Sudan University of Science and Technology

College Of Graduate Studies

Measurement of Normal Spleen Dimensions in Adult Sudanese Using Ultrasonography

قياس ابعاد الطحال الطبيعية للسوادنين البالغين باستخدام الموجات فوق الصوتية

A Thesis Submitted for Partial Fulfillment of the award of M.Sc. Degree in Diagnostic Ultrasonography

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الايه الكريمه

قال تعالي:

(قل لو كان البحر مدادا لكلمات ربي لنفد البحر قبل ان تنفد كلمات ربي ولو جئنا بمثله مددا)

الايه(109) سورة الكهف

Dedication

To:

My family

My friends

My colleagues

Acknowledgment

First of all, I Thank Allah the almighty for helping me to complete this project. I Thank Dr. Mona my supervisor for her help and guidance, my great fullness for my all teachers in different educational levels, specially thanks for my teacher

Dr. Mohammed Elfadil

Finally I would like to thank everybody who helped me in this project.

Abstract

This study was done to measure the normal spleen dimensions in adult Sudanese, and to correlate these dimensions with the variables of age, gender, height, weight and body mass index, the study was done with the subjects lying in right lateral decubits in deep breath. The spleen dimensions were measured by centimeter. It was done during the period from May to August 2016 in Elmutakamil Medical Group, Khartoum state, using Medison ultrasound system machine. A number of 60 subjects were scanned (29 male, 31female).

The findings included that the mean value of Spleen length, width, Thickness were 10.3±1.2, 3.3±0.4, 3.9±0.6 for male and 9.2±0.9, 3.1±0.3, 3.6±0.6 for female, the spleen volume 73.3±23.1for male and 56.5±18.0cm3 for female. There were statistically significant differences between male and female in length, width and volume, and non-significant differences between male and female in depth .The means of length, depth, width and volume were, 10.2955, 9.2194, 3.8793, 3.5755, 3.28, 3.06, 7.32573, 5.65242 respectively for Male and Female, with corresponding significance values of t-tests 0.000 , 0.053 , 0.022 , 0.003.It was found that there is significant correlation between spleen length, height, weight and non-significant correlation with body mass index ,sig values were 0.003 ,025 and 0.418 respectively, there was non-significant correlation between spleen width and height ,weight and BMI. Also there was significant correlation between spleen depth and height and non-significant correlation with weight and BMI, the sig values were respectively. Furthermore there were significant correlation between spleen volume and height and non-significant correlation with weight and BMI, the sig values were 0.001and 0.141, 0.653 respectively.

ملخص البحث

اجريت هذه الدراسةِ لقيَاس ابعاد وحجمِ الطحال عند السودانيين (البالغين)، وكان الغرض من هذه الدراسة هو ربط هذه الابعاد بمتغيرات العُمر والجنس والارتفاع ووزن وكتلة الجسم .تم قيلس الطحال اثناء الاستلقاء الجانبي بالسنتميترات وكان المسح اثناء النفس العميق.اجريت الدراسة في الفترة مابين شهر مايوإلى أغسطس 2016 في (مجموعة المتكلمل الطبية) ولايةِ الخرطوم ، بإستعمال جهازميدسون للموجات فوق الصوتية . تم فحص عدد60 شخص (29 ذكور، 31 اناث).

اوضحت الدراسة ان القيم المتوسطة والانحراف المعياري لطولِ وعرض و سُمكَ وحجم الطحال كالتالي 10.3 ±1.2، 3.3 ±0.4، 3.9 ±0.6 و9.2 ±0.9، 3.1 ±0.3، 3.6 ±0.6 و73.3 ±23.1 و56.5 ±18.0 سنتيمترمكعب للذكور والاناث على التوالي.

هناك إختلافات هامّة ذات دلالات احصائية بين الذكور والاناث في طول وعرض وحجم الطحال وإختلافات غير هامّة بين الذكور والاناث في سمك الطحال، والقيم المتوسطة لطول وعمق وعرض وحجم الطحال على النحو الاتي (10.2955، 9.2194)، (3.8793، 3.5755)، (3.28، 3.06)، (7.32573، 5.65242) للذكور والاناث على التوالي، وهذه تطابق (0.000 ، 0.053 ، 0.022 ، 0.003) من اختبارات تي والتي تدل على ان ابعاد وحجم الطحال في الذكور اكبر من الاناث ، وَجد ان هناك علاقة هامة تربط بين طول الطحال وإرتفاع ووزن الجسم وعلاقة غير هامة مع كتلة الجسم وقيم اختبارات تي هي0.003 و0.025 و0.418 على التوالي ، ولاتوجد علاقة هامة بين عرض الطحال وارتفاع ووزن وكتلة الجسم .وجد ايضا ان هناك علاقة هامة بين سمك الطحال وارتفاع الجسم وغير هامة بين سمك الطحال ووزن وكتلة الجسم وقيم اختبارات تي هي 0.003و0.247و0.658

ايضا هناك علاقة هامة تربط بين حجم الطحال وارتفاع الجسم وعلاقة غير هامة بين حجم الطحال ووزن وكتلة الجسم وقيم اختبارات تي هي 0.001 و0.141 و0.653 .

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List of Abbreviations

Abbreviation	Meaning
SL	**Spleen length**
SW	**Spleen width**
ST	**Spleen thickness**
SV	**Spleen volume**
BMI	**Body mass index**

Chapter one

Introduction

Chapter one

1.Introduction

The spleen is the largest lymphoid organ with a parenchymal structure in the reticuloendothelial system and it is situated in the left hypocondrium (Ehimwenma et al, 2011).

the spleen size shows variations according to people, depending on the individual's height, age and sex (Danila ,2010). 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). Furthermore, splenic enlargement may be result of especially viral illnesses and is an crucial criterion in diagnosing primary myeloproliferative diseases (Spielmann et al, 2005). However, evaluation of splenic size by palpation can cause unreliable and wrong conclusions because spleen is not palpable untill 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).

Furthermore study in Turkish adults found that all dimensions were greater in males than females and spleen length decreased with increase in age in both genders.(celiktas. et al.2015) , another study found that spleen length, Weight and thickness were decreased within increase in age with all parameters greater in males than in female and all dimension are greater in male than in female. (Narora et al.2010).more ever study was done in collegiate athletic population found that mean(SD) splenic length in men larger than women. (Mayahuza et al.2016).

1.2 **Problem:**

The normal spleen size generally stated in a book or journal that carried out their study in different nation with different body characteristic therefore adoption of their normal might not give a true result, therefore measurement depend on Sudanese and attributed to body characteristic will give a better dynamic value.

1.3 Objectives:

1.3.1General objectives:

Assessment of spleen dimensions and volume in adult Sudanese in order to compare the variation in respect to international index.

1.3.2 Specific objectives

- To measure the length, width, thickness and volume of the spleen.
- To correlate spleen measurements with gender, age and body mass index.
- To compare between the spleen measurements in Sudanese and the international index.

1.4 Over view of the study

This study falls into five chapters, chapter one, which is an introduction, deals with theoretical framework of the study. It present the statement of the study problems , objectives of this study , chapter two includes theoretical background and previous study , while chapter three discusses the material and method then chapter four include presentation of the results and finally chapter five consists of discussion , conclusion , recommendation .

Chapter Two

Literature Review

Chapter two

Literature review

2.1 Theoretical Background

2.1.1 Anatomy of the Spleen:

The spleen is situated principally in the left hypochondriac region, but its superior extremity extends into the epigastric region; it lies between the fundus of the stomach and the diaphragm. It is the largest of the ductless glands, and is of an oblong, flattened form, soft, of very friable consistence, highly vascular, and of a dark purplish color. (Henry, 2000)

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 of the left side (Fig 2.1), and the intervening lower border of the left lung and pleura. (Henry, 2000).

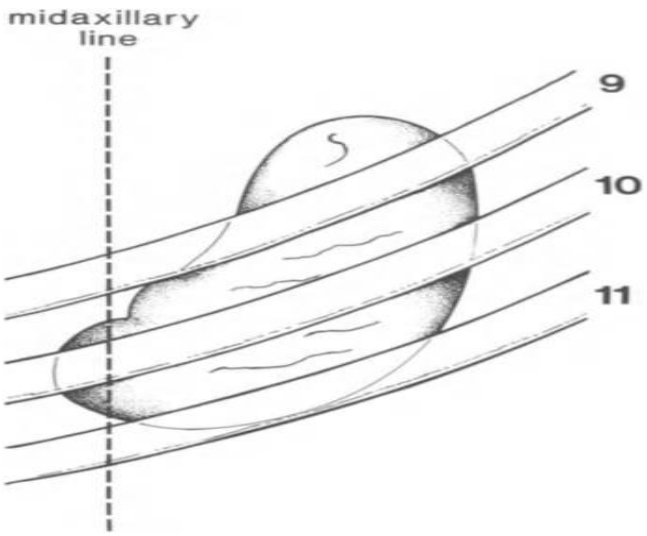


Fig 2.1. The diaphragmatic surface of the normal spleen, showing its relationship to the ninth, tenth, and eleventh ribs (Anthony J, 2002).

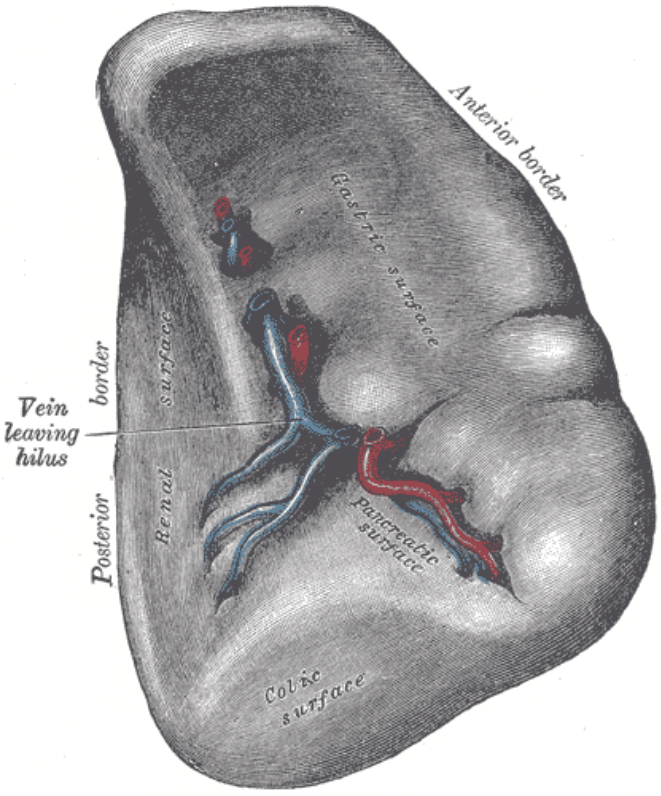


Figure 2.2The visceral surface is divided by a ridge into an anterior or gastric and a posterior or renal portion. (Henry, 2000).

- 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 below this 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 anterior surface of the left kidney and occasionally with the left suprarenal gland. (Henry, 2000).
- The superior extremity (extremitas superior) is directed toward the vertebral column, where it lies on a level with the eleventh thoracic vertebra. The lower extremity or colic surface (extremitas inferior) is flat, 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 the 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. 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. 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 lienal vessels pass between its two layers (Fig. 2.3). The other fold,

the gastrolienal 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 lienal artery run between its two layers. The lower end of the spleen is supported by the phrenicocolic ligament. (Henry, 2000).

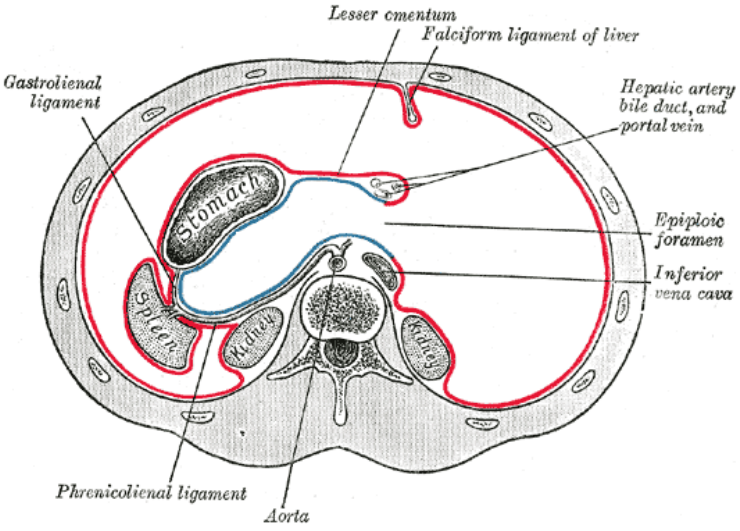


Fig 2.3 Horizontal disposition of the peritoneum in the upper part of the abdomen.

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, being 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 9 kilos, Frequently in the neighborhood of the spleen, and especially in the gastrolienal 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 internal 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 phrenicolienal and gastrolienal ligaments,The fibroelastic coat (tunica albuginea) invests the organ, and at the hilum is reflected inward upon the vessels in the form of sheaths. From these sheaths, as well as from the inner surface of the fibroelastic coat, numerous small fibrous bands, trabeculæ (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 tissues, the latter predominating. 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 variations 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).

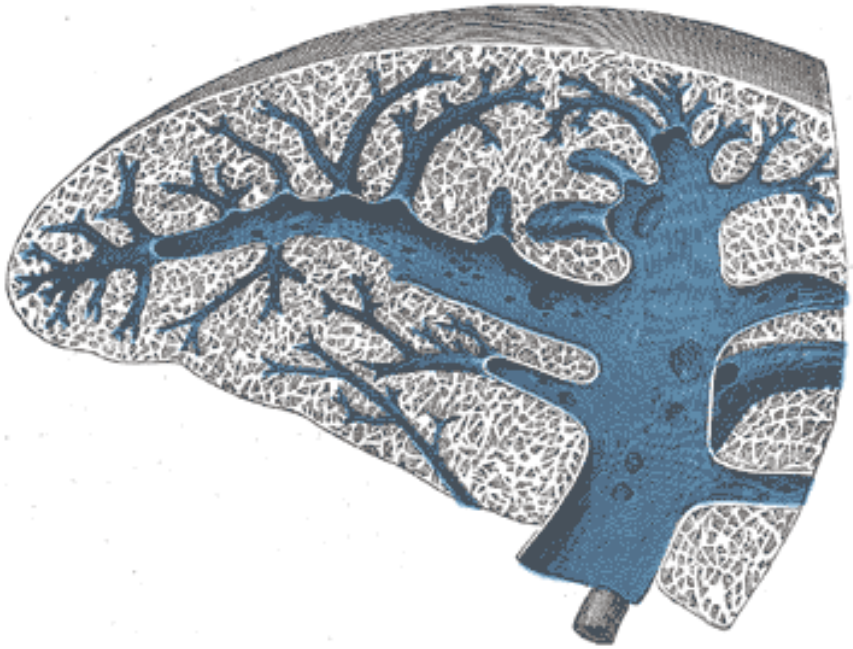


Fig 2.4 Transverse section of the spleen, showing the trabecular tissue and the splenic vein and its tributaries (Henry, 2000).

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)

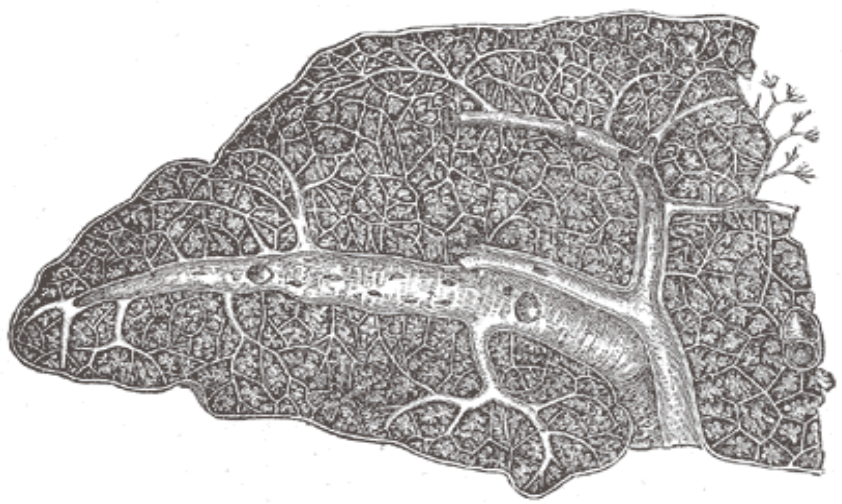


Fig 2.5 Transverse section of the human spleen, showing the distribution of the splenic artery and its branches (Henry , 2000).

2.1.1.4 Blood vessels of the Spleen:

The lienal artery is remarkable for its large size in proportion to the size of the organ, and also 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 the 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 interstices of the reticulum formed by the branched sustentacular cells. Each of the larger branches of the artery supplies chiefly that region of the organ in which the branch ramifies, having no anastomosis with the majority of the other branches,The arterioles, supported by the minute trabeculae, traverse the pulp 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 trabeculæ. (Henry, 2000).

2.1.2 Functions 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. Again, like the spleen, the liver, with its large mass of phagcytic Kupffer cells lining vascular sinusoids, is an important site of clearance 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 more effectively than can lymph nodes or other lymphoid tissues (Rowley, 1950).

2.1.3 Pathology of The Spleen:

2.1.3.1 Anatomic variation

2.1.3.1.1 Accessory spleen

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

2.1.1.1.1 polysplenia

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

2.1.1.1.2 Splenosis

A second form of ectopic splenic 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).

2.1.3.2 Splenomegaly

2.1.3.2.1 Infection

- Acute. Infectious mononucleosis; viral hepatitis; cytomegalovirus infection; septicemia (including tuberculous); salmonelloses; relapsing fever; tularemia; splenic abscess; toxoplasmosis.
- Subacute and chronic Chronic septicemias; tuberculous splenomegaly, leprosy; Yesinia; subacute bacterial endocarditis; brucellosis; syphilis; malaria; leishmaniasis; schistosomiasis; systemic fungal disease; inflammatory pseudo tumor. (Anthony,2002).

2.1.3.2.2 Immune proliferative and non infectious granulomatous disorders:

Angioimmunoblastic lymphadenopathy; angiofollicular hyperplasia; systemic lupus erythematosus; rheumatoid arthritis; Still's disease; rheumatic fever; Behcet's syndrome; serum sickness; sarcoidosis; berylliosis; necrotizing splenic granulomas. (Anthony,2002).

2.1.3.2.3 Vasculitides

Polyarteritis nodosa; leukocytoclastic angiitis; peliosis.

2.1.3.2.4 Congestive splenomegaly

- Intrahepatic. Portal cirrhosis; postnecrotic scarring; biliary cirrhosis; Wilson's disease; hemochromatosis; veno-occlusive disease; congenital fibrosis; bilharziasis.

- Portal vein obstruction Thrombosis, stenosis, atresia; cavernous malformation; arteriovenous aneurysm; obstructive lesions at porta hepatis.
- Splenic vein obstruction. Thrombosis, stenosis, atresia; angiomatous malformation; obstruction by pancreatic disease, splenic arterial aneurysm and retroperitoneal fibrosis.
- Hepatic vein occlusion. Budd-Chiari syndrome.
- Cardiac. Acute, chronic or recurrent congestive cardiac failure; constrictive pericarditis (Banti's syndrome).(Anthony ,2002).

2.1.3.2.5 Hematological disorders

- Hemolytic disorders.
- Hereditary red blood cell membrane disorders; thalassemia; sickle-thalassemia; sickle cell disease (early stages); hemoglobin-SC disease.
- Myeloproliferative disorders. Primary (agnogenic myeloid metaplasia); polycythemia vera (variable); essential thrombocythemia (variable).
- Miscellaneous. Primary splenic hyperplasia; megaloblastic anemias; iron deficiency.(Anthony ,2002).

2.1.3.2.6 Neoplasm

- Hematolymphoid. Acute leukemias; chronic leukemias; prolymphocytic leukemia; hairy cell leukemia; malignant lymphoma; dendritic cell tumors; systemic mastocytosis; plasma cell myeloma.
- Metastatic. Carcinoma, especially lung and breast; melanoma; neuroblastoma; malignant teratoma; choriocarcinoma
- Benign. Hamartoma (single, multiple); hemangioma (capillary, cavernous); lymphangioma; lipoma.(Anthony,2002)

2.1.3.2.7 Miscellaneous

- Storage diseases. Gaucher's disease; Neimann-Pick disease; ceroid histiocytosis; 0Tangier disease; Hurler's syndrome; Hunter's syndrome.
- Cysts. Pseudocyst; epidermoid (epithelial) cyst; echinococcal (hydatid) cyst.

Others. Amyloidosis; Albers-Schonberg disease; hereditary hemorrhagic telangiectasia; hyperthyroidism. (Anthony, 2002)

2.1.4 Normal sonography

2.1.4.1 Basic ultrasound physics

Ultrasound is made up of mechanical waves that can transmit through different materials like fluids , soft tissues and solids. It has a frequency higher than auditory limit of 20 kHz, Ultrasound frequency is defined as the number of ultrasound waves per second ,the velocity of ultrasound in a specific medium equals the frequency of ultrasound multiplied by its wave length ,there are different method that control the way ultrasound waves are emitted from the ultrasound transducers they can be either interrupted or continues , interrupted emission generates brightness (B) mode images while continues emission generates Doppler mode ,imaging one line over time is called the moving mode (M mode),changing the frequency of ultrasound waves will control the penetration and resolution of the images .(Fikri et al,2011).

2.4.2 Ultrasound machine

medical ultrasound machine generate and receive ultrasound waves brightness mode is the basic mode that is usually used ,ultrasound waves are emitted from piezoelectric crystals of the ultrasound transducer depending on the acoustic impedance of different materials, which depends on their density, there are different methods that can control the quality of ultrasound waves including timing of ultrasound wave

emission, frequency of waves ,the received ultrasound signal can be amplified by increasing the gain ,the operator should know sonographic artifacts which may distort the studied structures or even show un real ones probes of low frequencies should be used for deep structures while probes of high frequencies should be used for superficial structures ,ultrasound waves are emitted perpendicular to the surface of the transducer, it is possible to widen the deep sonographic field by bending the surface of the transducer (convex array transducer),waves will be parallel to each other when the probe surface is flat (linear array transducer) ,linear array transducers usually have high frequencies (10-12MHz),less penetration and excellent resolution.(Fikri et al,2011).

2.1.5 Normal sonography

2.1.5.1splenic measurement

The size of a normal spleen depends on gender, age, and body-height. However, the length of the spleen is an adequate indicator of size for most purposes and provides a useful baseline for monitoring changes in disease status".

The wide range of what a normal sized adult spleen is, combined with its complex three dimensional shape makes it particularly difficult to establish a normal range of sonographic measurements. Nonetheless, a study of almost 800 normal adults found that in 95% of patients, the length of the spleen was less than 12 cm, the breadth less than 7 cm and the thickness less than 5 cm .(Denis et al, 2005).

2.1.5.2 Scanning Technique

The long axis of the spleen lies along the tenth rib. Remember that the posterior aspect of any given rib is higher than its anterior aspect. This means that the posterior extremity of the spleen will be higher than its anterior extremity. Most authors suggest that the patient be scanned in the right lateral decubitus (left side up) position and that the left tenth or

eleventh intercostal spaces be used as access to the spleen. You will be scanning in the left coronal plane and should be able to achieve a long axis scan and by turning the transducer ninety degrees, a short axis scan. A 5 MHz medium length transducer may be used since the spleen is a poorly attenuating structure located just behind the ribs. Sector scanners are easiest for intercostal work but many prefer the image from a curvilinear transducer, in spite of the larger transducer face, a modest inspiration will depress the diaphragm and spleen inferiorly so they can be visualized. The lower ribs may be elevated by having the patient raise the left arm over their head. Greater access may be achieved by inserting a pillow between the waist and the table. (Denis et al, 2005).

2.1.5.3 Sonographic Appearances

The splenic parenchyma is extremely homogeneous and therefore the spleen has a uniform mid to low level echogenicity. The echogenicity is usually slightly greater than that of the normal liver and higher than that of the normal renal cortex. In Longitudinal scan, the diaphragm will be at the head end of the patient; in transverse scans, a portion of diaphragm will be on the patient's left. (Denis et al, 2005).

2.2 Previous Studies:

This study in north Indian adults established normal splenic measurement in 150 adult subjects (78 males and 72 females, ages 18 to 76 years) using ultrasonography The mean values of the age, height, weight and body mass index (BMI) of subjects, spleen width (SW), spleen length (SL), spleen thickness (ST) and spleen volume .

These measurements were found to be 36.37±10.83 years, 164.22±4.72 cm, 60.26±7.11 kg, 22.30±2.09 kg/m2, 7.58±1.56 cm, 9.87±1.28 cm, and 3.34±0.79 cm and 136.05±61.14 cm3 in females respectively. Additionally, in males same dimensions were 40.50±12.77 years, 174.41±6.57 cm, 76.33±8.54 kg, 25.06±2.10 kg/m2, 8.75±1.84 cm, 11.01±1.186 cm, 4.12±1.09 cm and 220.70±115.35 cm3 respectively (Narora et al.2010).

Another study in trukish adults established normal splenic measurement in 160 subjects (80 males & 80 females) in age between 20 and 60 years. they found that spleen length,weight and thickness were decreased in increase in age with all parameters greater in males than in female and all dimension are greater in male than in female. (celiktas.m et al.2015).

Another study established normal spleen dimensions using ultrasound in 400 Nigerian adults, There were 212 males and 188 females, their age ranged between 20 and 70 years. The mean age of the subjects and (±standard deviation) were 33.0 years (±12.0), mean height was 1.64 m (±0.1) and mean weight was 61.4 kg (±11.0). The mean splenic length, width and depth for the subjects studied were 101.6 mm (±13.7), 46.8 mm (±8.2), and 86.8 mm (±12.7), respectively, There was positive correlation between subjects height and weight with splenic length ($P < 0.001$ and $P < 0.001$), depth ($P < 0.01$ and $P < 0.001$) and width ($P < 0.01$ and $P < 0.001$).(MAYahuza et al.2016).

Furthermore study in a healthy collegiate athletic in Americans found that the Mean splenic length was 10.65 (1.55) cm and width, 5.16 (1.21) cm. Men had larger spleens than women ($p<0.001$).(Hosey ,2006).

Chapter three

Materials and methods

Chapter three

Materials and Methods

3. Methodology

3.1types of the study

Cross –sectional descriptive study

3.2 population of the study

Male and female with different age, selected randomly from relatives, friends and colleagues.

3.3 sample size

Adult subjects of age ranged between 20 and 70 Years.

3.4 Exclusion Criteria:

Those excluded from the study included subjects with age younger than 20 years, history of splenic resection or prolonged febrile illness, infection, congestion (portal hypertension, splenic vein thrombosis, congestive heart failure), hematological disorder that may compromise the splenic size such as sickle cell disease, chronic renal disease, chronic liver disease, focal lesions, or any known malignancy and also pregnant women.

3.5 Area of the study:

This study was conducted at Elmutakamil medical group, Khartoum state.

3.6 Duration of the study:

This study was conducted during the period from May to August 2016.

3.7Materials:

All studies were obtained with high resolution ultrasound machine (Medison sonoacex8 ultrasound system).

3-8 Data collection

The data collected by using data collecting sheet it is designed to cover the gender ,age ,height, weight and body mass index of subject .

3-9 Technique

The measurement of the spleen made during deep inspiration with patient in right lateral decubitus, scanning obtained in the left coronal plane for long axis scan and by turning the transducer ninety degrees for a short axis scan.

The measurement is length: by measuring the longest dimension in a sagittal, parasagittal or coronal plane. 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: on a transverse scan the width is measured as the greatest dimension perpendicular to the thickness, The splenic volume (SV) was calculated manually by using the standard clinical prolate ellipsoid equation for spleen [0.524 × splenic index (length × width × thickness)].

3-10 Data analysis

Data were analyzed using SPSS statistical program for significance of tests.

Chapter four

Result

Chapter four

Result

The following tables presented the data obtained from 60 patients who were examined using ultrasonography. The spleen length, width , thickness and volume were measured. Patient's age, weight, height and body mass index (BMI) were also measured.

Table (4.1) show distributions of (length, depth, width and volume) with respect to gender:

	gender	Mean	Std. Deviation
Length	Male	10.2955	1.15882
	female	9.2194	.92981
Depth	Male	3.8793	.60379
	female	3.5755	.58638
Width	Male	3.28	.426
	female	3.06	.265
volume	Male	7.32573	23.100531
	female	5.65242	18.015511

Table (4.2): show t-test for Equality of Means of two groups (male and female):

	T	Sig. (2-tailed)
length	3.980	.000
Depth	1.977	.053
Width	2.361	.022
volume	3.140	.003

Table (4.3) show distributions of (length, depth, width and volume) with respect to age:

		N	Mean	Std. Deviation
Length	20-30 Years	23	9.7043	1.10141
	31-40 Years	19	9.5205	1.10454
	41-50 Years	9	10.0978	0.95971
	More than 60 Years	9	9.9333	1.67481
	Total	60	9.7395	1.17090
Depth	20-30 Years	23	3.7591	0.70666
	31-40 Years	19	3.5132	0.42093
	41-50 Years	9	4.0144	0.32730
	More than 60 Years	9	3.7778	0.80743
	Total	60	3.7223	0.60933
Width	20-30 Years	23	3.10	0.371
	31-40 Years	19	3.22	0.318
	41-50 Years	9	3.27	0.452
	More than 60 Years	9	3.11	0.379
	Total	60	3.17	0.366
Volume	20-30 Years	23	6.65076	24.263889
	31-40 Years	19	5.62677	15.173216
	41-50 Years	9	7.53102	18.017640
	More than 60 Years	9	6.66843	28.952914
	Total	60	6.46119	22.122087

Table (4.4): show ANOVA table for difference between age groups in (length, depth, width and volume):

		Sum of Squares	F	Sig.
Length	Between Groups	2.433	.579	0.631
	Within Groups	78.457		
	Total	80.889		
Depth	Between Groups	1.658	1.529	0.217
	Within Groups	20.248		
	Total	21.906		
Width	Between Groups	.255	0.623	0.603
	Within Groups	7.638		
	Total	7.893		
Volume	Between Groups	2474.290	1.750	0.167
	Within Groups	26399.528		
	Total	28873.818		

Table (4.5) Measure of effect of height to spleen length and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-2.248	3.884		-.579	.565
Height	.072	.023	.376	3.088	.003

R	R Square
.376	.141

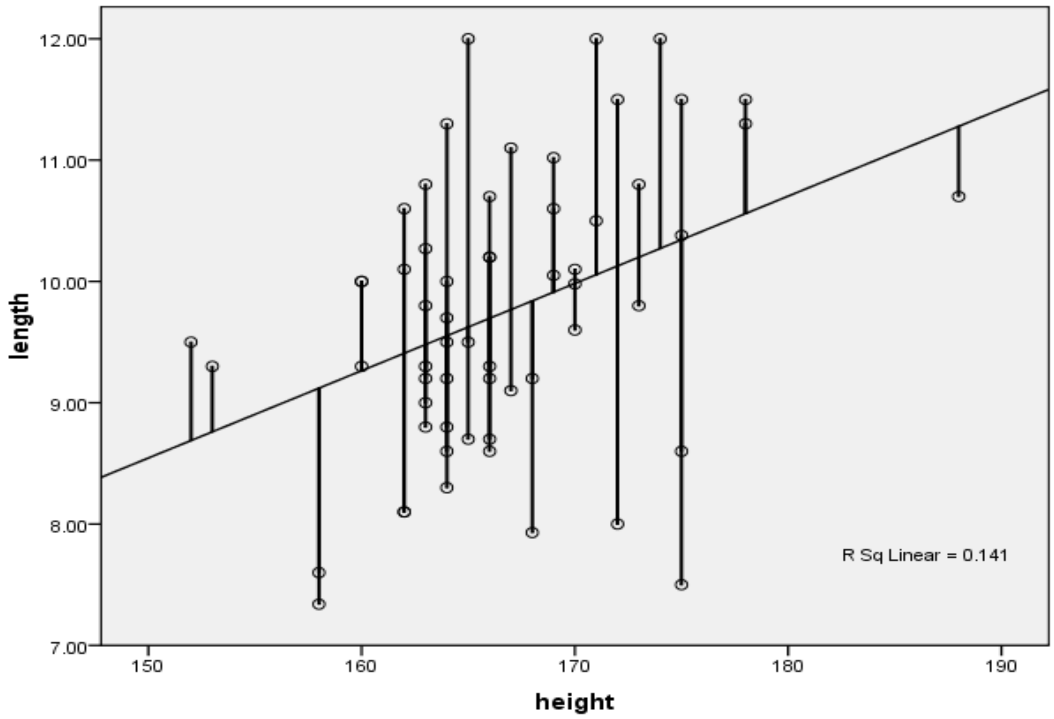


Figure 4-1 shows correlation between spleen length and body height

Table (4.6) Measure of effect of weight to spleen length and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	7.866	.826		9.518	.000
Weight	.027	.012	.289	2.303	.025

R	R Square
.289	.084

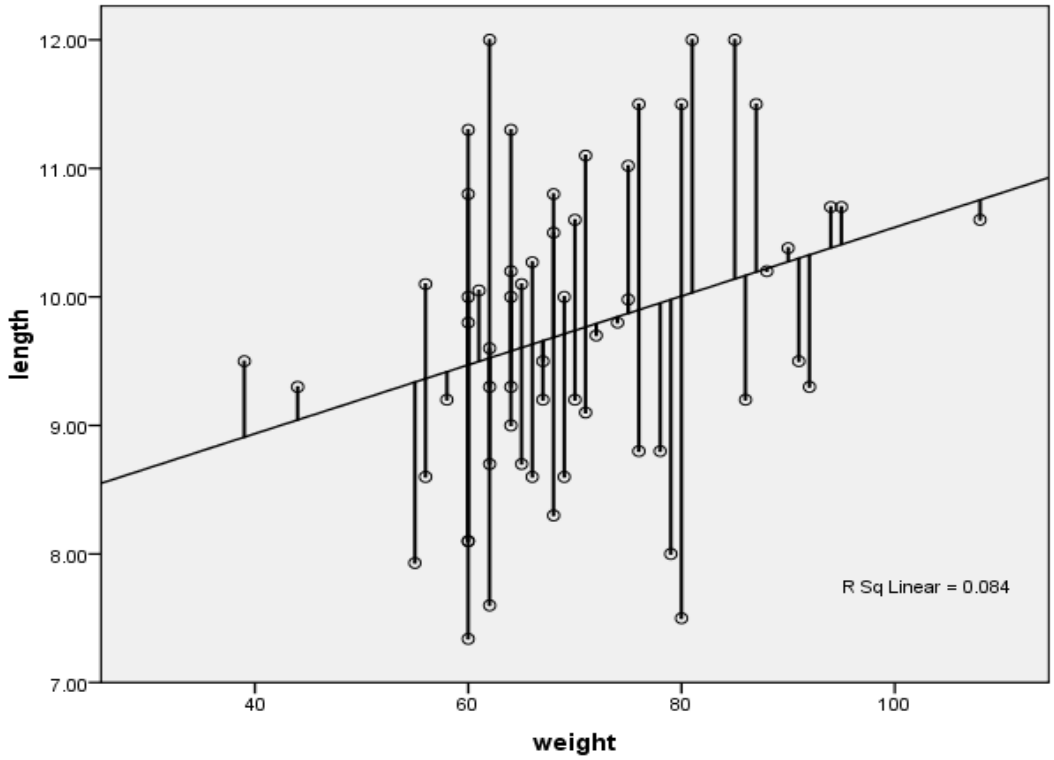


Figure 4-2 shows correlation between spleen length and body weight.

Table (4.7) Measure of effect of BMI to length and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	8.999	.920		9.780	.000
BMI	.030	.037	.107	.816	.418

R	R Square
.107	.011

Table (4.8) Measure of effect of height to spleen depth and model coefficients test

Model		Un-standardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
	(Constant)	-2.478	2.023		-1.225	.226
	Height	.037	.012	.374	3.067	.003

R	R Square
.374	.140

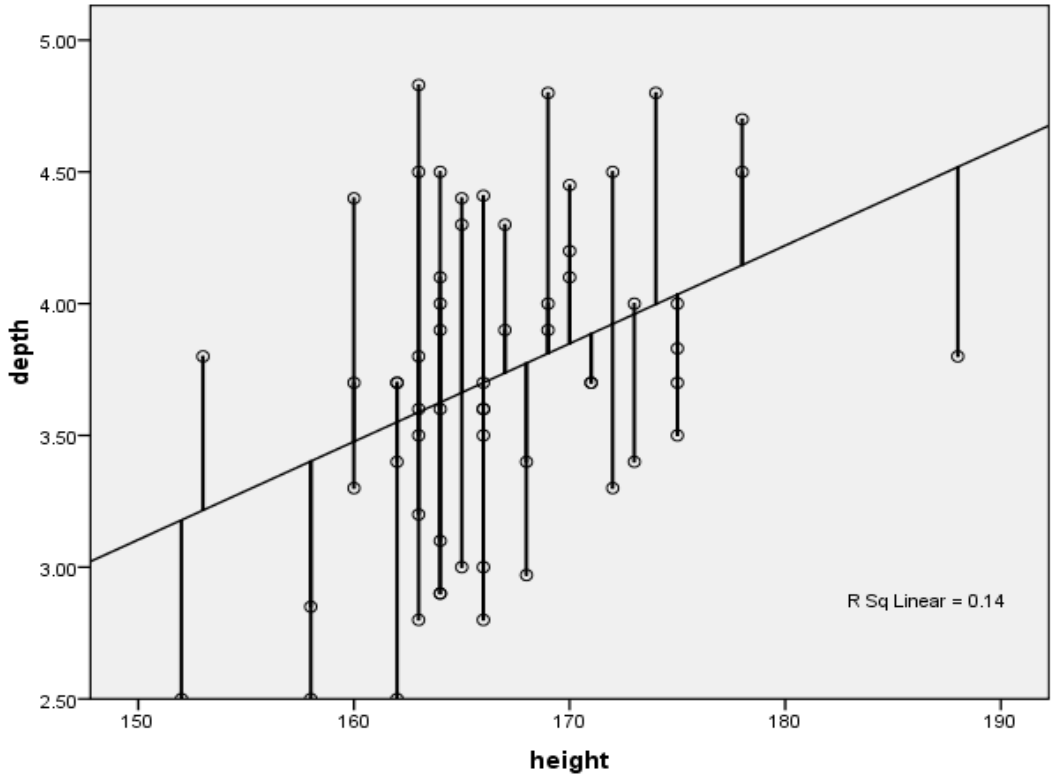


Figure 4-3 shows correlation between spleen depth and body height.

Table (4.9) Measure of effect of weight to spleen depth and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	3.211	.444		7.230	.000
Weight	.007	.006	.152	1.170	.247

R	R Square
.152	.023

Table (4.10) Measure of effect of BMI to spleen depth ("and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	3.512	.481		7.304	.000
BMI	.008	.019	.058	.444	.658

R	R Square
.058	.003

Table (4.11) Measure of effect of height to spleen width and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1.671	1.294		1.291	.202
Height	.009	.008	.150	1.155	.253

R	R Square
.150	.022

Table (4.12) Measure of effect of weight to spleen width and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.276	.269		12.167	.000
Weight	-.002	.004	-.055	-.420	.676

R	R Square
.055	.003

Table (4.13) Measure of effect of BMI to spleen width and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	3.269	.289		11.320	.000
BMI	-.004	.011	-.048	-.363	.718

R	R Square
.048	.002

Table (4.14) Measure of effect of height to spleen volume and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	185.130	72.069		-2.569	.013
Height	1.499	.432	.414	3.468	.001

R	R Square
.414	.172

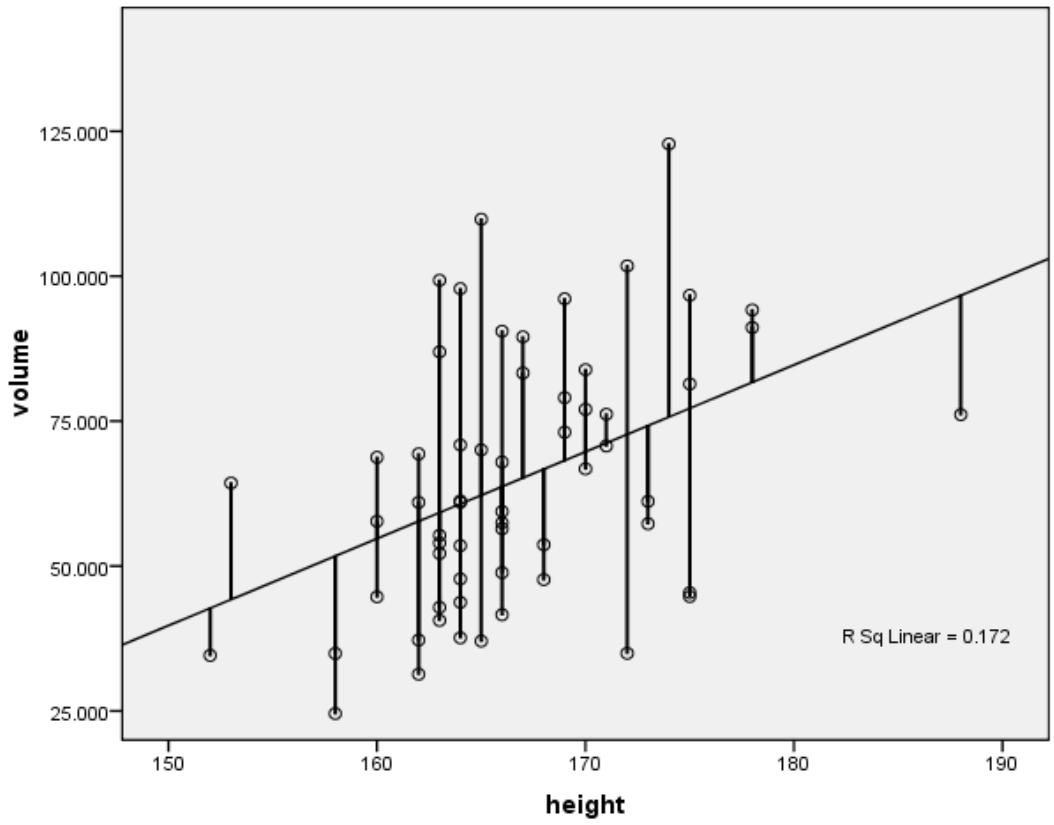


Figure 4-4 shows correlation between spleen volume and body height.

Table (4.15) Measure of effect of weight to spleen volume and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	41.116	16.008		2.568	.013
Weight	.336	.225	.192	1.491	.141

R	R Square
.192	.037

Table (4.16) Measure of effect of BMI to spleen volume and model coefficients test:

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	56.823	17.453		3.256	.002
BMI	.314	.694	.059	.452	.653

R	R Square
.059	.004

Table (4-17) Pair wisely correlation coefficients between (height, weight and BMI) and (length, depth, width and volume) with respect to gender:

Gender			length	depth	width	volume
Male	height	Pearson Correlation	.452	.339	.137	.411
		Sig. (2-tailed)	.014	.072	.480	.027
		N	29	29	29	29
	weight	Pearson Correlation	.405	.028	-.085	.258
		Sig. (2-tailed)	.029	.886	.662	.176
		N	29	29	29	29
	BMI	Pearson Correlation	.171	-.160	-.088	.079
		Sig. (2-tailed)	.375	.408	.649	.684
		N	29	29	29	29
Female	height	Pearson Correlation	-.032	.286	-.112	.190
		Sig. (2-tailed)	.864	.119	.547	.305
		N	31	31	31	31
	weight	Pearson Correlation	.312	.252	-.030	.201
		Sig. (2-tailed)	.088	.171	.871	.277
		N	31	31	31	31
	BMI	Pearson Correlation	.248	.241	.063	.178
		Sig. (2-tailed)	.179	.192	.735	.338
		N	31	31	31	31

Chapter five

Discussion, conclusion and Recommendation

Chapter five

Discussion, conclusion and Recommendation

5-1 Discussion

In this study 60 subjects from(20-70years).male 29 (48٪)and female31 (51٪) were examined using ultrasound ,the mean values for body characteristic height ,weight and BMI are 168.9±6.3 ,69.8±9.9 ,24.6±2.8 and 164.5± 5.2 ,70.2±14.9 ,25.9±5.0 for male and female respectively. We found that The mean value of SL,SW,ST are 10.3±1.2 ,3.3±0.4 ,3.9±0.6 and 9.2±0.9 ,3.1±0.3 ,3.6±0.6cm for male and female respectively. Spleen length in this study within match study in African-Americans (Hosey ,2006), Splenic volume is calculated using with standard ellipsoid formula (0.524 x width x length x thickness),is 73.3±23.1and 56.5±18.0cm3 for male and female respectively table 4-1.

In this study we found that there were statistically significant differences between males and females in (length, width and volume) and non-significant differences between male and female in (depth) the means of (length, depth, width and volume) are, (10.2955, 9.2194), (3.8793, 3.5755), (3.28, 3.06), (7.32573, 5.65242) for Male and Female respectively ,with corresponding significance values of t-tests (0.000 , 0.053 , 0.022 , 0.003) which implies that the men had larger spleen than female in relation of spleen to gender, this match with (Narora et al.2010,Mayahuza et al.2016, Hosey,2006) table 4.2.

The study showed that in relation of spleen to age, the age groups were relatively the same in (length, depth, width and volume), The Sig. values are 0.631, 0.217, 0.603 and 0.167 for (length, depth, width and volume) which indicates there is no differences in means this mismatch the

previous study Celiktas.m et al.2015, Narora et al.2010 ,may be due to small sample size in this study table 4.3.

We found that there is significant correlation between spleen length, height, weight and non-significant correlation with body mass index ,sig values were 0.003 ,025 and 0.418 respectively table 4-5.4-6.4-7.

This study showed that there was significant correlation between spleen depth and height and non-significant correlation with weight and BMI with depth, the sig values were 0.003,0247 and 0.658 respectively table 4-8.4-9.4-10.

The study showed that there was non-significant correlation between spleen width with height, weight and BMI, the significant values were o.253, 0.676 and 0.718 respectively table 4-11.4-12.4-13.

Furthermore there were significant correlation between spleen volume and height and non-significant correlation with weight and BMI, the sig values were 0.001and 0.141, 0.653 respectively table 4-14.4-15.4-16.

5.2 conclusion

The study concluded that the Sudanese men had larger spleen than female the mean of normal spleen dimensions was found to be .3±1.2 ,3.3±0.4 ,3.9±0.6 and 9.2±0.9 ,3.1±0.3 ,3.6±0.6 for male and female respectively, spleen volume for both male and female are 73.3±23.1and 56.5±18.0cm³.
The spleen dimensions were significantly correlates with subject height and weight, SL significantly correlates with subject height and weight, while the depth just significantly correlates with subject height.
We can predict splenic dimension for subject from body characteristic by this equation

Spleen length = (height× 0.072) + (Weight × 0.027)+ (BMI × 0.03).

Spleen width = (height× is 0.009) +(weigh× 0.002) + (BMI × 0.004) .

Spleen depth = (Height × 0.37) +(weight× 0.007) + (BMI × 0.008).

Spleen volume = (Height × 1.499) +(weight× 0.336) + (BMI × 0.314).

The Sudanese spleen dimensions are greater in male than female its same as Turkish , north Indian and Americans adults but they were different in correlation to age ,they were decreased with increase in age and no significant correlation in Sudanese with age .

5.3 Recommendations

Using of other imaging modalities like computed tomography and magnetic resonance imaging is recommended to confirm the results.

More study and researches are needed with spleen texture, position in consideration for more reliable result.

More study and researches are needed using Doppler for blood perfusion and its relation with spleen size to obtain accurate results.

Further study in measurement of spleen dimension and spleen volume with larger sample of Sudanese population for more accurate results is needed.

References

Anthony J. Bowdler, MD, PhD (2002), the Complete Spleen: Structure, Function, and Clinical Disorders. 2 ed. Springer Science + Business Media New York.

Celiktas.M, ozandac .S Goker,p .& Bokkir,M,G , Sonographic determination of normal spleen size in Turkish adults. *Int. J. Morphol.*, ***33(4)***:1401-1405, 2015.

Carol,M.R,stephaine,R,W.,J.william.C.,Deborah,L.,.2011,diagnostic ultrasound,4th edition, *Patricia Tannian,united states of America.*

Dhingra, B.; Sharma, S.; Mishra, D.; Kumari, R.; Pandey, R.M. & Aggarwal, S. Normal values of liver and spleen size by ultrasonography in Indian children. *Indian Pediatr., 47(6)*:487-92, 2010.

Danila, M. The ultrasound examination of the spleen. *Med. Ultrason., 12(3)*:253-4, 2010.

Denis gratton et al.the burwin institute of diagnostic ultrasound .abdominal ultrasound ,burwin institute,Canada,2005

De Odorico, I.; Spaulding, K. A.; Pretorius, D. H.; Lev-Toaff, A. S.; Bailey, T. B. & Nelson, T. R. Normal splenic volumes estimated using three-dimensional ultrasonography. *J. Ultrasound Med., 18(3)*:231-6, 1999.

Ehimwenma, O. & Tagbo, M. T. Determination of normal dimension of the spleen by ultrasound in an endemic tropical environment. *Niger. Med. J., 52(3)*:198-203, 2011.

Fikri m,ashraf f,clinical ultrasound phYearsics, journal of emergencies, trauma and shock oct-dec;4(4): 501-503.2011.

Henry Gray (2000), Anatomy of the Human Body 2 ed. Philadelphia: LEA & Febiger pp. 1821-1865.

Hosey, R. G.; Mattacola, C. G.; Kriss, V.; Armsey, T.; Quarles,J. D. & Jagger, J. Ultrasound assessment of spleen sizein collegiate athletes. *Br. J. Sports Med., 40(3)*:251-4, 2006.

Narora ,p.k .sharma,A.sahai,R.singh.sonographic measurement of the spleen in relation to age aprospective study in north Indian adults.J.Anat.soc.india.59(2)177-181 2010.

Spielmann, A. L.; DeLong, D. M. & Kliewer, M. A. Sonographic evaluation of spleen size in tall healthy athletes. *AJR Am. J. Roentgenol., 184(1)*:45-9, 2005.

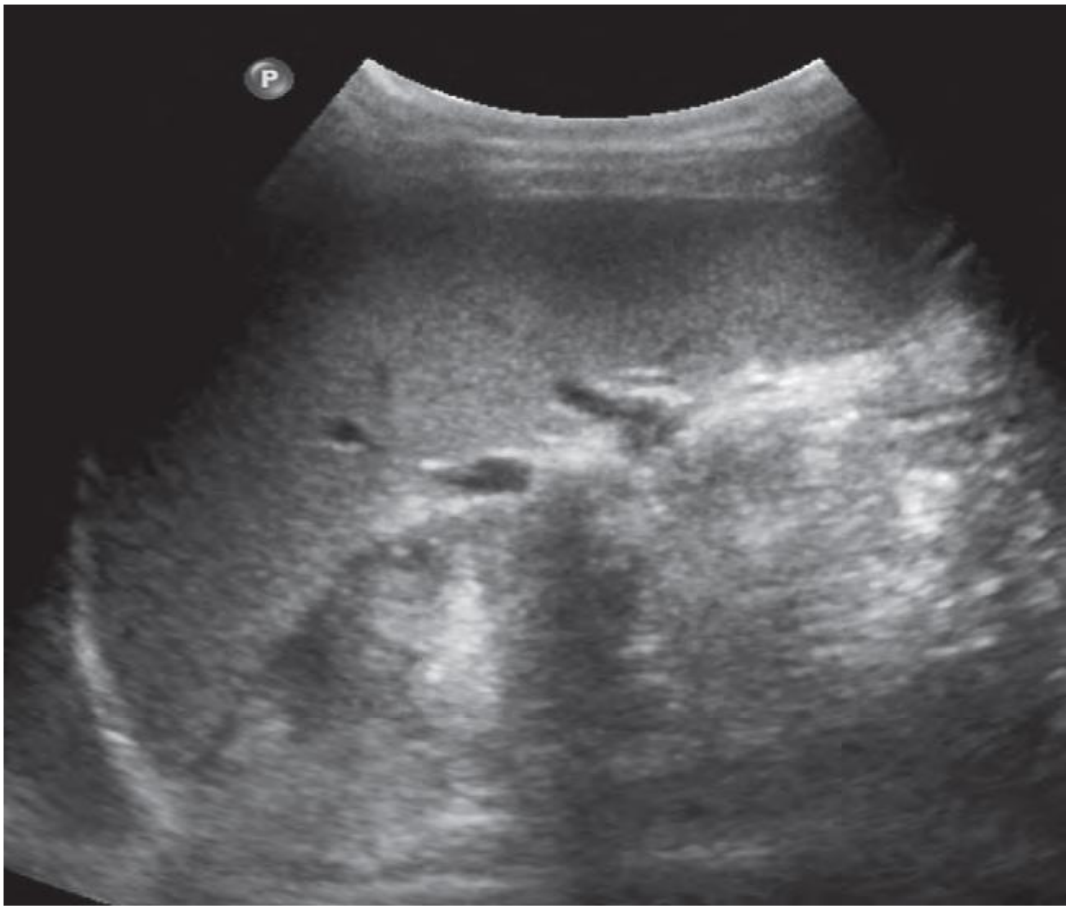
APPENDICES

Appendix 1

Data Collection Sheet:

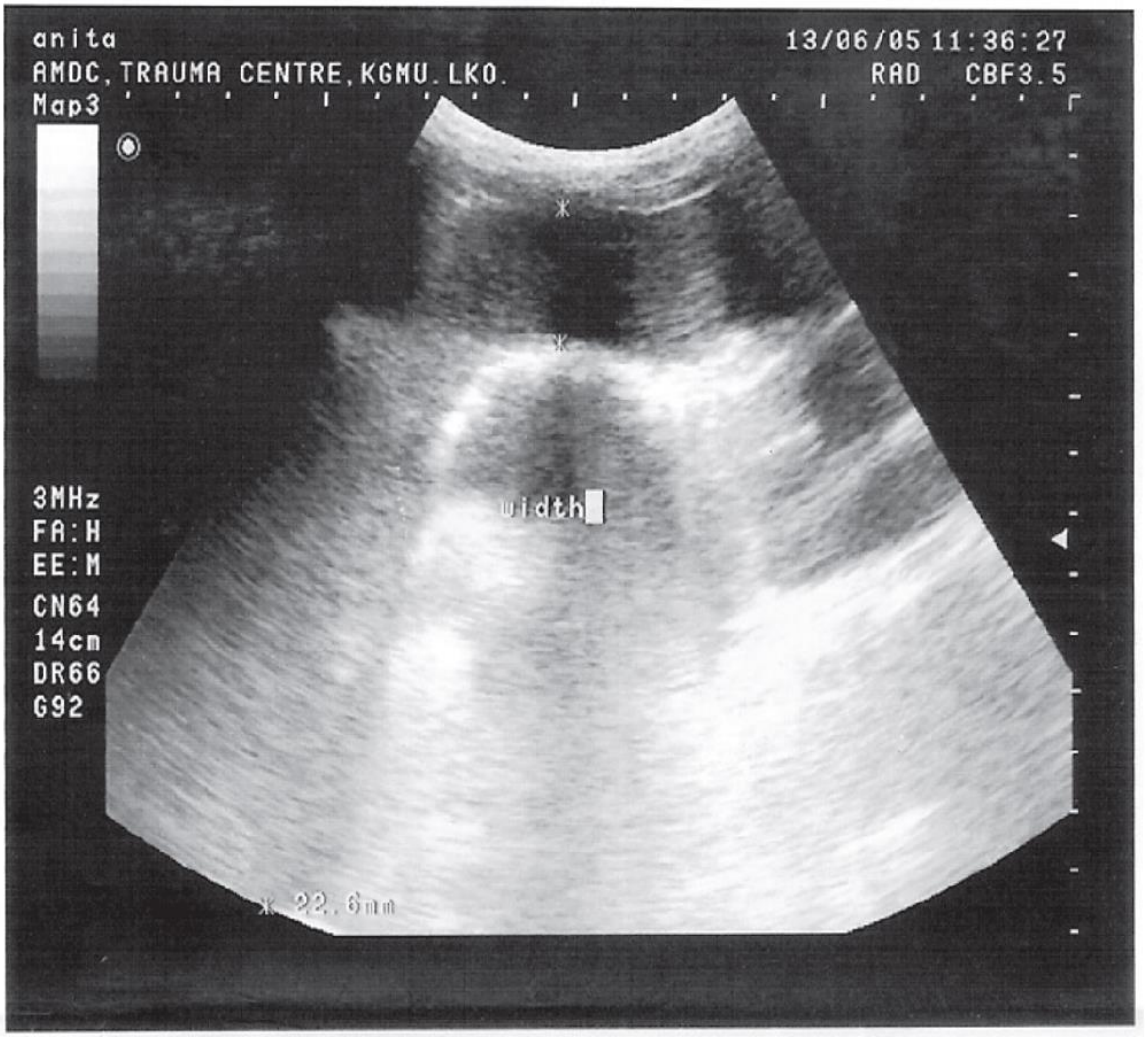
No.	Gender	Age	height	weight	BMI	SL	SW	ST	SV	No pathology

Images for explanation



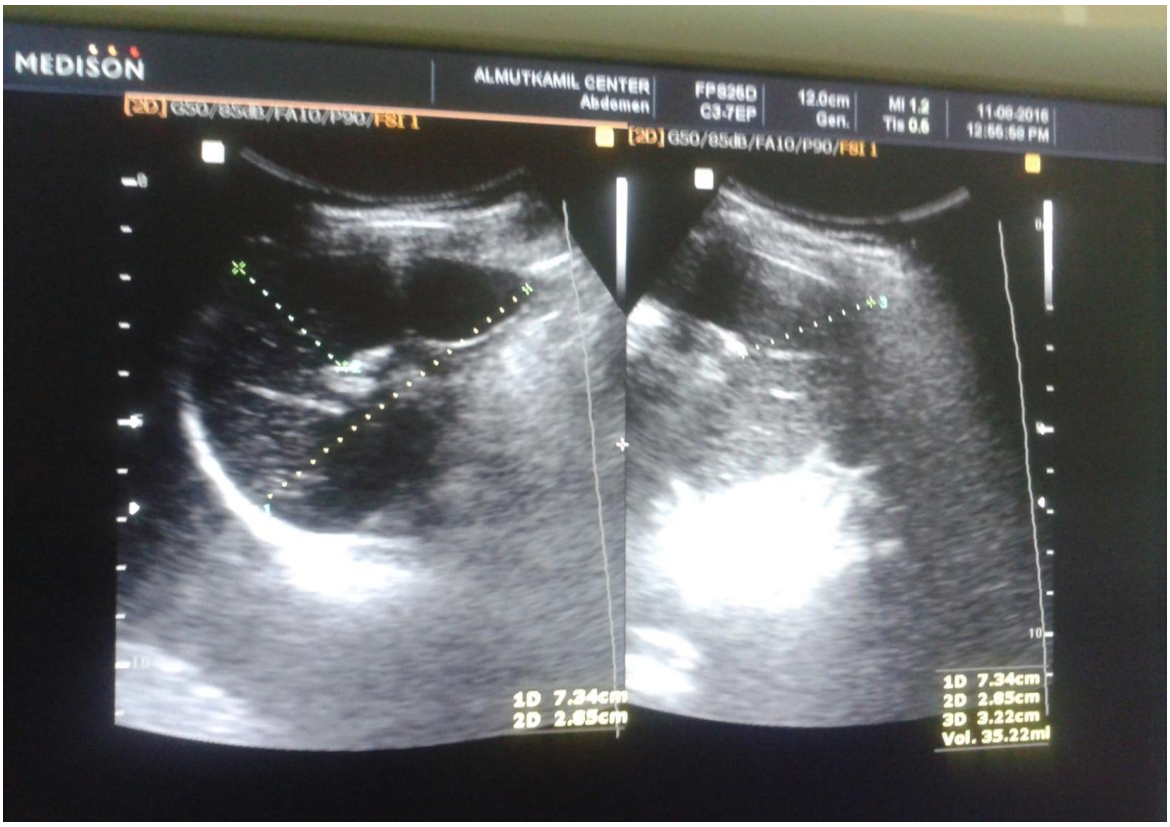
Img NO 1 Normal echogencity of spleen (carol, 2011)

Img NO 2 measurement of of Splenic Length (L) & Splenic Thickness (T)., j.anat.soc.india59(217-1817)(2010).



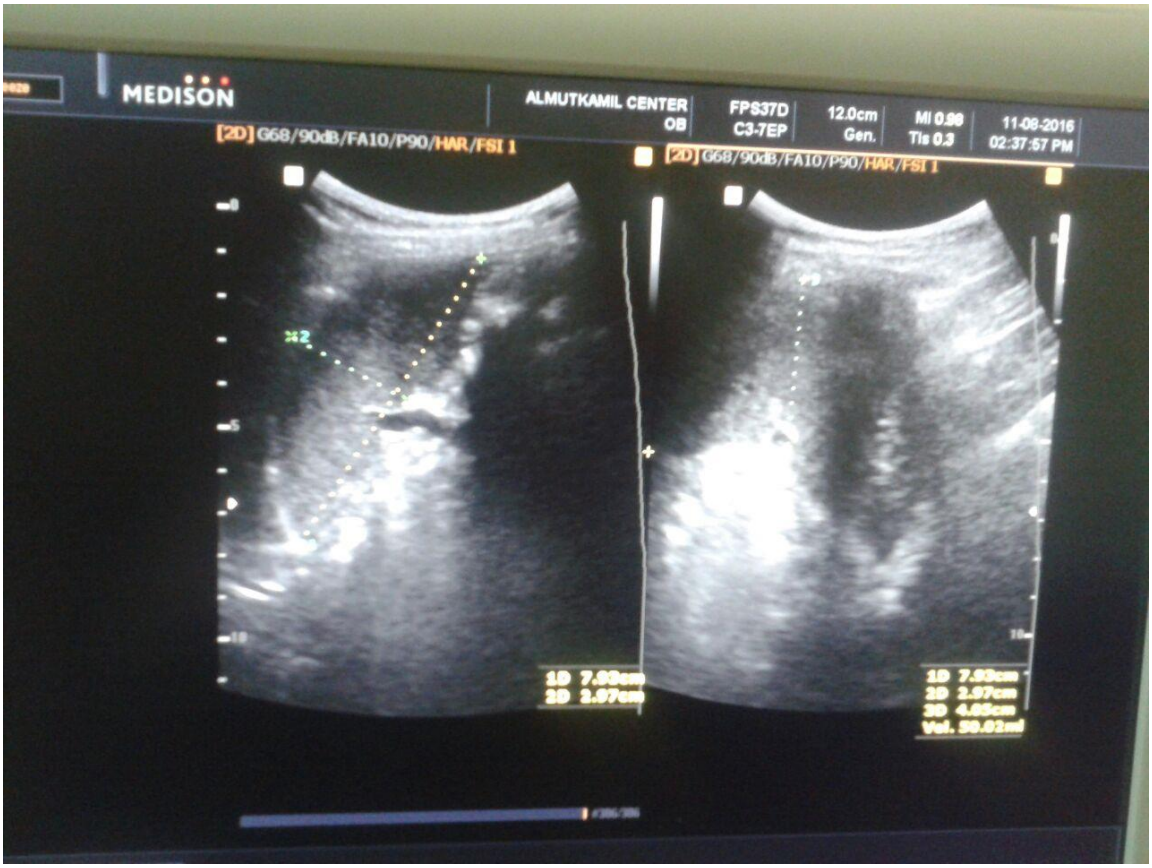
Img NO 3 show measurement of Splenic Width (W).)., j.anat.soc.india59(2)177-181(2010) .

Appendix 2

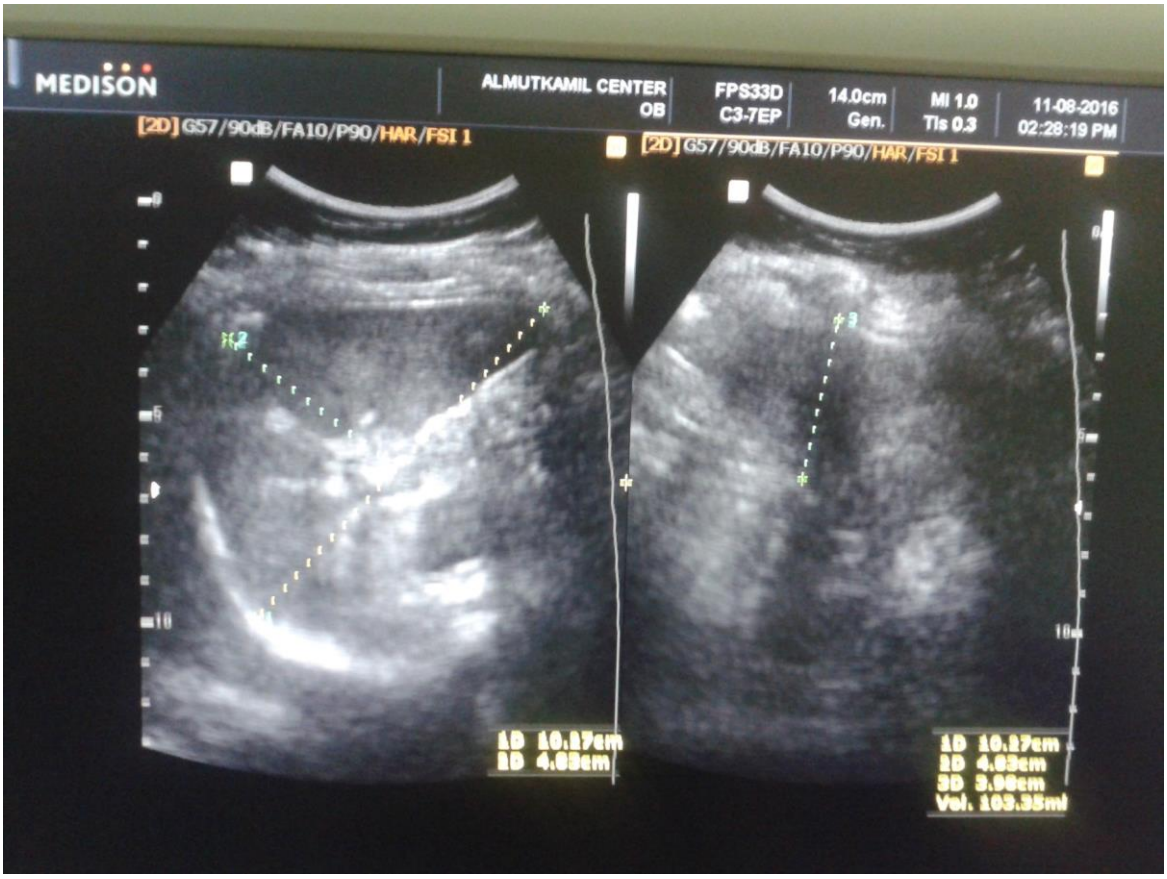


Img NO 4 Trans abdominal ultrasound image show measurement of spleen dimensions and volume for 35 years female with subject in right lateral decubitus

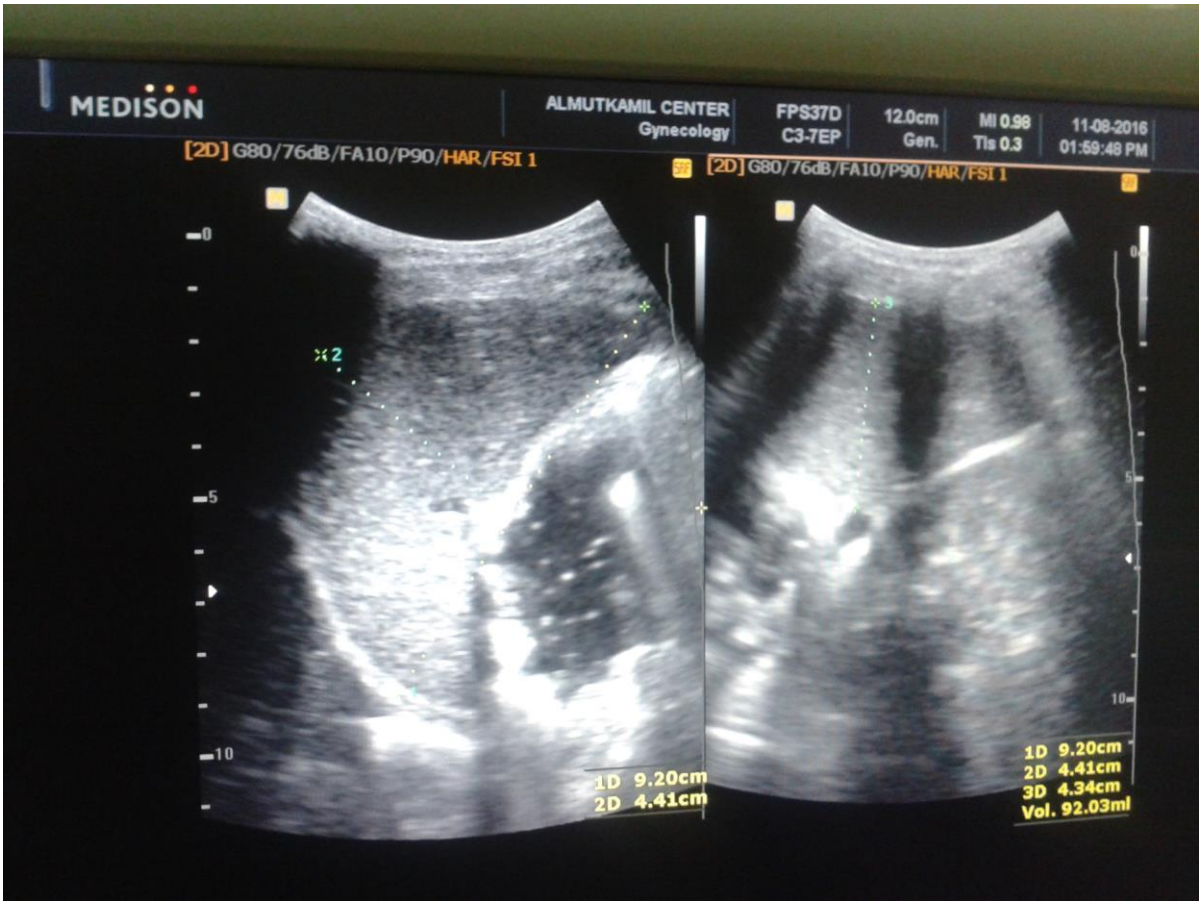
Img NO 5 Trans abdominal ultrasound image show measurement of spleen dimensions and volume for 26 years female with subject in right lateral decubitus



Img NO 6 Trans abdominal ultrasound image show measurement of spleen dimensions and volume for 70 years male with subject in right lateral decubitus



Img NO 7 trans abdominal ultrasound image show measurement of spleen dimensions and volume for 26 years male with subject in right lateral decubitus



Img NO 8 Trans abdominal ultrasound image show measurement of spleen dimensions and volume for 30 years female with subject in right lateral decubitus