Sudan University for Science and Technology

College of Graduate Studies

Measurement of Normal Spleen in Pediatrics Using Ultrasonography

قياس الطحال الطبيعي للاطفال باستخدام الموجات فوق الصوتية

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

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الآيـــة

قال تعالى:

((اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (1) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (2) اقْرَأْ وَرَبُّكَ الْأَكْرَمُ (3) الَّذِي عَلَّمَ بِالْقَلَمِ (4) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ (5)))

سورة العلق الآية (1 – 5)

Dedication

To my great soft mother

To my great husband

To my daughters and son

To my sisters and brothers

To all my friends

Acknowledgement

My acknowledgements and gratefulness firstly to my god who gave me the gift of the mind and blessed and guided me to accomplish this thesis.

My gratitude is extended to my supervisor Dr. Ahmed Mustafa Abukonna for his support and his good guidance and help through this thesis.

My gratitude is also extended to Amany Momen for her great help in the collection of data of this research.

Finally I would like to thank everyone who helped me in preparing and finishing this study.

List of Contents

List of Tables

List of Figures

Abstract

This was a cross-sectional descriptive study counted out at Omdurman pediatric Hospital from January to July 2019, which aims to evaluate the spleen size in pediatric. 70 subjects were enrolled in the study; persons who referred to ultrasound department for abdomen ultrasound were included. Any person suspected with abnormal splenic measurement by ultrasound examination was excluded .The population of this study includes (35 males and 35 females) aged (1 – 16 years)

Trans- abdominal scanning was done for all cases using ESAOTI Ultrasound machine with curve linear probe (3.5 MHz). Data collected using a special data collection sheet designed to assess the child's age, weight and height, spleen dimension (length width and thickness).

The result of the study revealed that the splenic measurements were (length 6.92 ± 1.63176 cm, width 3.1716 ± 0.711 cm and thickness 2.64 ± 0.55 cm, a roughly linear correlation between splenic length and age (r = 0.7) was found for the total group of children. Likewise, good correlation was found between splenic length and patient's height (r = 0.7) and weight (r = 0.68). No statistically significant difference was seen between boys and girls, where males had slightly longer spleens than females, generally correlating with their larger size overall.

Determination of pathologic changes in size of spleen necessitates knowing the normal range of dimensions in healthy neonates, infants, and children. Presented data are applicable in daily routine Sonography. Body height should be considered the best criteria to correlate with longitudinal dimensions of the spleen.

المستخلص

كانت هذه دراسة وصفية مقطعية في مستشفى حوادث الاطفال امدرمان من يناير 2019 حتى يوليو 2019و التي تهدف الى تقييك طول الطحال للاطفال في عمر عام حتى سته عشر عاماً باستخدام الموجات فوق الصوتية كان هناك 70 طفلا (35 ذكور و 35 اناث) وكل طفل عمرة اكثرمن ست عشرة عام او لديهم مشاكل في الطحال تم استبعادهم من هذه الدراسة.

تم اجراء المسح عبر البطن لجميع الحالات باستخدام جهاز إزاوتى مديكال مع محول الطاقة 3.5 ميقا هرتز. البيانات التي تم جمعها باستخدام ورقة جمع البيانات الخاصة المصممة لقيم عمر الطفل و الوزن و الطول و ابعاد الطحال (طول و سمك) وحللت البيانات باستخدام الحزمة الاحصائية للعلوم الاجتماعية

أظهرت الدراسة أن قياسات الطحال كانت (الطول 6.92 ± 1.63176 سم ، العرض 3.1716 ± 0.711 سم وسمك 2.64 ± 0.55 سم ، تم العثور على ارتباط خطي تقريبا بين طول الطحال والعمر (معامل ‘رتباط = 0.7) للمجموعة الكلية وبالمثل ، تم العثور على علاقة جيدة بين طول الطحال وطول المريض (معامل إرتباط = 0.7) والوزن (معامل إرتباط = 0.68) ، ولم يلاحظ وجود فروق ذات دلالة إحصائية بين الأولاد والبنات ، حيث كان للذكور طحال أطول قليلاً من الإناث ، مترابطة بشكل عام مع حجمهم الأكبر عموما.

يستلزم تحديد التغيرات المرضية في حجم الطحال معرفة النطاق الطبيعي للأبعاد عند الولدان الأصحاء والرضع والأطفال .البيانات المقدمة قابلة للتطبيق في التصوير بالموجات فوق الصوتية الروتيني اليومي. يجب اعتبار ارتفاع الجسم أفضل المعايير للربط مع الأبعاد الطولية للطحال.

Chapter one

Introduction

Chapter one

Introduction

1.1 Introduction:

The spleen is largest organ in the reticuloendothelial system. Spleen size can be used as indicator of disease activity in variety of disorders of the reticule endothelial system. The spleen responds to different pathologic states by dimensional change. Malaria and sickle cell disease with a geographical bias are known to cause changes in spleen size. Spleen length varies widely according to age also malignancy (Konuş et al., 1998). Among various growth Child hood is an important period of growth for many 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 .there are several methods measuring spleen size including abdominal CT and MR (Guibaud, 2001). However, these approaches have disadvantages such as radiation exposures and high costs. In comparison, Sonography is a safe for and simple method for evaluating spleen length (Guibaud, 2001).

Unfortunately, there is still no consensus on how to define splenomegaly in pediatric patients. Furthermore, the reference values for B-mode spleen ultrasound reported in the literature are controversial, with differences depending, at least in part, on the ethnic heterogeneity of studied pediatric populations that include subjects with different ethnic backgrounds, country of origin and residence. Racial differences and interfering genetic or infectious factors may influence spleen size (Shah et al., 1996).

Considering that the spleen volume could greatly influence the results of splenectomy, it is mandatory to have normal values for the pediatric population in the geographic area where the surgical approach is performed (Guibaud, 2001).

In Sudan, there is absence of domestic reference for spleen length as far as we know; no study was published in the open literature, regarding the spleen length for school age children.

Aim of this study was to obtain normal percentile values in Caucasian children of both sexes, aged 0–18 years, and to evaluate the relationship between splenic measurements and body proportions.

1.2 Problem of the study;

Lack of references which demonstrate the normal splenic length values in Sundance children

1.3 objectives;

1.3.1 General objective;

To measure normal spleen length in school age children using ultrasonography.

1.3.2 Specific objective:

- To correlate age and Wight to splenic length.
- To identify the splenic length in both genders.
- To compare the results in this study with other ethnic groups.

1.4 Thesis overview:

The study consist of Chapter one include the introduction, chapter two include the previous study and literature review ,chapter three include the material and method chapter four contains the results ,chapter five consist of discussion, conclusion and recommendation.

Chapter Tow

Theoretical Background and Literature Review

Chapter tow

Theoretical background and literature review

2.1 Anatomy of the spleen:

The spleen is an intra-peritoneal organ located in posterior portion of left upper quadrant of the abdomen It lies parallel to the diaphragm, medially and anteriorly to the kidney, inferiorly and medially to the tail of pancreas and splenic flexure medially. It is convex along it is superior lateral border and concave medially. The contour is generally smooth but contour lobulation can be seen as normal variant. The splenic artery enters and splenic vein leaves medially at the hilum with the artery being the most posterior vessel (Zheng et al., 2015).

The spleen is organ of the lymphatic system located in the left side of the abdominal cavity under the diaphragm, the muscular portion between the abdomen and the chest in humans it is the size of a fist and is well supplied with blood, as the lymphatic circulation, the spleen is primary filtering element for the blood. In humans, spleen is brownish in color and located in the left upper quadrant of the abdomen (Dong et al., 2015).

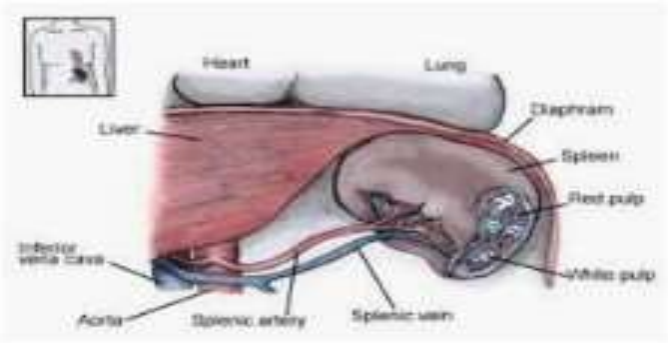

Figure (2-1) spleen Anatomy (Snell, 2012)

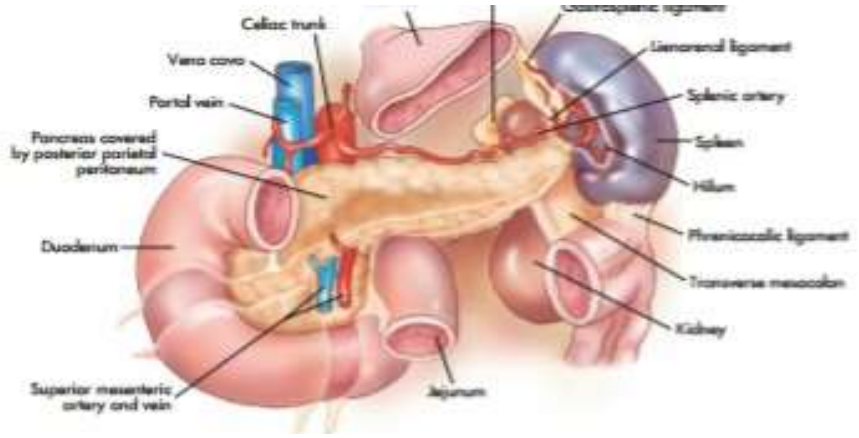

Figure (2-2) shows anatomy of spleen (Zheng et al., 2015)

Figure (2-3) show structures of the spleen (Paraskevas et al., 2016)

2-1-1Development:

The spleen appears about the fifth week as localized thickening of the mesoderm in the dorsal mesogastrium above the tail of the pancreas with the change in position of the stomach and in contact with left kidney. The part of the dorsal mesogastrium which intervened between the spleen and the greater curvature of the stomach form the gastrosplenic ligament (Ignjatovic et al., 2002).

2-1-2 Structure of the spleen:

The external coat or serous coat (tunica serosa) is derived from the peritoneum, it is thin, smooth and in the human subject intimately adherent to the fibroblastic coat, it is invests the entire organ, except at the hilum and along the lines of reflection of the phrenic lineal and gastrolienal ligament (Chadburn, 2000).

The fibroblastic coat (tunica albuginea) invests the organ, and at the hilum is reflection inward upon the vessels in the form of sheaths. From these sheaths, as well as from the inner surface of the fibroblastic coat, numerous small fibrous bands, trabeculae (figure 2-2) are given in all direction; these uniting constitute the frame of the spleen. The spleen than for consists of a number of small spaces or areolae, formed by trabeculae in these areolae contained the splenic pulp (Bajwa and Kasi, 2018).

The fibroblastic coat, the sheaths of the vessels and the trabeculae, are composed of white and yellow elastic fibrous tissues. The later predominating is owing to the presence of the elastic tissue that the spleen possesses considerable amount of elasticity, which allows of the very great variation in size that is present under certain circumstances (Bajwa and Kasi, 2018).

In addition to these constituent this tunic ,these is found in man , in a small amount of non – striped muscular fiber; and in some mammalian e-g dog, pig and cat a large amount , so that the trabeculae appear to consist chiefly of muscular tissue . The spleen is encased in thick connective tissue capsule, inside the mass of splenic tissue of two types; Red pulp and white pulp (which do not separate into regions but intermingle distributed throughout the spleen (Ignjatovic et al., 2002).

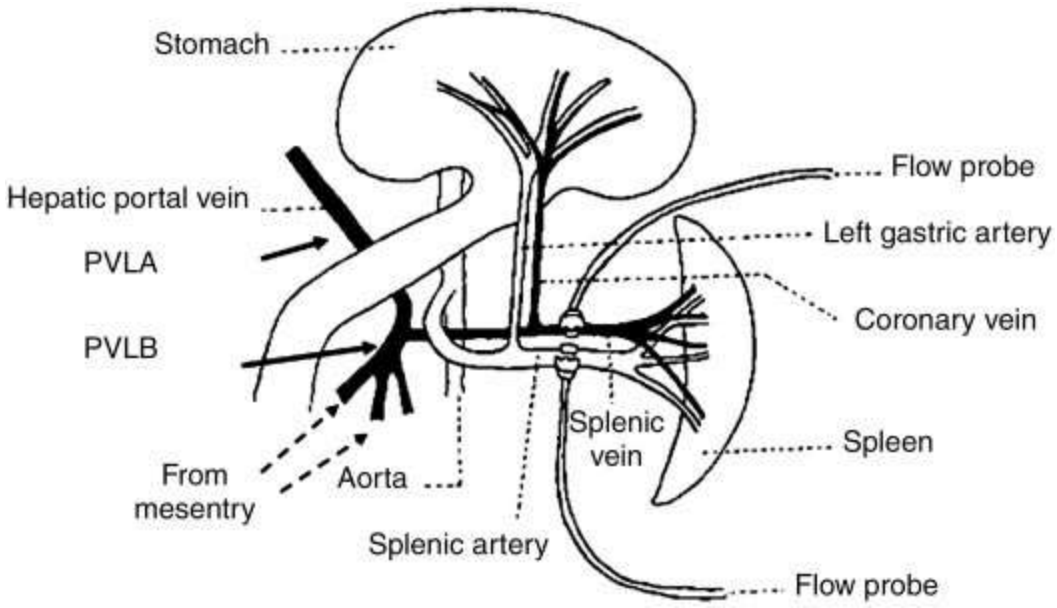

Figure (2-4) shows splenic circulation (Bajwa and Kasi, 2018)

The white pulp is lymphatic tissue that usually surrounds splenic vessels. The red pulp is network of cannels (sinuses) filled with blood and it is in the red pulp that most of the filtration occurs. The splenic pulp (pulpalienis) is a soft mass of a dark reddish – brown color, resembling grumous blood; it is consist of affine reticulum of fibers, continuous with those of trabeculae, to which are applied fat, branching cells. The meshes of the reticulum are filled with blood, in which however the whit corpuscles are found to be in large proportion than they are in ordinary blood.

The large rounded cells, termed splenic cells, are also seen; these are capable of amoeboid movement and often contain pigment and red blood corpuscles in their anterior. The cells of the reticulum each possess around 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 the cell of the Malpighi and bodies (Bajwa and Kasi, 2018).

2-1-3Neurovascular supply:

Spleen is highly vascular organ that receives its arterial blood supply from the splenic artery. This vessel arises from the coeliac trunk, running laterally along the superior aspect of the pancreas, with in the splenorenal ligament. As the artery reaches the spleen, it branches in to five vessels, each supplying a different part of organ. These arterial branches do not anastomose with each other – giving rise to vascular segments without affecting the others (procedure known as a sub total splenectomy. Venous drainage occurs through the splenic vein. It combines with superior mesenteric vein. It combines with superior mesenteric vein to form the hepatic portal vein (Menezes et al., 2014).

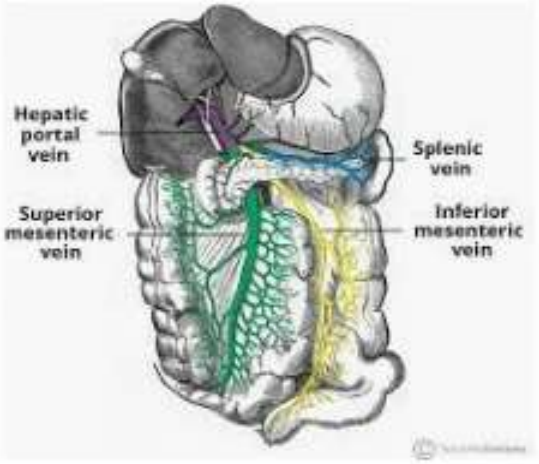

Figure (2-5) show venous portal system-draining into the hepatic portal vein (Menezes et al., 2014)

The lineal artery is remarkable for it is large size in proportion to the size of the organ, and also for it is tortuous course. It divides into six or more branches, which enter the hilum of the spleen and ramify throughout it is substance, receiving sheaths also invest the nerve and vein.

Each branches run in the transverse axis of the organ, from within out word, diminishing, in size during it is transit, and giving off in it is passage smaller branches – some of which pass to the anterior, and others to the posterior part. These ultimately leave the trabeculae sheaths and terminate in the proper substance of the spleen in small tufts or pencils of minute arterioles, which open in to the interstices of the reticulum formed by the branched sustent acular cells. Each of the large branches of the artery supplies chiefly that region of the organ in which the branch ramifies, having no anastomosis with majority of the other branches. The nerve supply to the spleen is from the celiac plexus. The nerves are chiefly non modulated. They distributed to the blood vessels and to smooth muscle of the capsule and trabecular (Zheng et al., 2015).

2-1-4 Accessory spleen:

An accessory spleen is a small splenic nodule extra to the spleen usually formed in early embryogenesis. Accessory spleens are found in approximately 10% of the population and are typically around 1 cm in diameter. Splenosis is condition where displaced pieces of the spleen tissue (often following trauma or after splenectomy, auto transplant in the abdominal cavity as accessory spleens). Polysplenia is a congenital disease manifested by multiple small accessory spleens rather the single, full sized normal spleen. Poly splenia sometimes occur alone, but is often a companied by other developmental abnormalities, such as intestinal malformation, biliary atresia or cardiac abnormalities such as dextrocardia. These accessory spleens are non – functional (Xu et al., 2016).

Figure (2-6) shows accessory spleen (Benter et al., 2011)

2-2 Physiology of the spleen:

2-2-1Spleen function:

The Spleen is useful for the production antibodies against antigen present in blood and it is the only organ that performs such function, Other organs may produce antibodies against antigens seen or present in tissue the spleen also produces large amounts of B and T lymphocytes through its white pulp It is the body It therefore removes old or bad blood cells and platelets and it destroys bacteria and foreign organism by a process of opsonization and also phagocytosis to include its function of process of producing antibodies .The spleen stores about 33% of all platelets to in the entire body and It is involved in hematopoiesis in the fetus and may be implicated in extra medullary hematopoiesis in certain disease condition in the adult . In addition to these function of the spleen also serves in many lower animals , and to little extent in man a reservoir for storing up blood which may then be released into circulation when it is required, as in sudden loss of blood (Paraskevas et al., 2016).

2.2.2 Microcirculation in the spleen;

The open system suggests that there is on continuity between the ellipsoids and the sinusoids Blood from the ellipsoids are discharged into the reticulum of the spleen from which they are absorbed into the sinusoids. The sinusoid makes up the red pulp of the splenic pulp they are connected to the venules as per any of the mechanisms above and from the venules they discharge their blood into the splenic vein. The sinusoid are lined by special endothelial cells which are banana shaped and contain myofibrils that allow them to contract thereby opening up channels by which blood is discharged into the splenic substance. They are called stave cells. Red blood cell passes through the sinusoidal spaces. When they are old, they are unable to pass across and they are then destroyed by the splenic macrophagic system (Paraskevas et al., 2016).

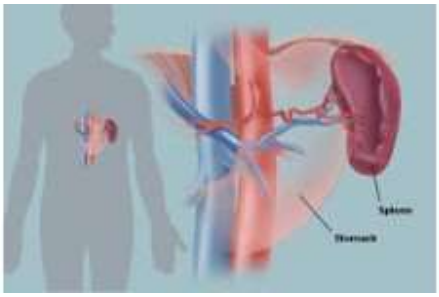

Figure (2-7) spleen function (Paraskevas et al., 2016)

2-2-3 Splenomegaly:

Splenomegaly is enlargement of the spleen, and is one of the four clinical signs of hypersplenism, which includes; some reduction in the number of circulations, blood cells affecting granulocyte, erythrocytes or platelets in any combination, a compensatory proliferative response in the bone marrow, and the Potential to correction these abnormalities by splenectomy. Splenomegaly is usually associated with increased workload (such as in anemia's, which suggests that it is response to hyper function. It is there for not surprising that splenomegaly is associated with

any disease process that involves abnormal red blood cells being destroyed in spleen. Other common causes include congestion due to hypertension and infiltration by leukemia and lymphoma (Menezes et al., 2014).

Figure (2-8) shows splenomegaly (Xu et al., 2009)

2 - 3 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 my 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 (Al-Salem et al., 1998).

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 (Benter et al., 2011).

The right lateral decubitus or axillary position enables the sonographer to scan in an oblique fashion between the ribs. Variations in patient respiration may also facilitate imaging of the spleen; deep inspiration causes the lungs to expand with air and displaces the diaphragm; the lungs may expend so fully that the cost phrenic angle is obscured and visualization of the spleen is impeded. The sonographer should observe the patient's breathing pattern and modify the amount of inspiration to adequately image the spleen without interference from the air-filled lungs (Benter et al., 2011).

At least 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. Sonographer should look at the left pleural space 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. 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 on transverse image at the hilum of the spleen. The sonographer should observe the flow of the splenic artery and vein with color Doppler (Xu et al., 2009).

Figure (2-9) shows Intercostal scan plane and normal spleen image (Benter et al., 2011)

2.4 Ultrasound appearance of the spleen:

The normal spleen has affine, homogeneous texture, with smooth margins and a pointed inferior edge. The texture of the spleen is actually considered to be more echogenic than that of the liver. As the spleen enlarges, echogenicity further increases. The shape of the spleen has considerable variation .The spleen has two components joined at the hilum: a super medial component and an inferolateral component. On transverse scans, it has a "crescan" 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 superomedial component or the inferolateral component may enlarge independently. The irregularity of these component makes it difficult to assess mild splenomegaly accurately (Benter et al., 2011).

Figure (2-10) show normal spleen image (A) long and (B) transverse (https:/www medical news today .com)

2.5 Ultrasound measurements:

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 a convex superior and concave inferior surface .The size of a normal spleen depends on gender, age and body-height. The wide range of what normal sized adult spleen

is combined with its complex three dimensional shape makes it particularly difficult to establish a normal range of sonogrphic measurements (Benter et al., 2011).

2.5.1 Measurement for adults:

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. The measurements are obtained by measuring the longest dimension in a sagittal ’ parasagittal or coronal plane thickness on a transverse scan the hailer thick ness 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 (Catalano et al., 2006).

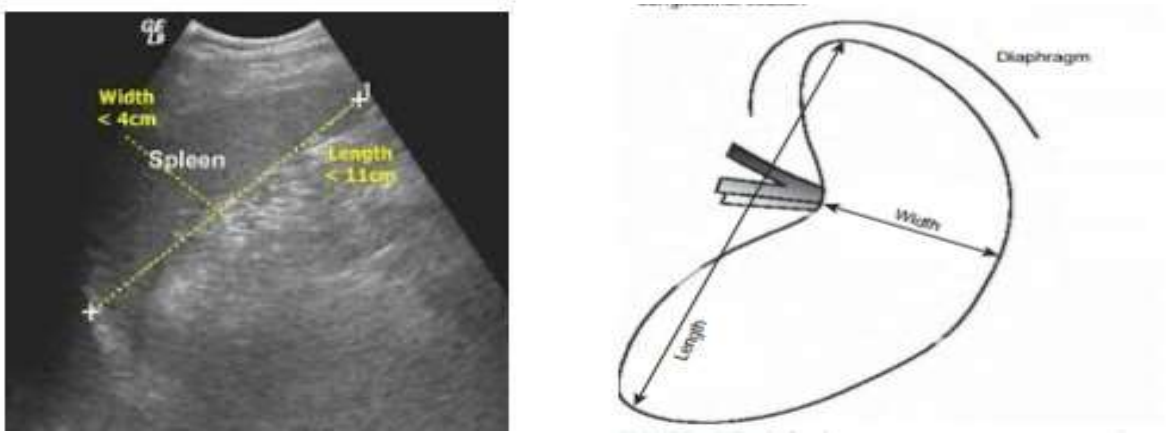

Figure (2-11) show Sonographic measurements of spleen (Catalano et al., 2006)

2.5.2 Measure meant for children :

The protocols to measure the spleen in the children much like them measuring the spleen in the adult

Table 2.1 Normal spleen size in 230 infant) and children Length of spleen (cm)

Age (number)	10th perecentile	median	90thmercentil	Suggested upper limit.
0-3 month (n=28)	3.3	4.5	5.8	6.0
3-6 month (n=13)	4.9	5.3	6.4	6.5
6-12 month (n=17)	5.2	6.2	6.8	7.0
1-2 years (n=12)	5.4	6.9	7.5	8.0
2-4 years (n=24)	6.4	7.4	8.6	9.0
4-6 years (n=39)	6.9	7.8	8.8	9.5
6-8 years (n=21)	7.0	8.2	9.6	10.0
8-10 years (n=16)	7.9	9.2	10.5	11.0
10-12 years (n=17)	8.6	9.9	10.9	11.5
12-15 years (n=26)	8.7	10.1	11.4	12.0
15-20 years (n=17)				
Female	9.0	10.0	11.7	12.0
Male	10.1	11.2	12.6	13.0

2-6 Previous study:

A study conducted by (Paterson et al., 1999) stated that the spleen in infants and children is commonly involved in a variety of pathologic processes. Some of these processes cause isolated splenic disease, whereas others involve the spleen as part of a systemic illness. To facilitate differential diagnosis of splenic abnormalities, a pattern-oriented approach to the imaging evaluation of the pediatric spleen was developed. With this approach, splenic anomalies are categorized as anomalies of splenic shape (clefts, notches, lobules), location (eg, wandering spleen), number (polysplenia, asplenia), or size (splenomegaly, splenic atrophy); solitary lesions (eg, cysts, lymphangiomas, hemangiomas, hamartomas); multiple focal lesions (eg, trauma, infection and inflammation, neoplasms, storage disorders); and diffuse disease without focal lesions (eg, infarction, heavy metal deposition, hemangioendotheliomas, peliosis). A variety of imaging modalities can be used in splenic assessment, including computed tomography, magnetic resonance imaging, ultrasound, and technetium-99m scintigraphy. The imaging appearance of the pediatric spleen depends on the patient's age and the modality used; however, familiarity with the spectrum of radiologic patterns of splenic involvement will facilitate correct diagnosis and prompt treatment.

Another study conducted by (Al-Imam et al., 2000) revealed that Splenic lengths in Iraqi subjects are similar to those in American, Chinese and Jordanian subjects up to the age of 15 years. The spleen to left kidney ratio is strikingly constant with a mean value of 1. Using 2 SD above the mean as a guide, the upper limit of normal for spleen to left kidney ratio is 1.25. The study concluded that splenomegaly should be suspected in children if the spleen is more than 1.25 times longer than the adjacent kidney.

(Elbasher, 2017) established a local ultrasonic splenic length which can be used as a reference for Sudanese healthy school age children, this study conducted in 2015

(104males 111females 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 - 10.4cm) there was significant difference between the spleen length in males and length and females (p.valueo.0001), the mean length of spleen in females is greater than in males.

Study done by (Suliman, 2017) the aim to the study is to measure the normal spleen in primary school age using ultrasonography conducted in (151 children 80 female and 71male)the result showed a significant relation was found between spleen measurements and age , weight ,heightened body mass index ,also a significant difference between the spleen measurements in males and females was found with the mean spleen measurements in males was greater than in females.

Chapter Three

Materials and Method

Chapter Three

Materials and Method

3.1 Material:

3.1.1 Machine used

Diagnostic ultrasound equipment model ESATOE Medical" Aquila" standardized transabdominal scan using curvilinear transducer 3.5MHZ was carried on.

3.1.2 Subjects:

Seventy subjects were enrolled in the study; persons who referred to ultrasound department for abdomen ultrasound were included. Any person suspected with abnormal splenic measurement by ultrasound examination was excluded .The population of this study includes (35 males and 35 females) aged (1 – 16 years) with normal status.

The researcher got an ethical approval from the hospital and the department to collect the data from the patient and verbal agreement from the patient.

3.2 Method:

3.2.1 Technique Used:

Trans-abdominal ultrasound technique was performed with patient laying in supine position angle the probe between the ribs intercostally from postero lateral approach.

Each subject from sample was fasting for 8hours and having abdominal preparation then ultrasound scan for splenic measurement (length, width, thickness, splenic weight, also body weight and height must be measured.

3.2.2 Design of the study:

This study is cross-sectional analytical study conducted in Khartoum state at Omdurman pediatric hospital from March to June 2019.

3.2.3 Method of data analysis:

Data were collected with special data collection sheet encompass patient demographic data and ultrasound findings. Then the Data were analyzed using SPSS and excel software. Descriptive statistics as well as correlations were performed.

Chapter Four

Results

Chapter four

Results

4-1 Results

Table (4.1) frequency distribution of sex

Sex	Frequency	Percent	Valid percent	Cumulative percent
Male	35	50.0	50.0	5.0.0
Female	35	50.0	50.0	5.00
total	70	100.0	100.0	

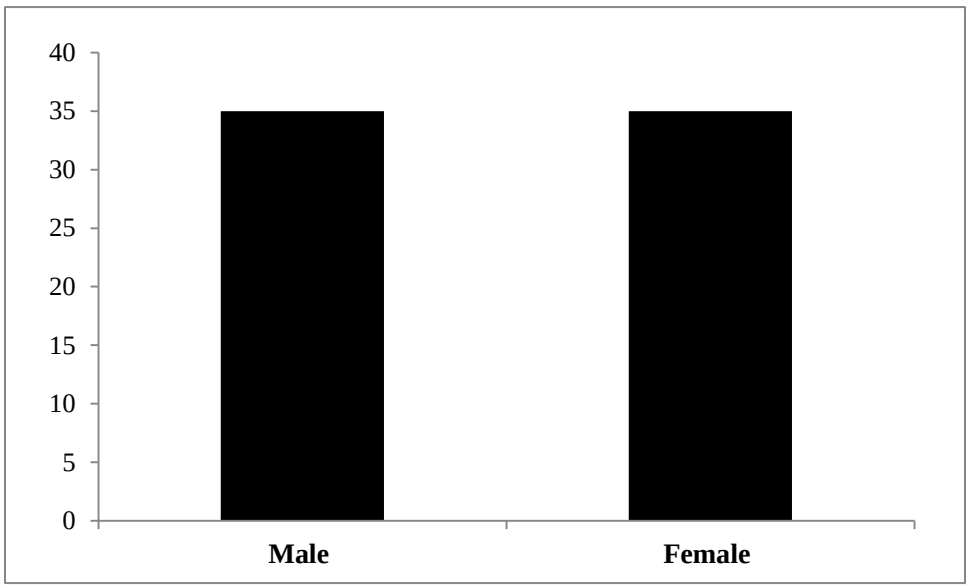

Figure (4.1) Shows frequency distribution of sex

Table (4.2) show Minimum, mean and standard deviation for age, weight and height of children.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	70	1	16	6.94	4.705
Weight	70	5.0	54.0	18.729	10.5867
Height	70	57	162	100.51	27.364

Table (4.3) show Minimum, mean and standard Deviation for Spleen Length, Spleen Width and Spleen Thickness.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Spleen Length	70	4.00	10.45	6.9269	1.63176
Spleen Width	70	2.13	5.40	3.1716	.71160
Spleen Thickness	70	1.50	4.10	2.6423	.55100

Table (4.4) show Minimum, mean and Standard Deviation of spleen length and Spleen Width and Spleen Thickness for male and female .

Group Statistics					
	Gender	N	Mean	Std. Deviation	Sig. (2-tailed)
Spleen Length	Male	35	7.0137	1.43269	0.659
	Female	35	6.8400	1.82632	0.659
Spleen Width	Male	35	3.2737	.69230	0.232
	Female	35	3.0694	.72587	0.232
Spleen Thickness	Male	35	2.7183	.55483	0.251
	Female	35	2.5663	.54443	0.251

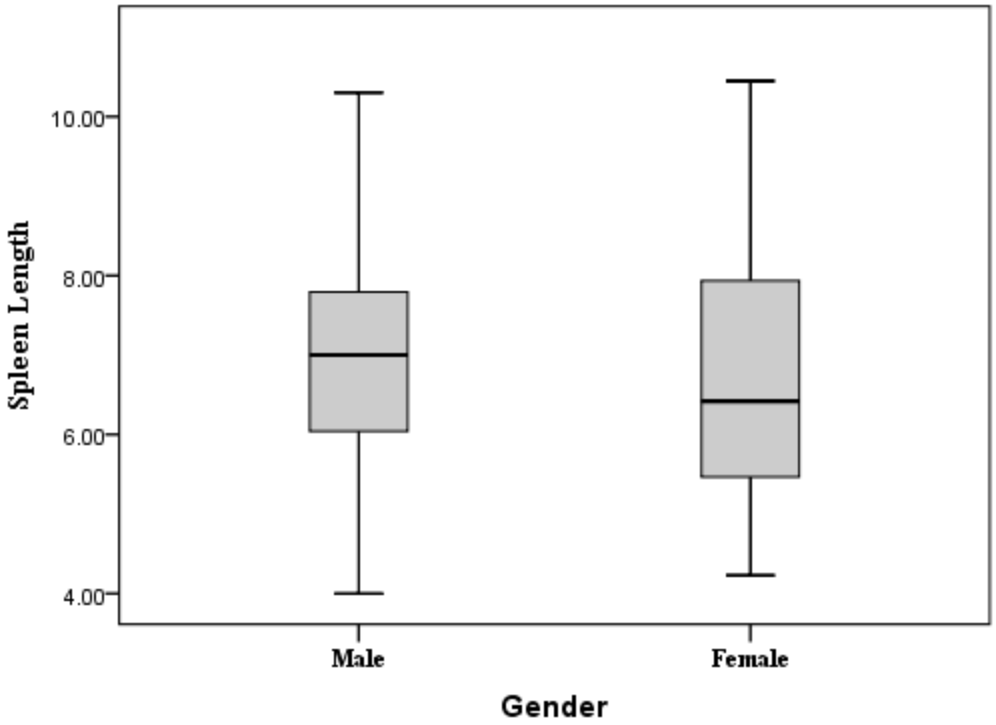

Figure (4.2) Shows spleen length in both genders

Table (4.5) show correlation between age, weight and height of children and Length, Width and Thickness of Spleen

		Age	Weight	Height
Spleen Length	Pearson Correlation	.699**	.649**	.683**
	Sig. (2-tailed)	.000	.000	.000
	N	70	70	70
Spleen Width	Pearson Correlation	.588**	.570**	.567**
	Sig. (2-tailed)	.000	.000	.000
	N	70	70	70
Spleen Thickness	Pearson Correlation	.539**	.471**	.512**
	Sig. (2-tailed)	.000	.000	.000
	N	70	70	70
**. Correlation is significant at the 0.01 level (2-tailed).				

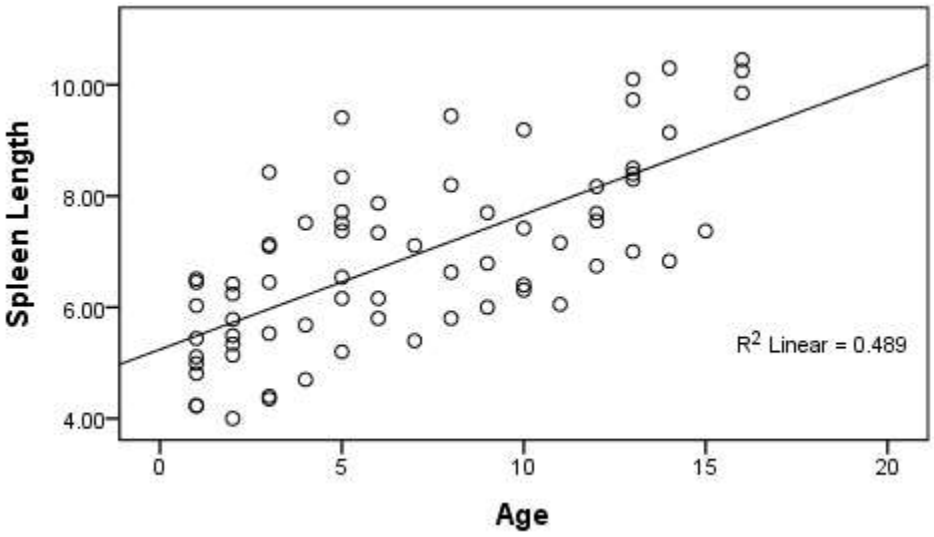

Figure (4.3) Shows relation between age and spleen length

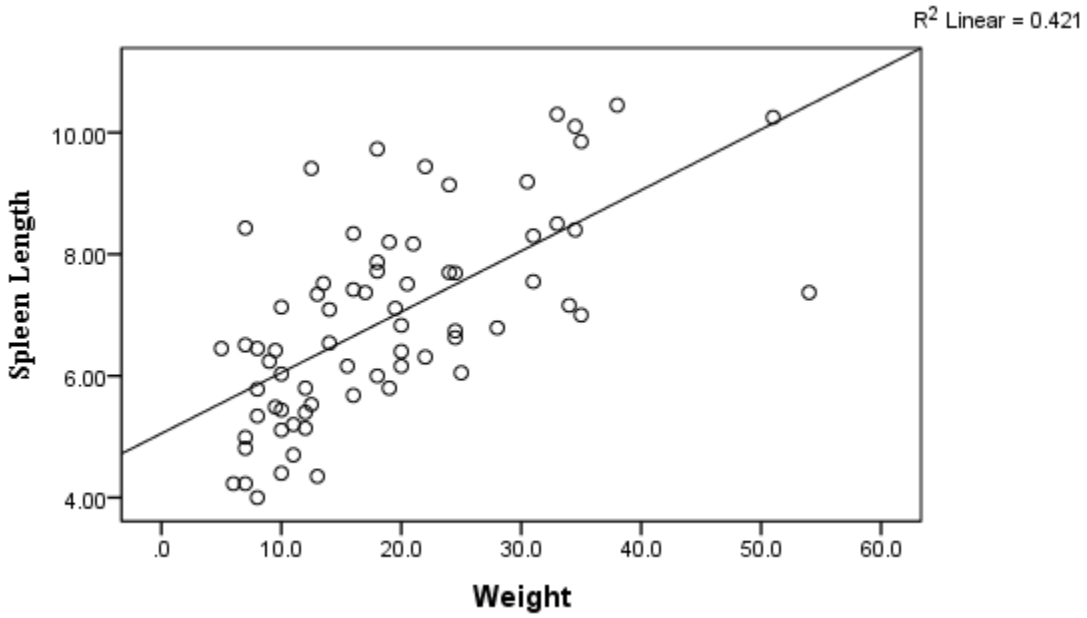

Figure (4.4) scatter plot Shows relation between weight and spleen length.

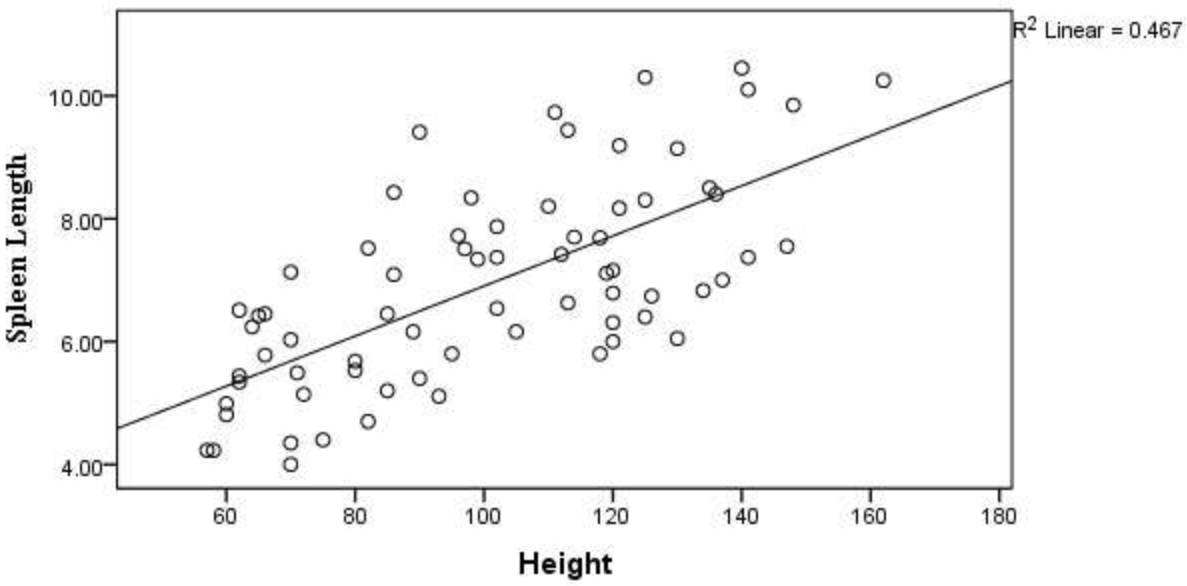

Figure (4.5) scatter plot Shows relation between height and spleen length.

Chapter Five

Discussion, Conclusion and Recommendation

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5-1 Discussion:

Evaluation of splenic size by percussion and palpation is notoriously inaccurate. Radiologic methods and scintigraphy, although dependable, require radiation exposure. The calculation of splenic volume in children by using Sonographic measurements can be cumbersome and time-consuming and therefore impractical for routine clinical use. Our purpose was to establish the normal range of splenic size in a population of children, from full-term neonate to 16-year-old, to develop a practical, reliable Sonographic approach for measurement, and to establish guide-lines for normal splenic size in children. 70 healthy Sudanese pediatric were enrolled in the study, the mean of body weight was 18.729 kg with and the mean of body height is 100.51 cm.

The splenic measurements were (length 6.92 ± 1.63176 cm with, width 3.1716 ± 0.711 cm and thickness 2.64 ± 0.55 cm, these measurements are consistent with previous normal values reported for general pediatric population (Andrews etal., 2010). A roughly linear correlation between splenic length and age (r = 0.7) was found for the total group of children. Likewise, good correlation was found between splenic length and patient's height (r = 0.7) and weight (r = 0.68). No statistically significant difference was seen between boys and girls, where males had slightly longer spleens than females, generally correlating with their larger size overall. This result was in line with previous studies (Rosenberg et al., 1991, Suliman, 2017).

Sonography provides a simple, practical, reliable means for obtaining splenic length measurements in infants and children. Our technique, however, does not

allow volume measurements as other authors' techniques have, but instead serves as a guide for selecting those patients who require more quantitative estimations of splenic size. Several groups have determined normal splenic volume and weight and found that splenic weight is related to the age and sex of the patient (Picardi et al., 2002).

We found these techniques far too cumbersome and time-consuming for practical everyday use and suggest the following upper-limit guidelines for sonographically assessing splenic length in children with our one-step coronal measurement; lower limit was 4 cm and upper limit was 10.4 cm.

Determination of pathologic changes in size of spleen necessitates knowing the normal range of dimensions in healthy neonates, infants, and children. Presented data are applicable in daily routine Sonography. Body height should be considered the best criteria to correlate with longitudinal dimensions of the spleen.

5.2 Conclusion:

This study defines normative values for spleen size for Sudanese pediatric population. The variation in normal splenic dimensions in this study group underling the diversity of body types observed .the normal limit of spleen measurements are important during a sonographic examination. The study found that there was strong significant correlation between splenic length and age, weight and height.

5-3 Recommendations:

- All 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.
- In the Sudan there are different types of races, and this may affect different organs measurements, there for further studies should be done for these variables including different areas and tribes in the Sudan, and in Sudan.
- The splenomegaly in all ultrasound clinics detected just by the length measurement of the spleen, but the spleen measurements must include the width and the thickness to get the splenic volume and weight

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Appendices

Data Sheet :

No	Patients information				Ultrasound measurement of spleen		
	sex	age	weight	height	length	width	thickness

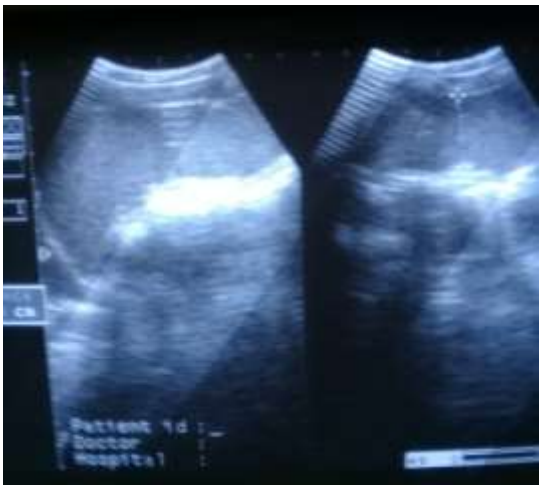

Image 1 Sagittal and transverse U/S image of spleen for female in 8 years old age 113 height and 22 Kg weight.

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Image 1 Sagittal and transverse U/S image of spleen for female in 1 years old age 60 height and 7.5 Kg weight.