Dedication

To……

My family

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My teachers

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My friends

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My colleagues

Acknowledgements

I extremely grateful to many people who supported me during the preparation of this study.Firstly, I would like to express my deep gratitude to my supervisor Dr.**Caroline Edward Ayad**forher supports and advice. Also great thanks to the staff of Radiology department in Royal care hospital,Alzatona hospital androyal scanfor their helps to complete the study.Many thanks to Department of Radiology: Fedail Hospital, Alfaisal Hospital, Alzitona Hospital, AlturkyCenter,and College of Medical Radiological Science, Sudan University of Science and Technology to allow the authors to perform this work.Finally, I would like to sincerely thank my teachers for their consistent mental support

Abstract:

The advent of computed tomography (CT) has considerably facilitatedthe diagnosis of lesions of the liver, The objective of this study was
To characterize liver lesions in triphasic spiral computerized tomography and To evaluate the diagnostic value of triphasic spiral Computerized Tomography (CT) Hounsfield (HU) and pattern in differentiating focal liver lesions.The study was conducted in Department of RadiologyFedail Hospital, Alfaisal Hospital, Alzitona Hospital, AlturkyCenter.The study was obtained during the period spanned from January 2014up to December 2016.This study 138 patients with liver disease underwent triphasic liver (CT) 64 male 74 female . After injection of contrast material, the liver was scanned in arterial, portal and delay phases Triphasic liver CT enables to characterize a wide range of hepatic infiltration, focal liver lesions, including the benign and malignant lesions as well as metastases that occur most frequently.Triphasic CT scan is an acknowledged non-invasive imaging technique and can be used as first line imaging modality for differentiating focal liver lesions using this quantification method and its homogeneity in all of the scanning phases. Benign lesions like haemangioma can be reliably differentiated from malignant liver lesion using the texture and HU values .It is also particularly supportive for hyper vascular lesions which can be easily overlooked on routine CT scanning; therefore unnecessary biopsies can be avoided.

المستخلص:

توصيف افات الكبد باستخدام الاشعة المقطعية متعددة الكواشف،وقد اجريت الدراسة في عدة اقسام اقسام الأشعة, مستشفى فضيل، مستشفى الفيصل،مستشفى الزيتونة، ومركز التركي وكانت خلال . فترة امتدت من يناير 2014الي ديسمبر 2016،وكانت 138مريضا يعانون من أمراض الكبد64من الذكور 74 من الإناث .

وكان الهدف من هذه الدراسةتوصيف آفات الكبد في ثلاثي الأطوار التصوير المقطعي المحوسب الحلزوني وتقييم القيمة التشخيصية للثلاثي الأطوار التصوير المقطعي المحوسب الحلزونيهاونسفيلد (HU) ونمط في التفريق آفات الكبد.

بعد حقن مادة تباين عن طريق الدم تم مسحها ضوئيا علي الكبد ، .تم تقييم تعزيز كل آفة في كل مرحلة، وتم جدولة الآفات وفقا لأنماط .وقد صنفت طبيعة الآفة بشكل متجانسة، غير متجانسة أو كثافة الإشارة. الاشعة المقطعيه ثلاثي الأطوار يمكن توصيف مجموعة واسعة من آفات الكبد بما في ذلك الآفات الحميدة والخبيثة وكذلك انتشار الورم وهو الاكثر ظهور في الاشعة المقطعية ، لابد من استحدام ثلاثي الاطوار كخط أول في التصوير للتمييز آفات الكبد و استخدام هذا الأسلوب الكمي والتجانس في جميع مراحل المسح. آفات حميدة مثل الورم الوعائي الدموي يمكن أن تكون متباينة بشكل موثوق من آفة الكبد الخبيثة باستخدام نسيج والرقم الزري(HU) القيم. بستخدام ثلاثي الاطوار يمكن التخلص من استخدام اخز عينه(Biopsy) .

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Chapter One

1.1Introduction:

Focal liver lesions can be defined as any lesion in the liver other than the typical parenchyma and can be of unpredictable size. These lesions can be benign or malignant. Prevalence of various liver lesions has marked differences across geographic regions and ethnic groups.[Edward Boas et al 2015] .

Although the recent evolution of diagnostic radiologic technologies has changed the setting of hepatic imaging, misdiagnoses during early disease development may prevent patients from obtaining advantageous management. There is insufficient diagnostic performance for both the early detection and the characterization of small liver lesions even with computed tomography (CT) and magnetic resonance (MR) imaging techniques. As such, there is a need to improve on morphology-based CT and MR imaging using contrast agents for the early detection and characterization of hepatic disease. [Edward Boas et al 2015]

Spiral computed tomography (CT) has rapidly gained acceptance as the preferred CT technique for routine liver evaluation because it provides image acquisition at peak enhancement of the liver parenchyma during a single breath hold In addition, the fast data acquisition allows successive scanning of the entire liver at different moments after injection of contrast material, thus creating the possibility of multiphase liver CT.

Recent studies have reported an improvement in lesion detection if arterial phase imaging is performed in addition to portal venous imaging, especially in the presence of hyper vascular neoplasms, such as hepatocellular carcinoma (HCC).[Hoon et al 2001]

In the present study, we appraised a triphasic spiral CT technique that allows imaging of the entire liver parenchyma and liver lesions in arterial, portal,

and equilibrium phases. The rationale behind the protocol was the phase's sensitivity for lesion detection, and the additional information on the vascularity of lesions that may help to clarify the character of lesions. The study was designed to characterize different liver lesions using triphasic spiral liver CT.

The advent of computed tomography (CT) has considerably facilitated the diagnosis of lesions of the liver. However, the underlying reasons why hepatic tumors are detectable by CT have received little attention . CT investigations of such lesions have mostly been confined to pathologic evaluation, and no detailed reports have appeared on the correlation between the CT number and the types of lesions in the liver tissue. In the present investigation we measured, in liver lesions, the quantities of Hounsfield number which is a normalized value of the calculated x-ray absorption coefficient of a pixel a normalized index of x-ray attenuation used in CT imaging. that could contribute to the lesion character, and analyzed the correlation between the diagnosis, the CT number and then discuss the associated findings. Also, in liver with metastases, the contents CT HU were measured as an attempt to elucidate the factors underlying the detection of hepatic lesions as a high- or low-density area. Since no studies have correlated CT findings with actual Hounsfield quantification of different focal hepatic lesions, our aim is to discern whether or not enhanced and unenhanced CT determination of hepatic focal lesions based on image attenuation data (Hounsfield units) is significantly changed .Verified correlation of these radiologic parameters may facilitate the development of a reliable and noninvasive standard measurement of liver HU for both clinical and research objectives. As well in the current study, we evaluated a triphasic spiral computed tomogram technique that allowed imaging of the liver in arterial, portal and equilibrium phases and to correlate the CT findings with the underlying causes. Several studies have been done worldwide on the role of triphasic CT scan in characterizing and differentiating lesions. However, to the best of our knowledge, no data has been published locally, so purpose of this study was to describe the role of triphasic CT scan in focal liver lesions and to determine its diagnostic value

1.2 Problem of the study:

Although the recent evalution of diagnostic radiologic technologies has changed the setting of hepatic imaging, misdiagnoses during early disease development may prevent patients from obtaining advantageous management. There is insufficient diagnostic performance for both the early detection and the characterization of small liver lesions even with computed tomography (CT). As such, there is a need to improve on morphology-based CT using contrast agents for the early detection and characterization of hepatic disease.

1.3 Objectives:

1.3.1General Objective:

To Charterized of Liver lesion Using Tri Phase Multi Slice CT

1.3.2 Specific Objective:

-To measure the of CT number ,size of the lesion and, characterize shape

-to evaluate the common site of liver mass between the phases in data collection

-To correlation between the finding diagnosis in each scan phase

-To evaluate the MDCT in the detection liver metastases using phase technique

1.5 Overview of the study:

This study will consist of five chapters Chapter one, which is an introduction, deals with theoretical frame work of the study. It presents the statement of the study problems, objectives of the study. Chapter two is divided into two sections, section one deal with theoretical background of

CT liver radiography(anatomy, physiology and pathology)and CT unit, and Section two deals with production of x-ray and radiation units and measurement, literature review (previous studies). Chapter three discusses the material and method. Chapter four includes result presentations. Finally chapter five will include the discussion, conclusion, recommendation and appendix.

Chapter two

2- Background and Literature review

2.1 Anatomy of the liver:

The liver is the largest solid organ in the body. In adults, the liver can weigh up to 1.5 kilograms (kg). It is in the upper-right abdomen, just under the rib cage and below the diaphragm (the thin muscle below the lungs and heart that separates the chest cavity from the abdomen). The liver is part of the digestive system.This is the largest organ in the body. It is related by its domed upper surface(Thieme 2004)

to the diaphragm, which separates it from pleura, lungs, pericardium and heart. Its postero-inferior (or visceral) surface abuts against the abdominal oesophagus, the stomach, duodenum; hepatic flexure of colon and the right kidney and suprarenal, as well as carrying the gall-bladder.The liver is divided into a larger right and small left lobe, separated superiorly by the falciform ligament and postero-inferiorly by an H-shaped arrangement of fossae(Harold 2006)

anteriorly and to the right—the fossa for the gall-bladder posteriorly and to the right—the groove in which the inferior vena cavaliesembedded anteriorly and to the left—the fissure containing the ligamentumteres posteriorly and to the left—the fissure for the ligamentumvenosum.

The cross-bar of the H is the *portahepatis*. Two subsidiary lobes aremarked out on the visceral aspect of the liver between the limbs of this H the *quadrate lobe* in front and the *caudate lobe* behind.The ligamentumteresis

the obliterated remains of the left umbilical veinwhich, in utero, brings blood from the placenta back into the fetus. The ligamentus (Harold 2006) venosumis the fibrous remnant of the fetal ductusvenosuswhich shunts oxygenated blood from this left umbilical vein to the inferior vena cava, short-circuiting the liver. It is easy enough to realize, then, that the grooves for the ligamentumteres, ligamentumvenosum and inferior vena cava, representing as they do the pathway of a fetal venous trunk, are continuousin the adult. See also fetal circulation page 38.Lying in the portahepatis (which is 2 in (5 cm) long) are thecommon hepatic ductanteriorly the hepatic artery—in the middle the portal vein—posteriorly.

As well as these, autonomic nerve fibres (sympathetic from the coeliac)

2-1-1Peritoneal attachments:

The liver is enclosed in peritoneum except for a small posterior bare area, demarcated by the peritoneum from the diaphragm reflected on to it as the upper and lower layers of the coronary ligament. To the right, these fuse to form the right triangular ligament.(E Harold 2006)

The falciform ligamentascends to the liver from the umbilicus, somewhat to the right of the midline, and bears the ligamentumteres in its free border. The ligamentumteres passes into its fissure in the inferior surface of the liver while the falciform ligament passes over the dome of the liver and then divaricates. Its right limb joins the upper layer of the coronary ligament and its left limb stretches out as the long narrow *left triangular ligament* which, when traced posteriorly and to the right, joins the lesser omentum in the upper end of the fissure for the ligamentumvenosum.(E Harold 2006)

The lesser omentumarises from the fissures of the portahepatis and the

ligamentumvenosum and passes as a sheet to be attached along the lesser curvature of the stomach. Structure.(Harold 2006).

2.1.2 Structure:

The liver has 2 main lobes: the larger right lobe and the smaller left lobe. Each lobe is divided into segments.

The lobes are separated by a band of tissue called the falciform ligament (also called the broad ligament), which helps attach the liver to the diaphragm.(Harold2006)

A layer of connective tissue, called Glasson's capsule or the capsule, covers the liver.

2-1-3Segmental anatomy:

The gross anatomical division of the liver into a right and left lobe, demarcatedby a line passing from the attachment of the falciform ligament on the anterior surface to the fissures for the ligamentumteres and ligamentumvenosum on its posterior surface, is simply a gross anatomical descriptiveterm with no morphological significance. Studies of the distribution of the hepatic blood vessels and ducts have indicated that the true morphological and physiological division of the liver is into right and left lobes demarcated by a plane which passes through the fossa of the gall-bladder and thefossa of the inferior vena cava. Although these two lobes are not differentiated .(Harold Ellis2006).

by any visible line on the dome of the liver, each has its own arterialand portal venous blood supply and separate biliary drainage. This morphologicaldivision lies to the right of the gross anatomical plane and in thisthe quadrate lobe comes to be part of the left morphological lobe of the liver while the caudate lobe divides partly to the left and partly to the right

lobeThe right and left morphological lobes of the liver can be further subdividedinto a number of segments, four for each lobe (Fig. 72c). Thestudentneed not learn the details of these, but of course to the hepatic surgeon, carrying (Harold 2006)

out a partial resection of the liver, knowledge of these segments, with their individual blood supply and biliary drainage, is of great importance. At the hilum of the liver, the hepatic artery, portal vein and bile duct each divide into right and left branches and there is little or no anastomosis between the divisions on the two sides. From the region of the portahepatis, the branches pass laterally and spread upwards and down

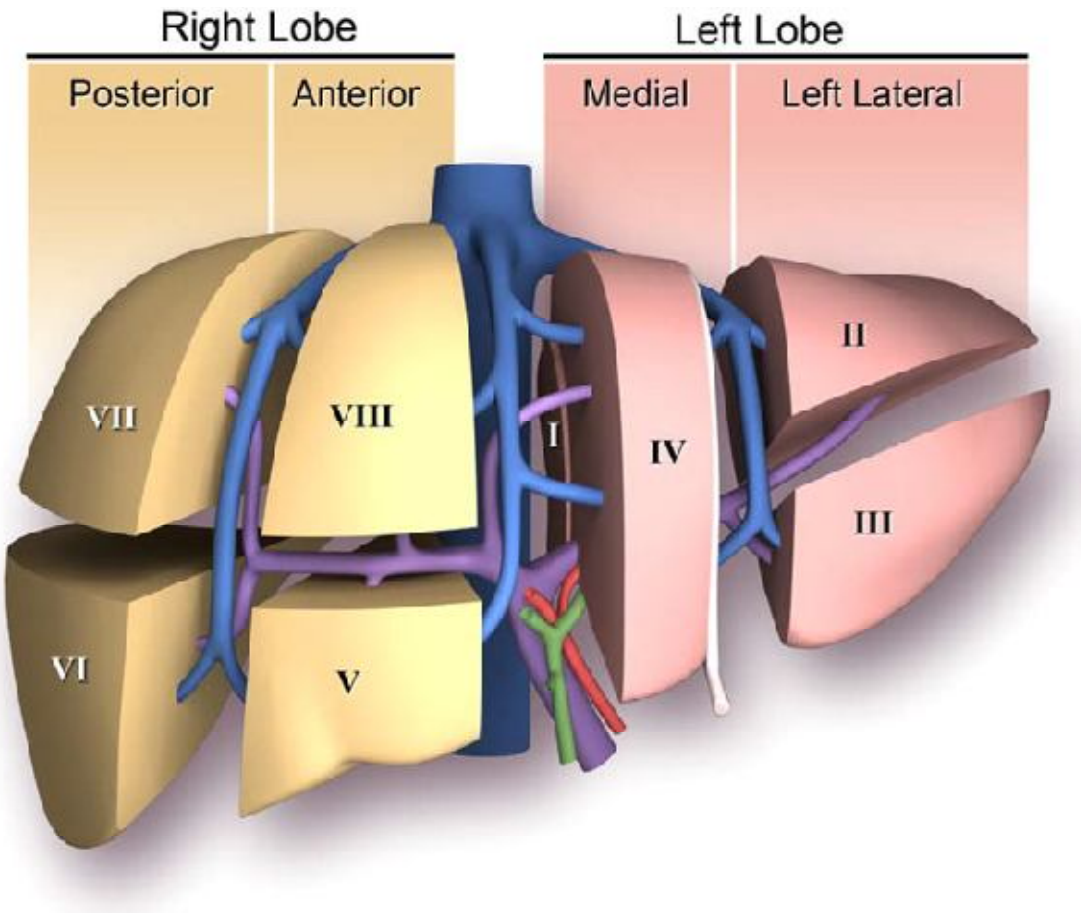

Figure (2_1) show Segmental.(E Harold 2006)

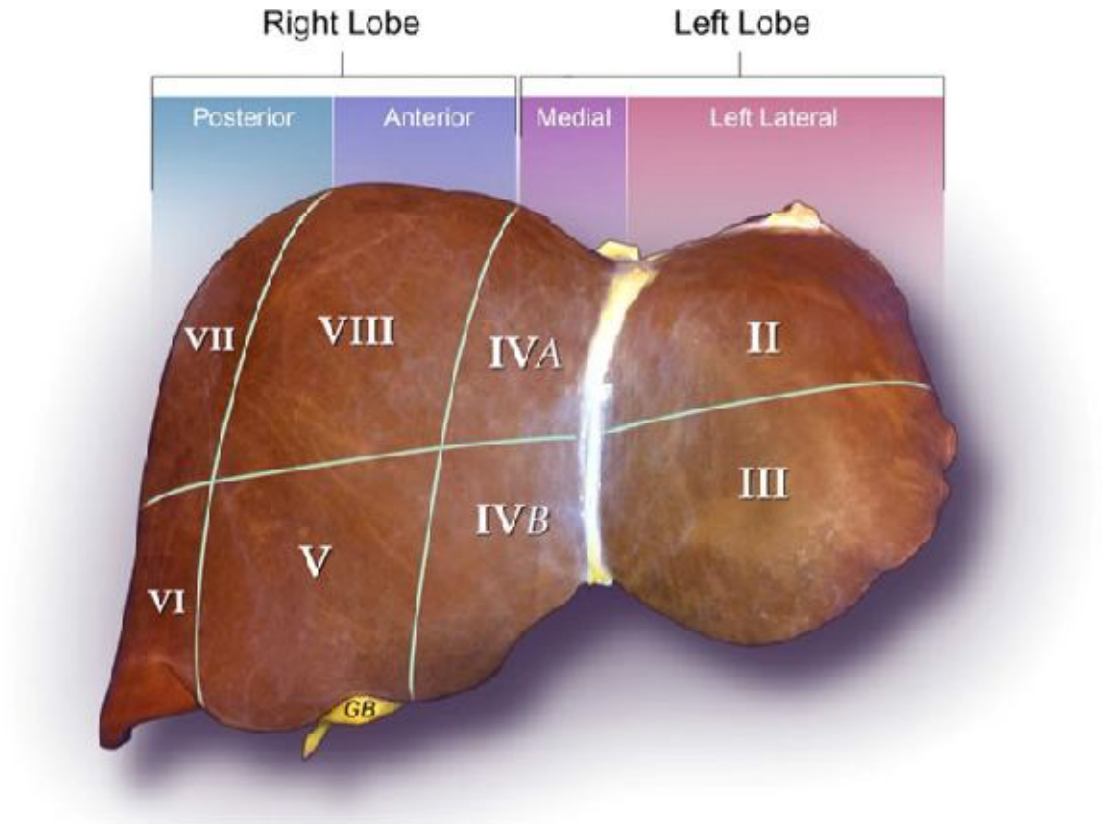

Figure (2_2)) show Segmental.(E Harold 2006)

segments II and III is known as a left lateral segmentectomy. Resection of segment IV is known as a left medial segmentectomy, resection of segments V and VIII is known as a right anterior segmentectomy, and resectionof segments VI and VII are known as a right posteriorsegmentectomy. Resection of segments II, III, and IV isknown as the left lobe resection or left hepatectomy. Resection
of segments V, VI, VII, VIII is known as right loberesection or right hepatectomy. Extended right hepatectomy (Soleret al. 2001)

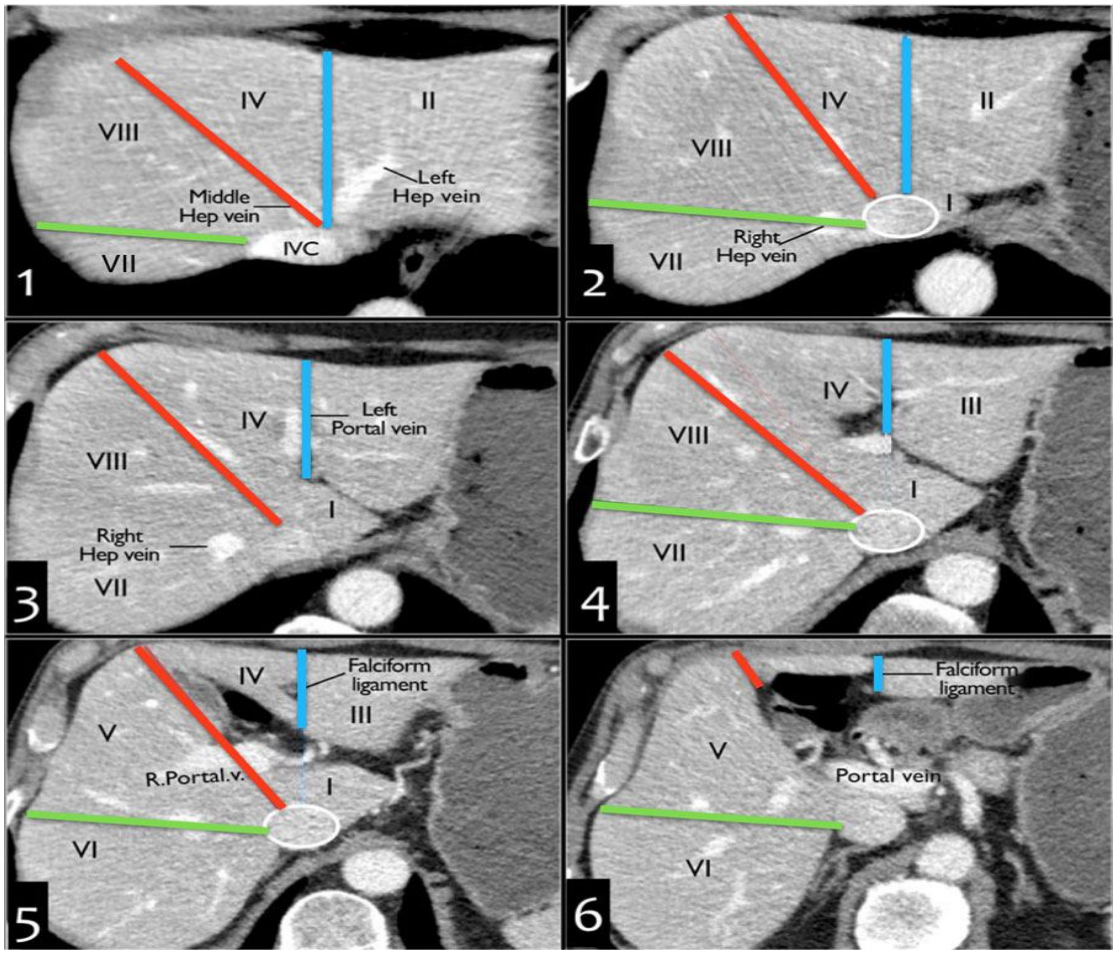

Figure (2_3) liver segments on cross sectional imaging

Left lobe: lateral(II/III) vs medial segment (IVA/B) Extrapolate a line along the falciform ligament superiorly to the confluence of the left and middle hepatic veins at the IVC (blue line) , **Left vs Right lobe: IVA/B vs V/VIII** Extrapolate a line from the gallbladder fossa superiorly along the middle hepatic vein to the IVC (red line). **Right lobe: anterior (V/VIII) vs posterior segment (VI/VII)** Extrapolate a line along the right hepatic vein from the IVC inferiorly to the lateral liver margin (green line)

2.1.4 Blood vessels

Unlike most other organs, the liver has 2 major sources of blood Portal vein carries blood from the digestive system to the liverApproximately 75% of the liver's blood supply comes from the portal vein. Hepatic artery –supplies the liver with oxygen-rich blood from the heartMost of the blood is removed from the liver through 3 hepatic veins (the right, middle and left hepatic veins) found inside the liver.(Harold2006)

2-1-4-1 hepatic veins:

These veins are massive and their distribution is somewhat different from that of the portal, hepatic arterial and bile duct systems already described. There are three major hepatic veins, comprising a right, a central and a left. These pass upwards and backwards to drain into the inferior vena cava at the superior margin of the liver. Their terminations are somewhat variable but usually the central hepatic vein enters the left hepatic vein near its termination. In other specimens it may drain directly into the cava. In addition, small hepatic venous tributaries run directly backwards from the substance of the liver to enter the vena cava more distally. .(Harold 2006).
to the main hepatic veins. Although these are not of great functional importance they obtrude upon the surgeon during the course of a right hepatic lobectomy.(Harold2006).

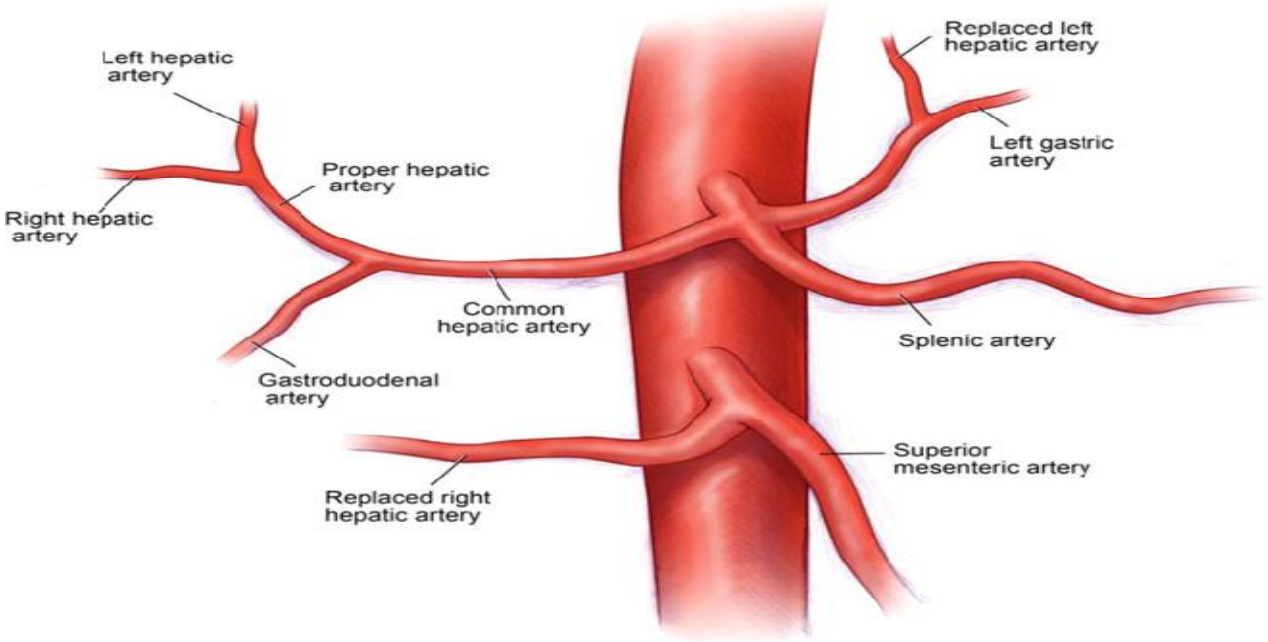

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Figure 2-4 common hepatic artery ,superior mesenteric artery and splenic artery(Soler et al. 2001)

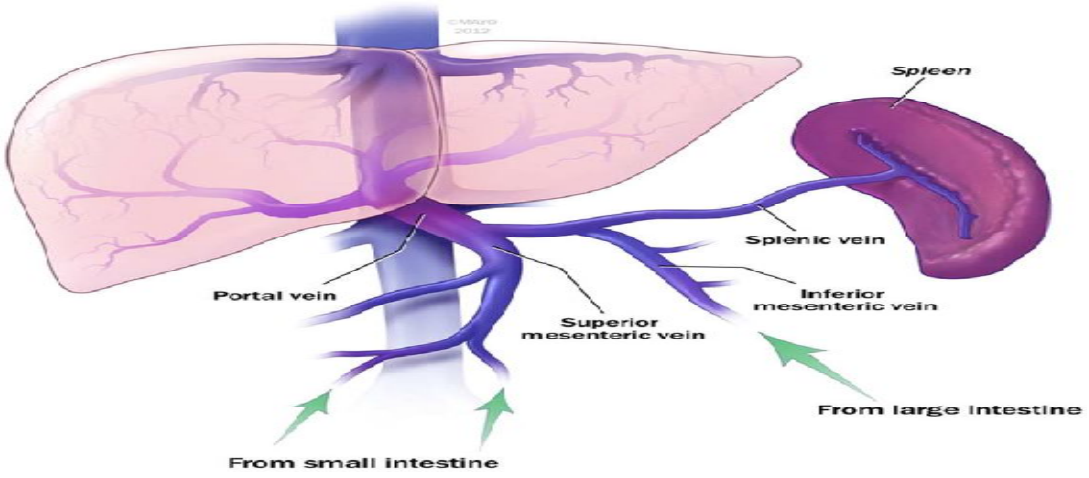

Figure (2_5) show IVC, portal vein , superior mesenteric vein and splenic vein (Soler et al. 2001)

2.1.5 Bile ducts:

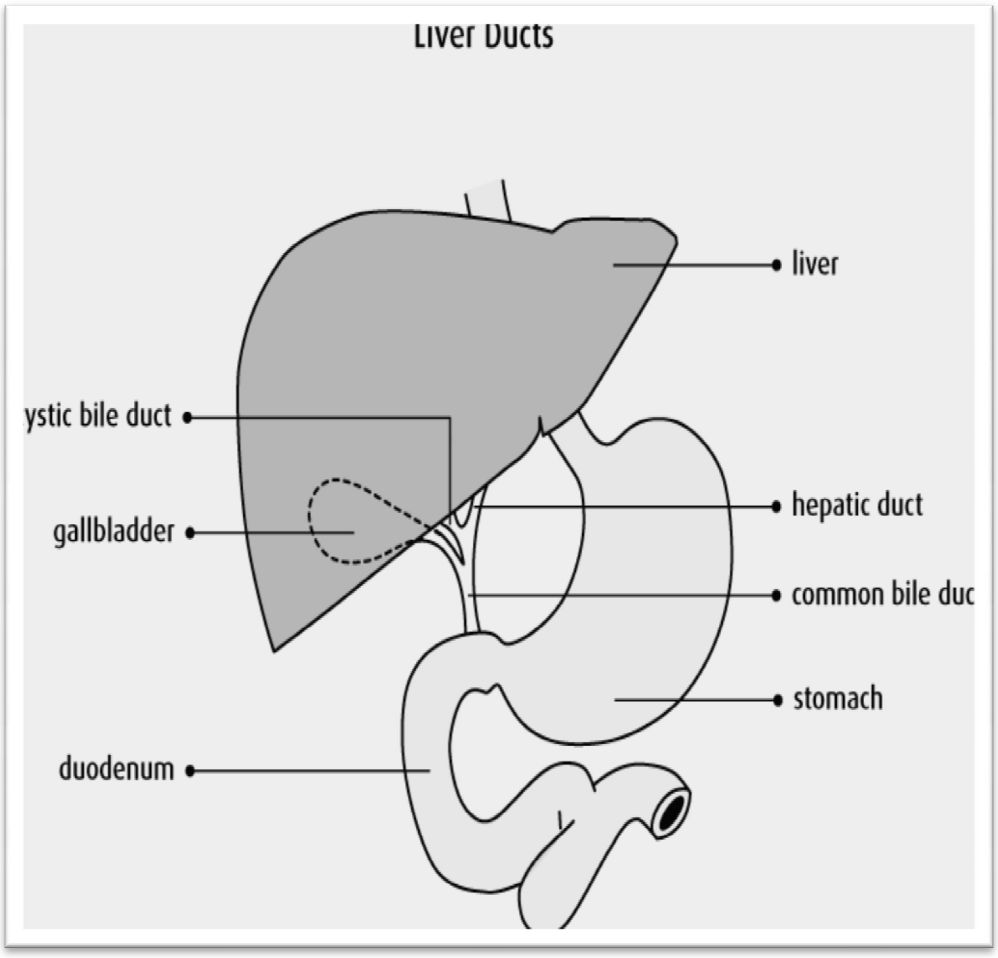

Figure (2_6) show bile duct ,hepatic duct ,common bile duct (Soler et al. 2001)

The liver, gallbladder and small intestine are connected by a series of thin tubes called ducts. One function of the liver cells (hepatocytes) is to produce bile. Bile is a yellow-green fluid that helps digest fat. Bile travels through a series of ducts in the liver to the small intestine or to the gallbladder for

storage.Bile is collected from the liver in hepatic ducts.Two hepatic ducts leave the liver and join to form the common hepatic duct.The cystic bile duct leaves the gallbladder and joins the common hepatic duct to form the common bile duct.The common bile duct empties bile into the duodenum.(chan et al 2013)

2.2 Liver physiology

Removing and excreting body wastes and hormones as well as drugs and other foreign substancesThese substances have entered the blood supply either through production by metabolism within the body or from the outside in the form of drugs or other foreign compounds. Enzymes in the liver alter some toxins so they can be more easily excreted in urine.Synthesizing plasma proteins, including those necessary for blood clotting: Most of the 12 clotting factors are plasma proteins produced by the liver. If the liver is damaged or diseased, it can take longer for the body to form clots. Other plasma proteins produced by the liver include albumin which binds many water-insoluble substances and contributes to osmotic pressure, fibrogen which is key to the clotting process, and certain globulins which transport substances such as cholesterol and iron.(chan et al 2013). Producing immune factors and removing bacteria, helping the body fight infectionThe phagocytes in the liver produce acute-phase proteins in response to microbes. These proteins are associated with the inflammation process, tissue repair, and immune cell activities.Producing bile to aid in digestion: Bile salts aid in fat digestion and absorption. Bile is continuously secreted by the liver and stored in the gallbladder until a meal, when bile enters the beginning of the small intestine. Bile production ranges from 250

mL to 1 L per day depending of amount of food eaten.Excretion of bilirubin: Bilirubin is one of the few waste products excreted in bile. Macrophages in the liver remove worn out red blood cells from the blood. Bilirubin then results from the breakdown of the hemoglobin in the red blood cells and is excreted into bile by hepatocytes. Jaundice results when (chan et al 2013)

bilirubin cannot be removed from the blood quickly enough due to gallstones, liver disease, or the excessive breakdown of red blood cells.Storing certain vitamins, minerals, and sugars The liver stores enough glucose in the form of glycogen to provide about a day's worth of energy. The liver also stores fats, iron, copper, and many vitamins including vitamins A, D, K, and B12.Processing nutrients absorbed from digestive tract The liver converts glucose into glycogen, its storage form. This glycogen can then be transformed back into glucose if the body needs energy. The fatty acids produced by the digestion of lipids are used to synthesize cholesterol and other substances. The liver also has the ability to convert certain amino acids into others.(chan et al 2013)

2.3 liver Pathology:

There are more than a hundred kinds of liver disease; these are some of the most common

2.3.1 Cirrhosis:

is a slowly progressing disease in which healthy liver tissue is replaced with scar tissue, eventually preventing the liver from functioning properly. The scar tissue blocks the flow of blood through the liver and slows the processing of nutrients, hormones, drugs, and naturally produced toxins. It

also slows the production of proteins and other substances made by the liver.(chan et al 2014)

Causes of liver CirrhosisThe most common causes of cirrhosis of the liver Hepatitis C, fatty liver, alcohol abuse.

SymptomsLoss of appetite ,Lack of energy ,Weight loss ,Jaundice ,Fluid retention(edema) and swelling in the ankles and abdomen (often an early sign) ,A brownish or orange tint to the urine ,Light colored stools, Confusion and personality changes ,Fever.(chan et al 2014)

2.3.2 Polycystic liver disease:

Is a rare condition that causes cysts -- fluid-filled sacs -- to grow throughout theliver. A normal liver has a smooth, uniform appearance. A polycystic liver can look like a cluster of very large grapes. Cysts also can grow independently in different parts of the liver. The cysts, if they get too numerous or large, may cause discomfort and health complications. But most people with polycystic liver disease do not have symptoms and live a normal life(chan et al 2014).

Causes of Polycystic Liver Disease The majority of people with polycystic liver disease inherit the conditionPolycystic kidney disease (PCKD), with its frequency increasing with age and advanced renal disease.Symptoms of Polycystic Liver DiseaseAbdominal pain, Bloating or swelling in the abdomen, bleeding into a cyst, Infection of a cyst, Bile duct obstruction and jaundice (yellowing of the skin and eyes).

2.3.3 Fatty liver disease:

Some fat in your liver is normal. But if it makes up more than 5%-10% of the organ's weight, you may have fatty liver disease.

There are two main types of fatty liver disease: Alcoholic liver disease, (ALD)Nonalcoholic fatty liver disease (NAFLD)

Cassese of fatty liver disease Alcoholic Liver Disease (ALD)Alcohol, Hepatitis c (which can lead to inflammation in your liver), too much iron in your body, being obese.Nonalcoholic Fatty Liver Disease (NAFLD**)** Overweight or obese, High cholesterol and diabetes as well. , Medication, Viral hepatitis, Autoimmune or inherited liver disease, Fast weight loss, Malnutrition.

Symptoms of Fatty Liver DiseaseFeeling tired, Loss of weight or appetite, Weakness, Nausea, Confusion, poor judgment, or trouble concentrating.You might have some other symptoms, too. Your liver may get larger. You could have a pain in the center or right upper part of your belly. And the skin on your neck or under your arms may have dark, colored patches.

2.3.4 Hepatocellular Carcinoma:

Hepatocellular carcinoma is a cancer that starts in your liver. Causes of Hepatocellular carcinoma:Hepatitis B or hepatitis C, cirrhosis. , Heavy alcoholicdrink, Obesityand diabetes. .

SymptomsPain in the upper right part of your belly ,A lump or feeling of heaviness in your upper belly ,bloating or swelling in your belly ,Loss of appetite and ,feelings of fullness ,Weight loss ,weakness or deep fatigue

,nausea and vomiting ,Yellow skin and eyes ,Pale and chalky bowel movement and dark urine ,Fever.(chan et al 2014)

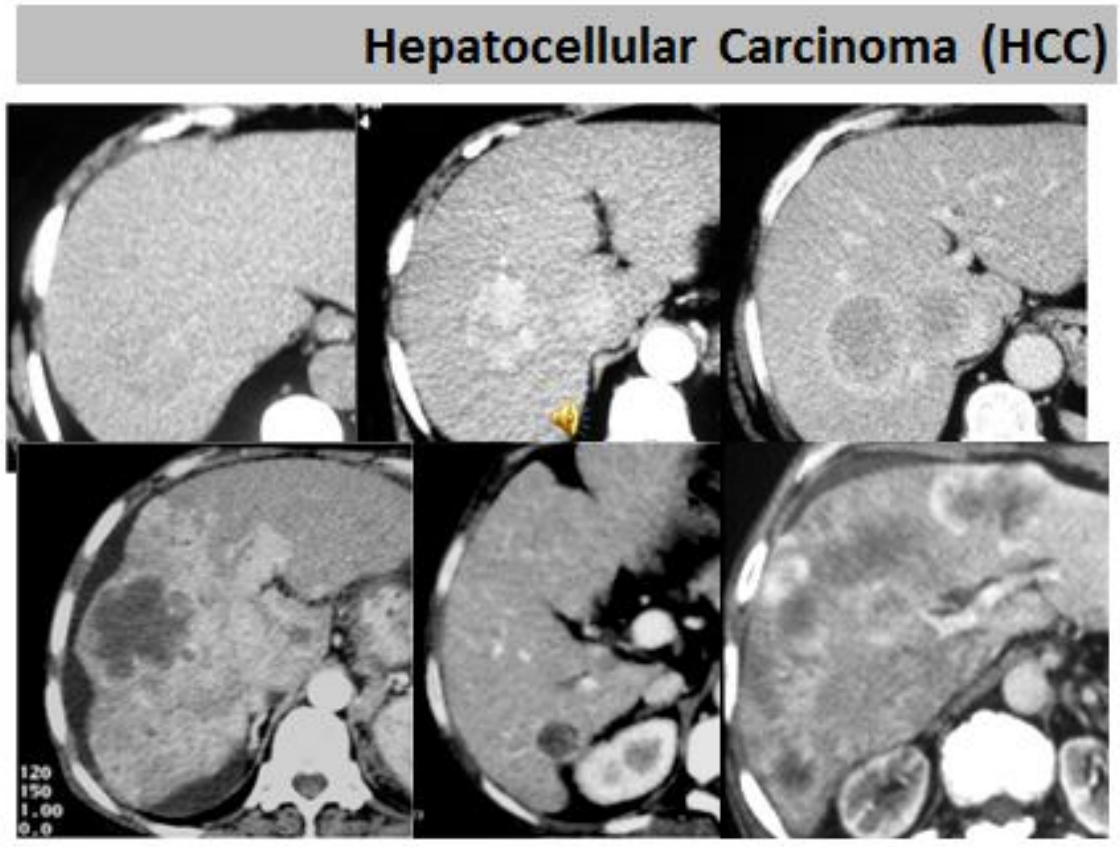

Figure (2_7) show HCCct.(chan et al 2014)

2.3.5 Enlarged Liver (Hepatomegaly):

Causes of hepatomegalyInflammation or fatty liver. This could be from:

obesity ,An infection ,Some medication or alcohol ,Toxins ,Certain types of hepatitis ,Autoimmune disease ,Metabolic ,Genetic disorders .

Symptoms of hepatomegalyA feeling of fullness, Discomfort in your belly, Yellowing of the skin or eyes (jaundice), Weakness, Nausea, Weight loss.

2.3.6 Liver Abscess:

A liver abscess is a pus-filled mass inside the liver**,** Causes of liverabscessCommon causes are abdominal infections such as appendicitis or diverticulitis due to haematogenous spread through the portal vein

Type of liver abscessThere are three major forms of liver abscess, classified by etiology Pyogenic liver abscess, which is most often polymicrobial, accounts for 80% of hepatic abscess cases in the United States Amoebic liver abscess due to entamoebahistolytica accounts for 10% of cases Fungal abscess, most often due to Candida species, accounts for less than 10% of cases Symptoms of liver abscess Symptoms of amebic liver abscess Abdominal pain particularly in the right upper part of the abdomen; pain is intense continuous or stabbing, Cough, Fever and chills, Diarrhea (in only one-third of patients), General discomfortor ill feeling (malaise).(chan et al 2014)

Symptoms of Pyogenic Liver Abscess Vomiting, fever, right upper abdominal pain, sudden dramatic weight losssuch as 10 pounds in a few weeks, dark-colored urine, whitish or clay-colored stool, diarrhea.

2.3.7**Hepatic haemangiomas** :

are thought to be congenital in origin, non-neoplastic, and are almost always of the cavernous subtype. Blood supply is predominantly hepatic arterial, similar to other liver tumours. A peripheral location within the liver is most common .Sub typestypical hepatic haemangiomaandatypical hepatic haemangiomahepatic haemangiomagiant hepatic haemangioma and flash filling hepatic haemangioma: can account for up to 16% of all hepatic haemangiomas

2.3.7.1Radiographic features of Hepatic haemangiomas

2.3.7.1.1 Ultrasonographyhaemangiomas

typically well-defined hyperechoic lesionsa small proportion (10%) are hypoechoic, which may be due to a background of hepatic steatosis, where liver parenchyma itself is of increased echogenicitycolour Doppler: may show peripheral feeding vessels contrast enhanced ultrasoundarterial phase: peripheral nodular discontinuous enhancementportal venous and delayed phases: continued "filling in" of the lesion, until the entire hemangioma is hyperechoic relative to background liverSee hyperechoic liver lesions for a further differential.(chan et al 2014)

2.3.7.1.2 CThaemangiomas

Most haemangiomas are relatively well defined. The dynamic enhancement pattern is related to the size of its vascular space [1]. Features of typical lesions includenoncontrast: often hypoattenuating relative to liver parenchymaarterial phase: typically show discontinuous, nodular, peripheral enhancement (small lesions may show uniform enhancement)portal venous phase progressive peripheral enhancement with more centripetal fill-indelayed phase: further irregular fill-in and therefore iso- or hyper-

attenuating to liver parenchymaOther described features include:.(chan et al 2014)

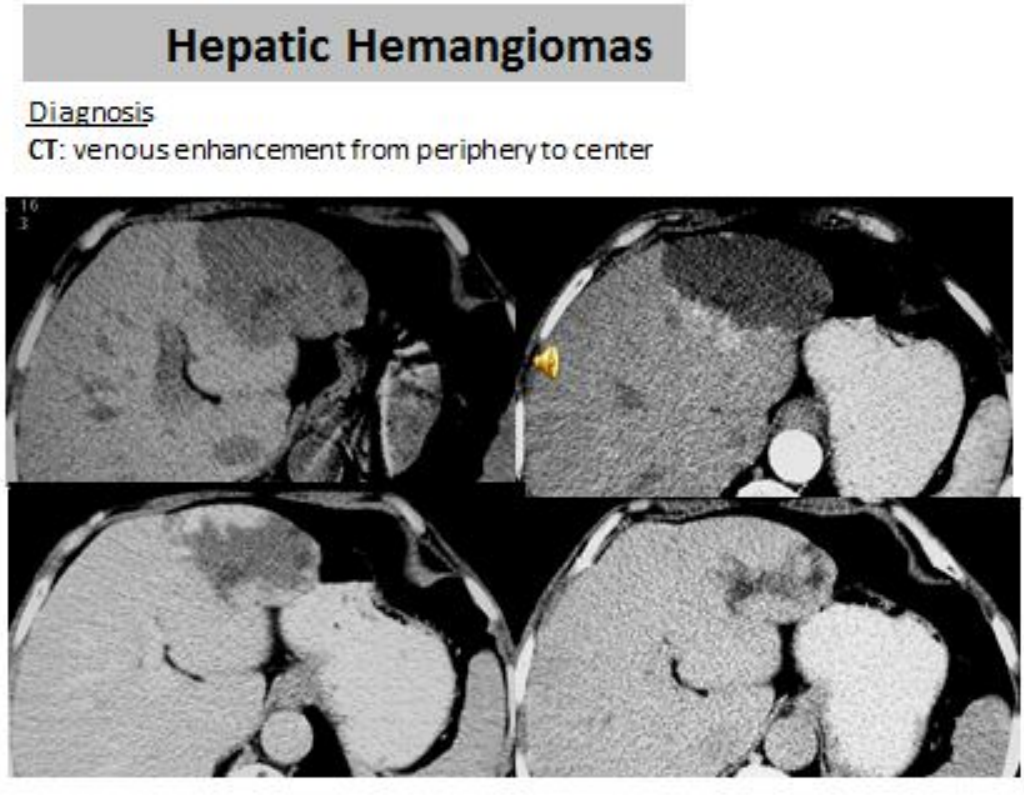

Figure (2_8) show Hemangiomact venous enhancement.CT(chan et al 2014)

2.3.7.1.3 MRIhaemangiomas

Typical features include T1: hypointense relative to liver parenchymaT2: hyperintense relative to liver parenchyma, but less than the intensity of CSF or of a hepatic cystT1 C + (Gd): often shows peripheral

nodulardiscontinuous enhancement which progresses centripetally (inward) on delayed imageshaemangiomas tend to retain contrast on delayed (>5 minutes) contrast-enhanced imagesatypical haemangiomas may demonstrateslightly altered enhancement patterns

T1 C + (hepatobiliary contrast, Eovist)in general, delayed imaging with Eovist/Gd- BOPTA may not be helpful since haemangiomas can have a variable appearance that ranges from hypointensity to diffuse and central enhancementDWI: hyperintense on diffusion-weighted imaging (DWI) even with high b-values due to slow blood flow and are hypointense on ADC map indicating restricted diffusion [16].(chan et al 2014)

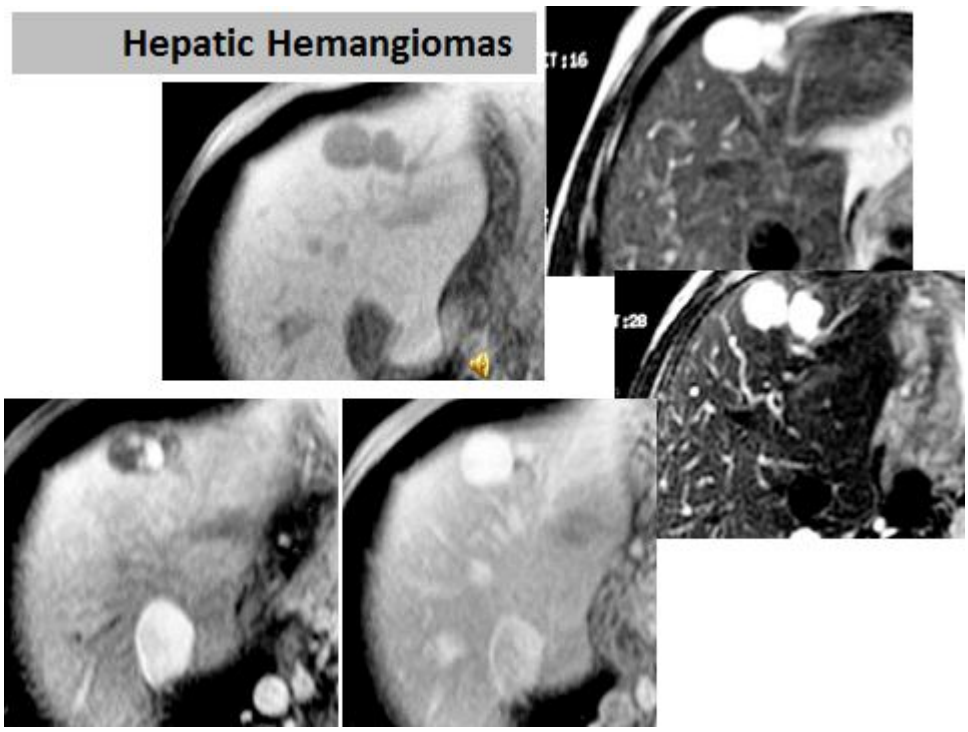

Figure (2_9) show HemangiomaMRI.(chan et al 2014)

2.3.7.1.4Nuclear medicinehaemangiomas

SPECT^{99}Tc RBC labelled SPECT can be sensitive for larger lesions and typically demonstrate decreased activity on initial dynamic images followed by increased activity on delayed, blood pool images.

2.3.8 Liver Metastases:

A liver metastasis is a cancerous tumor that has spread to the liver from another place in the body.Causes of Liver MetastasesThe risk that cancer will spread (metastasize) to the liver depends on the location of the original cancer. Primary cancers that are most likely to spread to the liver are cancers of the: Breast ,colon ,rectum ,kidney ,esophagus ,lung ,skin ,ovaries ,uterus ,pancreas ,stomach..(chan et al 2014)

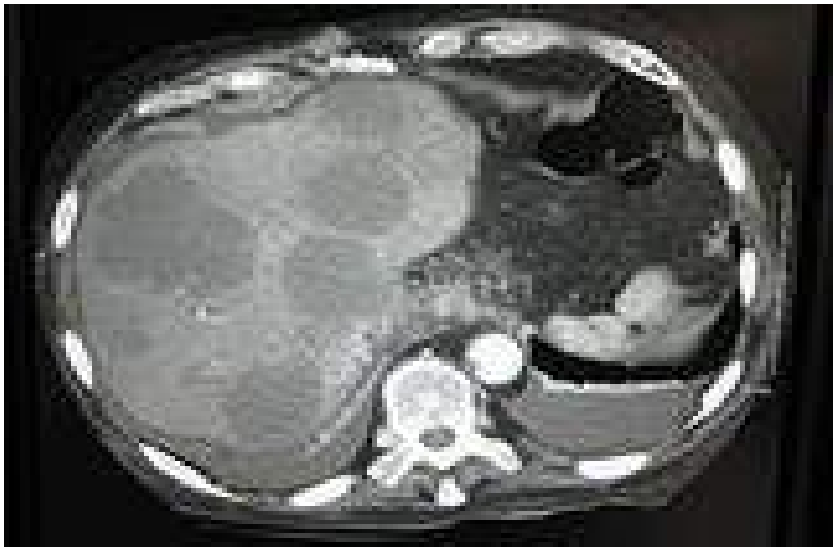

Figure (2_10) show CT Metastases.(chan et al 2014)

Symptoms of Liver Metastases loss of appetite ,weight loss ,dark-colored urine ,abdominal swelling or bloating ,jaundice (yellowing of the skin or the whites of the eyes) ,pain in the right shoulder ,pain in the upper right abdomen ,nausea ,confusion ,sweats and fever

2.4 Computed tomography (CT)

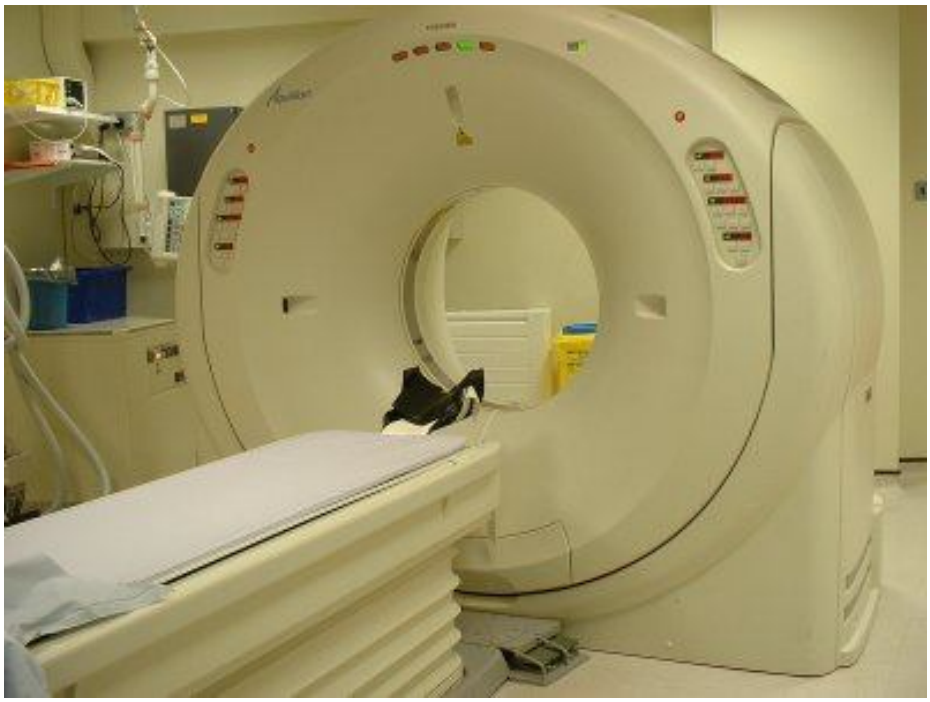

Figure (2_11) showComputed axial tomographyor computer –assisted tomography (CAT)

2.4.1 CT History:

CT was invented in 1972 by British engineer Godfrey Hounsfield of EMI Laboratories, England and by South Africa-born physicist Allan Cormack of Tufts University, Massachusetts. Hounsfield and Cormack were later awarded the Nobel Peace Prize for their contributions to medicine and science.(https://en.m.wikipedia, org/wiki/ct scan)

The first clinical CT scanners were installed between 1974 and 1976. The original systems were dedicated to head imaging only, but "whole body" systems with larger patient openings became available in 1976. CT became widely available by about 1980. There are now about 6,000 CT scanners

installed in the U.S. and about 30,000 installed worldwide.(https://en.m.wikipedia, org/wiki/ct scan)

During its 25-year history, CT has made great improvements in speed, patient comfort, and resolution. As CT scan times have gotten faster, more anatomy can be scanned in less time. Faster scanning helps to eliminate artifacts from patient motion such as breathing or peristalsis. CT exams are now quicker and more patient-friendly than ever before. Tremendous research and development has been made to provide excellent image quality for diagnostic confidence at the lowest possible x-ray dose.

2.4.2 CT Protocolling:

The happens when an exam is requested A requisition is completed.The requested exam is protocolled according to history, physical exam and previous exams. The patient information is confirmed The exam is then performed images are ready to be interpreted in uncomplicated exam – 5-10 minutes after completion complicated exams with reconstructions take at least 1 hour but usually 1-2 hours.

2.5 Contrast Media:

Different tissues within the body attenuate the beam of X-rays to different degreesSince 1973 an imaging technique known as computed tomography (CT) has developed to become one of the most important radiological examinations in the industrialised countries. CT uses conventional X-rays in a thin nondivergent beam to produce cross sectional images of the body. The X-ray tube and an array of detectors mounted within a supporting framework, rotate round the patient with each scan. CT produces digitalized

images, although these are usually printed onto hard copy film in a format that is useful for transfer and viewing throughout the hospital. By electronic means CT improves via a higher contrast sensitivity, the natural radiological contrast between organs. However, it cannot create contrast where none exists naturally. CT is exceptionally sensitive to contrast media and can detect abnormalities, caused by disease, following an injection of an intravenous dose of contrast medium. This procedure is known as "enhancing" the scan. About 43% of all CT procedures involve the use of a contrast medium. CT is widely used throughout the body but the most frequently investigated areas using this technique are neuroradiology (brain and lumbar spine) and general radiology of the chest, abdomen and pelvis. It is particularly useful for the diagnosis, staging and follow up of malignant disease. There are numerous types of contrast media which have different applications, depending on their differing chemical and physical properties. Radiological contrast media are usually water soluble solutions, but there is one commonly used variety that is based on a suspension of large insoluble particles.

2.6 CT Generations:

2.6.1 Definition of Generation:

Classification of computed tomography (CT) Based upon: arrangement of components and mechanical motion required to collect data.“Generation” the order in which CT scanner design has been introduced and each has a number associated with it. Higher generation number NOT a higher performance systems(https://en.m.wikipedia,org/wiki/ct scan) First

Generation Design: single X-ray source and single X-ray detector cell to collect all the data for a single sliceSource and detector, rigidly coupled.Beam: Pencil beam translated across patient to obtain set of parallel projection.Measurements at one angleSource/detector rotate slightly and a subsequent set ofmeasurements are obtained during a translation past patient.Process is repeated once for each projection angle until 180 projections , across a 24 cm FOVTranslation and rotation process, this geometry is referred to as a translate/rotate scanner.

2.6.2 **FirstGeneration**

EMI Mark I scanner (1973)Earliest versions:4.5 minutes for a single scan and thus were restricted to some regions (patient motion controlled).Later versions: procedures = series of scans procedure time reduced somewhat by using two detectors so that two parallel sections were acquired inone scanContrast resolution of internal structures was unprecedented, images had poor spatialResolution very poor.

2.6.3 Second Generation:

Design: multiple detectorsB/C X-ray source emits radiation over a large angle, the efficiency of measuring projections was greatly improvedSource and array of detectors are translated as in a first generation system.but since beam measured by each detector is at a slightly different angle with respect to object, each translation step generates multiple parallel ray projections

Multiple projections obtained during each traversal past the patientthis scanner is significantly more efficient and faster than 1st one.

This generation:a translate/rotate scanner.Second CTPros: reducing scan time The trunk could be imagedBy adding detectors angularly displaced, several projections could beobtained in a single translation Early versions: 3 detectors each displacedby1(https://en.m.wikipedia, org/wiki/ct scan)

Since each detector viewed the x-ray tube at a different angle, a single translation produced3projectionsThe system could rotate 3°to the next projection rather than 1°make only 60 translations instead of 180 to acquire a complete section Scan times were reduced X 3 Later versions: up to 53 detectorsFastenough (tens of seconds) topermit acquisition during a single breath holdFirst designs to permit scans of the trunkBecause rotating anode tubes could not.

2.6.4 Third Generation:

Design: larger array Of detectors(300-700detectors, usually circularShorter scanning time (2 sec)Designers: pure rotational scanning motion could be used , then it would be possible to use higher-power ,rotating a node x-ray tubes and thus improve scan speeds in thicker body parts “Slam-bang translational motion”was replaced with smooth rotational motion

higher-output rotating anode x-ray tubes could be usedgreatly reducing scan timesX-ray tube is collimated to a wide x-ray beam (fan-shaped)Directed toward an arc-shaped row of detectorsTube and detector array rotate around patient Different projections are obtained during rotation by pulsing x-ray source or by sampling the detectors at a very high rate.

Third CTImprovement in detector and data acquisition technologydetector array with enough, high spatial resolution cells to allow measurement of a

fan-beam projection of entire patient cross-sectionSampling considerations required scanning an additional arc of one fan angle beyond 180°, although most scanners rotate 360° for each scan.

Current helical scanners are based on modifications of rotate-rotate designsScan times = few seconds or less, and recent versions are capable of subsecond scan timesImaging process is significantly faster than 1st or 2nd generation systemsRotate/rotate, wide fan beam

(https://en.m.wikipedia,org/wiki/ct scan)

Number of detectors increased substantially (to more than 800 detectors)Angle of fan beam increased to cover entire patientEliminated need for translational motionMechanically joined x-ray tube and detector array rotate

TogetherNewer systems have scan times of ½ secondCons: very high performance detectors are needed to avoid ring artifacts and the system is more sensitive to aliasing than 1st or 2nd generation scanners.

2.6.5 Fourth Generation:

Design: stationary detector ring & rotating X-ray tubeReduced motion resulted in reduction in complexityStationary detector requires a larger acceptance angle for radiation, and is therefore more sensitive to scattered radiation than the 3rd generation geometryRequire larger number of detector cells and electronic channels (higher cost) to achieve the same spatial resolution and dose efficiency as a 3rd generation systema rotate-stationary or rotate only geometry(https://en.m.wikipedia, org/wiki/ct)

Fourth CTDesign: also eliminated translate-rotate motionCircular array of FIXED detectors scanSource only rotates within a stationary ring of detectorslarger fan beam.Shorter scanning timeEarly versions: had some 600 detectorsLater versions: had up to 4,800Limitation: less efficient use of detectors , less than 1/4 are used at any point during scanningOnly the x-ray generator and tube rotate at 360 ,thusshortening the scanning time even more

2.6.6 5th Generation:

Design: x-ray tube is a large ring that circles 0 patient, opposed to detector ringUse: for cardiac tomographic imaging “cine CT”X - rays produced = high - energy electron beamNo moving parts to this scanner gantryIt is capable of 50 - millisecond scan times and can produce 17 CT slices/secondstationary/stationary geometry(https://en.m.wikipedia, org/wiki/ct scan)

2.6.7 Sixth Generation:

1990,Significant advancement in technologyAllowed 3D image acquisition within a single breath holdSpiral/Helical CTDesign: x-ray tube rotates as patient is moved smoothly into x-ray scan fieldSimultaneous source rotation, table translation and data acquisitionProduces one continuous volume set of data for entire regionData for multiple slices from patient acquired at 1sec/slice

2.6.8 Seventh Generation:

New Technology, single row had its limitationDesign: multiple detector arrayThe collimator spacing is wider and more of the x-rays that are produced by the tube are used in producing image dataOpening up the collimator in a single array scanner increases slice thickness, reducing spatial resolution in the slice thickness dimensionWith multiple detector array scanners, slice thickness is determined by detector size, not by the collimatorSeventh Generation CT“turbo-charged” spiralUp to 8 rows of detectors4 rows, large volume of patient scanned 1 BH(thorax, abdomen, pelvis) at onceAllows 1mm sections though chest in 20 secImprovement in detailsProblem with PACS, stain on storage systemSeventh CTCone Beam & multiple parallel rows of detectorsWidened (z-direction) x ray beam & detector array to acquire multiple (4-64 slices simultaneously)Advantage: reducing scan time/ increase z-resolutionDisadvantage: less scatter rejection compared to single slice, very expensive

2.7Advantages andDisadvantagesof computerized tomography

Better detail compared with ultrasonography.Relatively quick compared with MRI scanning.Most systems can be scanned - eg, brain to leg. (https://en.m.wikipedia,org/wiki/ct scan)Requires breath holding which some patients cannot manage.Artifact is common - eg, metal clips.CT scans of the brain can be affected by bone nearby.High doses of radiation are involved in CT scanning - chest CT scan is equivalent to 350 chest X-rays; CT abdomen to 400 chest X-rays and CT pulmonary angiography 750 chest X-rays.There is also a risk of childhood cancer and leukemia in mothers who have imaging during pregnancy.[However, some of the studies are small and difficult to interpret due to confounding factors. Imaging to aid

potentially fatal conditions during pregnancy should not be withheld.(https://en.m.wikipedia, org/wiki/ct scan) .

2.8CT Scanworke

Computed tomography (CT) medical-imaging systems generate three-dimensional (3-D) images of internal body structures using complex x-ray and computer-aided tomographic imaging techniques.
The x-ray images used to generate the tomographic images are generated first by exposing the patient to a fan-shaped x-ray beam and then detecting the projected image on a thin semicircular, digital x-ray detector. The patient is placed between the source and detector, and the detector is configured with its geometric center located at the x-ray source. Each image is an x-ray projection of a very thin transverse slice of the body. To collect the multitude of x-ray projections necessary to generate a tomographic CT image, both the x-ray source and detector are rotated about a patient within a supporting gantry. While the source and detector rotate, images are collected and stored. As in a traditional x-ray, the signal levels in the image slice represent the relative radio density of the patient along a line from the x-ray source to the corresponding pixel location. (https://en.m.wikipedia, org/wiki/ct scan).

To improve image-capture times and resolution, manufacturers utilize multislice CT imaging techniques. Instead of a single 2D detector array which provides only a single image slice, multislice imaging uses a 3-D array. The added imaging dimension allows the system to generate multiple slices in parallel. Photo detector arrays used in CT imaging have as many as 1000 detectors in the long dimension along the semicircular detector arch;

16 or more detectors are positioned in the shorter dimension tangential to the arch. The number of detectors in the short dimension determines the number of available image slices.https://en.m.wikipedia,org/wiki/ct scan

The patient is exposed to a fan-shaped x-ray beam and the projected image is detected on a thin, semi-circular digital x-ray detector. Modern CT imaging systems can also generate images in any plane within the body by using a technique called spiral CT. In a spiral-CT system the patient is slowly moved into the center of the gantry while the x-ray source and detector rotate about the patient. Very-high-speed computers are necessary to process the images collected in this manner. Sophisticated tomographic imaging techniques are used to produce the required image. Block diagram of a **CT imaging system**. For a list of Maxim's recommended CT imaging

X-Ray DetectionEarly CT imaging systems accomplished x-ray detection using both scintillation crystals and photo-multiplier tubes. The scintillation crystals converted x-rays to light and the photomultiplier tubes converted these light signals to a usable electrical signal. Modern CT systems now employ more sophisticated scintillation crystal materials and solid-state photo detector diodes for this purpose.
The output from each photodiode is a current proportional to the light striking the diode. These currents can be directly converted to a voltage by a low-noise transimpedance amplifier (TIA), or integrated over time using a capacitor or active integrator op-amp circuit to produce a voltage output. Integration of the current from each diode can be accomplished in multiple ways. Capacitance in the photodiode detector array itself can be used for this purpose. The signals from these capacitors are multiplexed using FET

switches in the diode-array detector. The signals are then routed to the digital acquisition system (DAS) which amplifies and converts the signals to a digital format using high-resolution analog-to-digital converters (ADCs). An alternative method routes the signals from every photodiode to an integrator in the DAS. In these implementations, the integrated current signals are converted to a voltage, sampled at the same time, and multiplexed into the input of an ADC.

2.9Machine Components of CT scanner:

Gantry ,Data Acquisition System (DAS) and Operating console

2.9.1 Gantry:

The gantry is the 'donut' shaped part of the CT scanner that houses the components necessary to produce and detect x-rays to create a CT image. The x-ray tube and detectors are positioned opposite each other and rotate around the gantry aperture. Continuous rotation in one direction without cable wrap around is possible due to the use of slip rings(https://en.m.wikipedia, org/wiki/ct scan)

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Figure (2_12) CT compound

gantry aperture (720mm diameter) ,microphone ,sagittal laser alignment light ,patient guide lights ,x-ray exposure indicator light emergency stop buttons ,gantry control panels ,external laser alignment lights ,patient couch and ECG gating monitor (https://en.m.wikipedia,org/wiki/ct scan)

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Figure (2_13)**CT Gantry Control Panel:**

gantry tilt (+/-30 degrees) ,laser alignment lights on/off ,couch in/out

free (manual) couch movement,zero couch position ,couch up/down

home button (couch out & down) (https://en.m.wikipedia,org/wiki/ct scan)

2.9.2 Detectors:

Two types of detectors are usedScintillation Detectors,Gas filled Detectors.

Scintillation Detectors **,**Materials usedSodium Iodide ,Bismuth Germanium Oxide ,Cesium Iodide and CadmiumTungstateGas Filled DetectorsMaterials Used:Xenon ,Krypton and Xenon +Krypton.

2.9.3Data Acquisition System:

Data acquisition systems (DAS) interface between the real world of physical parameters, which are analog, and theartificial world of digital computation and control. Withcurrent emphasis on digital systems, the interfacing functionhas become an important one; digital systems are usedwidely because complex circuits are low cost, accurate, andrelatively simple to implement. In addition, there is rapidgrowth in the use of microcomputers to perform difficultdigital control and measurement functions.

Computerized feedback control systems are used in manydifferent industries today in order to achieve greater pro-ductivity in our modern industrial societies. Industries thatpresently employ such automatic systems include steelmaking, food processing, paper production, oil refining,chemical manufacturing, textile production, cement manufacturing, and others.

The devices that perform the interfacing function between analog and digital worlds are analog-to-digital (A/D)and digital-to-analog (D/A) converters, which togetherare known asdata converters.

Some of the specificapplications in which data converters are used include datatelemetry systems, pulse code modulated communications,automatic test systems, computer display systems, videosignal processing systems, data logging systems, andsampled data control systems. In addition, every laboratorydigitalmultimeter or digital panel meter contains an A/Dconverter.(https://en.m.wikipedia, org/wiki/ct scan)

2.9.4 Operating Console:

CT imaging systems can be equipped with two or three consoles. One consoles is used by the CT radiologic .Technologist to operate the imagine system .Another console may be available for a technologist to post –process images for filming and filing .A third console may be available for the physician to view the images and manipulate image Contrast , size ,and general visual appearance. The operating console contains meters and controls for proper imaging factors, for proper mechanical movement of the gantry and the patient couch , and for the use of computer commands that allow image reconstruction and transfer. The physicians viewing console accepts the reconstructed image from the operators console and displays it for viewing and diagnosis. (https://en.m.wikipedia,org/wiki/ct scan)

2.9.5 Image Reconstruction in CT:

Image reconstruction in CT is a mathematical process that generates images from X-ray projection data acquired at many different angles around the patient. Image reconstruction has a fundamental impact on image quality and therefore on radiation dose. For a given radiation dose it is desirable to reconstruct images with the lowest possible noise without sacrificing image accuracy and spatial resolution. Reconstructions that improve image quality can be translated into a reduction of radiation dose because images of acceptable quality can be reconstructed at lower dose. – (https://en.m.wikipedia,org/wiki/ct scan)

CT gantry couch top ,couch pedestal ,couch control pedals (up/down & in/out) and Velcro patient immobilization strap The patient lies on the couch (also known as a table) and is moved through the CT gantry aperture during the CT examination. Depending on the body part to be scanned and

the protocol selected the patient may be positioned supine or prone and either head or feet first. A weight limit for the couch of approximately 205kg (450lb) is specified by the manufacturer beyond which the movement of the table is not guaranteed to be accurate and may even resultindamage. (http://www.wikiradiography.net/m/m/page/Gantry)

The couch top is usually made of carbon fiber due to its strength and low x-ray attenuation properties. A thin radiolucent mattress and a pillow are placed on the couch top to increase patient comfort. Detachable Velcro straps can be used to help immobilize and secure an active patient. The couch top must be capable of moving at least 1800mm to allow the patient to be scanned from 'head-to-toe' without having to be repositioned. The couch pedestal (or base) houses the electronic and mechanical components that allow the couch to move in both the horizontal (longitudinal) and vertical direction. The pedestal allows the height of the table to be altered in the vertical direction to make it easier for patients with varying levels of mobility to access it. The foot pedals offer an alternate to using the controls on the CT gantry to move the couch up/down and in/out. The couch can also be moved remotely by the CT operator from the control console. During conventional slice-by-slice scanning the couch is indexed (moved) between each scan depending on the slice thickness and slice instrumentation (degree of overlap or separation) that has been selected for that examination. For spiral/helical CT, including multislice CT, the couch is translated through the gantry at a constant speed depending on the length of the area to be scanned, the total scan time, and the pitch that has been selected.

2.10Radiographic techniques:

2.10.1Preparation of CT

.Release cloths and wear gown ,Away any metal object ,The patient well not eat or drink anything 8 hours before examination.,Stop medication will made allergies ,Obtain RFT (renal function test) and Inform the physician if there is any possibility of pregnancy. (Thomsen 2003).

2.10.2 Technique CT Abdomen:

Patient positioningCenter the patient within the gantry and Patient supine (feet or head first).

Scan rangeScan from top of liver to either iliac crest or pubic symphysis, depending on clinical indications.

Suspension of respirationPatient should be instructed to hold his \her breath at end of inspiration.

Oral contrast is often used to enhance CT images of the abdomen and pelvis. There are two different types of substances used for oral CT contrast. The first, barium sulfate, is the most common oral contrast agent used in CT. The second type of contrast agent is sometimes used as a substitute for barium and is called Gastrografin.

r and kidneys. "Intravenous" means that the contrast is injected into a vein using a small needle. Some imaging exams of the abdomen and gastrointestinal system use both the intravenous iodine and orally administered barium contrast for maximum sensitivity.The intravenous CT contrast is clear like water and has a similar consistency. It is typically packaged in glass bottle or vial. A sterile syringe is used to draw it from the

bottle or a power injector is used to administer the contrast. Typically between 75 cc to 150 cc (about 2.5 oz. to 5 oz) of contrast is used depending upon the patient's age, weight, area being imaged and cardiovascular health.(S. Thomsen 2003).

2.10.3Liver techniques:

Single phase CECTScan is typically to evaluate liver pathology and acute abdomen or suspected abdomen infection, with imaging usually in portal venous phase.

DualphaseliverThis scan is performed for further characterization of a known or suspected liver lesion. With imaging usually arterial and delay or artiovenous and delay This scan is performed for further characterization of a known or suspected liver lesion in a non-cirrhotic patient and to “rule out liver metastases,” particularly in patients with malignancies known to produce hyper vascular metastases (breast, renal, melanoma, neuroendocrine, GI stromal tumor, sarcomas, thyroid, and testicular.) (S. Thomsen 2003).

Tri PhaseStudy of Liver Triphasic spiral liver Computed Tomography (CT) isa standardized procedure for the detection andcharacterization of a large variety of benign and malignantliver lesions.

This helps in the decline of mortality and morbidity rates among patients with liver disease Spiral computed tomography has gained acceptance as the preferred computed tomography technique for routine liver evaluation because it provides image acquisition at peak enhancement ofliver parenchyma during a single breath hold. In addition fast data acquisition

allows successive scanning ofthe entire liver at different intervals after injection of theiodinatedcontrast material, thus creating the possibility ofmultiphaseliver computed tomography The purpose of this study was to investigate if Triphasic Spiral CT (arterial, portal and equilibrium phases) can improve the characterization of noncystic focal lesions Triphasic Spiral CT improves the characterization of HCC, FNH, adenoma and hemangioma. The arterial and the equilibrium phases add no information to the yield of the portal venous phase in metastases, except for those from pancreas neuroendocrine tumors in the arterial phase. In our experience, patients with unclassified lesions at US or conventional CT, suspected HCC and metastases from pancreas neuroendocrine tumors should be submitted to Triphasic CT of the liver. This technique however does not appear to be indicated in the study of liver metastases. From hypo vascular tumors, while it improves the detection of FNH and adenoma.

Triphasic CT scan is a good non-invasive tool andcan be used as first line imaging modality fordifferentiating benign and malignant focal liver lesion. Benign lesions like haemangioma can be reliablydifferentiated from malignant liver lesion; thereforeunnecessary biopsies can be avoided. It is also particularlyuseful for hypervascular lesions which can be easilymissed on routine CT scanning.

Guide line biopsyThere are two types of liver biopsy core biopsy fine needle aspiration (FNA).

Core biopsyA core biopsy is used to assess the liver tissues when general disease Fine needle aspiration (FNA) An image guided FNA is carried out with a much thinner needle and is used for taking a biopsy of a specific

lesion (abnormality) area within the liver. These too are nearly always carried out in Australia with image guidance.

http://m.cancer.org/treatment/understandingyordiagmosis/forwomenfacingbreaseastbiobreastiopsy.

2.14 Previous Studies:

(Helsinki 2003). This study was conducted in compliance with ethical principles based on the declaration of , the International Conference on Harmonization Guidelines for Good Clinical Practice (GCP) and the Japanese (GCP) , and was reviewed and approved by the institutional review board at each of the 15 centers involved in the study . Informed written consent was obtained from all patients . Spiral computed tomography Spiral CT examinations were performed with single or multi detector CT scanners . Unenhanced and triphasic contrast enhanced image were obtained with the same slice thickness as that of the MRI images . Between 80 and 120 ml of iodine contrast agent (300 _ 320 mg/ml) as the fixed dose was injected at a rate 2 _ 4ml/s according to routine practice of each site .Arterial , portal , venous and delayed phase imaging were preformed with the same delay as for dynamic MR imaging.

(Sik Yu et al2011) to validate the additional merit of the thinner coronal reformation images from multidetector CT (MDCT) for making the diagnosis of hepatic cystSThe multiphasic CT examinations were performed with a 64-MDCT scanner (Somatom Sensation 64, Siemens Medical Solutions, Erlangen, Germany). Scanning was performed craniocaudally using the following parameters: detector configuration: 0.6 × 64 mm, gantry rotation time: 0.33 second, pitch: 1, effective mAs: 250 and kVp: 120. Each

acquisition was performed during one breath-hold of 4-9 seconds, depending on the scan range. After obtaining an unenhanced imaging of the upper abdomen, multiphasic dynamic imaging was performed (the arterial, portal and equilibrium phases). At the time of CT scanning, the arterial and delayed phase acquisitions were restricted to the upper abdomen. The portal venous phase CT examinations included the whole abdomen and pelvis, from the diaphragmatic dome to the anal verge. To determine the scanning delay for the hepatic arterial phase imaging, a 15-second delay from the time of 100 HUs of aortic enhancement was set as the starting time for the arterial phase imaging, and this was followed by portal phase imaging, which was conducted 30 seconds from the starting point of the arterial phase imaging. Three-minute delayed equilibrium phase imaging was added for the triple-phase imaging. The transverse section data was reconstructed twice for the portal venous phase scanning: first with 5-mm-thick sections at 5-mm intervals in the transverse plane and then with 0.6-mm thick sections at 0.6-mm intervals in the transverse plane. The second set of reconstructed transverse scans was then reformatted in the coronal plane with 2-mm sections at 2-mm intervals. Reconstruction was performed with a commercially available console system that was designed for rapid reconstruction (Somaris/5 syngoCT 2006 A-W, Siemens, Erlangen, Germany), which enabled the acquisition of isotropic multiplanar reformations using the source CT data set. The average number of images was 55 for the transverse scan with 5-mm-thick sections (range: 44-60 images) and 65 for the coronal scan with 2-mm-thick sections (range: 60-80 images). For interpretation, both the transverse and coronal image sets were routinely transferred to a PACS as separate series of scans.The attenuations (mean: 17.2 HUs, standard deviation: ± 14.4) on the thinner coronal images

were significantly lower than those (mean: 40.7 HUs; standard deviation: ± 20.6) on the thicker transverse images for the small hepatic cysts (≤ 10 mm on the transverse image, $p < 0.01$). Twenty-three (79%) of the 29 cysts between 5 mm and 10 mm and 21 (51%) of 41 lesions up to 5 mm showed a mean HU value of 20 or less on the coronal reformation images.By reducing the partial volume effect, routine coronal reformation of MDCT with a thinner section thickness can provide another merit for making a confidential diagnosis of many small sub-centimeter hepatic cysts, and these small cysts are not easily characterized on the conventional transverse images

.

(PJ Robinson 2003) Distinguishing between small benign malformationsin the liver and early metastatic disease remains difficult The following characteristics of each lesion were recorded: size (maximum diameter in millimetres), shape (round or irregular), edge (sharp or unsharp), attenuation (water or soft tissue attenuation, visually assessed), internal structure (homogeneous or heterogeneous). These lesion characteristics were recorded on the first CT study for each patient, and subsequent studies were then examined to identify changes in the lesion. On the basis of serial CT images, each lesion was characterized as either stable or unstable. The unstable group included those lesions which disappeared or diminished in size over the period of observation, as well as those that enlarged. Where lesions were thought to have changed in size, the CT images were reviewed by a second observer and then by both readers in consensus

(F Edward Boas et al 2015)

Hepatic artery and portal vein blood supply coefficient calculated form triphasic liver ct examination can be used to classify hypervascular liver

lesion. These coefficient improve the specificity for diagnosing malignancy in liver lesions . When combined with traditional relative

Chapter Three

3 Material and Methods

3.1 Area, Duration

The study was done at four hospitals in Khartoum State Fedail Hospital, AlfaisalHospital , AlzitonaHospital and AlturkyCenter study was obtained during the period spanned from January 2014 up to January 2017.

3.2Material

3.2.1Patients

This study was 138 patient 64 were male and 74 were female and. All were examined with a triphasic liver CT protocol. The patients data were registered: including (age, gender, type of examination, Liver lesion CT number in addition to final radiological findings) .Patients were included if focal liver disease was suspected clinically or if previous imaging studies depicted hepatic lesions with a nonspecific appearance. The patients ages were classified as ages ranged between <10 and >60 years : Frequency and percentage were detected as follows <10 were 2(2%),11-20 were 2(2%),21-30 were 6(6.1%) , 31-40 were 6(6.1%) , 41-50 were 12(12.1%),51-60 were 42(42.4%) and ages>60 were 29(29.3%)..Patients were included if focal liver disease was suspected clinically or if previous imaging studies depicted hepatic lesions with a nonspecific appearance. Among these 15 patients were referred with a known primary malignancy and was suspected metastatic disease. 9 patients with chronic liver disease were referred because of possible hepato cellular carcinoma (HCC).

3.2.2Machines

Fedail Hospital, the CT scan machine manufactured by an Germany company (Siemens 16slices).The tube voltage used was 150kVp and 180-200mAs, 2)AlfaisalHospital, CT scan machine manufactured by an Japanese company (Toshiba 4slice) ,The tube voltage used was 150 kVp and 180-200 mAs,3) AlzitonaHospital, CT scan machine manufactured by an Japanese company (Toshiba 64 slice) .The tube voltage used was 150kVp and 200-

240mAs, 4) AlturkyCenter, CT scan machine manufactured by an Japanese company (Toshiba64) .The tube voltage used was 150 kVp and 200-240 mA

3.3CT Acquisition

A triphasic liver CT protocol was developed in which we used a spiral CT scanner .With the triphasic liver CT protocol, the entire liver was scanned successively in arterial, portal, and equilibrium phases. After obtaining a scout view, an unenhanced scan of the liver was acquired with 10 mm/sec table speed, 10-mm collimation. On the unenhanced scan, the craniocaudal extent of the liver was measured. 5-mm collimation and 5 mm/sec table speed were used acquisition in arterial and portal phases together were 50 rotations. The craniocaudal extent of the liver determined the number of required rotations in portal phase. The remaining number of rotations was used for the arterial phase, and table speed and collimation were adjusted to cover the entire liver. Depending on the craniocaudal extent of the liver, 5-mm collimation with 10 mm/sec table speed and 10-mm collimation with 20 mm/sec table speed were used in the arterial phase. Patients were positioned in supine position with head first, center between xiphoid process to iliac creast.The longitudinal alignment light in the midline and thehorizontal one passes just below the lower costal margin .A total from 50 to 70 mL of nonionic contrast material [Omnipaque], was injected with a power injector (into an antecubital vein).Flow rate from 3.5 to 4 contrast, the entire livers was scanned in arterial phase. After the end of the arterial phase, the liver was scanned in portal phase from 35 to40 sc, the patient was asked to breathe in and to reposition the scan plane cephalad to the liver. The scan obtained in the equilibrium phase, was 15 min after injection of contrast material.

3.4 MethodImage Interpretation

Images were reviewed on films. Comparison of the sections at the same anatomic level in the three different phases of contrast enhancement was done. Each study was interpreted by one radiologist. The enhancement characteristics of each phase were assessed by grading the attenuation of the arterial and portal venous system in comparison to liver parenchyma. The arterial, portal, and equilibnum phase images were reviewed for the presence of liver lesions. The appearance of each lesion in each phase was described on the basis of the homogeneity of the lesion in comparison to surrounding parenchyma in that phase .Additional features, defined by typical location, size and CT number (Hounsfield unit)of the lesion were used .

3.5Statistical analyses

All data obtained in the study were documented and analyzed using SPSS program version16. Descriptive statistics, including mean ± standard deviation, were calculated. Anova test was applied to test the significance of differences, p-value of less than 0.05 was considered to be statistically significant.

3.6Ethical considerations

Special consideration was given to the right of the confidentiality and anonymity for all participants. Anonymity was achieved by using number for each participant to provide link between the collected information and the participants. Justice and human dignity was considered by teaching the selected participant equally when offering them an opportunity to participatein the research. Permission for conducting the study was obtained from head of the radiology department at Khartoum hospitals.

Chapter Four

4. Result

4.1General characteristics of the sample studied

Table4. 1 .Descriptive Statistics Of The Gender Distribution,

N =138		Frequency	Percentages%

Gender	Male	64	41.0
	Female	74	59.0

Table4. 2Liver Texture, Affected Lobes

Liver texture	Homogeneous	13	33.3
	Heterogeneous	24	61.5
	Mixed	2	5.1
Liver affected Lobe	Right lobe	25	64.1
	Left lobe	6	15.4
	Both Right and Left Lobes	8	20.5

Table 4.3 Lesion Texture At Different Scanning Phase And Final diagnosis

Lesion Texture at non contrast	Homogeneous	16	41.0
	Heterogeneous	22	56.4
	Not seen	1	2.6
Lesion Texture at	Homogeneous	12	30.8

Arterial phase	Heterogeneous	27	69.2
Lesion Texture at Venus Phase	Homogeneous	11	28.2
	Heterogeneous	28	71.8
Lesion Texture at Equilibrium	Homogeneous	14	35.9
	Heterogeneous	25	64.1
Final Diagnosis	Abscess/Hypo/Homogeneous	1	2.6
	Cyst Hypo/Homogeneous	2	5.2
	Heamangiomas	7	17.9
	Hepato Cellular Carcinoma	9	23.1
	Hepatic Hydatid Cysts	1	2.6
	Metastases	15	38.5
	Multi-Cystic Lesions Hypo/Homogeneous	1	2.6
	Multi-Cystic Lesions And Abscess Hypo/Hemogenious	1	2.6
	Other Masses	2	5.2

Table4.4Descriptive Statistics Of The Liver And Lesion Dimensions (Mean Std. Deviation, Median, Minimum, and Maximum.)

	Liver Variables			**Lesion Variables**		
	liver Dimension (mm)	Liver height (cm)	Liver Width (cm)	lesion Dimension (mm)	lesion Height (cm)	lesion Width (cm)
Mean	265.43	6.31	5.45	43.53	6.57	5.66

Median	276.00	5.450	4.81	23.16	5.61	5.00
Std. Deviation	60.48	4.24	3.02	57.38	4.29	2.86
Minimum	112.84	1.73	1.31	0.00	1.34	1.70
Maximum	449.35	23.50	12.70	298.45	23.50	13.00

Table4.5 Descriptive Statistics Of The Lesion Attenuation CT Number (HU) Values At Different Scanning Phases (Mean, Std. Deviation, Median, Minimum, And Maximum.)

	Non Contrast CT number(HU)	**Arterial Phase CT number(HU)**	**Venus Phase CT number(HU)**	**Delay Phase CT number(HU)**
Mean	21.7421	19.6590	30.2237	20.6538
Median	34.5000	46.0000	49.5000	47.0000
Std. Deviation	99.64	141.55	108.92	164.04
Minimum	-558.00	-831.00	-601.00	-968.00
Maximum	122.50	86.00	109.00	100.00

Table 4.6 Multiple Comparisons Of The Lesion Size At Different Scanning Phases With Liver Size

Dimension	**Lesion Size**	**Mean Difference**	**Sig.**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Liver size	lesion Size non contrast	221.899(*)	.000	195.5245	248.2746
	lesion Size arterial phase	217.793(*)	.000	191.4180	244.1681
	lesion Size venous phase	215.273(*)	.000	188.8989	241.6489

	lesion Size equilibrium phase	216.7745(*)	.000	190.3995	243.1495

* The mean difference is significant at thep≤0 .05 level.

Table4.7 Correlations Between the Liver Sizes, Lesion Size at Different Scanning Phases with Final Diagnosis

	Dimension		Final Diagnosis
Spearman's rho	Liver Size	Correlation Coefficient	.029
		Sig. (2-tailed)	0.861
		N	39
	Lesion Size (Non Contrast)	Correlation Coefficient	.336(*)
		Sig. (2-tailed)	0.039
		N	39
	Lesion Size Arterial Phase	Correlation Coefficient	.388(*)
		Sig. (2-tailed)	0.016
		N	39
	Lesion Size Venous Phase	Correlation Coefficient	.295
		Sig. (2-tailed)	0.072
		N	39
	Lesion Size Delay Phase	Correlation Coefficient	.317
		Sig. (2-tailed)	0.053
		N	39

* Correlation is significant at the 0.05 level (2-tailed).

Table 4.8 Cross Tabulation and Correlations between the Diagnosis and the Lesions Texture at Different Scanning Phases.

		Non Contrast		Artery Phase Texture		Venous Phase Texture		Equilibrium Phase Texture	
		*HM	HT	HM	HT	HM	HT	HM	HT
Diagnosis	Haemangiomas	5	2	5	2	5	2	5	2
		13.5%	5.4%	13.5%	5.4%	13.2%	5.3%	13.2%	5.3%

	Simple Cyst	2	0	2	0	2	0	2	0
		5.4%	.0%	5.4%	.0%	5.4%	.0%	5.4%	.0%
	Metastases	5	9	2	13	2	13	3	12
		13.5%	24.3%	5.3%	34.2%	5.3%	34.2%	7.9%	31.6%
	Hepatic Hydatid Cysts	1	0	1	0	0	1	1	0
		2.7%	.0%	2.6%	.0%	.0%	2.6%	2.6%	.0%
	Abscess	0	1	0	1	0	1	0	1
		.0%	2.6%	.0%	2.6%	.0%	2.6%	.0%	2.6%
	Hepato cellular Carcinoma(Hcc)	2	7	2	7	1	8	2	7
		5.4%	18.9%	5.3%	18.9%	2.6%	21.0%	5.3%	18.4%
	Ischemia+ Infiltration	1	0	0	1	1	0	1	0
		2.7%	.0%	.0%	2.6%	2.6%	.0%	2.6%	.0%
	Multi-Cystic Lesions With Abscess	0	2	0	2	0	2	0	2
		.0%	5.4%	.0%	5.3%	.0%	5.3%	.0%	5.3%
Total		16	21	12	26	11	27	14	24
		43.2%	56.8%	31.6%	68.4%	28.9%	71.1%	36.8%	63.2%
P value		P-v ≤0.105		P-v ≤0.059		P-v ≤0.031		P-v ≤0.038	
Comments		*HT stands for heterogeneous, HM stands for homogeneous**The patients that does not appear in the statistics the lesions (Metastases)appears as iso intense							

Table (4.9): Liver lesions CT (Hounsfield) at different scanning phase and *p-value.*

	Equilibrium Phase CT(HU)	**Arterial Phase CT(HU)**	**Venous Phase CT(HU)**	**Delay Phase CT(HU)**
****Hemangiomas***	37.26±24.5	44.22±16.01	53.50±29.7	48.44±24.9
Cyst	32.62±72.5	34.57±69.7	38.54±71.2	37.86±67.2
******Metastases***	46.95±47.2	53.24±46.4	64.45±47.7	59.14±37.2
Abscess	-128.59±286.3	-196.04±423.3	-132.09±312.6	-209.17±506.2
Ischemia	39.20±0.0	44.30±0.0	51.50±0.0	42.60±0.00

***** (HCC)***	48.20±53.8	59.80±48.6	64.70±49.6	61.86±46.5
P-value	**0.001**	**0.000**	**0.000**	**0.000**

****The essential** criteria of evaluation of liver hemangiomas CT images are as follows:hypodense or isodense lesion on precontrast CT images;early peripheral nodular ring enhancement in arterial phase with centripetal fill-in in portal venous phase; and isodense lesion in the delayed phase. Based on these criteria our study considers the findings.**** Valuable** sign in differential diagnosis of hemangioma and malignant liver lesion is peripherichypodense rim at the periphery of the mass. It indicates malignant neoplasm and is never seen in hemangiomas.***** Liver**metastasesmay be hypovascular or hypervascular*

Table (4.10): Liver lesions characteristics/pattern as homogeneous (HM) and heterogeneous (HT) at different scanning phase and *p-value*.

Final Diagnosis	***Equilibrium Phase***		***Arterial Phase***		***Venous Phase***		***Delay Phase***	
	HM	HT	HM	HT	HM	HT	HM	HT
Hemangiomas	18(18.2%)	3(3.0%)	16(16.2%)	5(5.1%)	16(16.2%)	5(5.1%)	17(17.2%)	4(4.0%)
Cyst	10(10.1%)	2(2.0%)	10(10.1%)	2(2.0%)	9(9.1%)	3(3.0%)	10(10.1%)	2(2.0%)
Metastases	16(16.2%)	22(22.2%)	7(7.1%)	31(31.3%)	4(4.0%)	34(34.3%)	6(6.1%)	32(32.3%)
Abscess	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)	1(1.0%)	3(3.0%)
Ischemia	2(2.0%)	0(0.0%)	0(0.0%)	2(2.0%)	2(2.0%)	0(0.0%)	2(2.0%)	0(0.0%)
HCC	4(4.0%)	18(18.2%)	2(2.0%)	20(20.2%)	1(1.0%)	21(21.2%)	3(3.0%)	19(19.2%)
Total	51(51.5%)	48(48.5%)	36(36.4%)	63(63.6%)	33(33.3%)	66(66.7%)	39(39.4%)	60(60.6%)
P-value	0.000		0.000		0.000		0.000	

Table (4.11) The Associated findings existing with different liver lesions presented as cross tabulation

Associated findings	**Final Diagnosis of the Liver**						Total
	Hemangiomas	**Cyst**	**Metastases**	**Abscess**	**Ischemia**	**HCC**	
Uterine Cancer	9(13.5%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	9(13.5%)
Renal cell carcinoma	0(0.0%)	0(0.0%)	3(4.5%)	0(0.0%)	0(0.0%)	0(0.0%)	3(4.5%)
Lung Metastases	0(0.0%)	1(1.5%)	1(1.5%)	0(0.0%)	0(0.0%)	2(3.0%)	4(6.0%)

Spleen Metastases	0(0.0%)	0(0.0%)	5(7.5%)	0(0.0%)	0(0.0%)	0(0.0%)	5(7.5%)
Pancreatic Cancer	0(0.0%)	0(0.0%)	8(12.0%)	0(0.0%)	0(0.0%)	0(0.0%)	8(12.0%)
Breast/Adrenal Cancer	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(3.0%)	2(3.0%)
Lung mass	0(0.0%)	0(0.0%)	7(10.4%)	0(0.0%)	0(0.0%)	3(4.5%)	10(14.9%)
Gallbladder mass	0(0.0%)	0(0.0%)	3(4.5%)	0(0.0%)	0(0.0%)	0(0.0%)	3(4.5%)
Splenomegly	0(0.0%)	1(1.5%)	3(4.5%)	1(1.5%)	0(0.0%)	4(6.0%)	9(13.5%)
Ascites	1(1.5%)	0(0.0%)	2(3.0%)	0(0.0%)	2(3.0%)	3(4.5%)	8(11.9%)
Renal cyst	2(3.0%)	2(3.0%)	0(0.0%)	1(1.5%)	0(0.0%)	0(0.0%)	5(7.5%)
Ca stomach	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(1.5%)	1(1.5%)
Total	12(17.9%)	4(6.0%)	32(47.8%)	2(3.0%)	2(3.0%)	15(22.4%)	67(100.0%)
P-value	*The correlation between the CT findings in the liver and other associated findings is found to be significant at p≤0.005.* p=0.000						

Chapter five

5.1 Discussion.

The presence of benign focal liver lesions such as cysts, hemangiomas is of high frequency and characterization of these lesions is essential. In addition, in many patients who are referred for liver CT, one does not know what kind

of abnormality will be present. Consequently, the preferred liver CT technique should combine a high sensitivity for lesion detection with a good ability for lesion characterization, to differentiate lesions that do need further diagnostic tests or treatment from lesions that do not.Tables (4.1) gender.Tables (4.2) liver texture affect lobes ,lesion texture at different scanning Tables (4,4) presented the liver dimensions, height and width in addition the lesions Table (4.5)measurements and lesion CT number (Hounsfield).

To meet the characterization requirements, a triphasic spiral CT technique was obtained to image the entire liver in arterial, portal, and equilibrium phases. A contrast material protocol was used to achieve sufficient arterial opacification during the arterial phase, intense parenchyma opacification in the portal phase, and hyper attenuating vascular space in the equilibrium phase. The liver texture was also evaluated, most of the liver changes was as Heterogeneous 24 out of the 39 patients followed by 15 were homogeneous and mixed the right lobe of the liver was found to be the most affected lobe 25 out of the 39patients. Lesion texture at non contrast images appears: homogeneous, heterogeneous, or not seen as iso intense. Lesion texture at arterial, venous and delay phases were presented as high frequency of heterogeneity. This was presented .

Table (4.6) shows the multiple comparisons of the lesion size at different scanning phases with liver size, the results showed significant relation at $p \geq 005$.

Spearman's rho analyses was obtained and the liver and lesion size were evaluated and correlated with the CT final diagnosis, no significant relation

was detected regarding the liver size with the final diagnosis . Lesion Size at non contrast examination, Arterial Phase, Delay Phase was found to be significant at 0.039, 0.016, and 0.053 respectively. This was presented in table .Triphasic liver CT is a standardized CT procedure, designed to enable detection and characterization of a large variety of liver lesions, also in the presence of different pathologic conditions. The portal phase images, is acquired at the peak of liver enhancement are the focus of the protocol and are essential for lesion detection but the results showed that there is weak significant relation between the final diagnosis and lesion size in the venous phase. Arterial phase images are helpful in the detection of hyper vascular lesions and are essential for the characterization of a large percentage of lesions Tables (4. 8). Equilibrium phase images further aid in lesion characterization. Our results demonstrate that characterization of frequently occurring benign focal liver lesions, including hemangioma, simple cyst, multi-cystic lesions, abscess and hepatic hydatid cysts which represented 14 [33.5%] of the 39 patients affected with liver lesions. 7 [17.9%] of 39 hemangiomas, 2 [5.2%] of the 39 were cysts, and 2 [5.2%] of other masses. Hepato Cellular Carcinoma affected 9[23.1%] and Metastases constituting 15[38.5%] out of the 39 patients.

All lesions with a homogeneous appearance were found to be benign. Conversely, heterogeneous lesions, in patients with a hyper vascular primary tumor represented malignant disease and regarding the results the triphasic techniques which characterize the lesions as homogenous or heterogeneous was found to be significantly correlated with the diagnosis to differentiate lesions as benign or malignant or metastases as seen in table (4.8).

In our Radiology department, we should decide in which patients to use triphasic liver CT. The liver is scanned with resultant increased radiation exposure. In addition, the procedure takes more time than single-phase spiral CT because of the large number of images acquired that all have to be interpreted. Therefore, one has to limit its use to patients who are likely to gain from this additional burden.

Regarding the study results patients with unclassified lesions at non contrast CT images, or patients with possible metastases from hyper vascular primary tumors, and suspected HCC constitute the vast majority of those who undergo triphasic liver CT . In these patients, triphasic liver CT should be performed as an important procedure, to provide most information needed for clinical management.

CT is particularly suited for the evaluation of metastatic disease, benign and malignant lesions as well as the inflammatory as cystic or abscesses in arterial and venous and the equilibrium phase as well .Similarly Helical CT is the preferred examination in the United States for surveillance for metastatic disease after treatment of the primary neoplasm, with multi detector CT representing the current evaluations and results.

Because most hepatic metastases are relatively hypo vascular compared with normal liver parenchyma, the lesions are hypo attenuating when imaged during the peak of hepatic parenchyma enhancement (portal venous phase). In general, therefore, imaging during the portal venous phase of hepatic enhancement is adequate to detect most hepatic lesions in most patients these results were consistent with what was mentioned in the previous studies .

Triphasic spiral liver computed tomography (CT) is a standardized procedure for the detection and characterization of a large variety of liver lesions. Spiral computed tomography has gained acceptance as the preferred computed tomography technique for liver evaluation because it provides image acquisition at peak enhancement of liver parenchyma during a single breath hold.[8,9] In addition fast data acquisition allows successive scanning of the entire liver at different intervals after injection of the iodinated contrast material, thus creating the possibility of multiphase liver computed tomography.

Attenuation of different liver findings in equilibrium phase and three contrast enhanced phases was shown in table (4.9). From the table we can notice that there were significant differences between attenuation values of lesions in arterial, venous and delay phase. The results of attenuation dynamics of hepatocellular carcinoma (HCC) are higher in all of the scanning phases when compared with hemangiomas, while it is similar to the attenuation of the metastatic lesions.The causes of increased the Hounsfield value for the (HCC) is that the (HCCs)are usually hyper vascular lesions that derive most of their blood supply from the hepatic artery with the portal venous contribution decreasing as the grade of malignancy increases. And it’s associated altered portal venous blood flow may help reveal more lesions on the hepatic arterial phase than on the portal venous phase. This is what we found in our study. In our study, most the (HCC) presented as heterogeneous; and were better seen in portal phase. These findings are in keeping with the well-known hyper vascularity of (HCC). This was similar to what was previously mentioned The significance and the importance of caring about the phase of enhancement is the fact that

lesions seen during only the hepatic arterial phase may require biopsy and patients with hyper vascular malignancies may respond to therapy.

Most metastases to the liver are hypo vascular and consequently are best detected during the portal venous phase. Hypervascular primary malignancies (HCC)and certain metastases (pancreatic carcinomas, pheochromocytomas) have a proportionately greater hepatic arterial blood supply and, as a result, may be visible only on hepatic arterial phase images.Regarding this fact the Hounsfield measured a high attenuation values in all of the scanning phase and this fact is consistent to our associated findings is that the 8(12.0%) of the cases of liver metastases; were found to have pancreas cancer and 2(3.0%) of the cases with HCC have adrenal tumor table (4.11).

The current study with spiral CT allows more rapid image acquisition and allows greater separation of arterial and venous phase. Our results differ from earlier study in that the hypervascular liver tumors were superiorly presented on venous phase images (64.70±49.6HU) rather than early arterial phase images (59.80±48.6HU). Our findings regarding tumor conspicuity is similar to those of tumor-to-parenchyma differences reported by Foley et al In previous study; tumor to liver contrast difference occurred in late arterial phase, as regards portal venous phase was found to be superior to or equivalent to late arterial phase. These findings are similar to results of Foley et al.

Because of the high frequency of benign focal liver lesions such as cysts, hemangiomas, characterization of these lesions is essential.

Liver hemangiomas is a benign well-defined vascularized lesion. Hemangioma is composed of multiple vascular channels surrounded by

endothelium cells with thin fibrotic stroma. Our study findings showed that 3(3.0%) out of 21 cases of hemangiomas were found to be heterogeneous in the equilibrium phase while 5 (5.1%) were found to be heterogeneous in both arterial and venous phase and 4(4.0%) in delay phase, this was presented in table (2) .Many hemangiomas have non-homogenous structure because of fibrosis, necrosis, and cystic zones. On unenhanced CT scans hemangiomas are hypo dense with well-defined boarders. Performing contrast enhanced CT peripheral nodular enhancement with centripetal fill in was observed as well as globular enhancement in hemangiomas was seen; this was found similar to another author .Most of the hemangiomas enhance rapidly and intensively in arterial phase. This sign makes it more difficult to differentiate hemangiomas from other hyper vascular tumors as HCC. This enhancement gives it feature of high HU in arterial phase, this was presented in table(4.9)

Our study demonstrated that some metastases cases showed the same enhancement pattern, another previous studies have mentioned the same findings is that up to 8% of all cases of metastases can be similar to hemangiomas This is the value of using HU in differentiating the metastases from hemangiomas as seen in table (4.9).

Most of the hemangiomas appear heterogenic lesions that enhance normally table (4.10).In the delay phase hemangiomas become isodense to surrounding liver parenchyma. This is one of the most important signs in differential diagnostics of hemangioma (it becomes 48.44±24.9 after 53.50±29.7) with slight peripheral enhancement was seen. This way of contrast uptake is typical of hemangioma that, according to some authors, is the last stage of the development of hemangioma.

The preferred liver CT technique should combine multiple phases for lesion detection with a good ability for lesion characterization as well as to differentiate lesions that do need further diagnostic tests or treatment therefore a triphasic spiral CT technique was used to image the entire liver in arterial, portal, and equilibrium phases.

In our study the heamangioma and cysts appear homogeneous in all of the scanning phase; this was presented in table (4.10) while abscess was found to have very low attenuation values in all phases.In the current study, metastatic lesions were either heterogeneous or homogenous table (4.10). Most of the hyper vascular metastatic lesions were best visualized on venous phase images rather than on arterial or delay phase. Most of them become iso or hypo in equilibrium phases making it difficult to diagnose on single phase thus signifying the importance of both arterial and delay phase images.

Liver is the second most common organ, where different malignant tumors metastasize. 80% patients with extrahepatic tumor are expected to have liver metastases. Our study showed that 32(47.8%) out of 67 patients having liver metastases have also associated findings: 3(4.5%) have renal cell carcinoma (RCC),1(1.5%) have lung metasteses,5(7.5%) spleen metastases,8(12.0%) pancreatic cancer, 7(10.4%) have lung masses, 3(4.5%) have gallbladder mass,3(4.5%) have splenomegly and 2(3.0%)are with ascites as seen in table (4.11).

In our cases metastases look different; the justification of that appearance is due to variations in cellular differentiation, fibrosis, necrosis, hemorrhage, and blood supply as mentioned by Kristina. et al; (2012) . This appearance was seen in metastases from (RCC), and some types of lung cancer this also was consistent with the same study [18]

Hyper vascular liver metastases (HU) is 53.24±46.4 in the arterial phase and 64.45±47.7(HU) in venous phase was found to be higher than the equilibrium phase, and were found in most of the cases. This was mentioned in previous studies that primary tumors that are the most likely to metastasize to the liver are pancreatic (70-75%), breast, gall-bladder and extra hepatic bile ducts, colon and rectal (about 60%), and stomach (about 50%)[18]

On contrast enhanced CT images characteristic of enhancement of liver metastases is determined by the primary tumor. Hypo vascular liver metastases look hypo dense on CT images, while hyper vascular liver metastases look hyper dense (greater than liver parenchyma)[18]

The borders of metastases may be sharply defined, ill-defined, or nodular, and their shape may be ovoid, round, or irregular[18] this is why our result findings showed 22(22.2%) heterogeneous pattern in equilibrium phase and 31(31.3%) in arterial and 34(34.3%) in venous phase and 32(32.3%) in the delay phase with few cases of homogeneous pattern in all enhancement phases as seen in table (4.10)

The triphasic CT examination can create certain diagnostic quandary, including the inability to specifically quantification difference of some lesions seen only on the hepatic arterial phase and not on the equilibrium or portal venous phase ,although good results were noted in our results. Lesions were labeled to have high (HU) was considered as malignant or metastases; because of hyper vascularity and the consistency with the patient's history of renal cell carcinoma (RCC) and gastrointestinal malignancy (Ca Stomach)table(1) and table(4.11).

Regarding the results, the typical CT features and the (HU) may help in differentiating liver lesions significantly table(1) and (2). There are

significant relationship between the (HU) and the CT diagnosis as hemangiomas, cyst, metastases, abscess, ischemia, hepatocelluler carcinoma(HCC), in equilibrium phase, arterial phase, venous phase, delay phase at p=0.001,0.000,0.000,0.000 respectively. The correlation between the CT findings in the liver and other associated findings is found to be significant at $p \leq 0.005$.

Our study has some limitations like small sample size especially for benign lesions. Interobserver agreement for interpretation of CT images was not calculated. Other potential limitation is that scans were performed on different CT Scanners.

5.2 Conclusion:

Triphasic liver CT enables to characterize a wide range of hepatic infiltration, focal liver lesions, including the benign and malignant lesions as well as metastases that occur most frequently.Triphasic CT scan is an acknowledged non-invasive imaging technique and can be used as first line imaging modality for differentiating focal liver lesions using this quantification method and its homogeneity in all of the scanning phases. Benign lesions like haemangioma can be reliably differentiated from malignant liver lesion using the texture and HU values .It is also particularly supportive for hyper vascular lesions which can be easily overlooked on routine CT scanning; therefore unnecessary biopsies can be avoided.

5.3 Recommendation

- To used HU and the texture or decretive of the better in the diagnosis liver lesion

- To evaluate the size of all the scan phase because small lesion was mention to be malignant

- To scan upper to xiphoid and lower to iliac crest there may be additional or associated finding

- Any present of liver lesion should be contractile

5.4 **Referance**

Baron RL, Dodd GD, Holbert BL, Oliver JH, Cam B. (1994)Helical biphasic contrast CT in evaluation of hepatocellular carcinoma . Radiology; l93(P):435.

Bonaldi VM, Bret I'M, Reinhold C, Atni M. (1995).Helical CT of the liver: value ot an early hepatic arterial phase. Radiology; 197: 357-363.

Ch'en IY, Katz DS, Jeffrey RB Jr, et al. (1997) Do arterial phase helical CT images improve detection or characterization of colorectal liver metastases J Comput Assist Tomogr; 21(3):391-397.

Foley WD, Mallisee TA, Hohenwalter MD, Wilson CR, Quiroz FA, Taylor AJ. (2000)Multiphase hepatic computed tomography with a multi row detector computed tomography scanner. AJR Am J Roentgenol; 175: 679-85.

Hollett, Brooke Jeffrey R, Nino-Murcia M, Jorgensen MJ, Harris DP. (1995)Dual-phase helical CT of the liver: value of arterial phase scans in the detection of small (< 1.5 cm) malignant hepatic neoplasms. AJR; 164:879-884.

Hwang GT, Kim MJ, Yoo HS, Lee JT. (1997)Nodular hepatocellular carcinoma, detection of arterial, portal and delayed phase images at Spiral CT. Radiology,;202:383-88

J. Ueda,Y . Kobayashyi,.Kenkoh, .Koiket, .Kubo,Y . Takanaon D K. Har (1988) Distribution of Water, Fat, and Metals in Normal Liver And In Liver Metastases Influencing Attenuation On Computed Tomography ActaRadiologica29 http://medical-dictionary.thefreedictionary.com/CTnumber

Kristina Zviniene (2012). Differential Diagnosis of Hepatocellular Carcinoma on Computed Tomography,Hepatocellular Carcinoma - Clinical Research, Dr. Joseph W.Y. Lau (Ed.), ISBN: 978-953-51-0112-3, InTech,Available from: http://www.intechopen.com/books/hepatocellular-carcinoma-clinical-research/differential-ctdiagnostics-of-hepatocellular-

Iannaccone R, Laghi A, Catalano C, Rossi P, Mangiapane F, Murakami T, et al. (2005)Hepatocellular carcinoma, role of unenhanced and delayed phase multi detector row helical computed tomography in patients with cirrhosis. Radiology; 234: 460-7.

Johnson PT, Fishman EK. (2006) IV Contrast selection for MDCT: Current thoughts and practice. AJR Am J Roentgenol; 186: 406-15.

Jones EC, ChezmarJL, Nelson RC, Bernardino ME. (1992)The frequency and significance of small (< 15 mm) hepatic lesions detected by CT. AJR; 158:535-539

Miller FH, Butler RS, Hoff FL, Fitzgerald SW, Nemcek AA Jr, Gore RM. (1998)Usingtriphasic helical computed tomography to detect focal hepatic lesions in patientswith neoplasms. AJR Am J Roentgenol; 171: 643-9.

Murakami T, Kim T, Oi H, et al. (1995)Detectability of hypervascular hepatocellular cancinoma by arterial phase images of MR and spinal CT. ActaRadiol; 36:372-376.

Oliver JH, Baron RL, Federle MP, Rockette HE Jr. (1996)Detecting hepatocellular carcinoma, value of unenhanced or arterial phase computed tomography imaging or both used in conjunction with conventional portal venous phase contrast enhanced computed tomography imaging. AJR Am J Roentgenol;167: 71- 7

Sheafor DH, Frederick MG, Paulson EK, Keogan MT, DeLong DM, Nelson RC. (1999).Comparison of unenhanced, hepatic arterial-dominant and portal venousdominant phase helical CT for the detection of liver metastases in women with breast carcinoma. AJR Am J Roentgenol; 172: 961-8.

Takayasu K, Moriyama N, Muramatsu Y, Makuuchi M, Hasegawa H, Okazaki N et al(1990). The diagnosis of small hepatocellular carcinomas efficacy of various imaging procedures in 100 patients. AJR Am J Roentgenol; 155:49-54.

Thieme 2004 and E Harold 2006 anatomy of liver

Vallls C, Andia E, Rocca Y, Cos M, Figueras J. (2002)Computed tomography in hepatic cirrhosis and chronic hepatitis. Semin Ultrasound, CT MRI; 23: 37-61.

5.5Apendex

- Hemangioma: age 45y , Male

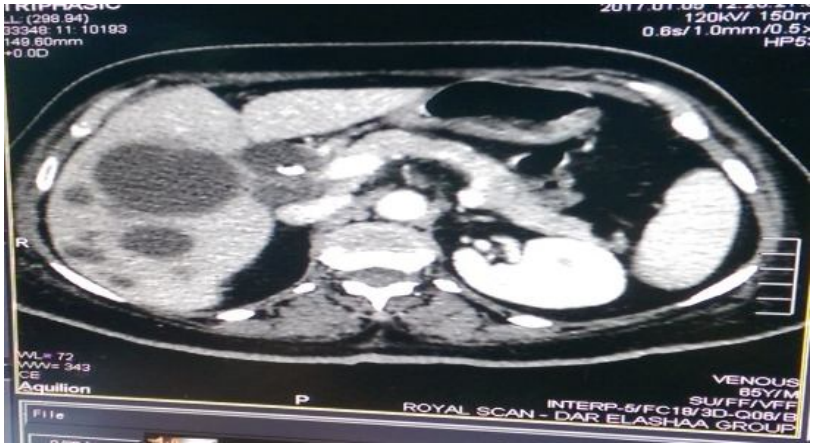
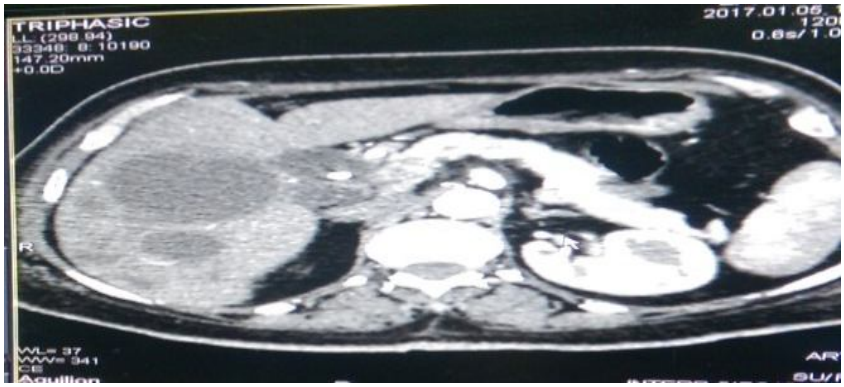


Figure 5.1 (**arterial phase)**



- Figure5.**2 (Veins phase)**

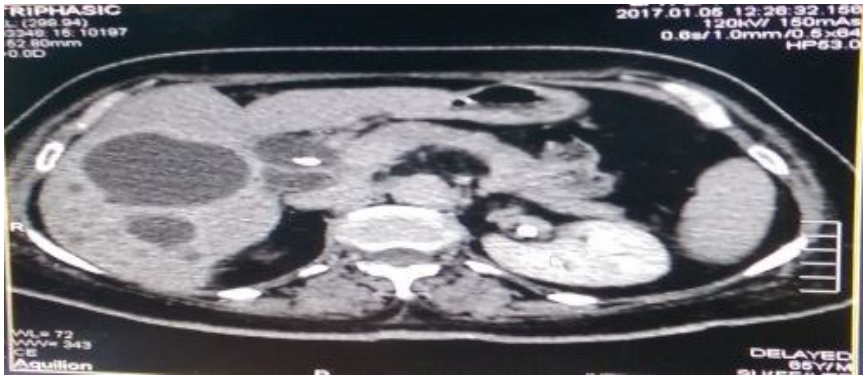


Figure 5.3(**Delay phase)**

-HCC age 75 , Female

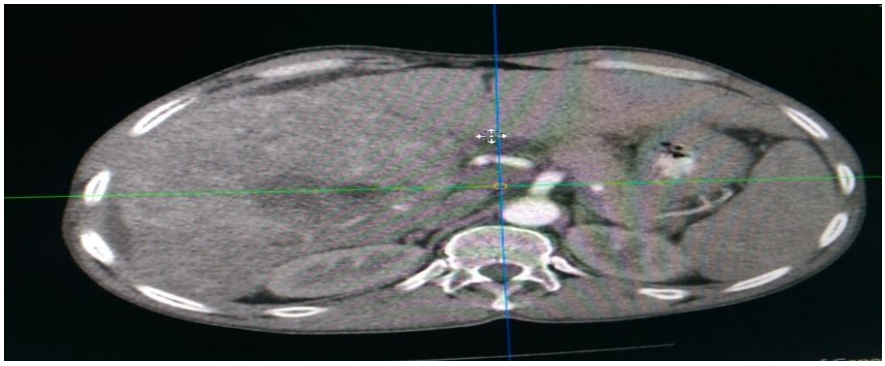
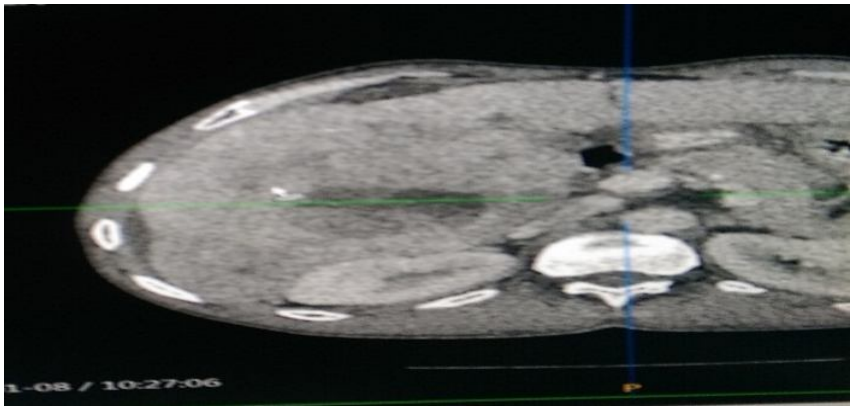


Figure5.4 (arterial phase)



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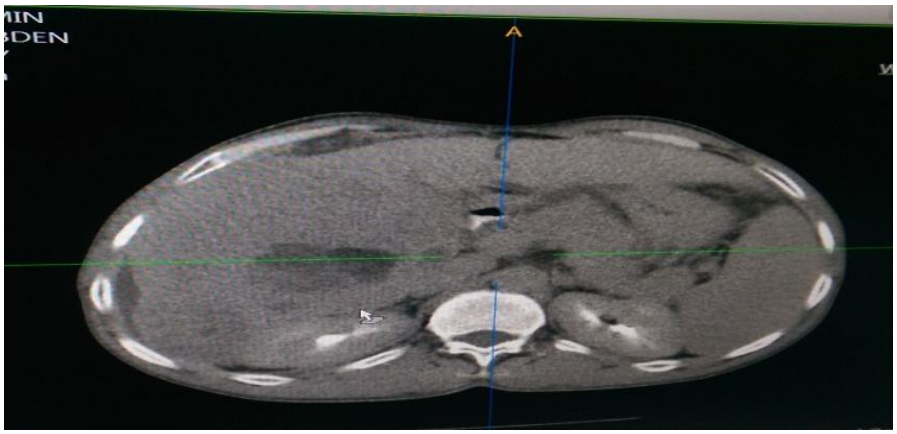


Figure 5.6(**Delay phase)**

- **Metastasis age 65 , Female**

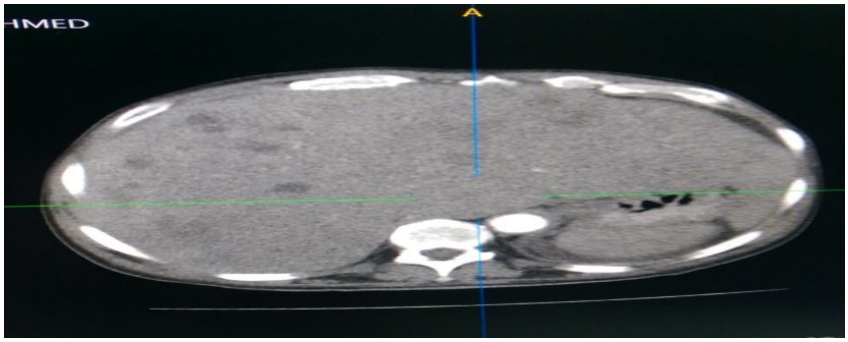


Figure 5.7(arterial phase)

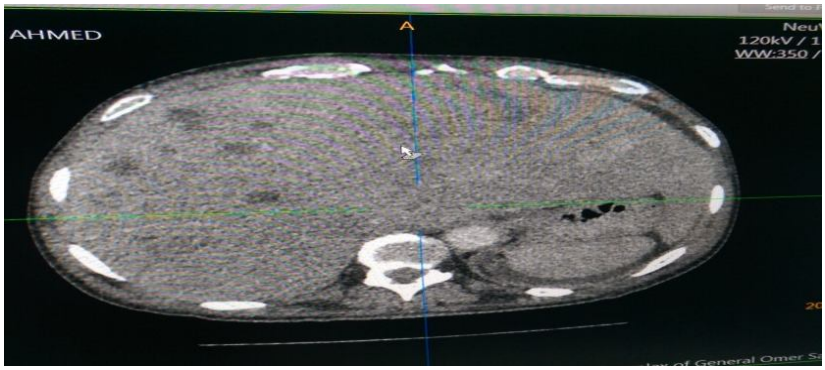
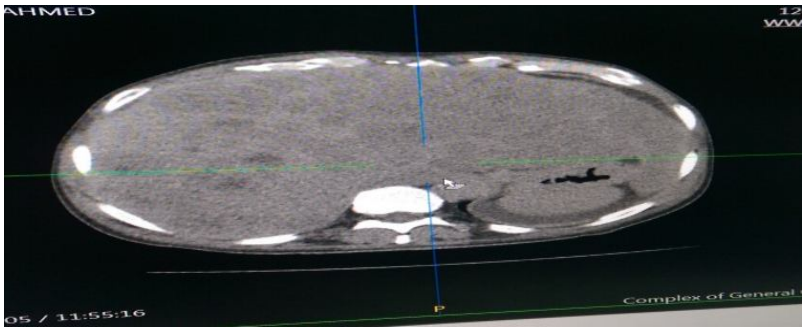


Figure 5.8 (veins)



- Figure 5.9(**Delay phase)**

- **Cyst age 56, Male**

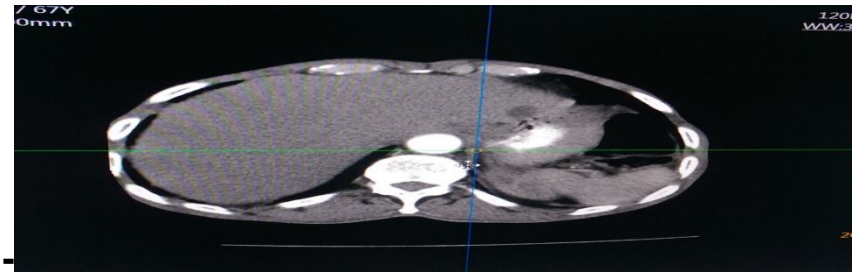


Figure 5.10(arterial phase)

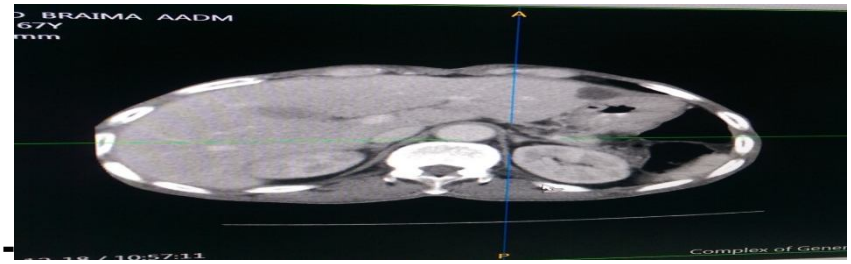


Figure 5.11(**Veins)**

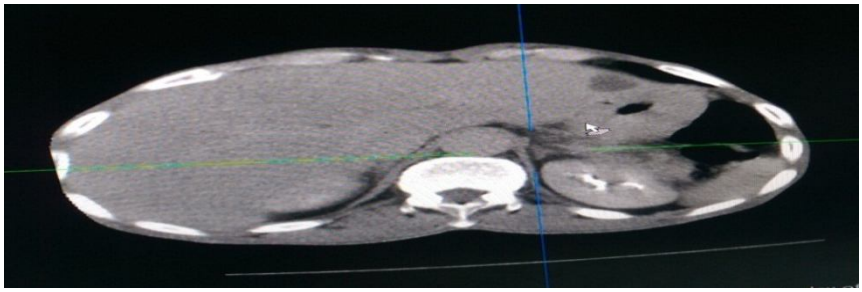


Figure 5.12 (-Delay phase)

- **Metastasis (artterial phase) age 34 , Female**

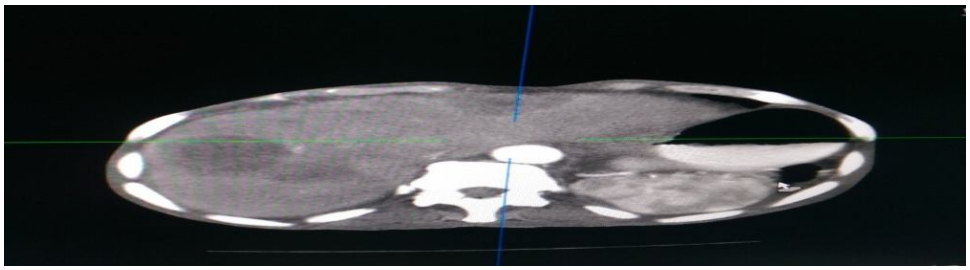


Figure 5.13

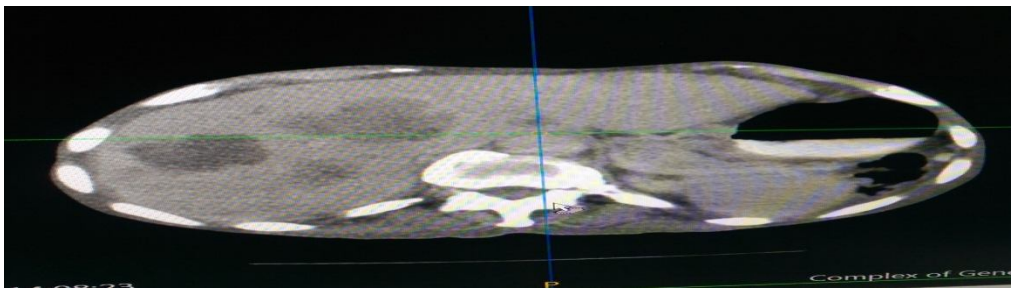


Figure 5.14(Veins phase)

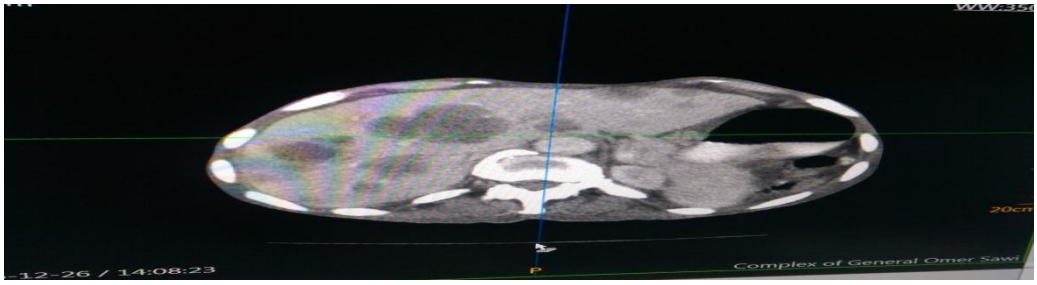


Figure 5.15 (**DELAY Phase)**

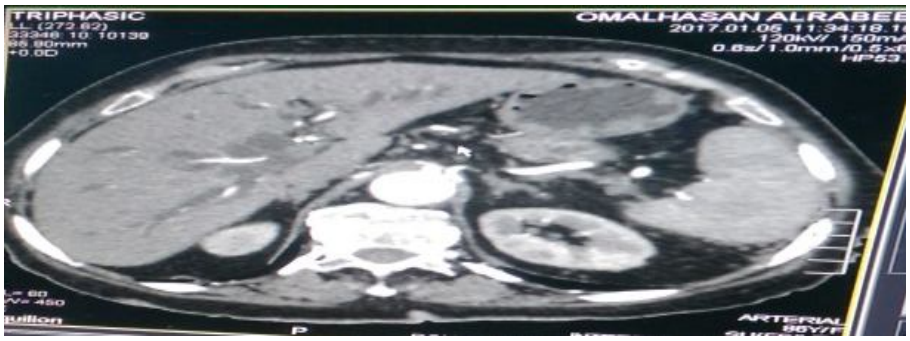
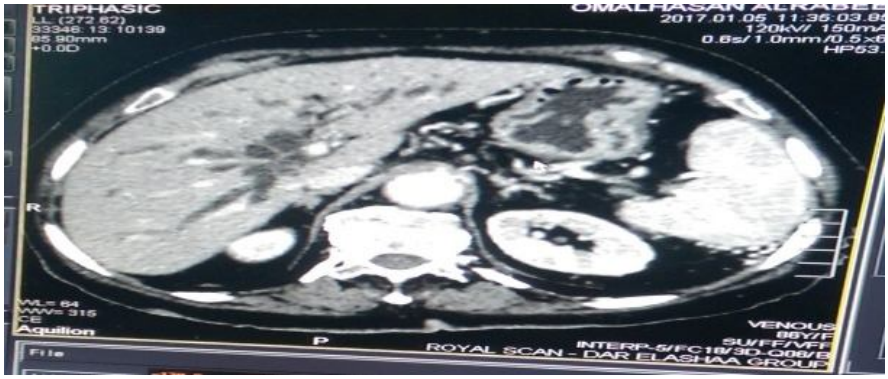


Figure 5.16(arterial phase)



- Figure **5.17(Veins phase)**

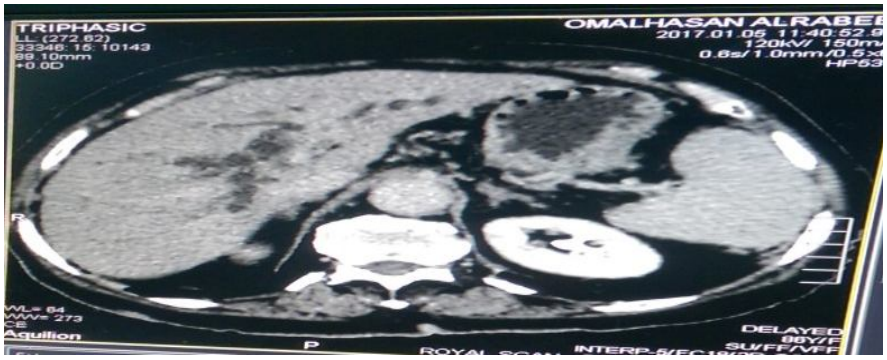


Figure 5.18 **(Dealay)**

- **Cyst age 72 , Male**

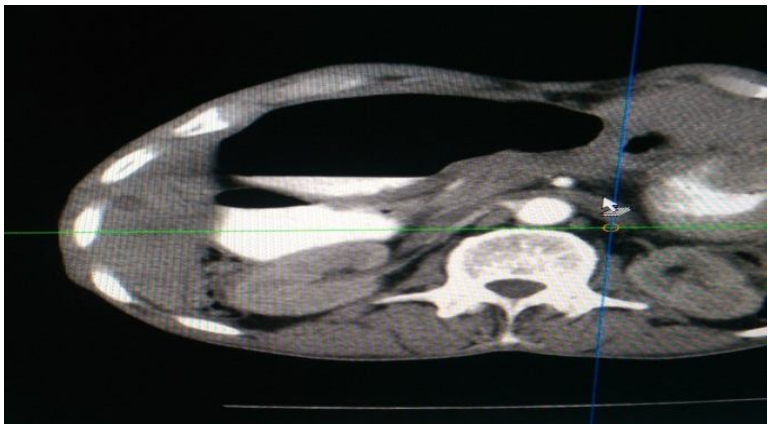
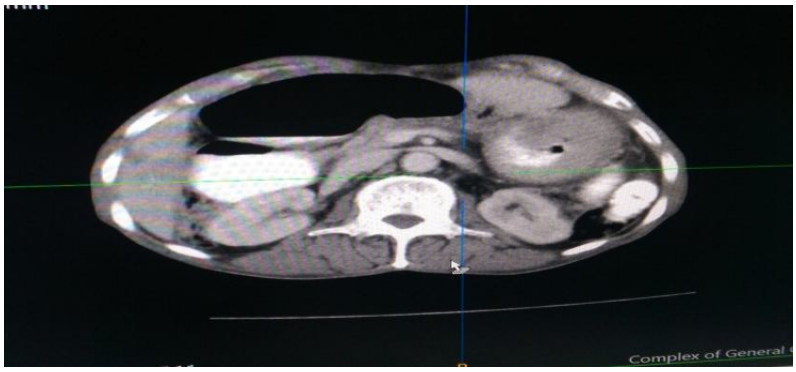
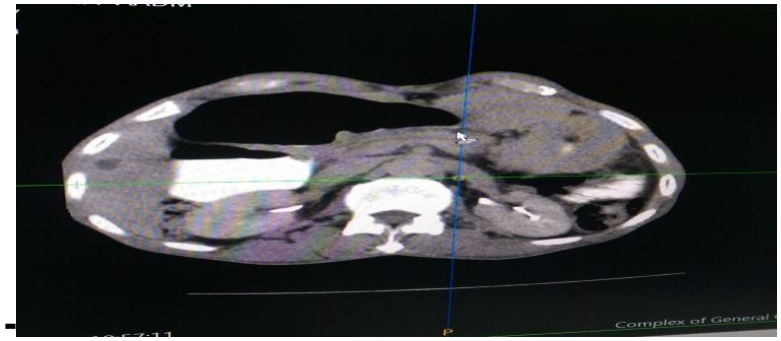


Figure 5.19(arterial phase)



- Figure 5.20 (**Veins phase)**



- Figure 5. 21 (**Delay phase)**