

# Chapter One

## Introduction

### 1.1 preludes

Spleen is largest organ in the reticulo-endothelial system and graveyard RBC's. Its response to different pathological status (infection) and geographic change palpation and percussion are standard bedside techniques to document spleen size but they were far from accurate to detect small increase in size so it is clinically useful method of measuring spleen.[ashwin-2011]

The spleen is situated principally in the left hypochondriac region, however; its superior extremity extends into the epigastric region. It also lies between the fundus of the stomach and the diaphragm. The spleen is considered 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. In addition, the spleen is highly vascular and reddish purple; its size and weight are variable. Moreover, a normal spleen is not palpable. The spleen is a functionally complex organ. It is an intraperitoneal organ weighing 75-100 g in the adult.

The spleen is the most vascular organ of the body, and approximately 350 L of blood passes through it per day. The spleen contains approximately 1 unit of blood at a given time. .[ashwin-2011]

The human spleen also creates lymphocytes for the destruction, recycling of old red-blood cells, a blood reservoir, supplies the body with blood in emergencies such as a bad cut, and also the location where white blood cells trap organisms.

The size of the spleen may be roughly estimated on the plain film, especially if the organ is enlarged, [calcified](#) lesions such as granulomas or [cyst](#) walls.

US give good information on the shape and size of the spleen and on any [pathological](#) changes that may be present either hypo- or hyper-echogenicity.

The best images of the spleen are obtained by [CT](#), which also gives information on any [calcification](#) present, e.g. in granulomas or [cyst](#) walls and allows precise measurement of splenic size. [Pathological](#) changes are seen as on US but often with greater clarity, especially after iv contrast infusion.

On MRI [diffuse](#) infiltrates such as occur, for instance, in [lymphoma](#), may be seen more clearly than on US and [CT](#), but essentially [MRI](#) and [CT](#) are of equal value. The free choice of imaging [plane](#) may be one advantage offered by [MRI](#).

Localized changes, such as tumors can be shown by [radionuclide](#) imaging, though the [specificity](#) and spatial [resolution](#) of the technique are inferior to US and [CT](#).

Images of splenic function may be obtained with autologous radio labelled blood cells.

Angiography is not often used for diagnostic purposes (except in acute bleeding) but may be used as a step in embolizing the spleen or splenic [artery](#) in the treatment of hypersplenism, [trauma](#) or [aneurysm](#). [David Standertskjold-Nordenstam 2008]]

## **1.2problem:**

The variation in the anthropometric feature of various population races and region of the zone and socioeconomic status of the Sudan make the population of this region was ignored [there is no previous studies] .so there is no comprehensive anthropometric study on the normal measurement of spleen and therefore it was thought pertinent to undertake present study to evaluate The normal measurement of spleen in adult Sudanese population.

The size of spleen in adult Sudanese compared to international index and since the organ measurement usually affected by body characteristic this might lead to wrong diagnosis therefore there is need to compare this measurement to the body characteristic and hence we can have our own index

### **1.3 objectives**

General objective of this study is: To evaluate normal spleen measurement in adult Sudanese using ct in order to find new index for Sudanese.

Specific objective is to:-

- Measure spleen (length, width & volume)
- To correlate spleen measurement (age, height & weight)
- To Compare the spleen measurement with other population
- To study the variable between male and female measurement.

### **1.4 significance of study:**

This study provides a good information about Sudanese splenic measurement & hence it can be used as a guide line to proper Sudanese index.

### **1.5 overview of study**

This study will consist of five chapters, Chapter one deal with the introduction Chapter two includes the theoretical back ground and the previous studies, Chapter three detailed the materials and methods then Chapter four presents the results and Chapter five presents the discussion, conclusion and recommendations

## Chapter Two

### Literatures review

#### 2.1 Anatomy

The spleen has 2 ends, 3 borders, and 2 surfaces, as follows:

The 2 ends: The anterior end of the spleen is expanded and more like a border; it is directed forward and downward to reach the maxillary line. The posterior end is rounded; it is directed upward and backward and rests on the upper pole of the left kidney. [Ashwin pai 2011]

The 2 surfaces: diaphragmatic and visceral.

The diaphragmatic surface (facies diaphragmatica; external or phrenic surface) which is convex, smooth, and is directed upward, backward, and to the left, except at its upper end, where it is directed slightly medialward. 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, and the intervening lower border of the left lung and pleura. . [Ashwin pai 2011]

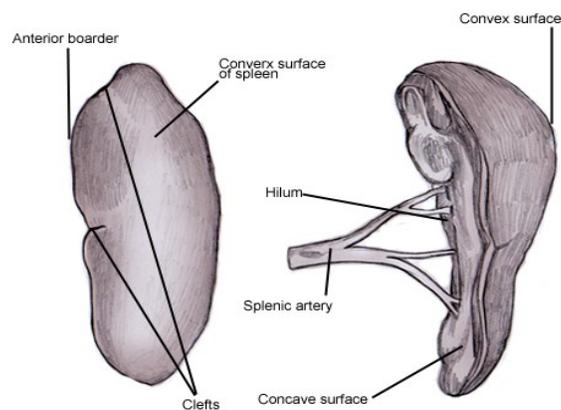


Figure 2.1 The surfaces and the splenic notches. . [Ashwin pai 2011]

The visceral surface is divided by a ridge into an anterior or gastric and a posterior or renal portion

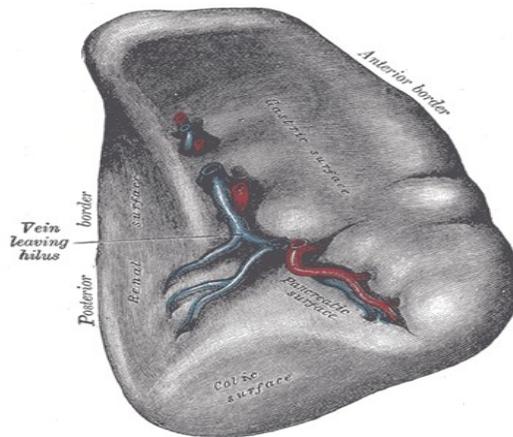


Figure 2.2 The visceral surface of the spleen. [Ashwin pai 2011]

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. Near its medial border Presented a long fissure termed the hilum. This is pierced by several irregular apertures for the entrance and exit of vessels and nerves. [Lewis 1918]

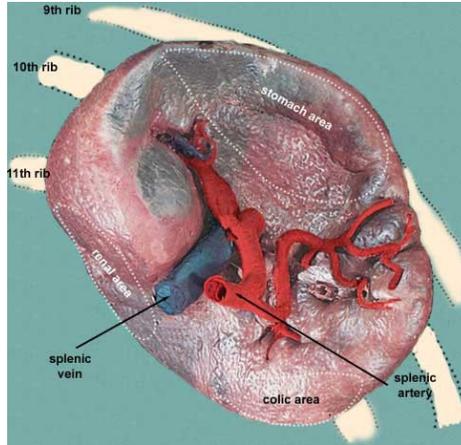


Figure 2.3 The gastric surface of the spleen[Lewis 1918]

The renal surface (facies renalis) 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. [grey's anatomy-yahoo Education].

The 3 borders: 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[Lewis 1918]

### **2.1.1 The Peritoneal relations:**

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 . The other fold, the gastrosplenic ligament, is also formed of two layers, derived from the general cavity and the omental respectively, where they meet between the spleen and stomach 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 phrenicocolicligament. The splenorenal ligament: This ligament extends from the hilum of the spleen to the anterior surface of the left kidney; it contains the tail of the pancreas and splenic vessels[Ashwin 2011]

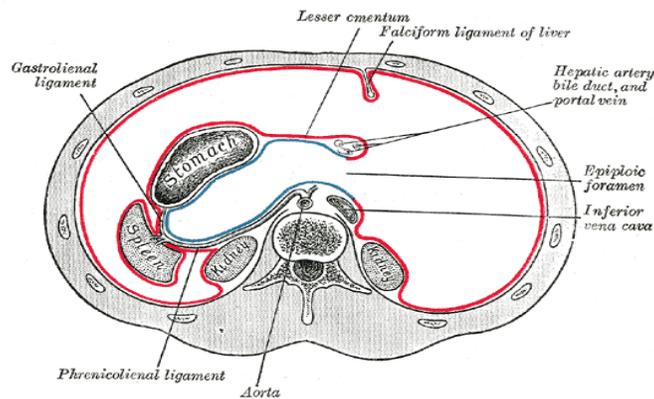


Figure 2.4 Adult Spleen and ligamentous attachment[Lewis 1918]

### 2.1.2 Hilum of the spleen

The hilum lies on the inferomedial part of the gastric impression It transmits the splenic vessels and nerves and provides attachment to the gastrosplenic and splenorenal (lien renal) ligaments[Ashwin 2011]

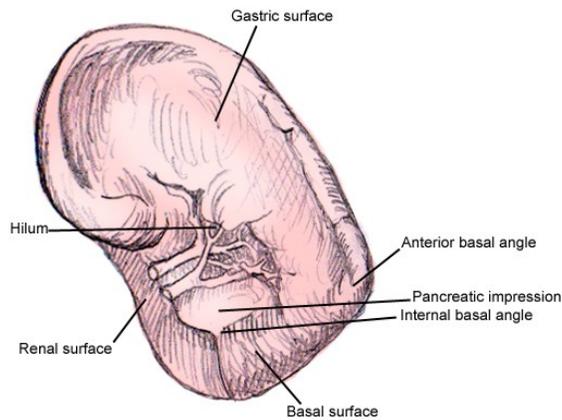


Figure 2.5 Spleen showing the different surfaces and impressions caused by different organs with relation to the hilum of the spleen[Ashwin 2011]

### 2.1.3 Development of the spleen

The spleen develops in the cephalic part of the dorsal mesogastrium, from its left layer; during the sixth week of intrauterine life, into a number of nodules that soon fuse to form a lobulated spleen. Notching of the superior border of the adult spleen is the evidence of its multiple origins. [Www. Medscape .com]

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. [Lewis 1918]

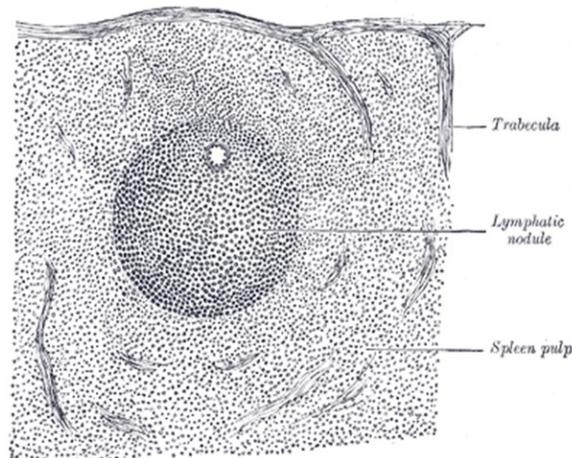


Figure 2.6 shows Transverse section of a portion of the spleen[Lewis 1918]

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 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 accessorius*; *supernumerary spleen*). They vary in size from that of a pea to that of a plum.[Lewis 1918]

#### **2.1.4 Structure of the spleen.**

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 gastrolial ligaments.

The fibro elastic 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 fibro elastic coat, numerous small fibrous bands, trabeculæ, 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 areola, formed by the trabeculæ; in these areola is contained the splenic pulp. [Lewis 1918]

The fibro elastic coat, the sheaths of the vessels, and the trabeculæ, 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-stripped muscular fiber; and in some mammalian, e. g., dog, pig, and cat, a large amount, so that the trabeculæ appear to consist chiefly of muscular tissue.[Lewis 1918].

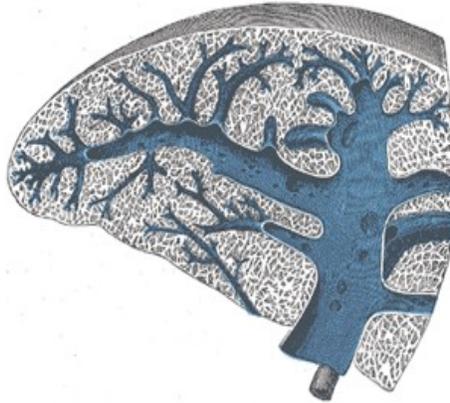


Figure 2.7 Transverse section of the spleen, showing the trabecular tissue and the splenic vein and its tributaries.[Lewis 1918].

The splenic pulp (*pulpa liens*) 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; they do not stain deeply with carmine, and in this respect differ from the cells of the Malpighian bodies. In the young spleen, giant cells may also be found, each containing numerous nuclei or one compound nucleus.[Lewis 1918].

### **2.1.5 Microscopic Anatomy of the spleen.**

The spleen is made up of 3 components, white pulp, red pulp, and vascular system. The white pulp consists of lymphatic nodules arranged around an eccentric arteriole called the Malpighian corpuscle. The red pulp is formed by a collection of cells in the interstices of the reticulum, in between the sinusoids. The

cell population includes all types of lymphocytes, blood cells, and fixed and free macrophages. The lymphocytes are freely transformed into plasma cells, which can produce large amounts of antibodies and immunoglobulin.[Ashwin pai2011]

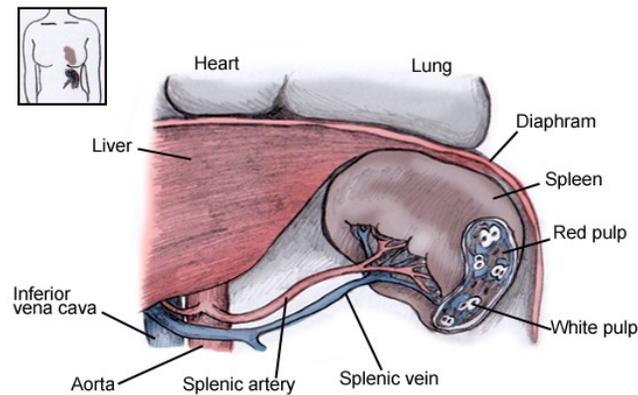


Figure 2.8 gross cut section showing the red pulp and the white pulp of the spleen. Also shown is the relation of the spleen to the diaphragm and the liver.[Ashwin pai2011]

### 2.1.6 Vascular system

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 receiving sheaths from an involution of the external fibrous tissue. Similar sheaths also invest the nerves and veins. .[Lewis 1918].

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. .[Lewis 1918].

The arterioles, supported by the minute trabeculæ, traverse the pulp in all directions in bundles (pencil) 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 [W. Muller 2010].

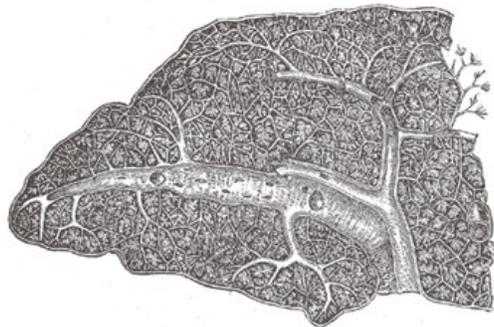


Figure 2.9 Transverse section of the human spleen, showing the distribution of the splenic artery and its branches [W. Muller 2010].

The altered coat of the arterioles, consisting of adenoid tissue, presents here and there thickenings of a spheroidal shape.

The lymphatic nodules (Malpighian bodies of the spleen). These bodies vary in size from about 0.25 mm. to 1 mm. in diameter. They are merely local expansions or hyperplasia of the adenoid tissue, which the external coat of the smaller arteries

of the spleen is formed. They are most frequently found surrounding the arteriole, which thus seems to tunnel them, but occasionally they grow from one side of the vessel only, and present the appearance of a sessile bud growing from the arterial wall. In transverse sections, the artery, in the majority of cases, is found in an eccentric position. These bodies are visible to the naked eye on the surface of a fresh section of the organ, appearing as minute dots of a semi opaque whitish color in the dark substance of the pulp. .[Lewis 1918].

In minute structure they resemble the adenoid tissue of lymph glands, consisting of a delicate reticulum, in the meshes of which lie ordinary lymphoid cells The reticulum is made up of extremely fine fibrils, and is comparatively open in the center of the corpuscle, becoming closer at its periphery. The cells which it encloses are possessed of ameboid movement. When treated with carmine they become deeply stained, and can be easily distinguished from those of the pulp. The arterioles end by opening freely into the splenic pulp; their walls become much attenuated, they lose their tubular character, and the endothelial cells become altered, presenting a branched appearance, and acquiring processes which are directly connected with the processes of the reticular cells of the pulp. In this manner the vessels end, and the blood flowing through them finds its way into the interstices of the reticulated tissue of the splenic pulp. Thus the blood passing through the spleen is brought into intimate relation with the elements of the pulp, and no doubt undergoes important changes. After these changes have taken place the blood is collected from the interstices of the tissue by the rootlets of the veins, which begin much in the same way as the arteries end. The connective-tissue corpuscles of the pulp arrange themselves in rows, in such a way as to form an elongated space or sinus. .[Lewis 1918].

They become elongated and spindle-shaped, and overlap each other at their extremities, and thus form a sort of endothelial lining of the path or sinus, which

is the radical of a vein. On the outer surfaces of these cells are seen delicate transverse lines or markings, which are due to minute elastic fibrillæ arranged in a circular manner around the sinus. Thus the channel obtains an external investment, and gradually becomes converted into a small vein, which after a short course acquires a coat of ordinary connective tissue, lined by a layer of flattened epithelial cells which are continuous with the supporting cells of the pulp. The smaller veins unite to form larger ones; these do not accompany the arteries, but soon enter the trabecular sheaths of the capsule, and by their junction form six or more branches, which emerge from the hilum, and, uniting, constitute the lienal vein, the largest radical of the portal vein. .[Lewis 1918].

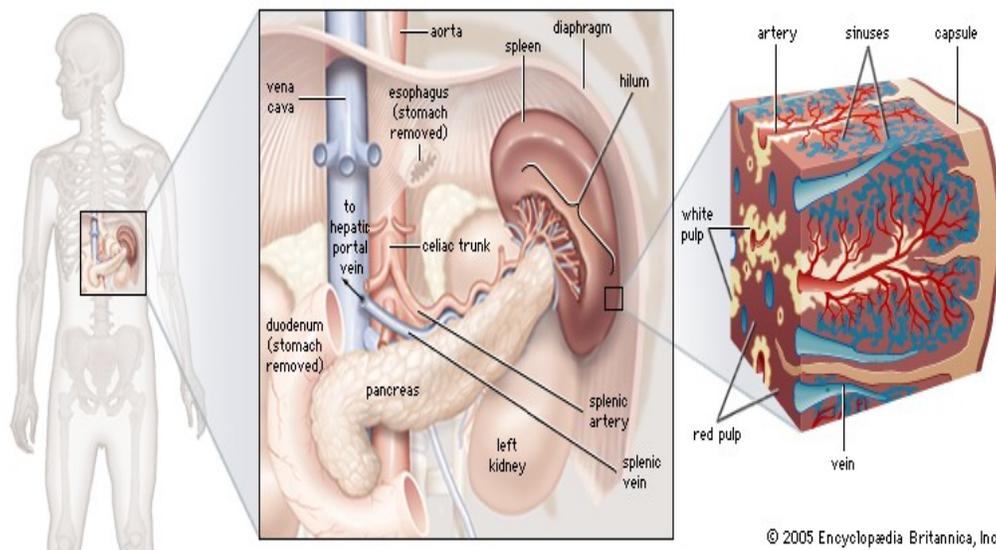


Figure 2.10 shows the portal vein. .[Lewis 1918].

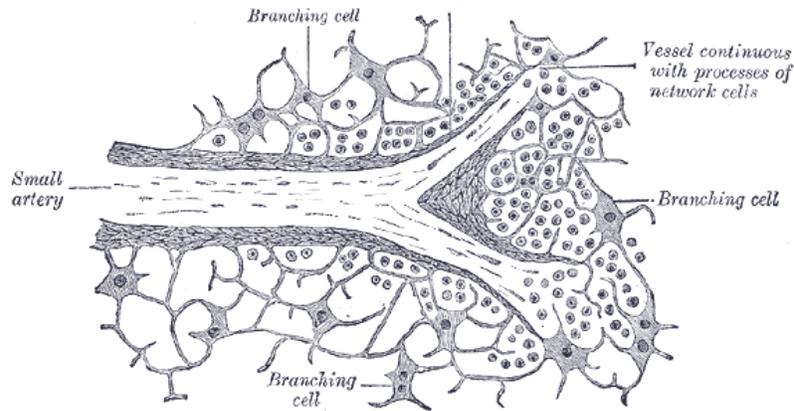


Figure 2.11 D Section of the spleen, showing the termination of the small blood vessels.[Lewis 1918].

### 2.1.7 Venous drainage

The principal venous drainage of the spleen is through the splenic vein. It is formed at the hilum and runs behind the pancreas then joins the superior mesenteric vein behind the neck of the pancreas to form the portal vein. Its tributaries are the short gastric, left gastro-omental, pancreatic, and inferior mesenteric vein

### 2.2 Physiology of the Spleen

Human spleen is an important constituent of the lymphatic system. It is concerned with producing lymphocytes, which is a type of [white blood cells](#). So, spleen is an integral part of the human immune system, as the lymphocytes are responsible for producing antibodies to fight against the foreign invaders. Antibodies are mainly associated with the destruction of the bacteria, virus or any other microorganisms

or germs that can cause several diseases. This immune function of the spleen is the subject matter of the white pulp of the organ.[Ashwin 2011]

The red pulp of the spleen on the other hand, is concerned with looking after the filtration activities, i.e. removing the old or damaged [red blood cells](#) from the body. It is also responsible for acting as a reservoir of blood to be supplied in time of emergencies like hemorrhagic shock or excess loss of blood due to cuts or injury. By acting as a filter, spleen recognizes as well as removes the old, damaged and malformed red blood cells from the body. The old red blood cells are then broken down by the macrophages, which are a type of phagocytes. .[Ashwin 2011]

Macrophages not only engulf and digest the red blood cells, but other invading microorganisms and debris as well.

Filtering the blood is one of the functions of the spleen, while destroying the old red blood cells; it saves some important components like iron from them. Iron is stored in the spleen as bilirubin and ferreting.

Iron preserved in this way is then transported to the bone marrow, which is the main site for synthesizing hemoglobin. Hemoglobin is a type of protein consisting of hem and globins and it transports oxygen from the lungs to all tissues and organs of our body. Apart from these functions, spleen also stores coenocytes, which is a type of leukocytes that help engulfing and digesting bacteria and other harmful microorganisms.[Ashwin 2011]

## **2.3 Pathlogy of Spleen**

Accessory spleens or splenunculi are natural anatomic variants formed from nodules that fail to fuse during development. These are found in various locations such as the gastrosplenic ligament, splenorenal ligament, gastrophrenic ligament, and gastrocolic ligament. They have also been reportedly found in broad ligament of the uterus and in the spermatic cord.

### **2.3.1 Splenomegaly**

A variety of disorders can cause the spleen to enlarge, sometimes to 2kg or more. Any conditions that cause a rapid breakdown of blood cells, such as hemolytic anemia, can place great strain on the spleen and make it enlarge. Other causes of splenomegaly include infections (such as glandular fever), liver disease and some cancers (such as Hodgkin's disease, leukemia and lymphoma [Mayr kur 2009])



Figure 2.12 axial CT showing splenomegaly [Mayr kur 2009]

### **2.3.2 Hypersplenism**

The two characteristic features of hypersplenism are splenomegaly and a deficiency of one or more blood components. It seems that an enlarged spleen is sometimes overactive and will destroy more blood cells than necessary. Symptoms depend on which blood component is lacking. For example, if red blood cells are deficient, anemia will be the result (with symptoms including fatigue and pallor). Most cases of hypersplenism are caused by disorders somewhere else in the body, such as cirrhosis of the liver [Mayr kur 2009]

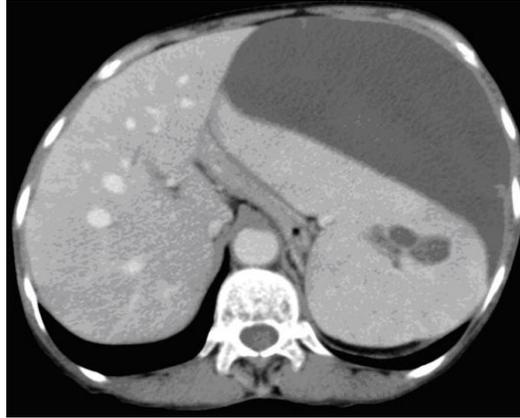


Figure2.3.13 Axial CT image shows Hypersplenism [Mayr kur 2009]

### 2.3.3 Splenic rupture

Certain disorders, including glandular fever, can occasionally make the enlarged spleen delicate enough to spontaneously rupture. A sudden blow to the abdomen can split the outer capsule of the spleen and cause bleeding into the abdominal cavity. There are various degrees of splenic rupture. When bleeding is life threatening, surgery to remove the spleen (splenectomy) is needed [Mayr kur 2009]

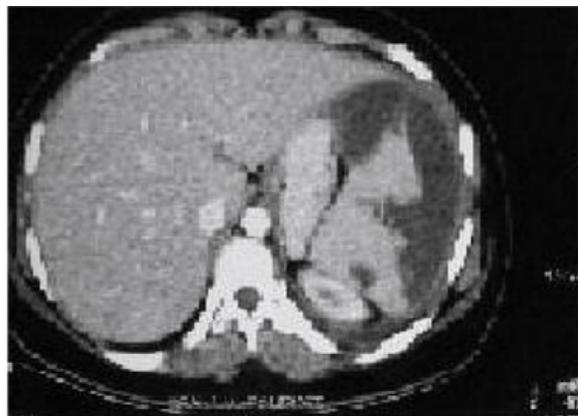


Figure2.14 Axial CT  
[Mayr kur 2009]

image shows spleen rupture

Figure 2: Non-contrast computerized tomography scan showing perisplenic fluid collection

### 2.3.4 [Sickle cell disease](#):

In this inherited form of anemia, abnormal red blood cells block the flow of blood through vessels and can lead to organ damage, including damage to the spleen. People with sickle cell disease need immunizations to prevent illnesses their spleen helped fight. [Mayr kur 2009]

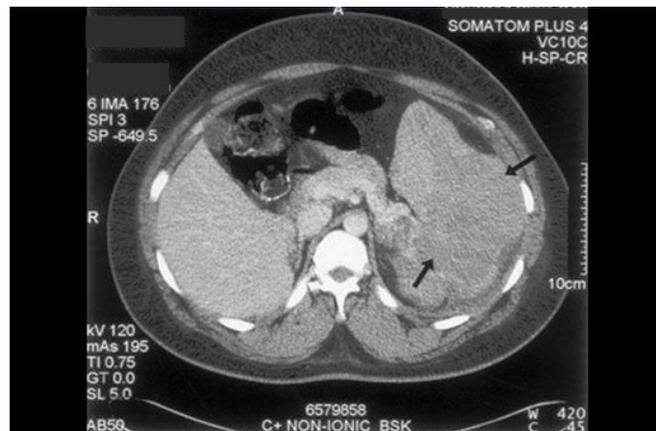


Figure2.15 Axial CT image shows [Sickle cell disease](#) [Mayr kur 2009]

**2.3.5 [Thrombocytopenia](#)** : (low platelet count): An enlarged spleen sometimes stores excessive numbers of the body's platelets. Splenomegaly can result in abnormal few platelets circulating in the bloodstream where they belong [Mayr kur 2009].

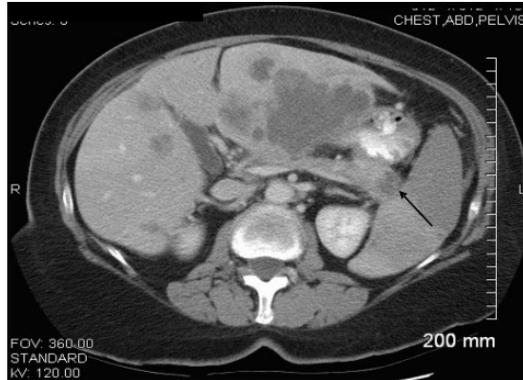


Figure2.16 Axial CT image shows [Thrombocytopenia](#) [Mayr kur 2009]

**2.3.6 Asplenia:** is a rare condition in which there is a [congenital absence of the spleen](#). or one that functions [Mayr kur 2009]



Figure2.17 Axial CT image shows Asplenia [Mayr kur 2009]

**Accessory spleen:** About 10% of people have a small extra spleen. This causes no problems and is considered normal. [Mayr kur 2009]

### **2.3.7 Methods of Spleen Investigation:**

Physical examination: By pressing on the belly under the left ribcage, a doctor can feel an enlarged spleen. He or she can also look for other signs of illnesses that cause splenomegaly.

Liver and spleen scan: A small amount of radioactive dye is injected into the arm. the dye moves throughout the body and is collected in both of these organs.

### **2.3.8 Spleen Treatments**

Splenectomy: The spleen is removed by surgery, either through laparoscopy (multiple small incisions) or laparotomy (one large incision).

Vaccinations: After spleen removal, it's important to get vaccinations against certain bacteria, such as H. influenza and S. pneumonia. An absent spleen increases vulnerability to these infections.

Usually, treatments for spleen conditions focus not on the spleen, but on treating the underlying condition.

## **2.4 Previous Studies:**

Mittal R, Chowdhary D, 2010, studied the normal standards of liver and spleen by ultrasonography in the Rajasthan population. The average length of the spleen was

9.40±0.91 cm (males) and 9.34±0.95 cm (females). The average width of the spleen in males as well as in females was 3.45±0.59 cm. The normal values of the dimensions of the liver and spleen are important parameters during a sonographical examination. This study provides valuable data from the Rajasthan population. So, this study will be of importance in the daily practice in radiology clinics.

[Journal of Clinical and Diagnostic Research. 2010 Gust]

Dr. Adil Asghar, 2011 had done amorphometric Study of Spleen in North Indian Adult Population, The mean length, width and thickness of spleen were 10.67±1.62 cm, 6.26±1.66 cm and 4.86±1.22 cm respectively. All linear splenic dimensions have significant positive correlation with height of patients and normative data can be produced with the help of regression formula developed with the help of statistics which can be used as research tool where objective determination of splenomegaly is required.

[Journal of Clinical and Diagnostic Research. 2011 October].

Dr. I. J. Okoye had done a study that aimed to establish ultrasonic splenic dimensions which can be used as tomogram for adult Nigerians. The normal splenic sizes obtained ranged from 9.9 -11.5cm (length - L), 6.0-7.5cm (Width W) and 4.0- 4.5cm (thickness -T). The splenic dimensions for males were 11.1 + 0.7cm (L), 7.3 + 0.2cm (w) and 4.2+ 0.2cm (T). The corresponding values for females were 10.6 + 0.7cm, 6.8 + 0.5cm and 4.2 +0.2cm respectively; thus showing a statistically significant difference between the males and females ( $P < 0.05$ ). A poor correlation was shown to exist between splenic dimensions and age but splenic weight increased with body weight ( $r=0.75$ ). Even though value of the splenic sizes were similar to those of a Caucasian population compared with them ( $P>0.05$ ),.

This finding appears to bear credence to existing opinion by Chauhan et al that splenic recession rather than splenomegaly is prevalent in adults living in endemic falciparum zones. Statistically significant differences between splenic length and weights of the sexes have been established by the study. The good correlation between subject height and splenic length portends profound options of predicating subjects splenic size and matching his ultrasound values with this predicted splenic length ( $SPL = 1.2 + 0.063$ ) [West African Journal of Radiology]

[Zainab Mustapha](#) provided this study to determine the normal range of spleen size in an adult African population, 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 body mass index. Mean spleen volume in African adults is smaller than data from Western sources, and cannot be explained by difference in body habits. [European Journal of Radiology]

Moore KL 1992 studied the normal dimensions of spleen by ultrasonography in, Nigeria. For the males the mean age was 32.4 years ( $\pm 9.2$  SD), mean height was 175.0 cm ( $\pm 7.3$  SD), mean weight was 72.5 kg ( $\pm 10.1$  SD), and mean body mass index was 23.6 ( $\pm 2.8$  SD) and the females the mean age was 29.7 years ( $\pm 9.0$  SD) mean height was 164.6 cm ( $\pm 5.8$  SD), mean weight 64.1 kg ( $\pm 12.9$  SD), and mean BMI was 24.9 ( $\pm 1.4$  SD). For the males the mean splenic length, width, depth, and volume were 11.1 cm ( $\pm 0.9$  SD), 4.4 cm ( $\pm 0.5$  SD), 7.8 cm ( $\pm 0.6$  SD), and 202.7 cm<sup>3</sup> ( $\pm 49.4$  SD), respectively. For the females the corresponding values of splenic length, width, depth, and volume were 10.1 cm ( $\pm 0.7$  SD), 4.0 cm ( $\pm 0.4$  SD), 7.1 cm ( $\pm 0.5$  SD), and 153.7 cm<sup>3</sup> ( $\pm 33.2$  SD), respectively. Comparison between mean splenic dimension parameters for males and females (from unpaired t-test

determination) showed a statistically significant difference ( $P < 0.001$  for splenic length, width, depth, and volume). There was also statistically significant increasing value correlation between subjects' weight and height (in favor of height) when compared to spleen length, width, depth, , and volume. The other parameters show no significant correlation in both female and male. In particular there was also no statistically significant correlation of splenic measurements with age in either sex. This is similar to what was noted in other centers.

[Clinically oriented anatomy. 3 rd ed. USA: Williams and Wilkins; 1992. p. 184-7].

## **Chapter Three**

### **Material and methods**

## **3.1 materials**

### **3.1.1 Study sample**

Fifty Sudanese adult patients (25male-25female), patient age range between [20-60] years, underwent computed tomography examination for abdomen. In this study included the age between 20-60 years because in this range the spleen was completed the process of development, and the researcher excluded the patients with any disease that may affect the spleen.

### **3.1.2 Area, duration, and data analysis**

This is community based descriptive study .It took place in Khartoum states with the permission from in different hospitals and centers, Modern Medical Center, Yastabshoren medical center and East Nile Hospital. The study was conducted during the period from December to March. The data were analyzed using excel program and simple frequency tables.

### **3.1.3 Machine characteristics**

This study used a dual general electric and Philips CT scanner. The GE HiSpeed NX/I [1970] technology provides the scanner with many features such as Real time beam tracking, Highlight detector, Auto mA, Optimum helical pitches and Bowtie filter. The gantry and table allows for a 120cm scan range. It is also equipped with positioning lights and breathing lights. This scanner allows acquiring two thin slices simultaneously in the same amount of time and would take for a single slice scanner. The GE machine heat storage is 20,000 HU and its tube uses oil/air for cooling. Even though this CT scanner is dual slice, it can handle 3D and 4D imaging.[GE health care]

## **3.2 Methods**

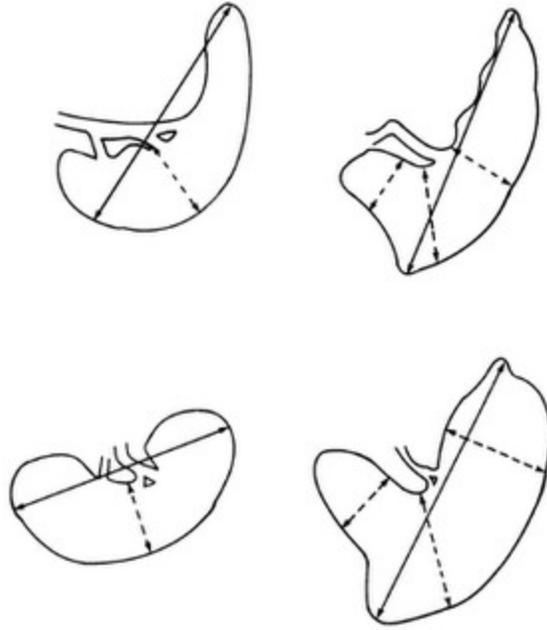
The patients were asked not to eat or drink anything for 4-6 hours before the exam and asked to remove jewelry and wear a hospital gown during the study.

### **3.2.1 Methods of scanning:**

. The technologist begins by positioning the patient on the CT examination table, usually lying flat on their back or less commonly, on their side or prone with their hand over the head. Straps and pillows may be used to help the patient maintain the correct position and to hold still during the exam. This exam requires a special dye, called contrast media, to be delivered into the body through venous system. Due to contrast reactions, the technologist usually asks the patient about their history of allergies and their current health issues. the Contrast that is given through a vein (IV) Before the test starts, the patient will be asked to drink diluted contrast orally. CT scans were performed using protocol of axial images from the xiphoid process to pubic bone. For better imaging, reconstruction is used with 3mm thickness to obtain coronal sections. In addition, the technical parameters that were used in this study were 120 kV, 100 mA current; 10mm increments, 10mm slice thickness with identical reconstruction index and a rotation time of 1.5 sec.

### **3.2.2 Methods of measurements:**

Splenic length, thickness, and width were retrospectively calculated around 10<sup>th</sup> rib from CT scans image .The spleen thickness was measured from the hilum of the spleen to the outer cortex; the width is measured from two higher points across the spleen, and the length is measured from sagittal reconstruction image. The volume is calculated by multiplying length, width and thickness. The unit of measurements used is metric. The patients were also measured for length, waist, and weight using same metric units. The researcher used the methods that used in figure 3.18[Anna.s.lev 1996].



### 3.18 Methods of measurements

Width=solid arrow thickness=dashed arrow splenic index=(length x width x thickness)

Length = was measured along the long axis, in the sagittal plane.

Width = is the longest splenic diameter that can be drawn on any transverse image.

Thickness = is measured at the level of splenic hilum and is the distance between inner and outer (peripheral) borders of the spleen.

Normal splenic index is from 120 to 480 cm<sup>3</sup>. [Anna.s.lev 1996].

## Chapter Four

### Results

This study includes 50 patients (25 male and 25 female) coming to the CT department for CT abdomen , All the images were diagnosed as normal Spleen the images were used to assess the spleen size in Sudanese patients as well as to assess the relation between the spleen size and patients age, hight, weight ,BMI The results included the age group mean and standard deviations as well as the linear relation between the variables in male and female and the whole sample .

Table 4.1 Shows the Spleen measurements for male.

<b>Spleen measurements for male (cm)</b>	<b>Mean <math>\pm</math>SD</b>
Thickness	4.6 $\pm$ 0.6
Length	10.2 $\pm$ 1.0
Width	6.0 $\pm$ 0.7
CTNumber	47.4 $\pm$ 3.8
Volume	280.6 $\pm$ 71.6

Table 4.2 Shows the Data for male.

<b>Patient Measurements For male (cm)</b>	<b>Mean <math>\pm</math> SD</b>
Age	41.7 $\pm$ 11.4

Table 4.3 Shows the Spleen measurements for Female.

<b>Spleen Measurements For Female (cm)</b>	<b>Mean ± SD</b>
Thickness	4.6± 0.6
Length	9.6 ± 1.1
Width	5.3 ± 0.7
CT Number	47.0 ± 4.6
Volume	235.9±6 8.4

Table 4.4 Shows the Data for Female.

<b>Patient measurements for female (cm)</b>	<b>Mean ± SD</b>
Age	49.0± 9.7

Table 4.5 Shows the Spleen measurements for the whole Sample ( Male and Female).

<b>Spleen Measurements For Total (cm)</b>	<b>Mean ± SD</b>
Thickness	4.6± 0.7
Length	9.9 ±1.1
Width	5.6 ± 0.7
CT NUBER	47.2 ±4.2
Volume	258± 70

Table 4.6 Shows the Patient Data for the whole Sample ( Male and Female):

<b>Patient measurements for the whole sample (cm)</b>	<b>Mean <math>\pm</math>SD</b>
Age	45.3 $\pm$ 11.1

Figure 4.19 The linear correlation between the spleen thickness and patient age ( Female)

Figure 4.20 The linear correlation between the spleen length and patient age( Female)

Figure 4.21 The linear correlation between the spleen width and patient age( Female)

Figure 4.22 The linear correlation between the spleen CT number and patient age( Female)

Figure 4.23 The linear correlation between the spleen Volume and patient age (Female)

The Following Figures Shows The Data Related To The Male Patient And Spleen Measurements:

Figure 4.24 The linear correlation between the spleen thickness and patient age (male)

Figure 4.25 The linear correlation between the spleen length and patient age (male)

Figure 4.26 The linear correlation between the spleen CT number and patient age (male)

Figure 4.27 The linear correlation between the spleen width and patient age (male)

The Following Figures Shows The Data Related To The Male and Female Patient( Total Sample) And Spleen Measurements:

Figure 4.28 The linear correlation between the spleen volume and Patient age.

Figure 4.29The linear correlation between the spleen width and Patient age.

Figure 4.30The linear correlation between the spleen CT number and Patient age.

Figure 4.31 The linear correlation between the spleen width and Patient age.

Figure 4.32 The linear correlation between the spleen thickness and

Patient age

Figure 4.33 the linear correlation between the spleen volume and Patient age.

## **Chapter Five**

### **(Discussion, conclusions, and recommendations)**

#### **5.1 discussion**

This study is attempt to find out an index for normal spleen in adult Sudanese using the CT scan as well as to find out the relation between male and

female related to spleen measurement (length, width, thickness, CT number, Volume) and patient age.

The data were collected for patient's age between 20-60 years old. The results showed that the length, width and thickness of spleen are correlated with age.

The study showed that the average length of spleen was  $10.2 \pm 1.0$  cm (male) and  $9.6 \pm 1.1$  cm (female) as presented in table 4.1/4.3. these measurements compared to Study done by Mittal R and Chowdhary D using ultrasound measurements found that the average length of the spleen was  $9.40 \pm 0.91$  cm (males) and  $9.34 \pm 0.95$  cm (females), , Mittal spleen length measurements were lower by 3.45cm in males and 1.85 cm in females. Another study done by DrAdil found that the spleen length in both male and female was  $6.26 \pm 1.66$  which is higher than this study in both male by .26cm and female by .96 cm. Dr. Okoye found in his study that the spleen length in male was  $11.1 + 0.7$ cm and in female was  $10.6 + 0.7$ cm which is higher by .9 cm in males and 1.0 cm in females when compared with this study. In another study done by Moore found that the spleen length was 11.1 cm in males and 10.1 cm in females. Compared to this study the length is higher in both male and female. The linear relation between the patient age and spleen length decreased by .0001 (female) as in figure 4.2 and by 0.037 (male) as in figure 4.7 for each year of age.

The study showed that the average width of spleen was  $6.0 \pm 0.7$  cm (male) and  $5.3 \pm 0.7$  cm (female) as presented in table 4.1/4.3. Study done by Mittal R and Chowdhary D using ultrasound measurements found that the average width of the spleen was  $3.45 \pm 0.59$  cm in both male and female. cm (males), compared to this study, Mittal spleen width measurements were lower by 3.45 cm in males and 1.85 cm in females. Another study done by Dr Adil found that the spleen width in both male and female was  $6.26 \pm 1.66$  cm which is higher than this study in both male

and female. Dr. Okoye found in his study that the spleen width in male was  $7.3 + 0.2$  cm and in female was  $6.8 + 0.5$  cm which is higher by 1.3 cm in males and lower in females by 1.5 cm when compared with this study. In another study done by Moore found that the spleen width was 4.4 cm in males and 4.0 cm in females. Compared to this study the width is higher in both male and female. It was found that the spleen width was decreased by 0.064 (female) and by 0.052 (male) as it was presented in figure 4.3 (female) and 4.9 (male) for each year of age.

The study showed that the average thickness of spleen was  $4.6 \pm 0.6$  cm (male) and  $4.6 \pm 0.6$  cm (female) as presented in table 4.1/4.3. Study done by Dr Adil found that the spleen thickness in both male and female was  $4.86 \pm 1.22$  cm which is higher than this study in both male and female by 0.26 cm. Dr. Okoye found in his study that the spleen thickness in male was  $4.2 \pm 0.2$  cm and in female was  $4.2 \pm 0.2$  cm which is lower by .4 cm in both males and females in when compared with this study. It was found that the spleen thickness was decreased by 0.001 (female) and by 0.001 (male) as it was presented in figure 4.1 (female) and 4.6 (male) for each year of age.

This study found that the CT number  $47.4 \pm 3.8$  in males and  $47.0 \pm 4.6$  in females, no other studies done CT measurements. It was found that the spleen CT number was decreased by 0.06 (female) and by 0.043 (male) for each year of age as it was presented in figure 4.4/4.9.

In this study the spleen volume was found 280.0 cm<sup>3</sup> for male and 235.9 as presented in table 4.1/4.3. In a study done by Moore found that the spleen volume was 202.7 cm<sup>3</sup> in males and 153.7 cm<sup>3</sup> in females. Compared to this study the measurement is higher in male by 78 cm<sup>3</sup> and in female by 72 cm<sup>3</sup>, Which means that the spleen volume decrease by 3.3 cm<sup>3</sup> (male) and by 3.3 cm<sup>3</sup> (female) as in figure 4.5/4.10.

The differences in the measurements found in this study and previous studies are due to body characteristics and race.

## **5.2 Conclusion**

The study conclude that The spleen measurement for the length, width, thickness and volume and CT number was found to be  $10.2\pm 1.0$  cm,  $6.0\pm 0.7$ cm,  $4.6\pm 0.7$  cm,  $280\pm 71.6$  cm<sup>3</sup>,  $47.4\pm 3.8$  in male and  $9.6\pm 1.1$ cm,  $5.3\pm 0.7$  cm,  $4.6\pm 0.7$  cm,  $235.9\pm 68.4$  cm<sup>3</sup>,  $47.0\pm 4.6$  in female respectively.

The relation between spleen measurements (length, width, thickness and volume ) with age in male was found to be length decreased by 0.0011 in female and by 0.037 (male), width was decreased by 0.064 (female) and by 0.052 (male) , thickness was decreased by 0.001 (female) and by 0.001 (male), spleen volume decrease by 3.3 cm (male) and by 3.3 cm (female). Unlike other measurements, the CT number CT number was increased by 0.06 (female) and decreased by 0.043 (male)

In some studies the researcher spleen measurements results are higher, and in other studies are lowers as mentioned in the discussion, due to race and geographic change

### **5.3 Recommendations**

The researcher recommended that:

More research should be done using a large sample of patients for further assessment

Researcher suggests that doing the same studies using normal patients, and compare the spleen relationship with kidneys is important.

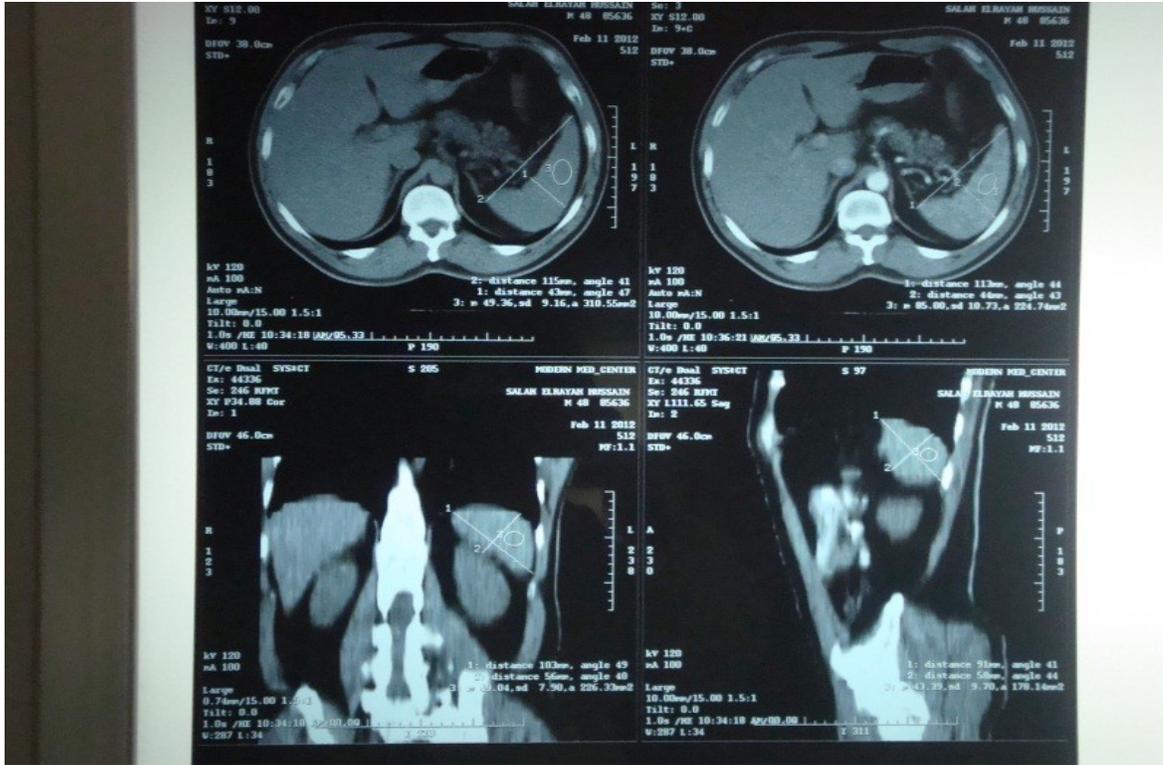
Similar studies should be done using different modalities such as ultrasound and magnetic resonance imaging due to the fact that they are safer.

Follow up the measurement of the changes of the spleen size with age from childhood could also be conducted





**Non contrast Axial and Sagittal CT image for female [25 years] show the measurements of spleen width and thickness in the level T12**



**Non contrast Axial, Coronal and Sagittal CT image for female[ 20 years] show the measurements of spleen in the level T12**

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