بسم الله الرحمن الرحيم

Sudan University for science and technology

College of Graduate Studies

Measurement of liver among Sudanese adults using Computed Tomography

قياس الكبد لدي السودانين البالغين باستخدام الاشعة المقطعية المحوسبة

A Thesis submitted for partial fulfilment for the requirement of M.Sc degree in diagnostic radiological technology

Prepared by:

Eslam Ali Alsiddeg Hag Eldoow

Supervised by:

Prof: Hussein Ahmed Hassan Ahmed

2016

الاية

قال تعالي :

﴿ وَمِنْهُمْ مَنْ يَقُولُ رَبَّنَا آتِنَا فِي الدُّنْيَا حَسَنَةً وَفِي الآخِرَةِ حَسَنَةً وَقِنَا عَذَابَ النَّارِ﴾

سوره البقرة(201)

Dedication

To my father.

To my mother.

To my brothers and sisters.

To my teachers.

To my friends.

To my colleagues.

Acknowledgement

Iamindebted to all those who directly or indirectly,have made it for me to write this research.

Iwould like to express my deep gratitude to Dr.**Hussein Ahmed Hassan**.

For his encouraging, supervision and guidance of this research.

My thanks go to staff technologist in Ibn-Alhaitham Diagnostic center and

Dar Alelj specialized hospital.

Finally, special thanks to my family and friends who were of great help during the whole study period.

Abstract

This is descriptive study and was conducted in three months during the period from September 2016, To December 2016 in Ibn Alhaitham Diagnostic center and DarAleljspecialized Hospital. This study carried out in a sample of 100 patients (44males and 56 females) who underwent to abdominal computed tomography examination fordifferent reason.

The objective of this study is to evaluate normal liver measurementsin Sudanese using computed tomography and correlated to age and gender. The study was The main results of this study were that the mean and standard deviationof all sample liver texture and measurementsfor mid hepticcraniocaudad, Maximum craniocaudad, maximum transverse and mid hepticantero posterior was found to be54.8 ±1.93 Hounsfield, 14.1±0.50, 15.1±0.54, 18.0 ±0.61, 14.2±0.50 centimeter respectively.

Themain results of this study were that themean andstandard deviation of male liver texture and measurement for mid hepticcraniocaudad, Maximum craniocaudad, maximum transverse and mid hepticantero posterior was found to be 54.8±1.93 Hounsfield, 14.1± 0.54, 15.2 ±0.56, 18.0 ±0.62 and 14.2 ±0.52 centimeter respectively. And female liver texture and measurements for mid hepticcraniocaudad, maximum craniocaudad, maximum transverse dimension ,mid hepticantero posterior was found to be 54.8 ±1.93 Hounsfield , 14.1± 0.51 ,15.2 ±0.54 , 18.1 ±0.60, 14.3 ±0.50 centimeter respectively.

The study concluded were that correlation between livertexture and measurements (mid-hepatic cranio-caudad,maximum cranio-caudad, maximum transverse dimension,mid-hepatic antero-posterior) decreasedwith age and this indicate that size of liver decreased with age.And also the study concludedno difference between males and females subjects at liver textureand measurements.The study recommendedfuture studies should be done use Positron Emission Tomography / Computed TomographyScan.

ملخص الدراسة

هذه الدراسة الوصفية قد اجريت هذه الدراسة في ثلاثة اشهر خلال الفترة من سبتمبر 2016 الي ديسمبر 2016 في مركز ابن الهيثم التشخيصي ومستشفي دار العلاج التخصصي.اجريت هذه الدراسة علي عينة من100 مريضا(44 ذكورا و56اناثا) الذين خضعوا لفحص الاشعة المقطعية للبطن للاسباب مختلفة.

الهدف من هذه الدراسة هو تقييم قياسات الكبد طبيعية في مختلف السوداني باستخدام التصوير المقطعي وربطها بالعمر والنوع.

اهم نتائج هذه الدراسة ان المتوسط والانحراف المعياريلنسيج وقياسات الكبد لكل العينات تشمل(متوسط الكبد علوي–سفلي، اقصي علوي–سفلي، الحد الاقصي العرضي،متوسط الكبد الامامي –الخلفي) وجدت 54.8 ±1.93 معامل التوهين الخطي ،14.1 ±0.50,15.1 ±0.54,18.0 ±0.64,14.2 ±0.50سمعلي التوالي.

اهم نتائج هذ الدراسة ان المتوسط والانحراف المعياري لنسيج وقياسات الكبد للذكور تشمل(متوسط الكبد علوي–سفلي، اقصي علوي–سفلي، الحد الاقصي العرضي،متوسط الكبد الامامي –الخلفي) وجدت 54.8 ±1.93معامل التوهين الخطي،14.1±0.54 ،15.2± 0.56 ،18.0± 0.62 ،14.2± 0.52 سم علي التوالي.

وبالنسبه للاناث ان نسيج وقياسات الكبدتشمل(متوسط الكبد علوي–سفلي، اقصي علوي–سفلي، الحد الاقصي العرضي،متوسط الكبد الامامي –الخلفي) وجدت 54.8± 1.93معامل التوهين الخطي، 14.1± 0.51,15.2± 0.54,18.1± 0.60,14.3± 0.50 سم علي التوالي.

خلصت الدراسة ان العلاقة بين نسيج وقياسات الكبد التي تشمل (متوسط الكبد علوي–سفلي،اقصي علوي–سفلي، الحد الاقصي العرضي، متوسط الكبد الامامي–الخلفي) تنخفض مع تقدم العمر وهذا يشير الي ان حجم الكبد ينخفض مع العمر.

وايضا خلصت الدراسة انه لا يوجد فرق بين الذكور والاناث علي نسيج وقياسات الكبد.

توصي الدراسة الدراسات القادمة يجب ان تعمل باستخدام التصوير المقطعي بالاصدار البوزيتروني/ التصوير المقطعي بالكمبيوتر.

List of tables

List of figure

2	Coronal CT image for female (65 years) show measurements of maximum craniocaudad.	
3	Axial CT image for male (29 years) show measurements of maximum transverse dimension.	
4	Axial CT image for male (65 years) show measurements of mid hepticantero posterior.	
5	Coronal CT image for male (60 years) show measurements of maximum craniocaudad.	

List of abbreviations

AP	Antero- posterior
CAT	Computed Axial Tomography
CL	Caudate Lobe
CRL-R	Caudate To Right Lobe Ratio
CT	Computed Tomography
CT VC	Computed Tomography Virtual colonoscopy
FLD	Fatty Liver Disease
IVC	Inferior Vena Cava
LT	Left
MRI	Magnetic Resonce Imaging
MCL	Midclavicular
MHP CC	Mid-hepatic Craniocaudad
Max CC	Maximum Craniocaudad
MHP AP	Mid-hepatic Antero-posterior
NAFLD	Non Alcoholic Fatty Liver Disease
NPO	Nothing by mouth
PET	Positron Emission Tomography
SPECT	Single Photon Emission Computed Tomography
US	Ultra Sound

Content

Chapter One

Introduction

Chapter one

1.1 Introduction:

Midpoint of IVC should be taken as standard reference point to measure thetransverse width of CL for finding CL/RL ratio, for diagnosing conditions of liver.The study showed that the caudate lobe measurements (right to left Diameterantero-posterior Diameter, caudate to right lobe ratio) and the right lobe diameterincreased with age and this indicate that the size of liver and caudate lobe increased as the age increased**.**(Abd Elhady.2016).

The liver is largest organ in human body. During development liver size increase with age, averaging 5 cm span at 5 year and attaining adult size by age 25.the size depend on several factors: age,sex,body size and shape as well as the particular examination technique utilized(e.g. palpation versus percussion versus radiographic).(Wolf. 1990).

Estimation of liver size can be used as an index to monitor various aspects of liver disease and response to treatment, Serial magnetic resonance imaging (MRI) may be used to monitor patient treatment and determine management .Mid-clavicular (MCL), cranio-caudad (CC), or Mid-hepatic (MHP) CC measurements have been used in ultrasound (US) to estimate liver size, These methods have been extrapolated to advanced imaging modalities, including computed Tomography (CT) and MRI. (Vermaet al.2010).

Liver attenuation values inverse relation with age in adults and apositive association between liver volume andage in children, no such significant relationship between volume and age emerged in adults. (Meier et al 2007).

1.2 Problem of the study:

The variation in the anthropometric feature of various population races , regions of the zoneand also the liver size usually affected by the body characteristic including length,weight,age so that might lead to wrong diagnosis therefore is need to putnew index for liver size.

1.3OBJECTIVE:

1.3.1 General Objective:

-To measurement of liver among Sudanese adults using computed tomography.

1.3.2 SPECIFIC Objective:

-To evaluate texture of normal liver.

-To measure Mid-hepatic point cranio-caudad.

-To measure Maximumcranio-caudad to liver tip.

-To measure Maximum transverse dimension of the liver.

-To measure Mid-hepatic pointantero-posterior dimension of the liver.

-To correlate liver measurements and texturewith age.

-To compare liver measurements and texture with gender.

1.4 Significant of the study:

This study provides good information about Sudanese liver measurement and it used as guide line to proper Sudanese index.

1.5 Overview of study:

Chapter one – introduction and objectives of the study.

Chapter two – literature review and background studies.

Chapter three – Materials and Methods.

Chapter four –Results.

Chapter five – Discussion, Conclusion and Recommendation.

References and Appendixes.

Chapter Two

Literature reviews and Background studies

Chapter Two
Background

2.1 Anatomy:

The liver is a large, complex organ with numerous functionsthat include metabolic regulation, hematologic regulation, andbile production. It is the largest organ of the abdomen, occupyinga major portion of the right hypochondriac and epigastricregions, sometimes extending into the left hypochondriac andumbilical regions. The liver is bordered superiorly, laterally,and anteriorly by the right hemidiaphragm (Lorrie, 2007).

The medial surface is bordered by the stomach, duodenum,and transverse colon; the inferior surface is borderedby the hepatic flexure of the colon; and the posterior surfaceis bordered by the right kidney. The liver issurrounded by a strong connective tissue capsule (Glisson'scapsule) that gives shape and stability to the soft hepatictissue. It is also entirely covered by peritoneum except forthe gallbladder fossa, the surface opposed to the inferior venacava (IVC), and the bare area (liver surface between thesuperior and inferior coronary ligaments),Within the liver there are several main grooves or fissuresthat are useful in defining the lobes and boundaries of thehepatic segments. (Lorrie,2007).

The umbilical fissure (fissure for ligamentumteres) divides the left hepatic lobe into medial andlateral segments. The fissure for the ligamentumvenosumseparates the caudate lobe from the left lobe, and the trans-verse fissure (portal) contains the horizontal portions of theright and left portal veins. The inter-lobar fissure (main lobarfissure), also called the fissure for the gallbladder, divides theright from left lobes of the liver .The hilum ofthe liver, the porta

Hepatis, is located on the inferomedialborder of the liver. It is the central location for vessels to enterand exit the liver. (Lorrie, 2007).

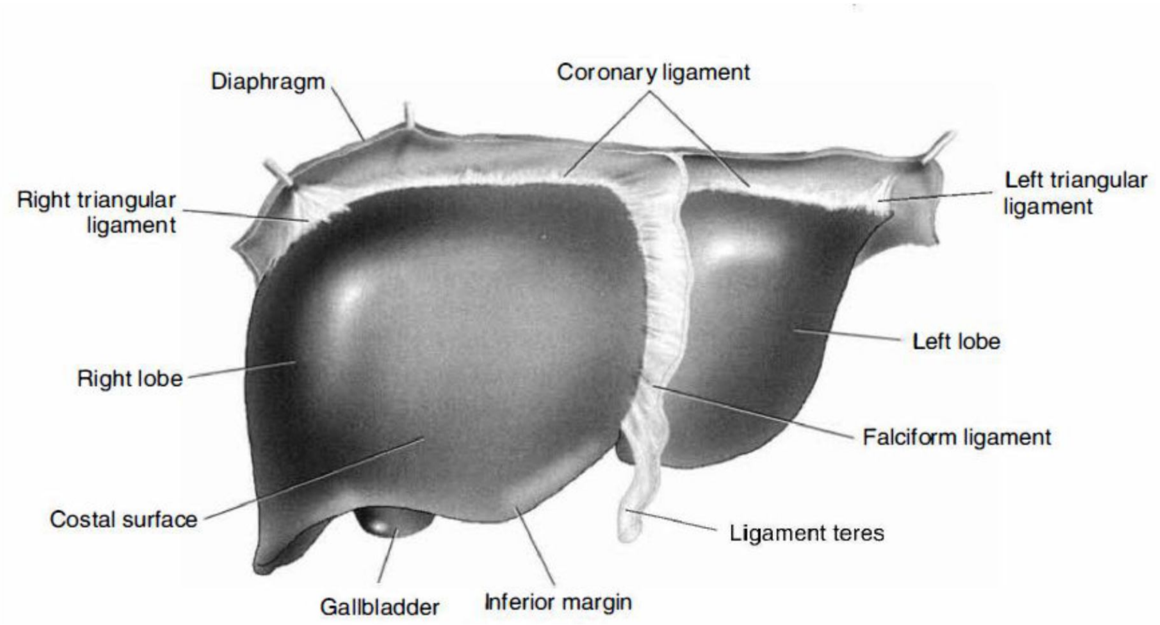


Figure 2.1: The Anterior view of the liver(Lorrie, 2007).

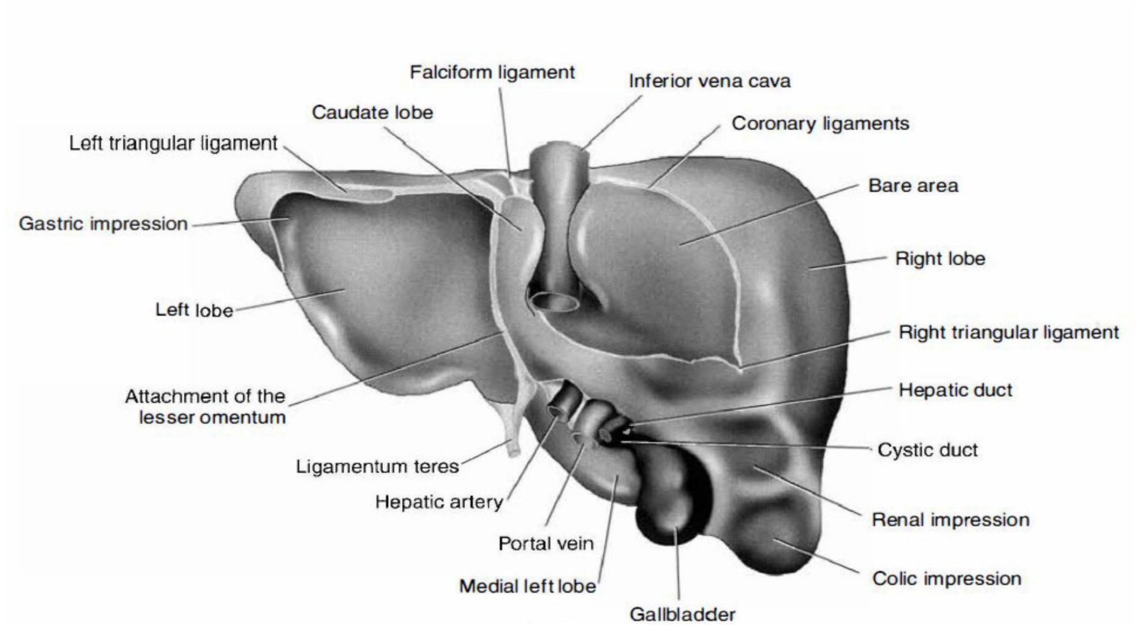


Figure 2.2: The posterior view of the liver(Lorrie, 2007).

2.1.1 Surface Anatomy

The liver can be divided into lobes according to surface anatomyor into segments according to vascular supply. The four lobescommonly used for reference based on surface anatomy are theleft, right, caudate, and quadrate. The left lobe is the mostanterior of the liver lobes, extending across the midline. It isseparated from the right lobe by the interlobar fissure, animaginary line drawn through the gallbladder fossa and themiddle hepatic vein to the inferior vena cava. (Lorrie, 2007).

The smallest lobeis the caudate lobe, which is located on the inferior andposterior liver surface, sandwiched between the lVC and theligamentumvenosum. The quadrate lobe is located on theanteroinferior surface of the left lobe between the gallbladderand the ligamentumteres. The round, cordlike, ligamentumteres is a remnant of the fetal umbilical vein and runs alongthe free edge of the falciform ligament. The falciform ligamentprovides the structural support that attaches the uppersurfaces of the liver to the diaphragm and upper abdominalwall. (Lorrie, 2007).

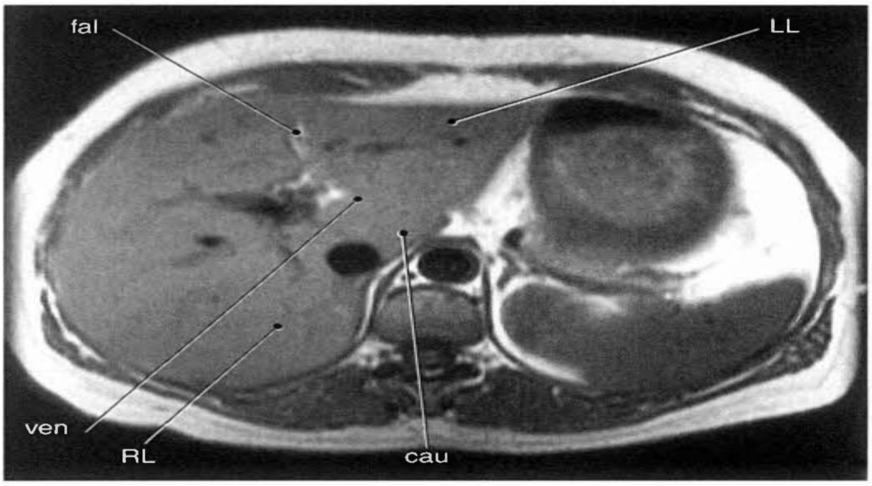


Figure 2.3: Axial, Tl-weighted MR scan of abdomen with lobes of liver (Lorrie, 2007).

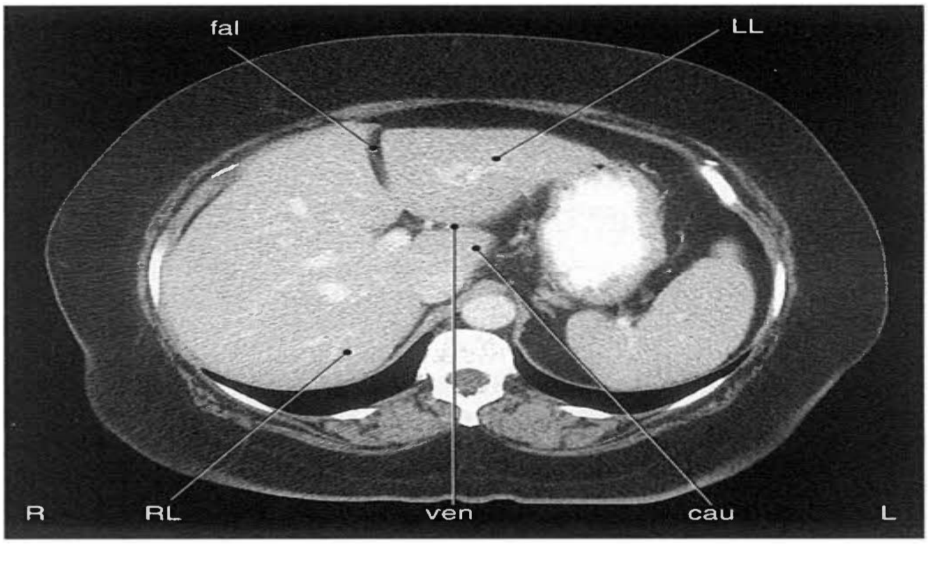


Figure 2.4 Axial CT scan of abdomen with lobes of liver(Lorrie, 2007).

2.1.2 Segmental anatomy:

Current practice favors dividing the liver into eight segments, according to itsvascular supply, which can aid in surgical resection. According to the Frenchanatomist Couinaud, the liver can be divided into segments based on the branchingof the portal and hepatic veins. The three main hepatic veins divide the liverlongitudinally into four sections.(Lorrie, 2007).

The middle hepatic vein divides the liver into right and left lobes. The right lobe isdivided into medial and lateral sectors by the right hepatic vein, and the left lobe isdivided into medial and lateral sectors by the left hepatic vein. Each section is thensubdivided transversely by the right and left portal veins, creating nine segmentsnumbered counterclockwise from the IVC. Each segment can be consideredfunctionally independent with its own hepatic artery, portal vein, and bile duct anddrained by a branch of the hepatic vein (Lorrie, 2007).

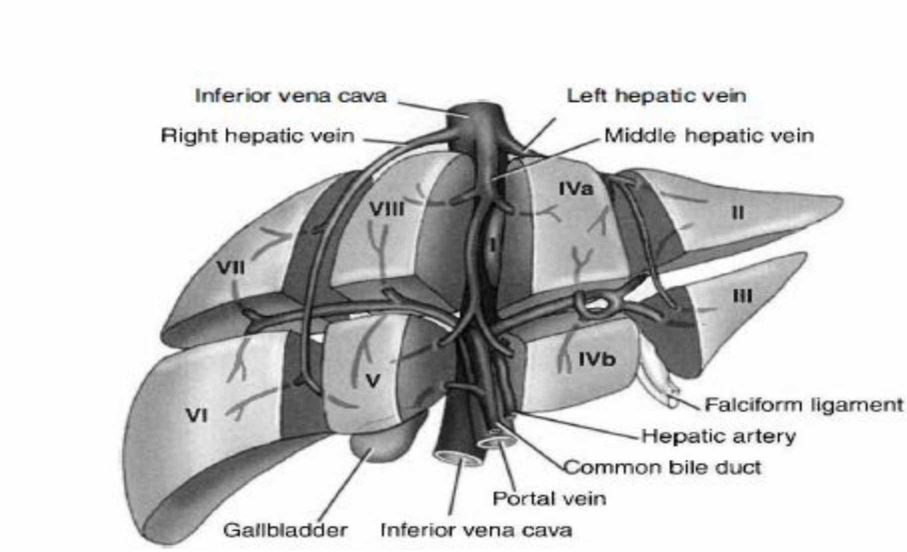


Figure 2.5: Anterior view of segmentation of liver(Lorrie, 2007).

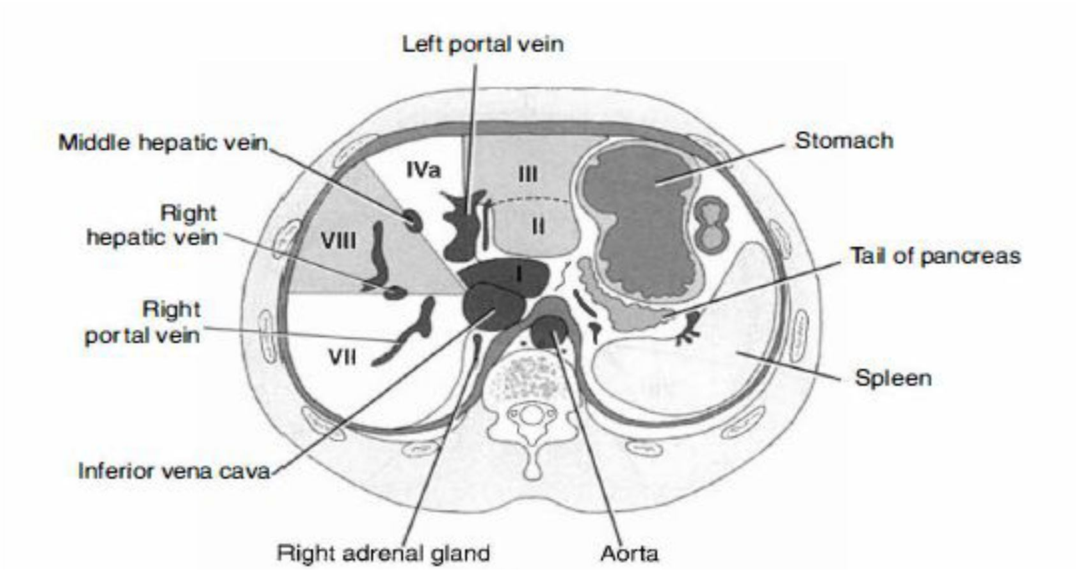


Figure 2.6: Axial view of liver segments(Lorrie, 2007).

2.1.3Portal Hepatic System

The liver receives nutrient-rich blood from the gastrointestinaltract via the portal hepatic system. The major vessel of this system is the portal vein, which isformed in the retroperitoneum by the union of the superiormesenteric and splenic veins, posterior to the neck of thepancreas .It passes obliquely to theright, posterior to the hepatic artery within the lesser omentum,and enters the liver at the portahepatis. (Lorrie, 2007).

At the portahepatis,the portal vein branches into right and left main portal veinsthat then follow the course of the right and left hepatic arteries. The right portal vein first sendsbranches to the caudate lobe, then divides into anterior andposterior branches that subdivide into superior and inferiorbranches to supply the right lobe of the liver. The left portalvein initially courses to the left, then turns medially toward theligamentumteres. It branches to supply the lateral segments(segments II and III) of the left lobe and the superior andinferior segmental branches of segment IV. (Lorrie, 2007).

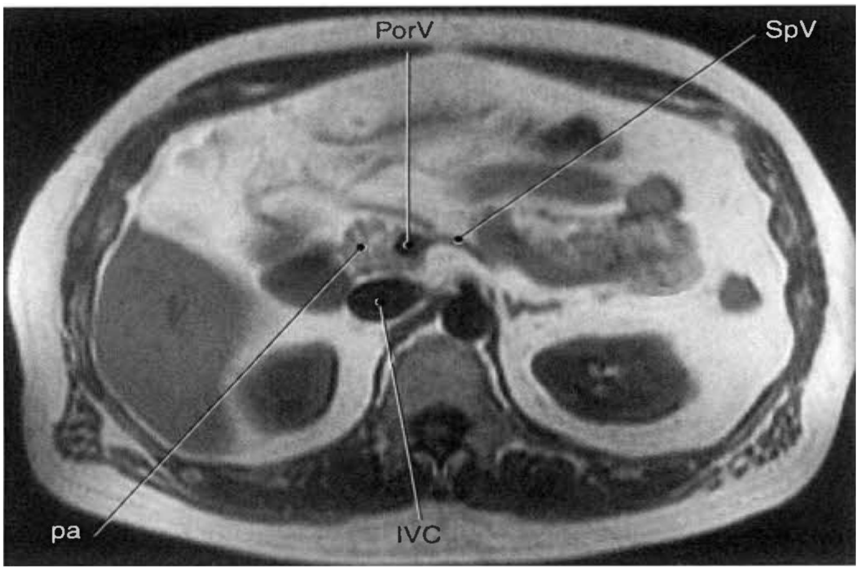


Figure 2.7 Axial, Tl-weighted MR scan of abdomen with portal and splenicveins.

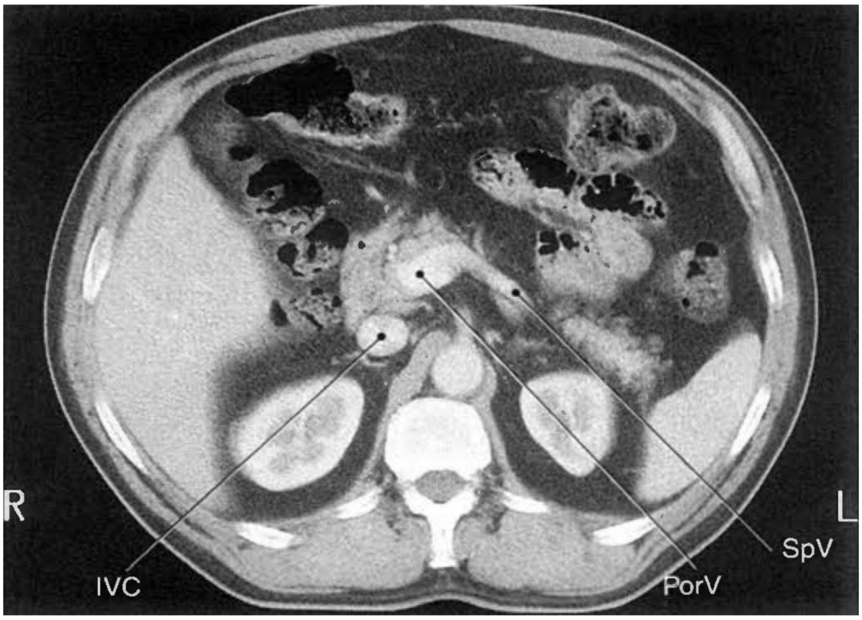


Figure 2.8 Axial CT scan of abdomen with portal and splenic veins. (Lorrie, 2007).

2.1.4Vasculature

The liver is unusual in that it has a dual blood supply, receiving arterial blood (20%-25%) from the common hepatic artery and nutrient-rich venous blood (75%-80%) from the portal vein. The common hepatic artery usually arises as one of the three branches off the celiac artery, coursing to the right to enter the lesser omentum anterior to the portal vein .It branches into the right gastric and gastro duodenalarteries just above the duodenum and continues in the hepatoduodenal ligament as the proper hepatic artery.While within or just before entering the portahepatis, the proper hepatic artery divides into left and right hepatic arteries that continue to branch and supply the lobes of the liver.(Lorrie, 2007).

The right hepatic artery is larger than the left and supplies the majority of the right lobe of the liver. It passes posterior to the uncinate process of the pancreas and runs along the posterior wall of the bile duct into the right hepatic lobe. The lefthepatic artery is located between the lesser curvatures of the stomach and approaches the liver in the lesser omentum and branches to supply the caudate, quadrate, and medial and lateral segments of the left lobe of the liver. The venous drainage of the liver occurs via the small interlobar and intersegmental hepatic vessels that merge into the three major hepatic veins, emptying directly into the IVC, just below the diaphragm.(Lorrie, 2007).

The right hepatic vein, the largest, lies between the right anterior and posterior hepatic segments, drains segments V, VI, and VII, and enters the IVC at the right lateral aspect. The middle hepatic vein lies in the interlobar fissure, drains segments IV, V, and VIII, then enters the IVC at the anterior or right anterior surface. The smallest hepatic vein, the left hepatic vein, courses between the medial and lateral segments of the left lobe, drains segments II and III, then enters

The left anterior surface of the IVC .Frequently, the middle and left hepatic veins converge to form a common trunk before emptying into the lVC just below the

diaphragm. The IVC lies in a groove along the posterior wall of the liver and ascends into the thoracic cavity through the caval hiatus of the diaphragm and enters the right atrium of the heart.(Lorrie, 2007).

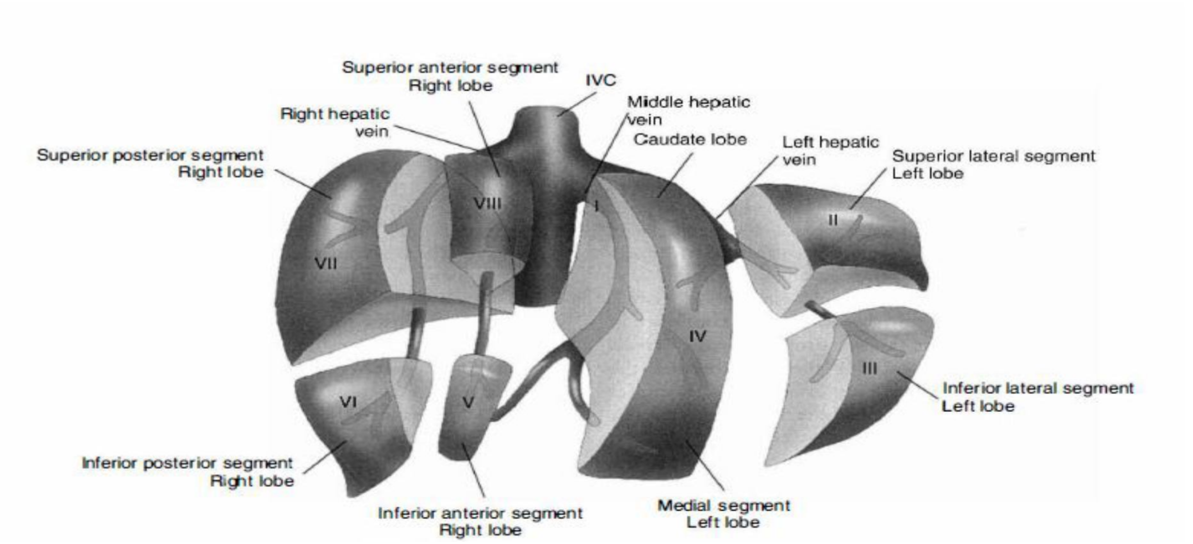


Figure 2.9: Couinaud's segmentation of the liver with hepatic veins.(Lorrie, 2007).

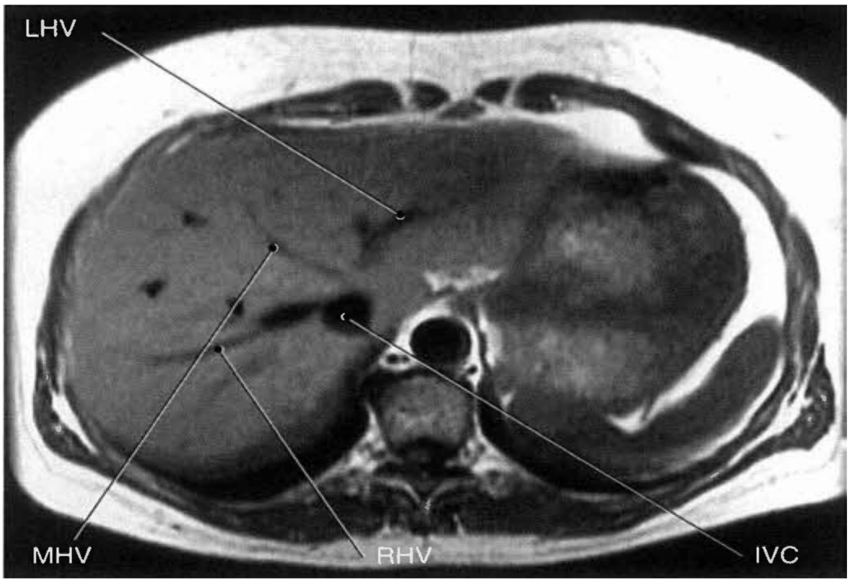


Figure 2.10 Axial, Tl-weighted MR scan of abdomen with hepatic veins(Lorrie, 2007).

2.2 Physiology:

The bile produced in the liver is collected in bile canaliculi, which merge from bile ducts. These eventually drain into the right and left hepatic ducts, which in turn merge to form the common hepatic duct. The cystic duct (from the gallbladder) joins with the common hepatic duct to form the common bile duct. (Wiki/Human_Physiology 2016).

Bile can either drain directly into the duodenum via the common bile duct or be temporarily stored in the gallbladder via the cystic duct. The common bile duct and the pancreatic duct enter the duodenum together at the ampulla of Vater. The branching of the bile ducts resemble those of a tree, and indeed term "biliary tree" is commonly used in this setting. The liver is among the few internal human organs capable of natural regeneration of lost tissue: as little as 25% of remaining livercan regenerate into a whole liver again. This is predominantly due to hepatocytes acting as unipotential stem cells. There is also some evidence of bio potential stem cells, called oval cell, which can differentiate into either hepatocytes or cholangiocytes (cells that line bile ducts). The various functions of the liver are carried out by the liver cells or hepatocytes.The liver produces and excretes bile requires for dissolving fats. Some of the biledrains directly into the duodenum, and some is stored in the gallbladder.(Wiki/Human_Physiology 2016).

The liver performs several roles in carbohydrate metabolism such asgluconeogenesis (the formation of glucose from certain amino acids, lactate orglycerol), Glycogenolysis (the formation of glucose from glycogen), Glycogenesis(the formation of glycogen from glucose) and the breakdown of insulin and other

Hormones. The liver is responsible for the mainstay of protein metabolism. Theliver also performs several roles in lipid metabolism: cholesterol synthesis**,** theproduction of triglycerides (fats)**.**

The liver produces coagulation factors I (fibrinogen), II (prothrombin), V, VII, IX,X and XI, as well as protein C, Protein S and antithrombin.The liver breaks downhemoglobin, creating metabolites that are added to bile as pigment and also breaksdown toxic substances and most medicinal products in a process called drugmetabolism. This sometimes results in toxication, when the metabolite is moretoxic than its precursor. The liver converts ammonia to urea and stores a multitudeof substances, including glucose in the form of glycogen, vitamin B12, iron, andcopper. The liver is responsible for immunological affects the reticuloendothelialsystem if the liver contains many immunologically active cells, acting as a 'sieve'for antigens carried to it via the portal system. (Wiki/Human_Physiology 2016).

2.3 Pathology:

Alcohol is a known toxin, which, when metabolized by the liver, causes cellular Damage, alcohol abuse has long been associated with liver disease. Alcohol cannot.

Be stored in the human body, and therefore, the liver must convert it, throughOxidation, to alcohol dehydrogenase, acetaldehyde, and acetate, all of which Reduce cellular function. This leads to interference with carbohydrate and lipid Metabolism. Oxidation also results in reduced gluconeogenesis and increased fatty Acid synthesis associated with alcohol metabolism. Chronic alcohol abuse often Leads to fatty liver followed by hepatitis, cirrhosis, hepatocellular carcinoma, or all of these diseases. (Kowalczyk, 2014).

Fatty liver is the most frequent early response to alcohol abuse. Changes in liver Function result in a buildup of lipids such as triglycerides, which are deposited in the liver cells. This condition is usually asymptomatic; however, patients may Havehepatomegaly. Fatty infiltration may be demonstrated by using CT or Solography,but CT is currently the examination of choice. CT demonstrates the Fatty depositsas hypo dense. (Kowalczyk, 2014).

Factors other than alcohol abuse may also lead to fatty infiltrates within the liver.
Obese individuals with type 2 diabetes mellitus, metabolic syndrome, hyper-Lipidemia, or all of these diseases are at an increased risk of developing Nonalcoholic fatty liver disease (NAFLD). This pathology develops as lipids Accumulate within the hepatocytes forming free radicals. At some point, the liverCannot rid itself of the excessivetriglycerides. This results in an excess of fattyAcids within the liver, which leads to fatty infiltration of the liver, termed steatosis, and fatty liver disease. In the early stages, NAFLD is oftenasymptomatic, andDiagnosis requires biopsy of liver tissue. Although the disease progresses slowly, itMay advance to cirrhosis of the liver if left untreated. Management includesImplemntation of weight loss programs and exercise programs as treatment forInsulin resistance and associated metabolic disturbances. (Kowalczyk, 2014).
Cirrhosis is a chronic liver condition in which the liver parenchyma andArchitecture are destroyed, fibrous tissue is laid down, and regenerative nodules
Areformed. In its early stages, it is usually asymptomatic, as it may take months orEven years before damage becomes apparent. Cirrhosis affects the entire liver andIs considered an end-stage condition resulting from liver damage caused by Chronicalcohol abuse, drugs, autoimmune disorders, metabolic and genetic Disease,chronic hepatitis, cardiac problems, and chronic biliary tract obstruction.(Kowalczyk, 2014).
Ascites is the accumulation of fluid within the peritoneal cavity is also seen as a Result of portal hypertension and the leakage of excessive fluids from the portal Capillaries. Much of this excess fluid is composed of hepatic lymph weeping fromthe liver surface. It is associated with approximately 50% of deaths from cirrhosis. Ascites may also result from chronic hepatitis, congestive heart failure, renal Failure, and certain cancers. (Kowalczyk, 2014).

A hemangioma is the most common tumor of the liver. It is a benign neoplasm Composed of newly formed blood vessels, and these neoplasms may form in other Places within the body. For instance, a port-wine stain on the face (a superficialPurplish red birthmark) is an example of a hemangioma elsewhere in the body. Hemangiomas are generally well-circumscribed, solitary tumors. They may range in size from microscopic to 20 cm. They are more common in women than in men,Especially in postmenopausal women. (Kowalczyk, 2014).

Hepatocellular carcinoma, a primary neoplasm of the liver. An association between Cirrhosis and hepatocellular carcinoma exists, with chronic hepatitis B or C and Alcoholism associated with each. Thus, the incidence of this neoplasm is on the rise Because of an increase in chronic hepatitis B and C infections in the United States.

Most primary hematomas originate in the liver parenchyma, creating a large central Mass with smaller satellite nodules. Although vascular invasion is common, death Occurs from liver failure, often without extension of the Cancer outside the liver. Hepatocellular carcinoma is suspected in patients with cirrhosis who experience an Unexpected deterioration and in patients with increased jaundice, abdominal pain, Weight loss, ascites, or a rapid increase in liver size. Plain abdominal radiographs May demonstrate hepatomegaly. (Kowalczyk, 2014).

2.4 CT machine:

CT scanners are complex, with many different components involved in the Process of creating an image. Adding to the complexity, different CT Manufacturers often modify the design of various components. From a Broad perspective, all makes and models of CT scanners are similar in that they consist of a scanning gantry, x-ray generator, computer system,operator's console, and physician's viewing console. Although hard-copyfilming has largely been replaced by workstation viewing and electronicarchiving, most CT systems still include a laser printer for transferring CTimages to film. (Lois, 2011).

The computer is a unique subsystem of the CT imaging system.X-ray tubes produce the x-ray photons that create the CT image. Theirdesign is a modification of a standard rotating anode tube, such as the typeused in angiography. Tungsten, with an atomic number of 74, is often usedfor the anode target material because it produces a higher-intensity x-raybeam. CT tubes often contain more than one size of focal spot; 0.5 and 1.0mm are common sizes. Early CT scanners used recoiling system cables torotate the gantry frame. Current systems use electromechanical devicescalled slip rings. Slip rings use a brush like. Apparatus to provide continuous electrical power and electroniccommunication across a rotating surface. They permit the gantry frame torotate continuously, eliminating the need to straighten twisted systemcables. (Lois, 2011).

As the x-ray beam passes through the patient it is attenuated to somedegree. To create an x-ray image we must collect information regardingthe degree to which each anatomic structure attenuated the beam. In CT,detectors used to collect the information. The detector array comprisesdetector elements situated in an arc or a ring, each of which measures theintensity of transmitted x-ray radiation along a beam projected from the x-raysource to that particular detector element. Detectors can be made fromdifferent substances, each with their own advantages and disadvantages.All new scanners possess detectors of the solid-state crystal variety.Detectors made from xenon gas have been manufactured but have largelybecome obsolete as their design prevents them from use in MDCTsystems. (Lois, 2011)

High-frequency generators are currently used in CT. They are smallenough so that they can be located within the gantry. Generators producehigh voltage and transmit it to the x-ray tube. CT generators produce highkV (generally 120–140 kV) to increase the intensity of the beam, whichwill increase the penetrating ability of the x-ray beam and thereby reducepatient dose. In addition, a higher kV setting will help to reduce the heatload on the x-ray tube by allowing a lower MA setting. Reducing the heatload on the x-ray tube will extend the life of the tube. **(**Lois, 2011).

The patient lies on the table (or couch, as it is referred to by somemanufacturers) and is moved within the gantry for scanning. The processof moving the table by a specified measure is most commonly calledincrementation, but is also referred to as feed, step, or index. Helical CTtable incrementation is quantified in millimeters per second because thetable continues to move throughout the scan. The degree to which a tablecan move horizontally is called the scan able range, and will determinethe extent a patient can be scanned without repositioning. Thespecifications of tables vary, but all have certain weight restrictions. Onmost scanners, it is possible to place the patient either head first or feetfirst, supine or prone. Patient position within the gantry depends on theexamination being performed. **(**Lois, 2011)

2.5 Previous studies:

The study was done by**Douglas C. Wolf** Evaluation of the Size, Shape, and Consistency of the Liver. The liver is the largest organ in the human body. During development, liver size increases with increasing age, averaging 5 cm span at 5 years and attaining adult size by age 15. The size depends on several factors: age, sex, body size and shape, as well as the particular examination technique utilized (e.g., palpation versus percussion versus radiographic). By percussion, the mean liver size is 7 cm for women and 10.5 cm for men .A liver span 2 to 3 cm larger or smallerthan these values is considered abnormal. The liver weighs 1200 to 1400 g in the adult woman and 1400 to 1500 g in the adult man.

Another study done by**Sachit K et al**the present study validates single hepatic measurements; MHP CC, Max CC andMHP AP dimensions and their products as good indicators of hepatic size and a reliable methodof comparing liver size on serial studies. Both CC measurements had similar correlation withhepatic volume. Max CC measurement of liver size to liver tip and MHP CC hepatic dimensionsare easy and practical measurement methods for routine use.

Another study done by **AbdElhady**showedMidpoint of IVC should be taken as standard reference point to measure thetransverse width of CL for finding CL/RL ratio, for diagnosing conditions of liver.The study showed that the caudate lobe measurements (right to left Diameteranteroposterior Diameter, caudate to right lobe ratio) and the right lobe diameterincreased with age and this indicate that the size of liver and caudate lobeincreased as the age increased.Also the study showed that the texture of caudate lobe increased with age.

Also other study done by **JM Meier et al** found significant inverse relationship betweenliver attenuationand age in adult and a positive association between liver volume and age in children, no such significant relationship between volume and age emerged in adults.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Study design:

Descriptive study.

3.1.2 Study area:

Sudanese population.

3.1.3 Study place:

Ibn-Alhaitham Diagnostic center and Dar-Aleljspecialized hospital.

3.1.4 Study Duration:

From 1/9/2016 -1/12/2016.

3.1.5 Inclusion criteria:

Normal patients.

3.1.6 Exclusion criteria:

Disease patients.

3.1.7 Equipments:

Figure 3.1: Toshiba sensation 4 slices in Ibn-Alhaitham Diagnostic center

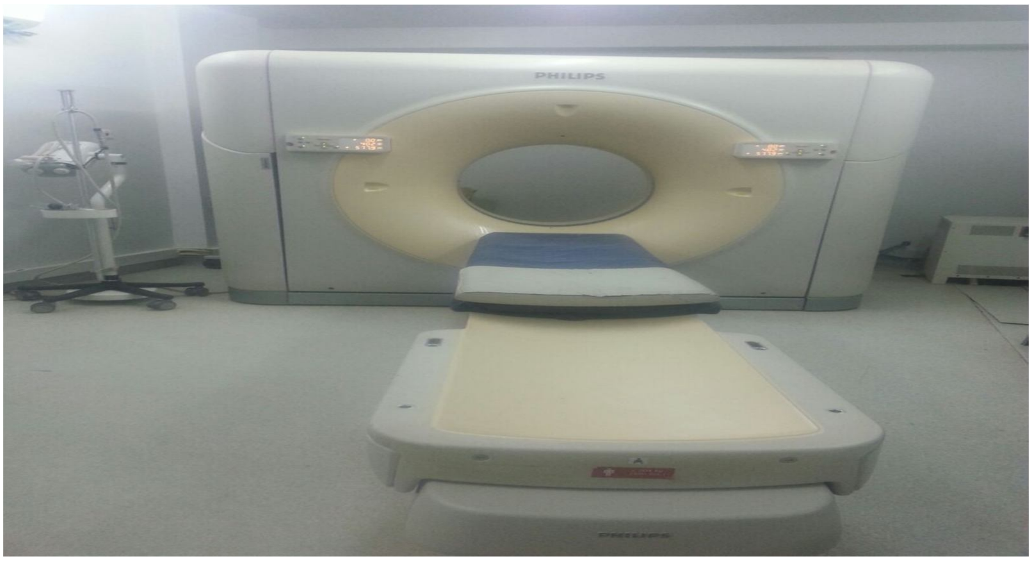


Figure 3.2: Philips 64 slices in DarAlelj specialized hospital.

3.2 Methods

3.2.1 Technique used:

The patient should be NPO from midnight until the time of the examination. Foodand fluids should be withheld for at least 8 hours prior to exam.

Oral contrast: 400 ml 45 minute before scan,200 ml just before scan.

Patient is supine position (feet first),Land mark: xiphoid tip.

Scout: AP, Pre contrast scans.

IVcontrast: 4-5 ml/sec, 100-150 ml.

Protocol used liver triphase: Arterialphase,portalphase, Delayed phase.

Slicethickness:4-5mm.

Breathe hold: Suspended expiration.

3.2.2 Image interpretation and measurements:

All CT image were studied for the study group sample, to measure liver and to evaluate liver texture. The data analysis statistically using SPSS.

Midhepatic point craniocaudad (MHP CC):

Perpendicular measurement on the coronal images from the hepatic dome to the inferior margin of the liver passing through the mid-hepaticpoint.

Maximum CC to liver tip (Max CC):

Greatest obtainable craniocaudad dimension of theliver from the hepatic dome to the liver tip on coronal or sagittal reconstructed images.

Maximum transverse dimension:

The maximum measurement from the right to left marginsof the liver at the level of the portal vein.

MHP APmeasurement:

The MHP was defined as half way between the mid vertebra and right lateral margin of the liver at the level of main portal vein on a transverse section.

This measurement taken at the levelof the midhepatic point from anterior to posterior margin of the liver.

Chapter Four

Results

Chapter four

Results

The following tables and figures represent data obtained from randomly selectedsample of patients (44 males and 56 females) who underwent CT abdomen for differentindications.

Table 4.1: The distributionof sample according to gender.

Gender	Frequency	Percentage %
Male	44	44%
Female	56	56%
Total	100	100%

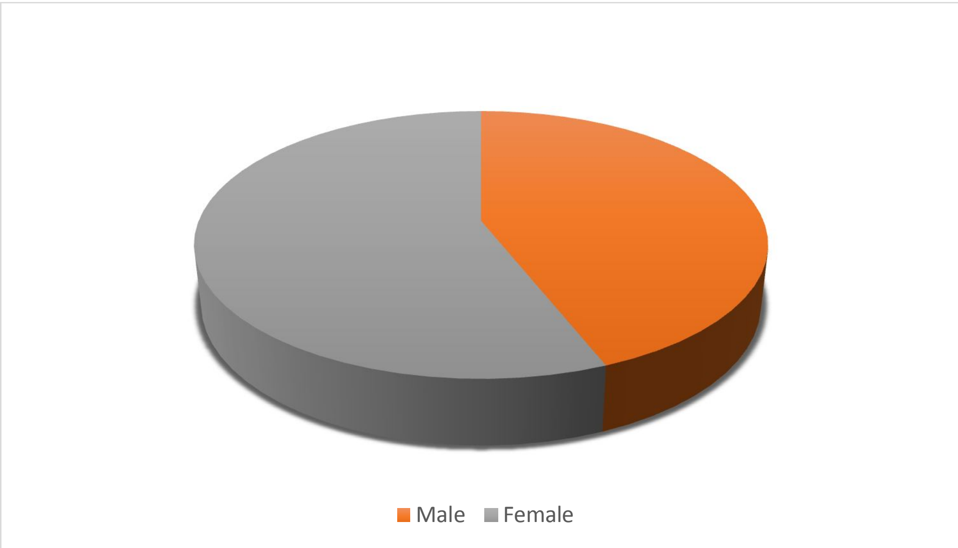
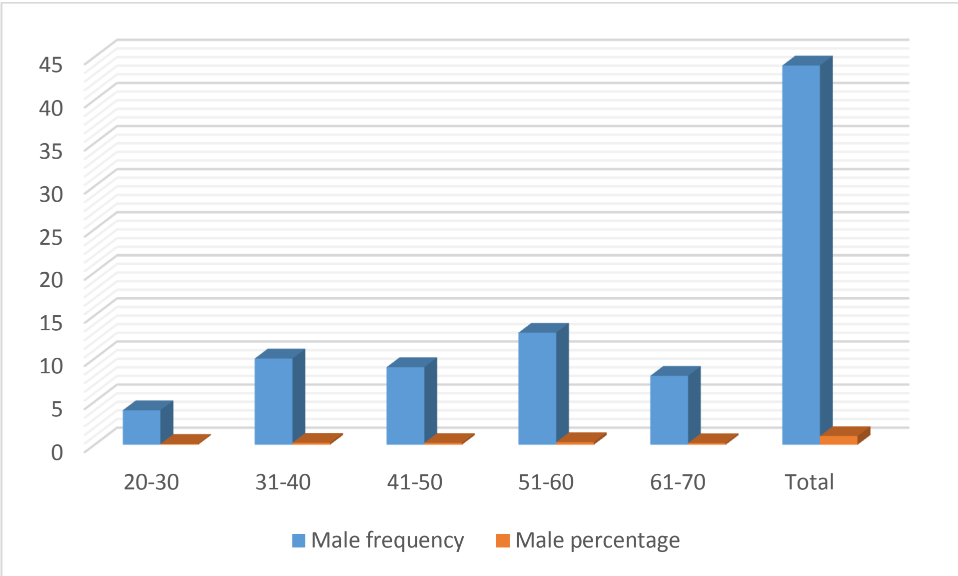


Figure 4.1: The distributionof sample according to gender.

Table 4.2: Thedistribution of Male in the study group age**.**

Age class	**Male frequency**	**Male percentage%**
20-30	4	9.09%
31-40	10	22.7%
41-50	9	20.5%
51-60	13	29.5%
61-70	8	18.2%
Total	44	100%



Figures 4.2: Show the distribution of male in the study group age.

Table 4.3: The distribution of female in the study group age**.**

Age class	Female frequency	Female percentage%
20-30	10	17.9%
31-40	5	8.9%
41-50	16	28.6%
51-60	16	28.6%
61-70	9	16%
Total	56	100%

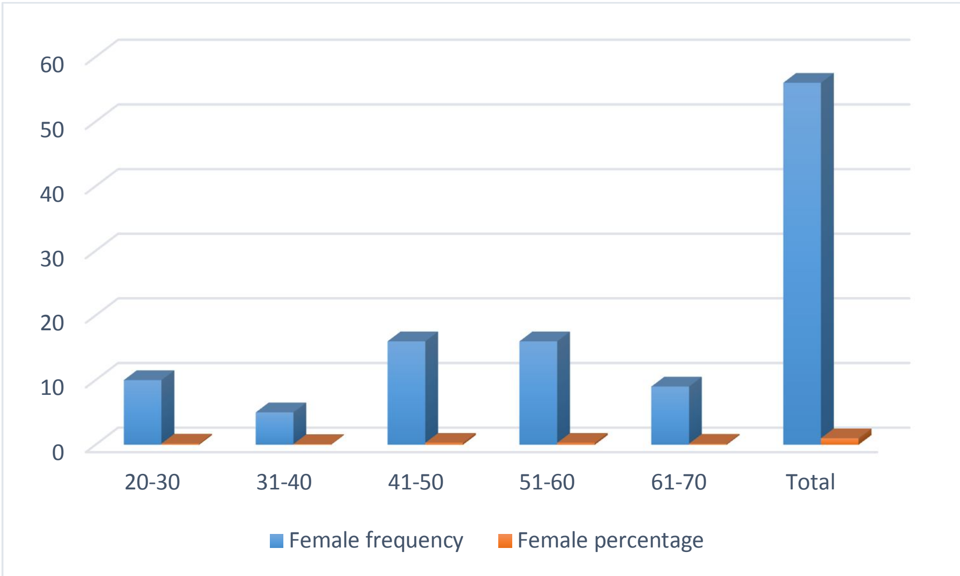


Figure 4.3: The distribution of female in the study group age**.**

Table4.4: Mean of study group age.

Gender	Mean
Male	47
Female	46

Table 4.5: Male liver measurements and texture (minimum, maximum, mean, standard deviation).

	N	Minimum	Maximum	Mean	Std. Deviation
Mid-hepatic craniocaudad	44	13.1	14.9	14.141	.4938
Maximum craniocaudad	44	14.1	16.0	15.175	.5657
Maximum transverse dimension	44	16.8	18.8	18.016	.6235
Midhepatic anteroposterior	44	13.5	14.9	14.261	.5217
Texture(HU)	44	50	58	54.84	2.045

Table 4.6: Femaleliver measurements and texture (minimum, maximum, mean, standard deviation).

	N	Minimum	Maximum	Mean	Std. Deviation
Mid-hepatic craniocaudad	56	13.2	14.9	14.138	.5158
Maximum craniocaudad	56	14.1	16.0	15.209	.5435
Maximum transverse dimension	56	16.8	18.9	18.066	.6094
Midhepatic anteroposterior	56	13.2	15.1	14.320	.5043
Texture(HU)	56	51	59	54.84	1.866

Table 4.7: liver Measurements and texturefor all samples (minimum, maximum, mean and standard deviation).

	N	Minimum	Maximum	Mean	Std. Deviation
Mid-hepatic point craniocaudad	100	13.1	14.9	14.059	.5055
Maximum craniocaudad	100	14.1	16.0	15.188	.5474
Maximum transverse dimension	100	16.8	18.9	18.028	.6192
Midhepticanteroposterior	100	13.2	15.1	14.284	.5081
Texture(HU)	100	50	59	54.84	1.937

Table 4.8: Show correlation between age and texture of liver.

		Age	Texture(HU)
Age	Pearson Correlation	1	-.788**
	Sig. (2-tailed)		.000
	N	100	100
Texture(HU)	Pearson Correlation	-.788**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4.4: Scatter plot diagram shows the linearrelationbetween the age and the texture, as age increase the liver texture decreased by 0.1.

Table4.9:show correlation between age and mid hepticraniocaudad.

		Age	Midhepatic point craniocaudad
Age	Pearson Correlation	1	-.803**
	Sig. (2-tailed)		.000
	N	100	100
Mid hepatic poincraniocaudad	Pearson Correlation	-.803**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

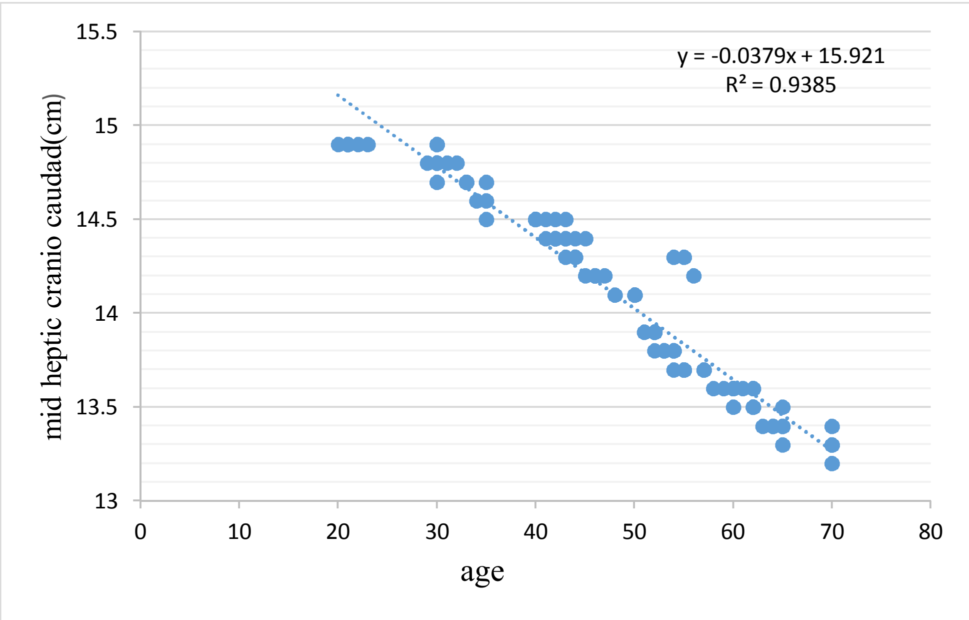


Figure 4.5: Scatter plot diagram shows the linearrelation between the age and mid-hepatic pointcranio-caudad, as age increased the mid-hepatic cranio-caudad decreased by 0.03.

Table 4.10: show correlation between age and maximum craniocaudad.

		Age	Maximum craniocaudad
Age	Pearson Correlation	1	-.671**
	Sig. (2-tailed)		.000
	N	100	100
Maximum craniocaudad	Pearson Correlation	-.671**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

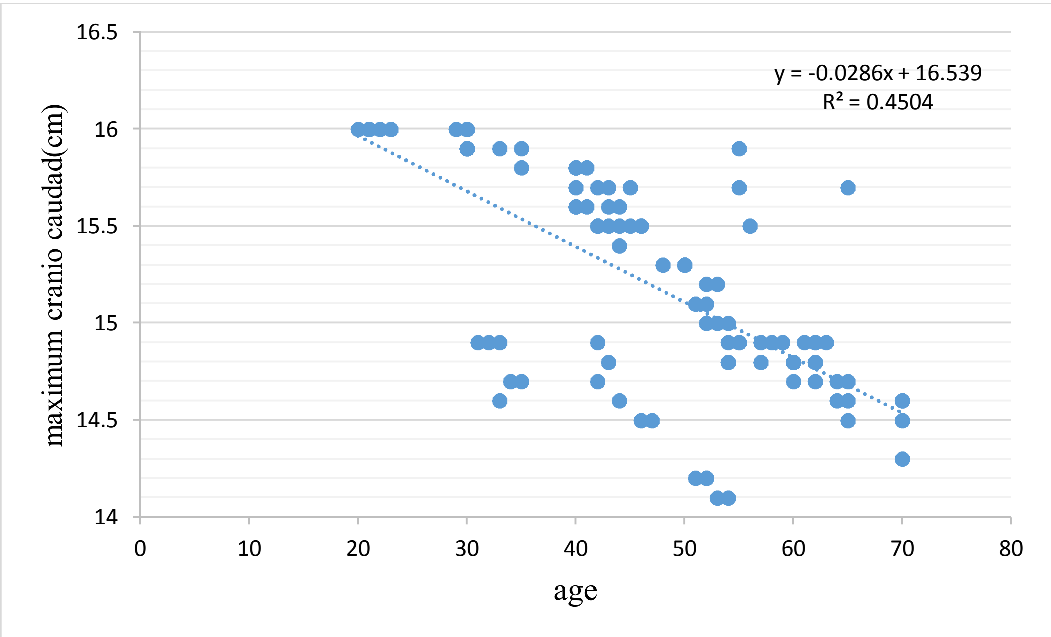


Figure 4.6: Scatter plot diagram shows the linearrelation between the age and maximum craniocaudad**,** as age increase the maximumcraniocaudaddecreased by 0.02.

Table 4.11: show correlation between age and maximum transverse dimension.

		Age	Maximum transverse dimension
Age	Pearson Correlation	1	-.920**
	Sig. (2-tailed)		.000
	N	100	100
Maximum transverse dimension	Pearson Correlation	-.920**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

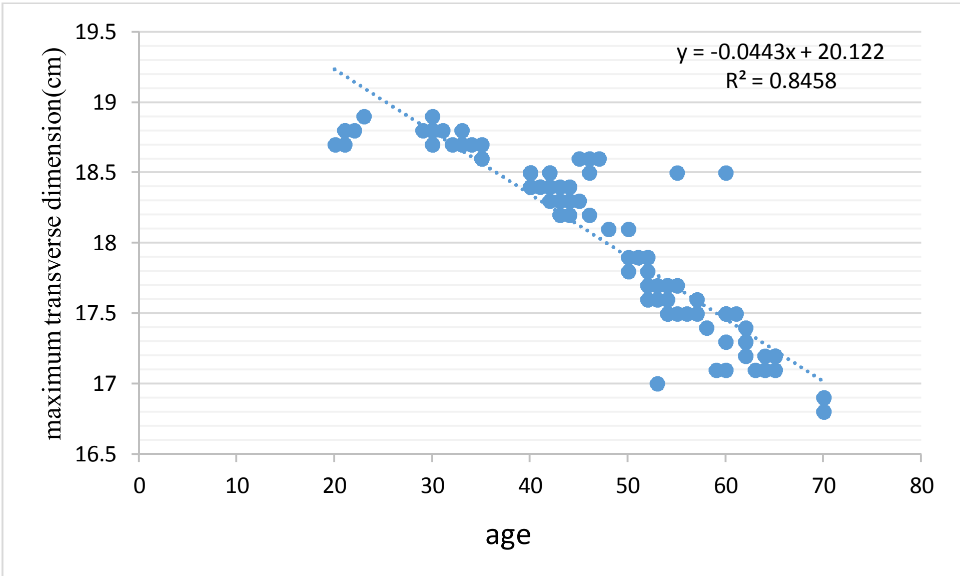


Figure 4.7: Scatter plot diagram shows the linear relation between the age and maximum transverse, as age increased the maximum transverse dimension decreased by 0.04.

Table 4.12:show correlation between age and mid hepticantero posterior.

		Age	Midhepticanteroposterior
Age	Pearson Correlation	1	-.796**
	Sig. (2-tailed)		.000
	N	100	100
Midhepticanteroposterior	Pearson Correlation	-.796**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

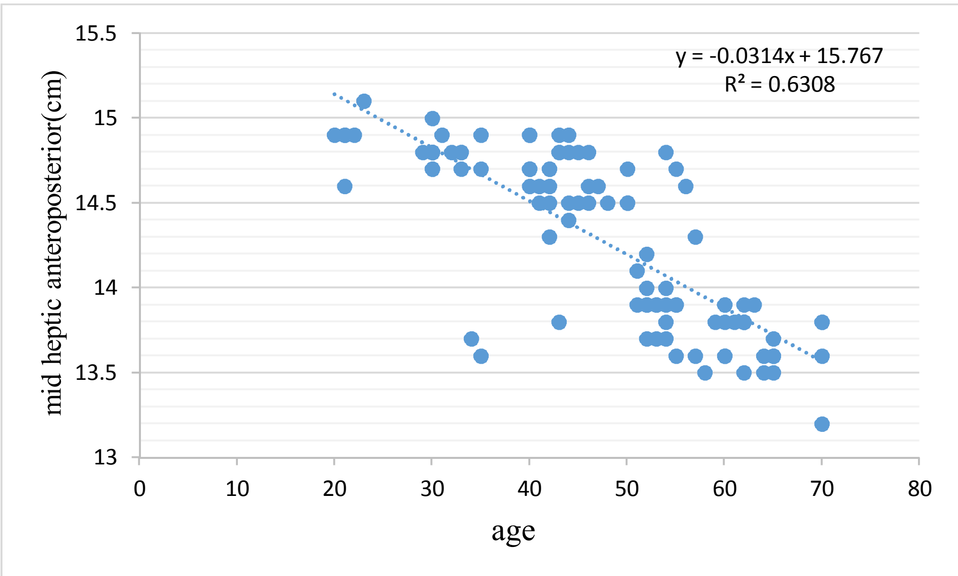


Figure 4.8: Scatter plot diagram shows the linearrelation between the age and Mid-hepatic antero-posterior, as age increased the mid-hepatic antero-posterior decreased by 0.03.

Chapter Five

Discussion, Conclusion & Recommendations

Chapter five
Discussion, Conclusion & Recommendations

5.1 Discussion:

This study is aimed to evaluate normal liver measurement in Sudanese using CT to find new index for Sudanese. The study took into consideration the normal liver measurements and texture correlated that with age.

The study showed that the mean and STD of male liver texture and measurement for mid hepticcraniocaudad, maximum craniocaudad, maximum transverse and mid hepticantero posterior was found to be 54.8±1.937 HU ,14.1± 0.54938 cm, 15.2 ±0.5657cm, 18.0 ±0.6235 cm and 14.2 ±0.5217 cm respectively. And female liver texture and measurements for mid hepticcraniocaudad, maximum craniocaudad, maximum transverse dimension ,mid hepticantero posterior was found to be 54.8 ±1.937 HU , 14.1± 0.5158 cm ,15.2 ±0.5435 cm , 18.1 ±0.6094 cm, 14.3 ±0.5043 cm respectively. This study showed no difference in liver measurementsand texture between males and females subjects as in tables (4.5, 4.6).

This study showed mean and STDof liver texture (CT number)54.84±1.937 HU for all sampleas presented in table (4.7),these measurements compare to study done by JM Meier.2007 found 54.24±8.29 HU which was decreased by 0.6 HU.

The correlation between age and liver texture of this study showed that there was significant correlation at (P_value0.01) and the liver texturedecreased by factor 0.1with age as in figure 4.4.

This study showed mean and STD of mid-hepatic craniocaudad 14.1±0.502 cm for all sample as in table (4.7), these measurements compare to study done by Verma.2010 foundmean of midhepatic craniocaudad was 12.4±2.3 cm which was decreased by 1.7 cm.

The correlation between age and mid-hepatic point of this study showed that there was significant correlation at (P_value0.01) and mid-hepatic craniocaudaddecreased by factor 0.03with age as in figure 4.5.

This study showed mean and STD of maximum craniocaudad 15.1±0.547 cm for all sample as in table (4.7), these measurements compare to study done by Verma.2010 found mean and STD of maximumcraniocaudad was 17.8±2.3 cm which was increased by 2.7cm.

The correlation between age and maximum craniocaudadof this study showed that there was significant correlation at (P_value0.01) and maximum craniocaudad decreased by factor 0.02with age as in figure 4.6.

This study showed mean and STD of maximum transverse dimension 18.0±0.619 cm for all sample as in table (4.7), these measurements compare to study done by Verma.2010 found mean of maximum transverse dimension was 18.4±2.6cm which was increased by 0.4cm.

The correlationbetween age and maximum transverse dimension of thisstudy showed that was significant correlation at (P_value0.01) and maximum transverse dimension decreased by factor 0.04with age as in figure 4.7.

This study showed mean and STD of mid-hepatic pointanteroposterior 14.3±0.508 cm for all sample as in table (4.7), these measurements compare to study done by Verma.2010 found mean of mid-hepatic point anteroposteriorwas 14.8±2.7cm which was increased by 0.5cm.

The correlation between age and mid-hepatic point anteroposterior of this study showed that was significant correlation at(P_vaule 0.01) and midhepatic point decreased by factor 0.03with age as in figure 4.8.

5.2 Conclusion:

The study showed that no different between male and female subject in the liver measurements and liver texture.

The study showed that liver measurements (midhepatic craniocaudad, maximumcraniocaudad, maximum transverse dimension and midhepticanteroposterior) decreased with ageand this indicate liver size decreased withage.

Also the study showed that the texture of liver decreased with age.

5.3 Recommendations:

-Future studies in evolution of liver measurement should be done with larger sample of population for more accurate results.

-Future studies should be done with several body characteristic in correlation with liver measurements.

-Future studies should be done use PET/ CT scan

-Future studiesshould be done evolution of liver measurements in child.

References

Douglas C. Wolf. (1990). Chapter 94: Evaluation of the Size, Shape and Consistency of the liver.

Eiman M AbdAlhady. Characterization of Normal Caudate lobe in Sudanese population by using computed tomography(AThesis)2015.

http://en.wikibooks.org/wiki/Human_Physiology.thepage appeared on 1 Dec 2016 04:58:57 GMT.

Jeffrey M. Meier, , AbassAlavi, SireeshaIruvuri, SaadAlzeair, Rex Parker, Mohamed Houseni, Miguel Hernandez-Pampaloni, Andrew Mong, and Drew A. Torigian, Assessment of Age-Related Changes in Abdominal Organ Structure and Function With Computed Tomography and Positron Emission Tomography Seminar in nuclear medicine 2007-Elsevier.

Jessie T Childs, Kerry A Thoirs, Adrian J Esterman Computed tomography volume measurements of the liver using a liver segmentation and analysis package: an intra- and inter-rater reliability study Journal of Biomedical Graphics and Computing 2015, Vol. 5, No. 2.

Lois E. Romans, 2011, computed tomography for technologists: a comprehensive Text, Wolters Kluwer Health/Lippincott Williams & Wilkins, Philadelphia, pages 14-20.

Lorrie L. Kelley and Connie M. Petersen, 2007, Sectional Anatomy for Imaging Professionals, 2end edition, Elsevier Inc., Philadelphia, page 353-367.

Nina Kowalczyk, 2014, Radiographic Pathology for Technologists, six edition, Elsevier Inc., Philadelphia, pages 200-211.

Verma, Sachit K.; McClure, Kristen; Parker, Laurence; Mitchell, Donald G.; Verma, Manish; and Bergin, Diane, "Simple linear measurements of the normal liver: Inter observer agreement and Correlation with hepatic volume on MRI" (2010). Department of Radiology Faculty Papers. Paper

Appendix (1)

Figure 1: Coronal CT image for female (65years) show measurements of mid-hepatic craniocaudad.

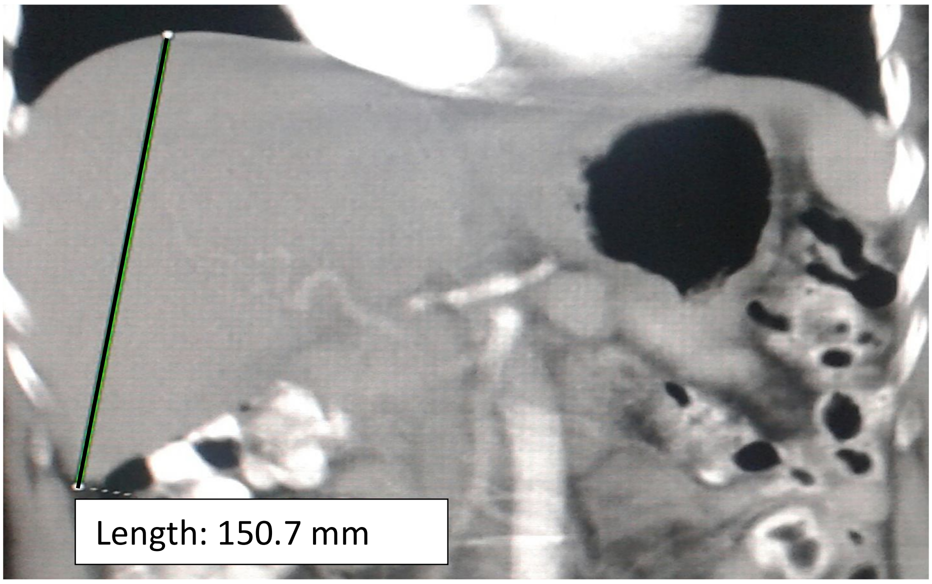


Figure 2: Coronal CT image for female (65 years) show measurements of maximum craniocaudad.

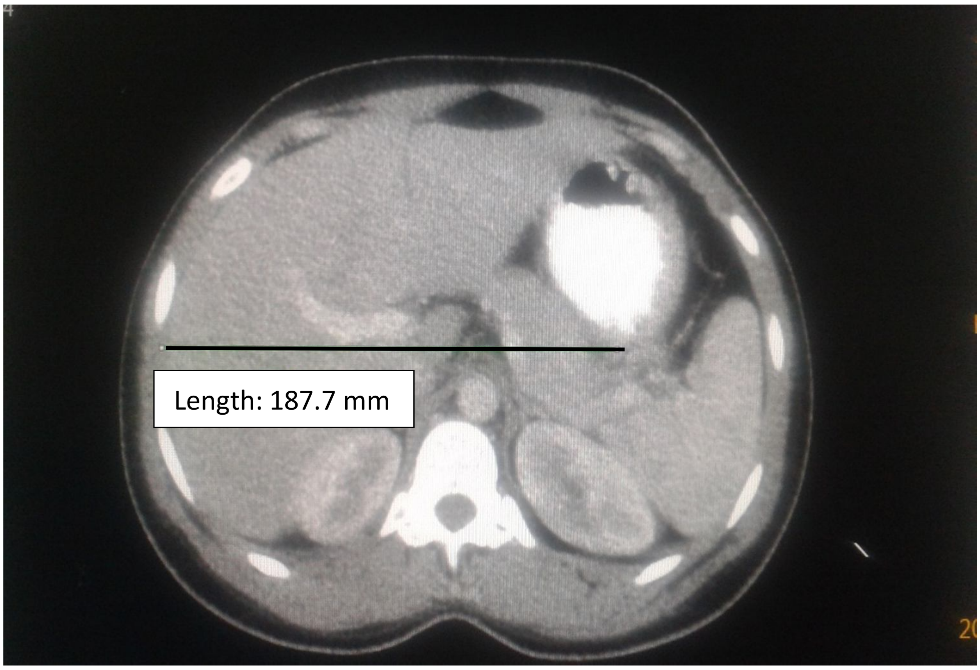


Figure 3: Axial CT image for male (29 years) show measurements of maximum transverse dimension.

Figure 4: Axial CT image for male (65 years) show measurements of mid hepticantero posterior.

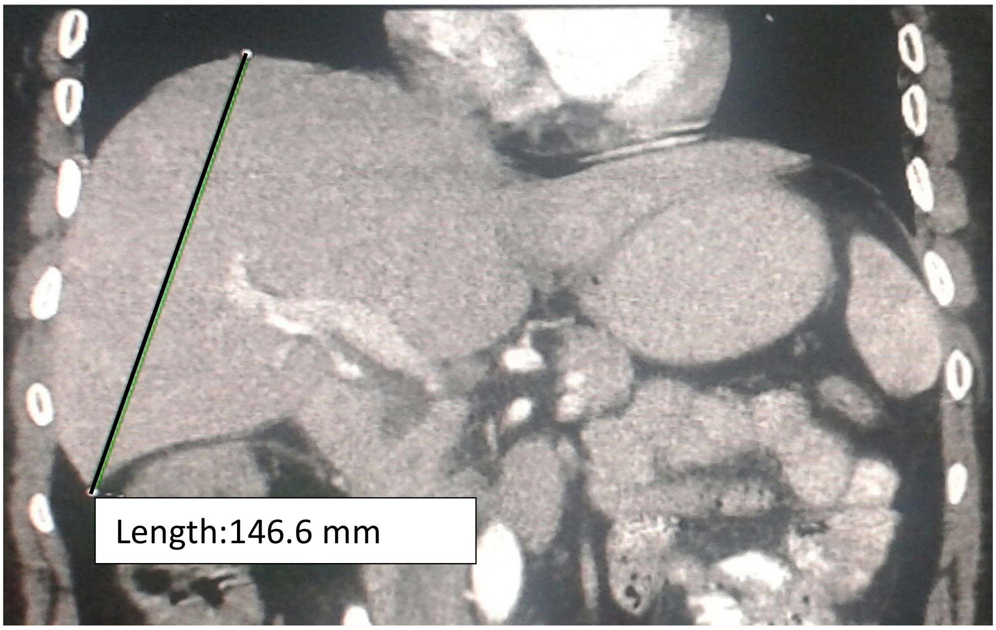


Figure 5:Coronal CT image for male (60 years) show measurements of maximum craniocaudad.

Appendex(2)

Sudan University of Science and Technology
Collage of Graduate Study
Measurement of liver among Sudanese adult by using
Computed tomography
Data collection sheet

No	Gender	Age	Midhepticcra niocaudad	Maximum craniocaudad	Maximum transverse dimension	Midheptic anteroposterior	Texture (HU)	CT finding