Sudan University of Science and Technology

College of Graduate Studies

Measurement of Visceral Organs in Sudanese Children Using Ultrasonography

قياس الأعضاء الحشوية عند الأطفال السودانيين باستخدام الموجات فوق الصوتية

A thesis submitted for the diagnostic fulfillment of PhD Degree in Medical Ultrasound

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قال تعالى:

وَمَا بِكُم مِّن نِّعْمَةٍ فَمِنَ اللَّهِ ۖ

سورة النحل

وقال تعالى:

وَكُلَّ شَيْءٍ أَحْصَيْنَاهُ كِتَابًا (29)

سورة النبأ

صدق الله العظيم

Dedication

To the soul of my parents who encouraged me to get the best out of me,

To my wife and children who motivated me to finish this work,

To my brothers and sisters whom I love,

To my three children who made me realize the true meaning of dedication, Wigdan, Eltayeb and Bayan,

To my companions and colleagues and everyone who helped make this dream come true,

And of course I shall not forget, to my nephew Eltayeb Elkhedir who has the massive credit for his ever ending efforts and support, in accordance with his father Dr Elkhedir Ahmed who after Allah made this work possible.

Acknowledgements

To whom my life is given a purpose I would like to thank Allah, and I would offer my sincere thanks to my supervisor Dr. Mona for her efforts and support by editing and reflecting this work and for her generous encouragement patience after me,

I would also like to acknowledge Sudan University of Science and Technology for allowing me to conduct my research and providing me any form of assistance I need.

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I'd like to also thank Alsheikh Khalid Medical Complex for their never ending support and for easing the process of my data collection phase.

Abstract

This study was conducted in Khartoum state, in the ultrasound department of Sheikh Khalid medical complex. The problem of the study is lack of reference for physicians to refer to when needing standards to compare the values of the liver, kidneys and spleen of their patients and determine whether the organs are diseased or healthy, there are no many previous studies were made with the same specifications on the same region. The purpose of this study is to evaluate normal visceral organs in Sudanese children using ultrasonography it was conducted to specify the measurements of the liver, spleen and kidneys for children from ages (6 months up to 14 years). This study is classified and analyzed using SPSS (Standard Package for Social Science), the analysis result showed that the data collection for 302 children according to age from 6 months to 14 years. The study found that there was significant difference in liver and spleen length in different gender ($p <$ than 0.01 and 0.05 respectively) but no significant difference in measurements of kidney in both gender $p > 0.05$, the mean measurements is slightly more in male than female. The study concluded the linearity in relationship between liver span, spleen length, both kidney length and age, weight, height, BMI. The study concluded that the visceral organs can be estimated dynamically using age following equation (liver span, spleen, Rt kidney, Lt kidney) every one year length increase (0.38, 0.21, 0.251, 0.253 cm) respectively. In using height following equation every 1 cm height (liver, spleen, Rt kidney, Lt kidney) height had influenced the parameter of the three organs by length increase (0.041, 0.03, 0.0385, 0.038 cm) respectively.

In using weight following equation every 1 kg weight the (liver, spleen, Rt kidney, Lt Kidney) length increase (0.0781, 0.0666, 0.0664, 0.068 cm) respectively. In using BMI following equation every 1 kg cm2 (liver, spleen, Rt kidney, Lt kidney) length increase (0.1409, 0.1564, 0.1148, 0.1152 cm) respect.

ملخص الدراسة

أجريت هذه الدراسة في السودان في قسم الموجات فوق الصوتية في مجمع الشيخ خالد الطبي بولاية الخرطوم .مشكلة الدراسة هي عدم وجود مرجعية للأطباء للرجوع إليها عند الحاجة لمعايير لمقارنة قيم الكبد والكلى والطحال لمرضاهم وتحديد ما إذا كانت الأعضاء مصابة أوصحية ، إضافة إلى أنه لم يتم إجراء العديد من الدراسات السابقة بنفس المواصفات على نفس المنطقة. الغرض من هذه الدراسة هو تقييم الأعضاء الحشوية الطبيعية لدى الأطفال السودانيين باستخدام الموجات فوق الصوتية التي أجريت لتحديد قياسات الكبد والطحال والكلى للأطفال من سن (6 أشهر إلى 14 سنة) .تم تصنيف هذه الدراسة وتحليلها باستخدام SPSS (الحزمة القياسية للعلوم الاجتماعية) ، وأظهرت نتيجة التحليل الذي تم جمعه ل 302 طفلا بمدرسة الاندلس الخاصة بنين وبنات ومستشفي وعد التخصصي في الشريحة العمرية من 6 أشهر إلى 14 سنة أن مقاييس هذه الأعضاء تتناسب طرديا مع عمر الطفل وطوله. وجدت الدراسة أن هناك اختلافاً كبيرًا في طول الكبد والطحال في جنس مختلف ($p <$ من 0.01 و 0.05 على التوالي) ولكن لا يوجد فرق كبير في قياسات الكلى في كلا الجنسين $p > 0.05$ ، والقياسات المتوسطة هي أكثر قليلاً في الذكور من الإناث . وخلصت الدراسة إلى العلاقة الخطية بين حجم الكبد وطول الطحال وطول الكلى والعمر والوزن والطول ومؤشر كتلة الجسم.

خلصت الدراسة إلى أنه يمكن تقدير الأعضاء الحشوية ديناميكيًا باستخدام معادلة العمر التالية (حجم الكبد، الطحال، الكلية اليمني، الكلية اليسري) كل عام تكون الزيادة (0.38 ، 0.21 ، 0.251، 0.253 سم) على التوالي. باستخدام معادلة الطول التالية كل واحد سنتمتر ارتفاع (حجم الكبد، الطحال، الكلية اليمني، الكلية اليسري) هنالك أثرعلى معامل الأعضاء الثلاثة بزيادة الاطوال (0.041، 0.03، 0.0385 ، 0.038 سم) على التوالي. عند استخدام المعادلة التالية للوزن كل واحد كجم وزن (حجم الكبد، الطحال، الكلية اليمني، الكلية اليسري) هنالك زيادة في الطول (0.0781، 0.0666 ، 0.0664 ، 0.068 سم) على التوالي. أيضا عندما نستخدم المعادلة التالية لمؤشر كتلة الجسم كل واحد كجم في السنتمتر المربع (الكبد ، الطحال ، الكلى اليمني، الكلية اليسري) هنالك زيادة في الطول (0.1409 ، 0.1564 ، 0.1148 ، 0.1152 سم) على التوالي

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Introduction

CHAPTER ONE

1.1 Introduction:

Sonography provides a quick assessment of visceral organ dimensions without any risk of radiation. Available data is limited for the liver and the spleen in children, which causes difficulty in defining hepatomegaly and splenomegaly sonographically. The purpose was primarily to document the normal range of dimensions of the liver in children. The relationship of each dimension with sex, age, bodyweight, height, and body surface area was determined. The spleen is a soft, purple colored organ which is considerably larger than in most cadavers BHC Normally, the spleen does not extend inferior to the left costal margin; hence a normal spleen is seldom palpable through the anterolateral abdominal wall.[1] It varies in size and shape but it is usually 12 cm long, 5 cm thickness, and 7 cm wide. As a result of increased appreciation of the spleens function in the body's defense against disease, Splenectomy is no longer performed as hastily as in the past. (Snell, 2018)

As a clinical guideline, the distance that the spleen extends below the left costal margin is often used to monitor spleen size, but clinical examination of splenic size is notoriously inaccurate. In a study evaluating spleen size in patients with sarcoidosis, splenomegaly was present in 57% of the patients (using sonographic criteria to evaluate size) but only clinically palpable in 8%. The range in reported sensitivity of assessing splenomegaly by palpation of the abdomen varies from 50% at best to the more realistic estimate of 17%. In addition, mild splenomegaly may be difficult to identify by clinical examination. in a study of a healthy collegiate athletic

population found that spleen size was larger in men and white athletes than in women and black athletes. (Snell, 2018).

Prior to the development of sonography, size, particularly the measurement of radiographic spleen length was obtained from plain radiography. A potential cause of inaccuracy and drawback of this method was that plain radiographs give a composite shadow which may not be entirely the spleen. (Snell, 2018)

It has been found that splenic size is better evaluated by ultrasonography, computed tomography or magnetic resonance imaging than by plain radiography. Several studies have sought to develop standards for splenic size, utilizing a variety of imaging techniques such as computed tomography, scintigraphy, magnetic resonance imaging, and sonography. (Teach me Series, 2019)

Ultrasonography affords a useful noninvasive role in evaluating the spleen and used for best advantage, it can demonstrate the existence and composition of splenic masses, disruption of splenic texture or outline, progressive changes in masses and the size of the spleen.

There were significant correlations between all renal dimensions with age, weight, height, In the regression analysis, the most significant contributing factor to renal growth was height , there was statistically significant differences were observed between right and left kidneys length and volume but there is no significant difference between other kidney measurements(width and breadth).also the study found that was no significant difference in the kidney length and volume among boys and girls in all age groups. Scatter plots were created, and they showed a close linear relationship between height and renal length and renal volume.

Renal size is an important parameter in the assessment of a child with renal disease since the kidney continues to grow in size after birth and reaches the near adult size of 10 cm by 12 years of age decrease or increase in

kidney size is an important sign of renal disease. Thus while evaluating a child presenting for the first time with a sudden deterioration of renal functions; it is the kidney size which helps differentiate acute kidney injury where the size maybe normal or large, from an acute exacerbation of chronic kidney disease (CKD) where the kidney size is invariably small. (Carol et al, 1993)

The research presents reliable practical reference for normal standard kidney, liver and spleen length and volume values by sonography in healthy pediatric population in Sudan.

Liver size varies widely according to age, sex, height and weight. Many diseases can affect their size ranging from infective processes to malignant ones.

An ultrasound measurement of the liver size in children of different age groups is necessary to help the pediatrician exclude hepatomegaly as well as to properly diagnose the subject by comparing these measurements with the standards of which this study is dedicated to provide.

Ultrasonography is a non-invasive, established, safe, quick and an accurate method of measurement for the organ sizes (Midclavicular Line Longitudinal Diameter – MCLLD) as it is the most commonly applied measures of estimating liver size in routine diagnostic circumstances and is proved to be the best measured diameter in differentiating between healthy and diseased liver (Teach me anatomy, 2019).

1.2 Problem of the study:

Lack of reference for physicians to refer to when needing standards to compare the values of the liver, kidney and spleen of their patients and determine whether the organ is diseased or healthy, add to that no many previous studies were established with the same specifications on the same

region, in addition of differentiating between healthy and diseased organs by comparing their lengths with the standard ones.

1.3 Purpose of the Study:

The purpose was primarily to document the normal size of the liver, kidneys and spleen in healthy children and the relationship of these measurements with the sex, age, height and weight.

1.4 Research Objectives:

1.4.1 General Objectives:

As there're no previous studies established on the standard size of liver, kidneys and spleen, then the purpose of the study is to generate and make an available reference for doctors to refer to when comparing lengths.

1.4.2 Specific Objectives:

1. To evaluate the relationship between somatic parameter and the size of Liver, Kidneys and spleen measured with ultrasonography in normal Sudanese children.

2. To find out the normal sonographic measurements of the size of kidneys, liver and spleen and its relation with the somatic variables.

3. To find the normal dimension of visceral organs dynamically in respect to body characteristics.

1.5 Significance of the Study:

The study provides general size for the liver, spleen and kidneys for subjects associated with their sex, age, weight and height so as to decrease measurements errors to cure diseases early.

1.6 Overview of the Study:

The concern is about normal measures of liver, spleen and kidneys using Trans-Abdominal ultrasound. Accordingly it falls into five chapters: chapter one is the Introduction including brief anatomy, the problem, and objectives. Chapter two includes detailed background about the anatomy

and sonogram of the three organs. As well as the literature review. Chapter three deals with materials and methods used to conduct this study. Chapter four illustrates the results using figures and tables. Chapter five presents discussion, conclusion and recommendations of the study followed by references and appendices.

Chapter Two

Anatomy of the Visceral Organs

CHAPTER TWO

2.1 Anatomy of the liver

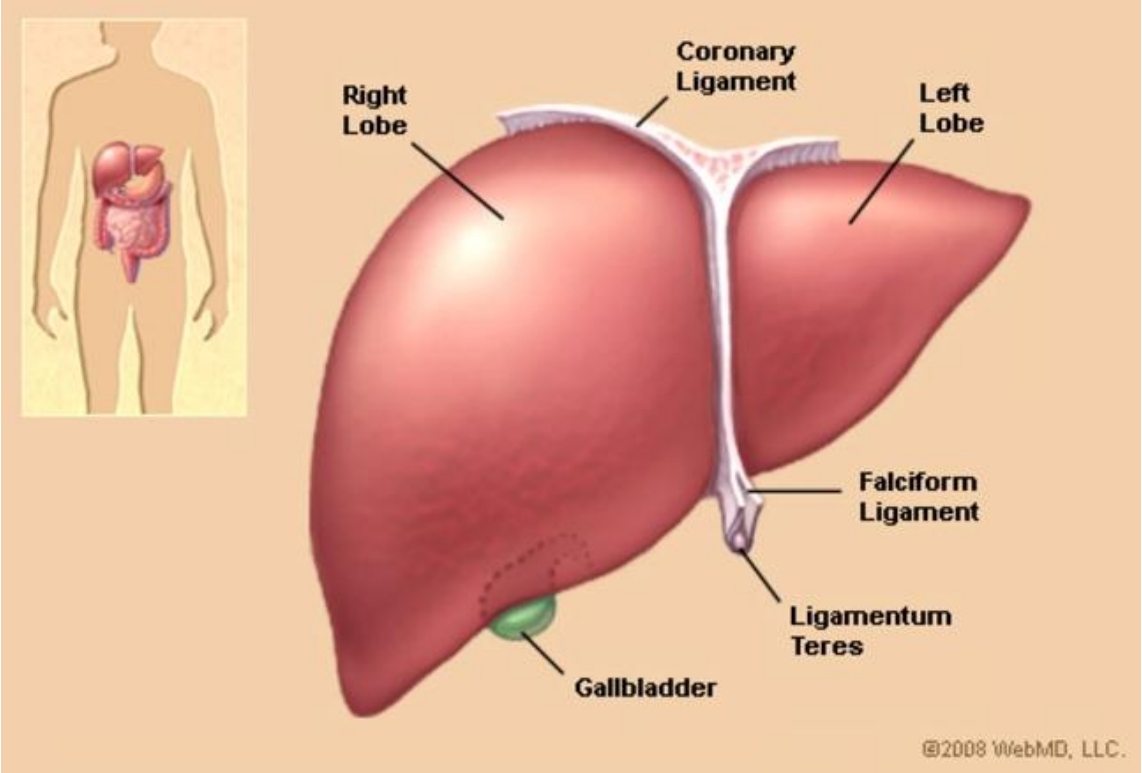


Figure 2.1 Anatomy of the Liver (Web MD, LLC, 2008)

The liver is a large intraperitoneal organ located in right upper quadrant of the abdomen under the right costal margin. Divide into the right and left lobes according to functional units relates to the distribution of blood flow and anatomic subdivision.

The functional subdivision of the liver depend upon the blood supply through the portal venous system and hepatic arteries. A plan between the gallbladder fossa and the sulcus of the inferior vena cava divides the liver into functional right and left lobes. (Teach Me Series, 2019)

This plan corresponds to the major, or main, lobar fissure. The right lobe of the liver lies to the right side of the fissure, the left lobe lies to the left of the fissure. The left lobe is further subdivided by the left hepatic vein into a lateral segment and a medial segment (quadrate lobe). The right lobe is subdivided into anterior and posterior segments by an arbitrary line between the two branches of the right portal vein. This arbitrary line corresponds to the right hepatic vein. (Teach Me Series, 2019)

The caudate lobe is a separate functional unit that receives its blood supply from both the right and left portal veins. It is not a portion of either the right or left lobes. There is a rounded prominence along the anterior-inferior aspect of the caudate lobe known as the papillary process.

The liver is divided anatomically into right and left lobes by the falciform ligament and the ligamentum teres. (Teach Me Series, 2019)

The portion of the liver to the right of the falciform ligament is considered the right lobe, while that part to the left of the ligament is termed the left lobe.

Traditional anatomic systems divide the liver to right of the falciform ligament into the right lobe, caudate lobe, and quadrate lobe according to the surface characteristic of the visceral portion of the liver. (Teach Me Series, 2019)

The visceral surface of the liver contains multiple depressions and grooves arranged in the shape of an “H” the right lobe of the liver consist of that portion of the liver to the right of right vertical limb of the “H” which is formed by a line between the inferior vena cava posteriorly and the gallbladder fossa anteriorly.

The left lobe is composed of the liver tissue to the left side of the left vertical limb of the “H” which is formed by a line between the inferior

vena cava posteriorly and the gallbladder fossa anteriorly. (Teach Me Series, 2019)

The left lobe is composed of the liver tissue to the left side of the vertical limb of the left vertical limb of the "H", which is formed by the fissure for the ligamentum venousum posteriorly and the fissure for the ligementum teres anteriorly. The transvers line of the "H" corresponds to the porta hepatis. The caudate lobe is the portion of the liver between the inferior vena cava and the fissure for the ligamentum venosum. The quadrate lobe is defined as the portion of liver between the ligamentum teres and the gallbladder.

Although the contour and size of the river are variable, the right lobe usually is two to three times larger than the left lobe. (Teach Me Series, 2019)

The superior surface of the liver is closely related to the diaphragm. The posterior surface of the right lobe of the liver is in contact with the right kidney laterally and the inferior vena cava medially. The inferior vena cava has a short course through the liver before emptying into the right atrium. The gallbladder fossa is situated along the anterior free margin of the liver, while the hepatic flexure of the colon lies inferiorly. The left lobe of the liver generally is relatively small; through occasionally it extends across the midline to lie in the left upper quadrant of the abdomen. The inferior and posterior surfaces of the left lobe are closely related to the antrum and body of the stomach. It also lies in close proximity to the splenic vessels and pancreas. (Teach Me Series, 2019)

The liver has a dual blood supply. About 80 percent comes through the portal vein and 20 percent via the hepatic artery .Three hepatic Venus drains blood from the liver into the inferior vena cava.

The portal vein is formed by the splenic vein and superior mesenteric vein and, occasionally, by the inferior mesenteric vein. The main portal vein ascends upward and to the right toward the porta hepatices, where it bifurcates into right and left branches. The diameter of the normal portal vein, which changes with different phases of respiration, is usually less than 12 millimeters. (Teach Me Series, 2019)

The portal vein is related to the inferior vena cava posteriorly and the head of the pancreas inferiorly.

The left branch of the portal vein originates to the right of midline. It is located somewhat anteriorly and superiorly to the right portal vein. The left branches of the portal vein runs cephalad along the surface of the caudate lobe and then curves backward to the left and anteriorly before dividing into two branches. The one to the left goes to the lateral segment, the one to right goes to the medial segment. The main trunk of the left portal vein, which corresponds to the umbilical portion of the left portal vein in the fetus, also supplies the caudate lobe. (Teach Me Series, 2019)

The right branch of the portal vein is larger than the left and runs a transverse course. It penetrates the right lobe of the liver and divides into branches to the anterior and posterior segments.

There are three hepatic veins: right, middle, and left the right hepatic vein (RHV) courses through the arbitrary line between the anterior and posterior division of the right portal vein and divides the superior portion of the right lobe into the superior anterior segment and the superior posterior segment .The middle hepatic vein (MHV) runs along the main lobar fissure and divides the liver into right and left lobes. The left hepatic vein (LHV) courses through the left intersegmental fissure and separates the superior, medial, and lateral segments. (Carol et al, 1993)

The intrahepatic portal branches can be distinguished from branches of the hepatic veins by the appearance of their wall echoes. The wall of the portal

vein are usually thicker and highly echogenic because they contain large amounts of collagen. Conversely, the margins of the hepatic veins are less prominent and less echogenic due to the insignificant amount of collagen show increased echogenicity near their confluence with the inferior vena cava, especially if the sound beam is perpendicular to the vessel. (Carol et al, 1993)

Anterior way to differentiate hepatic veins from branches of the portal vein is to follow its course to its origin or drainage. A third method to distinguish these vessels is to observe the direction of the angle between the branches. The Apex of the angle between portal vein branches is directed transversely toward the porta hepatis, while that of the hepatic venous branches is directed in the longitudinal plane toward the inferior vena cava. The only exception is the caudal portion of the liver, where the angle between branches of the portal and hepatic veins is directed longitudinally.

A fourth method to differentiate branches of the hepatic and portal veins is to observe the caliber of the vessels. Portal vein branches appear larger toward the porta hepatis, while branches of the hepatic veins enlarge as the approach the inferior vena cava and diaphragm (Carol et al, 1993)

Fissure and ligaments

The fissure and ligaments in the liver are well visualized sonographically because they are much more echogenic than the normal liver parenchyma. The increased echogenicity of the fissures and ligaments is most likely due to the fat and collagen tissue within and around these structures. (Carol et al, 1993)

The fissure for the ligamentum venousum represents the fibrous remnant of the ductus venosum. It is situated superior to the main portal vein and extends from the porta hepatis deep into the liver parenchyma. It is seen

sonographically as an echogenic band separating the posteriorly situated caudate lobe of the liver from the more anteriorly positioned lateral segment. (Carol et al, 1993)

The major (main) interlobar fissure is an incomplete fissure that runs in the plane between the gallbladder fossa and the sulcus for the inferior vena cava. It divides the liver into functional right and left lobes. following the course of the major fissure can aid in locating a severely contracted gallbladder (sulcus sign) , especially either a diseased one containing multiple calculi as a result of chronic cholecystitis or a collapsed normal gallbladder due to the patient having eaten. (Carol et al, 1993)

The ligamentum teres is an inferior continuation of the falciform ligament into the liver parenchyma. It divides the left lobe of the liver into a lateral and medial segment (quadrate lobe). On a transverse sonogram, the ligamentum teres appears as around hyperactive echogenic focus just to the right of the midline on a transverse sonogram. Although it can simulate a neoplasm, the ligamentum teres can be differentiated by virtue of its linear echogenic configuration in the sagittal plane. The ligamentum extends from the anterior surface of the liver to the porta hepatis. If the umbilical vein is reanalyzed and the lumen becomes patent because of portal hypertension, a son lucent focus may be seen within the echogenic ligament.

The falciform ligament is located along the anterior surface of the liver. It courses in the right parasagittal plane from the umbilicus to the diaphragm and continues from the rectus abdominis muscle to the bare area of the liver. The falciform ligament then continues to help form the coronary ligaments. (Carol et al, 1993)

2.1.1 Physiology of the liver:

The liver regulates most chemical levels in the blood and excretes a product called bile. This helps carry away waste products from the liver.

All the blood leaving the stomach and intestines passes through the liver. The liver processes this blood and breaks down, balances, and creates the nutrients and also metabolizes drugs into forms that are easier to use for the rest of the body or that are nontoxic. More than 500 vital functions have been identified with the liver. Some of the more well-known functions include:

Production of bile, which helps carry away waste and break down fats in the small intestine during digestion, add to it production of certain proteins for blood plasma, plus production of cholesterol and special proteins to help carry fats through the body and it converts excess glucose into glycogen for storage (glycogen can later be converted back to glucose for energy) and to balance and make glucose as needed, it is also responsible for regulation of blood levels of amino acids, which form the building blocks of proteins and processing of hemoglobin for use of its iron content (the liver stores iron). It also converts poisonous ammonia to urea (urea is an end product of protein metabolism and is excreted in the urine). And it has the privilege of clearing the blood of drugs and other poisonous substances. Regulating blood clotting and Resisting infections by making immune factors and removing bacteria from the bloodstream is also its function. In addition to Clearance of bilirubin, also from red blood cells. If there is an accumulation of bilirubin, the skin and eyes turn yellow.

When the liver has broken down harmful substances, its by-products are excreted into the bile or blood. Bile by-products enter the intestine and leave the body in the form of feces. Blood by-products are filtered out by the kidneys, and leave the body in the form of urine. (Carol et al, 1993)

2.1.2 Pathology of the Liver:

2.1.2.1 Cirrhosis

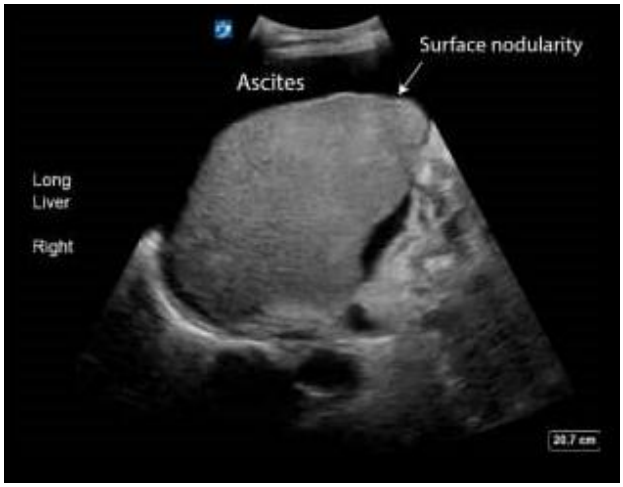


Figure 2.2 Liver Cirrhosis

www.criticalcare-sonography.com

Making the histologic diagnosis of cirrhosis and hepatitis is usually an easy task, but not always. Many times, the cause of a fibrotic or inflammatory process in the liver can be difficult to recognize because the liver responds to a wide range of injuries in only a limited number of ways. However, certain patterns of injury and other microscopic features when applied in the appropriate clinical setting can help differentiate various causes of such processes. (criticalcare-sonograpghy, 2016)

2.1.2.2 Alcoholic fibrosis and cirrhosis:

When present concurrently, micro nodular cirrhosis, Mallory bodies, and fatty change are highly indicative of alcoholic injury. Fatty change and Mallory bodies, however, can resolve over time (2 to 4 weeks and 6 to 12 weeks, respectively), and alcoholic injury can induce a cirrhosis with larger nodules, probably caused by periodic abstinence from alcohol intake,

during which time more regeneration of the hepatocytes probably can occur. (ultrasoundcases.info)

2.1.2.3 Hepatomegaly:

Hepatomegaly is the condition of having an enlarged liver.[4] It is a non-specific medical sign having many causes, which can broadly be broken down into infection, hepatic tumors, or metabolic disorder. Often, hepatomegaly will present as an abdominal mass. Depending on the cause, it may sometimes present along with jaundice. (criticalcare-sonograpghy, 2016)

2.1.2.4 Focal Fatty Infiltration:

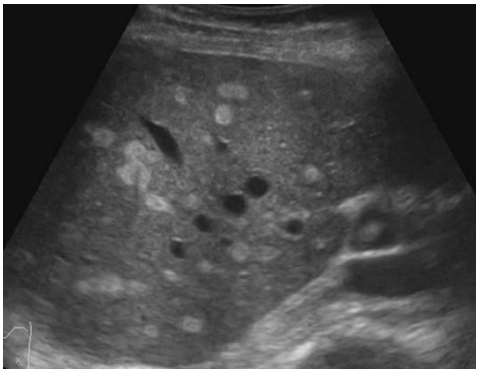


Figure 2.3 Focal Fatty Infiltrations

(www.ultrasoundcases.info)

2.1.2.5 Hepatic Fibrosis

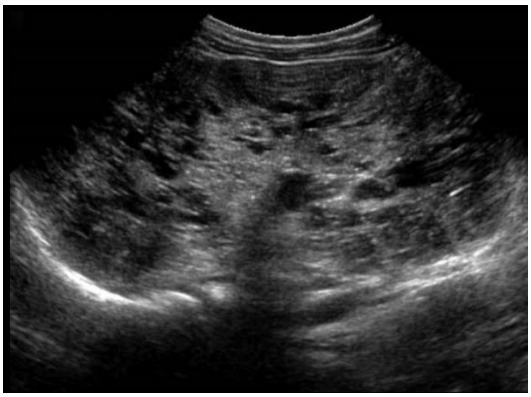


Figure 2.4 Hepatic Fibrosis

(www.ultrasoundcases.info)

2.1.2.6 Benign Liver Tumor:

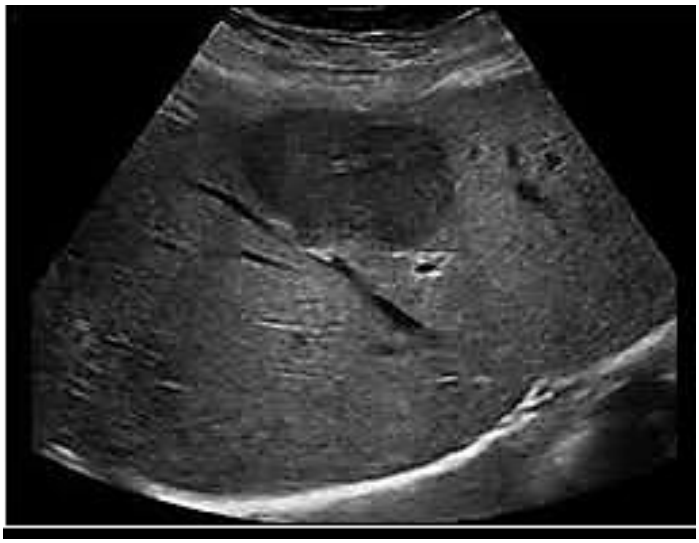


Figure 2.5 Benign Liver Tumor

(www.ultrasoundcases.info)

2.1.2.7 Focal Nodular

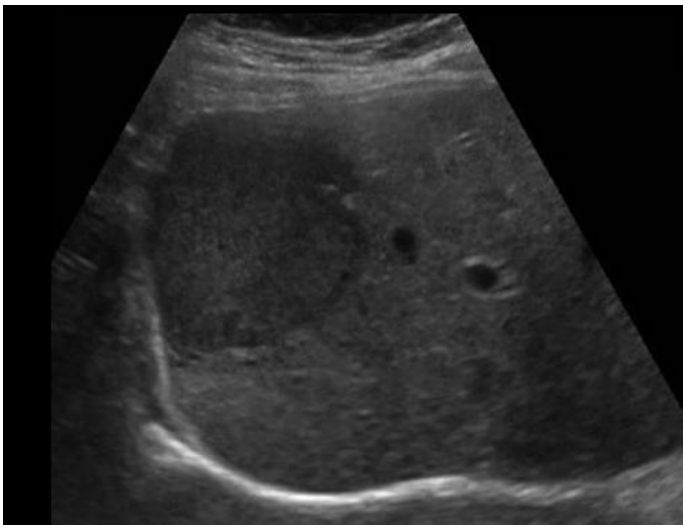


Figure 2.6 Focal Nodular

(www.ultrasoundcases.info)

2.1.2.8 Hepatic Adenoma

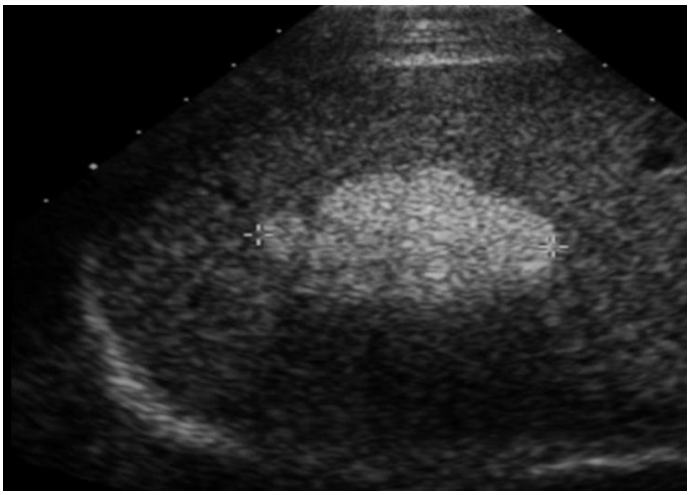


Figure 2.7 Hepatic Adenoma

(www.ultrasoundcases.info)

2.1.2.9 Congenital Hepatic Fibrosis

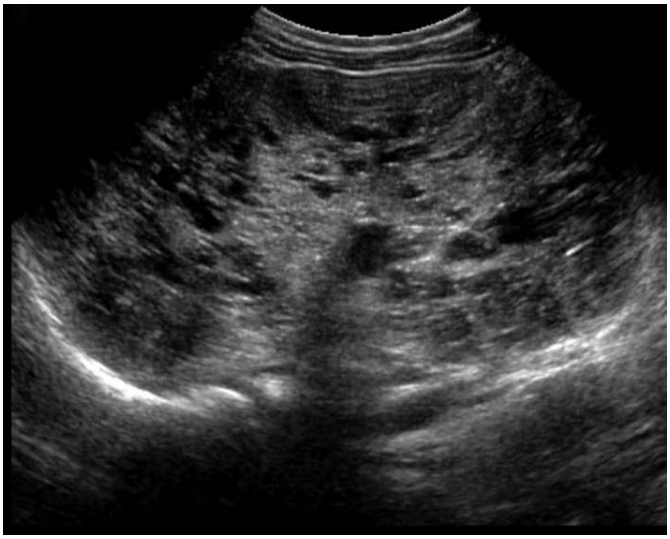


Figure 2.8 Congenital Hepatic Fibrosis

(www.ultrasoundcases.info)

2.1.2.10 Acute Hepatitis

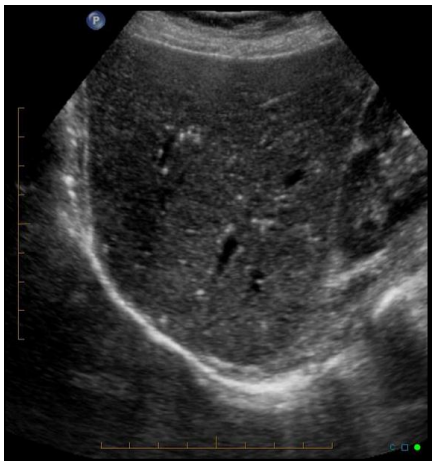


Figure 2.9 Acute Hepatitis

(www.ultrasoundcases.info)

2.1.2.11 Clinical Syndromes:

Acute hepatitis: asymptomatic with recovery HAV and HBV infection during childhood • Acute hepatitis- symptomatic with recovery Uncommon for HCV

Chronic hepatitis: Continued or relapsing disease for > 6 months – Hallmark of HCV

Fulminant hepatitis: Progression to hepatic failure within 2 – 3 weeks – In the US, most commonly HAV and HBV (adults)

Carrier state: Harbor replicating virus and can transmit the organism.

2.1.2.4 Drug Induced Injury:

The liver is the major drug metabolizing and detoxifying organ, many drugs can cause liver disease through various mechanisms:

The drug or one of its metabolites is directly toxic to the liver, and reduces the immunologic or hormonal defense of the host. Also the drug or one of its metabolites becomes a happen to convert an intracellular protein into an immunogenic signal.

2.2 Anatomy of the Spleen:

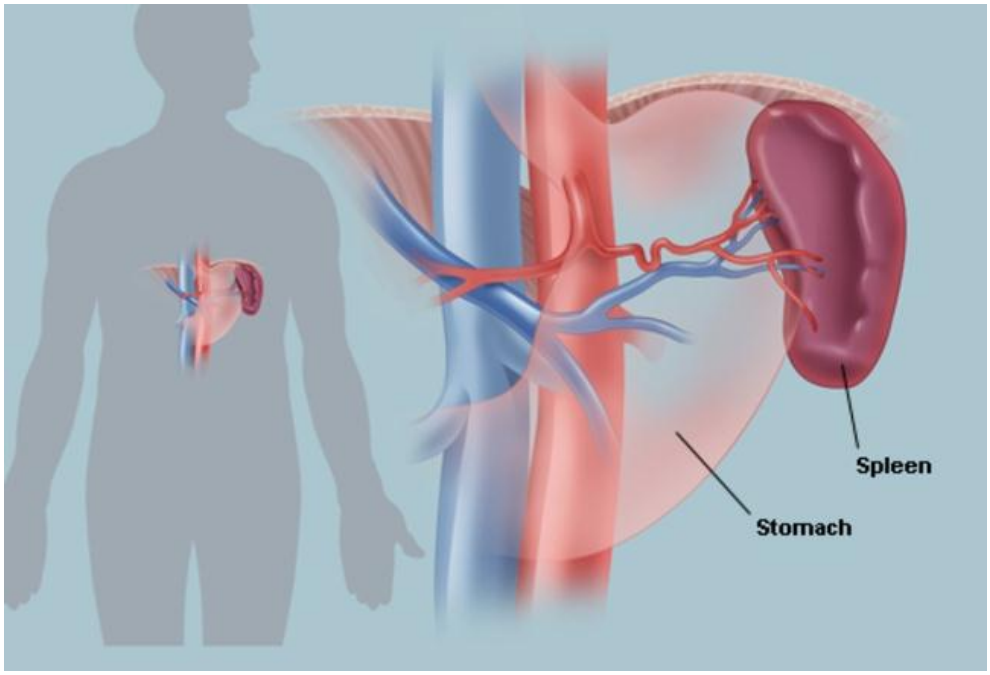


Figure 2.10 Anatomy of the Spleen

2.2.1 Basic structure of the spleen:

Although it varies in size between individuals, a spleen is typically around 3–5.5 inches long and weighs 5.3–7.1 ounces (oz). The spleen is a soft organ with a thin outer covering of tough connective tissue, called a capsule.

Anything that relates to the spleen is referred to as splenic; the spleen receives blood through the splenic artery, and blood leaves the spleen through the splenic vein. Although the spleen is connected to the blood vessels of the stomach and pancreas, it is not involved in digestion. (Snell, 2018)

The spleen contains two main regions of tissue called white pulp and red pulp.

Red pulp: Contains venous sinuses (cavities filled with blood), and splenic cords (connective tissues containing red blood cells and white blood cells).

White pulp: Mostly consists of immune cells (T cells and B cells).

The spleen's primary job is to filter the blood. As blood flows into the spleen, it performs a quality control service, detecting any red blood cells that are old or damaged. Blood flows through a maze of passages in the spleen. Healthy cells flow straight through, but those considered to be unhealthy are broken down by large white blood cells called macrophages (Teach me anatomy, 2019).

Once the red blood cells are broken down, the spleen stores useful leftover products, such as iron, which it eventually returns to the bone marrow, which makes hemoglobin (the iron-containing part of blood).

The spleen also stores blood — the blood vessels of the spleen can expand significantly. In humans, around 1 cup of blood is kept in the spleen, ready to be released if there is a significant loss of blood, after an accident, for instance. Interestingly, when a racehorse is at rest, up to half of its red blood cells are kept in the spleen. (Teach me anatomy, 2019)

The spleen also plays a role in the immune response by detecting pathogens (bacteria, for instance), and producing white blood cells in response.

Around one-quarter of our lymphocytes (a type of white blood cell) are stored in the spleen at any one time.

The spleen clears out old platelets from the blood; it also acts as a reservoir for platelets.

As a fetus is developing, the spleen makes red blood cells, but after the fifth month of gestation, it stops.

The spleen also produces compounds called opsonins, such as proper din and tufts in that help the immune system. (Teachmeanatomy, 2019)

2.2.2 Physiology of the Spleen:

The spleen's primary functions are to filter the blood and help defend the body against pathogens. In this article, we will explain its anatomy, what it does, and what happens when it goes wrong.

Although in medieval times, people thought that the spleen was the source of anger, hence the phrase "venting your spleen," it is nothing to do with anger or any other emotions for that matter.

The spleen sits in the upper left of the abdomen, protected by the rib cage. It is the largest organ of the lymphatic system, the circulation of the immune system. It recycles old red blood cells and stores platelets (components of the blood that help stop bleeding) and white blood cells. (Teachmeanatomy, 2019)

2.2.3 Pathology the spleen:

There are some conditions that can involve the spleen, these include:

2.2.3.1 Accessory spleen: An estimated 10–15 percent of people have an additional spleen. The second spleen is usually much smaller — around 1 centimeter (cm) in diameter. Generally, it causes no health problems.

2.2.3.2 Ruptured spleen: This can occur following an injury and cause life-threatening internal bleeding. Sometimes, the spleen will burst at the time of the injury; other times, it will burst days or weeks later. Certain diseases, such as malaria and infectious mononucleosis, make a ruptured spleen more likely because they cause the spleen to swell and the protective capsule to become thinner.

2.2.3.3 Sickle cell disease: This is an inherited form of anemia; the condition is characterized by a dysfunctional type of hemoglobin. In this form of anemia, red blood cells are abnormally shaped (crescent-shaped) and block the flow of blood, causing damage to organs, including the spleen.

2.2.3.4 Thrombocytopenia: If the spleen becomes enlarged, it may store too many platelets, meaning that there are not enough in the rest of the body's circulatory system. Without platelets available to help blood clot, the primary symptom of thrombocytopenia is bleeding.

2.2.3.5 Spleen cancer: If cancer starts in the spleen, it is known as primary spleen cancer; if it spreads to the spleen from another site, it is called secondary. Both types of cancer are rare. (criticalcare-sonograpghy, 2016)

2.2.3.6 Splenic infarction:

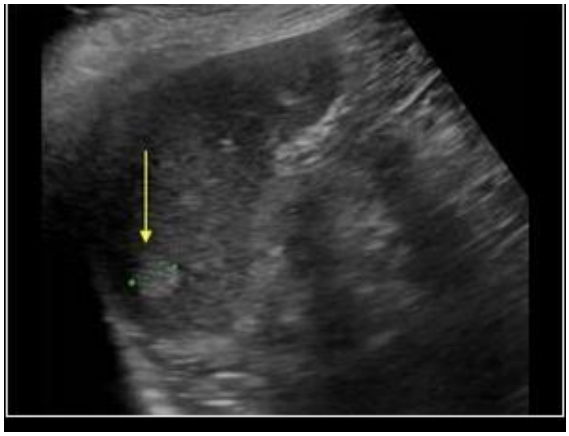


Figure 2.11 Splenic Infarction

(www.ultrasoundcases.info)

If the blood supply to the spleen is reduced, it is known as splenic infarction. This occurs if blood supply through the splenic artery is cut off by, for instance, a blood clot. This is often very painful, and treatment depends on the underlying cause. (Teachmeanatomy, 2019)

2.2.3.7 Enlarged spleen (splenomegaly):

This can occur due to a variety of conditions, such as infectious mononucleosis (mono), blood cancers (such as leukemia), bacterial infections, and liver disease. Sometimes, the spleen is carrying out its regular work, but it is overactive (hypersplenism); it may, for instance, be destroying too many red blood cells or platelets.

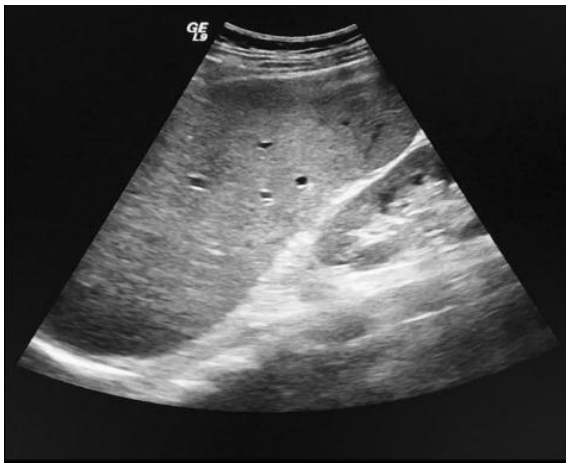


Figure 2.12 Enlarged spleens (splenomegaly):

www.radiopedia.org

2.2.3.9 Splenic Hemangioma:

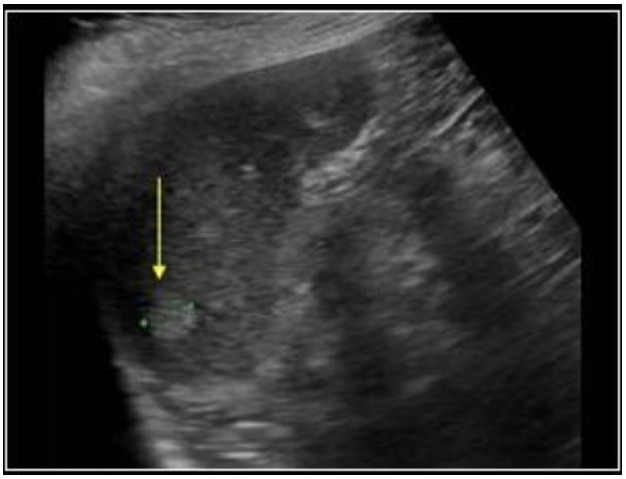


Figure 2.13 Splenic Hemangioma

www.radiopedia.org

2.3 Anatomy of the Kidney:

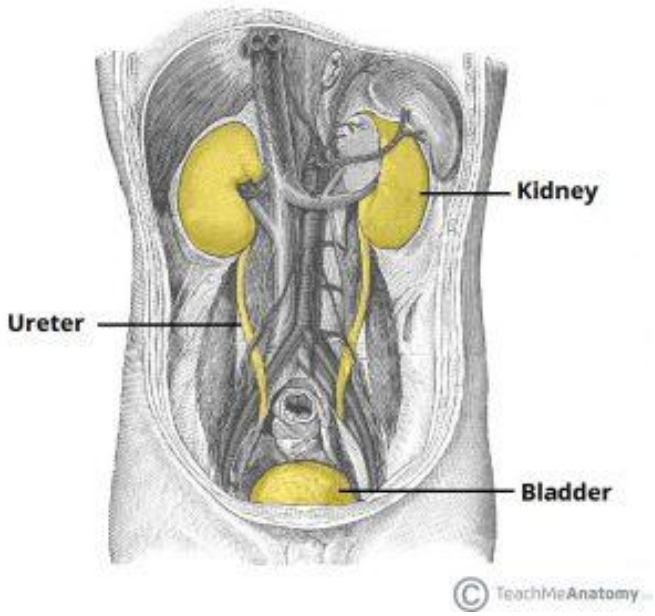


Figure 2.14 Overview of the urinary tract.

(Teachmeanatomy 2019)

The **kidneys** are bilateral bean-shaped organs, reddish-brown in color and located in the posterior abdomen.

Metabolic waste and excess electrolytes are excreted by the kidneys to form **urine**. Urine is transported from the kidneys to the bladder by the ureters. It leaves the body via the urethra, which opens out into the perineum in the female and passes through the penis in the male. (TeachMeSeries Ltd, 2019)

2.3.1 Anatomical Position

The kidneys lie **retroperitoneally** (behind the peritoneum) in the abdomen, either side of the vertebral column.

They typically extend from **T12 to L3**, although the right kidney is often situated slightly lower due to the presence of the liver. Each kidney is approximately three vertebrae in length.

The adrenal glands sit immediately superior to the kidneys within a separate envelope of the **renal fascia**.

2.3.2 Kidney Structure

The kidneys are encased in complex layers of fascia and fat. They are arranged as follows (deep to superficial):

Renal capsule – tough fibrous capsule.

Perirenal fat – collection of extraperitoneal fat.

Renal fascia (also known as Gerota's fascia or Perirenal fascia) – encloses the kidneys and the suprarenal glands.

Pararenal fat – mainly located on the posterolateral aspect of the kidney. (TeachMeSeries Ltd, 2019)

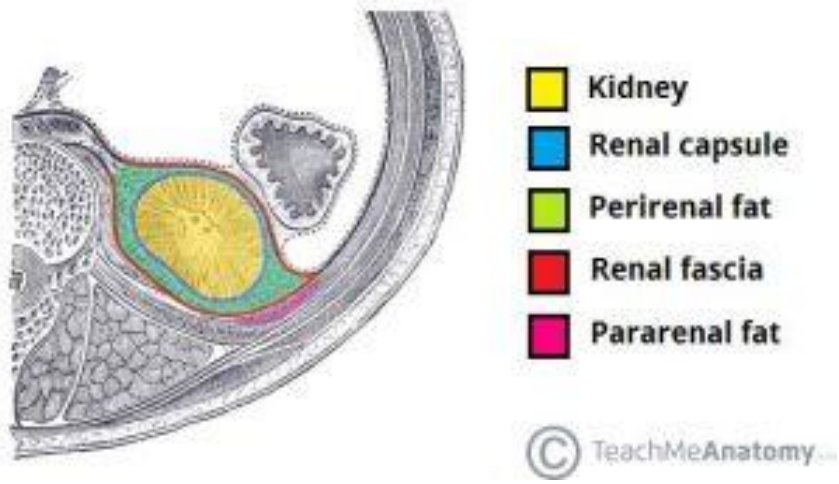


Figure 2.15 The external coverings of the kidney.
(Teachmeanatomy 2019).

Internally, the kidneys have an intricate and unique structure. The renal parenchyma can be divided into two main areas – the outer **cortex** and inner **medulla**. The cortex extends into the medulla, dividing it into triangular shapes – these are known as **renal pyramids**.

The apex of a renal pyramid is called a **renal papilla**. Each renal papilla is associated with a structure known as the **minor calyx**, which collects urine from the pyramids. Several minor calices merge to form a **major calyx**. Urine passes through the major calices into the **renal pelvis**, a

flattened and funnel-shaped structure. From the renal pelvis, urine drains into the ureter, which transports it to the bladder for storage.

The medial margin of each kidney is marked by a deep fissure, known as the **renal hilum**. This acts as a gateway to the kidney – normally the renal vessels and ureter enter/exit the kidney via this structure (TeachMeSeries Ltd, 2019).

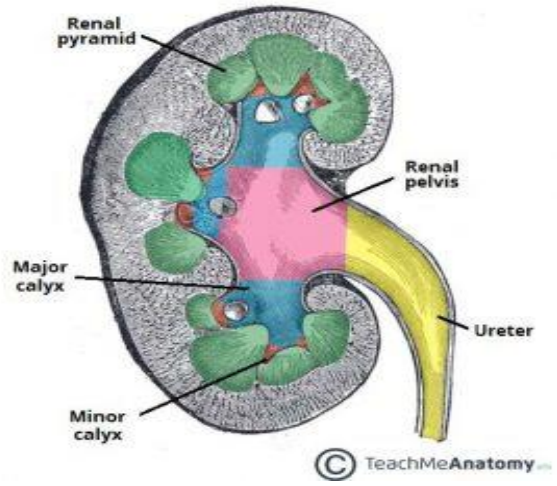


Figure 2.16 The internal structure of the kidney.

(Teachmeanatomy 2019).

2.3.3 Anatomical Relations

The kidneys sit in close proximity to many other abdominal structures which are important to be aware of clinically:

	Anterior	**Posterior**
Left	• Suprarenal gland • Spleen • Stomach • Pancreas • Left colic flexure • Jejunum	• Diaphragm • 11th and 12th ribs • Psoas major, quadratus lumborum and transversus abdominis • Subcostal, iliohypogastric and ilioinguinal nerves
Right	• Suprarenal gland	• Diaphragm

- Liver
- Duodenum
- Right colic flexure
- 12^{th} rib
- Psoas major, quadratus lumborum and transversus abdominis
- Subcostal, iliohypogastric and ilioinguinal nerves

2.3.4 Arterial Supply:

The kidneys are supplied with blood via the **renal arteries**, which arise directly from the abdominal aorta, immediately distal to the origin of the superior mesenteric artery. Due to the anatomical position of the abdominal aorta (slightly to the left of the midline), the right renal artery is longer, and crosses the vena cava posteriorly (Teachmeanatomy 2019).

The renal artery enters the kidney via the renal hilum. At the hilum level, the renal artery forms an **anterior** and a **posterior** division, which carry 75% and 25% of the blood supply to the kidney, respectively. Five **segmental arteries** originate from these two divisions. (TeachMeSeries Ltd, 2019)

The **avascular plane of the kidney** (line of Brodel) is an imaginary line along the lateral and slightly posterior border of the kidney, which delineates the segments of the kidney supplied by the anterior and posterior divisions. It is an important access route for both open and endoscopic surgical access of the kidney, as it minimizes the risk of damage to major arterial branches.

Note: The renal artery branches are anatomical end arteries – there is no communication between vessels. This is of crucial importance; as trauma or obstruction in one arterial branch will eventually lead to ischaemia and necrosis of the renal parenchyma supplied by this vessel.

The segmental branches of the renal undergo further divisions to supply the renal parenchyma:

- Each segmental artery divides to form **interlobar arteries**. They are situated either side every renal pyramid.
- These interlobar arteries undergo further division to form the **arcuate arteries**.
- At 90 degrees to the arcuate arteries, the **interlobular arteries** arise.
- The interlobular arteries pass through the cortex, dividing one last time to form **afferent arterioles**.
- The afferent arterioles form a capillary network, the glomerulus, where filtration takes place. The capillaries come together to form the efferent arterioles.

In the outer two-thirds of the renal cortex, the efferent arterioles form what is a known as a **peritubular network**, supplying the nephron tubules with oxygen and nutrients. Long, straight arteries called vasa recta supply the inner third of the cortex and the medulla. (TeachMeSeries Ltd, 2019)

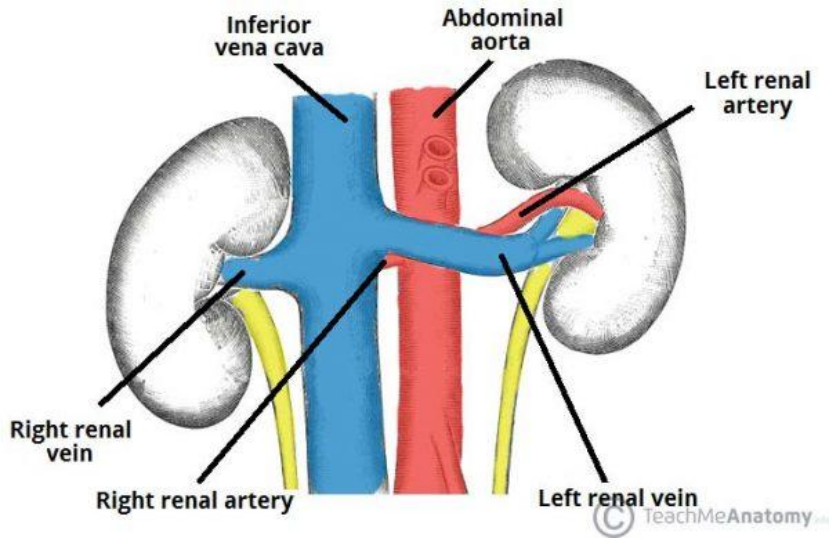


Figure 2.17 Arterial and venous supply to the kidneys.
(Teachmeanatomy 2019).

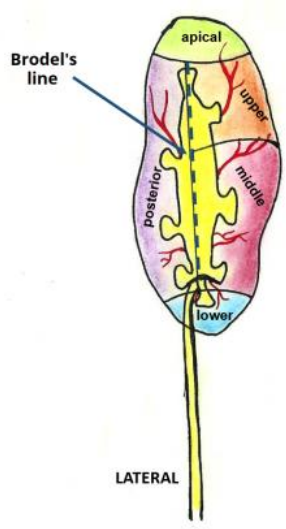


Figure 2.18 Arterial supply to the kidney can be divided into five segments.

(Teachmeanatomy 2019).

2.3.5 Physiology of the Kidneys:

1. The kidney plays a major role in the control of the consistencies of internal environment; the blood flowing in the kidney is filtered (**glomerular filtration**) so that the entire blood constituent except blood cells and plasma proteins go in to micro tubular system. Kidneys play a dominant role in regulating the composition and volume of the extracellular fluid (ECF) they normally maintain a stable internal environment by excreting in the urine appropriate amounts of many substances. These substances include not only waste products and foreign compounds, but also many useful substances that are present in excess because of eating, drinking, or metabolism. This chapter considers the basic renal processes that determine the excretion of various substances the kidneys perform a variety of important functions:

One-They regulate the osmotic pressure (osmolality) of the body fluids by excreting osmotically dilute or concentrated urine.

2. They regulate the concentrations of numerous ions in blood plasma, including Na +, K +, Ca2 +, Mg 2 +, Cl bicarbonate (HCO 3), phosphate, and sulfate.

3. They play an essential role in acid–base balance by excreting H+ when there is excess acid or HCO3 -when there is excess base.

4. They regulate the volume of the ECF by controlling Na+ and water excretion.

5. They help regulate arterial blood pressure by adjusting Na+ excretion and producing various substances (e.g., renin) that can affect blood pressure.

They eliminate the waste products of metabolism including urea (the main nitrogen-containing product of protein metabolism in humans), uric acid (a product of purine metabolism), and creatinine (a product of muscle metabolism).

6. They remove many drugs (e.g., penicillin) and foreign or toxic compounds. (George A. Tanner, 2015)

2.3.6 Endocrine Function of the Kidney:

The kidney produce several substances, some of which may not strictly be labeled as hormones, these are rennin, erythropoietin and vitamin D3. These substances either act locally or are responsible for the production of other hormonal agents. (George A. Tanner, 2015)

2.4 The Previous Studies:

2.4.1 Normal Variants:

In the 1st trimester, the developing kidneys ascend in the fetal abdomen. If the progress is hampered, this can result:

24.1.1 Dromedary Humps: are prominent focal bulges on the lateral border of the left kidney. They are normal variants of the renal contour, caused by the splenic impression onto the superolateral left kidney

Dromedary humps are important because they may mimic a renal mass, and as such is considered a renal pseudotumour (figure 2.4.1.1). (Gaillani, 2003)

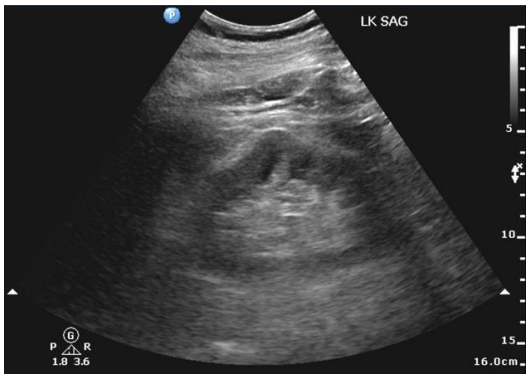


Figure 2.19 Sagittal US image Dromedary humps (Gaillani, 2003)

2.4.1.2 Extra Renal Pelvis: refers to the presence of the renal pelvis outside the confines of the renal hilum. It is a normal variant that]] in ~10% of population. All the major calyces form the renal pelvis. An external pelvis usually appears dilated giving a false indication of an obstructive pathology. Subsequent investigation with CT, usually clarifies the false interpretation on ultrasound (figure 2.4.1.2). (Gaillani, 2003)

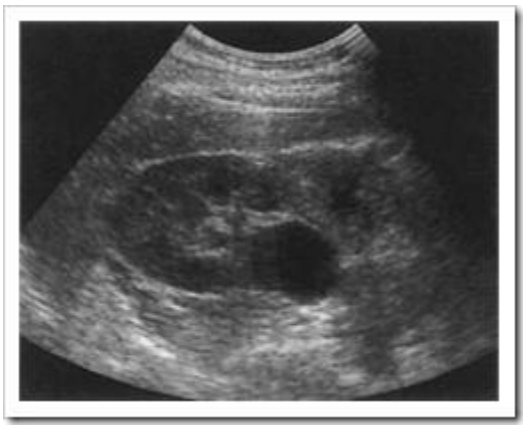


Figure 2.20 Sagittal US image Extra Renal Pelvis (Gaillani, 2003)

2.4.1.3 Junctional parenchymal defects: in renal imaging are a normal variant .It results from incomplete embryonic fusion of ranunculi sonographic appearance: It can be seen as a triangular echogenic cortical defect, frequently seen in upper lobe parenchyma. The defect is the

extension of sinus fat into the cortex, usually at the border of the upper pole and interlobar region of the kidney (figure 2.4.1.3). (Gaillani, 2003)

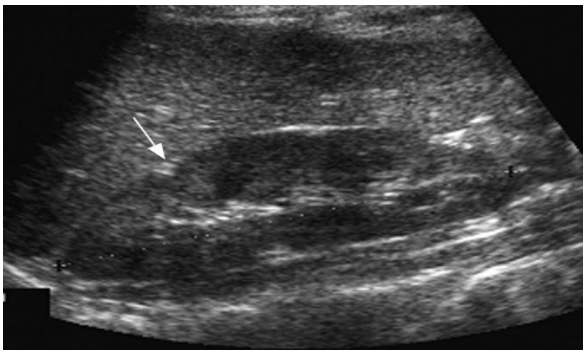


Figure 2.21 Sagittal image Junctional Parenchymal Defects (Gaillani, 2003)

2.4.1.4 Duplex kidney :appears as 2 central echo complexes with intervening renal parenchyma. Hydronephrosis at one pole is suggestive of a duplex kidney. Although hydronephrosis can occur at either pole, it is more common in the upper one.

Occasionally, two distinct collecting systems and ureters can be observed on ultra-sonographic images figure (2.4.1.4). (Gaillani, 2003)

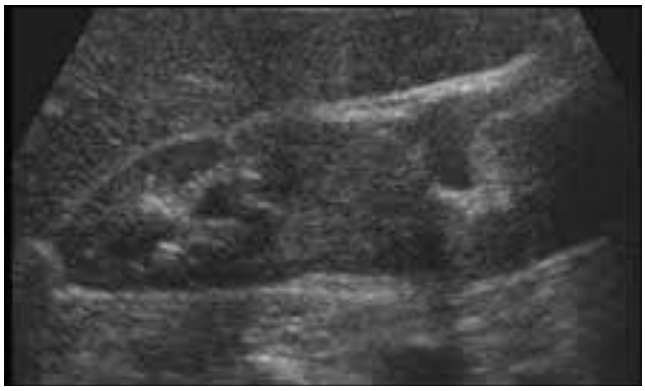


Figure 2.22 Sagittal image Duplex kidney (Gaillani, 2003)

2.4.2 Congenital anomalies of the kidney:

Congenital anomalies of the kidney and urinary tract(CAKUTs) occur in 3–6 per 1000 live births and are responsible for 34–59% of chronic kidney disease (CKD)and for 31% of all cases of end-stage kidney disease (ESKD) in children in the United States. (Gaillani, 2003)

2.4.2.1 Ectopic Kidney: An ectopic kidney is a kidney located outside the renal bed. The kidney can be located anywhere between the pelvis and upper abdomen. However, most ectopic kidneys are located in the pelvis and are called pelvic kidneys. Often ectopic kidneys lie on an unusual plane which may impair the normal drainage of the organ. (Gaillani, 2003)

2.4.2.2 Fused Ectopia – "In crossed renal Ectopia, both kidneys are found on the same side. In 85% to 90% of cases, the ectopic kidney will be fused to the other kidney. Usually the lower pole of the normally positioned kidney is fused to the upper pole of the ectopic kidney. The pelvis of the ectopic kidney is directed interiorly. (Gaillani, 2003).

2.4.2.3 Congenital Fusion (Horseshoe Kidney): "Horseshoe kidney is the most common renal fusion anomaly, with a prevalence of approximately 1:400 births and a male predominance. The lower poles of the kidneys fuse and this fused area is called the isthmus. The hilum of each kidney looks forwards and the ureters always pass in front of the connecting in ultrasound, the isthmus can be seen anterior to the aorta and IVC; the low position and abnormal renal alignment will be seen figure (2.4.2.1.) (Gaillani, 2003)

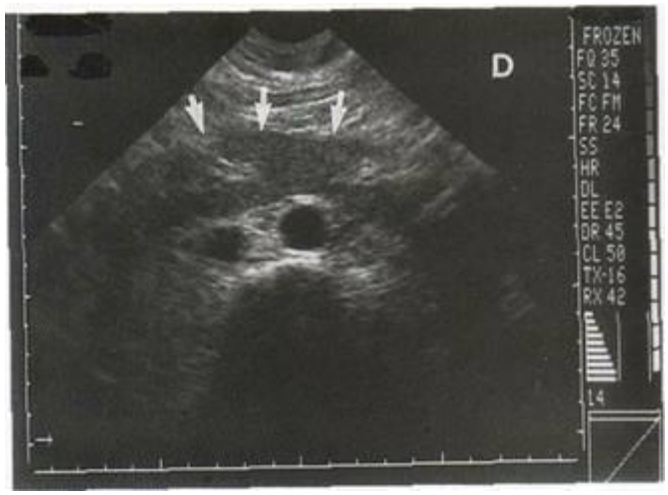


Figure 2.23 Sagittal image Horseshoe Kidney (Gaillani, 2003)

2.4.3 Renal Cystic Disease:

2.4.3.1 Simple Renal Cysts: These true cysts have a serious epithelial lining and are fluid filled, benign cortical masses. They meet all the ultrasound criteria of a simple cyst: they are spherical, anechoic, and thin-walled and have accentuated posterior enhancement, Sonographic Appearances: these lesions range in size from a few millimeters to several centimeters. They are most frequently unilocular (Figure 2.4.3.1). (Gaillani, 2003)

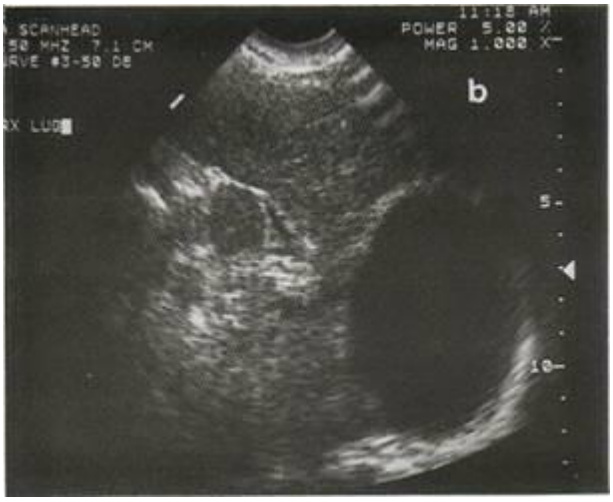


Figure 2.24 Sagittal image Simple Renal Cyst (Gaillani, 2003)

2.4.3.2 Atypical Renal Cyst: An atypical renal cyst is any cyst that does not meet the strict criteria of a simple cyst. Many atypical cysts are simple cysts complicated by hemorrhage or infection Sonographic appearances complicated (i.e. atypical) cyst.

2.4.3.3 Para pelvic Cysts: Para pelvic cysts are cysts of the renal sinus. Generally, they are anechoic and exhibit posterior acoustic enhancement "Para pelvic cysts are rarely purely spherical, figure (2.4.3.2).

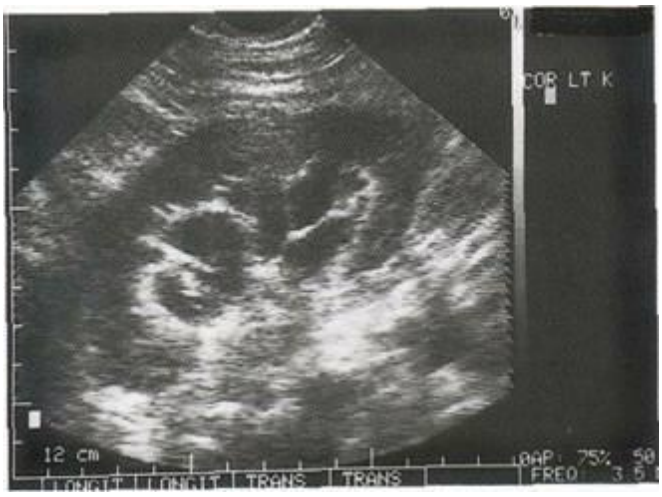


Figure 2.25 Sagittal image Para Pelvic Cyst (Gaillani, 2003)

2.4.3.4 Autosomal Recessive Polycystic Renal Disease (ARPRD): Autosomal recessive polycystic kidney disease is an inherited disorder characterized by nephromegaly, microscopic or acroscopic cystic dilatation of the renal collecting tubules and periportal hepatic fibrosis. The renal abnormalities are seen early in life ,while the liver pathology becomes predominant with increasing age.

ARPRD is associated with pulmonary hypoplasia., Sonographic appearances **:** In the early stages, the kidneys appear enlarged and contain more cysts than expected for the patient's age. The cysts involve both the cortex and medulla. In later stages, the kidneys are huge (sometimes reaching 20 cm) And contain numerous cysts with little residual cortex. The cysts do not communicate with each other or with the calyces and renal pelvis. The cysts may be complicated with infection or hemorrhage and contain debris or focal wall calcification. Renal stones are common. (Gaillani, 2003)

2.4.4 Hydronephrosis:

Hydronephrosis refers to dilatation of the renal collecting system most frequently caused by incomplete or complete obstruction.

Hydro ureter is dilatation of the ureter also caused by complete or incomplete obstruction.

Sonographic Appearances of Hydronephrosis:

Mild - there is minimal dilatation of the collecting system. The calyces are blunted but some pyramidal indentation remains. On ultrasound, this appears as a single, ellipsoidal fluid collection spreading the central echo complex. Slight dilatation of the renal pelvis and calyces will be seen (Figure 2.4.4.1).

Moderate - the calyces are clubbed and there is no pyramidal indentation in to the calyces. On ultrasound, there is a lobulated fluid collection with a few setae between the distended calyces. The parenchymal thickness is preserved.

Severe - the calyces are still discretely defined and separate from each other. The collecting system is markedly dilated with thinning of the parenchyma.

Extreme - the calyces are so distended that they blend into one another except for residual margins that appear as thin septae. On ultrasound there are multiple rounded fluid containing structures which are the distended calyces. These distended calyces displace the central echo complex and totally replace the normal parenchyma.

Hydroureter appears as a fluid distended and often tortuous ureter whereas **megaureter** is a congenitally dilated ureter).

Hydronephrosis and the Neonate - The collecting system should not be larger than one third the anteroposterior measurement of the kidney . (Gaillani, 2003)

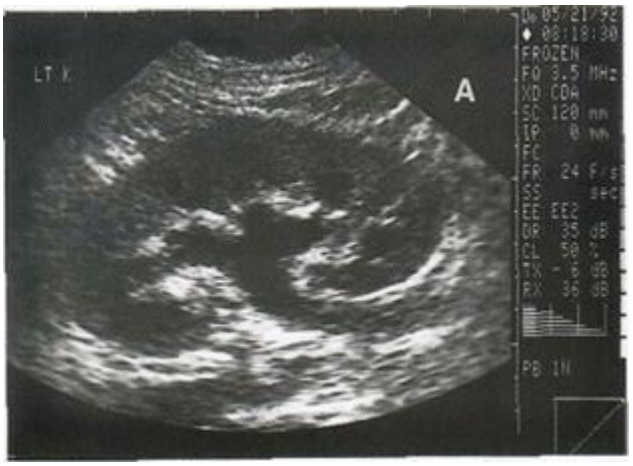


Figure 2.26 Sagittal image Mild Hydronephrosis (Gaillani, 2003)

2.4.5 Renal Calculus Disease:

Urolithiasis is most prevalent in males aged 20-40 years.1 Calculi can form in any part of the urinary tract but most form in the kidneys.

2.4.5.1 Collecting System Stones: The reflectivity of stones located in the renal sinus may be equal to that of the renal sinus itself, therefore, it may be beneficial to scan with the patient hydrated if collecting system calculus is being considered (figure 2.4.5.1). (Gaillani, 2003).

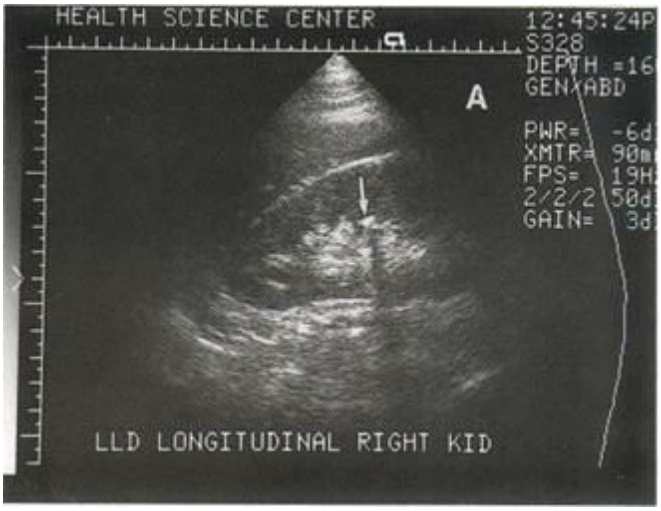


Figure 2.27 Sagittal image a single shadowing stone (Gaillani, 2003)

2.4.5.2 A staghorn calculus: is a stone that completely fills the entire collecting system (i.e. the pelvis and calyces). It is usually associated with chronic infection and obstruction. Sonographic appearance a staghorn calculus appears as a curved echogenic structure in the renal sinus area. The acoustic shadow created by the calculus often hides any associated hydronephrosis (Figure 2.4.5.2). (Gaillani, 2003)

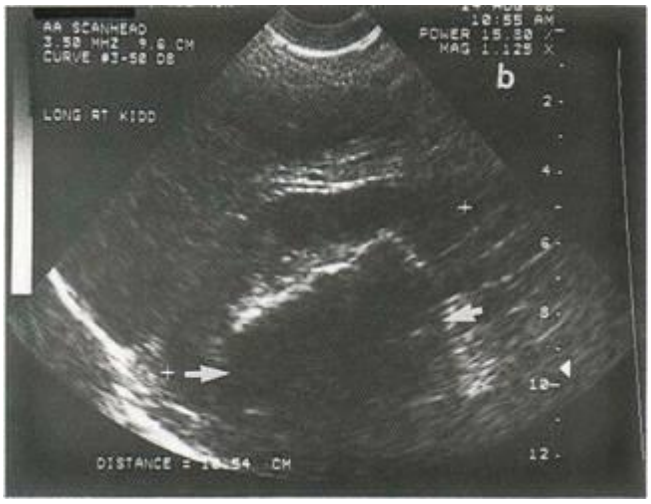


Figure 2.28 Sagittal image Statham calculus (Gaillani, 2003)

2.4.6 Neoplasm:

2.4.6.1 Benign Lesions:

2.4.6.1.1 Angiomyolipoma (AML):

AML is a benign solid tumor containing variable amounts of blood vessels (angio), smooth muscle (myo) and fat (lipoma), sonographic appearances depend upon the predominance of one of the three components. Typically, AMLs are extremely hyperechoic indicating the predominance of fat however if muscle or vascular components predominate the lesion may be hypoechoic, Shadowing is demonstrated in 33% of AMLs. AML's show significant growth when followed by US over time Tumors range from 1 or 2 cm to more than 20 cm,2 however tumors less then4 cm tend to be asymptomatic. "AML is difficult to differentiate from RCC (renal cell arcinoma) when the renal tumor. (Figure 2.4.6.1.1)

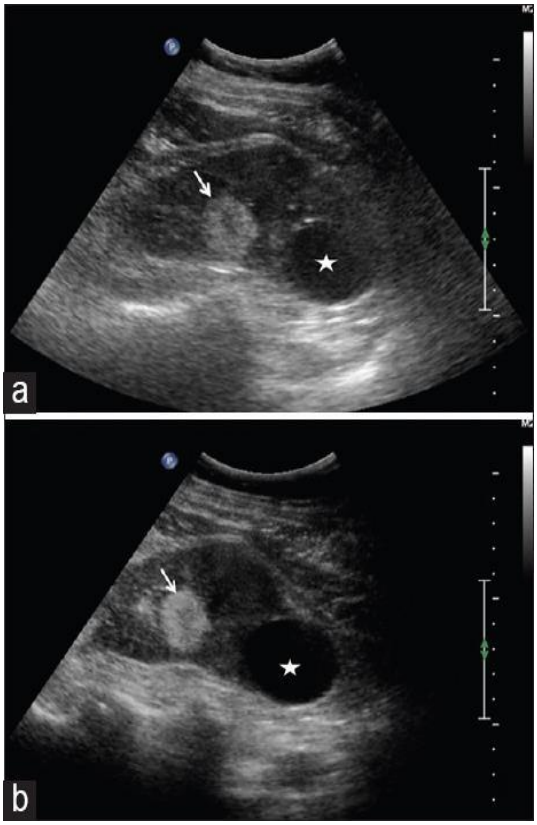


Figure 2.29 Sagittal image Angiomyolipoma, simple cyst (*)

(Wringer, 2010)

2.4.6.1.2 Oncocytoma: Oncocytoma is a benign solid renal tumor occurring most often in men in their 60's. It is usually asymptomatic and an incidental finding, Sonographically the tumor is solid, homogeneous and generates low levels of echogenicity. A satellite central hyperechoic scar is seen in about 25% of cases and then only in lesions greater than 3 cm. However, “no imaging finding reliably distinguishes this tumor from renal cell carcinoma. Diagnosis is made by surgical excision (figure 2.4.7.1.2).

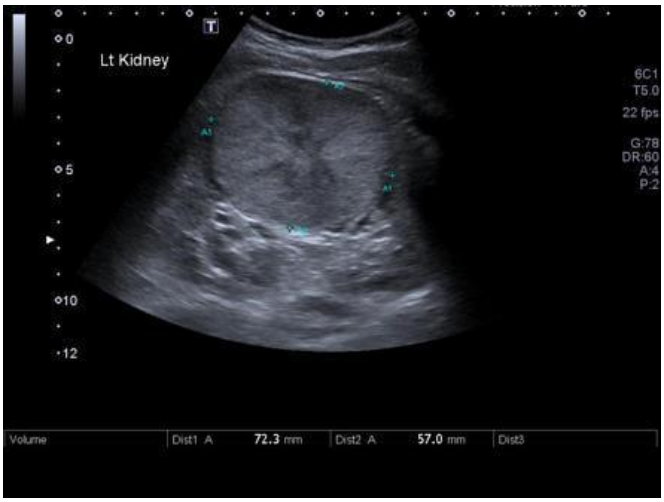


Figure 2.30 sagittal image renal lesion, with the central satellite non-enhancing scar, is typical for renal Oncocytoma (Sikma, 2014)

2.4.6.2 Malignant Lesions:

2.4.6.2.1 Renal Cell Carcinoma (RCC):

This is a primary tumor of the renal parenchyma thought to originate from the renal tubular epithelium. It is also called a **hypernephroma** or a **renal adenocarcinoma**. Renal cell carcinomas (RCC) are the most common primary malignant renal parenchymal tumors (86%).3 These tumors occur most frequently in males between the fifth to the seventh decade. They are usually unilateral and clinically silent until they become large (figure 2.4.6.2.1).

Sonographic findings**:** Characteristically a spherical, solitary, unilateral tumor of variable size and echogenicity. The majority of tumors are either isoechoic or hypoechoic to the normal renal parenchyma; however, 10% are more echogenic than normal renal parenchyma.

(A complex echo pattern usually indicates areas of hemorrhage, necrosis or tumor vascularity.

- Calcification is common (up to 18%) and variable in appearance: punctuate, coarse, central, peripheral or curvilinear.
- The mass frequently distorts the collecting system .Hydronephrosis is not a common feature.

- RCC is a non-encapsulated tumor; therefore, the borders are poorly defined.
- Cystic forms of RCC most often have thick walls and internal debris. RCC arising within simple cysts are rare and appear as
- Multicystic form of RCC has thick walls (>2mm) and thick septations.
- Metastasis – Metastatic lymph adenopathy is usually near the renal vessels and around and between the IVC and aorta.1, two Hepatic metastasis may be by direct extension or hematogenous spread. (Hepatic metastases have variable appearances.
- In 20% of cases, RCC extends into the renal vein and in 10% of cases it extends as far as the IVC Tumor thrombi are typically homogeneous, generate low level. (Gaillani, 2003)

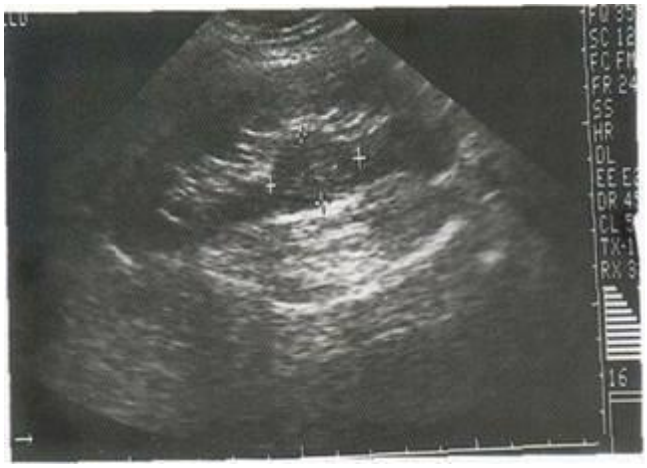


Figure 2.31 sagittal image renal cell carcinoma (Gaillani, 2003)

2.4.6.2.2 Transitional Cell Carcinoma (TCC): This is a malignancy involving the epithelial lining of the renal collecting system, ureters or bladder, ultrasound appearances of a renal pelvic TCC are characteristically those of a solid, homogeneous, hypoechoic or isoechoic mass centrally located within the renal sinus. It causes a separation of the central echo complex. TCC tumors commonly obstruct the urinary tract; therefore, there may be evidence of focal calyceal or renal pelvis dilatation. (Gaillani, 2003).

2.4.6.2.3 Leukemia: "Lymphoma and leukemia have a predilection for infiltration of the renal parenchyma and often cause focal or diffuse renal enlargement. "Acute lymphoblastic leukemia is the most common form to involve the kidney sonographically, appear, as a diffuse, bilateral renal enlargement is most common with loss of corticomedullary definition. The parenchyma may have increased or decreased echogenicity. There may be distortion of the central echo complex. Discrete renal masses are UN common but when they occur they resemble lymphoma figure 2.4.6.2.3 (Gaillani, 2003)

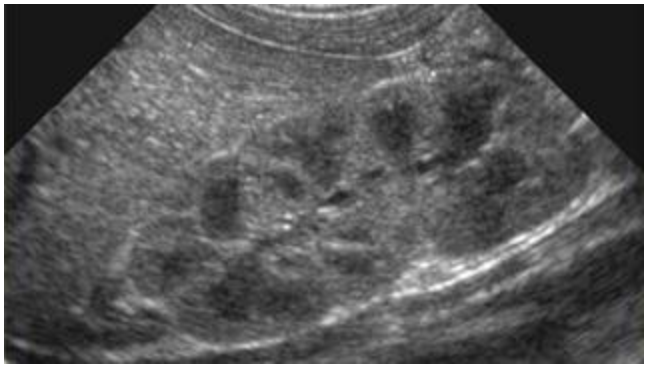


Figure 2.32 RT kidney enlarge and heterogeneous (Leukemia).

(Gaillani, 2003)

2.4.6.2.4 Nephroblastoma: A nephroblastoma is a rapidly growing malignant tumor of the kidneys, consisting of embryonal elements. It is also known as Wilma's tumors, Wilma's embryoma or embryonal carcinoma. A nephroblastoma is the most common renal tumor in children. It is seen most commonly in children between 2 to 3 years of age sonographically a Wilma's tumor is characteristically a large, intracranial, solid mass with a well-defined margin or pseudo capsule of fibrous tissue and compress renal parenchyma. The tumor may be homogeneous or heterogeneous, if necrosis or hemorrhage has occurred. "The tumor rarely is calcified, rarely crosses midline, and rarely envelopes major blood vessels, such as the aorta or IVC (figure 2.4.7.6). An adrenal

neuroblastoma, common to a similar age group, does cross midline, has calcifications in half the cases and does envelope blood vessels., Wilma's tumor may extend to regional lymph nodes or into the renal vein and IVC. Vascular extension does not occur with neuroblastoma. (Gaillani, 2003)

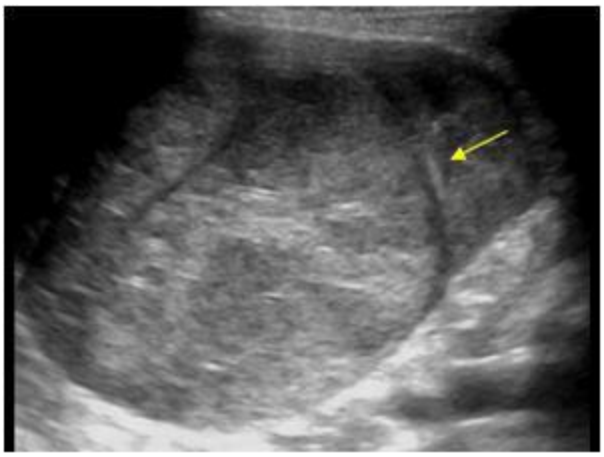


Figure 2.33 Sagittal image RT renal, homogenous mass (Nephroblastoma) (Gaillani, 2003

2.4.6.2.5 Metastases to Kidney:

Metastases to the kidney are usually asymptomatic and demonstrated in patients with a known malignancy which has already metastasized elsewhere. Spread to the kidneys is via the hematogenous route. The most common primary tumors associated with renal metastases are from the lung, breast and RCC of the contralateral kidney. Less common are colon, stomach, cervix, ovary, pancreas and prostate primaries, sonographic appearance of renal metastases is nonspecific (Gaillani, 2003)

2.4.7 Medical Renal Disease:

This term describes renal disorders that are initially treatable with medicine rather than surgery, Normal or enlarged kidneys in patients with suspected medical renal disease usually require biopsy for definitive diagnosis of the underlying abnormality. In general, adult patients with renal lengths of less than nine cm. are considered to have abnormally small, end stage kidneys, and biopsy is usually not required because the underlying renal disease is

unresponsive to treatment. Patients require dialysis or renal transplant. The hallmark of diffuse parenchymal renal disease is a diffuse increase in echogenicity throughout the parenchyma of both kidneys with prominent echo poor pyramids. Later the pyramids become less distinct and difficult to differentiate from the cortex until corticomedullary differentiation is lost. (Gaillani, 2003)

2.4.7.1 Acute Renal Failure: Renal failure is considered acute if it develops over days or weeks, and chronic if it spans months or years. Acute or chronic renal failure may result from insufficient renal perfusion (Perirenal causes), intrinsic renal disease (renal causes), or obstructive aeropathy (post renal causes). In the setting of ARF, the main purpose of the US study is to exclude hydronephrosis (figure 2-4-7-1) (Gaillani, 2003)

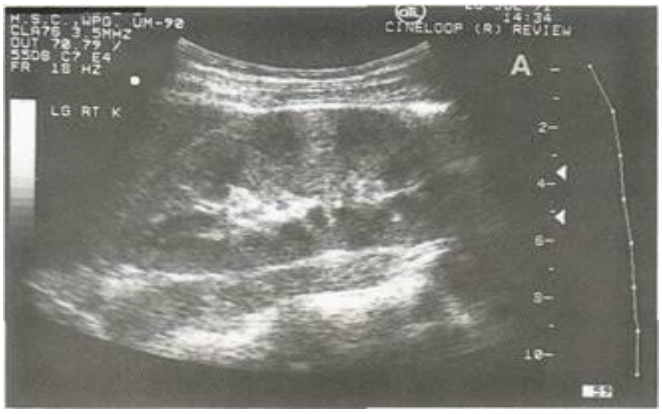


Figure 2.34 Sagittal image Acute Renal Failure. The kidney is enlarged, the cortical echogenicity is increased and the pyramids are enlarged (Gaillani, 2003)

2.4.7.2 Chronic Renal Failure (CRF): Diabetes mellitus is the most common cause of CRF other common causes are glomerulonephritis, chronic pyelonephritis, renal vascular disease, gout and polycystic renal disease. Sonographically, there is an initial renal enlargement; however, with time there is a reduction in size and an increase in cortical echogenicity. The corticomedullary junction is preserved. Later as the disease progresses, the medulla is usually not identified. In end stage

kidney, the kidney is small and hyperechoic with a loss of distinction between the cortex, medulla and central sinus echoes. Figure (2.4.7.2).

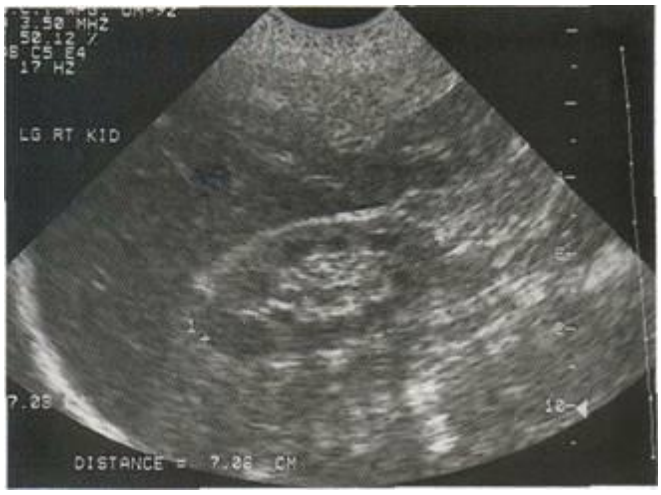


Figure 2.35 Sagittal image Chronic renal failure secondary to diabetic nephropathy. The long axis measures 7.08 cm, renal cortex is more echogenic (Gaillani, 2003)

2.4.8 Renal Infections:

Most renal infections occur via the ascending route. They are usually caused by contaminants from the intestinal tract Instrumentation, stasis, calculi, and vesicoureteral reflux are predisposing factors. Hematogenous infection also occurs as the result of intravenous drug abuse, tuberculosis and in immunocompromised patient. (Hung-Wen Kao, 2008)

2.4.8.1 Acute Pyelonephritis (Acute Bacterial Nephritis): Acute pyelonephritis is infection of the renal pelvis, calyces and parenchyma. This is most often (85%) caused by an ascending Escherichia coli (E. coli) infection, ultrasound is used to rule out obstructions or abscesses in patients who have not responded to antibiotics or who have progressive symptoms. Most kidneys demonstrate no abnormality however, edema may result in diffuse renal enlargement In addition, and there may be decreased parenchymal echogenicity and loss of corticomedullary differentiation. The

walls of the renal pelvis or major calyces may be thickened (figure 2.4.8.1) (Hung-Wen Kao, 2008)

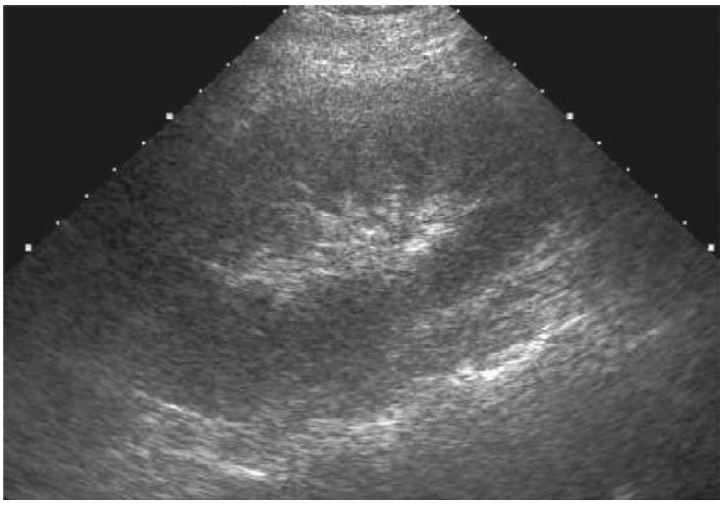


Figure 2.36 Sagittal image Diffuse Acute Pyelonephritis (Hung-Wen Kao, 2008)

2.4.8.2 Acute Focal Bacterial Nephritis (Lobar Nephronia): Studies of pyelonephritic kidneys suggest that each lobe is infected as a unit and that the severity of the infection may vary considerably from one renal lobe to another. The term acute, focal bacterial nephritis is applied to disproportionately severe infection of one or more lobes (figure 2.4.8.2) The severity of lobar infections in such cases falls somewhere between the usual form of pyelonephritis and renal abscess.

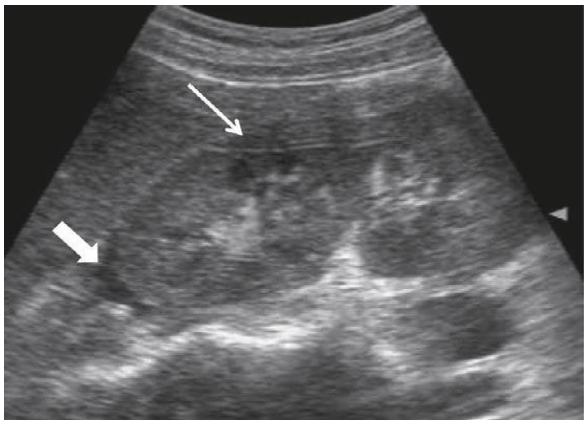


Figure 2.37 Sagittal image Focal pyelonephritis, hypo echogenicity in the middle portion(thin arrow) and a small perinephric fluid collection (thick arrow). (Hung-Wen Kao, 2008)

2.4.8.3 Renal Abscess: Renal abscess is a collection of purulent material confined to the renal parenchyma. Patients at high risk for the development of a Perirenal abscess include patients on hemodialysis, diabetics and intravenous drugs on sonography, a renal abscess appears as a hypoechoic mass with thick irregular walls or a capsule and increased through-transmission. (Hung-Wen Kao, 2008) (Figure 2.38).

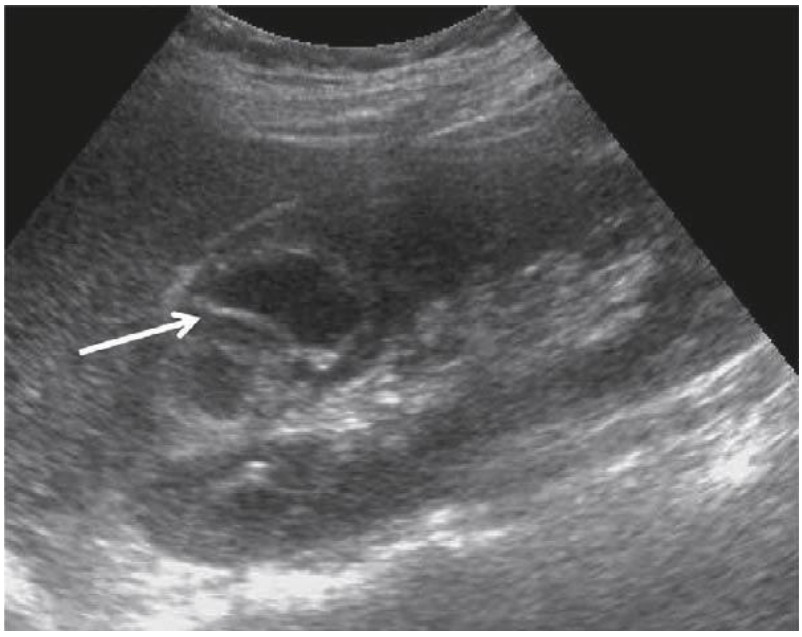


Figure 2.38 Sagittal image Renal abscess. (Heterogeneous hypoechoic mass (arrow) with a well-defined border (Renal Abscess). (Hung-Wen Kao, 2008)

2.4 The Previous Studies:

1. Mete (2017) studied Normal values of liver size by ultrasonography in children in the Eastern Anatolia region. The study was conducted to determine the normal range of liver dimension and the relationship of each with sex, age, body height, and weight in healthy children. The study comprised 310 healthy children (150 girls and 160 boys) with ages ranging from 3 days to 16 years in children in the Eastern Anatolia Region. Children who had underlying malignant tumors, infections, hematologic diseases, or other conditions that could alter organ size were excluded. All measured organs were sonographically normal. One dimension (Midclavicular Line Longitudinal Diameter – MCLLD) was obtained for liver with ultrasonography. The result MCLLD of this organ showed the strongest correlation with body height. Also, no statistically significant differences were found between the two sexes in any age group for MCLLD (t-test, $p > 0.05$). Therefore, all data were rearranged without being separated according to sex. The study concluded the normal range of MCLLD can be used to objectively measure the size of the organ in children who have clinically suspected organomegaly. The presented data are applicable in daily routine sonography.

2. Eze et. al (2017) carried out a research about Sonographic Assessment of Normal Renal Parenchymal and Medullary pyramid thicknesses among Children in Enugu, this was a cross sectional study, the subjects were 512 children aged 1-17 years scanned with ultrasound equipment with 3.5 MHz and 5 MHz curvilinear transducers. the RPT was measured perpendicularly to the long axis of the kidney from the medullary papilla to the renal capsule and MPT was measured from the apex to the base of the medullary pyramid on the same plane. the age and somatometric parameters of the subjects were recorded ,the results: mean± SD of RPT and MPT for the right kidney were 12.62±1.67 mm and 7.10±0.92 mm and the left kidney

were 12.81±1.7 and 7.23±0.94 mm respectively. there was a significant difference between the right and left RPT and MPT ($p<0.05$). The right and left RPT correlated strongly with age, body surface area (BSA), height, and weight but moderately with body mass index (BMI). A moderate positive correlation was observed between MPT and age, BSA, height, and weight. however, a weak correlation was observed between MPT and BMI. Conclusion: Nomograms of RPT and MPT in relation to age could be useful for grading hydronephrosis in children. (C.U. Eze a, February 2016)

2. Safia (2016) studied Sonographic Renal Measurements for Sudanese Children, This study was conducted to evaluate the association between renal dimensions and somatic parameters and analyze the affecting factors for renal size during growth to provide a reliable and practical reference for normal standard kidney length and volume values in Sudanese children. The study examined 60 Sudanese children ages from 1month to 14 year age including a total of 33 boys and 27 girls without renal problems. The maximum renal length (L) (cm), Breadth (orthogonal anterior-posterior diameter or D) (cm) and width (W) (cm) of each kidney were measured by ultrasound Esaote Pie Medical with convex 3.5 frequency transducer. Kidney volume was calculated as 0.523 x L x D x W (cm3) an age and anthropometric indices including height (cm), weight (kg) and body mass index (m2/kg) were collected through a medical record review. The mean renal length, and volume with standard deviation (SD) were estimated for every group of age. The renal length and volume were determined and corresponded with different somatic variables. Descriptive statistics with Regression analysis was done. There were significant correlations between all renal dimensions with age, weight, height, In the regression analysis, the most significant contributing factor to renal growth was height , there was statistically significant differences were observed between right and left kidneys length and volume but there is no significant difference between

other kidney measurements(width and breadth).also the study found that was no significant difference in the kidney length and volume among boys and girls in all age groups. Scatter plots were created, and they showed a close linear relationship between height and renal length and renal volume. The study presents reliable practical reference for normal standard kidney length and volume values by sonography in healthy pediatric population in Sudan.

3. Caroline et. al (2014) studied Ultrasound quantification of kidneys length and width to establish normal values in healthy Sudanese school aged children, This study were conducted to characterize the kidneys of Sudanese school aged children sonographically, and correlate with their demographic indices, as well as to establish a local reference of normal values. A total of 215 healthy children were included, 104 (48.4%) were males and 111 (51.6%) were females. All children underwent ultrasound examination for abdomen, coupling gel was used and longitudinal and transverse scans were obtained. The study showed that the normal Left Kidney Length was 7.9 ± 0.8, 8.1 ± 0.7.Left Kidney Width 3.9 ± 0.5, 3.9 ± 0.5 and Right Kidney Length 8.0 ± 0.8, 8.3 ± 0.8, Right Kidney Width 3.4 ± 0.4, 3.4 ± 0.4 for males and females respectively . Significant differences were noticed between two genders for left and right lengths (p-values =0.017, 0.037).A significant relationship at p-value 0.000 was detected between the kidneys measurements and children age, weight, height, abdomen circumference(AC) and Body mass index(BMI). The Left Kidney Length/spleen length ratio was found to be decreased in the ages of 9 and10 years for females and Right Kidney Length/liver length ratio was increased in the ages 8, 10 years for females. This study revealed that the kidneys measurements for Sudanese school aged children differed from what was mentioned in the previous studies in the same age groups. To the best of our knowledge, in clinical practice there are no pediatric kidneys length

and width equations for interpretation of sonographic examinations. Reference values were established .We hope this study contributes to daily practice in ultrasound clinics. These measurements can be considered as typical, and should be used for adequate comparison in evaluation of children kidney diseases.

4. Maha et. al (2013) studied Establishment Local Reference of Spleen Length in Sudanese Normal School Age Children Sonographically, This study was conducted to establish a local ultrasonic splenic length which can be used as reference for Sudanese healthy school age children and determine the normal standards spleen length related to gender, age, body weight, height, body mass index (BMI), and abdominal circumference. The study was done in Alsidiga School and Hamza Ibn Abdmutalib School in Bhari city from January 2012-February 2012, and examined 215 healthy school-aged children (7–13 years) from city centers were evaluated. Gender, age, weight, height, BMI, and abdominal circumference were determined for each case. The sonographic examination for spleen length performed with a high resolution real time scanner (SSD-500 Aloka Medical System) fitted with a 3.5MHz convex transducer; all of the measured spleens had a normal position, shape, and echo texture. The children were separated into 7 groups according to age and were classified to male and female. The result showed that The mean length of the spleen was found to be 9.5-10.4cm.There was significant difference between the spleen length in male and female (P-value 0.000), the mean length of spleen in female is greater than in male, there is significant relation between spleen length and age, weight, height, abdomen circumference and BMI. The study concluded that the spleen length obtained in this study was in different range of values reported in previous studies. The mean spleen length in female is greater than male .By applying the above equations the spleen length can be estimated, a local reference of spleen length was

established; further studies are required to establish national reference of spleen length and volume in Sudan.

5. Bhavna et. al (2009) studied Normal Values of Liver and Spleen Size by Ultrasonography in Indian Children, this study was conducted to establish standards of liver and spleen length by ultrasonography in healthy Indian children, based on age, sex and somatometric parameters. The study enrolled 650 asymptomatic children between the age-group 1 month to 12 years, visiting the outpatient department either for routine immunization or accompanying their siblings, between January to December 2005. Any child under evaluation for/ follow-up case of a condition which could affect the size of the spleen or liver e.g. viral hepatitis, malaria, hemolytic anemia, enteric fever, congestive heart failure and malnutrition. The result showed parents of a total of 650 children were approached for enrolment in the study, of which 42 refused permission and 11 were excluded. Thus, 597 children (347 [58.1%] boys) between the age-group 1 month to 12 years (mean [SD] age 56.5 [41.9] month) visiting the out-patient department either for routine immunization (268, 44.9%) or asymptomatic children accompanying their siblings (329, 55.1%) were evaluated during the study. The median age was 48 month (range, 1-156 month). The age and sex distribution of the study population is shown in Table I. The mean (SD) splenic length was 6.99 (1.36) cm (males, 7.06cm; females, 6.88cm) and the mean (SD) liver length was 9.59 (1.98) cm (males, 9.63 cm; females, 9.54 cm). The spleen and liver length of healthy children from 1 month to 12 year according to age and sex is given in Table II. The spleen size and the liver size increased significantly with the age ($P<0.05$). Liver and spleen length correlated significantly with the height ($r=0.84$ and 0.73) and weight ($r=0.79$ and 0.69). The results provide a standard set of normal range of liver and spleen size according to weight, height, age and sex of the children, as determined by ultrasonography. Also found height to be a

significant correlate of the liver and spleen size across all ages and weights, in both the sexes.

6. OznurL et. al (1998) studied Normal Liver, Spleen, and Kidney Dimensions in Neonates, Infants, and Children: Evaluation with Sonography, this study was conducted to determine the normal range of dimensions for the liver, spleen, and kidney in healthy neonates, infants, and children. This prospective study involved 307 pediatric subjects (169 girls and 138 boys) with normal physical or sonographic findings who were examined because of problems unrelated to the measured organs. The subjects were 5 days to 16 years old. All measured organs were sonographically normal. At least two dimensions were obtained for each liver, spleen, and kidney. Relationships of the dimensions of these organs with sex, age, body weight, height, and body surface area were investigated. Suggested limits of normal dimensions were defined. The result showed dimensions of the measured organs were not statistically different in boys and girls. Longitudinal dimensions of all three organs showed the best correlation with age, body weight, height, and body surface area. Height showed the strongest correlation of all. This correlation was a polynomial correlation. The study concluded determination of pathologic changes in size of the liver, spleen, and kidneys necessitates knowing the normal range of dimensions for these organs 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 these organs.

Chapter Three

Materials and Methods

CHAPTER THREE

3.1 Materials:

The study compromised 302 healthy children with age ranging 6 months to 14 years. Hematologic disease or other conditions that could alter organ size were excluded.

All measured organs were sonographically normal; Mid Clavicular Line Longitudinal Diameter (MCLLD) was obtained for measurement with ultrasonography.

The retrospective patience record study of the liver, kidneys and spleen by ultrasound is limited in Elsheikh Khalid Medical Centre. Most children were completely healthy although some were undergoing follow-up for descended tests. All subjects included have demonstrated normal homogenous pattern for the organs.

The machines used were:

1. Aloka PHD prosound SSD-4000 sv, Model PC-1531B SN M00482.3 probes – TAS / curve linier / TVS linier.
2. Mindray DP-1100 plus digital ultrasonic diagnostic imaging system, probe curve linier 3.5 Mhz.

Putting into consideration that most of the work was done by the second machine.

3.2 Technique:

The sonographic examinations were performed with a high resolution real time scanner with 3.5 MHz convex transducers and with the children in supine position using gel.

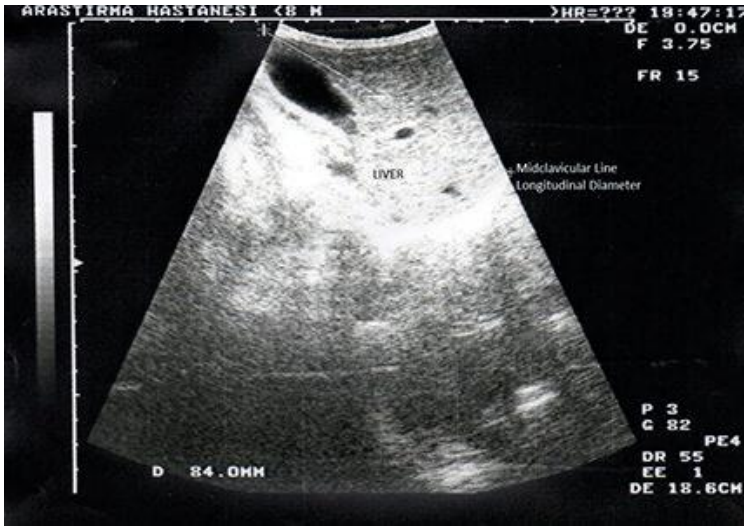
The examination was done with the children in the supine position, left lateral decubitus, lateral oblique positions for the right kidney and right lateral decubitus or lateral oblique positions for the left kidney. Scans are

performed in the sagittal and transverse planes from the anterior approach using the liver and spleen as acoustic windows. For measurements of length: the maximal longitudinal axes were evaluated from the ventral side. The calipers were placed on the outer edges of the caudal and cranial side in a sagittal plane to obtain the maximum longitudinal renal length .The width was measured from the ventral ultra-sonographic section of the kidney, the width that is perpendicular to the longitudinal length was obtained. The spleen and liver length was also measured using computer curser. The children weight, height, abdomen circumference and BMI were measured and recorded in a

Master data sheet.

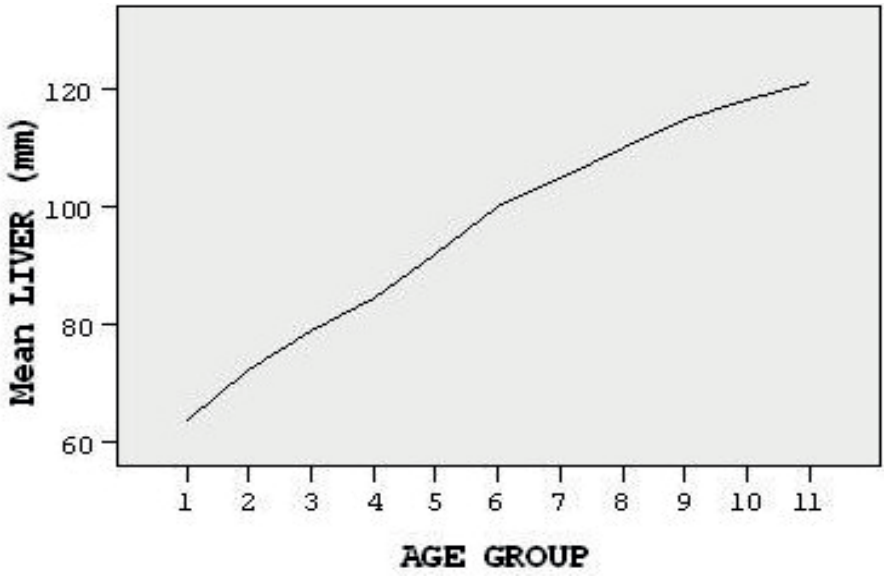
3.3 Method:

MCLLD is a most commonly applies measures of estimating liver size in routine diagnostic situations and is proved to be the best measures diameter in differentiating between healthy and diseased liver. for each subject was measured; the upper and lower points of measurements of the liver, kidney and spleen were measured from sonographic images.



Measurement of MCLLD from hepatic dome to lower hepatic margin

(Teachmeanatomy 2019).



The line graph shows the distribution of MCLLD of the Liver (mm) According to age group

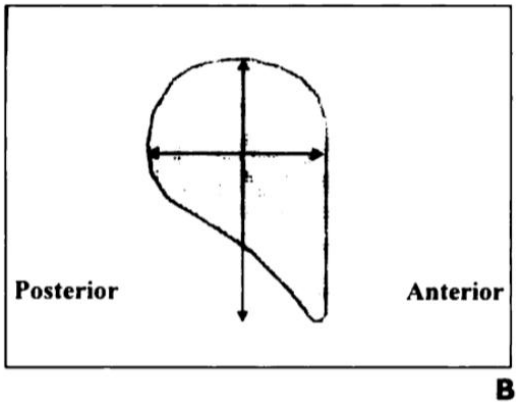


Figure 3.1 Longitudinal and anteroposterior dimensions of right and left lobes were measured.

Measurement of the spleen:

Spleen Length was taken by measuring the longest dimension in a Coronal plane. Longitudinal dimensions in the coronal plane were obtained with the subject in the supine or slightly right lateral decubitus position; longitudinal size measurement was performed between the most supero medial and the most inferno lateral points of the spleen.

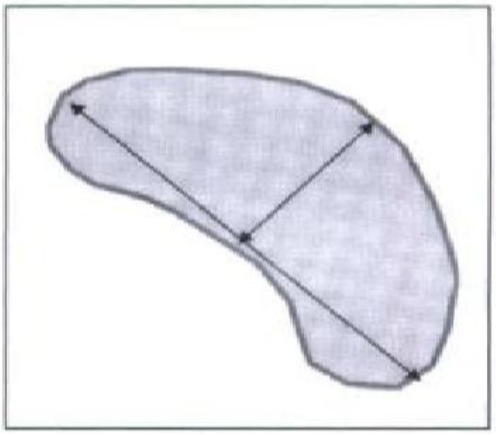


Figure 3.2 how longitudinal and transverse dimensions of spleen were measured in coronal section passing through splenic hilum (Teachmeanatomy 2019).

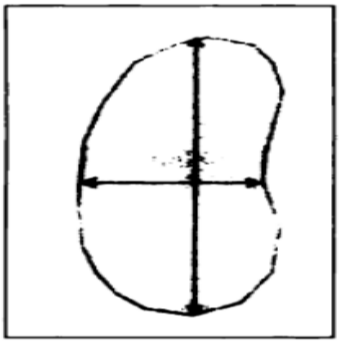


Figure 3.3 How longitudinal and transverse dimensions of kidney were measured in coronal section passing through renal hilum (Teachmeanatomy 2019).

3.4 Ethical Consideration:

The patients were selected absolutely randomly with no specific targets, no personal identification was asked for and therefor no data will be published considering the confidentiality between the researcher and the patients.

Chapter Four

Results

CHAPTER FOUR

4. Results

Table (4.1) Frequency distribution of gender

Gender	Frequency
Male	174
Female	128
Total	302

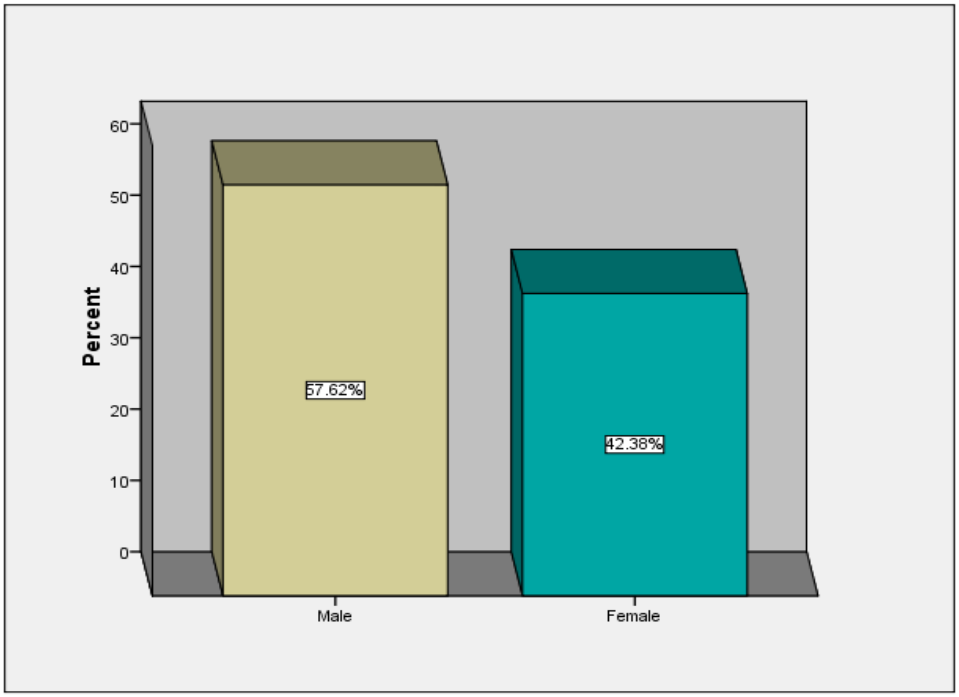


Figure (4.1) Frequency distribution of gender

Table (4.2) Frequency distribution of age\years

Age \years	**Frequency**
0.5-5	34
5.5-10	136
10.5-14	132
Total	302

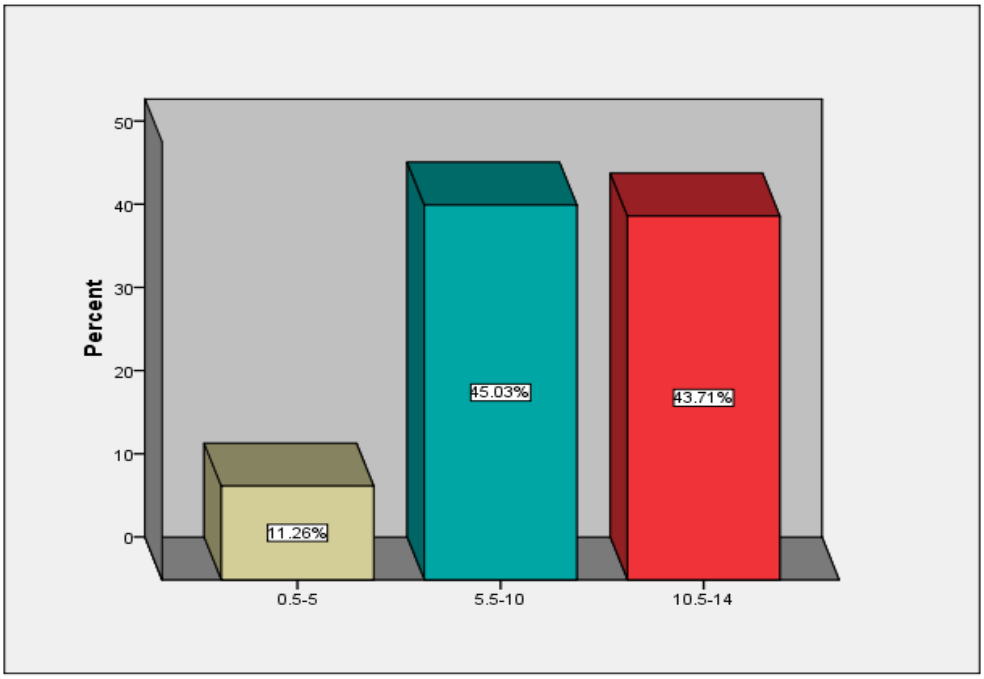


Figure (4.2) Frequency distribution of age\years

Table **(4.3)** descriptive statistic for age, height, weight, liver span, spleen length, Right Kidney and left kidney length and width (minimum, maximum, mean ± Std. Deviation)

Variables	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age (Yrs)	.5	14.0	9.36	3.12
Weight (Kgs)	5	68	28.03	10.88
Height (cm)	59	168	130.88	20.42
BMI (Kg\cm^2)	9.69	36.00	15.77	3.16
Liver span	7.2	15.9	11.01	1.21
Spleen length	4.8	10.3	7.34	1.12
RTK length	4.9	10.8	8.33	1.03
LTK length	4.9	11.7	8.51	1.05
RTK width	2.1	8.7	3.29	.52
LTK width	2.3	7.4	4.09	.62
Valid N (list wise)				

Table (4.4) compare means liver span, spleen length, Right Kidney and left kidney length and width (minimum, maximum, mean ± Std. Deviation) in different age group

Age \years		**Liver span**	**Spleen length**	**RTKL**	**LTKL**	**RTKW**	**LTKW**
0.5-5	Mean	9.40	6.45	6.72	6.90	2.89	3.36
	Std. Deviation	1.15	1.18	.925	.95	.43	.67
	Minimum	7.2	4.8	4.9	4.9	2.1	2.3
	Maximum	11.6	9.1	8.1	9.1	3.8	5.8
5.5-10	Mean	10.61	6.86	8.08	8.28	3.14	3.93
	Std. Deviation	.892	.81	.70	.71	.35	.53
	Minimum	8.3	5.0	6.2	6.4	2.5	2.9
	Maximum	13.0	9.5	9.6	10.3	4.8	7.4
10.5-14	Mean	11.82	8.06	9.00	9.15	3.54	4.43
	Std. Deviation	.85	.95	.75	.81	.57	.45
	Minimum	9.8	6.0	6.3	7.2	2.3	3.4
	Maximum	15.9	10.3	10.8	11.7	8.7	5.9
Total	Mean	11.01	7.34	8.33	8.51	3.29	4.09
	Std. Deviation	1.21	1.12	1.03	1.05	.52	.62
	Minimum	7.2	4.8	4.9	4.9	2.1	2.3
	Maximum	15.9	10.3	10.8	11.7	8.7	7.4

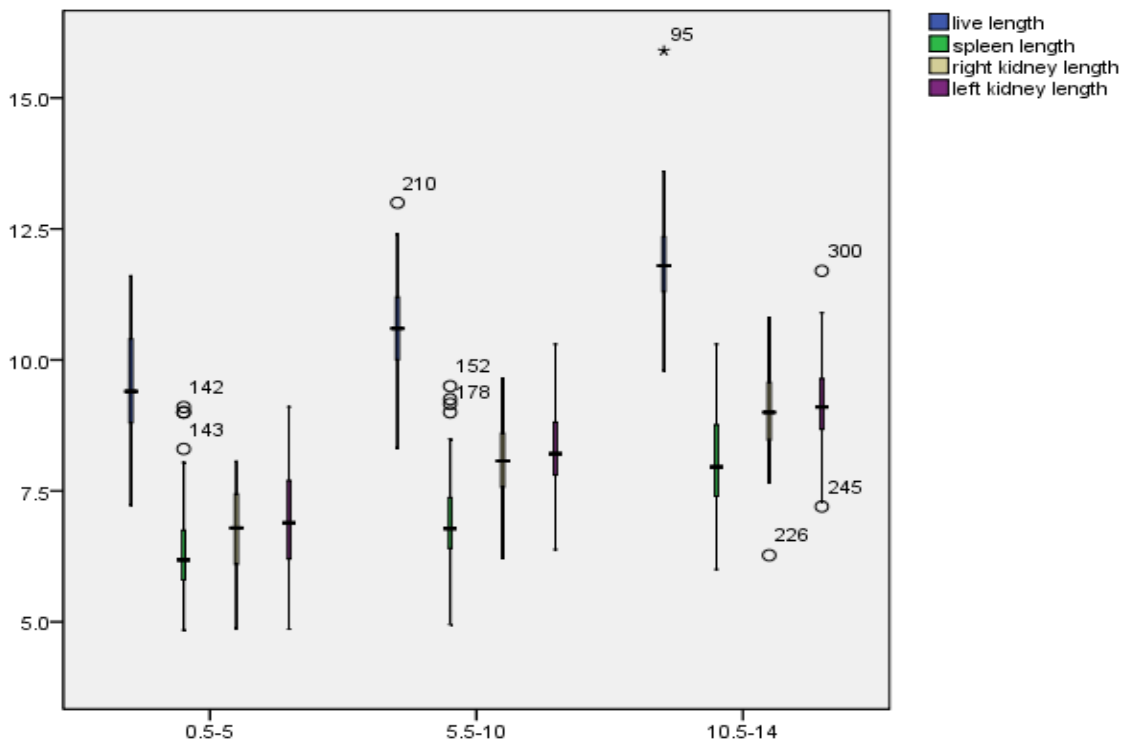


Figure (4.3) plot box shows mean splenic length in different age group

Table (4.5) compare means liver span, spleen length, Right Kidney and left kidney length in different gender

a. Mean

Organs	Gender	Mean	Std. Deviation	Std. Error Mean
Liver span	Male	11.242	1.1360	.0861
	Female	10.685	1.2376	.1094
Spleen length	Male	7.454	1.0818	.0820
	Female	7.177	1.1512	.1017
RTK length	Male	8.403	1.0253	.0777
	Female	8.240	1.0356	.0915
LTK length	Male	8.602	1.0658	.0808
	Female	8.385	1.0180	.0900
RTK width	Male	3.338	.4344	.0329
	Female	3.222	.6162	.0545
LTK width	Male	4.127	.6528	.0495
	Female	4.031	.5682	.0502

b. Independent sample t-test to compare mean liver span , spleen length , Right Kidney and left kidney length in different gender

	t	Sig. (2-tailed)
Liver span	4.053	.000
	4.000	.000
Spleen length	2.137	.033
	2.117	.035
RTK length	1.365	.173
	1.362	.174
LTK length	1.784	.076
	1.796	.074
RTK width	1.905	.058
	1.809	.072
LTK width	1.329	.185
	1.357	.176

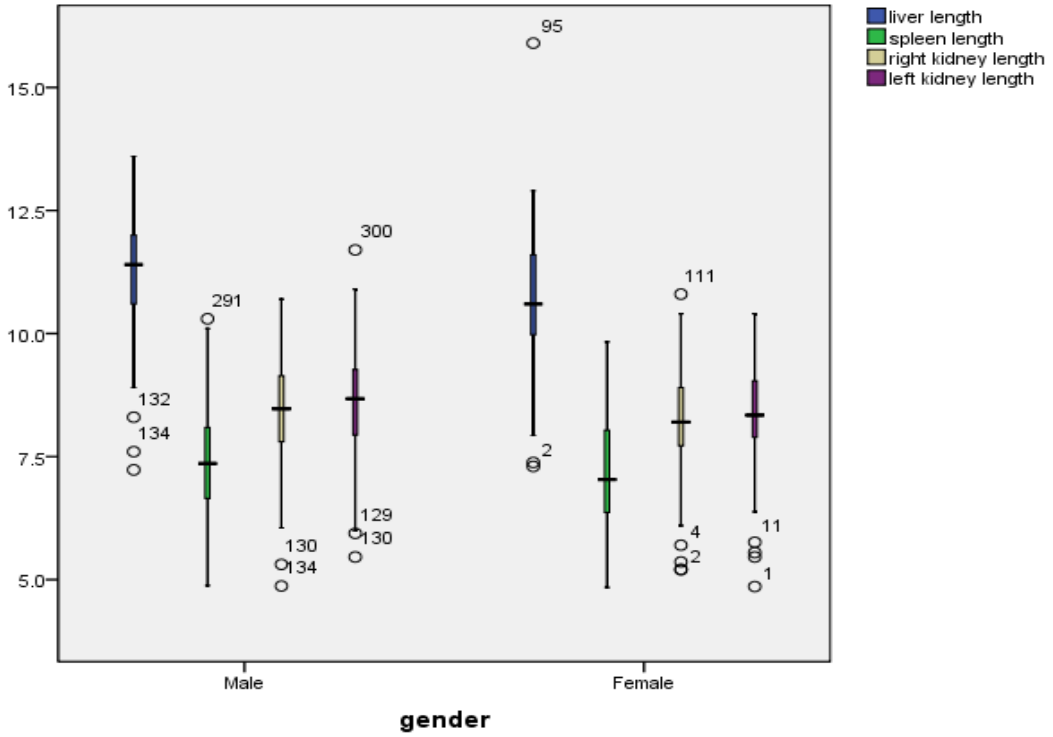


Figure (4.4) plot box shows mean splenic length in different gender

Table (4.6) correlation between age, height, weight, BMI and liver span, spleen length, Right Kidney and left kidney length

		Age	Weight	Height	BMI
Liver span	Pearson Correlation	.730**	.702**	.708**	.369**
	Sig. (2-tailed)	.000	.000	.000	.000
Spleen length	Pearson Correlation	.603**	.648**	.548**	.443**
	Sig. (2-tailed)	.000	.000	.000	.000
RTK length	Pearson Correlation	.762**	.722**	.762**	.353**
	Sig. (2-tailed)	.000	.000	.000	.000
LTK length	Pearson Correlation	.753**	.705**	.740**	.347**
	Sig. (2-tailed)	.000	.000	.000	.000
RTK width	Pearson Correlation	.470**	.513**	.436**	.359**
	Sig. (2-tailed)	.000	.000	.000	.000
LTK width	Pearson Correlation	.622**	.585**	.631**	.241**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	302	302	302	302
**. Correlation is significant at the 0.01 level (2-tailed).					

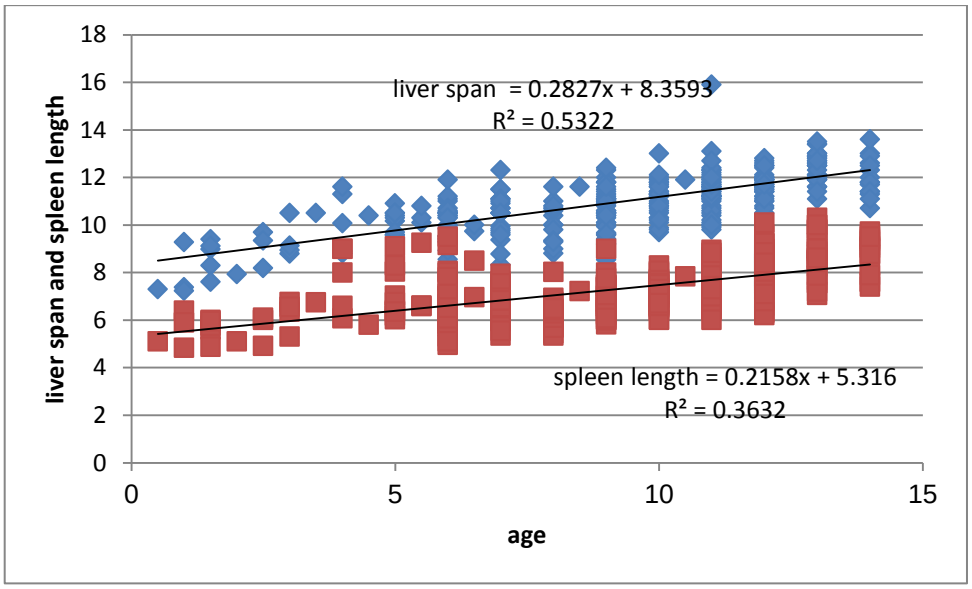


Figure (4.5) scatterplot shows relationship between age liver span and splenic length

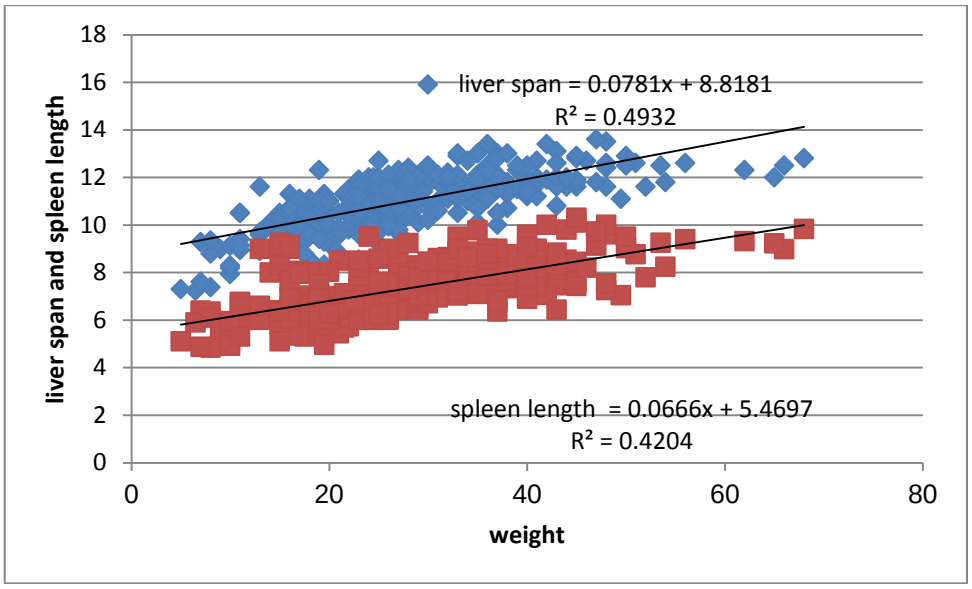


Figure (4.6) scatterplot shows relationship between weight liver span and splenic length

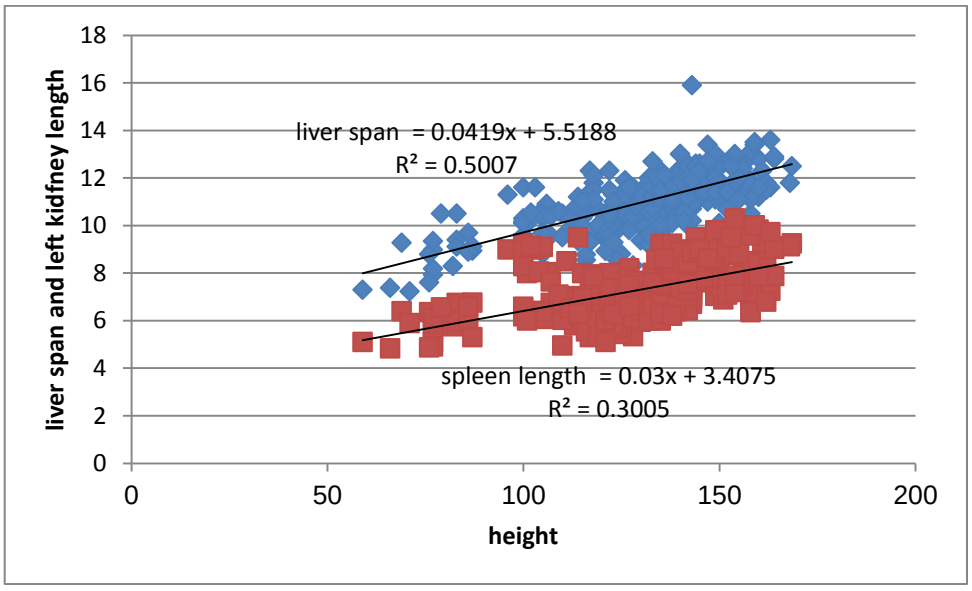


Figure (4.7) scatterplot shows relationship between height liver span and splenic length

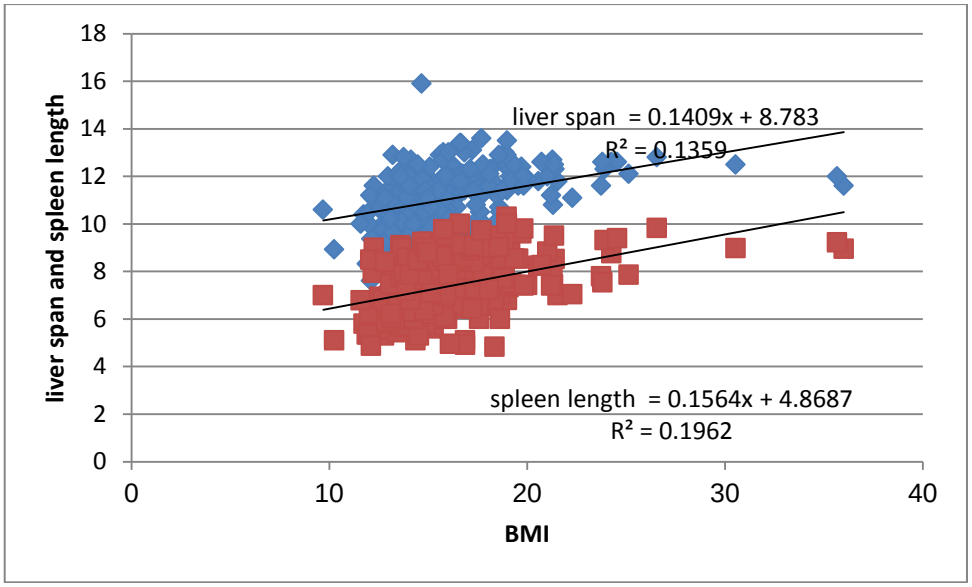


Figure (4.8) Scatterplot shows relationship between BMI liver span and splenic length

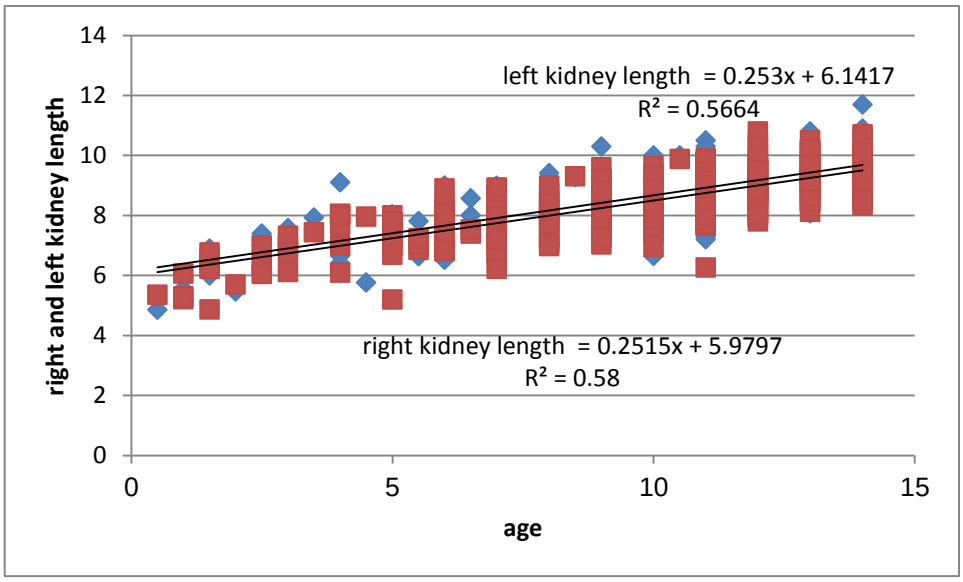


Figure (4.9) scatterplot shows relationship between age and both kidney length

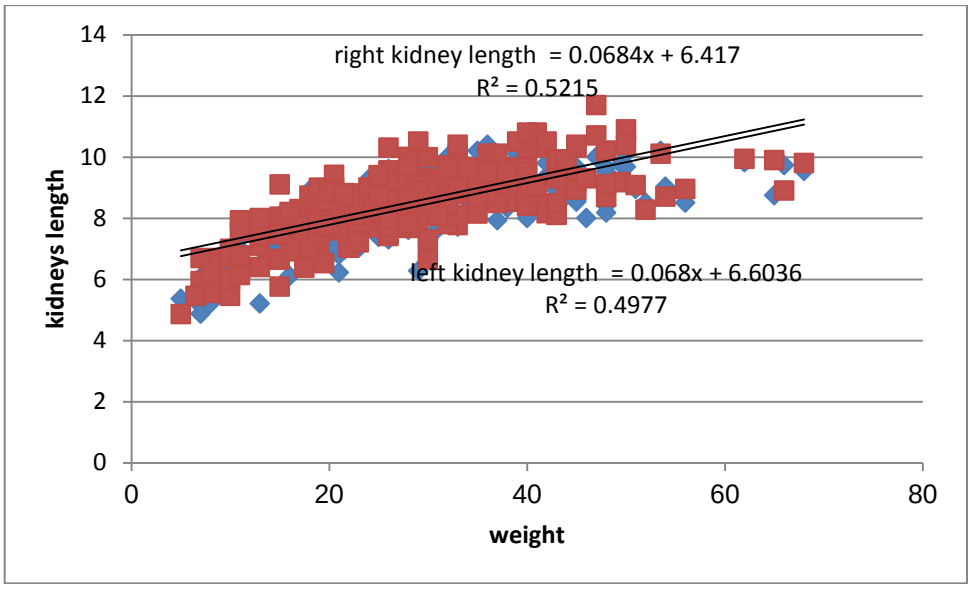


Figure (4.10) scatterplot shows relationship between weight and both kidney length

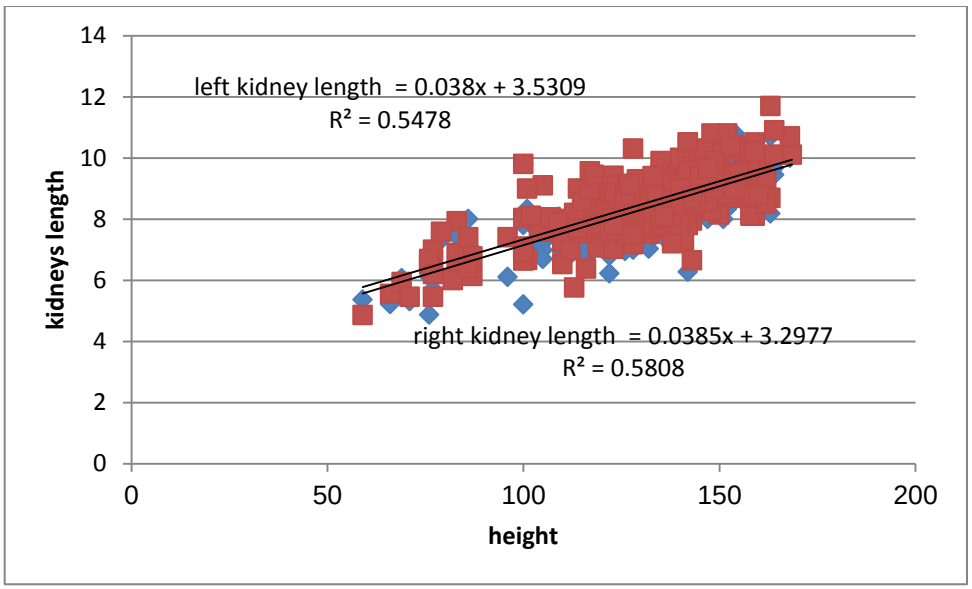


Figure (4.11) scatterplot shows relationship between height and both kidney length

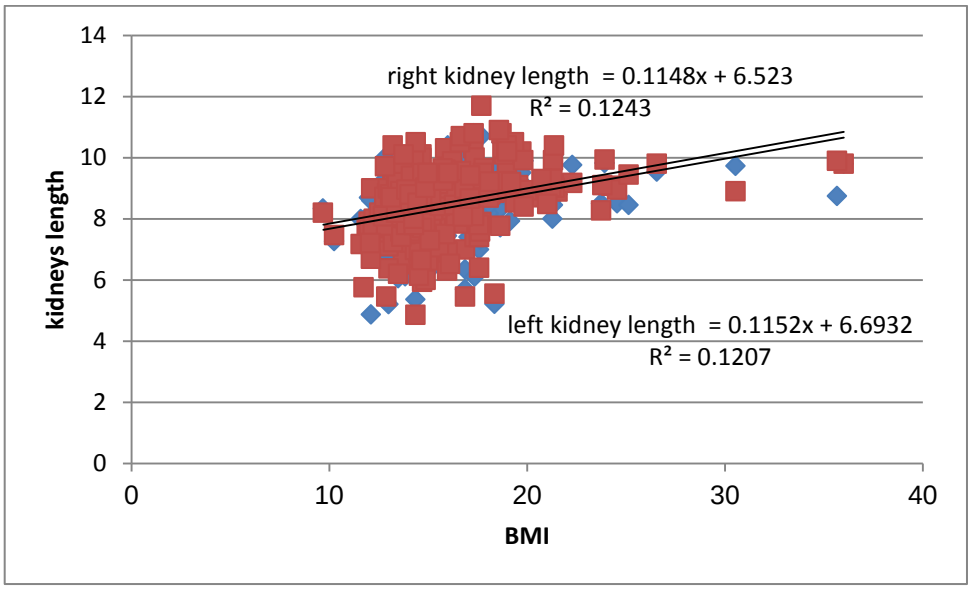


Figure (4.12) scatterplot shows relationship between BMI and both kidney length

Chapter Five

Discussion, Conclusion & Recommendations

CHAPTER FIVE

Discussion, Conclusion & Recommendations

5.1 Discussion:

This was cross sectional study carried out in Khartoum state ,the main objective of this study focused to measure the normal size of liver spleen and kidneys in Sudanese children using ultrasonography ,the study was performed on 302 children with normal liver spleen and kidneys , 57.6% of them male gender. Table (4.1)

The ages divided into 3 age groups, 45% in age group 5.5 -10 years (group one), followed by 43.7% for age 10.5-14 years (group two) then 11.3% in age group from 6 month to 5 years (group three) table (4.2)

The study found that the age, height, weight, BMI respectively was ranged (0.5-14years) with mean 9.36.±3.12 years, (59-160 cm) mean 130.88±20.42 cm, (5-68) mean28.03±10.88 kg, (9.69-36.00) mean 15.77±3.16kg \cm^2

Concerning measurement of liver span the study found that it from 7.2-15.9 cm with mean 11.01±1.21 this results agree with the study by Bhavna, Suvasini, Devendra, Reema, Ravindra, Shailendra, 2009.

The spleen length ranged from 4.8-10.3 cm with mean 7.34±1.12 cm, this results agree to the study by Maha, Caroline, Elsaffi, Samih, 2013. Right kidney length measurement was 8.33±1.03 cm (4.9-10.8 cm) while left kidney length was 8.51±1.05 cm4.9-11.7cm) , this results clarified that the left kidney is longer than right kidney which is agree to the study rendered by (C.U. Eze a, February 2016).

The study found that there was significant difference in liver spleen and both kidney measurements in different age group ($p < 0.01$) , the mean liver span in 0.5-5 years age was 9.4±1.15 cm, for 5.5 -10 years

10.61±0.89cm and for 10.5-14 years 11.82±0.85 cm. The spleen length for in 6 months - 5 years age was 6.45±1.18 cm, for 5.5 -10 years 6.86±0.81cm and for 10.5-14 years 8.06±0.95 cm, the right kidney length is 6.72± 0.92cm in 0.5-5 years age was, for 5.5 -10 years 8.08±0.70 cm and for 10.5-14 years 9.00±0.75 cm and the left kidney length is 6.90± 0.95cm in 0.5-5 years age was (4.9-9.1), for 5.5 -10 years 8.28±0.71 cm and for 10.5-14 years 9.15±0.81 cm.

The study found that there was significant difference in liver and spleen length in different gender p less than 0.01 and 0.05 respectively but no significant difference in measurements of kidney in both gender p > 0.05, table (4.5 b) , the mean measurements is slightly more in male than female, the mean liver ,spleen ,right and left kidney length 11.24,7.45,8.40, 8.60 cm for male , 10.68,7.17,8.24,8.38 for female ,table (4.5 a)

The study found that there was significant correlation between age, height, weight, BMI of participant and liver span , spleen length , right and left kidney length respectively ($P<0.01$) , (table 4.6).

Linear regression shows linearity in relationship between liver span , spleen length and age , the study predict measurement of both using age by the following coefficient:

Liver Span = 0.08 cm/kg * weight + 0.3 cm/year * age + 8.4

The study shows linearity in relationship between liver span, spleen length and weight (R^2= 0.49 , 0.42 respectively)

Liver Span = 0.08 cm/kg * weight + 0.3 cm/year * age + 8.4

The study shows linearity in relationship between liver span, spleen length and height

Liver Span = 0.04 cm/cm * height + 0.3 cm/year * age + 8.4

The study showed very week linearity in relationship between liver span and splenic length with BMI

Liver span = 0.1409 BMI + 8.783 (R^2 = 0.1359)

Spleen length = 0.1564 BMI + 4.8687 (R^2 = 0.1962)

The study shows strong linearity in relationship between age and both kidney length

Left kidney length = 0.253 age + 6.1417 (R^2 = 0.5664)

Right kidney length = 0.2515 age + 5.9797 (R^2 = 0.58)

These results clarified that for every year's age kidney length increased by 0.25 cm, as shown in figure (4.9)

Concerning relationship between height and kidney length, the study shows strong linearity in relationship between height and both kidney length, figure (4.11)

Left kidney length = 0.038x

Right kidney length = 0.0385x

From the results of the study there was linearity in relationship between weight and both kidney length as shown in following formulae:

Right kidney length = 0.0684x + 6.417 (R^2 = 0.5215)

Left kidney length = 0.068x + 6.6036 (R^2 = 0.4977),

figure (4.10)

From the results of the study there was weak linearity in relationship between BMI and both kidney length as shown in following formulae :

Right kidney length = 0.1148x + 6.523 (R^2 = 0.1243)

Left kidney length = 0.1152x + 6.6932 (R^2 = 0.1207),

this results clarified that for every I Kg\cm ^{2} kidney length increased 0.11 cm, figure (4.12).

5.2 Conclusion:

Determination of pathologic changes in size of the liver, spleen, and kidney necessitates knowing the normal range of dimensions for these organs 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 these organs.

The study found that liver span the liver in Sudanese children ranged from 7.2-15.9 cm with mean 11.01±1.21. The spleen length ranged from 4.8-10.3 cm with mean 7.34±1.12 cm. Right kidney length measurement was 8.33±1.03 cm, ranged from 4.9-10.8 cm while left kidney length was 8.51±1.05 cm with ranged 4.9-11.7cm, this results clarified that the left kidney is longer than right kidney.

The study concluded that there was significant difference in liver spleen and both kidney measurements in different age group ($p < 0.01$)

The study found that there was significant difference in liver and spleen length in different gender ($p <$ than 0.01 and 0.05 respectively) but no significant difference in measurements of kidney in both gender $p > 0.05$, the mean measurements is slightly more in male than female.

The study found that there was significant correlation between age, height, weight, BMI of participant and liver span , spleen length , right and left kidney length respectively ($P<0.01$).

The study concluded the linearity in relationship between liver span, spleen length, both kidney length and age, weight, height, BMI according to the following formulae:

Liver span = 0.0781 weight + 8.8181($R^2 = 0.4932$)

Spleen length = 0.0666 weight + 5.4697 ($R^2 = 0.4204$)

Liver span = 0.0419 height + 5.5188 (R^2 = 0.5007)

Spleen length = 0.03 height + 3.4075(R^2 = 0.3005)

The study predict liver span, spleen length , right and left kidney length in different age using following prediction formulae:

Liver span =0.28*age +8.35 (R^2= 0.532)

Spleen length = 0.21*age +5.31 (R^2= 0.363)

Left kidney length = 0.253 age + 6.1417 (R^2 = 0.5664)

Right kidney length = 0.2515 age + 5.9797 (R^2 = 0.58).

The study concluded that the visceral organs can be estimated dynamically using age following equation (liver span, spleen, Rt kidney, Lt kidney) every one year length increase (0.38, 0.21, 0.251, 0.253 cm) respectively. In using height following equation every 1 cm height (liver, spleen, Rt kidney, Lt kidney) height had influenced the parameter of the three organs by length increase (0.041, 0.03, 0.0385, 0.038 cm) respectively.

In using weight following equation every 1 kg weight the (liver, spleen, Rt kidney, Lt kidney) length increase (0.0781, 0.0666, 0.0664, 0.068 cm) respectively. In using BMI following equation every 1 kg cm2 (liver, spleen, Rt kidney, Lt kidney) length increase (0.1409, 0.1564, 0.1148, 0.1152 cm) respect.

To sum up our findings we consider that this study has fulfilled its purpose of becoming a local and international reference for physicians to refer to when comparing measurements of normal organs to those which are diseased.

5.3 Recommendations:

1. It is important for Sudanese to have their own population specific nomograms of the kidneys in the studied age group as American and European population data cannot be used as universal patterns. Our results could be generalized to the wider international community where there is need for each country to establish their own specific nomograms of kidney size in school-age children with reference to the body parameter that shows the best correlation with kidney dimensions as height and weight might show variation in different ethnic origins or races,
2. Integrated devices are required for all types of departments.
3. Training the specialist on how to deal with children and make ultrasound for them.
4. Developing flexible laws from the state to assist the researcher in carrying out research and overcoming difficulties for him.
5. Further studies should be done with larger sampling and covered the majority of Sudan areas and tribes adding other individual factors.
6. Include modalities (CT, MRI and Doppler ultrasound scan) in further performed studies

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Appendices

Appendix 1

DATA COLLECTION FORM

القياسات				طوله	وزنه	العمر	الجنس	الرقم
Lt Kidney	Rt Kidney	Spleen	Liver					
								1
								2
								3
								4
								5
								6
								7
								8
								9
								10
								11
								12
								13
								14

Appendix 2

chart for measurements of liver span, spleen length, Right Kidney and left kidney length in different age in Sudanese children

Age (Yrs)		Liver span	Spleen length	Right kidney length	Left kidney length
0.5	Mean	7.300	5.100	5.360	4.860
	Minimum	7.3	5.1	5.4	4.9
	Maximum	7.3	5.1	5.4	4.9
1	Mean	7.960	5.713	5.527	5.650
	Std. Deviation	1.1370	.7966	.4646	.2551
	Minimum	7.2	4.8	5.2	5.5
	Maximum	9.3	6.4	6.1	5.9
1.5	Mean	8.680	5.638	6.162	6.514
	Std. Deviation	.7268	.4526	.7499	.3582
	Minimum	7.6	4.9	4.9	6.0
	Maximum	9.4	6.0	6.8	6.9
2	Mean	7.930	5.100	5.700	5.460
	Minimum	7.9	5.1	5.7	5.5
	Maximum	7.9	5.1	5.7	5.5
2.5	Mean	9.077	5.670	6.467	6.867
	Std. Deviation	.7960	.6601	.4856	.6110
	Minimum	8.2	4.9	6.0	6.2
	Maximum	9.7	6.1	7.0	7.4
3	Mean	9.340	6.242	6.808	6.752
	Std. Deviation	.7857	.6438	.5075	.6109
	Minimum	8.8	5.3	6.1	6.1
	Maximum	10.5	6.8	7.3	7.6
3.5	Mean	10.500	6.750	7.440	7.930
	Minimum	10.5	6.8	7.4	7.9
	Maximum	10.5	6.8	7.4	7.9
4	Mean	10.134	7.734	7.372	7.512
	Std. Deviation	1.3053	1.3538	.8264	1.0880
	Minimum	8.8	6.1	6.1	6.4
	Maximum	11.6	9.0	8.1	9.1
4.5	Mean	10.400	5.800	7.960	5.760
	Minimum	10.4	5.8	8.0	5.8
	Maximum	10.4	5.8	8.0	5.8

5	Mean	10.179	7.133	7.173	7.669
	Std. Deviation	.4673	1.0872	.8481	.3246
	Minimum	9.6	6.0	5.2	7.1
	Maximum	10.9	9.1	8.0	8.0
5.5	Mean	10.400	7.480	7.050	7.120
	Std. Deviation	.3606	1.5329	.2000	.6126
	Minimum	10.1	6.6	6.8	6.6
	Maximum	10.8	9.2	7.2	7.8
6	Mean	10.227	6.732	7.697	7.900
	Std. Deviation	.7594	1.1714	.5097	.5583
	Minimum	8.6	5.0	6.8	6.5
	Maximum	11.9	9.5	8.9	9.0
6.5	Mean	9.870	7.725	7.470	8.285
	Std. Deviation	.1838	1.0819	.0990	.4031
	Minimum	9.7	7.0	7.4	8.0
	Maximum	10.0	8.5	7.5	8.6
7	Mean	10.379	6.740	7.846	7.922
	Std. Deviation	.9719	.6729	.7652	.6337
	Minimum	8.3	5.3	6.2	6.4
	Maximum	12.3	7.9	8.9	9.0
8	Mean	10.104	6.278	7.918	8.221
	Std. Deviation	.8393	.7201	.6456	.6174
	Minimum	8.8	5.4	7.0	7.1
	Maximum	11.6	8.0	9.0	9.4
8.5	Mean	11.600	7.220	9.310	9.270
	Minimum	11.6	7.2	9.3	9.3
	Maximum	11.6	7.2	9.3	9.3
9	Mean	10.704	6.862	8.248	8.431
	Std. Deviation	.8752	.6385	.5743	.6976
	Minimum	8.5	5.8	7.0	7.2
	Maximum	12.4	9.0	9.6	10.3
10	Mean	11.123	7.109	8.459	8.689
	Std. Deviation	.7556	.5687	.6909	.6137
	Minimum	9.7	6.0	7.0	6.6
	Maximum	13.0	8.3	9.6	10.0
10.5	Mean	11.900	7.840	9.880	10.000
	Minimum	11.9	7.8	9.9	10.0
	Maximum	11.9	7.8	9.9	10.0
11	Mean	11.445	7.502	8.637	8.734
	Std. Deviation	1.0055	.6719	.7143	.7869
	Minimum	9.8	6.0	6.3	7.2
	Maximum	15.9	9.0	9.9	10.5

12	Mean	11.733	7.966	9.008	9.124
	Std. Deviation	.5546	.9165	.7164	.5957
	Minimum	10.5	6.2	7.8	8.0
	Maximum	12.8	10.1	10.8	10.3
13	Mean	12.423	8.707	9.293	9.440
	Std. Deviation	.6044	.8586	.6027	.7259
	Minimum	11.1	7.1	8.1	8.1
	Maximum	13.5	10.3	10.5	10.8
14	Mean	12.007	8.739	9.439	9.873
	Std. Deviation	.7995	.7885	.7325	.8449
	Minimum	10.7	7.4	8.3	8.8
	Maximum	13.6	9.7	10.7	11.7
Total	Mean	11.006	7.336	8.334	8.510
	Std. Deviation	1.2099	1.1183	1.0311	1.0496
	Minimum	7.2	4.8	4.9	4.9
	Maximum	15.9	10.3	10.8	11.7
P value	<0.01				