudanese population.

The subject were scanned 70 (31 males – 39 females ) were divided to five groups according to the age . The mean of age was 46 years. The finding included that the mean of standard deviation of the spleen measurement for male of splenic length , width depth and volume were  $9.4\text{cm} \pm 1.1$  ,  $4.2 \text{ cm} \pm 0.7$  ,  $4.05 \text{ cm} \pm 0.7$  and  $88.7 \text{ cm}^3 \pm 34$ , female of splenic length , width depth and volume were  $8.8\text{cm} \pm 1.1$  ,  $3.9 \text{ cm} \pm 0.5$  ,  $4.02\text{cm} \pm 0.4$  and  $74.6 \text{ cm}^3 \pm 22.1$ . There were statistically significant differences between male and female in splenic length and volume and non significant differences between male and female in width and depth .There was significant correlation between splenic length and volume with subject height and non significant correlation between splenic dimensions and BMI .

There was strong linear association of splenic length with height ( $R^2=0.2$ ).

The study conducted that the male had longer spleen length than female.

There was association of splenic length and volume with subject, height and weight but no association between splenic length and volume with age and BMI for male and female.

The values cut of point reference values of normal splenic measurement in adult Sudanese population.

## مستخلص الدراسة

هذه الدراسة عرضية مقطعية تمت فى الفترة من ديسمبر 2018 م وحتى فبراير 2019 م بمركز صحى عبودة الثورة الحارة التاسعة بامدرمان- ولاية الخرطوم- السودان.

الهدف من هذه الدراسة لقياس ابعاد وحجم الطوحوال لدى السودانيين البالغين وتمثبات القياسات فى طول الطوحوال ,ارتفاعه وعرضه وسمكة وايجاد العلاقة بينها وبين متغيرات الشخص (النوع , العمر , الطول والوزن وكتلة الجسم).

تم فحص عدد 70 متطوع (31 ذكر و 39 انثى) وتقسيمهم الى خمسة فئات عمرية متوسط الاعمار 46 سنة وتم استبعاد اى متطوع لديه امراض قد تتسبب فى تضخم الطوحوال كانت القياسات بالسنتيمتر، جمعت البيانات باستخدام استمارة جمع البيانات التى تحتوى على متغيرات العمر والنوع والوزن ثم احتسب حجم الطوحوال باستخدام الموجات فوق الصوتية وتم تحليلها احصائيا باستخدام برنامج التحليل الاحصائى.

وضحت نتائج الدراسة بان متوسط قياس طول الطوحوال , عرضة , ارتفاعه وحجمه للذكور على النحو التالى  $1.1 \pm 9.4$  سم ,  $0.7 \pm 4.2$  سم,  $0.7 \pm 4.5$  و  $88.7 \pm 34$  سم3, اما للاناث فكانت على النحو التالى  $8.8 \pm 1.1$  سم,  $3.9 \pm 0.5$  سم,  $0.04 \pm 4.02$  سم و  $22 \pm 74.6$  سم3

وجدت الدراسة ان هناك اختلافات بين طول وحجم الطوحوال بين الذكور والانثى ولا يختلفون فى سمكه وارتفاعه، هنالك علاقة بين طول الطوحوال وحجمه مع طول الشخص ووزنه للذكور والاناث ولا توجد علاقة بين هذه القياسات مع العمر وكتلة الجسم وكانت النتائج ان هنالك اختلاف فى طول وحجم الطوحوال بين الذكور والاناث ولا يوجد اختلاف فى سمكة وعرضه ايضا .

توجد علاقة خطية بين طول الشخص وطول الطوحوال تتمثل بالمعادلة ( $R^2 = 0.2$ ) .

النتائج التى تم التوصل اليها ان طول الطوحوال للذكر اطول من الانثى وهنالك علاقة بين طول الطوحوال وحجمه مع طول الشخص وكتلة الجسم للذكور والاناث.

هذه القيم تحدد مرجعية لقياس الطوحوال لدى السودانيين البالغين.

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### **List of abbreviation**

Abbreviation	Meaning
SL	Spleen Length
SW	Spleen Width
ST	Spleen Thickness
SV	Spleen Volume
BMI	Body Mass Index

# Chapter one

## 1.1 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 is the largest lymphoid organ in the body an large part of the reticuloendothelial system and is situated in the left hypochondrium (Ehimwenma et al,2011) .

The spleen size show variations according to people , depending on the individual's height , age and sex (Danila ,2010) . The size of the spleen undergoes change in accordance with the nutritional status of the body as it exhibits a slight growth after meals.

Splenomegaly is an indicator of varieties of inflammatory , infectious , infiltrative , metabolic , neoplastic, hematopoietic diseases and the other diseases like portal hypertension , glycogen storage disorder , leukemia , lymphoma , melanoma , celiac disease (Odorico et al . , 1999).

Evaluation of splenic size by palpation can cause unreliable and wrong conclusions because spleen is not palpable until it is enlarged 2 to 3 times its size (Dhingra et al., 2010).

Ultrasonography is commonly used to diagnose splenomegaly and to determine the spleen size and it is safe, quick and reliable method for the calculation of splenic dimensions(Dhingra et al.2010).

The spleen normally measured along its long axis, the normal spleen measured 8 to 12 cm in length 7 to 8 cm in anteroposterior diameter, and less 6 cm in thickness.

## **1.2 problem of the study**

To the knowledge of researcher there is no reference value for spleen measurements in Sudanese population.

## **1.3. Objectives**

### **1.3.1 General Objectives:**

Assessment of normal size of spleen in adult Sudanese using ultrasoonography .

### **1.3.2 Specific Objectives**

- To establish the standard splenic measurements in normal Sudanese adults by using ultrasound .
- To measure the length , width , thickness and volume of the spleen .
- To correlate spleen measurements with gender , age, height and BMI .

## **1.4 Thesis layout :**

This thesis is concerned with the measurement of spleen in adults Sudanese individuals . It divided into the five chapters. Chapter one , which is an introduction , deals with theoretical frame work of the study. It presents the statement of the study problems , objectives of the study , it also provides an outlines of the thesis . Chapter two includes theoretical background material for thesis , and literature review (previous studies) . Chapter three deals with materials and method used to measure the spleen .

Chapter fours deal with (results) data presentation . Chapter five discusses the data (discussion) , analysis , and conclusion , recommendations for this thesis and suggestions for future work .

## **Chapter two**

### **Literature Review**

#### **2.1 theoretical background**

##### **2.1.1 Anatomy of the spleen:**

The spleen is an intra peritoneal organ located in the posterior portion of the upper quadrant of the abdomen . It lies parallel to the shaft of the tenth ribs. it is related to the diaphragm superiorly , laterally and posteriorly, to the stomach medially and anteriorly to the kidney inferiorly and medially to the tail of pancreas and splenic flexure medially . ( Henry 2000 ) its convex along its superior lateral border. And concave medially, the contour is generally smooth but contour lobulation can be seen as normal variant, the splenic artery enters and splenic vein leaves medially . At the hilum with the artery being the most posterior vessel . The normal adult spleen measuring 11 - 13 cm in length , 6 - 8 cm in anteroposterior dimension and 4 - 6 cm in transverse dimension . Figure 2.1 . (Anthony j, 2002) .

##### **2.1.1.1 development :**

The spleen appears about the fifth week as a localized thickening of the mesoderm in the dorsal mesogastrium above the tail of the pancreas . With the change in position of the stomach the spleen is carried to the left , and comes to lie behind the stomach and in contact with the left kidney . The part of the dorsal mesogastrium which intervened between the spleen and the greater curvature of the stomach forms the gastrosplenic ligament . (Henry. 2000) .

##### **2.1.1.2 relations:**

The diaphragmatic surface (faces diaphragmatic , external or phrenic surface) is convex , smooth , and is directed upward , backward , and to the left . except at its upper end , where it is directed slightly medial ward . It is in relation with the under surface of the diaphragm , which separates it from the ninth , tenth , and eleventh ribs side (Fig 2.1) , and the intervening lower border of the left lung and pleura . (Anthony j, 2002) .

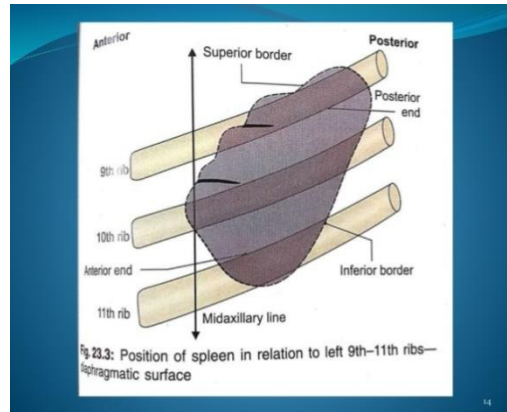


Fig (2.1) the diaphragmatic surface of the normal spleen, showing its relationship to the ninth, tenth, and eleventh ribs(Anthony j, 2002).

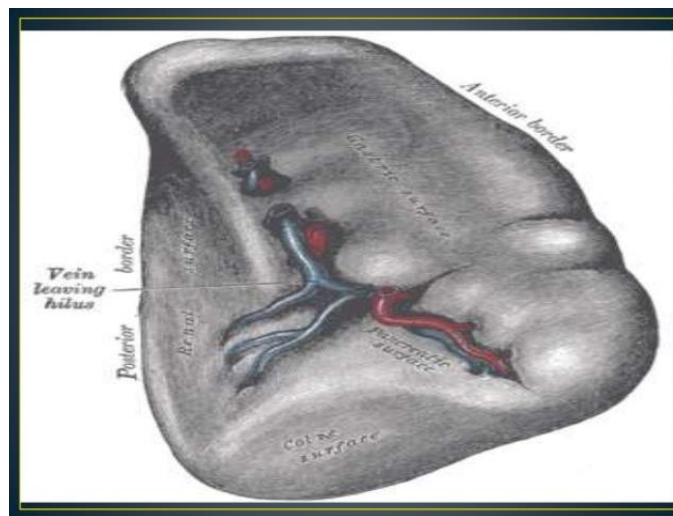


Fig (2.2) the visceral surface is divided by a ridge into an anterior or gastric and a posterior or renal portion. (Henry, 2000).

- The gastric surface (facies gastrica), which is directed forward, upward, and medialward, is broad and concave, and is in contact with the posterior wall of the stomach; and with the tail of the pancreas. It presents near its medial border a long fissure, termed the hilum. This is pierced by several irregular apertures, for the entrance and exit of vessels and nerves.(Henry, 2000).
- The renal surface (facies renalis)(fig. 2.2) is directed medialward and downward. It is somewhat flattened, is considerably narrower than the gastric surface, and is in relation with the upper part of the interior surface of the left kidney and occasionally with the left suprarenal gland. (Henry, 2000).
- The superior extremity (extremities superior) is directed toward the vertebral column, where it lies on a level with the eleventh thoracic vertebra. The lower extremity or colic surface (extremities inferior) is the triangular in shape, and rests upon the left flexure of the colon and the phrenicocolic ligament, and is generally in contact with the tail of pancreas. The anterior border(margo anterior) is free, sharp, and thin, and is often notched, especially below; it separates the diaphragmatic from the gastric surface.(Henry 2000).
- The posterior border margo posterior), more rounded and blunter than the anterior, separates the renal from the diaphragmatic surface; it corresponds to the lower border of the eleventh rib and lies between the diaphragm and left kidney. The intermediate margin is the ridge which separates the renal and gastric surfaces. The inferior border(internal border) separates the diaphragmatic from the colic surface, the spleen is almost entirely surrounded by peritoneum, which is firmly adherent to its capsule(Henry 2000).

- It is held in position by two folds of this membrane. one, the phrenicolienal ligament, is derived from the peritoneum, where the wall of the general peritoneal cavity comes into contact with the omental bursa between the left kidney and the spleen; the lineal vessels pass between its two layers(Fig. 2.3). the other fold, the gastrolieual ligament, is also formed of two layers, derived from the general cavity and the omental respectively, where they meet between the spleen and stomach(Fig. 2.3); the short gastric and left gastroepiploic branches of the lineal artery run between its two layers. The lower end of the spleen is supported by the phrenicocolic ligament. (Henry, 2000).

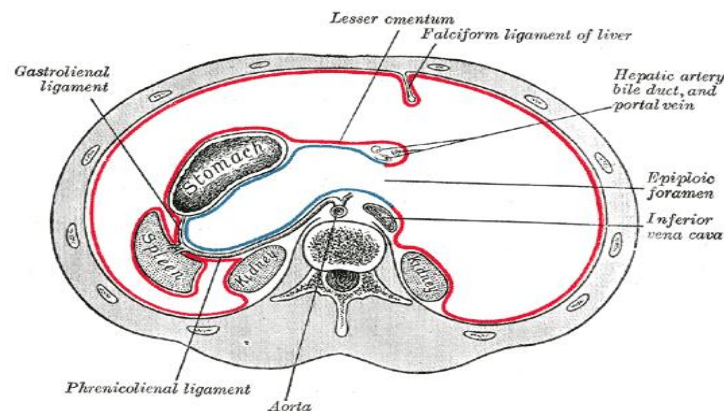


Fig (2.3) Horizontal disposition of the peritoneum in the upper part of the abdomen. (Henry 2000) .

The size and weight of the spleen are liable to very extreme variations at different periods of life, in different individuals, and in the same individual under different conditions. In the adult it is usually about 12 cm. in length, 7 cm. in breadth, and 3 or 4 cm. in thickness, and weighs about 200 grams. At birth its weight, in proportion to the entire body, is almost equal to what is observed in the adult, being as 1 to 350; while in the adult it varies from 1 to 320 and 400. In old age the organ not only diminishes in weight, but decreases considerably in proportion to the entire body, begin as 1 to 700. The size of the spleen is increased during and after digestion, and varies according to the state of nutrition of the body, being



large in highly fed, and small in starved animals. In malarial fever it becomes much enlarged, weighing occasionally as much as c9 kilos, frequently in the neighborhood of the spleen, and especially in the gastrolial ligament and greater omentum, small nodules of splenic tissue may be found, either isolated or connected to the spleen by thin bands of splenic tissue. They are known as accessory spleens (lien accessories; supernumerary spleen). They vary in size from that of a pea to that of a plum. (Henry, 2000).

### **2.1.1.3 structure:**

The spleen is invested by two coats:

An external serous and an interial fibro elastic coat.

The external or serous coat (tunica serosa) is derived from the peritoneum; it is thin, smooth, and in the human subject intimately adherent to the fibroelastic coat. It invests the entire organ , except at the hilum and along the lines of reflection of the phrenicolial and gastrolial ligaments, the fibroelastic coat (tunica albuginea) invests the organ, and at the hilum is reflected inward upon the vessels in the from of sheaths. From these sheaths, as well as from the inner surface of the fibroelastic coat, numerous small fibrous bands, trabeculae(Fig. 2.2), are given off in all directions; these uniting, constitute the frame-work of the spleen. The spleen therefore consists of a number of small spaces or areolae, formed by the trabeculae; in these areolae is contained the splenic pulp, the fibroelastic coat, the sheaths of the vessels, and the trabeculae, are composed of white and yellow elastic fibrous tissue, the latter predominating (Henry 2000).

It is owing to the presence of the elastic tissue that the spleen possesses a considerable amount of elasticity, which allows of the very great variation in size that it presents under certain circumstances. In addition to these constituents of this tunic, there is found in man a small amount of non-striped muscular fiber; and in some mammalia , e. g., dog, pig, and cat, a large amount, so that the trabeculae appear to consist chiefly of muscular tissue. (Henry, 2000).

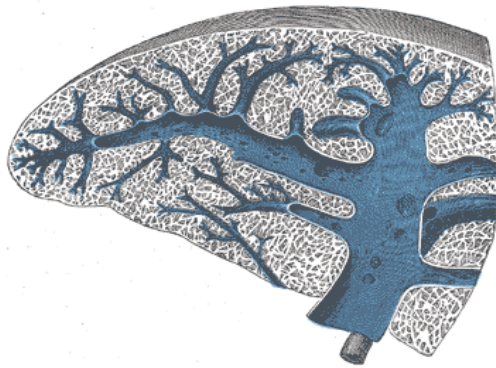


Fig (2.4) transverse section of the spleen tributaries(Henry, 2000).

The splenic pulp (pulpa lienis) is a soft mass of a dark reddish-brown color, resembling grumous blood; it consists of a fine reticulum of fibers, continuous with those of the trabeculae, to which are applied flat, branching cells. The meshes of the reticulum are filled with blood, in which, however, the white corpuscles are found to be in larger proportion than they are in ordinary blood. Large rounded cells, termed splenic cells, are also seen; these are capable of ameboid movement, and often contain pigment and red-blood corpuscles in their interior. The cells of the reticulum each possess a round or oval nucleus, and like the splenic cells, they may contain pigment granules in their cytoplasm. (Henry, 2000).

#### **2.1.1.4 Blood vessels of the spleen:**

The lineal artery is remarkable for its tortuous course . It divides into six or more branches , Which enter the hilum of the spleen and ramify throughout its substance (Fig . 2.3 ) , receiving sheaths from an involution of the external fibrous tissue . similar sheaths also invest the nerves and veins , Each branch runs in the transverse axis of organ , from within outward , diminishing in size during its transit , and giving off in its passage smaller branches , some of which pass to the anterior , others to the posterior part . These ultimately leave the trabecular sheaths , and terminate in the proper substance of the spleen in small tufts or pencils of minute arterioles , which open into the reticulum formed by the branched sustentacular cells .(Henry 2000)

Each of the larger branches of the artery supplies usiefly that region of the organ in which the branch ramifies , having no mastomosis whith the majority of the other branches , The arterioles , supported by the minute trabeculae , traverse the

plup in all directions in bundles (pencilli) of straight vessels . Their trabecular sheaths gradually undergo a transformation , become much thickened , and converted into adenoid tissue ; the bundles of connective tissue becoming looser and their fibrils more delicate , and containing in their interstices an abundance of lymph corpuscles . The nerves are derived from the celiac plexus and are chiefly non - medullated . They are distributed to the blood vessels and to the smooth muscle of the capsule and trabeculae . (Henry , 2000) .

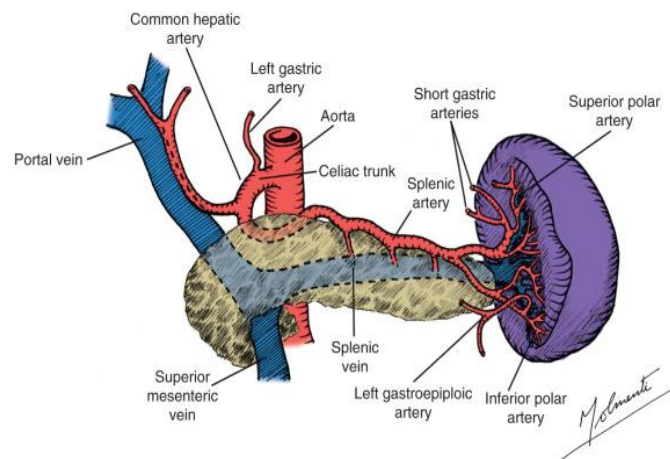


Fig (2.5) The circulation of the spleen ( Henry 2000 )

### 2.1.2 Physiology of the spleen :

As the largest secondary lymphoid organ , the spleen has a number of important roles in the immune response , including the clearance of effete or damaged cells from the bloodstream and host resistance to infection . Other organs serve some functions similar to those of the spleen . The widely dispersed system of lymph nodes situated throughout the host responds vigorously with antibodies and T – cells to foreign antigens that gain access to peripheral tissues (Rowly , 1995) .

Again , like the spleen , the liver , with its large mass of phagocytic kupffer cells lining vascular sinusoids , is an important site of particulate antigens from the bloodstream and a major contributor to resistance to infection . The spleen , however , has a unique place in host defense , because it combines all of these functions in one organ . Thus , because of its anatomic location directly connected

to the circulation , it responds promptly to blood borne antigens with antigen – specific immune responses , much effectively than can lymph nodes or other lymphoid tissue (Rowley , 1995) .

### **2.1.3 pathology of the spleen :**

#### **2.1 .3.1 splenomegaly :**

Splenomegaly is defined by increased splenic dimensions and volume . spleen longitudinal and transverse diameters averaged over 13 cm . respectively over 5 cm are considered splenomegaly . Besides measuring the spleen diameters , there have been studies that used the calculus of the maximum area of the spleen in order to classify the splenomegaly using ultrasound in study describing portal hypertension in cirrhotic patients defined a normal sized spleen by an area of < 45 cm<sup>2</sup> , a moderately enlarged spleen by 45 – 65 cm<sup>2</sup> , and a marked splenomegaly by an area of 75 cm<sup>2</sup> . Splenomegaly usually occurs associated with other organs pathology and sometimes it can be debut sign of a disease onset . Mild – to moderated splenomegaly (weight < 1000 g) are usually correlated with normal hypertension or with infections , while severe splenomegaly (weight 200 g) are common in hematological diseases , especially chronic aneamia and myelofibrosis



Fig (2.6) Enlarge spleen (splenomegaly) (Hosey 2006)

#### **2.1. 3.2 Splenic abscesses :**

It is important to know that in the course of infectious pathology of the spleen we can meet both types of spleen injury , focal and diffuse . focal and diffuse . Usually a homogenous , mild to moderate splenomegaly is found . In case of severe

infections of other organs that disseminate in the spleen (endocarditis , acute pancreatitis , postoperative infection complications ) occurring mainly in immune suppressed patients , splenic abscesses can be found . The accuracy of splenic abscesses is low , cited in literature as 0.14 – 0.17 % cases discovered at autopsy . A splenic abscess has a variable ultrasound . hypo or hyperechoic nodule . Large abscesses , usually unique , or multiple , are characteristic for microbial infection , and a wedge - formed abscess may typically be patients with infective endocarditis and associated septic embolism(Hosey 2006) .

Usually they appear with well – defined contour but with an irregular wall , multilocular , with homogenous , complex echotexture , most often hypoechoic . It may present debris , septa in case (characteristic for anaerobic infections) and posterior enhancement , usually are avascular on colour Doppler ultrasound . Splenic phlegmons by abscesses with a poorly border compared with the of the splenic parenchyma . Fungal abscesses , that are present in HIV other immunosuppressive disorders are caused by Mycobacterium , atypical mycobacteria , pneumocystis caring and candidiasis shows a characteristic of multiple small lesions with center and hypoechoic rim , the typical bull s eye appearance . The use of a high – frequency linear probe will enhance the detection of micro – abscesses . Sometimes the ultrasound cannot distinguish between splenic abscesses and only using standard and Doppler examination (Hosey 2006).



Fig (2.7) splenic abscesses (Hosey 2006 )

### 2.1.3.4 Splenic Hydatid Cyst

The frequency of splenic hydatid cyst is very rare ( less than 2 % off all hidydosis localizations ) and generally appears by haematogenous examination of a hepatic hydatid cyst and not as a primary localization of the disease . There for , when a splenic hydatid cyst is suspected , also another possible localization should be sought (peritoneal , hepatic) .



Fig (2.8) Splenic Hydatid Cyst ( Narora 2010 )

### 2.1.3.5 Focal Splenic Lesions

Focal splenic lesions are rare . the most recently published study , June 2010 by Neesse et al ., extended over 6 years ( between 2004 – 2009 ) . with a total of 50,000 abdominal ultrasound , only 279 ( less than 0.6 % ) focal splenic lesions were reported . The 279 patients (0.6 % ) with focal splenic lesions were diagnosed on B – mode ultrasound as follows :

72 cases (25.8 %) splenic infarction , 57 cases (20%) Non- Hodgkin's lymphoma , 51 cases (18.4 %) splenic incidentaloma (incidentaloma defined an incidentally detected focal Splenic Lesions , without patient's history of infection or trauma , lesion stable on follow – up examination ) , 35 cases (12.6%) splenic rupture , 7 cases (2.5 %) splenic abscess 25 cases (10%) miscellaneous splenic lesions (i.e., hemangioma , hamartoma) , and 32cases (11.5%) splenic metastases of solid tumours , focal splenic lesions can be single or multiple , benign or malignant .

Ultrasound is a proven procedure for detecting focal Splenic Lesions but their characterization is difficult , the ultrasound pattern often gives a characteristic for different pathologies.

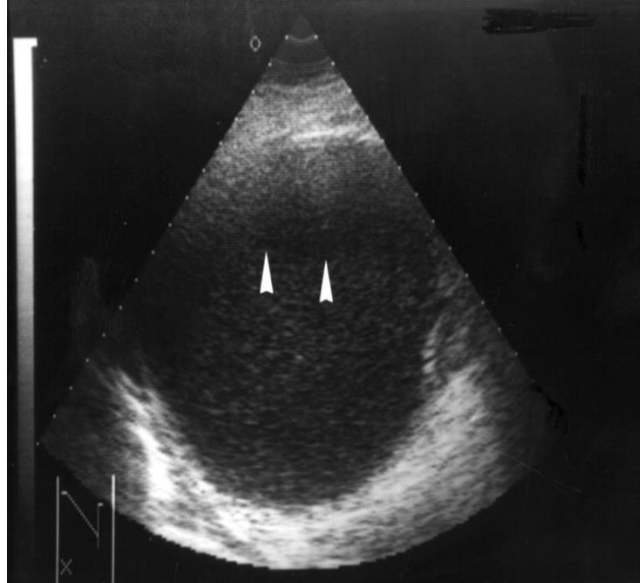


Fig (2.9) Focal Splenic Lesions ( Spiel man 2005 )

### **2.1.3.6 Benign Splenic Lesions**

#### **2.1.3.6.1 Splenic Cystic Lesions**

Splenic cystic lesions can be congenital ( true epidermoid or false post traumatic cysts ) characterized by the presence of an inner endothelial or post traumatic cysts ( pseudo cysts ) which don't have cellular lining . Ultrasound cannot make reliable differentiation between true cysts and pseudo cysts . The cysts usually appear as transonic areas , well – defined with sharp contour and posterior enhancement they can have ill – defined walls and may contain cholesterol crystals or debris that appear as internal echoes ( Spielman 2005 ) .

when they bleed , the cysts appear with fine , mobile echoes when the patient's position is changed , they appear highly inhomogeneous , difficult to be differentiated . In addition the splenic cysts have a predominantly cystic appearance at imaging . Cystic lesion may be inflammatory ( abscesses , hydatid cysts )

vascular , post traumatic ( hematoma , false cysts) , or benign tumor (hemangioma, lymphoma ) or malignant : ( lymphoma , metastasis ) ( Spielman 2005 ) .

Parenchymal calcifications are quite common, non-specific ,incidental findings, of different sizes. They could be secondary to splenic infarction , granulomas , tuberculosis or metastases( Spielman 2005 ) .

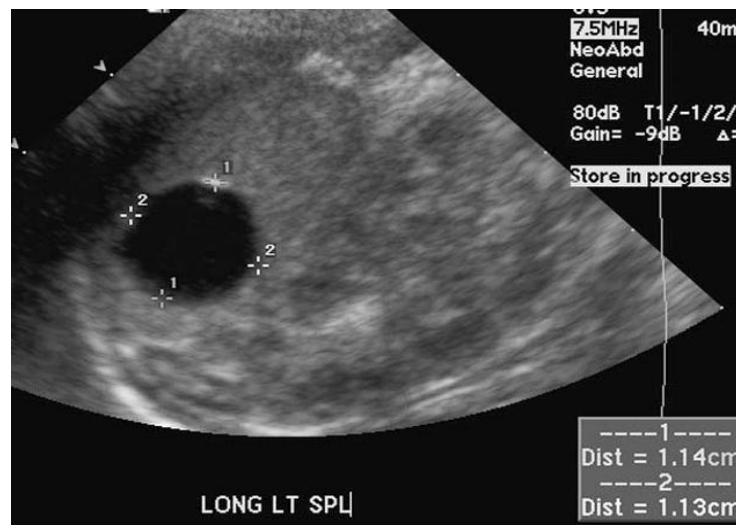


Fig (2.10) Splenic Cystic(Spielman 2005)

### 2.1.3.6.2 Solid Splenic Lesions

The solid splenic lesions have a different pattern in B – mode ultrasound , hyper – hypo – echoic than the surrounding normal tissue . benign primary tumors of spleen are rare and include hamartoma , hemangioma and cystic lymphoma(Danila2010) .

Splenic hemangiomas have been reported in up to 14% of autopsy studies . they can be found isolated or may occur in the Klippel – Trenaunay – Weber syndrome . There is no ultrasound specific pattern for hemangiomas . The majority are hyperechoic homogeneous lesions , with precise contour measuring less than 2 cm . Larger cavernous hemangiomas (> 3 cm ) may appear iso – to hypochoic with cystic changes or calcifications . They show posterior enhancement degree , with rapid or slow opacification( Danila2010) .





Fig (2.11) Splenic Cystic Lesions (Danila2010)

### **2.1.3.7 Malignant Diseases Of Spleen**

Although exceedingly rare , the primary malignant tumor of the spleen is an angiosarcoma . Angiosarcomas will appear sonographically as a complex or solid mass. More often , lymphoma and leukemia rather than angiosarcoma will involve the spleen . with lymphoma being cited as the most common malignancy of the spleen . diffuse involvement of lymphoma or leukemia will often produce splenomegaly . These malignant processes can also manifest as focal disease and be recognized as a hypoechoic mass or masses within the spleen. (Denis 2005 ) .

Lymphoma can be classified as Hodgkin lymphoma or non – Hodgkin lymphoma . Both are malignant disorders affecting the lymphocytes , with subsequent immune system compromise . The differentiation between these two types of cancers is performed microscopically . The presence of Reed – Sternberg cells indicates Hodgkin lymphoma. It can be treated and carries a high recovery rate. The other form of lymphoma , non – Hodgkin lymphoma , is not as managed but is more common . Metastatic disease to the spleen is rare and occurs late in the disease process . The most common primary locations are the breast , lung , skin (melanoma) , and ovary. (Denis 2005 ) .

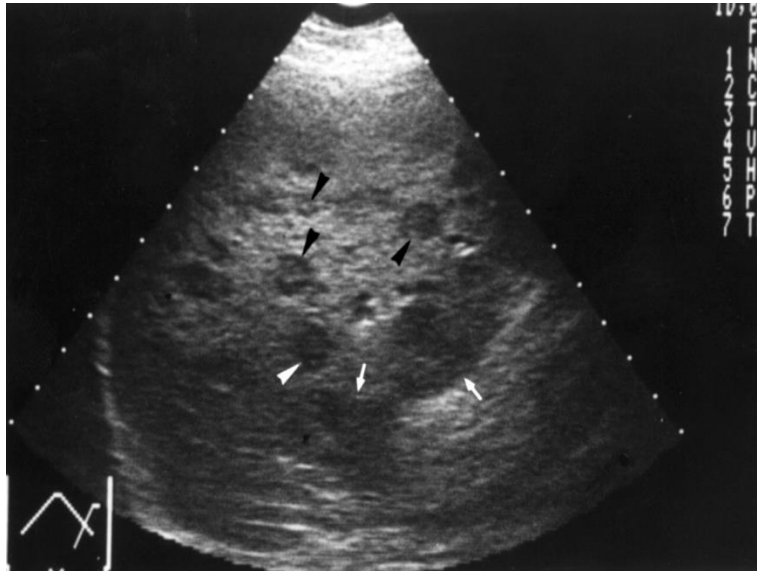


Fig (2.12) Malignant Diseases Of Spleen(Denis 2005 )

### 2.1.3.8 Splenic Metastases

Splenic metastases are mostly seen in far advanced malignant diseases, except in patients with testicular germ cell tumors, and small cell lung cancer in which the spleen might be the only abdominal organ showing a metastatic spread. Mostly splenic metastases have a hypoechoic appearance. But echogenicity alone is not a reliable sign for the lesion character ((Dhaingra2010).

Patients with testicular germ cell tumors (4 from 9 patients had splenic metastases), malignant melanoma (9 from 27 had spleen metastases), and small lung cancer (8 out of 106 had spleen metastases) have the highest frequency of splenic involvement. In the majority of cases a biopsy is not needed clinical context being clear, its proof or non-proof will not change the clinical management of these patients, Metastases are mostly hypoechoic with no or only little tumor vasculature on colour Doppler imaging (Dhaingra2010).

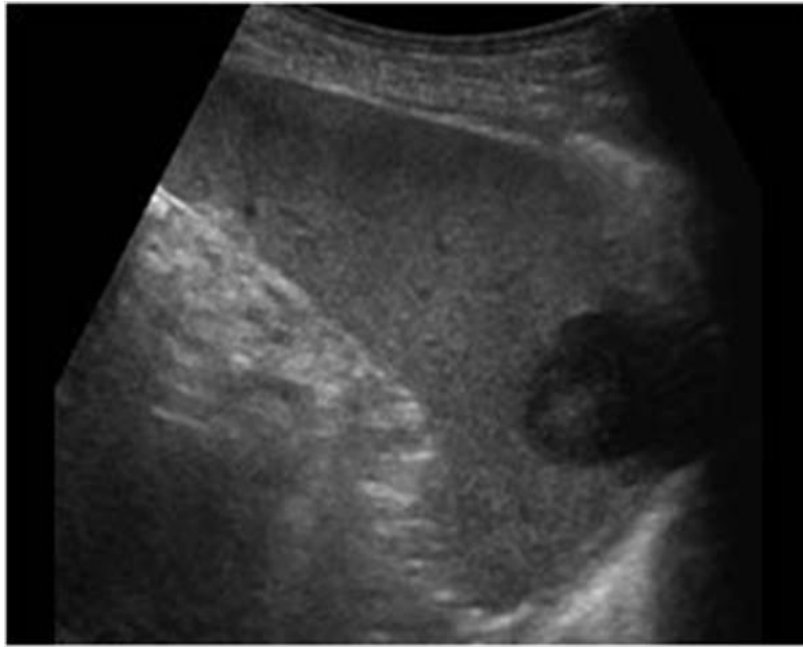


Fig (2.13) Splenic Metastases ((Dhaingra2010)

### **2.1.3.9 Vascular Disease**

#### **2.1.3.9.1 Infarction Of The Spleen**

Its considered the most common cause of focal lesions . The study done by Neesse et al , reported a frequency of 25.8 % splenic infarctions discovered from all focal splenic lesions . They are caused by the embolic occlusion of the branches Of the splenic artery or even of the splenic arterial trunk (thrompoembolic diseases , septic distance embolism ) or local in cases of acute pancreatitis , hematological disorders (sickle cell anemia leukemia , lymphomatous disorder) or other diseases ( sarcoidosis , erythematosis , polyarteritis nodosa ) (Danila2010) .

The ultrasound aspect differs according to the time elapsed from the initial (the occurrence of the infarction ) and the sizes of the infarction was often in the first 24 hours the splenic infarction , especially the small size one , can escape the ultrasound examination , appearing only as an area , ill – defined in the splenic parenchyma .After 24 hours the splenic infarction appears hypoechoic , with borders not always well , and dimensions generally underestimated (Danila2010) .

In time, due to fibrosis , splenic infarction appears hyperchoic , triangular (wedge – shape) with the base always orientated to the splenic capsule and with

capsular retraction . Sometimes the appearance can be nodular . Due, their dimensions decrease over time . They can keep the triangular or they can produce linear scars , from calcifications or they can turn on pseudocysts. Sometimes they can mimic a tumoral mass . On colour examination infarction areas do not present vascular signals (Danila2010) .



Fig (2.14) Infarction Of The Spleen (Danila2010)

### **2.1.3.9.2 Splenic Vein Thrombosis**

It is a common complication seen in patients with acute pancreatitis or sepsis. We also found splenic vein thrombosis in patients with hematologic malignancies. Recent partial or total thrombosis, in the first days appears hypoechoic and quite difficult to diagnose it on 2D or colour Doppler ultrasound examination.

### **2.1.3.10 Splenic trauma :**

The spleen is often affected in abdominal trauma, due to its fragility. In trauma ultrasound has a major role in detecting life threatening .

FAST protocol (Focused Assessment Of Sonography In Trauma )commonly used today to detect or exclude the presence of free fluid in the pericardium or in the abdomen in cases of trauma. Ultrasound is a fast technique, portable and proved that it can easily be integrated in to the resuscitation of the patients with trauma without delay the therapeutic measures. Routine abdominal ultrasound can be also performed beside in trauma centers Studies show that the use of screening ultrasound in the follow-up of traumatic patients can improve clinical decision making for the use of the emergency laparotom (Carol M 2005).

On the other side, in major trauma with clinically stable patients, contrast enhanced CT remains the method of choice, with the advantage of the entire examination of the abdominal cavity and the possibility of standardization . Its efficiency decreases in minor trauma, contusion, laceration which can be ignored or over estimated on CT scan But B-mode ultrasound has a poor detection rate in blunt splenic injury, especially in minor tissue damage, therefore it is not recommended in the assessment of stable traumatic patients. The spleen is the most frequently injured visceral organ in patients with blunt abdominal trauma. (Carol M 2005).

Fresh bleeds within the spleen can be difficult to identify with sonography. As they may appear isoechoic to the splenic tissue and can be located either subcapsular to or within the splenic parenchyma. Hematoma undergoes lysis the sonographic appearance may range from anechoic to echogenic or possibly complex (Carol M 2005).

A laceration may be noted as an echogenic line within the spleen immediately following trauma. In time, hemorrhagic cyst that result from trauma may have calcified wall (Carol M 2005).

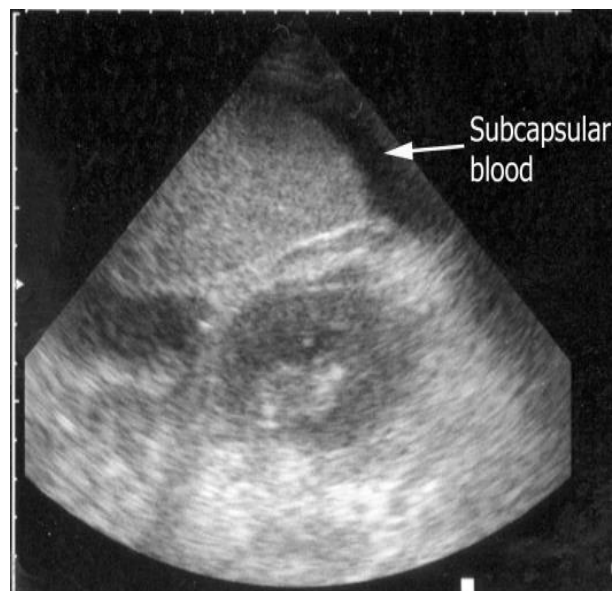


Fig (2.15) Splenic trauma (Carol M 2005)

## **2.1.3.11 Anatomical Variation**

### **2.1.3.11.1 Accessory spleen (splenules)**

It refers to one or more small foci of splenic tissue in the presence of an otherwise normal – sized spleen (Anthony , 2002 ) .

### **2.1.3.11.2 Poly Splenia**

Poly splenia is a condition in which multiple spleens present . As with the accessory spleen , these splenunculi are functional . (Anthony, 2002).

### **2.1.3.11.3 Splenosis**

A second from ectopic tissue results from the regeneration of splenic fragments implanted at suitably supportive sites for growth, usually following traumatic rupture of the organ , but also , less commonly , following splenic surgery . (Anthony ,2002) .

## **2.2 Previous Studies :**

Siddiqui and Hassan assessed the normal spleen in 2015 which proposed by various researchers conducted on Pub Med (Med line) Google scholars , Embase and other data bases till December 2014 to look for studies reporting normal spleen size using various technique. There is a large range of normal splenic dimension among individuals Among different techniques of normal spleen size, ultrasonographic measurements have been considered to be the most feasible and accurate. Ultrasonography can be useful technique as it is none invasive and does not involve any risk of radiation. Ultrasound, therefore has become the most common practice to differentiate pathologically enlarge or reduced spleen in patients (Siddiqui and Hassan 2015)..

Nouri et al ,Established local Reference of spleen length in Sudanese

Normal School Age Children sonographically in 2013 using 215 healthy school-aged children (7 -13 years)from city centers were evaluated ,gender, weight ,height, BMI and abdominal circumference were determined for each case. The sonographic examination for spleen length performed with high resolution real

time scanners (SSD-500 Aloka Medical system) fitted with a 3.5 MHZ convex transducer, all of the measured spleens had a normal position, shape, and echotexture. The children were separated into 7 groups according to age and were classified to male and female. They found that the mean length of the spleen found to be 9.5 -10.4 cm there was significant relation between spleen length and age, weight, height, abdominal circumference and BMI (Nouri et al, 2013).

Ezeofori et al in 2014 studied sonographic assessment of the normal limits of the spleen in healthy school children in south-East Nigeria to establish the normal values of splenic length in healthy school children in South – East Nigeria and to correlate them with body Indices using of 1315 children (633 boys and 682 girls) between the age of 5 to 17 years. The splenic length was measured between the most superiomedial and the most inferiolateral margins, at the level of the hilum. The length was correlated with the sex, age, weight, (WT) height, body mass index (BMI) and body surface area (BSA) of the subjects.

A regression model for spleen dimension from age and body habitus was computed. They found that there was a significant correlation between splenic length and age,  $p < 0.001$ . Males had statistically significant longer spleen length than females. The splenic length correlated best with BSA, followed by body WT and least with BMI (Ezeofori et al, 2014).

Badran, et al studied in 2015. Ultrasonographic assessment of splenic volume and its correlation with body parameters in a Jordanian population to estimate normal linear dimensions and volume of spleen in Jordanians using ultrasonography, and to correlate splenic volume with age and body parameters: height, weight, body surface area (BSA), and body mass index (BMI).

Using 205 volunteers (115 males and 90 females) not known to have any conditions likely to be associated with splenomegaly. The study was performed at the Radiology Department, Jordanian University Hospital, Amman, Jordan, between December 2013 and August 2014. All linear dimensions of spleen were measured, and splenic volume (index) was calculated using the standard prolate ellipsoid formula (length x width x depth x 0.523). The splenic volume was then analyzed with age and body parameters using the Pearson's correlation coefficient.

**Results :** The mean ( $\pm$ SD) splenic dimensions were 10.72 $\pm$ 1.37cm in length, 7.40  $\pm$ 1.52cm in width, 4.40 $\pm$ 1.47cm in depth, and 184,15 $\pm$ 79,56cm in volume. Men had larger spleens than women ( $p < 0,001$ ). Age had no significant effect on spleen volume ( $r = 0,11, p = 0,12$ ) There was a significant moderate positive correlation ( $p < 0.0001$ ), using Pearson's correlation coefficient, between the spleen volume, and other parameters (height, weight, BSA, and BMI, with correlation coefficient exceeding 0,3 (Badran, et al studied sonographic determination of normal spleen dimensions and anthropometric evaluation by ultrasonography from females and males in Turkish adults. These measurements were taken using an ultrasonography. The mean values of the ages, height, weight, and BMI of subjects, SW, SL, ST and SV calculated with ellipsoid formula, length x width x thickness x 0,523 were taken. These measurements were found to be 36,37 $\pm$ 10,83 years, 164,22 $\pm$ 4,72 cm, 60,26 $\pm$ 7,11kg 22,30 $\pm$ 2,09kg/m<sup>2</sup>, 7,58 $\pm$ 1,56 cm, 9,87 $\pm$ 1,28 cm, 3,34 $\pm$ 0,79 cm and 136,05 $\pm$ 61,14 cm<sup>3</sup> in females respectively. Additionally, in males same dimensions were 40,50 $\pm$ 12,77 years, 174,41 $\pm$ 6,57 cm, 76,33 $\pm$ 8,54 kg, 25,06 $\pm$ 2,10 kg/cm<sup>3</sup>, 8.75 $\pm$ 1,84 cm, 11,01 $\pm$ 186 cm, 4.12 1.09cm and 220.70 $\pm$ 115.35cm<sup>3</sup> respectively. The observations presented in this report have define anatomic parameters about spleen size that need to be taken in to consideration for reference data to determine population discrepancies and helpful for radiologist and clinicians (Celiktas et al 2015).

Tana et al studied in 2012 Ultrasonic Measurement of Normal Splenic size in infants and children in Paediatric Indian Population to measure normal splenic size in infants & children in Indian population by ultrasonography, to establish correlation of splenic size with age, height and weight.

Study was conducted in the department of anatomy, radiology and paediatric at a General Public Charitable Hospital Mumbai. The study group consisted of 80 children of both sexes, who were referred to the Radiology department for ultrasonography for abdominal and or pelvis problems unrelated to the spleen. The splenic length was measured by a radiologist using commercially available real time ultrasound system with a Toshiba ecocee using system particularly by using the convex probe.



They revealed that , P value is less than 0.001 for all age with splenic size . Splenic size with height , splenic size with weight indicate significant correlation of splenic size with age , height and weight Tanna et al studied in 2012 .

Mustafa et al , sonographic determination of normal spleen size in an adult African population in 2010 to determine the normal range of spleen size in an adult African population and compare the findings to published data to determine any correlation with echogenicity . Three hundred and seventy – four African adults without conditions that can affect the spleen or splenic abnormalities were evaluated with ultrasonography . Spleen length , width and thickness were measured and spleen volume calculated . Spleen size was correlated with age , gender , height , and body mass index .

**Results :** The mean spleen volume was 120 cm<sup>3</sup> . Spleen volume correlated with spleen width (  $r = 0.85$  ) .

Thickness (  $r = 0.83$  ) and length (  $r = 0.80$  ) . Men had a larger mean spleen volume than women , No correlation was found between spleen volume and age , weight , height , or BMI ( Mustafa et al 2010 ) .

Mittal and Chowdhary , A pilot Study Of The Normal Measurements Of The liver And Spleen By Ultrasonography In The Rajasthani Population to determine the normal standard of liver and spleen by ultrasonography in the Rajasthani population.

Two hundred subjects (100 males and 100 females )from Rajasthan were evaluated. The dimensions of the organs were measured 3 times and the mean values were recorded. The subjects were divided in to 5 groups according to their ages (11-70 yrs) .They found that the average longitudinal diameter of the right lobe of the liver was  $12.99 \pm 0.76$  cm (males ) and  $12.66 \pm 1.07$  cm ( females ) . The average length of the spleen was  $9.40 \pm 0.91$  cm ( males ) and  $9.34 \pm 0.95$  cm ( females ) . The average width of the spleen in males as well as in females was  $3.45 \pm 0.59$  cm (Mustapha 2010).

## **Chapter Three**

### **Materials and Methods**

#### **3.1 Materials**

##### **3.1.1 Subjects**

The study was performed in the ultrasound section department in Abodaa Healthy Center In Omdurman - Althawra – Sudan in 2018 conducted on 70 volunteers (Males 31 Females 39 ) . Adult patients were healthy volunteers persons who refered for U/S department for abdomen were included . \

Subjects underwent physical examination and completed a short standardized interview questionnaire to exclude any previous or current conditions that might involve the size of the spleen . For this study group , the following exclusion criteria was used :

- Clinical or laboratory evidence of infection .
- Hematopoietic diseases .
- Genetic diseases ( thalassemia and sickle cell anemia ) .
- Lymphadenopathy .
- Liver diseases ( cirrhosis or portal hypertension ) .
- Renal failure .
- History of splenic trauma .
- Non – traumatic benign splenic lesions ( infarction , lobulations cysts , accessory spleen , and hemangioma ) .
- Malignant lesions .
- Pregnancy .

##### **3.1.2 Machine**

Digital ultrasonic Diagnostic imaging system .

U/S machine model : DP - 6600 trans abdominal scan using curvilinear transducer 50/60 HZ150 VA was carried on .

Mindray Bio – Medical Electronics Co . Ltd .

## **3.2 Methods**

### **3.2.1 Technique Used**

Trans abdominal U/S technique was performed with Pt laying in supine position also the probe between the ribs intercostally from postero lateral approach .

Each subject from sample will be fasting for 8 hours and having abdominal preparation . The ultrasound scan for splenic measurements ( length – width – thickness – splenic volume – also body weight and height must be measured .

### **3.2.2 Sonographic appearance :**

The parenchyma is homogeneous, midgray or medium-level echoes. the normal spleen has a fine, homogeneous texture, with smooth margins and a pointed inferior edge. Interspersed within the spleen are small vascular structures that are seen as branching, anechoic, & round or tubular.

Closer to the hilum the larger venous structures can be distinguished from the smaller arterial branches. The outer contour of the normal spleen should appear smooth.

The echogenicity is usually slightly greater than that of the normal liver & higher than that of the normal renal cortex.

In longitudinal scans, the diaphragm will be at the head end of the patient; in transverse scans , a portion of diaphragm will be on the patients left (Denis et al 2005).

### **3.2.3 Spleen Measurement :**

**Length** : by measuring the dimension in a longitudinal section. The measure between the most superiomedial and the most inferolateral margins, at the level of hilum. (Ezeofori et, al 2014).

**Thickness** : on a transverse scan the hilar thickness is measured from the hilum perpendicular to the medial concave surface and the lateral convex surface .

**Width** : It the maximum distance between the medial and lateral borders of the spleen was measured on a plane perpendicular to the length. (Ezeofori et al 2014).

### **3.2.4 Data Collection**

Data were collected with special data collection sheet encompass patient .  
Demographic data and ultrasound findings .

### **3.2.5 Ethical Issue**

- Permission from U/S department was obtained .
- Agreement of patient .
- No patient identical data or details published .
- Safe use of U/S (Not invasive ) .

### **3.2.6 Statistical Analysis**

The data were analyzed by SPSS using L, W, T and volume were determine, then correlation between these variables and age, gender, height, weight BMI obtained.

## Chapter four

### Results

Table (4.1) frequency distribution of gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	31	44.3	44.3	44.3
Female	39	55.7	55.7	100.0
Total	70	100.0	100.0	

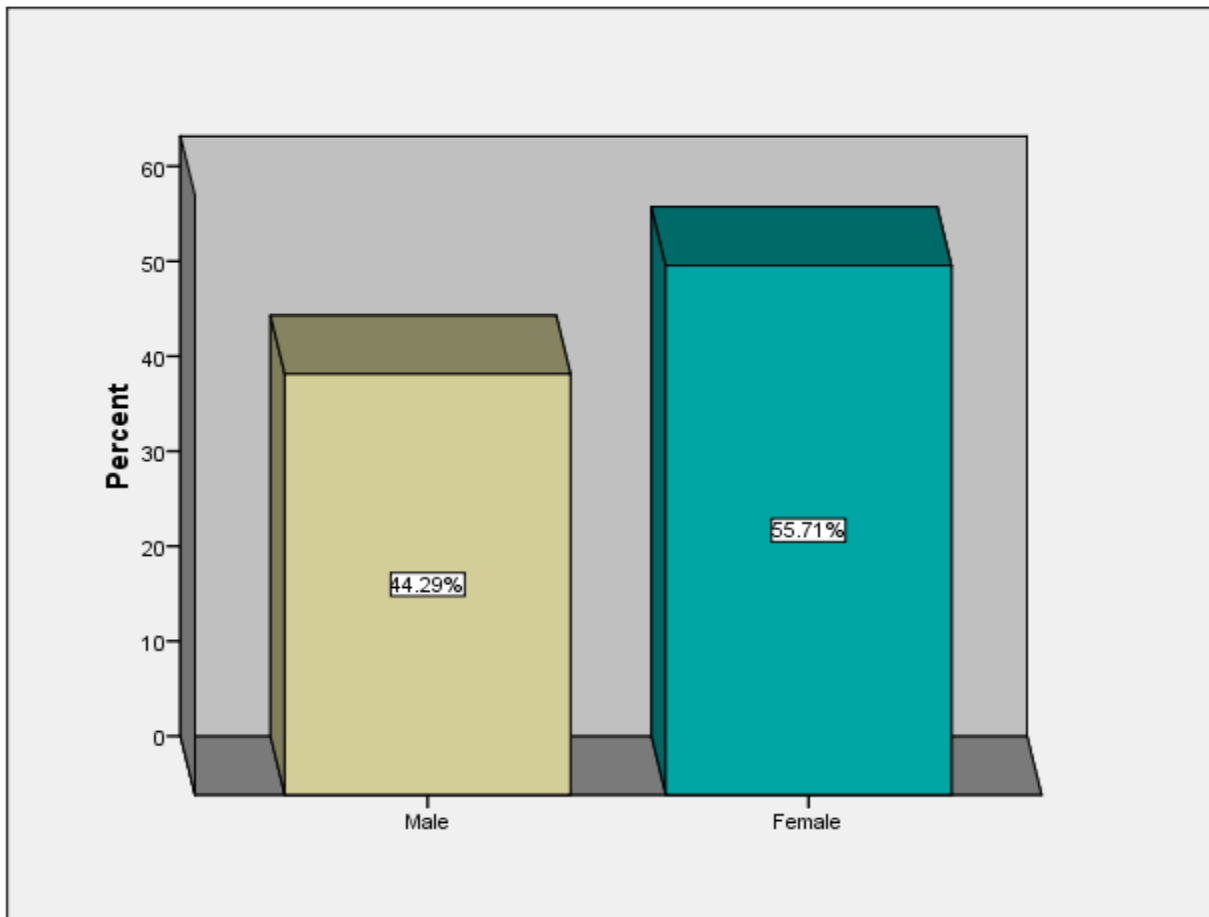


Figure (4.1) frequency distribution of gender

Table (4.2) frequency distribution of age \ years

Age \ years	Frequency	Percent	Valid Percent	Cumulative Percent
20-34	16	22.9	22.9	22.9
35-49	28	40.0	40.0	62.9
50-64	16	22.9	22.9	85.7
65-79	7	10.0	10.0	95.7
80-85	3	4.3	4.3	100.0
Total	70	100.0	100.0	

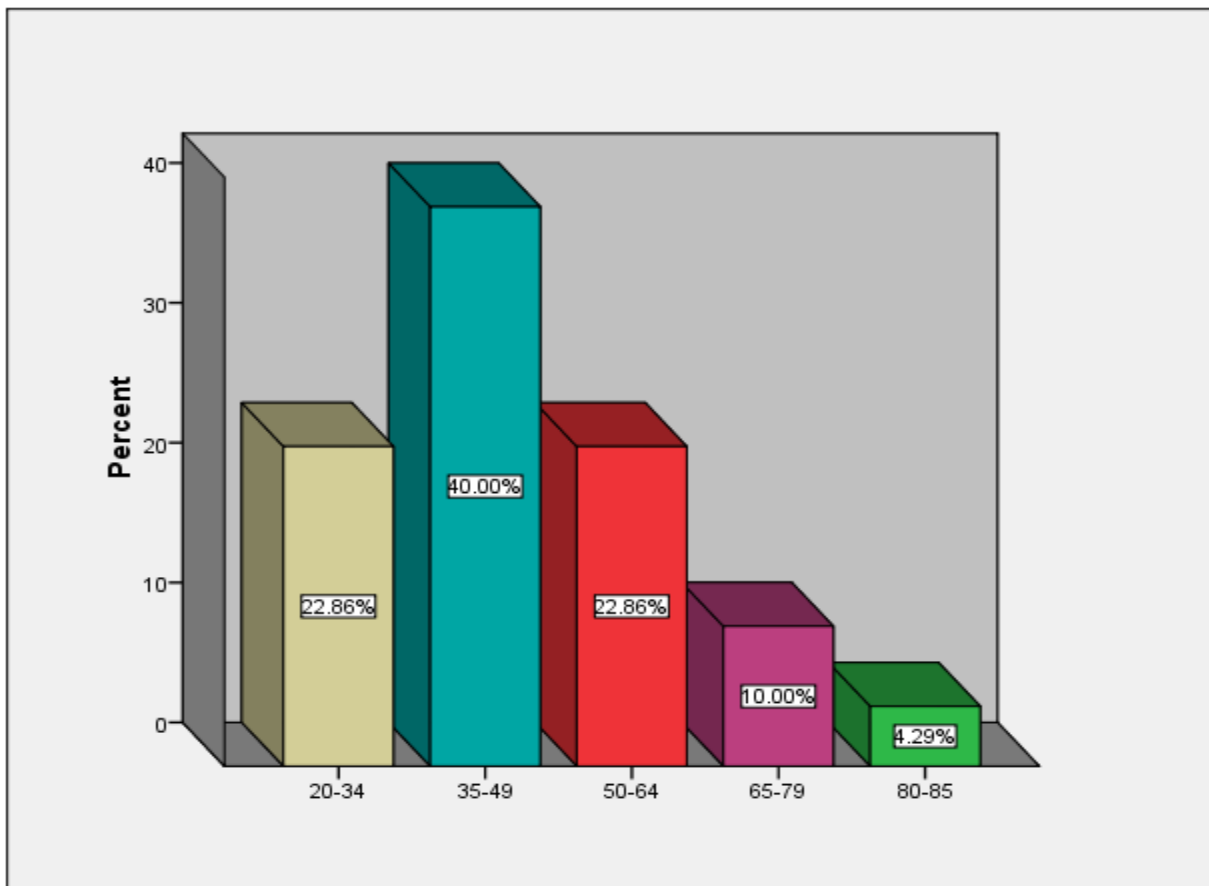


Table (4.2) frequency distribution of age \ years

Table (4.3) Descriptive statistic (minimum, maximum, means± Std. Deviation) for age, height, weight, BMI and splenic measurements

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Age	70	20	85	46.70	15.812
Height	70	135	186	165.00	11.397
Weight	70	42	117	72.91	13.761
BMI	70	17.16	45.18	26.9058	5.34549
Spleen length	70	6.0	12.2	9.089	1.1819
Spleen Width	70	2.6	5.5	4.086	.6286
Spleen Thickness	70	1.6	5.3	4.036	.5954
Spleen Volume	70	16.95	179.23	80.8832	28.72781
Valid N (listwise)	70				

Table (4.4) Compare means splenic measurements in different age group

Age \ years		Spleen length	Width	Thickness	Spleen volume
20-34	Mean	8.938	4.075	3.938	78.4002
	Std. Deviation	1.5019	.5434	.5909	35.01564
	Minimum	6.0	3.3	3.2	38.16
	Maximum	12.2	5.3	5.3	179.23
35-49	Mean	9.114	4.229	4.296	88.6236
	Std. Deviation	1.2011	.6694	.4534	28.07076
	Minimum	6.5	2.6	3.2	45.84
	Maximum	11.4	5.5	5.0	140.95
50-64	Mean	9.038	4.056	4.025	78.0718
	Std. Deviation	.7771	.5899	.3924	18.44449
	Minimum	7.7	2.9	3.3	42.04
	Maximum	10.0	5.0	4.6	105.91
65-79	Mean	9.700	3.843	3.571	74.7932
	Std. Deviation	1.2220	.7613	1.0012	34.97142
	Minimum	7.5	2.7	1.6	16.95
	Maximum	11.0	4.9	4.5	119.09
80-85	Mean	8.500	3.533	3.267	51.0866
	Std. Deviation	.8660	.2517	.0577	2.39148
	Minimum	8.0	3.3	3.2	48.33
	Maximum	9.5	3.8	3.3	52.47
P value		0.582	0.308	0.003	0.211

Table (4.5) Independent sample t-test for compare mean splenic measurements in different gender

a. Mean

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Spleen length	Male	31	9.432	1.1505	.2066
	Female	39	8.815	1.1483	.1839
Width	Male	31	4.248	.7302	.1312
	Female	39	3.956	.5077	.0813
Thickness	Male	31	4.052	.7434	.1335
	Female	39	4.023	.4551	.0729
Spleen volume	Male	31	88.7160	34.07048	6.11924
	Female	39	74.6572	22.18770	3.55288

b. Independent sample t-test

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
length	2.231	68	.029	.6169	.2765	.0650	1.1687
	2.230	64.430	.029	.6169	.2766	.0644	1.1694
Width	1.970	68	.053	.2920	.1482	-.0037-	.5877
	1.892	51.484	.064	.2920	.1543	-.0177-	.6017
Thickness	.198	68	.844	.0285	.1443	-.2594-	.3164
	.188	47.227	.852	.0285	.1521	-.2774-	.3345
volume	2.082	68	.041	14.05877	6.75126	.58685	27.53069
	1.987	49.220	.053	14.05877	7.07588	-.15913-	28.27667



Table (4.6) Independent sample t-test for compare mean splenic measurements in different BMI

a. Mean

	BMI	N	Mean	Std. Deviation	Std. Error Mean
Spleen length	Normal	24	9.125	1.3932	.2844
	Obese	46	9.070	1.0718	.1580
Width	Normal	24	4.017	.6445	.1316
	Obese	46	4.122	.6243	.0920
Thickness	Normal	24	4.004	.5916	.1208
	Obese	46	4.052	.6032	.0889
Volume	Normal	24	79.6255	32.59381	6.65318
	Obese	46	81.5394	26.85468	3.95951

b. Independent sample t-test

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Length	.185	68	.854	.0554	.2997	-.5427-	.6535
	.170	37.567	.866	.0554	.3254	-.6035-	.7143
Width	-.661-	68	.511	-.1051-	.1589	-.4222-	.2121
	-.654-	45.463	.516	-.1051-	.1606	-.4284-	.2182
Thickness	-.318-	68	.751	-.0480-	.1509	-.3491-	.2531
	-.320-	47.567	.750	-.0480-	.1500	-.3496-	.2536
Volume	-.263-	68	.794	-1.91392-	7.28311	-16.44713-	12.61929
	-.247-	39.636	.806	-1.91392-	7.74226	-17.56608-	13.73824

Table (4.7) correlation between body characteristic and splenic measurements

		Age	Height	Weight	BMI
Length	Pearson Correlation	.092	.460**	.247*	-.062-
	Sig. (2-tailed)	.451	.000	.039	.610
	N	70	70	70	70
Width	Pearson Correlation	-.165-	.214	.278*	.143
	Sig. (2-tailed)	.172	.075	.020	.238
	N	70	70	70	70
Thickness	Pearson Correlation	-.256*	.132	.171	.094
	Sig. (2-tailed)	.032	.275	.156	.441
	N	70	70	70	70
Volume	Pearson Correlation	-.139-	.338**	.280*	.058
	Sig. (2-tailed)	.252	.004	.019	.636
	N	70	70	70	70
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

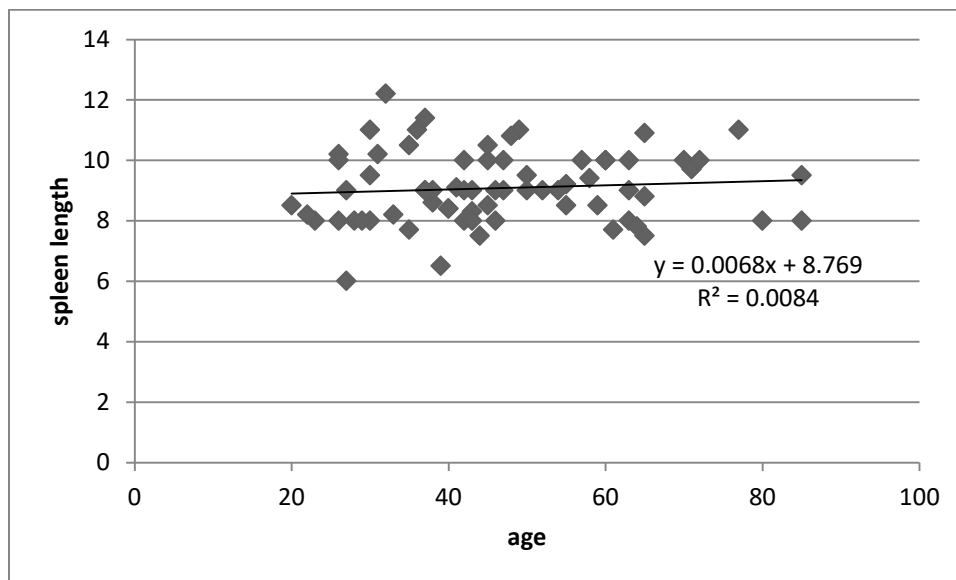


Figure (4.3) scatterplot shows relationship between age and splenic length

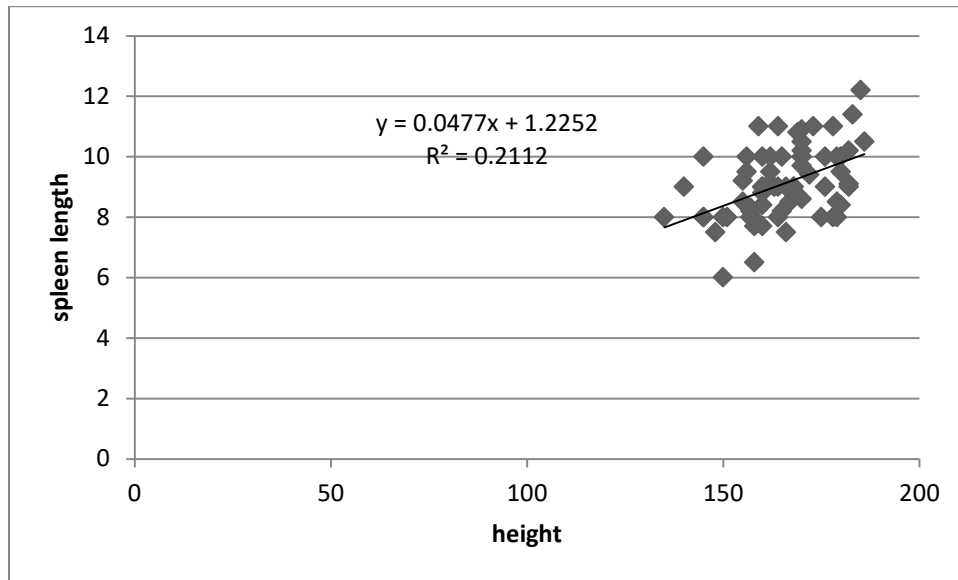


Figure (4.4) scatterplot shows relationship between height and splenic length

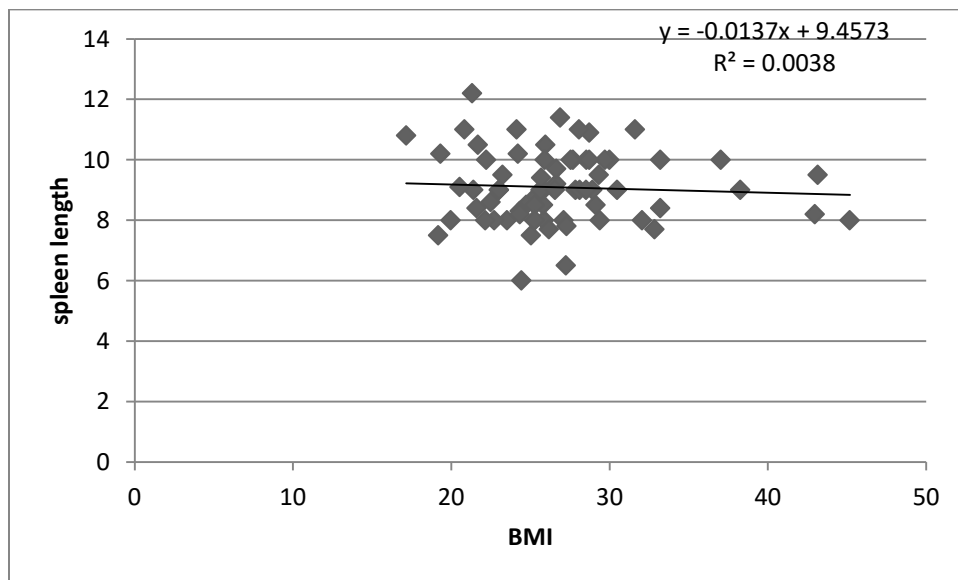


Figure (4.5) scatterplot shows relationship between BMI and splenic length

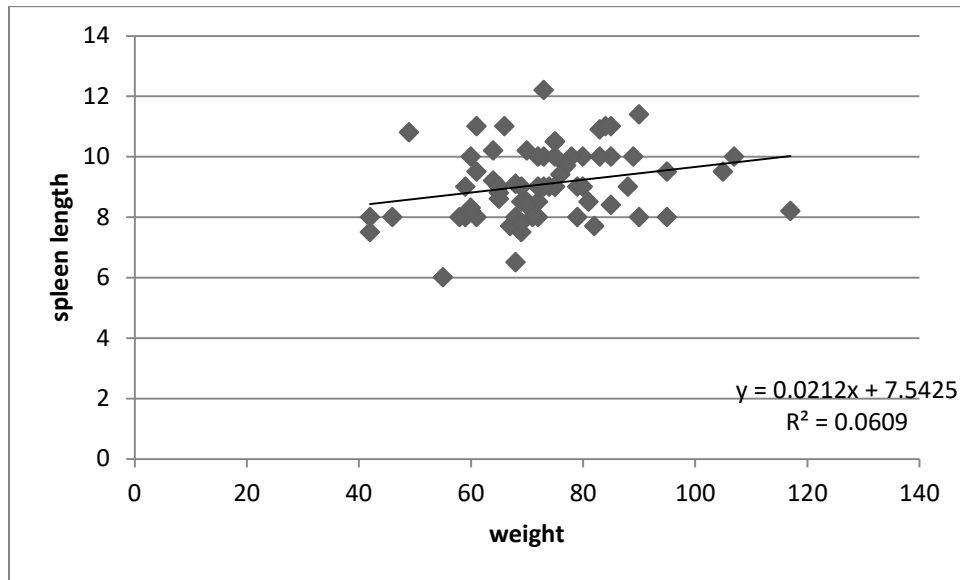


Figure (4.6) scatterplot shows relationship between weight and splenic length

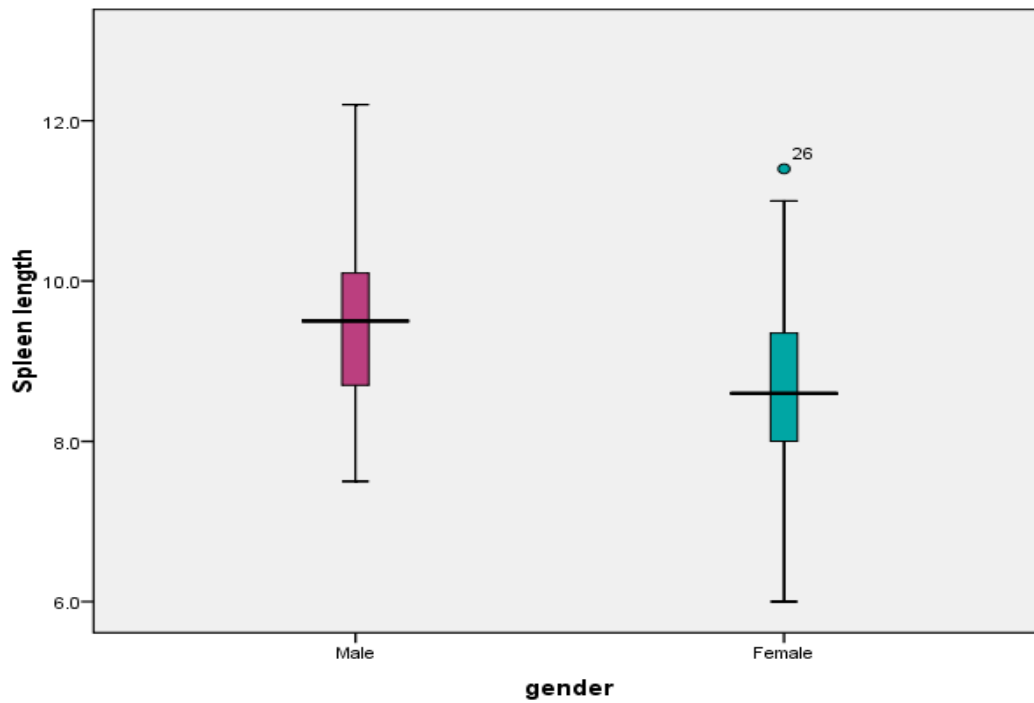


Figure (4.7) plot box shows splenic length in different gender

## Chapter Five

### Discussion , Conclusion and Recommendation

#### 5.1 Discussion

Table (4.1) and figure (4.1) show that 70 volunteers were evaluated in this study with different gender 31 males and 39 females .

Table (4.2) and figure (4.2) show frequency distribution of age (20-85) years to five groups the most (40%) of participants were (35-49) years old and ( 22.9% ) of them were 50-64 years. Also (22.9%0 for 20-34 years ,since (10%) of them were 65-79 years while the less (4.3%) were 80-65 years .Table4.3 showed minimum, maximum ,mean and standard deviation for age ,height ,weight ,BMI and splenic measurements there was statistically significant correlation between splenic length., volume and height for both male and female.

Table 4.3 show descriptive statistic of mean and standard deviation for age, height, weight, BMI and splenic measurements. Badran et al (2012) study explained that age had no significant effect on spleen volume I agree as in table 4.4 which show compare means splenic measurements in different age group there was no significant correlation age with spleen length and volume. Table 4.5 independent sample t-test show significant correlation between length and volume of spleen and gender male has taller and larger spleen than female here I agree with Mustapha et al (2010) and Ezeofori et al (2014) Table 4.6 show no significant correlation of splenic measurements and BMI. Table 4.7 show significant Person correlation of body height with spleen length and volume ( $P < 0.01$ ). But scatter plot show weakly positive relationship between age and splenic length ( $R^2 = 0.008$ ) ,in figure 4.3 . also in figure 4.4 show strong positive linear relationship between splenic length and height . Figure 4.5 show weakly negative linear correlation splenic length with BMI .

Figure 4.6 show weakly positive liner correlation splenic length with weight .

## **5.2 conclusion**

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

The data obtained in this study can provide crucial information for surgeons and radiologists about spleen and they can be used as reference values for evaluating pathologic changes in the spleen region . A local reference of spleen dimensions was established in this study with a different range of values reported previously . Setting a higher cut off point for defining splenomegaly in Sudanese should be considered .

### **5.3 Recommendations**

A larger study sample is required in order to improve the accuracy of our measurement .

Further studies are needed with larger study population and more backgrounds to explore wider environmental and genetic influences that might determine the splenic volume .

Discover more publications , questions and projects in spleen .

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## Appendix (1)

### Images

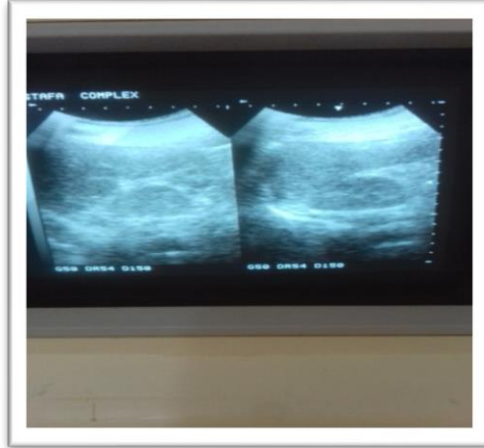
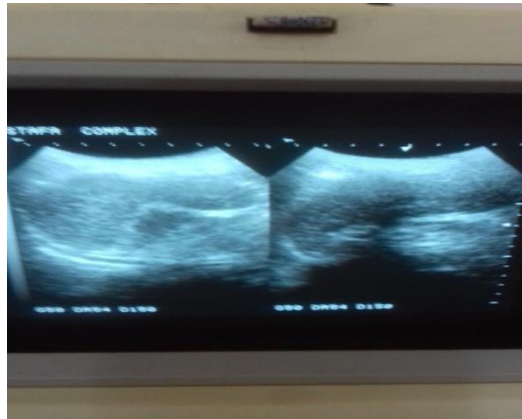


Image (1) : sagittal and transverse U/S image of spleen for male (26 years , 180 cm height and 72 Kg weight . SL 10 cm . SW 4.1 , ST 4.7 , SV 100 cm ) .



Image(2): Sagittal and transverse U/S image of spleen for male 31 years age , 180 cm height and 60 Kg weight . The spleen measurements (192 mm L , 48.8 W , 35.3 Th , V91.3 cm ) .



Image (5) :sagittal and transvers u/s image of spleen for female in 65 years age, 160 cm height and 65 kg weight. The spleen measurements(8.8 cm L, 3.8 W,4.4 Th, V71.8 cm<sup>3</sup>).



Image (6): sagittal and transvers u/s image of spleen for female in 40 years age, 167 cm height and 83 kg weight. The spleen measurements(8.4 cm L, 4.2 W,5 cm Th, V 80.1 cm<sup>3</sup>).



Image (7) :sagital and transvers u/s image of spleen for female in 46 years age, 157 cm height and 70 kg weight. The spleen measurements(9 cm L, 3.8 W,3.9 cm Th, V 67.8 cm<sup>3</sup>).



Image (8) sagital and transvers u/s image of spleen for female in 23 years age, 135 cm height and 45 kg weight. The spleen measurements(8.1 cm L, 3.7 W,3.9 cm Th, V 60.4 cm<sup>3</sup>).



Image (9) sagital and transvers u/s image of spleen for male in 85 years age, 180 cm height and 95 kg weight. The spleen measurements(9.5 cm L, 3.3 W,3.3 cm Th, V 54.5 cm<sup>3</sup>).



Image (10) sagital and transvers u/s image of spleen for male in 27 years age, 167 cm height and 65 kg weight. The spleen measurements(9 cm L, 3.7 W,4.4 cm Th, V 76.4 cm<sup>3</sup>).



Image (11) :sagital and transvers u/s image of spleen for male in 26 years age, 170 cm height and 74 kg weight. The spleen measurements(10.2 cm L, 3.6 W,3.8 cm Th, V 76 cm<sup>3</sup>).



Image (12) :sagital and transvers u/s image of spleen for female in 45 years age, 179 cm height and 68 kg weight. The spleen measurements(9.2 cm L, 3.4 W,3.6 cm Th, V 58.3 cm<sup>3</sup>).



## Appendix (3)

### The Machine



Mindray Bio – Medical Electronics Co . Ltd .