



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

**Sudan University of Science and Technology**  
**College of Graduate Studies**



## **Measurement of Normal Spleen Volume in Sudanese Children using Ultrasonography**

قياس حجم الطحال الطبيعي للاطفال السودانيين باستخدام الموجات فوق الصوتية

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

By:

**Hikma Bashir Osman ELkhaldy**

Supervisor:

**Dr. Asma Ahmed Alamin**

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## الآية

قال الله تعالى

بسم الله الرحمن الرحيم

(اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (١) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (٢) اقْرَأْ وَرَبُّكَ الْأَكْرَمُ (٣)  
الَّذِي عَلَّمَ بِالْقَلَمِ (٤) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ (٥))

صدق الله العظيم

سورة العلق

# Dedication

To My Parent

MY Brothers and Sisters

My Husband

My Children

To every child give us Smile, Pleasure & Happiness in this world.

# Acknowledgement

First of all I thank **ALLH** to complete this study.

I thank **Dr. Asma Ahmed Alamin** my supervisor for her help , guidance ,and advising.

Also I would like to thank all staff of Bashair hospital for their great help and support.

I think all teachers in different educational phases.

## **Abstract**

Ultrasound is one of the most widely used imaging modalities and it is an excellent tool for diagnosing medical issues in both children and adults' spleen ultrasound is one of this modalities choice to evaluate and assess measurement and pathological condition of this organ

This was a cross sectional descriptive study was done in Bashair hospital – Khartoum state from November 2019 to March 2020 which aim to evaluate spleen measurement {length, width thickness ,volume and BMI}in Sudanese children from 0 to17years

This study was done on 100 healthy child coming to ultra sound by abdominal pain([48 male and 52 female) Trans -abdominal scanning was done for all children using ultra sound machine Sefius UF -980 AG with curvilinear probe of 2 to3.5 megahertz.

The children were divided to five groups according to their age. The mean of age was  $(7.25\pm 6.26)$  years,. The study found that the mean of the spleen measurement (length, width, depth and volume,  $(8.48\pm 2.09)$  cm,  $(5.98\pm 1.77)$  cm  $(2.61\pm 0.72)$  cm,  $(68.85\pm 48.80)$  cm<sup>3</sup> respectively.

The result show there was no significant difference between male and female in spleen measurement, there was linear relation between splenic volume and height , weight , and BMI and there was significant relation between splenic measurement and age ( $p=0.00$ ) .

The study conducted that the male and female had the same spleen volume and there is no different between them unless in the older age above 15 years old. The values cut of point reference values of normal splenic measurement and volume in children Sudanese population

## ملخص الدراسة

الموجات الصوتية هي اكثر طرق التصوير الحديثه شيوعا وهي افضل وسيلة في التقييم والتشخيص الطبي للاطفال والبالغين والموجات الصوتية للطوحوال هي احدي الطرق المختارة لتقييم الحالة الطبيعية والمرضية لهذا العضو هذه دراسة وصفية مقطعية اجريت في مستشفى بشائر الجامعي بولاية الخرطوم في الفترة من نوفمبر 2019الي مارس2020 وهدفت هذه الدراسة الي تقييم ابعاد الطوحوال الطول والعرض والسماك بالاضافة الي حجم الطوحوال في الاطفال السودانيين من عمر صفر الي عمر 17 سنة اجريت هذه الدراسة علي 100 طفل سليم 48ذكور و52اناث خضعوا لفحص الموجات فوق الصوتية للبطن بجهاز Sefius UF -980 AG

تم تقسيمهم الي خمسة فئات عمرية وكان متوسط الاعمار (  $7.25 \pm 6.26$  ) سنة وتم استبعاد اي طفل لديه امراض تتسبب في تضخم الطوحوال وكانت القياسات بالسنتيمتر وجمعت البيانات بواسطة استمارة جمع البيانات التي تحتوى علي عمر الطفل ونوعه وطوله ووزنه ثم حسب حجم الطوحوال باستخدام الموجات فوق الصوتية وحلت البيانات بواسطة برنامج التحليل الاحصائي وكانت نتائج الدراسة ان متوسط طول الطوحوال وعرضه وسماكه وحجمه علي النحو التالي ( $8.48 \pm 2.09$ ) سم ( $5.98 \pm 1.77$ ) سم ( $2.61 \pm 0.72$ ) سم ( $68.85 \pm 48.8$ ) سم<sup>3</sup>.

اظهرت الدراسة عدم وجود فروق احصائية بين الاطفال الذكور والاناث وكانت هنالك علاقة خطية بين هذه القياساتمع عمر الطفل وكتلة الجسم . توجد علاقةخطية قوية بين حجم الطوحوال مع طول الطفل ووزنه ومؤشر كتلة الجسم وكانت هنالك علاقة معنوية بين قياسات الطوحوال والعمر تتمثل بالمعادلة ( $p=0.00$ ). النتائج التي تم التوصل اليها ان حجم الطوحوال للاطفال الذكور لا يختلف كثيرا عن حجم الطوحوال للاناث الا في الفئات العمرية الكبيرة فوق 15 سنة. هذه القيم تحدد مرجعية لقياس حجم الطوحوال لي الاطفال السودانيين.

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### List of Abbreviations

<b>Abbreviation</b>	<b>Meaning</b>
SL	Spleen Length
SW	Spleen Width
ST	Spleen Thickness
SV	Spleen Volume
BMI	Body Mass Index
C T	Computed Tomography
MRI	Magnetic Resonance Imaging
LUQ	Left Upper Quadrant

# **Chapter one**

## **Introduction**

# Chapter one

## 1-1 Introduction

Spleen is the largest lymphoid tissue in the body it is apart of reticulo endothelial system and has a role in the synthesis of blood proteins (Sandra, 2012) .

Childhood is an important period of growth for many organ systems. Among various growth parameters, spleen length is an important parameter used for the clinical evaluation of spleen growth and abnormalities Therefore, having a reliable reference for spleen size in children is valuable (Sandra ,2012 ) ,

There are several methods measuring spleen size including abdominal CT and MRI. However, these approaches have disadvantages such as radiation exposures and high costs. In comparison, ultrasonography is a safe r and simple method for evaluating spleen measurement (Lamb PM,2002) .

Spleen Size shows variations according to people depending on the individuals height, age, an sex (Danila, 2010) .

The spleen and left upper quadrant (LUQ) should be routinely evaluated on all abdominal investigation especially in patients with suspected splenomegaly, LUQ, or trauma (Rumak, 2011) .

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

The spleen may be palpable in (15-17%) of healthy neonate and (10 %) of healthy children (Aga mohammadi, 2001).

There is international standards value of normal spleen volume, any increase over that value will be indicator of assort of splenomegaly (Kamaya et al, 2006).

Normal measurement for the average adult should be 8-12 cm length 7 cm in width and 3to 4 cm in thickness. The spleen decrease slightly in size with

advancing age, the size of the spleen may vary in size in accordance with the nutritional status of the body (Sandra, 2012) .

In Sudan there is absence of domestic reference for spleen volume in children the importance of this study was to find out the normal volume in neonate and children and to determine it is correlation with gender, age, height and weight.

### **1-2Problem of the study:**

There is no reference demonstrate the normal splenic volume in Sudanese children.

### **1-3 Objectives:**

#### **1-3-1General objective:**

To measure normal splenic measurement in children from 0-17 year using ultra sonography.

#### **1-3-2Specific objectives:**

- To measure splenic volume in normal Sudanese children by using ultra sonography.
- To-establish standard value of spleen volume in children.
- To correlate the spleen volume with gender, age, weight and height.
- To show the effect of age and height in spleen volume.
- To find the relation between the spleen volume and children age, weight, height.

# **Chapter two**

## **Literature Review**

# Chapter two

## Theoretical Background and previous studies

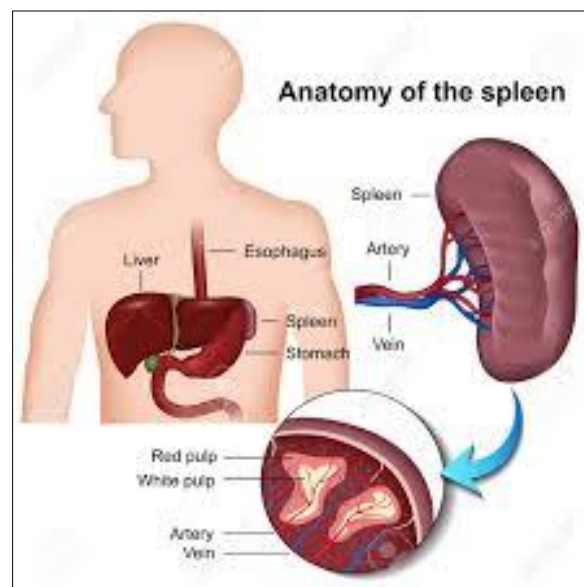
### 2-1 Theoretical Background

#### 2-1 -1Anatomy of the spleen:

The spleen lies in the left hypo chonrium, with it is axis along the shaft of the tenth rib. It is lower pole extends for word as far the mid axillary line The spleen is an intra peritoeal organ covered with peritoneum over it is entire extent ,except for small area at it is hillum, where the vascular structures and lymph nodes are located (fig 2-1) .

The spleen lies in the posterior left hypo chondrium between the funds of the stomach and the diaphragm (Sandra 2012) .

The spleen is of variable size and shape (e.g orange segment, tetrahedral triangular (but generally is considered to be ovoid with smooth, even borders and concave inferior surface (Sandra 2012) .



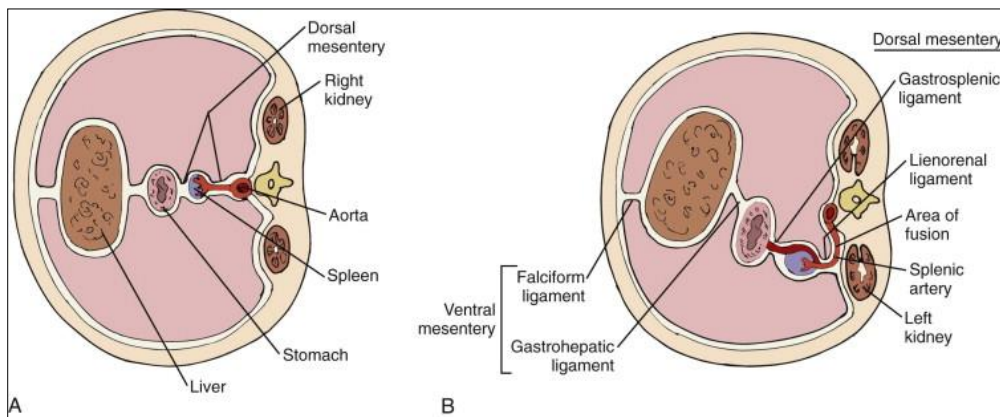
**FIG (2. 1)**spleen anatomy(Jon Oringer-2018)

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### 2-1-2 Spleen Embryology:

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



**Fig (2. 2)**spleen Embryology.

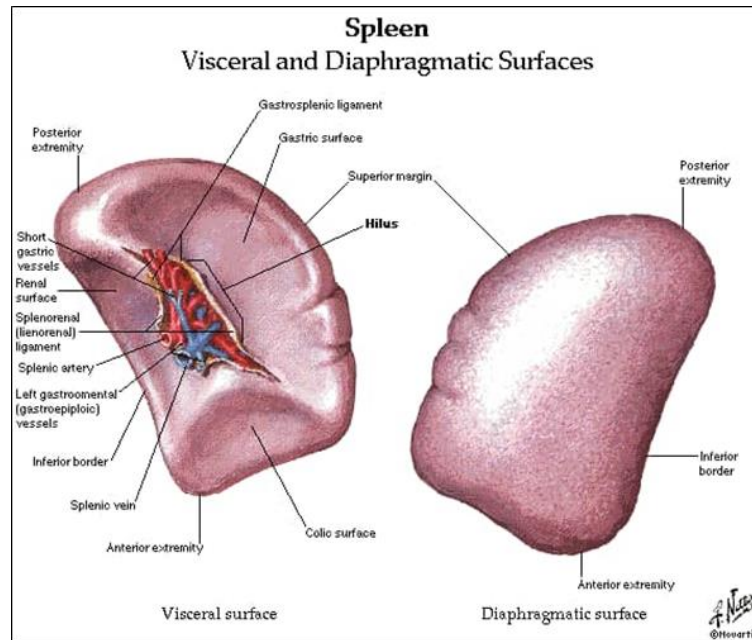
(Dachman ,1987)

A-Transverse section at the end of the fifth week show the spleen developing with in the dorsal mesogastrium .

B-As rotation begins, the splenic artery courses to the left in an area of the fusion of dorsal mesogastrium with the posterior peritoneum.

### 2-1-1- 2Realations:

-The diaphragmatic surfaceis convex and usually situated between the ninth and eleven ribs. The visceral or inferomedial surface has gentle indentation where it comes into contact with the stomach, left kidney, pancreas and splenic flexure.(fig 2-3) (Rumak, 2012) .



**Fig (2. 3)**Visceral and Diaphragmatic Surfaces of Spleen (Matstushita,2006)

-The gastric surface, which is directed forward, upward and medial ward ,is broad and concave ,and is contact with the posterior wall of the stomach (Henry2000)

-The renal surface ,is directed medial ward and down ward its flattened ,is considerably narrower than the gastric surface ,and in relation with upper part of the anterior surface of the left kidney and with the left supra renal gland (Henry2000) .

-The superior extremity surface is directed to the vertebral column, where it lie on a level with the eleventh thoracic vertebral column ,The colic surface or the lower extremity ,is flat ,triangular in shape and result upon the left flexure of the colon and the phrenic cocolic ligament and contact with the tail of pancreas. (Henry, 2000) .

- The anterior border is free, sharp ,and thin and is of notched especially below it separate the diaphragmatic from the gastric surface The posterior border more rounded and blunter than the anterior , separates the renal from the diaphragmatic surface ,The inferior border separates the diaphragmatic from the colic surface (Henry, 2000) .

The spleen is almost entirely surrounded by the peritoneum, it is held in position by two folds, the phrenico lienal ligament and the gastro lienal ligament, the lower end of the spleen is supported by the phrenicocolic ligament (Henry 2000).

### 2-1-1-3 Structure

The spleen is a soft organ with elastic properties and it has an outer coat of peritoneum which is firmly adherent to the internal fibro-elastic coat or splenic capsule that dips into the organ, forming trabeculae.

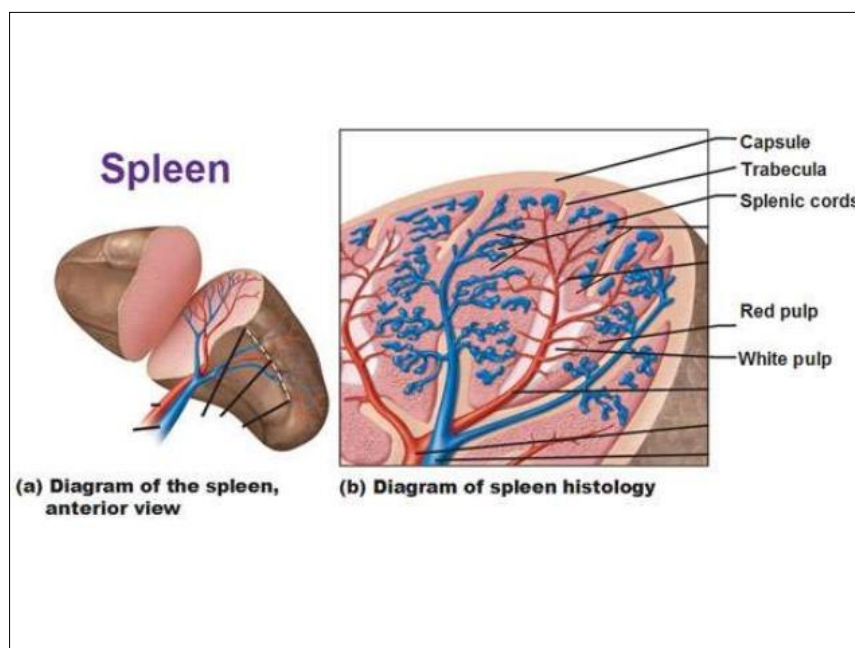


Fig (2. 4) Human anatomy spleen Structure (Elaine N Marieb 2016)

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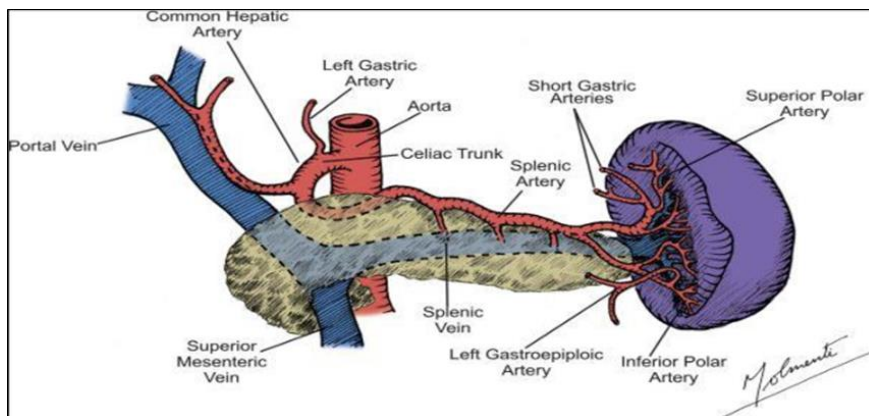
The spleen has a spongy interior called splenic pulp, the splenic pulps are of two kinds: The white pulp, it consists of peri arteriolar sheaths of lymphatic tissue with enlargement called splenic lymphatic follicles containing rounded masses of lymphocytes. These follicles are centers of lymphocyte production called primary lymphoid follicles, composed mainly of follicular Dendritic cells (FDC) and B cells, they are visible to the naked eye in freshly cut surface of spleen as whitish dots against the dark red background of red pulp, the white

pulp forms “islands” within a meshwork of reticular fibers containing red blood cells, macrophages and plasma cells.(<https://microbenotes.com>) .

.The red pulp, it consist of numerous sinusoids containing blood, separated by a net work of perivascular tissue which is referred to as splenic cord (fig2-4) contain numerous microphages and are the site of intense phagocytes activity , they also contain numerous lymphocytes ,which are derived from the white pulp.(<https://microbenotes.com>) .

#### **2-1-1-4Vascular supply of the spleen**

-Blood supplied to spleen is by the tortuous splenic artery that travel horizontally along the superior border of the pancreas .upon entering the splenic hilum ,the splenic artery immediatly branches into six smaller arteries to supply the organ with oxygenated blood to profuse the splenic parenchyma (fig2-5).



**Fig (2. 5)**The circulation of the spleen ( Henry ,2000 )

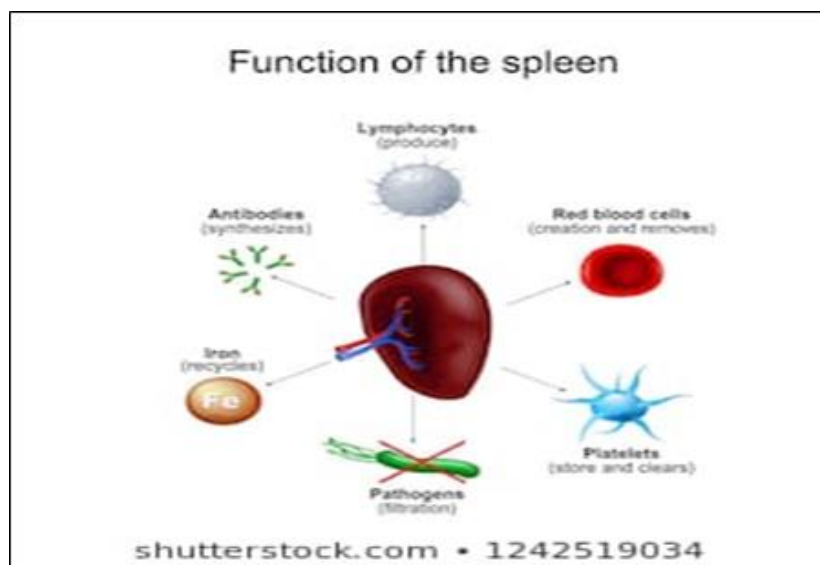
-the splenic vein is formed by multiple branches with in the spleen and leaves the hilum in horizontal direction to join the super mesenteric vein. the superior mesenteric vein returns un oxygenated blood from the bowel to from the main portal vein, the splenic vein travels along the posteromedial border of the pancreas (Sandra ,2012 ) .

-The lymph vessels emerge from the splenic hilum, pass through other lymph nodes along the course of splenic artery ,and drain into the celiac nodes.

-the nerves to spleen accompany the splenic artery and are derived from the celiac plexus.(sandra2012 ) .

### 2-1-2Physiology 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)



**Fig (2. 6)**Function of the spleen(Jon Oringer2018)

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## **2-1-3 Anatomical variation:**

### **2-1-3-1 Accessory Spleen**

An accessory spleen, or splenunculus, is a more common congenital anomaly that may be found in up to 30% of patients' spleens. It usually is found near the hilum or inferior border of the spleen but has been reported elsewhere in the abdominal cavity. It appears as a homogeneous pattern similar to that of the spleen. (Sandra 2012) Fig(2-7)



**Fig (2. 7)** Splenunculi. Longitudinal sonogram of the hilum of the spleen. There is a well-defined splenunculus lying in the hilum. It has the same echo pattern as the spleen. [https://Radiologykey.com](https://radiologykey.com)(2016)

### **2-1-3-2 Splenic Agenesis**

Complete absence of the spleen (asplenia), or splenic agenesis, is rare and by itself causes no difficulties. However, it may occur as part of a major congenital abnormality (Sandra, 2012)

### **2-1-3-3 Asplenic or polysplenia**

Poly splenia is a condition in which multiple spleens are present. As with the accessory spleen, (fig-8) these splenunculi are functional (Anthony, 2002).

The syndromes are associated with complex cardiac malformations, broncho-pulmonary abnormalities, or visceral heterotaxia (anomalous placement of organs or major blood vessels, including a horizontal liver, malrotation of the gut, and interruption of the inferior vena cava with azygos continuation) (Sandra 2012)





**Fig (2. 8)** sonography of poly splenia.

[https// word press .com](https://word press .com)(2016)

### **2-1-3-4Wandering Spleen**

The term wandering spleen describes a spleen that has migrated from its normal location in the left upper quadrant. It is the result of an embryologic anomaly of the dorsal mesentery that fails to fuse with the posterior peritoneum without supporting ligaments of the spleen. The patient may present with an abdominal or pelvic mass, intermittent pain, and volvulus (splenic torsion) The sonographer should use color Doppler to map the vascularity within the spleen. When torsion is complete , the vascular pattern shows decreased velocity(Sandra, 2012).



**Fig (2. 9 )** ultra sound of wandring spleen within the pelvic region

<https //Radiologkey.com>(2016)

### **2-1-3-5 Splenosis**

Splenosis is an acquired condition defined as auto transplantation of viable splenic tissue throughout different anatomic compartments of the body. It occurs after traumatic or iatrogenic rupture of the spleen. The splenic nodule is usually less than 5 Cm ,rounded and has the same echogenic properties of a normal spleen( RumK ,2012) .

### **2-1-3-6 The Upside Down Spleen**

This unusual position of the spleen has the hilum directed either towards head or laterally ,sonographically the upside –down spleen in longitudinal looks like the normal spleen in transverse and the up side down spleen in transverse looks like the normal spleen in longitudinal ,the up side down spleen is a normal variant and not clinically significant.(Devin Dean 2005 ) .

### **2-1-4 Ultrasound technique:**

The left upper quadrant may be imaged as the sonographer carefully manipulates the 2.5 MHz curvilinear transducer between costal margins to image the left kidney, spleen, and diaphragm. The sector transducer may fit between the intercostal margins better than the larger curved-array transducer. The spleen generally lies in an oblique pathway in the posterior left upper quadrant; therefore, the transducer may be placed in the intercostal margin and with a slow anterior to posterior sweep may demonstrate the long axis of the spleen.(Sandra,2012).

When the patient is lying supine, the problem of overlying air-filled stomach or bowel anterior to the spleen may interfere with adequate visualization; thus the patient should be rotated into a steep right decubitus position to permit better transducer contact between the ribs without as much bowel interference. The patient should be instructed to raise his or her left arm over his or her head to further open up the intercostal spaces to allow the transducer better access to the spleen. The right lateral decubitus, or axillary, position enables the sonographer to scan in an oblique fashion between the ribs.(Sandra,2012)



two images of the spleen should be recorded in the longitudinal and transverse plane. The longitudinal plane should demonstrate the left hemi diaphragm, the superior and inferior margins of the spleen, and the upper pole of the left kidney. The sonographer the left plee superior to the diaphragm to see if fluid is present in the lower costal margin. The long axis of the spleen is measured from its superior-to-inferior border.(Sandra,2012)

After the longitudinal oblique scan is completed, the transducer is rotated 90 degrees to survey the spleen in a transverse plane. The sonographer should obtain at least one transverse image at the hilum of the spleen. The sonographer should observe the flow of the splenic artery and vein with color Doppler. .(Sandra ,2012)

### **2-1-5 Sonographic appearance :**

Sonographically, the splenic parenchyma should have a fine uniform homogeneous mid- to low-level echo pattern, as is seen within the liver parenchyma (Figure2-10). The texture of the spleen is actually considered to be more echogenic than that spleen has considerable variation. The spleen has two components joined at the hilum: a supero medial component of the liver. As the spleen enlarges, echogenicity further increases. The shape of the spleen and an infero lateral component. On transverse scans, it has a “crescent” inverted comma appearance, usually with a large medial component and a thin component extending anteriorly. This part of the spleen may be seen to indent The fundus of the stomach. Moving inferiorly, only the lateral component is imaged. On longitudinal scans, the superior component extends more medially than the inferior component. The supero media lcomponent or the infero lateral component may enlarge independently.(Sandra 2012)

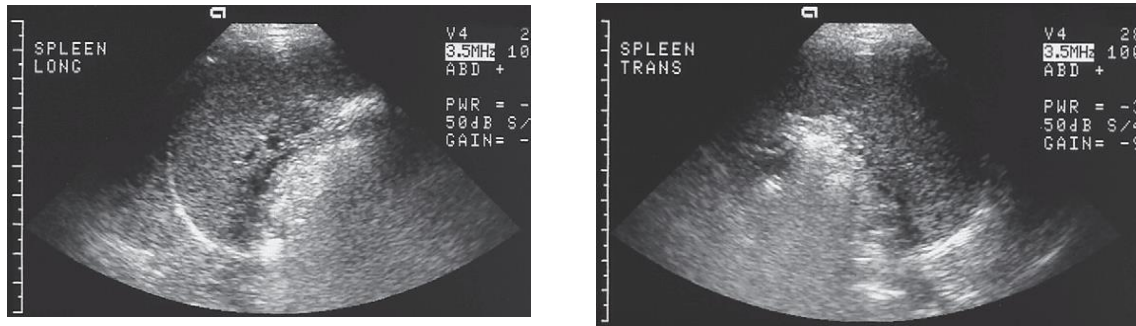


Fig (2-10) Normal spleen. Long (A) and transverse (B) images of the normal spleen. (Sandra 2012)

## 2-1-6 Spleen Measurement

### 2-1-6-1 Measurement for children

The protocols to measure the spleen in the children much like they measuring the spleen in the adult. (Rose bruyn, 2005)

### 2-1-6-2 Measurement for adults:

Measurement technique is illustrated in the following diagram (Fig 2.7) The measurements are obtained 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 and width on a transverse scan the width is measured as the greatest dimension perpendicular to the thickness. (Devin dean, 2005)

Splenic weight (SW) may be calculated by these same three measurements by the formula  $SW \text{ (grams)} = 0.43 \times L \times W \times Th$

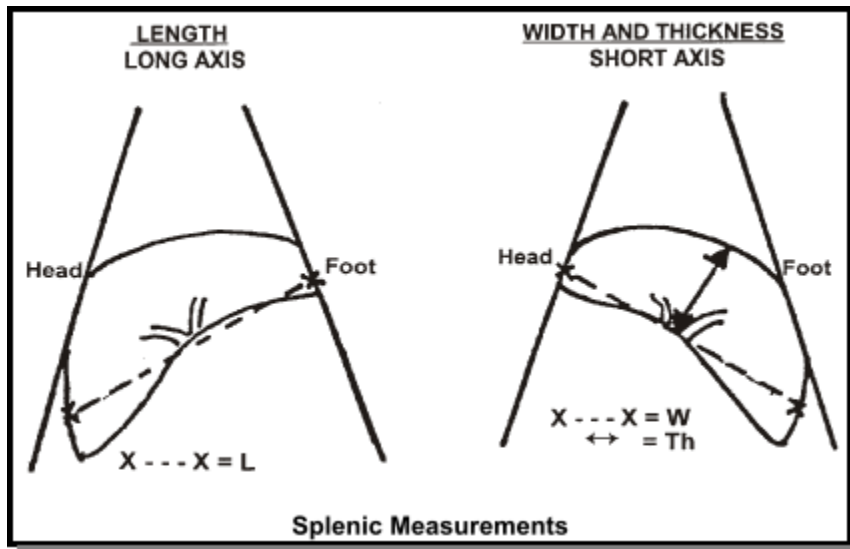
L is spleen length, W is spleen width, Th is thickness at hilum

The mean weight in adult is estimated at 150g. for women and 180g. for men. Splenomegaly is SW exceeding 200g.

Measurement technique is illustrated in the following diagram. The measurements are obtained (fig 2-11):

- Length: by measuring the longest dimension in a sagittal, para sagittal 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.



Fig(2-11)Sonographic measurements of the spleen. (Devin Dean,20)

## 2.2 Previous Studies:

(Stylianios et al 1996) investigated with ultrasonography (US) normal spleen length in healthy children. The study comprised 512 Greek children (274 girls and 238 boys) with ages ranging from 1 day (full-term neonate) to 17 years. The results showed that Spleen length was highly correlated with age, height, and weight; there was no statistically significant difference between the sexes. The exact pattern of these relationships was nonlinear (polynomial type of third order for age, height, and weight). Multiple regression analysis indicated that age, height, and either weight or BSA had significant positive associations with spleen length. The spleen lengths among the sample of 58 children whose height and weight were outside the normal ranges of growth parameters did not influence the proposed upper limits (almost all were within the 90% UCLs with respect to height and weight for the main sample).

(MahaNouri et al ,2012) established a local ultrasonic splenic length which can be used as reference for Sudanese healthy school age children. This study

conducted in 215 (104 males, 111 females) healthy school-aged Sudanese children (7–13 years) and the results showed that there is significant relation between spleen length and age, weight, height and BMI. The mean length of the spleen was found to be 9.5-10.4 cm. There was significant difference between the spleen length in males and females (P-value 0.000), the mean length of spleen in females is greater than in males .

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

**(Husam Eldin Yassien, 2015)** measured the normal spleen in Sudanese school age children using ultrasound. The study conducted in 120 (55 males, 65 females) healthy school-aged Sudanese children (6-15) year and the results showed that there is no obvious difference in measurements between female and male and there is statistically significant correlation between age and the spleen length .

Study done by **(Sharifa Suliman in 2017)** the aim of the study is to Measure the Normal Spleen in Primary School Age using Ultra sonography conducted in (151 children 80 F and 71 M) the result showed a significant relation was found between spleen measurements and age, weight, height and body mass index, also a significant difference between the spleen measurements in males and females was found with the mean spleen measurements in males is greater than in females .

**(Hanna Abass in 2017 )** the aim of her study to measure the normal spleen in primary school using ultra sound .the study conducted in 85 child (21 males and 24 females in Khartoum state and 23 males , 21 females from kurdufan state the result showed there was no liner association between splenic length and age, weight ,height. and there was strong significant correlation between splenic length age ,weight, height in both state .

# **Chapter Three**

## **Materials and Methods**

# Chapter Three

## Materials and Methods

### 3-1 Materials

#### 3-1-1 Design of the study:

This was a descriptive study designed to measure spleen volume in Sudanese children using B-mode ultrasonography.

#### 3-1-2 Population of the Study:

The study included children in ages of 0-17 years of both genders with no morphological abnormalities or other pathology.

#### 3-1-3 Sample size and type:

The sample of this study consist of 100 child, 48 males and 52femals

#### 3-1-4 Study area and Duration:

This study was carried out in Khartoum state , the data collected at Bashair hospital, , . The data collected during period from November2019 to March2020

#### 3-1-5 Inclusion criteria:

Healthy males and females Sudanese children with normal spleen position, shape and echo texture from 0 to 17 years old

#### 3-1-6 exclusion criteria:

Any children affected with malaria, malignant spleen diseases, benign spleen conditions, traumatic spleen or any other spleen pathology was excluded

#### 3-1-7 Equipments:

The data collected by SefiusUF- 980 AG Ultrasound machine, using curve linear transducers, frequencies of 2.5 - 5 MHz have

### 3-2 Methods

#### 3-2-1 Technique:

The spleen was examined with real time curvilinear transducer in sagittal and transverse planes, proper time gain compensation ,frequency, overall gain and depth were used and the procedure was explained to the children. Each child

was examined in right lateral decubitus position and in order to make the examination more transparent, inspiration was used, then the probe was placed along the lower left costal margin from the ninth to eleventh ribs, parallel with the intercostal spaces which was used as a scan window and splenic length(the maximum distance between the dome of the spleen and the splenic tip) was taken in a sagittal plane

### **3-2-2 Data collection:**

The data was collected using data collecting sheet design especially for the study which includes the following variables: Child's weight, age, gender, height, spleen length,

### **3-2-3 Method of data analysis:**

The data analyzed using SPSS and EXIL under windows, by finding the correlation, liner association and significant differences between spleen measurement BMI and geographic area.

### **3-2-4 Ethical Issue**

- Permission to use the collected data for scientific purpose
- Permission from U/S department was obtained .
- Agreement of child parent .
- No patient identical data or details publish .

# **Chapter Four**

## **Results**

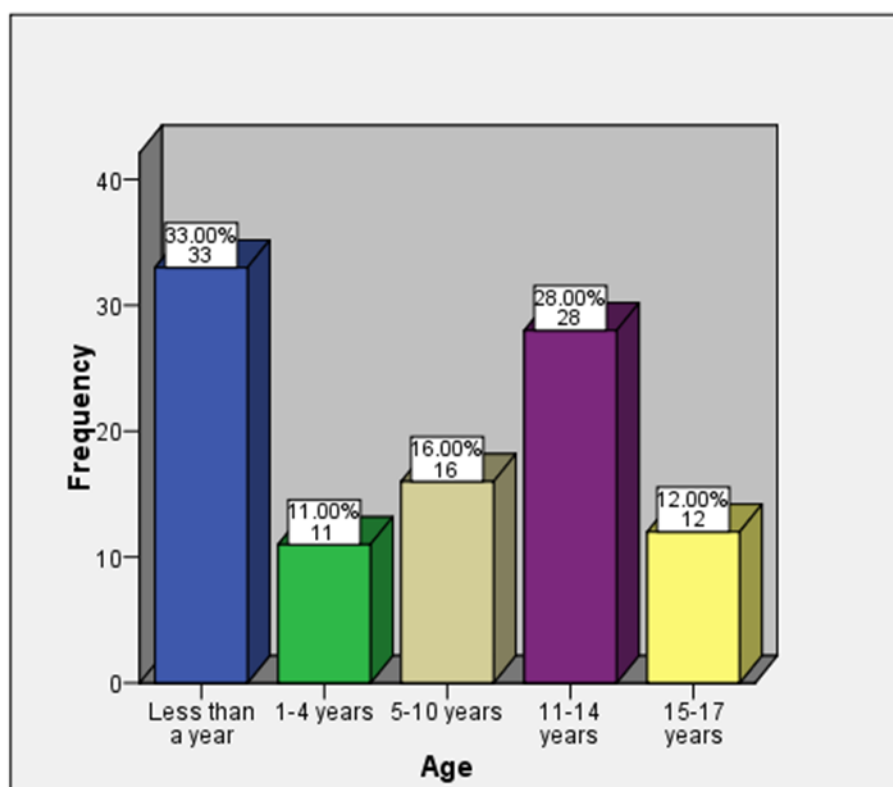


## Chapter Four

### The Results

**Table (4. 1)** Distribution of children according to age:

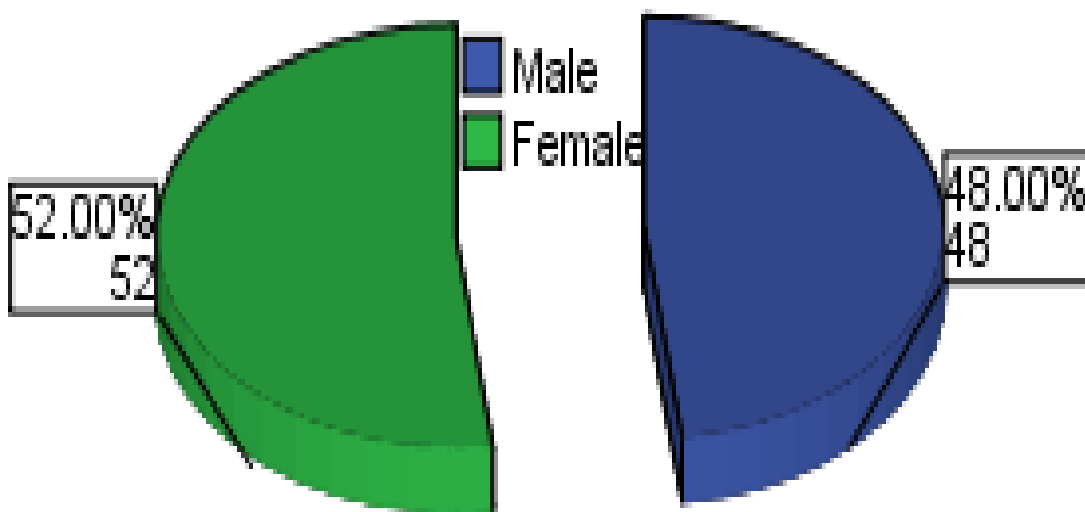
Age	Frequency	Percent	Valid Percent	Cumulative Percent
0-one a year	33	33.0	33.0	33.0
1-4 years	11	11.0	11.0	44.0
5-10 years	16	16.0	16.0	60.0
11-14 years	28	28.0	28.0	88.0
15-17 years	12	12.0	12.0	100.0
<b>Total</b>	<b>100</b>	<b>100.0</b>	100.0	



**FIG(4. 1)** distribution of children according to age

**Table (4. 2)**distribution of children according to gender:

<b>Gender</b>	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Male	48	48.0	48.0	48.0
Female	52	52.0	52.0	100.0
<b>Total</b>	<b>100</b>	<b>100.0</b>	100.0	



**Fig(4. 2)**distribution of children according to gender

**Table (4. 3)**Descriptive statistics for children personal characteristics:

	<b>N</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Deviation</b>
Age	100	0.003	17	7.25126	6.264893
Height	100	0.45	1.75	1.1465	0.42955
Weight	100	2.50	65.00	28.6640	20.28853
BMI	100	5.56	37.14	21.5928	9.43663

**Table (4. 4)**Descriptive statistics for children spleen measures:

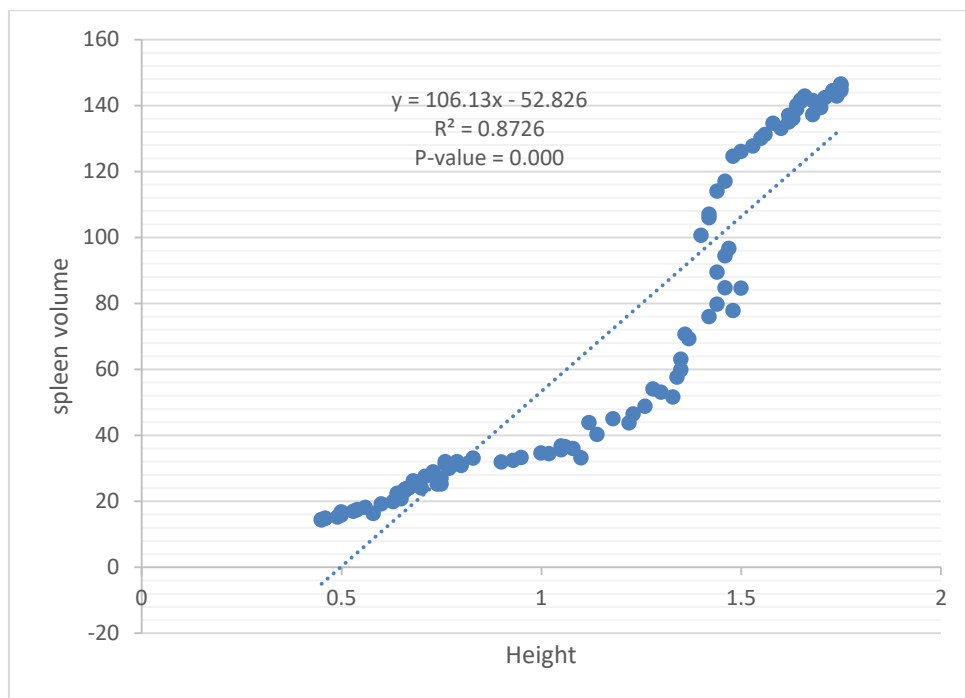
	<b>N</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Deviation</b>
Spleen length	100	4.70	12.00	8.4843	2.08968
Spleen width	100	3.20	10.99	5.9832	1.77217
Spleen thickness	100	1.50	4.0	2.6077	0.71806
Spleen volume	100	14.33	146.43	68.8519	48.80278

**Table (4. 5)**ANOVA test to compare spleen measurements with respective to age:

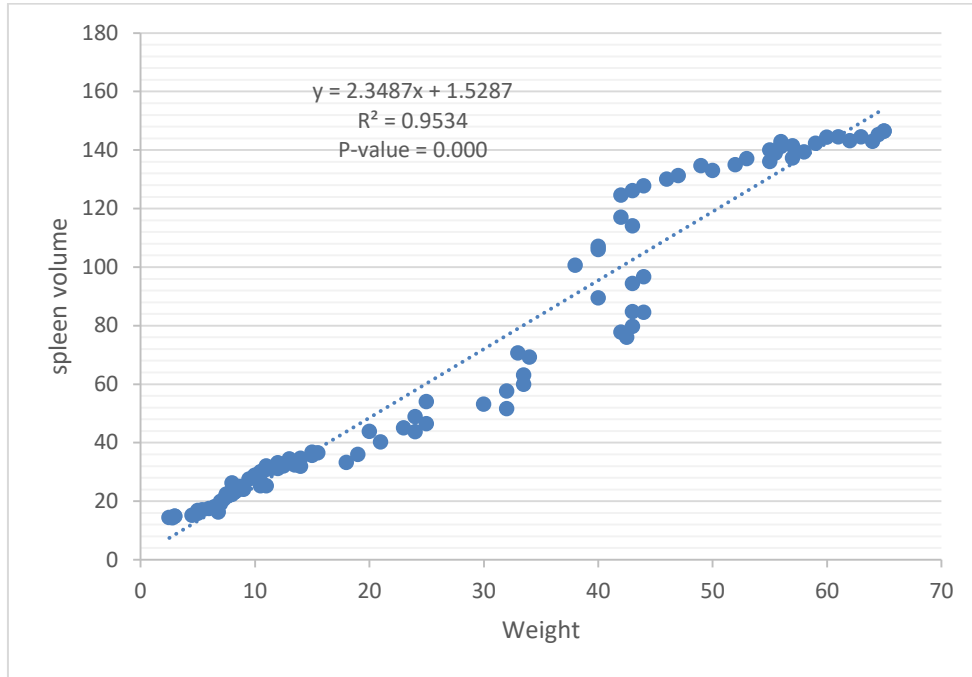
		<b>Mean</b>	<b>Std. Deviation</b>	<b>F-test</b>
				<b>P-value</b>
Spleen length	0-1 year	6.3791	0.89432	0.000
	1-4 years	7.2173	0.29217	
	5-10 years	8.1594	0.87227	
	11-15 years	10.3368	0.77113	
	15-17 years	11.5458	0.61992	
Spleen width	0-1 year	4.2509	0.54096	0.000
	1-4 years	4.7409	0.41932	
	5-10 years	5.5369	0.69084	
	11-15 years	7.9871	0.78675	
	15-17 years	7.8050	0.63692	
Spleen thickness	0-1 year	1.8536	0.14320	0.032
	1-4 years	2.2891	0.19927	
	5-10 years	2.4963	0.11342	
	11-15 years	3.2257	0.41007	
	15-17 years	3.3664	0.3431	
Spleen volume	0-1 year	22.1855	5.41480	0.000
	1-4 years	33.7782	1.93302	
	5-10 years	51.0194	11.02425	
	11-15 years	115.98	22.77112	
	15-17 years	143.14	2.77441	

**Table (4. 6)**t-test to compare spleen measurements with respective to gender:

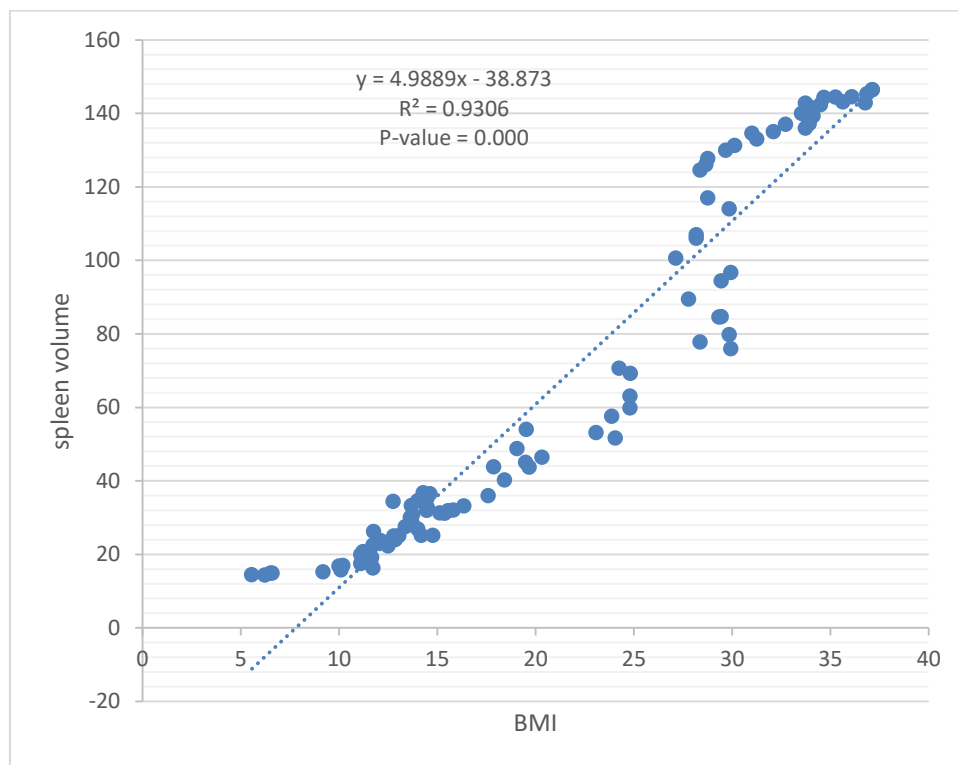
	Gender	N	Mean	Std. Deviation	t-test for Equality of Means
					P-value
Spleen length	Male	48	8.7023	2.06567	0.318
	Female	52	8.2831	2.11147	
Spleen width	Male	48	6.3052	1.89152	0.083
	Female	52	5.6860	1.61601	
Spleen thickness	Male	48	2.7504	.74769	0.425
	Female	52	4.0144	11.30232	
Spleen volume	Male	48	77.4469	51.28691	0.092
	Female	52	60.9181	45.44853	



**Fig(4. 3)** scatter polt show the linear relationship between height and spleen volume



**Fig(4. 4 )** scatter polt show the linear relationship between weight and spleen volume



**Fig(4. 5)** scatter polt show the linear relationship between BMI and spleen volume

# **Chapter Five**

## **Discussion, Conclusion and Recommendations**

## Chapter Five

### Discussion, Conclusion and Recommendations

#### 5.1 Discussion

Table (4.1) and figure (4.1) show that (33%) of children were (0-1) a years, since (11%) of them were 1-4 years, (16%) of them were 5-10 years and (28%) of them were 11-15 years, while (12%) of them were 15-17 years old.

Table (4.2) and figure (4.2) show that (52%) of children are females, since (This table shows that the children were aged from 0 days to 17 years with mean (7.25±6.26 years), since they were 0.45-1.75m with mean (1.147±0.43m) height and 2.5-65kg with mean weight (28.66±20.289kg), while the BMI was 5.56-37.14 with mean (21.593±9.437).

Table(4-3) This table shows that the children were aged from 0 days to 17 years with mean (7.25±6.26 years), since they were 0.45-1.75m with mean (1.147±0.43m) high and 2.5-65kg with mean (28.66±20.289kg), while the BMI was 5.56-37.14 with mean (21.593±9.437).

Table (4-4) This table shows that the children 'spleens measured as 4.7-12 with mean (8.48±2.09) for spleen length, 3.2-10.99 with mean (5.98±1.77) for spleen width and 1.5-4.0 with mean (2.61±0.72) for spleen thickness, while the spleen volume was 14.33-146.43 with mean (68.85±48.80).

Table (4.5) above shown that statistically significant differences between different age groups on the spleen measurements (length, width, thickness and volume, because all P-values the test are less than test significance level (0.05), comparing between different age groups shows that, the older the age the greater the spleen measurement, in other words, the spleen measurements are increase as age increase.

Table (4.6) above shown that statistically insignificant differences between male and female on the spleen measurements (length, width, thickness and volume, because all P-values the test are greater than test significance level (0.05), which indicate that male and female have the same spleen measurements.



Figure (4.3) shows the spleen volume significantly increases with height ( $R^2 = 0.87$  and  $p\text{-value} = 0.000$ ), which indicates that statistically significant relationship between spleen volume and child's height. Furthermore, we can use the values in the equation (spleen volume is  $-52.83$ , while it increases  $106.13$  units per meter in height). I agree with Tana et al studied in 2012 Ultrasonic Measurement of Normal Splenic size in infants and children in Pediatric Indian Population to measure normal splenic size in infants & children in Indian population by ultrasonography, to establish correlation of splenic size with age, height and weight.

Study was conducted in the department of anatomy, radiology and pediatric at a General Public Charitable Hospital Mumbai. The study group consisted of 80 children of both sexes, who were referred to the Radiology department for ultrasonography for abdominal and or pelvis problems unrelated to the spleen. The splenic length was measured by a radiologist using commercially available real time ultrasound system with a Toshiba ecocee using system particularly by using the convex probe. They revealed that, P value is less than 0.001 for all age with splenic size. Splenic size with height, splenic size with weight indicate significant correlation of splenic size with age, height and weight (Tanna et al studied in 2012).

Figure (4.4) shows the spleen volume significantly increases with weight ( $R^2 = 0.95$  and  $p\text{-value} = 0.000$ ), which indicates that statistically significant relationship between spleen volume and weight. Furthermore, we can use the values in the equation (spleen volume is  $1.53$ , while it increases  $2.35$  units per kg in weight).

Figure (4.5) shows the spleen volume significantly increases with BMI ( $R^2 = 0.93$  and  $p\text{-value} = 0.000$ ), which indicates that statistically significant relationship between spleen volume and BMI. Furthermore, we can use the values in the equation (spleen volume is  $38.87$ , while it increases  $4.99$  units per

an unit in BM I agree with Nouri et al ,Established local Reference of spleen length in Sudanese

Normal School Age Children sonographically in 2013 using 215 healthy school-aged children (7 -13 years)from city centers were evaluated ,gender, weight ,height, BMI and abdominal circumference were determined for each case. The sonographic examination for spleen length performed with high resolution real time scanners (SSD-500 Aloka Medical system) fitted with a 3.5 MHZ convex transducer, all of the measured spleens had a normal position, shape, and echotexture. The children were separated in to 7 groups according to age and were classified to male and female . They found that the mean length of the spleen found to be 9.5 -10.4 cm there was significant relation between spleen length and age, weight, height, abdominal circumference and BMI (Nouri et al, 2013 ).

## **5.2 Conclusion:**

The results showed that Spleen length was highly correlated with age, height, and weight; there was no statistically significant difference between the male and female.

The study found that there was a linear association between splenic volume and age, weight and heights of the child.

The data obtained in this study can provide crucial information for surgeons and radiologists about spleen and they can be used as reference values for evaluating pathologic changes in the spleen region especially in splenomegaly.

### **5.3 Recommendations**

- Working with children can be one of the most challenging and rewarding experiences.
- All hospital, health care centers and pediatric clinics must be provided by ultrasound units.
- Every child should be examined once by ultrasound as routine to observe internal organs growth during childhood.
- A larger study sample is required in order to improve the accuracy of our measurement .
- Using of other imaging modalities like computed tomography and magnetic resonance imaging is recommended to confirm the results.

## References

- Aga. Mohammadi S, Clane R Y. (2001). Solitary splenic metastasis Amjclin Oncol .:24:306-10.
- Anthony J .Bowdler , MD , PhD (2002) , The Complete Spleen :Structure ,Function ,and Clinical Disorders . 2 ed , Springer Science +Business Media New York ..
- Dachman AH, et al. (1987). Normal anatomy and Radiolog of liver ,Biliary Tract pancrease and spleen Baltimore williams , ,pp899-915
- Danila ,M. (2010). The ultrasound examination of the spleen ,Med. Ultrason., 12(3):253-4.
- Devin Dean, (2005), Abdominal Ultrasound and instrumentation.Part1 . Module1. 1sted. Theburwin institute of diagnostic medical ultrasound. Luneburg; Canada
- Dhingra , B ,: Sharma , S ,: Mishra , D,: Kumari , R,:Pandy , R.M. &Aggarwal , S . (2010). Normal values of liver and spleen size by ultrasonography in Indian children .,47(6):487-92.
- Henry Gray (2000) ,Anatomy of the Human Body 2 ed .Philadelphia: LEA &Febiger pp. 1821-1865. 29.
- Jane A. Bates, (2004), Abdominal Ultrasound How, Why and When.2nd ed. Elsevier. China
- Kamaya A, Weinstein S, Desser TS. (2006). Multiple lesions of the spleen: differential diagnosis of cystic and solid lesions. Semin Ultrasound CT MR;27:389.
- Rose de Bruyn, (2005). Pediatric ultrasound How, Why and When. Elsevier; London 403 .
- Rumack Cm ,et ,al (2011). Diagnostic ultrasound.4th ed. Elsevier mosby; Philadelphi
- Sandra, (2012). Textbook of Diagnostic Sonography. 7th ed. Elsevier Mosby. California.

[https://shutterstock .com](https://shutterstock.com) (2018)

<https://radiologykey.com> (2016)

<https://slideshare.com> (2016)

[https// wordpress.com](https://wordpress.com) (2016)

# **Appendices**

## Appendix-1

### US images

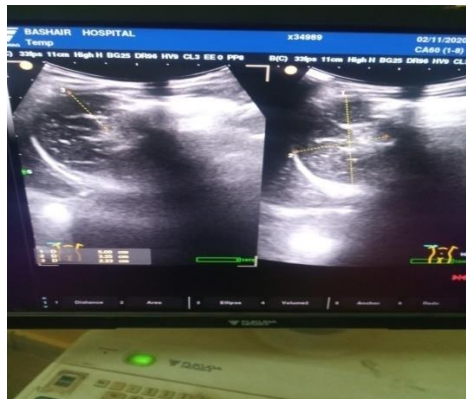


Image (1) : sagittal and transverse U/S image of spleen for male one year , height 80cm and 10 Kg weight . SL 7.5 cm . SW 4.8 , ST 1.9 , SV 30 cm 3



Image (2) : sagittal and transverse U/S image of spleen for male 5 year, height 1.08m and Kg 19weight . SL 6.5cm . SW 5.1 , ST 2.5 , SV35 cm 3) .

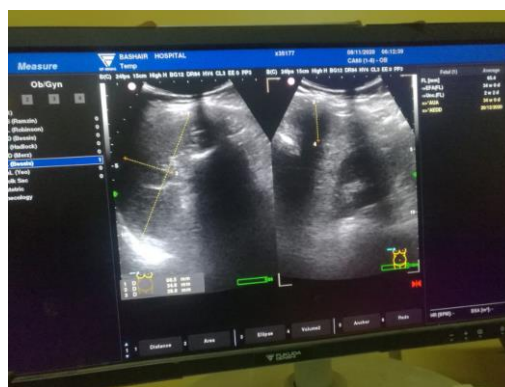


Image (3) : sagittal and transverse U/S image of spleen for female 8year , height 1.23m and 25 Kg weight . SL 8 cm . SW 5.3 , ST 2.4 , SV 46 cm 3) .





Image (4) : sagittal and transverse U/S image of spleen for female 16 year , height 1.68m and 57 Kg weight . SL9.9 cm . SW 7.9 , ST 3.8 , SV 137 cm 3)



Image (5) : sagittal and transverse U/S image of spleen for male 17year , height 1.75m and 65 Kg weight . SL 12cm . SW 7.1 , ST 3.9, SV 146 cm 3) .



**Appendix-3**  
**The Machine**



Sefius UF -980 AG