Sudan University of Science and Technology

College of Graduate Studies

Evaluation of Liver Tumors using Computed Tomography

تقيم إورام الكبد باستخدام الأشعة المقطعية المحوسبة

A thesis Submitted for Partial fulfillment for the Requirement of M.Sc. Degree in Diagnostic Radiologic Technology

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(الَّذِينَ آَمَنُوا وَتَطْمَئِنُّ قُلُوبُهُمْ بِذِكْرِ اللَّهِ أَلَا بِذِكْرِ اللَّهِ تَطْمَئِنُّ الْقُلُوب) {الرعد :28}

صدق الله العظيم

Dedication

I dedicate this research to my:

Loving mother& father,

Family,

Friends,

&

Everyone who teach me a word

Mohamed bakry

Acknowledge

Praise is to Allah who blessed me with knowledge of which I knew not and enable me write this thesis.

It is a great honor to express my deep gratitude and cordial appreciation to Dr. Ahmed Mostafa AbuKonna who gave me much of his effort, experience and close supervision throughout the work. He provided me continuous encouragement and support. His generous assistance and meticulous guidance had a pivotal role in the completion of this study. for providing me the experience, cooperation and close supervision throughout the work. He provided me continuous encouragement and support.

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My appreciation and deepest thanks to (FEDAIL, Khartoum, Royal Scan Hospital) for their great assistance for providing all practical facilities for the study

My great appreciation is extended to all those who shared either practically or morally in the accomplishment of this work.
I would like to extend my sincerest thanks and appreciation to those patients who helped me accomplish this study.

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List of Abbreviations

Abbreviation	Phrase
HCC	hepatocellular carcinoma
CT	Computed Tomography
HIV	Hepatitis
FLLs	Focal liver lesions
GIT	gastrointestinal tract
BUN	blood urea nitrogen
MDCT	multi-slice (multidetector-row) CT
3D	Three-dimensional
SW	slice width
EAP	early arterial phase
LAP	called late arterial phase
PVP	portal venous phase
CAST	a computer automated scanner technology
PPV	positive predictive value
FNH	focal nodular hyperplasia

ABSTRACT

Triphasic liver CT enables characterization of a wide range of focal liver lesions.

The general objective of the study is to evaluate the role of CT in diagnosis of liver lesions. And furthermore to determine which lesion in the liver with high incidence, and to find out the Geographic distribution of the liver lesions in Sudan

Sixty patients found to have focal tumoral liver lesions were recruited for 4 months period and their triphasic CT scans findings were evaluated and later correlated with final Diagnosis. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of triphasic CT scan were calculated.

The high incidence of liver lesions was (45%) in age group between (41-60) years old. The high incidence of was liver metastasis (33.3%) and solid mass (33.3%). and was commonest in age group (41-60) years old which had an incidence of (45%), it commonest in male, had an incidence of (60%), the most patients came from center, north and west of the Sudan.The solid mass of the liver was commonest in age group (61-80) years old had an incidence of (45%), it commonest in male, had an incidence of (65%), most patients came from central of the Sudan had incidence (50%) and it commonest in right lobe of the liver had incidence (50%).

Triphasic CT scan is a good non-invasive tool and can be used as first line imaging modality for differentiating benign and malignant focal liver lesions. Benign lesions like haemangioma can be reliably differentiated from malignant liver lesion; therefore unnecessary biopsies can be avoided.

ملخص الدراسة

فحص الكبد ثلاثي الأطوار يساعد في التمكن من تصنيف أورام الكبد المختلفة,الهدف الرئيسي للبحث هو تقويم أمراض الكبد باستخدام الأشعة المقطعية المحوسبة , و أيضا معرف أكثر أنواع أمراض الكبد انتشارا و توزيعها الجغرافي في السودان,60 مريضا وجدت لديهم مناطق متضررة بها أورام بالكبد. تم التنسيق لفترة أربع شهور وتم تقييم نتائج فحص الكبد ثلاثي الأطوار بالأشعة المقطعية وتم الربط بينها وبين التشخيص النهائي في وقت لاحق. حسبت الحساسية والنوعية والقيمة التنبؤية الإيجابية والقيمة التنبؤية السلبية ودقة التشخيص لجهاز الأشعة المقطعية لفحص الكبد ثلاثي الأطوار.

كان ارتفاع عدد حالات إصابات الكبد (45٪) في الفئة العمرية ما بين (41-60) سنة وكان اعلي عدد حالات الإصابات بالكبد ورم خبيث في الكبد (33.3٪) و ورم صلب (33.3٪). وهو اكثر شيوعا في الفئة العمرية (41-60) سنة والتي كانت نسبة الإصابة بها (45٪)،والأكثر شيوعا في الذكور، وكانت نسبة وجود الحالات (60٪)، وجاء معظم المرضى من وسط وشمال و غرب السودان وكانت الأورام الصلبة بالكبد أكثر شيوعا في الفئة العمرية (61-80) سنة بنسبة إصابة (45٪)، والأكثر شيوعا في الذكور، وكانت نسبة وجود الحالات (65٪)، وجاء معظم المرضى من وسط السودان والذي الإصابة فيه بنسبة (50٪)، والأكثر شيوعا في الفص الأيمن من الكبد بنسبة حدوث (50٪).

جهاز الأشعة المقطعية بفحص الكبد ثلاثي الأطوار هو فحص أمنة جدا ويمكن استخدامه كخيار أولي كطريقة للتصوير والتمييز بين أورام الكبد الحميدة والخبيثة.

أورام حميدة مثل ورم هيمانجيوما الذي يمكن تمييزه بدقة عالية من أورام الكبد الخبيثة. وبالتالي يمكن تجنب اخذ عينات من نسيج الكبد لأنه يصبح غير ضروري. بل هو أيضا مفيد بشكل خاص لأورام الأوعية عاليه الضغط التي يمكن تفويتها بسهولة على مسح الأشعة المقطعية الروتيني .

Chapter one

Evaluation of Liver Lesions using Computed Tomography

1.1 Introduction

Focal liver lesions can be defined as any lesion in the liver other than the normal parenchyma with or without causing structural and functional abnormality of hepatobiliary system and can be of variable size. These lesions can be benign or malignant. Prevalence of various liver lesions has marked differences across geographic regions and ethnic groups. Focal liver lesion is more likely to represent a metastatic deposit than primary malignancy in Europe and United States; however, hepatocellular carcinoma is the fourth most common hepatic disorder in Sudan with prevalence of 8-10%. This prevalence rate is high when compared to western data.

In a patient without known cancer or history of chronic liver disease, these lesions usually can be evaluated with serial follow-up imaging tests because nearly all will be benign. In patients with cancer, however, prompt determination of the cause of such lesions may be pivotal for defining prognosis and therapy. Small hepatic lesions were deemed benign in 51% of the 82% of patients with a known underlying malignancy. Benign hepatic tumors have been reported in up to 52% of the general population. It is therefore important to differentiate between benign and malignant focal liver lesions for further management of the patient.It is often difficult to characterize hepatic lesions with various imaging studies. Although histopathology is the gold standard, biopsy is always not possible as it is an invasive technique.

Computed tomography (CT) is the imaging modality most often used to evaluate focal liver lesions, however, the complex blood supply of the liver frustrates the search for an optimal contrast-enhanced CT protocol for the detection and characterization of focal hepatic lesions. Although the liver receives approximately 30% of its blood supply from the hepatic artery and 70% from the portal vein, most primary and secondary liver neoplasms receive 80-95% of their blood supply from the hepatic artery.Because of the

high frequency of benign focal liver lesions such as cysts, haemangiomas and focal nodular hyperplasia, characterization of these lesions is essential. 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 for lesions that do not. To meet these requirements, a triphasic spiral CT technique was developed to image the entire liver in arterial, portal, and equilibrium phases.

Although current literature search shows that MRI has a comparable rate in detection and classification of focal liver lesions, however, rapid availability and short scanning time made CT an ideal imaging technique. Recent studies have also reported an improvement in lesion detection if arterial phase imaging is performed in addition to portal venous imaging especially in the presence of hypervascular neoplasms, such as hepatocellular carcinoma.

In the current study, we evaluated a triphasic spiral computed tomogram technique that allowed imaging of the entire liver in arterial, portal and equilibrium phases. The rationale behind the protocol is that the portal phase is the most sensitive phase for lesion detection, whereas the arterial and equilibrium phases can supply additional information on the vascularity of the lesion which may help to identify the nature of lesion. The vascular haemodynamics is the key to detect characterization of hypervascular lesions.

Several studies have been done worldwide on the role of triphasic CT scan in characterizing and differentiating benign and malignant 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 accuracy.

1.2-problem of the study

The liver lesions have increased significantly in the last few years and still represent major health problem, with difficulty in diagnosis and invasive biopsy test.

1.3-objective of the study

1.3.1 General objective

To evaluate the role of CT in diagnosis of the liver lesions

1.3.2 Specific objective

- To determine which lesion in the liver with high incidence.
- To find out the Geographic distribution of the liver lesions in Sudan

1.4 Thesis overview:

Chapter one:

Contains introduction to the study and justification for why we do it.

Chapter two:

Contains Literature review for liver anatomy, physiology, pathology and CT

Chapter three:

Contains Materials and Method for planning, designing, how to gets the goals of the study.

Chapter four:

Contains results and data analysis of the study.

Chapter five:

Contains discussion, conclusion and recommendations of the study

Appendix:

Contains some images of CT triphasic scan test for patient under study

Chapter Two

LITERATURE REVIEW

2.1 Anatomy

Liver is the largest gland in the body; it is situated in the upper and right parts of the abdominal cavity, occupying almost the whole of the right hypochondria in the greater part of the epigastrium (Williams, 2005).

In the male it weighs from 1,4 to 1,6 Kg, in the female from 1,2 to 1,4 Kg. It is relatively much larger in the fetus than in the adult, constituting, in the former, about one eighteenth, and in the latter about one thirty-sixth of the entire body weight (Williams, 2005).

2.1.1 Surfaces of the liver:

The liver possesses three surfaces, superior, inferior and posterior:

The superior surface: comprises a part of both lobes, and as a whole is convex and fits under the vault of the diaphragm which in front separates it on the right from the sixth to tenth ribs and their cartilages, and on the left from the seventh to eight costal cartilages, it's middle part lies behind the xiphoid process, is in contact with the abdominal wall. Behind this the diaphragm separates the liver from the lower part of the lungs and pleura, the heart and pericardium (Williams, 2005).

The inferior surface: is uneven, concave, directed downward, backward and to the left. It is in relation with the stomach and duodenum, the right colic flexure, and the right kidney and suprarenal gland (Williams, 2005).

The posterior surface: is rounded and broad behind the right lobe, but narrow on the left. Over a large part of its extent it is not covered by peritoneum, this un covered portion is about 7, 5 cm. peritoneum, this uncovered portion is about 7.5 (Williams, 2005).

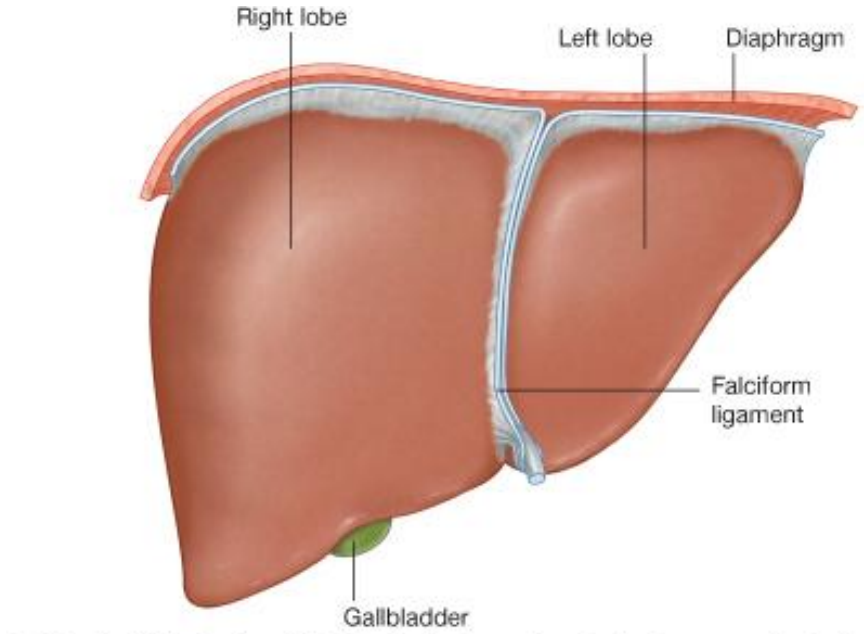


Figure 2.1 Anterior view of liver surface

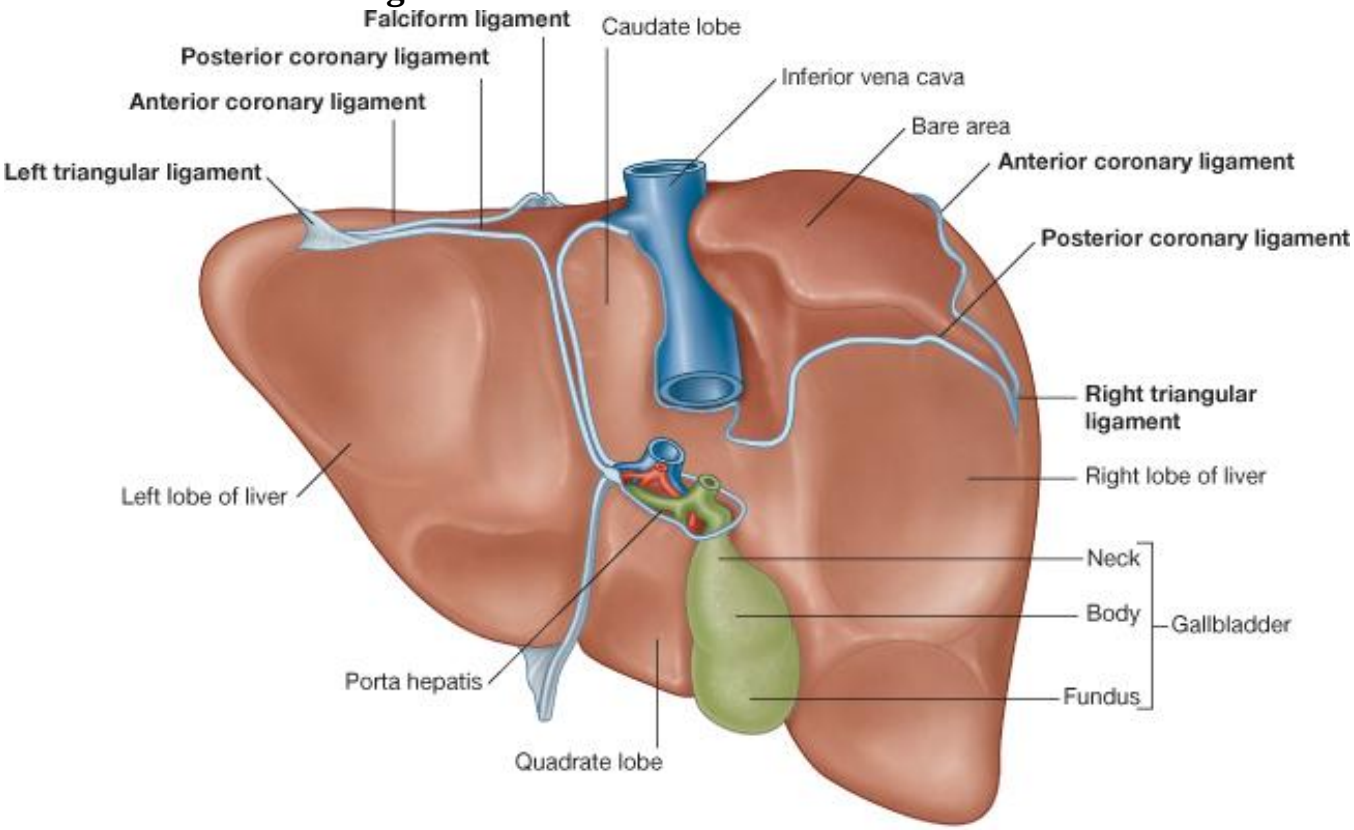


Figure 2.2 Posterior view of liver surface

2.1.2 Fossa of the liver:

The liver posses four fosse which are:

The left sagittal fossa : is a deep grove, which extends from the notch on the anterior margin of the liver to the upper border of the posterior surface of the organ. It separates the right and the left lobes (Williams, 2005).

The porta or transverse fissure: is a short but deep fissure, about 5cmin length, extending transversely across the under surface of the left portion of the right lobe, nearer its posterior surface than its anterior border. And separates the quadrate lobe in front from the caudate lobe and process behind. It transmits the portal vein, the hepatic artery and nerves, and the hepatic and lymphatic ducts. The hepatic duct lies in front and to the right, the hepatic artery to the left, and the portal vein behind and between the duct and artery (Williams, 2005).

The gall bladder fossa: is a shallow, placed on the under surface on the right lobe, parallel with the left sagittal fossa. It extends from the anterior free margin of the liver to the right extremity of the porta (Williams, 2005).

The inferior vena cava fossa: is a short deep depression occasionally a complete canal in consequence of the substance of the liver surrounding the vena cava. It extends obliquely up ward on the posterior surface between the caudate lobe and bare area of the liver, and is separated from the porta by the caudate process. On sitting open the inferior vena cava the orifices of the hepatic veins will be seeing opening in to this vessel at its upper part, after perforating the floor of this fossa (Williams, 2005).

2.1.3 Relations of the liver:

The body is in relation, by its upper surface, with the liver , by it's under surface, with comment of the transverse colon, and back usually with the upper end of the descending portion of the duodenum, but sometimes

with superior portion of the duodenum or pyloric end of the stomach. The fundus is completely invested by peritoneum, it is in relation in front with the abdominal parietes, behind with the transverse colon. The neck is narrow and curves upon itself like the letter S, at its point of connection with the pyloric duct it present a well marked constriction (Williams, 2005).

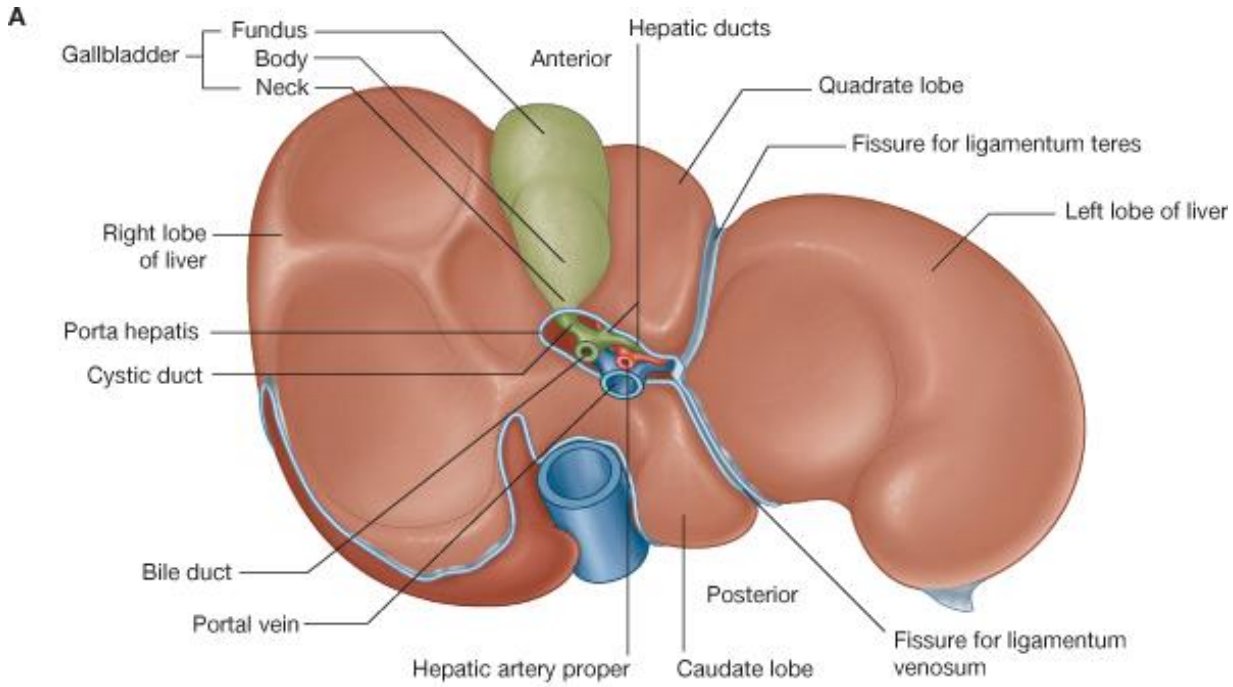


Figure 2.3 Inferior view of liver surface

2.1.4 Blood supply of the liver:

The liver is supplied by two main blood vessels on its right lobe:

The hepatic artery and the portal vein. The hepatic artery normally comes off the celiac trunk. The portal vein brings venous blood from the spleen, pancreas, and small intestine, so that the liver can process the nutrients and by products of food digestion, the hepatic veins drain directly in to the inferior vena cava (Snell, 2003).

2.1.5 Nerve supply of the liver:

Innervations of the liver are accomplished from the solar plexus through sympathetic trunk and the vagus nerve (Snell, 2003).

2.1.6 Excretory apparatus of the liver:

The excretory apparatus of the liver consist of (Snell, 2003). :

A-Hepatic duct: formed by the junction of the two main ducts, which pass out of the liver at the porta.

B-The gall bladder: This serves as a reservoir for the bile.

C-The common bile duct: formed by the junction of thehepatic duct and the cystic duct.

D-The cystic duct.

2.1.6 Segmentation of liver

The liver is further subdivided into segments, each supplied by a principal branch of the hepatic artery, portal vein and bile duct. Segments I, II, III and IV make up the functional left lobe, and segments V, VI, VII and VIII make up the functional right lobe. The right lobe can be further divided into a posterior and anterior section or sector. The right posterior section is made up of segments VI and VII, and the right anterior section is made up of segments V and VIII (Fasel, 2004).

The left lobe can also be divided into sections:

Segment IV is referred to as the left medial section, and segments II and III as the left lateral section. The hepatic veins lie in liver parenchyma between the sections. Segment I corresponds to the gross anatomical caudate lobe and segment IV to the quadrate lobe ,The value of the identification of the liver segments and sections according to vascular and biliary supply is that surgical resection of a segment, section, multiple segments, a lobe or greater volume of tissue may be performed whilst encountering the least number of

possible major vascular structures (Fasel, 2004).

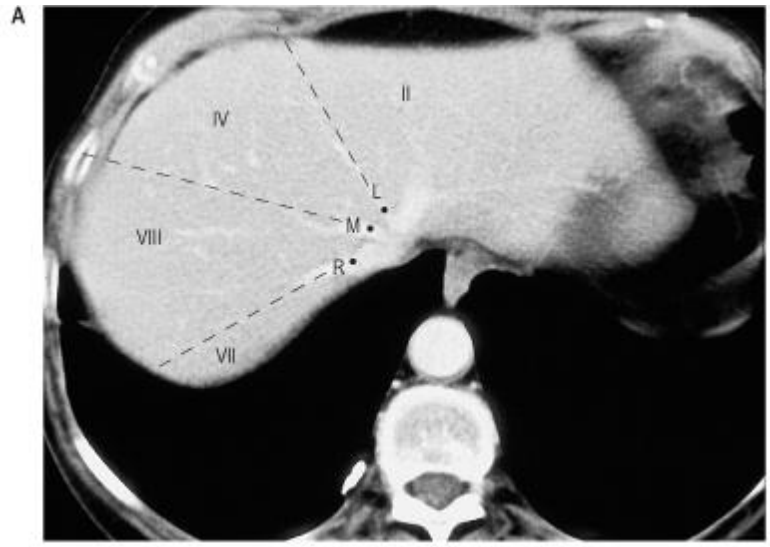


Figure 2.4 Axial CT for liver segments

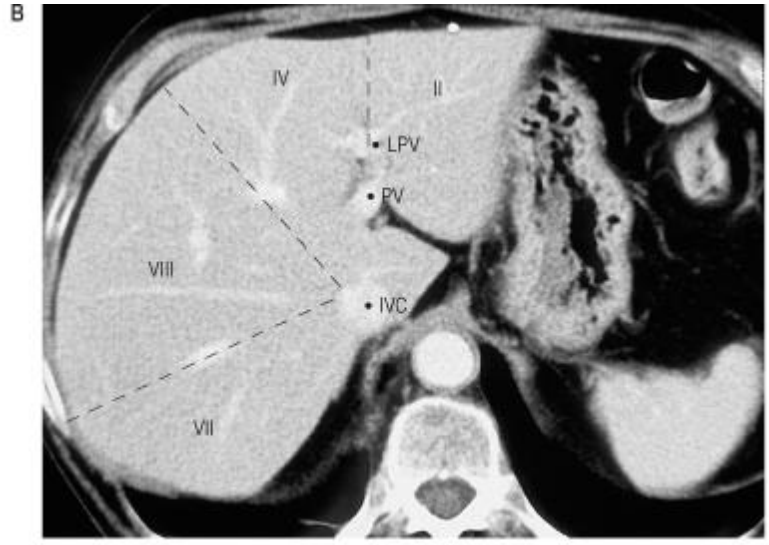


Figure 2.5 Axial CT for liver segments

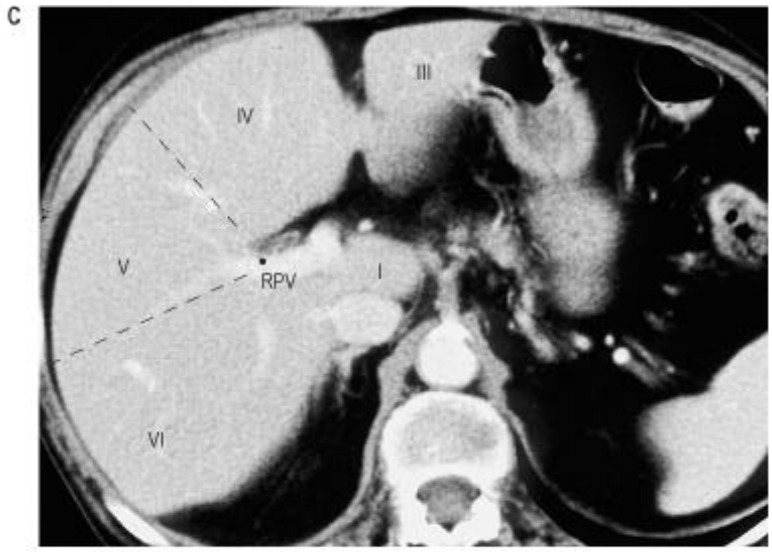


Figure 2.6 Axial CT for liver segments

Figure 85.6 Couinaud segments of the liver seen on axial CT scan. A, Contrast enhanced CT shows the left (L), middle (M), and right (R) hepatic veins at the superior aspect of the liver. B, Inferior to this the caudate lobe (segment I) lies between the inferior vena cava (IVC) and the main portal vein (PV). The left portal vein (LPV) separates segment II superiorly from segment III inferiorly. C, The right portal vein (RPV) divides segments V and VI inferiorly (C) from segments VII and VIII superiorly (B) (Fasel, 2004).

2.2 Liver physiology:

The liver is an organ in vertebrates including human. It plays a major role in metabolism and has a number of functions in the body including glycogen storage, plasma protein synthesis, and drug detoxification. It also produces bile, which is important in digestion. It performs and regulates a wide variety of high volume bio chemical reaction requiring specialized tissue (Waugh, 2006).The liver is supplied by two main blood vessels on its right lobe, the hepatic artery and the portal vein. The hepatic artery is

normally comes off the celiac trunk. The portal vein brings venous blood from spleen pancreas and small intestine, so that the liver can process the nutrient and by products of food digestion. The hepatic vein drains directly into the inferior vena cava (Waugh, 2006).

The bile produce in the liver is collected in bile canaliculi, which merge from bile duct these eventually drain into the right and the left hepatic ducts, which in turn merge to form the common hepatic duct. The cystic duct (from the gallbladder) joins with the common hepatic duct to form the common bile duct. Bile com either drains directly into the duodenum via the common bile duct or be temporarily stored in the gallbladder via the cystic duct , the bile ducts resemble those of a tree, and indeed term (biliary tree) is commonly used in this setting (Waugh, 2006).

The liver is among the few internal human organs capable of natural regeneration of lost tissue as little as 25% of remaining liver can regenerate into a whole liver again (Waugh, 2006).

There is also some evidence of biopotential stem cells, called oval cell, which can differentiate into either hepatocytes or cholangiocytes (cells that line bile ducts) (Waugh, 2006).

2.2.1 Function of the liver are:

1. The liver produces and execretes bile requires for dissolving fats.
2. The liver performs several roles in carbohydrate metabolism and the most important are (Waugh, 2006).

(a) Gluconeogenesis (the formation of glucose from glycogen).

(b) Glycogensis(the formation of glycogen from glucose).

(c) The breakdown of insulin and other hormones.

(d) The liver is responsible for the mainstay of protein metabolism.

(e) The liver also performs several roles in lipid metabolism.

(f) Cholesterol Synthesis.

(g) The production of triglycerides (fat).

3. The liver produces coagulation factor I-(fibrinogen) ,(prothrombin), ",as well as protein C, protein S ,and anti thrombin .

4-The liver breaks down hemoglobin, creating metabolites that are added to bile as pigment.

5-The liver breaks down toxic substance and most medicinal .products in process called drug metabolism .this sometimes result in toxication .when the metabolic is more toxic than its precursor.

6-The liver stores multitude, of substance, including glucose in the form of glycogen, vitamin B12, ion, and copper.

7-the liver convert ammonia to urea.

8-in the first trimester fetus, the liver is the main site of red blood cell production .by the 32 week, of gestation, the Bone marrow has almost completely taken over that task (Waugh, 2006).

2.3 Liver pathology:

2.3.1 Congenital disease:

2.3.1.1 Cystic disease of the liver:

Congenital cysts in the liver are rare and usually associated with cystic disease of the kidney (Carol, 2008).

2.3.1.2 Congenital hepatic fibrosis:

This is regarded as a form of cystic disease of the liver. It may be familial and sometimes accompanied by cystic disease of the kidney. Band of dense fibrous tissue containing mature bile duct element extend irregularly through the liver (Carol, 2008).

2.3.2 Acquired disease:

2.3.2.1 Inflammatory disease:

2.3.2.1.1 Bacterial infection:

The liver usually results from bacteriacmia associated with systemic infection. Typhoid, fever, leptospirosis and brucellosis may all produce focal necrosis and inflammation of the liver (Carol, 2008).

2.3.2.1.2 Viral infection:

A-Hepatitis:

Means any inflammatory lesion of the liver. In practice the term is not used for focal lesions such as an abscess, but only when there is diffuse involvement of the liver (Carol, 2008).

Acute viral hepatitis:

This an acute infection characterized by diffuse hepatitis with wide spread liver cell necrosis there are three well characterized (Carol Porth, 2008):

Hepatitis A: (HIV)

- Has an incubation period of 15-40 days.
- It transmitted by the faecal oral route.
- Infection is commonest on children.
- The infective agent is a picorna virus and associated 2 7nm particles occur in the blood and feces 3-4 weeks after exposure to the virus (Carol, 2008).

Hepatitis B:

- Has an incubation period of 50-180 days.
- Is most frequently transmitted by blood and blood products.

- The virus may also be present in body fluids, saliva, semen and vagina secretion and may also be transmitted by intimate physical contact including from mother to child and sexually.
- Occur in any age group and is a DNA virus (Carol, 2008).

Hepatitis D:

- This is defective RNA virus which usually requires HBV for its replication.
- Clinical illness is more severe and the liver injury more extensive than infection with HBV (Carol, 2008).

Hepatitis C:

- Has an incubation period 42-90 days.
- Transmitted by blood and blood products and now is most important cause of post transfusion hepatitis.
- Clinically, anti body to HCV appears between 1 and 6 months after the acute illness.
- Infection with virus is an important cause of chronic liver disease (Carol, 2008).

Hepatitis E:

- This has incubation period of 35-40 days.
- Is transmitted by the feacal oral route.
- The causative agent is a single stranded RNA virus.
- Affect young adult in whom it causes a mild illness with jaundice, however there is a high fatality rate in pregnant women (Carol, 2008).

2.3.2.2 Liver cirrhosis:

It is diffuse, chronic, progressive liver disease characterized by fibrosis, regeneration nodules, and loss of lobular pattern (Carol, 2008).

Additional features:

Severe necrosis and inflammation occur in progressive (decompensate) cirrhosis, while compensate cirrhosis contain no necrosis with less inflammation (Carol, 2008).

Classification:

Morphological:

- Micro nodular: size of nodule 3-5 mm with fine fibrous tissue band separation nodules.
- Macro nodular: size more than 5 mm with thin fibrous tissue band separation nodules.
- Mixed nodular: start as micro nodule and some become macro nodule then mixed (Carol, 2008).
- **Etiological:**
- Viral.
- Alcoholic.
- Wilson's disease (copper accumulation).
- Biliary: either primary or secondary.
- Alpha I anti trypsin deficiency: enzyme is retained in hepatocyte and become deficient in serum.
- Cryptogenic cirrhosis.
- Complications of cirrhosis:
- Liver failure.
- Hepato cellular carcinoma (Carol, 2008).

Portal hypertension due to:

Capillarization of sinusoid, fibrosis, regeneration nodules which compress blood vessels and formation of porto systemic shunt inside the liver itself (Carol, 2008).

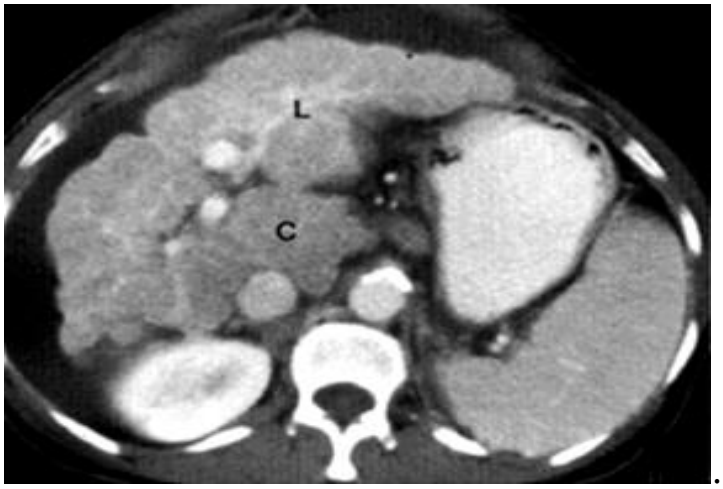


Figure 2.7 Axial CT for Abdomen show liver Classification.

Clinical presentation of cirrhosis:

All forms of cirrhosis are silent (a symptomatic) if symptomatic it leads to non specific symptom including (Carol, 2008). :

- Anorexia.
- Weakness.
- Loss of weight.
- Frank debilitation in advance cases (Carol, 2008).

2.3.2.3 Hepatic failure:

It is failure of liver to perform it's function when 80-90% of liver capacity is loss as a result of acute or chronic damage, with 70-95% mortality rate (Carol, 2008).

Predisposing factors:

- GIT hemorrhage due to portal hypertension.
- Systemic infection.
- Stress.
- Chronic heart failure.
- Electrolyte imbalance (Carol, 2008).

Clinic features:

- Jaundice.
- Abnormal liver function test.
- Hypo albumeniemia: edema and ascitis (accumulation of fluid in peritoneal cavity). (
- Hyper strogenemia (due to failure in liver metabolism of this hormone) **lead to:**

  1- Gynecomastia (hyper plasia of breast ducts in males).

  2-Testicular atrophy and disturbance in hair distribution (resembling women pattern).

  3- Spider nevi (central, pulsating, dilated arteride with radiating small vessels) and palmer erthema (local vaso dilatation) reflecting vascular change (Carol, 2008).
- Hyper ammonemia: defective liver urea cycle.
- Hepatic encephalopathy: rigidity, hyper reflexia and down grading mental status (loss of concentration, stopper confusion, semi coma, and finally ends with hepatic coma).
- Coagulopathy with risk of bleeding and more failure caused by bleeding.
- Hepatorenal syndrome: acute renal failure following hepatic failure with oligurea, high BUN (blood urea nitrogen) and creatinine without renal lesion. It is not primary kidney disease and may be due to systemic vaso dilation which results in impaired perfusion of kidney (Carol, 2008).

2.3.2.4 Benign lesions of liver

2.3.2.4.1 Focal nodular hyper plasia:

They are well defined nodules of 1-5 cm diameter which often have rominent central fibrous scar and are divided up by fibrous septa (Carol, 2008).

Nodular regeneration hyper plasai:

In this condition the liver appears nodular, but the nodules are not associated with fibrous around the edges (Carol, 2008).

2.3.2.4.2 Liver cyst:

These are part of hamarotosis, occur in combination with multiple pancreatic and renal cyst, containing liquid, complications such as super infection or hemorrhages are rare (Carol, 2008).

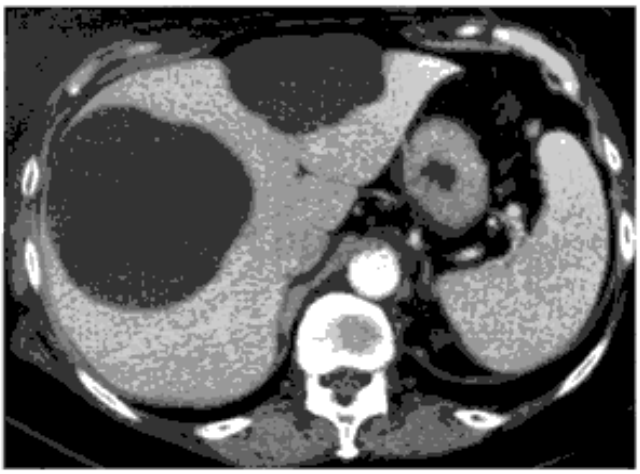


Figure 2.8 Axial CT for Abdomen show liver with polycystic disease .

2.3.2.4.3 Liver abscess:

a- Pyogenic abscess:

May be due to varies factors, abscess forming infection e.g. septic infection, biliary tract obstruction purulent inflammation (Carol, 2008).

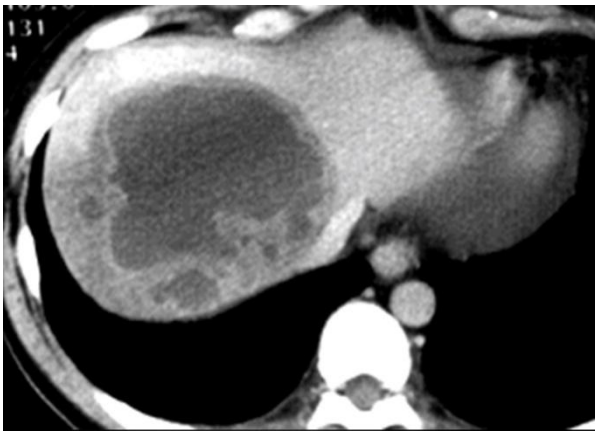


Figure 2.9 Axial CT for Abdomen show liver with Pyogenic abscess .

B-Amebic abscess:

Causes by the pyogenic pathogens occurs in 20% in all cases (Carol, 2008).

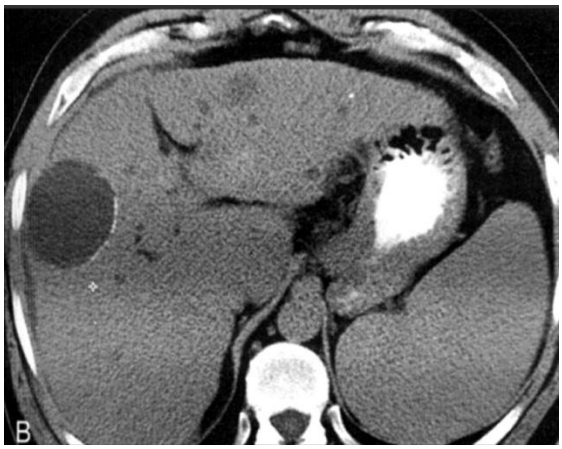


Figure 2.10 Axial CT for Abdomen show liver with Amebic abscess.

2.3.2.4.4 Echenococcus (hydate disease):

Develops from the larvae of echenococcus alverlaris(multi locularis and E-granulosus cystic uni locularis) .Variable morphological symptoms arise that primary affected liver, the other in order of frequency, lung, brain and spleen (Carol, 2008).

2.3.2.4.5 Hepatic lipoma:

It is only type of extremely rare mesodermal tumor described to date. Can be diagnosed on the bases of attenuation value and it's smoothly marginated appearance (Carol, 2008).

2.3.2.4.6 Liver cell adenoma:

This arised mainly in women related to the use of oral contraceptive, and in the men related to the use of anabolic or androgenic steroids, and rarely may arised in children or young adult (Carol, 2008).

They are usually well defined solitary nodules can be differentiated from non neoplastic liver or focal nodular hyperplasia by absent of fibrous septa ,portal tracts and bile duct within the nodules .And it difficult to differentiate from hepatic cell carcinoma (Carol, 2008).

2.3.2.4.7 Bile duct adenoma:

These are usually small white sub capsular nodules. They are composed of numerous small bile ducts pached close together within small amount of fibrous stroma (Carol, 2008).

2.3.2.4.8 Heamangioma:

These are well defined nodules composed of thin walled vessels set fibrous stroma .They are also often sub capsular ,they may become thrombosed ,sclerosed or calcified, they rare rupture (Carol, 2008).

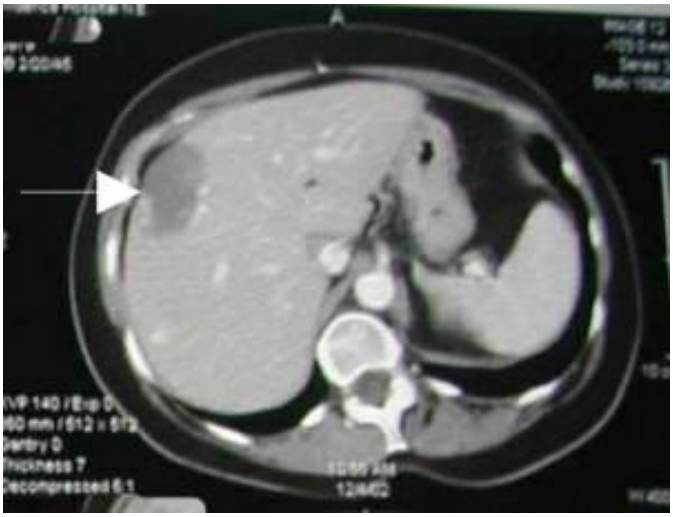


Figure 2.11 Axial CT for Abdomen show liver Heamangioma.

2.3.2.5 Malignant tumors:

2.3.2.5.1 Primary:

A-Hepato cellular carcinoma:

Usually arised on cirrhosis, manifest in patient in 6th and 7th decade and occur 3 times more in men than in women (Carol, 2008).

Hepato cellular carcinoma divided in to three categories:

- Multi centric intra hepatic metastases due to venous invasion.
- Solitary large masses 20 to 40%of all cases (Carol, 2008).

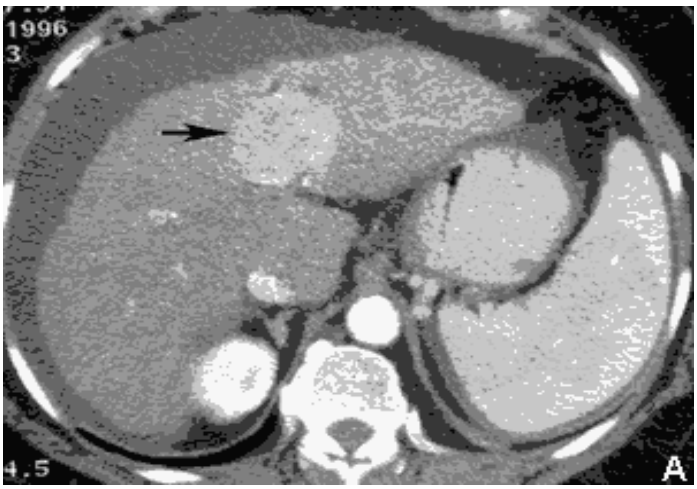


Figure 2.12 Axial CT for Abdomen show liver HCC.

b- **Cholangio carcinoma:**

Is much rare than hepato cellular carcinoma, affect women twice as often as men, usually in 5^{th} to 7^{th} decade of live, poorly vascularization. ,This disease is predominant in patient with gall stones, biliary carcinoma and sclerosizing cholangitis. This disease found in the region of hepatic bifurcation which leads to biliary obstruction (klatskin's tumor) (Carol, 2008).

2.3.2.5.2 Secondary:

1- Cystic liver metastases.

2- Calcified liver metastases (Carol, 2008).

2.4 Computer tomography

Figure 2.13 Computed tomography scan Machine

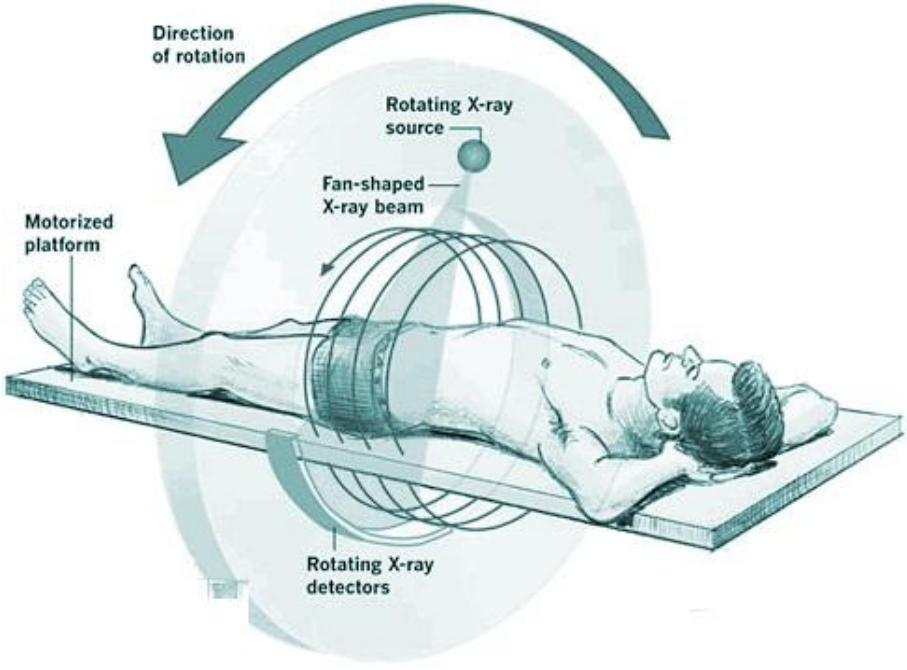


Figure 2.14 Anatomy of the Computed tomography scan

2.4.1 General feature

Following its introduction in a clinical setting in 1974, computed tomography (CT) underwent an extraordinary technical revolution in terms of both scanning time and spatial resolution, CT remained a cross-sectional technique with sequential acquisition of axial slices until the introduction of spiral (helical) CT at the end of 1980s.

Spiral technology, made possible by improvements in tube technology and electronic computing, has transformed CT from a two-dimensional into a true volumetric imaging modality (Ichikawa, 2012).Faster image acquisition, more rational use of contrast agent administration as well as use of image reformation on multiple planes offered incredible advances in terms of lesion identification, characterization and staging and opened up new indications for CT study (i.e. CT angiography for arterial vascular assessment and replacement of catheter angiography; CT colonography for evaluation of colonic disorders) (Riccardo, 2005).

A second revolution occurred when multi-slice (multidetector-row) CT (MDCT) was introduced (Ichikawa, 2012).Although the fi rst MDCT was a ”dual-slice” scanner, presented already in 1992 and consisting of two parallel detector rows that allowed the simultaneous acquisition of two interwoven helices, the real impact of multi-slice technology was observed at the end of 1998, when the fi rst four-slice CT equipment was introduced in a clinical setting (Ichikawa, 2012).MDCT, based on a four-row configuration of detectors, together with the development of sub-second gantry rotation time, offered the opportunity to overcome common limitations of single-slice CT scanners, especially in terms of scanning time and limited z-axis resolution (Riccardo, 2005) .

Technical evolution was followed by the development of 8- and 16-slice scanners, which became available between 2001 and 2002, and will continue with the 64-slice equipment expected by the end of this year . Technological development was followed by a change in liver imaging protocols (Ji H, 2010). The real advance in liver imaging was due to multiplanar and multiphasic capabilities of MDCT. Multiplanarity, due to the acquisition of 3D data sets with isotropic or nearisotropic voxels, resulted in the ability to analyse CT images on multiple planes (i.e. sagittal, coronal and oblique) making diagnosis of lesions in critical anatomic localization easier; isotropic volume also made the use of 3D rendering algorithms available, which is especially useful in the case of vascular reconstructions and virtual endoscopic views (Riccardo, 2005).

The multiphasic approach, made possible by fast scanning time, makes it possible to scan the liver parenchyma during pure vascular phases, offering a real arterial, portal and delayed phase. Optimization of vascular enhancement together with improved spatial resolution along the z-axis are expected to improve diagnostic accuracy in liver imaging (Ji H, 2010)

2.4.2 Technique

MDCT has transformed CT from a transaxial crosssectional technique into a 3D imaging modality. Whereas single-slice CT took at least 5 years to gain general acceptance, MDCT has been more rapidly accepted in the radiological community, with exponential growth in the use of these scanners in clinical practice. Major improvements (z-axis coverage speed and longitudinal resolution) translated into rapid hepatic imaging and the use of new imaging protocols, not possible with single-slice spiral CT. Thin sections, that can now be routinely used within a single breath hold, resulted in improved lesion detection and nearly isotropic image acquisition

providing high-resolution datasets available for multiplanar reformations (Ichikawa, 2012).

The possibility to scan through the entire liver in 10 s or less allowed MDCT to demonstrate three clear separate and distinct hepatic circulatory phases of iodine contrast distribution, i.e. pure arterial, arterioportal, venous and equilibrium phases. MDCT with the improvements in morphological and functional information compared with single-slice CT enables a comprehensive approach to hepatic imaging within a single examination. MDCT brings new challenges, concerning contrast injections protocols (including optimal timing and rate of contrast injection, total volume of contrast agent and ideal iodine concentration of contrast medium) and patients' dose exposure (Ichikawa, 2012).

2.4.2.1 Detector Configuration

The reason for a brief discussion about detector configuration, which might be beyond the aims of this chapter, lies in the differences among detector arrays of different CT constructors, especially when considering four-slice scanners; in fact, detector arrays of 16-slice machines are more homogeneous. The major consequence of a different design is the choice of scan parameters, which cannot be simply transferred from scanner to scanner, as with single slice CT. This means that scanning parameters need to be optimized as a function of the available equipment according to only a few general rules. At present, MDCT scanners may acquire 2, 4, 6, 8, 10 or 16 simultaneous sections. In all MDCT scanners, the number of slices that can be acquired is usually smaller than the number of detector rows (N), in order to obtain more than one collimation setting by adding together the signals of neighboring detector rows (Kopka, 2008).

The arrangement of detectors along the z-axis and widths of available slices vary among different systems. In particular three different detector array designs are currently available matrix, adaptive and hybrid detector arrays. ”Matrix” detectors consist of parallel rows of equal thickness; ”adaptive” detectors use detector rows with varying thickness. In the former type, the width of detector elements determines the thinnest possible section thickness and thicker sections are obtained by adding the signal from neighboring detector rows; in contrast, in the latter type, various section thicknesses can be gained using partial collimation and addition of signal of adjacent rows. Finally, ”hybrid” detectors use smaller detector rows in the centre and larger ones towards the periphery of the array. This design has been adopted mostly for 16-row scanners from all companies (Kopka, 2008).

2.4.2.2 Scan Parameters

In single-slice CT, the most important scan parameters can be provided in the form of a triplet including slice collimation (SC, in mm), table feed/rotation (TF, in mm) and reconstruction increment (RI, in mm). Depending on clinical indications, a compromise has to be reached between z-axis resolution and required scan length. The effective slice thickness or slice width (SW) can be calculated from slice collimation and pitch, P (=TF/SC). The suggested scan parameters for single-slice spiral CT of the liver are 5/8/4 (SC/TF/RI) and the SW is 6.2 .In four-slice spiral CT the same acquired raw data set can be used to reconstruct two or more data sets of varying thickness. For this reason, it is important to distinguish between acquisition parameters, given as (NxSC/TF), and reconstruction parameters, expressed as (SW/RI) . With multislice scanners, two definitions of pitch factor are used, depending on whether a section (P*=TF/SC) or total

collimation of the detector array (P=TF/NxSC) is chosen as the reference .The image quality of any given four-slice CT system depends on collimation, pitch, reconstruction interval. Collimation should be tailored to the purpose of the study, because a decreased collimator width (thus, an increase in pitch) results in a narrow reconstructed section thickness and improved spatial resolution, but in increased image noise and decreased length of coverage (Riccardo, 2005).

However, maximization of pitch may also result in a decrease in contrast resolution. Thus, the most appropriate choice of scanning parameters depends also on clinical indication to CT study. In fact, for example, for CT angiography where imaging is devoted to structures with very high attenuation, loss of contrast resolution caused by maximization of pitch can be disregarded. This is not the case with liver imaging where both good spatial and contrast resolutions are required; a practical approach for liver imaging is to use relatively thin collimation, increasing the pitch as needed to cover the entire liver (Kopka, 2008).

A small reconstruction interval with overlapping sections is advantageous both for multiplanar reconstructions and for detection of small lesions, because the smaller the reconstruction interval, the greater the longitudinal (z-axis) resolution; one major drawback is the loss of z-axis coverage. The choice of scan parameters with a four-slice CT scanner can follow two different approaches: ”fast spiral acquisition”, with the use of 5-mm slice thickness, similar to single-slice spiral CT, but with the advantage of much shorter scanning time; ”volumetric imaging” using a high-resolution protocol consisting of thin collimation and lower pitch, necessary to acquire an almost isotropic volume that can be further post-processed using multiplanar reformations, maximum intensity projection and volume-

rendering algorithms. For liver imaging a compromise between fast scanning, necessary to obtain pure vascular phases, and high-resolution scanning, necessary to reformat the datasets, has to be performed (Kopka, 2008).

This obligatory choice between scanning time and spatial resolution is not necessary any more with 16- slice spiral CT systems, as they combine the ability to acquire very thin slice images (narrow collimation) with a very fast scanning time (Kamel, 2009).

2.4.2.3 Strategy of Dataset Acquisition

The major impact of spiral CT technology on liver imaging is represented in the short scanning time, allowing the evaluation of the entire liver parenchyma during a single breath-hold. Fast scanning opened the era of multiphasic protocols, consisting of multiple passes through liver parenchyma during different vascular phases. Using a single detector spiral CT the examination usually consists of a biphasic scan with images acquired during arterial dominant phase followed by a portal venous phase . The rationale of this imaging protocol is based on the differences of blood supply between normal parenchyma and liver tumors' as hepatic vascularization comes predominantly from the portal vein, whereas each kind of liver tumor receives blood mainly from the hepatic artery (Kopka, 2008).

Exceptions to this rule are often represented by regenerating nodules and early well differentiated hepatocellular carcinomas. Therefore, if the arterial dominant phase is acquired as part of the imaging protocol, diagnosis of hypervascular benign and malignant tumors (focal nodular hyperplasia, hepatic adenomas, hepatocellular carcinomas, islet cell tumors and carcinoid) is improved compared with analysis of delayed phase of

enhancement alone .On the contrary, hypovascular liver tumors' (such as metastases), show low attenuation compared with normal parenchyma during both arterial and subsequent portal venous phases . However, the scanning time of a single-slice spiral CT scanner is too slow to obtain a pure arterial phase; the result is a hybrid phase, with mixed arterial and portal venous enhancement (usually slices acquired first in the volume have a pure arterial enhancement whereas subsequent slices show portal dominant enhancement) (Kamel, 2009).

Only with the advent of MDCT could the entire upper abdomen be scanned within 10 s or less. Fast acquisition offers the possibility to scan the liver during multiple phases of vascular enhancement. A complex multiphasic imaging protocol was optimized soon after the introduction of four-slice scanners (Graph. 1). It consists of four separate passes through liver parenchyma following i.v. injection of contrast medium (Graph. 2). The first two passes performed respectively in craniocaudal and caudocranial direction following the arrival of bolus of contrast medium are acquired within a single breath-hold of approximately 24 s; the delay time for scanning is calculated with a preliminary bolus test or is automatically defined using a bolus tracking technique (Kopka, 2008)..

The first pass, the so-called early arterial phase (EAP) acquires images where only arterial vessels are enhanced; the second pass, the so-called late arterial phase (LAP) obtains images during arterioportal enhancement. The first breath-bold is followed by a second 10-s scan during the portal enhancement (portal venous phase) (Kamel, 2009).

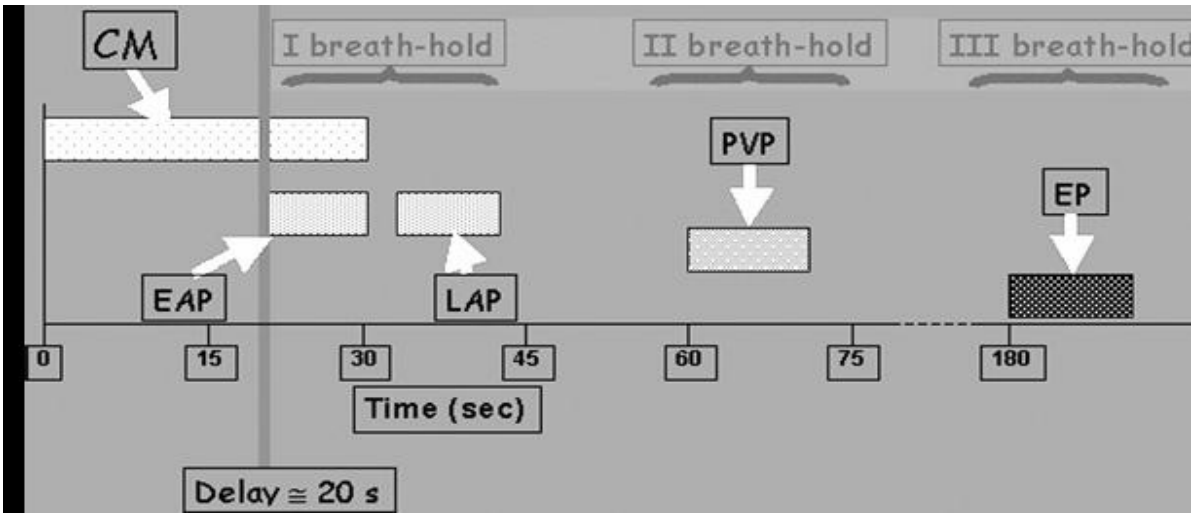


Figure 2.15 Diagram of multiphasic vascular enhancement of the liver. Around 20 s (representing the average delay time usually calculated on the basis of bolus test) following the beginning of contrast medium injection first breath-hold acquisition of two consecutive scans is obtained. At around 60 s the second breath-hold scan is acquired followed by the equilibrium phase. *CM*, contrast medium; *EAP*, early arterial phase; *LAP*, late arterial phase; *PVP*, portal venous phase; *EP*, equilibrium phase (Riccardo, 2005).

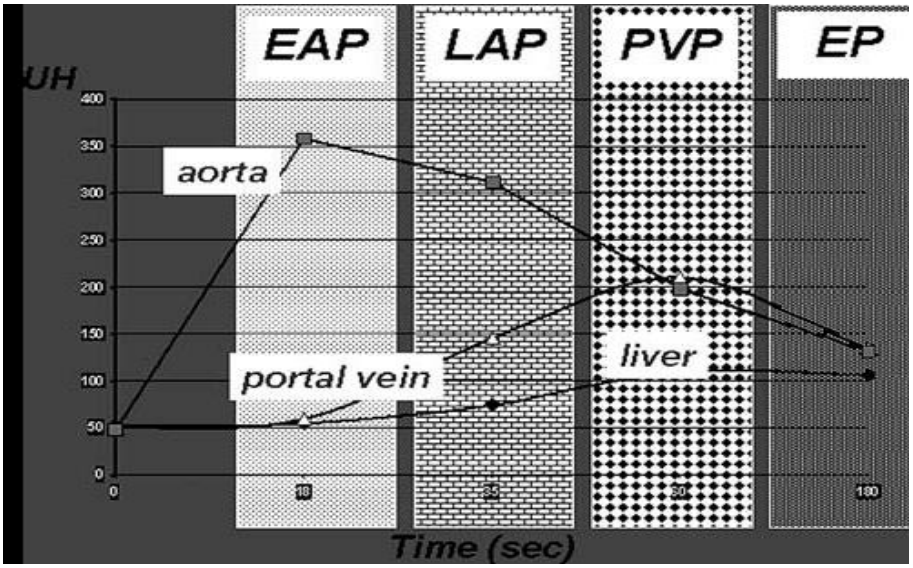


Figure 2.16 Time-density curves representing enhancement of aorta, portal vein and liver parenchyma during each scan. Please note clear separation of different vascular phases with early arterial phase demonstrating exclusive enhancement of arterial vessels with absolutely no venous contamination. *EAP*, early arterial phase; *LAP*, late arterial phase; *PVP*, portal venous phase; *EP*, equilibrium phase PVP) beginning 60 s after the injection of contrast medium. Finally, a 3-min delayed scan (equilibrium phase, EP) is acquired (Riccardo, 2005). The rationale for performing multiphasic examination is to maximize detection of hypervascular liver neoplasms, particularly in cirrhotic patients. At this time, no consensus has been reached about the use of a so-called double arterial phase.

Some authors reported that double arterial phase imaging of the liver with MDCT is effective for improving detectability of hypervascular hepatocellular carcinoma and for reducing the number of false-positive diagnoses (due to arteriovenous shunts); in particular sensitivity and positive predictive value for hypervascular HCC were 54% and 85% for EAP, 78% and 83% for LAP, and 86% and 92% for double arterial phase, respectively (Fig. 15) (Riccardo, 2005).

However, radiologists should recognize that the application of double arterial phase imaging to the liver may have crucial disadvantages for patients in terms of radiation exposure, as well as workload for personnel due to the huge number of acquired images, generating problems of filming, image interpretation and storage (”image pollution”) . On the other hand, other studies demonstrated that hypervascular neoplasms are best seen during LAP, with no contribution from EAP in terms of sensitivity. In our personal experience sensitivity and positive predictive value of respectively 48.5% and 96.4% in the EAP, 87.1% and 94% in the LAP were

obtained, with no tumors detected in the EAP which were not visible in the LAP (Fig. 16).

In another study, similar results were reported, with sensitivity of 88% with LAP and 90% combining EAP and LAP; both the values were statistically significant higher than 67% obtained with EAP alone (Fig. 17) (Kamel, 2009). The role of an EAP is the acquisition of pure arterial vascular datasets, where only arterial vessels are pacified. If the acquired volume is obtained with thin collimation and a reconstruction interval it can be used to generate high-quality vascular maps (CT angiography); these vascular maps may have an important role in pre-operative assessment of surgical candidates (liver resection or transplantation) or candidates for interventional procedures (catheter angiography) (Fig. 18) (Kamel, 2009).

The third imaging pass, the so-called portal venous phase (PVP), enables evaluation of isoattenuation or hypoattenuation of hypervascular lesions. In addition, in some patients, relatively hypovascular hepatocellular carcinomas and metastases from islet cell or carcinoid tumours may be detected only during this later acquisition scan . As is well known, the portal venous phase not only has the advantage of depicting hypovascular lesions but also is useful in demonstrating portal venous thrombosis, differentiating neoplasms from vessels, and identifying varices and shunts .Within the past decade, some investigators have advocated the use of delayed phase imaging for its potential added value in dynamic spiral CT imaging of the liver (Kopka, 2008)..

Lesion detection and conspicuity has been reported to be higher in the delayed phase than in the portal venous phase, resulting in an improved detection rate of well-differentiated hypovascular hepatocellular carcinomas, depicted as low-attenuating lesions and sometimes missed

when only arterial and portal venous phase scans are obtained . Furthermore, delayed phase imaging has additional value in characterization of hepatic lesions because it offers better visualization of capsule and mosaic patterns seen in some hepatocellular carcinomas, delayed peripheral enhancement of cholangiocarcinoma and ”fi lling-in” patterns of haemangioma (Figs. 19, 20).

In contrast, other authors demonstrated that the portal venous phase showed no signifi cant differences in lesion detection compared with delayed phase imaging, or better still when combined, spiral CT of the arterial and the delayed phases revealed 91% of lesions, whereas a combination of the arterial and portal venous phases or the combination of all three phases revealed 92% of lesions; therefore, the combination of the arterial and portal venous phases is equal to the combination of three phases for detection of hypervascular hepatocellular carcinomas, and the delayed phase becomes superfluous (Kopka, 2008)..

However, in this series of patients only hypervascular hepatocellular carcinoma was included, whilst in clinical practice, there are also cases of hypovascular hepatocellular carcinoma. This concept has been confirmed by other authors, who stated that portal venous-phase images are inferior to late phase images for detecting HCC nodules; in the same paper sensitivity of the unenhanced phase was also evaluated and it was demonstrated not to be necessary. Even with regard to the use of an unenhanced phase opinions are controversial with papers demonstrating no additionally detected lesions (hepatomas or metastases) compared with other phases and other experiences showing a 3% increase in the detection rate for hepatocellular carcinomas compared with arterial and portal venous phases (Kopka, 2008).

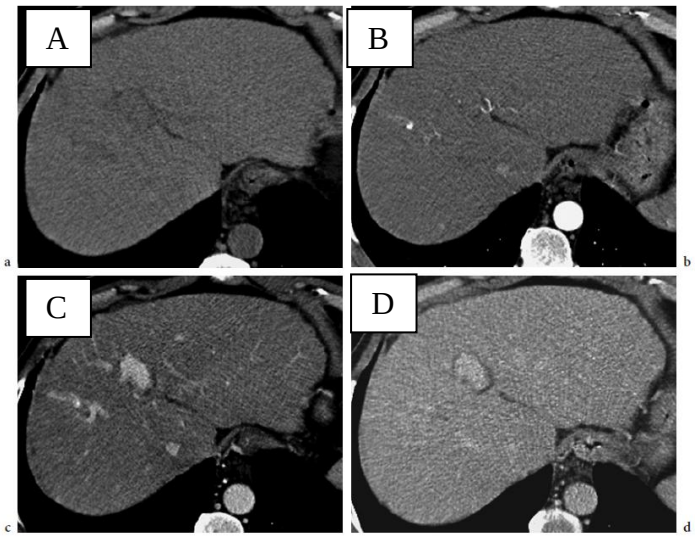


Figure 2.17 a–d. Arterioportal shunt. **A** On basal scan no lesion is detected. **B** On early arterial phase, intense enhancement of a pseudo-lesion is clearly depicted. **C** The enhanced pseudo-lesion follows vascular enhancement, with density similar to portal vein. **D** Delayed scan shows enhancement similar to surrounding parenchyma (Kopka, 2008).

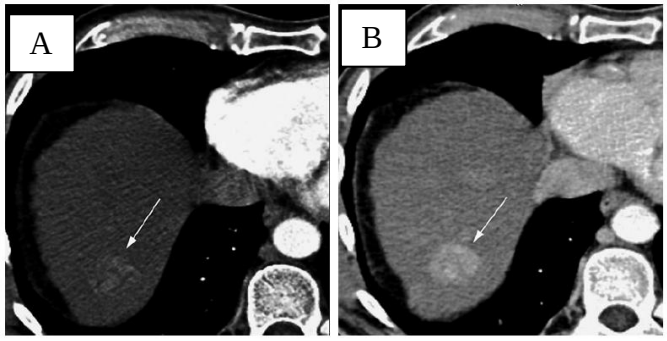


Figure 2.18 a,b. Hepatocellular carcinoma. **a** On early arterial phase hypervascular nodule is fairly seen (*arrow*). **b** Best conspicuity in lesion detection is obtained during late arterial phase (*arrow*) (Kopka, 2008).

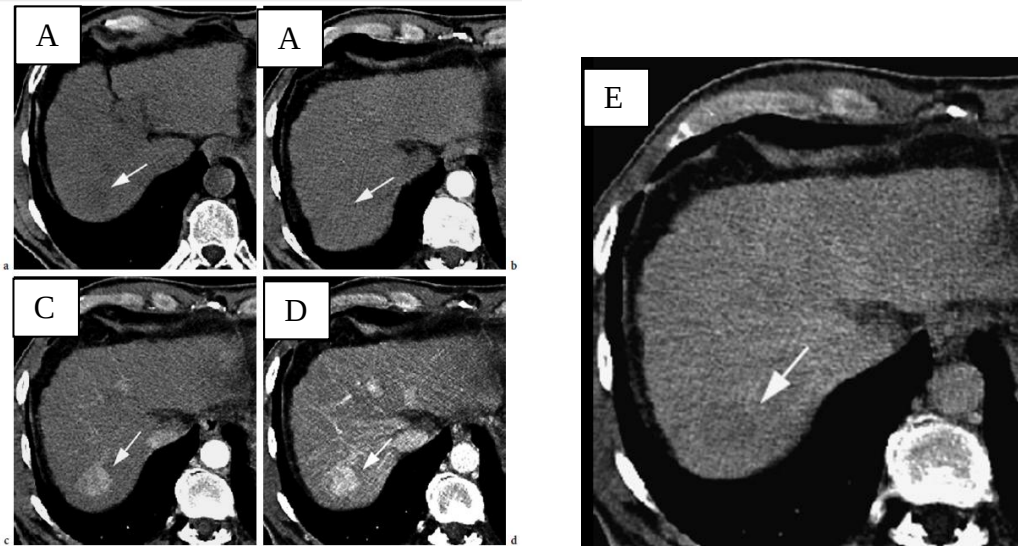


Figure 2.19 a–e. Hepatocellular carcinoma (*arrow*). **a** In the basal scan the lesion appears as a slightly hypodense nodular area. **b** No nodule is detected on early arterial phase. **c** In late arterial phase a marked hyperdense nodule is observed. **d** On portal venous phase contrast enhancement is still persistent. **e** Complete wash-out is demonstrated on equilibrium phase, where the lesion is detected as hypodense nodule (Kopka, 2008).

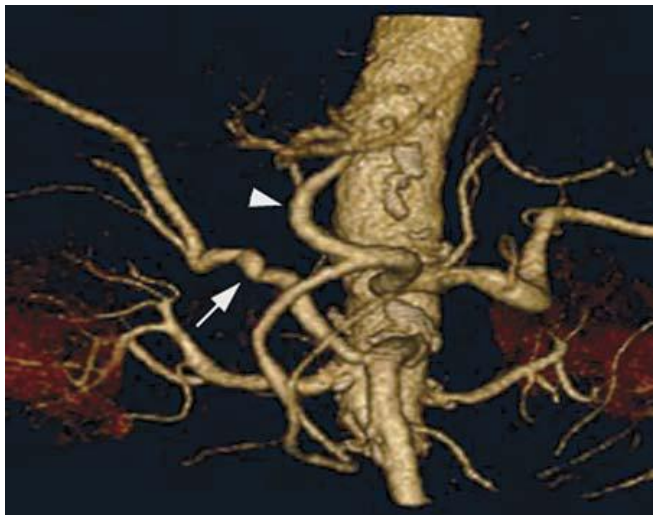


Figure 2.20 Volume-rendered 3D reconstruction of celiac trunk and superior mesenteric artery. Anomalous origin of right hepatic artery from superior mesenteric artery is demonstrated (*arrow*). Left hepatic artery has a normal origin from common hepatic artery (*arrowhead*) (Kopka, 2008).

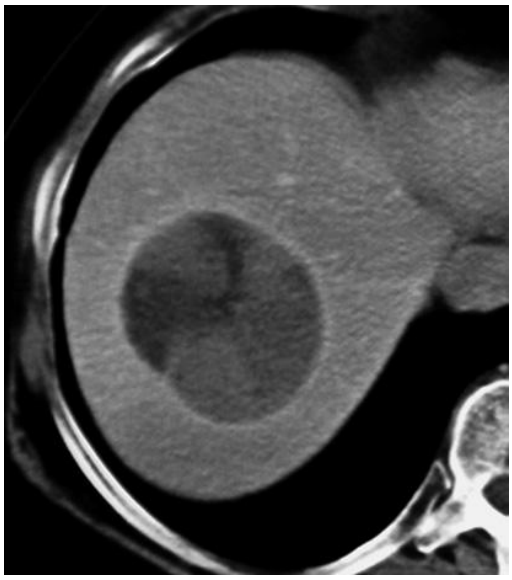


Figure 2.21 On delayed scan better visualization of capsule and mosaic pattern of HCC is demonstrated (Kopka, 2008).

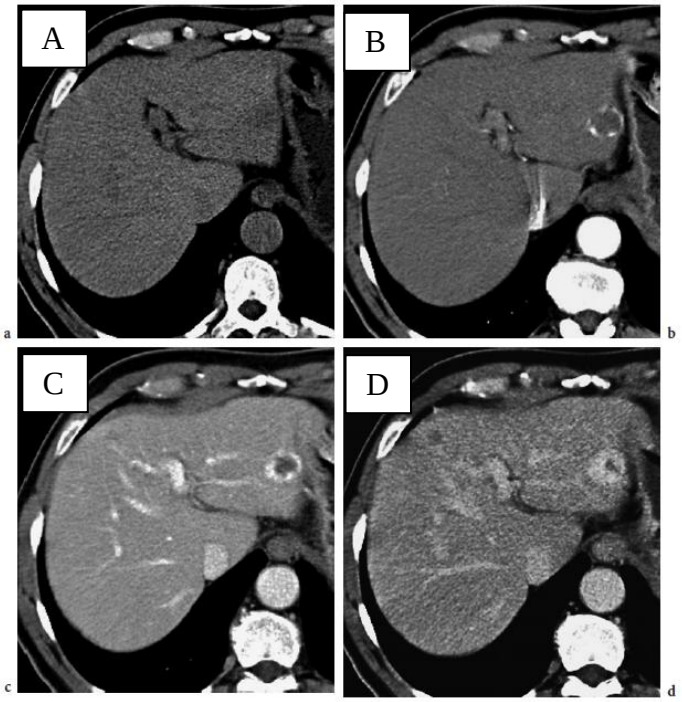


Figure 2.22 a–d. Typical haemangioma. **a** In the basal scan it appears as slightly hypodense area. **b** The lesion presents an initial peripheral enhancement during the arterial phase. **c** In the portal venous phase a

globular centripetal enhancement is observed. **d** In the delayed phase the lesion shows an almost complete filling (Kopka, 2008).

2.4.2.4 Suggestions for Scanning Protocols

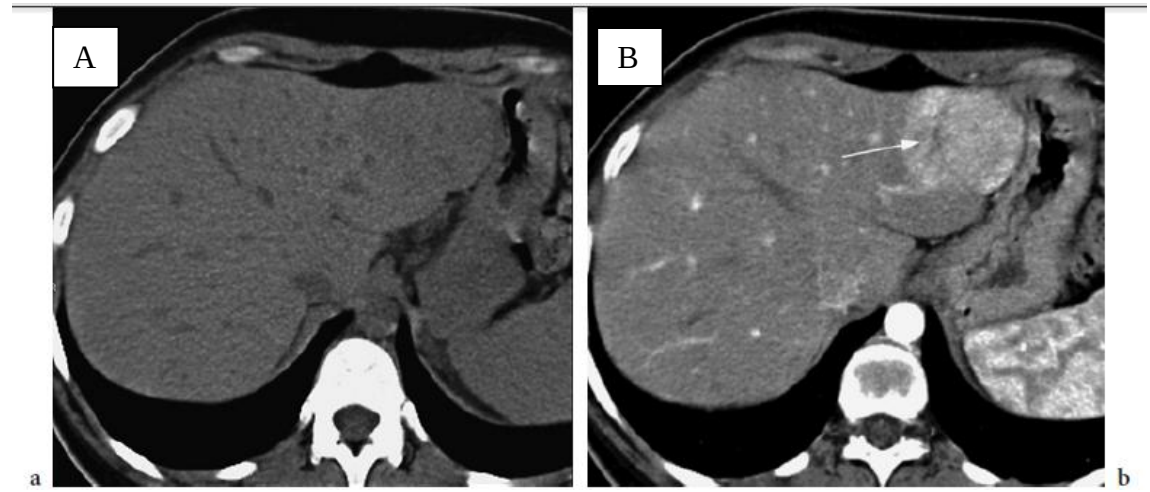
As noted earlier, several options for liver scanning are available. Theoretically a complete liver examination might include a pre-contrast scan, followed by contrast-enhanced acquisition obtained during the arterial (sometimes split into early and late arterial passes) and portal venous phases and a delayed equilibrium phase. For several reasons, including radiation exposure, data explosion with complex image viewing and storing, all the five phases are not acquired in each patient. Although there is not a clear consensus over this issue, the selection and combination of acquisition phases depends on clinical questions (Table 2.1).

In non-hepatopathic patients, with no history of neoplasia, our protocol includes a pre-contrast scan followed by late arterial and portal venous phases. The acquisition of a late arterial phase is justified by the relatively high percentage of hypervascular benign lesions (see focal nodular hyperplasia) which might be easily missed only on pre-contrast and portal venous phase (Fig. 21). A delayed scan is used only in cases of suspected haemangiomas if arterial and portal venous patterns are doubtful and there is the need to confirm complete and delayed enhancement (Riccardo, 2005).

Table 2.1 Suggest MDCT imaging protocol according to clinical indication

	UN	EAP	LAP	PVP	EP
Non-hepatopathic patient No history of neoplasia	+	–	+	+	±
Non-hepatopathic patient History of neoplasia (suspected hypovascular metastases)	+	–	–	+	–
Non-hepatopathic patient History of neoplasia (suspected hypervascular metastases)	–	–	+	+	±
Hepatopathic patient	?	±	+	+	+

UN, unenhanced scan; EAP, early arterial phase; LAP, late arterial phase; PVP, portal venous phase; EP, equilibrium phase.



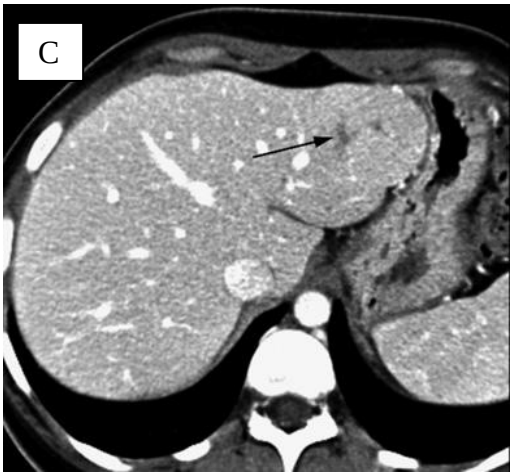


Figure 2.23 a–c. Focal nodular hyperplasia. a The lesion is fairly hypodense compared to normal hepatic parenchyma. b During the arterial phase it presents marked contrast wash-in with the evidence of a hypodense central scar (arrow). c During the portal venous phase, the lesion becomes isodense to liver but the central scar still remains hypodense (arrow) (Riccardo, 2005).

In non-hepatopathic patients, with a previous history of neoplasia with typical hypovascular liver lesions (i.e. colon cancer) the CT protocol is limited to a pre-contrast scan followed by a contrastenhanced scan obtained during the portal venous phase (Fig. 22). If patients have a history of tumour with possible hypervascular liver metastases (kidney, breast, islet cell tumours) a late arterial phase is added to the previous scanning protocol. A completely different approach is dedicated to hepatopathic patients. A pre-contrast scan is questionable since no benefi t was obtained in terms of identification of hepatocellular carcinoma compared with a dynamic contrast-enhanced study. Mandatoryare late arterial, portal venous and delayed phases, since they contribute to the identification of both hypervascular and well-differentiated hypovascular hepatocellular carcinomas. An early arterial phase is indicated only in cases where a vascular map is required (i.e. before chemoembolization, surgery, etc.) (Riccardo, 2005).

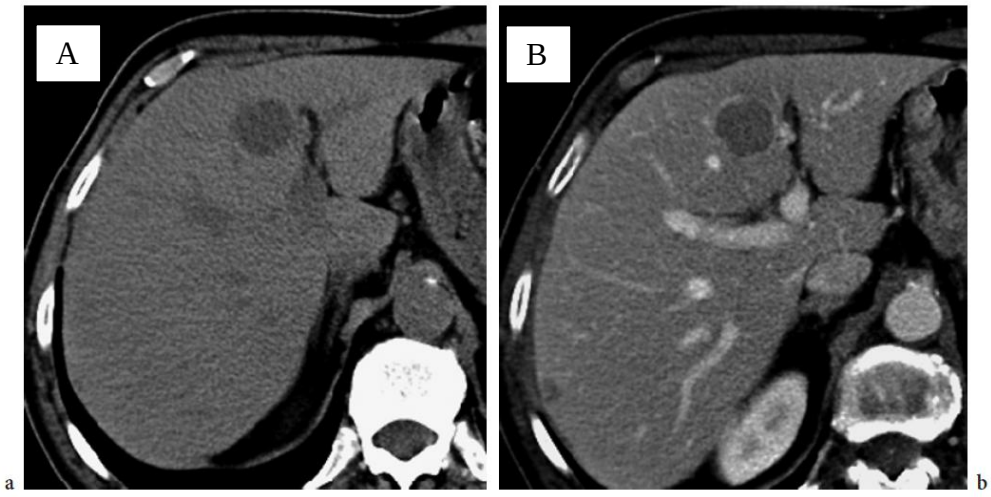


Figure 2.24 a,b. Typical pattern of hypovascular colorectal cancer metastasis. a Lesion is hypodense on unenhanced image. b Lesion remains hypodense 60 s after i.v. administration of contrast medium (Riccardo, 2005).

2.4.2.5 Timing and Intravenous Administration of Contrast Medium

In order to take full advantage of MDCT capabilities adequate timing and fl ow rate of injection should be carefully evaluated. Hepatic arterial enhancement is primarily influenced by the rate of iodine injection and timing of contrast bolus, whereas venous phase enhancement is determined by total dose of iodine administered to patients. Different circulatory phases can only be separated by precisely timing the scanning delay to the patient's individual circulation time; timing can be determined by using fi xed delay, a test bolus, or a computer automated scanner technology (CAST) (bolus tracking) (Kopka , 2008)

The use of fixed delay time cannot guarantee optimal separation between early and late arterial phases, due to inherent variability among individuals, such as patient size and cardiovascular status. A good biphasic study, including late arterial and portal venous phases can be reliably obtained in most cases using fixed delays of respectively 35–40 s and 60–70 s But a more rational use of MDCT can be accomplished by using a test bolus or by using bolus tracking software .The test bolus enables calculation of the circulation time and planning of the optimal scanning delay. It consists in the administration of 20–30 ml of contrast medium at the same flow rate to be used during spiral scanning (i.e. 3.5–5 ml/s) followed by the acquisition of a series of single-level, low dose (120 kVp, 10 mA), CT scans acquired every 2 s for around 40 s and starting immediately after the injection. Although test bolus is accurate in determining the optimal delay time, it does require additional contrast and increases the occupation time of

the scanner room. Automatic software is now very accurate at tracking aortic and liver enhancement curves (Kopka, 2008)..

It simplifies timing of the hepatic arterial phase, regardless of whether a single or double pass is required, and may reduce the volume of contrast required. The automatic bolus-tracking program is used to automatically start the first arterial phase scan after the injection of contrast material. This technique is capable of real-time monitoring; automatic calculation of CT values in a region of interest (ROI), and automatic initiation of diagnostic CT after the CT value of the ROI has reached a trigger threshold level after the injection of contrast material (Kopka, 2008)..

The main factor in relation to arterial enhancement is iodine flux (mg of iodine entering the cir**c**ulation per second), which depends on flow rate (ml/s) and concentration of contrast medium (mg of iodine/ml). Faster injection rates increase maximum enhancement of the aorta and arterial enhancement of liver. Although faster injection rates reduce time from injection to the beginning and the end of the arterial phase, faster injection rates do not decrease the duration of the arterial phase itself, but they increase temporal separation of arterial and portal scan phases, which is important to produce unique phases of imaging; the optimal flow rate should be considered equal to or higher than 3.5 ml/s (Kopka, 2008)..

High infusion rates are often limited by intravenous access and an effective alternative is a higher-concentration contrast medium (370 and 400 mg of iodine/ml); it is also advantageous in patients in whom there is a reduced signal/noise ratio on CT (heavy individuals and those requiring thin slices or reduced radiation dose). Several data in the literature support the hypothesis that an increase in contrast medium concentration results in a greater degree of enhancement and diagnostic efficacy for hypervascular

lesions; Awai et al. (2002) compared two iodine concentrations of Iopamidol (300 mg/ml and 370 mg/ml) with the same total iodine load per patient per body weight and a total lower volume of contrast material and shorter duration of injection time in patients with more concentrated contrast medium; no difference was observed in liver enhancement in all the contrasted passes, but during the first arterial phase aortic enhancement and the attenuation differences between the hepatic parenchyma and hepatic tumours were significantly higher with more concentrated contrast medium; the same results were obtained in different experiences (Kopka, 2008).

Venous phase enhancement is not modified by changes in fl ow rate since it is determined by the total given dose of iodine. So when total iodine dose is fixed but higher concentration and lower volume of contrast medium is used, an earlier and higher arterial enhancement and an improved depiction of hypervascular HCCs is obtained; this results in a greater diagnostic efficacy, employing an equal iodine dose without an increase in cost, because the cost of contrast material for CT examinations depends on the total amount of iodine in the contrast material . Because of the rapid scanning times of multidetector scanners, the entire liver may be scanned when a substantial volume of the injected contrast material remains in the dead space of the injector tubing, peripheral veins, right heart or pulmonary circulation, and central arteries (Kopka, 2008).

Enhancement of liver parenchyma is predominantly from contrast material delivered via the portal vein; therefore, the contrast material still in the dead space can be considered wasted for the purpose of hypovascular liver lesion detection. It was reported that the use of 50 ml of saline chaser to replace the last third (50 ml) of the standard contrast material bolus in order to push the bolus into the heart and further along in the circulation, reduces

the amount of contrast material remaining in the brachiocephalic vein and superior vena cava . Other benefits of this technique are the substantial cost savings and potential increase in safety (reduction of nephrotoxicity) inherent in replacing 50 ml of non-ionic contrast material with 50 ml of sterile saline solution (Kopka, 2008).

It is important to remark that liver enhancement and tumor conspicuity were not adversely affected by lower dose of contrast material. In another study, other authors showed that saline solution fl ush following low dose contrast material bolus improves parenchymal (the liver, the spleen, the pancreas and the renal cortex) and vascular (the portal vein, the inferior vena cava and the abdominal aorta) enhancement during abdominal MDCT study (Kopka , 2008)

2.4.2.6 Collimation and Slice Thickness

With MDCT the same acquired raw dataset can be used to reconstruct two or more datasets of varying thickness. The optimal slice thickness for MDCT of the liver and its value for detection and characterization of focal liver lesions was extensively investigated. In a preliminary experience scans were achieved during hepatic arterial and portal venous phases using a detector configuration of 4×1 mm with a pitch factor of 1.4. Slice thicknesses of 1, 2, 4, 6, 8, and 10 mm were retrospectively reconstructed and evaluated. It was observed that slice thicknesses of 2 or 4 mm proved to be most effective for the detection of focal liver lesions, with an identical detection rate of 96% (Kopka, 2008).

Thinner (1 mm) and thicker (6, 8 and 10 mm) slice thicknesses showed significantly lower detection rates (85%, 84%, 75% and 70%, respectively). Moreover, 1-mm slice thickness generated the highest number

of false positive findings. Lesion characterization was also significantly higher using 2 and 4 mm slice thicknesses. Results of 1- mm slice thickness were lower due to increased image noise which hindered the judgment of specific contrast material enhancement patterns; moreover, 1-mm slice thickness has longer acquisition times, increases patient radiation exposure and produces a high number of images (Fig. 23). Correct characterization decreased with thicker (>4 mm) slices due to partial-volume artifacts (Kamel, 2009).

The most significant differences between different protocols were recorded for lesions smaller than 11 mm. Sensitivity and positive predictive value (PPV) in lesion identification were investigated with a detector configuration of 4×2.5 mm and reconstruction thickness of 2.5 mm, 5.0 mm and 7.5 mm. No statistically significant differences in terms of sensitivities and PPV for slice thickness of 2.5 mm and 5 mm (76% and 73% of sensitivity; 69% of PPV) were observed; but a significantly lower sensitivity was demonstrated if 7.5 mm slice thickness is used (Kamel, 2009).

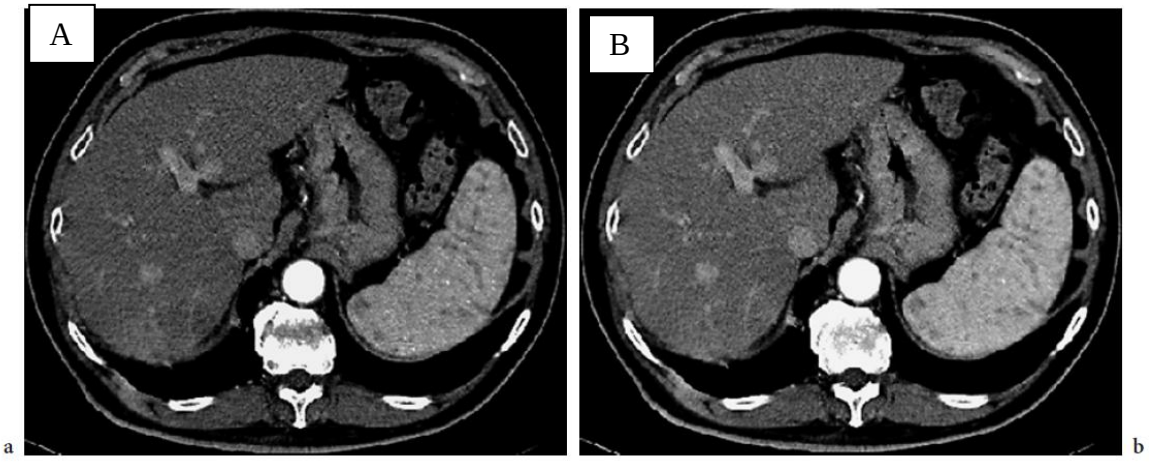


Figure 2.25 a, **b**. Image noise. From MDCT data set it is possible to reconstruct images with different thickness. a With thickness of 1.8 mm the

noise is high and image is grainy. b A 5-mm thick slice is affected by lower noise and reduced artifacts (Kamel, 2009).

2.4.2.7 Radiation Issues

Phantom studies have revealed a possible increase in radiation exposure when imaging protocols of MDCT scanners have been compared to those of single-slice CT scanners. In general, energy dose values of the abdomen increased by a factor of 2.6 with multislice CT compared to single-slice CT. To take full advantage of the potentials of MDCT, imaging protocols must be adapted and optimized but the radiation dose must also be taken into consideration. With MDCT there is a dramatic increase in radiation dose to the patient if mAs settings similar to those used for single-slice scanning are chosen (Kamel, 2009).

This can be due to either differences in scanner geometry (that result **a b Fig. 23 a,b.** Image noise. From MDCT data set it is possible to reconstruct images with different thickness. **a** With thickness of 1.8 mm the noise is high and image is grainy. **b** A 5-mm thick slice is affected by lower noise and reduced artifacts in higher CT dose index per milliamperes, CTDI), different pre-filtering or due to the fact that the effective mAs (=mAs/pitch; by defi nition independent of pitch and therefore better indicator of patient dose) settings are displayed instead of the real mAs settings on the user interface; thus, if the protocol used for MDCT has the same mAs setting as the single-slice scanner protocol, the user will administer a higher radiation dose to the patient, proportional to the pitch used on the single- slice scanner (Kamel, 2009).

For these reasons, scanning protocols should be designed not on the basis of previous milliampere settings but on actual dose values as indicated

by the CTDI , that can be displayed on the user interface of all MDCT scanners and represents the local dose quantity that indicates irradiation intensity inside the limits of the body regions as defined by the operator. It is a measure of the intensity of irradiation at a specified slice location and does not represent total radiation exposure. Dose-length product (DLP) is an integral dose quantity that describes total amount of absorbed radiation and represents the intensity and extent of irradiation for the entire series of CT examination (Kopka, 2008).

As different organs have different radiation sensitivity, normalizing the DLP on the basis of the specific organ, the effective DLP is obtained, which is the most relevant descriptor for assessing cancer risk. The result of DLP and effective DLP provide an estimate of effective dose with CT scanning. Dose reduction strategies may involve modifying scanning parameters or protocols to reduce radiation dose for individual patients or specific clinical situations and, technologic developments for improving scanner efficiency or improving image quality at low-dose CT scanning (Kopka, 2008).

2.4.3 Data Review Post-Processing

Due to the large number of slices generated by a single liver examination, especially if performed using a multiphasic study protocol, images should be analysed interactively by the operator on a secondary console. Today all the MDCT scanners are equipped with two separate consoles, one for data acquisition and the second for data viewing and processing. This approach requires powerful computers and user-friendly software in order to have a smooth data workflow. Real time interaction between operator and dataset is a mandatory pre-requisite (Riccardo, 2005). It is also important to have an absolutely seamless scrolling that lets the radiologist forget that he/she is

reviewing several hundred images. Scrolling should be mouse-controlled in a way that lets the user move from top to bottom of the dataset within a single move but also lets him finely evaluate a particular abnormality.

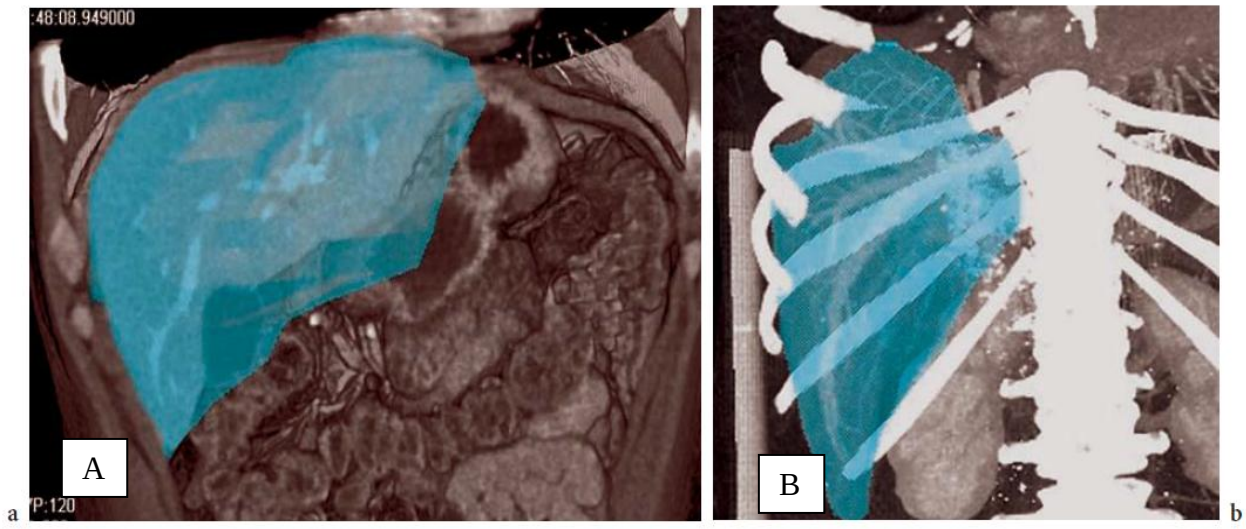
Slice thickness should interactively be chosen thick enough to reduce noise to a reasonable level but as thin as possible to keep partial volume effects low. It should be easy (one mouse click) to shift the image plane from axial to coronal or sagittal, or to change the viewing mode from thick multiplanar reformations to thin-slab maximum intensity projection (MIP) or even thin-slab volume rendering (VR). Image post-processing is based on more complex algorithms and is used for generating vascular reconstructions or for calculating hepatic volumetry (Riccardo, 2005).Three-dimensional vascular reconstructions can be obtained by using either maximum intensity projection (MIP), or surface-rendering or volume-rendering algorithms (Kamel, 2009).

For better anatomic representation and evaluation of spatial relationships, as well as for a faster and easier interaction with 3D datasets, volume rendering is the preferred reconstruction algorithm, although the diagnosis is derived from a combined evaluation of source and reconstructed images. With volume rendering, selective vessel representation is obtained using different rendering curves. A panoramic overview of the entire major abdominal branches can be obtained using a preset opacity curve showing only the vascular surface (Riccardo, 2005).

The evaluation of minor vessels (i.e. second, third, and more distal orders of collateral branches) requires the analysis of 3D datasets using interactive multiplanar cut planes (”oblique trim”) and by modulating the opacity of the anatomical structures under evaluation and window/level parameters in order to see vessels ”through” abdominal organs. A complete

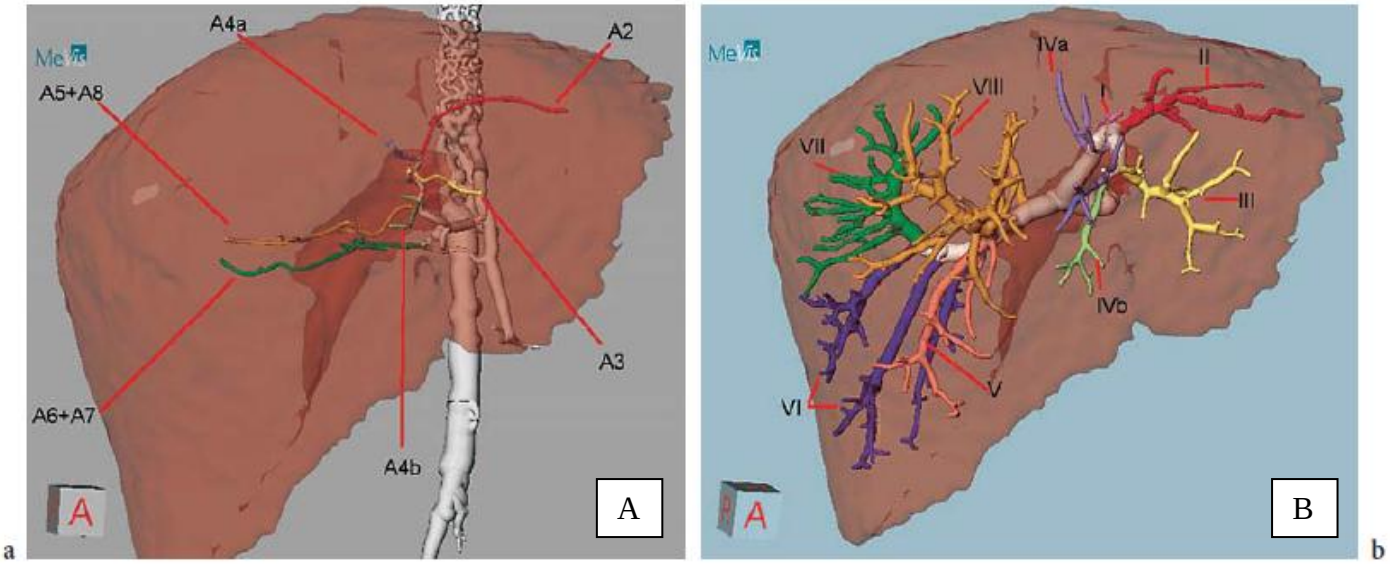
analysis of arterial and venous vessels can be obtained within a mean interpretation time of 10 min. Hepatic volumetry is another indication for post-processing liver datasets (Riccardo, 2005). Determination of liver volume is necessary in case of liver transplantation from a living donor (for both patient selection and surgical planning) and to evaluate the feasibility of hepatectomy, especially in the case of atypical resections (Fig. 24) .

An insufficient remnant liver volume calculated preoperatively might lead to performing iatrogenic occlusion of right or left portal vein in order to determine a lobar liver hypertrophy, making the resection feasible. Software for the calculation of liver volume is under development. From completely manual software where it was necessary to manually outline liver contour slice by slice, there are now semi-automatic and completely automatic programs. The latter are able to highlight different liver segments and to create vascular maps for arterial and portal afferences and for hepatic vein drainage. The volume of each single segment can be calculated and a simulation of surgical resection can be performed. Information can be displayed using coloured maps or 3D movies (Fig. 25) (Riccardo, 2005).



a b

Figure 2.26 a, b. Volumetric rendering of liver parenchyma. a Calculation of the entire liver. b Following virtual left hepatectomy,the volume of the remaining right liver lobe is calculated (Riccardo, 2005).



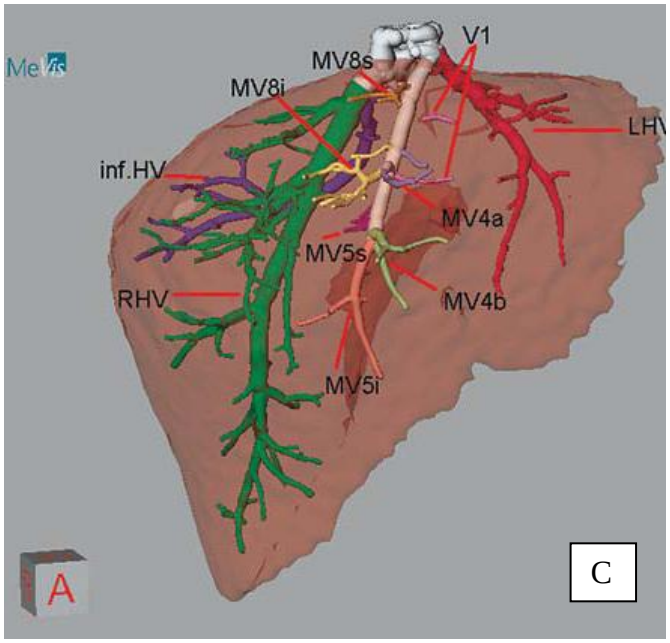


Figure 2.27 a.c Automatic segmentation of hepatic parenchyma by means of liver vessels definition. a Three-dimensional reconstruction of different segments of hepatic artery .b Three dimensional view of portal vein segmentation. c Similar view of segmental distribution of hepatic veins (Riccardo, 2005).

Chapter Three

Materials and Method

This is a retrospective study has been conducted in Fedail, Khartoum and Royal scan center. The aim of this study was to evaluate the liver lesions using computed tomography, the study was conducted in period from July 2015 to November 2015.

3.1-Subjects

A review of 60 patients referred for liver CT scan woth variable ages, symptoms and residence.

3.2-Machine used

Multi detectors computed tomography with automatic injector for contrast media and they are Toshiba, GE, and Siemens.

3.3-Inclusion criteria

a) All ages and sexes Patients.

b) Contrast-enhanced abdominal CT.

c) Patients with innumerable lesions in both liver lobes.

3.4-Exculusion criteria

a) Inappropriate contrast medium injection (for example: contrast medium extravasation)

b) Patients with contraindication for iodinated contrast medium

c) Incomplete images.

d) Images with artifacts (for example: respiratory artifacts) which would make density measurements inaccurate or unreliable

3.5-Study variables

A clinical sheet filled for each patient's age, residence, the computed tomography appearance for lesions with different shapes, sizes and contents and the suggested diagnosis.

3.6-Technique used

Machine Type	Number of detectors	Slice sickness	Amount of CM/ml	Arterial phase delay time/sec	Porto/Venus phase delay time/sec
Toshiba	64	Thin as possible	70	25	45
GE	2	5	95	27	48
Siemens	16	3-5	80	25	46

The entire liver will be scanned successively, in arterial, portal and equilibrium phases.

A 5mm collimation and 5mm/sec table speed will be used. All scans will be taken in the craniocaudal direction and during single breath hold. After obtaining a digital scout view, unenhanced scan of the liver will be obtained.100-200 ml of 65% iodinated contrast material will be given by using a power injector at a rate of 1.5 to 2ml/sec. After 22 or 27seconds,the entire liver will be scanned in arterial phase.22 seconds after the end of the arterial phase ,the liver will be scanned in portal venous phase. The 20 second interscan delay is for the patient to rebreath and reposition the scan plane cephalad to the liver. After these two phases the third scan will be

taken in the equilibrium phase, 8-10 minutes after injection of contrast the images acquired in different phases will be evaluated in detail to identify lesions

3.7-Measurement

Primary data were collected from patient's sheets, interview, and the computed tomography done for each patient.

3.8-Analysis

The results were picked up about the incidental findings. And with different figures, graphs, and groups it explained the role of computed tomography to detect the liver lesions.

3.9-Ethical consideration

The data collected from the patients and it kept secret, and it recorded as it collected from the patients, all this data collected according to the patient satisfaction and agreement.

Chapter Four

RESULTS

The study includes 60 patients with different age and sex, they were investigated in different computed tomography departments in Khartoum state, In period from (July 2015 to November 2015).

Table 4.1 liver lesions among sample of the study.

Pathology	Number	Percentage
Fatty liver	2	3.3%
Abscess	3	5%
Mass	20	33.3%
Metastasis	20	33.3%
Cirrhosis	5	8.3%
Cyst	10	16.7%

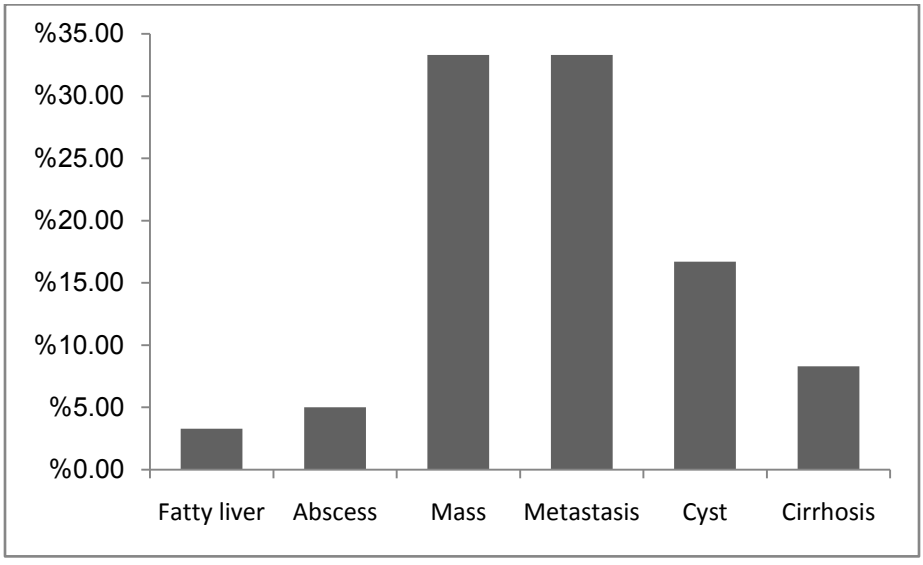


Figure 4.1 liver lesions

Table 4.2 Gender distribution

Sex	Number	Percentage
Male	25	41.7%
Female	35	58.3%

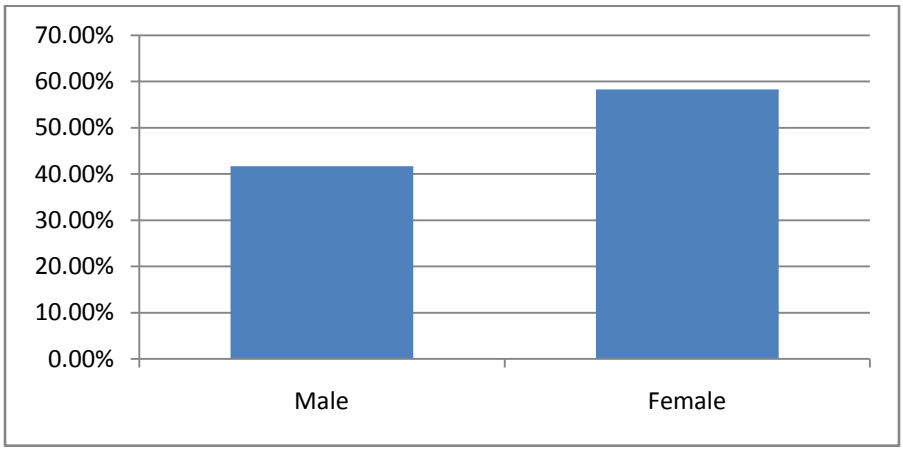


Figure 4.2 Gender distribution

Table 4.3 Distribution of age grouping.

Age group	Number	Percentage
(1-20)	6	10%
(21-40)	7	11.7%
(41-60)	27	45%
(61-80)	20	33.3%

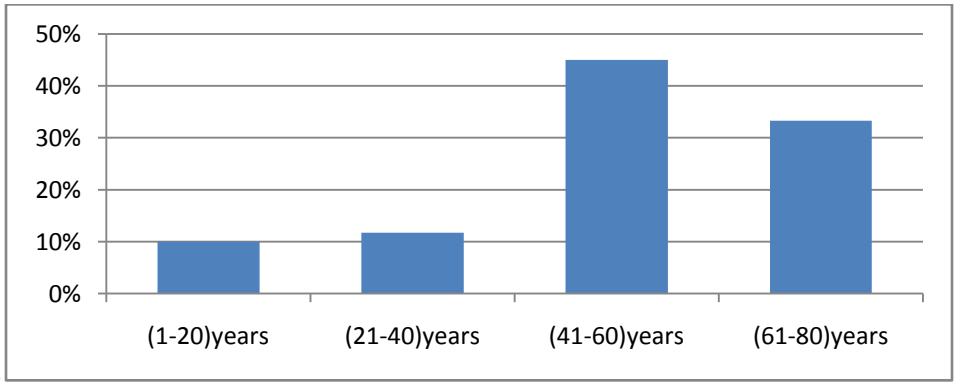


Figure 4.3 Age distribution

Table 4.4 Distribution of residence among the patients whom came from different places of Sudan to Khartoum state.

Residence	Number	Percentage
East	6	10%
West	9	15%
North	15	25%
South	5	8.3%
Center	25	41.7%

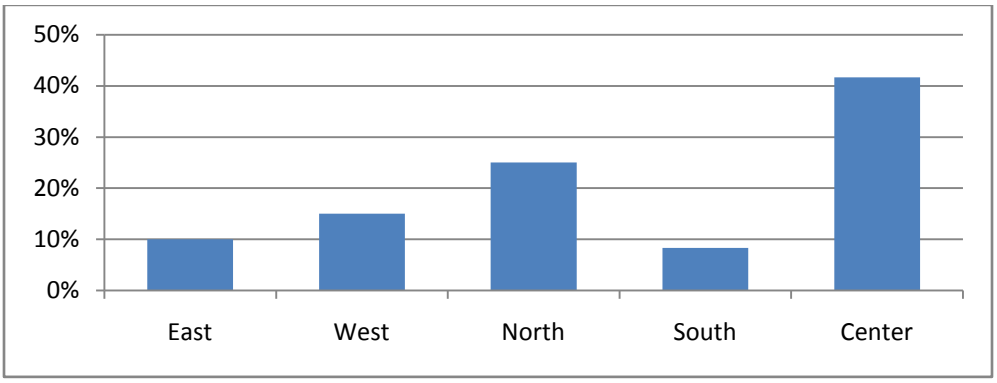


Figure 4.4 Distribution of residence.

Table 4.5shows that commonest signs and symptoms of patients with suspected liver lesions.

Sign and symptom	Number	Percentage
Fatigue	51	85%
Anorexia	59	98.35%
Low grade of fever	54	90%
Jaundice	25	41.7%
Ascites	18	30%
Bleeding	3	5%
Hepatomegally	31	51.7%
Other	17	28.3%

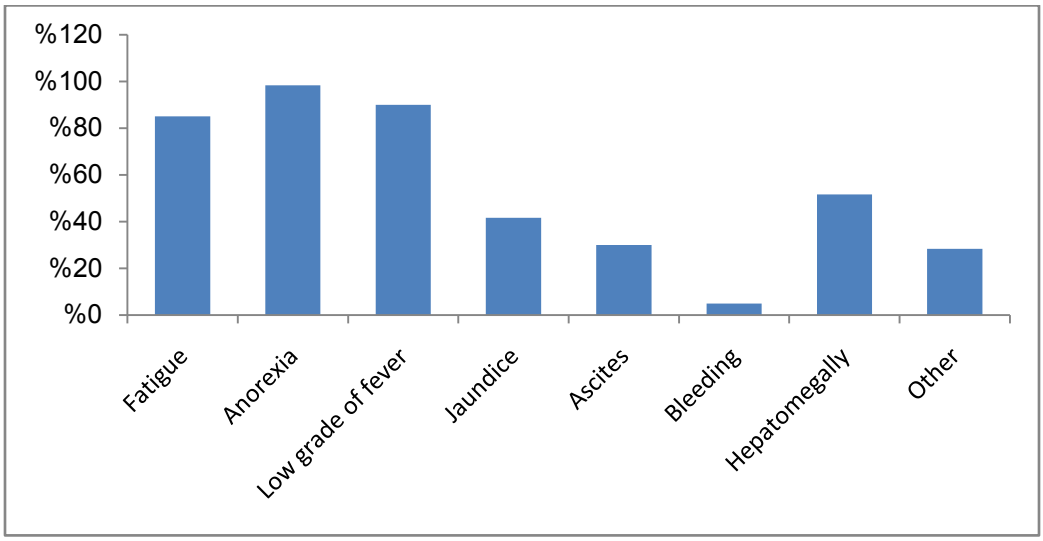


Figure 4.5 Commonest signs and symptoms

Table 4.6 Distribution of residence patients had liver cyst.

Residence	Number	percentage
south	0	0%
East	0	0%
West	2	20%
Center	5	50%
North	3	30%

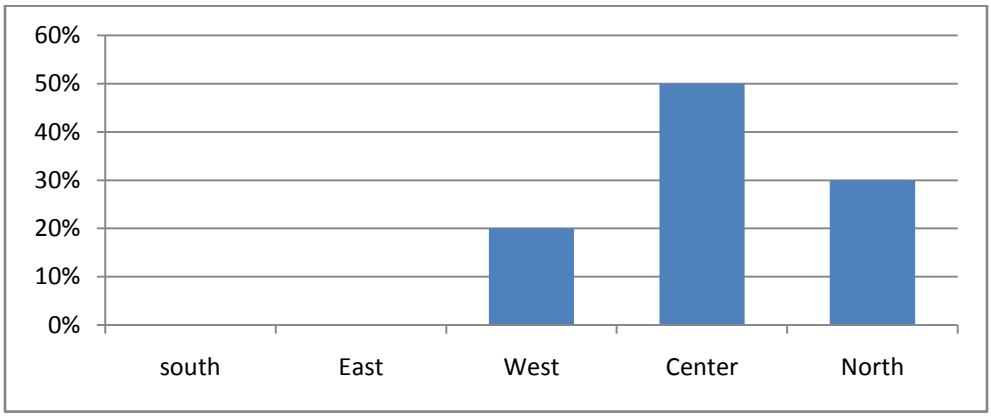


Figure 4.6 Distribution of residence patients had liver cyst.

Table 4.7 Distribution of residence among 3patients had liver abscess.

Residence	Number	Percentage
south	0	0%
East	0	0%
West	0	0%
Center	2	66.7%
North	1	33.3%

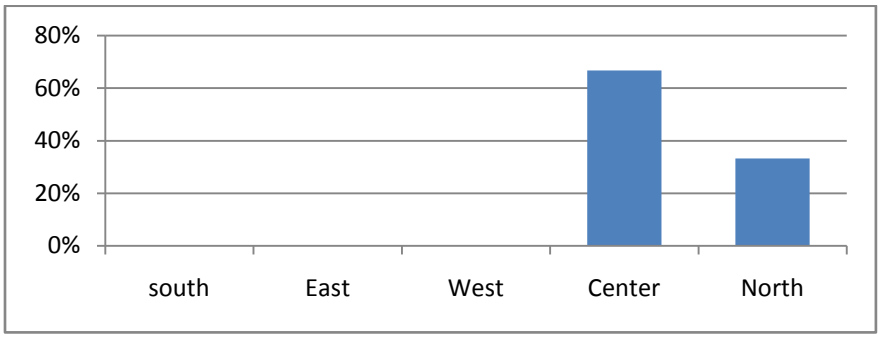


Figure 4.7 Distribution of residence among 3patients had liver abscess.

Table 4.8 Distribution of the appearance of liver abscess among 3 patients.

Appearance	Number	Percentage
Wall calcified	2	66.7%
Internal septation	3	100%

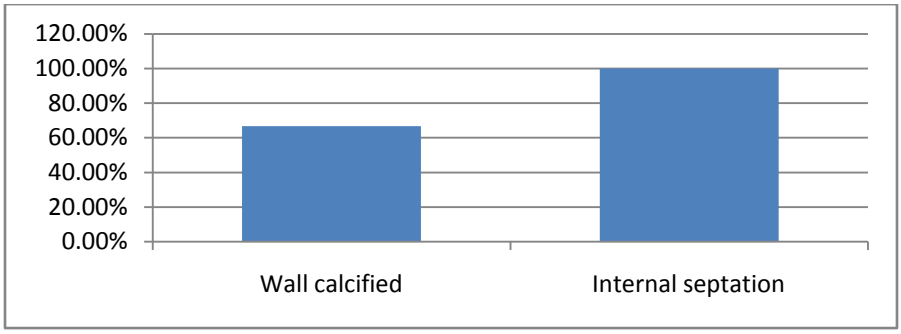


Figure 4.8 Distribution of the appearance of liver abscess among 3 patients.

Table 4.9 Distribution of residence among 5patients had liver cirrhosis.

Residence	Number	percentage
south	0	0%
East	0	0%
West	1	20%
Center	2	40%
North	2	40%

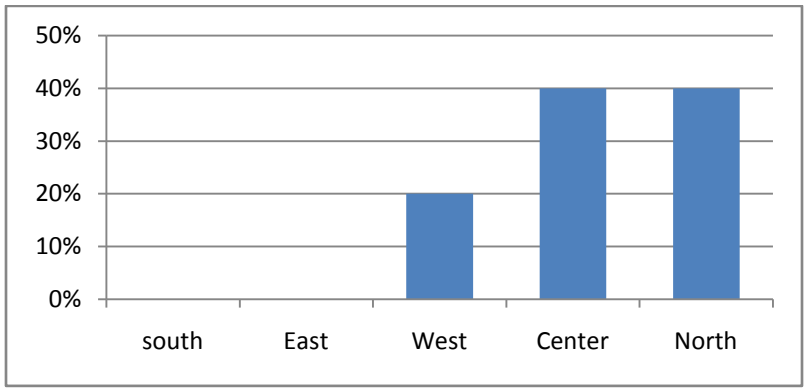


Figure 4.9 Distribution of residence among 5patients had liver cirrhosis.

Table 4.10 Distribution of the appearance of liver cirrhosis

Appearance	Number	Percentage
Small size	4	80%
Presence of ascitis	5	100%
Irregular out line	4	80%

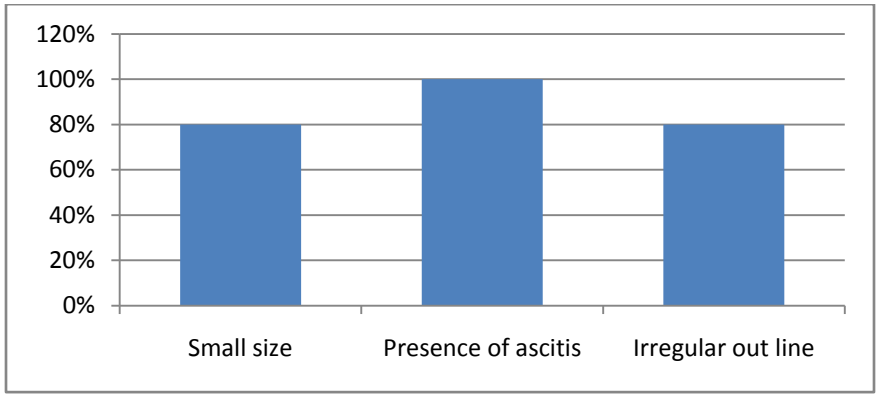


Figure 4.10 Distribution of the appearance of liver cirrhosis

Table 4.11 Distribution of residence patients diagnosed as liver metastasis.

Residence	Percentage	Number
south	15%	3
East	10%	2
West	25%	5
Center	30%	6
North	20%	4

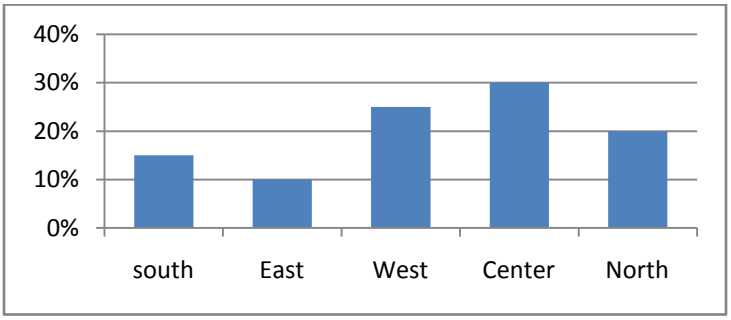


Figure 4.11 Distribution of residence patients diagnosed as liver metastasis.

Table 4.12 Distribution of the appearance of liver metastasis

Appearance	Percentage	Number
Hypo dense	80%	16
Enhancement	35%	7
Common bile ductdilation	5%	1
Irregular out line	15%	3

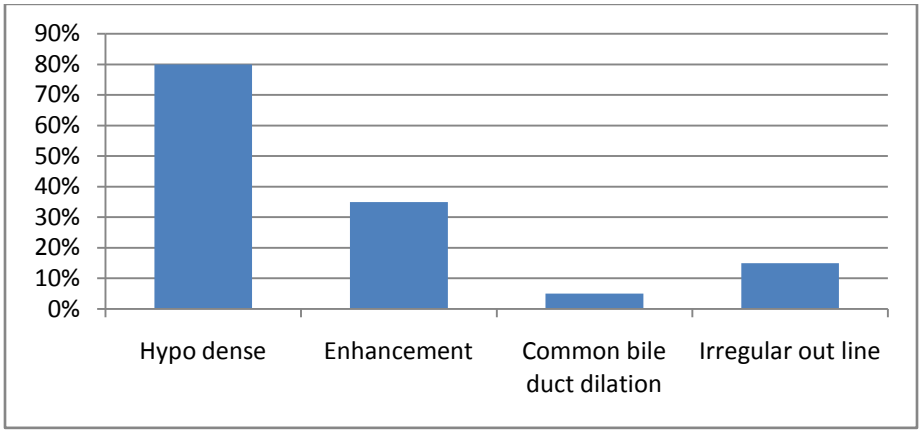


Figure 4.12 Distribution of the appearance of liver metastasis

Table 4.13 Distribution of the location of the metastasis in the liver.

Location	Number	percentage
Right lobe	7	35%
Left lobe	3	15%
Both lobes	9	45%
Caudate lobe	1	5%

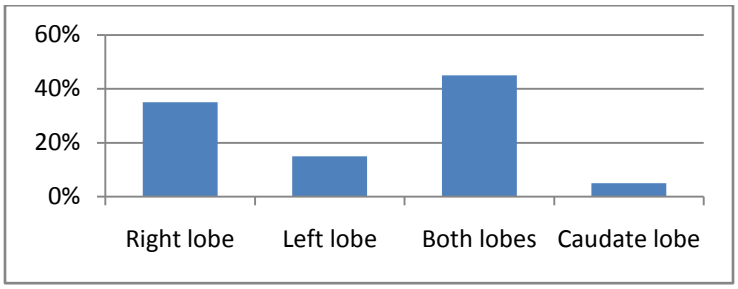


Figure 4.13 Distribution of the location of the metastasis in the liver.

Table 4.14 Distribution of the source of the metastasis of the liver.

Source	Number	Percentage
Lung	3	15%
Gastro intestinal tract	13	65%
Prostate	1	5%
Uterus (ovary)	1	5%
Pelvic	1	5%
Ureter	1	5%

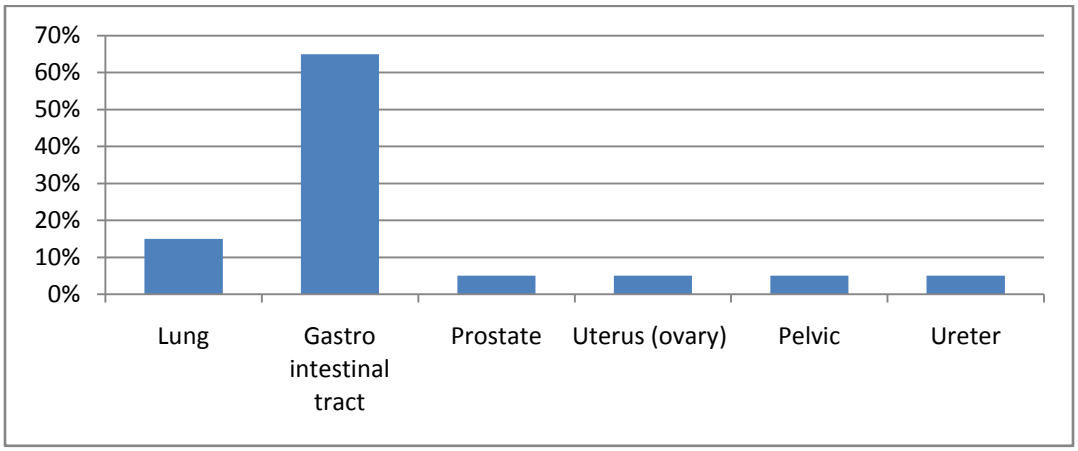


Figure 4.14 Distribution of the source of the metastasis of the liver.

Table 4.15 Distribution of residence patients diagnosed as solid mass in the liver.

Residence	Number	percentage
south	2	10%
East	3	15%
West	1	5%
Center	10	50%
North	4	20%

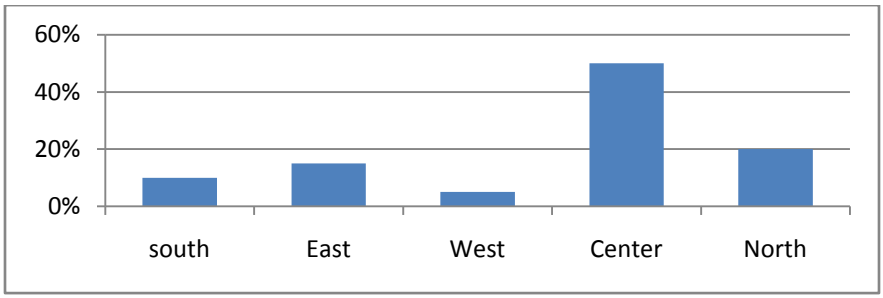


Figure 4.15 Distribution of residence patients with solid mass in the liver.

Table 4.16 Distribution of the appearance of the solid mass

Appearance	Number	Percentage
Hypo dense	19	95%
Enhancement	8	40%
Calcification	1	5%
Intra hepatic biliary dilation	7	35%
Heterogeneous	9	45%

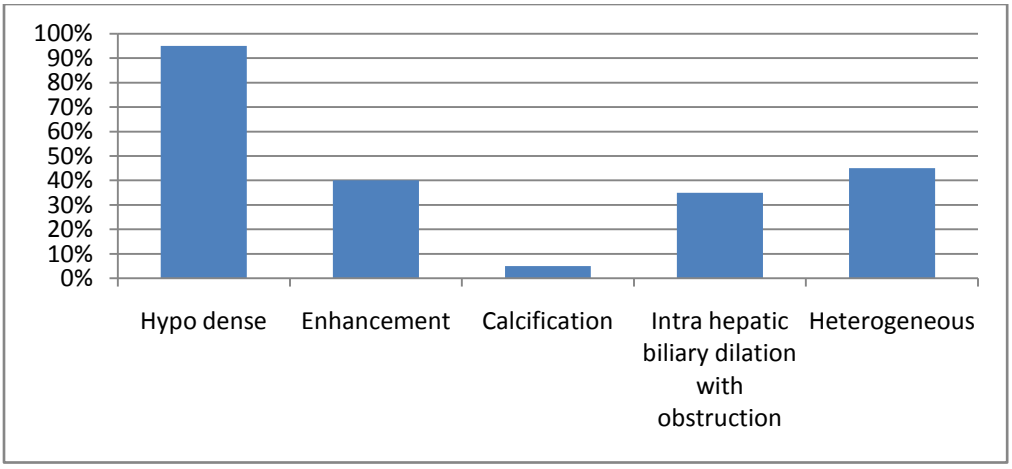


Figure 4.16 Distribution of the appearance of the solid mass

Table 4.17 Distribution of the location of the solid mass in the liver.

Location	Number	percentage
Right lobe	10	50%
Left lobe	3	15%
Both lobes	5	25%
Caudate lobe	2	10%

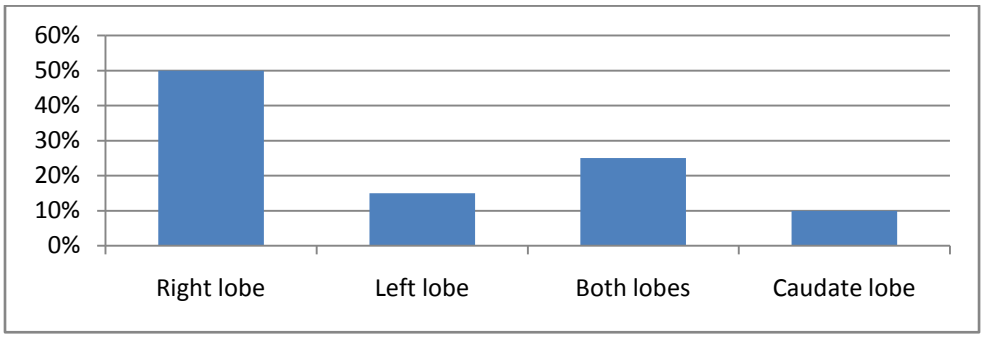


Figure 4.17 Distribution of the location of the solid mass in the liver

Table 4.18 Distribution of the probability of the solid mass in the liver.

Types	Number	Percentage
Cholangiocarcinoma	2	10%
Lymphoma	2	10%
Hamangioma	2	10%
Hepatocellular carcinoma	11	55%
Hepatoplastoma	1	5%
Other	2	10%

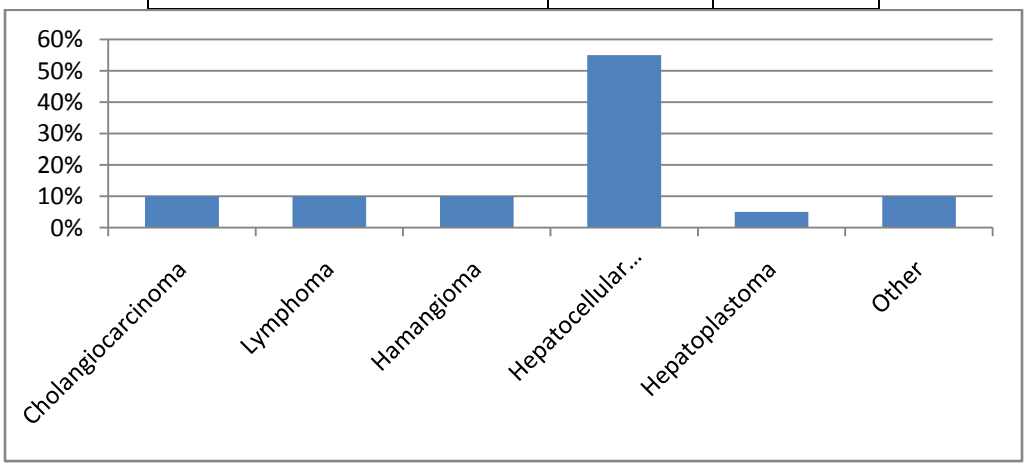


Figure 4.18 Distribution of the probability of the solid mass in the liver.

Table 4.19: Characteristic Features of Detected Hepatic Lesions on CT

Pattern of Enhancement	Phase of Acquisition with maximum lesion conspicuity	No of Cases	Suggested Diagnosis
The attenuation of the liver is at least 10 HU less than that of the spleen or if the attenuation of the liver is less than 40 HU	Non-enhanced	2	**Fatty liver**
	Portal venous phase		
	Delay phase		
Multifocal lesions with arterial phase enhancement and portal venous phase washout of contrast	Arterial phase	14	**Metastasis**
	Portal venous phase	6	
	Delay phase		
Multiple lesions with thick wall and central necrosis nor daughter cyst	Arterial phase		**Abscess**
	Portal venous phase	2	
	Delay phase	1	
Single lesion with sharp margins and near water density in the centre and does not show enhancement in the centre	Arterial phase		**Cyst**
	Portal venous phase	6	
	Delay phase	4	
Single heterogeneous lesion with hyperdense component	Arterial phase	17	**Mass**
	Portal venous phase	3	
	Delay phase		
Multiple regenerative nodules are isodense to rest of liver with lobar atrophy	Arterial phase		**Cirrhosis**
	Portal venous phase	4	
	Delay phase	1	

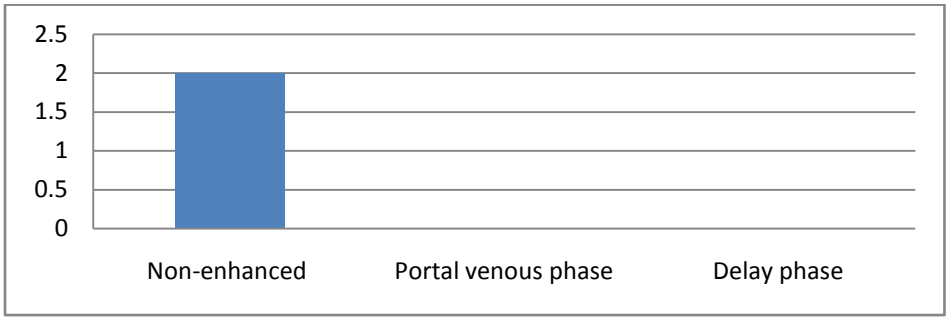


Figure 4.19 Distribution of the appearance of Fatty liver in Phase of Acquisition

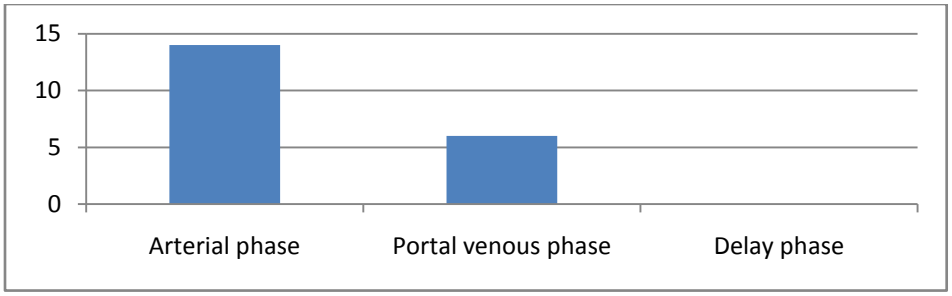


Figure 4.20 Distribution of the appearance of Metastasis in Phase of Acquisition

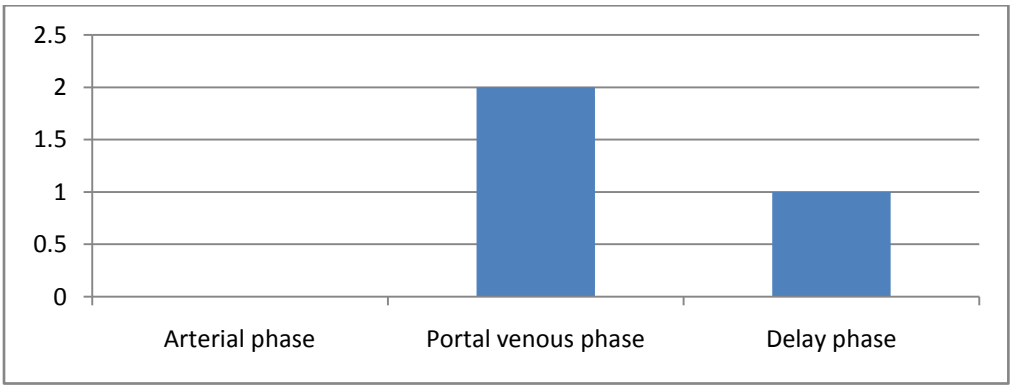


Figure 4.21 Distribution of the appearance of Abscess in Phase of Acquisition

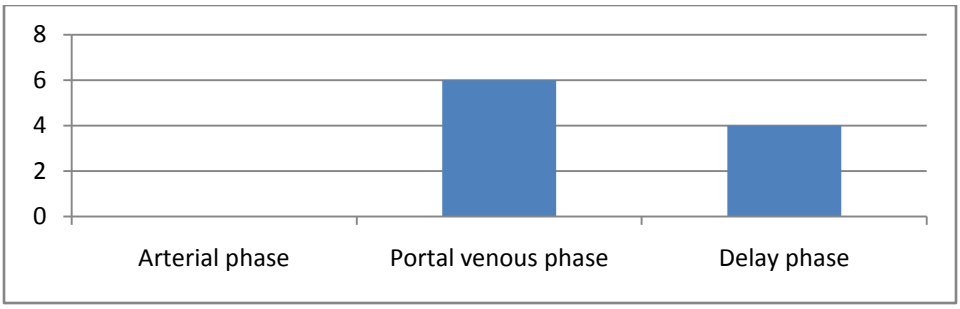


Figure 4.22 Distribution of the appearance of Cyst in Phase of Acquisition

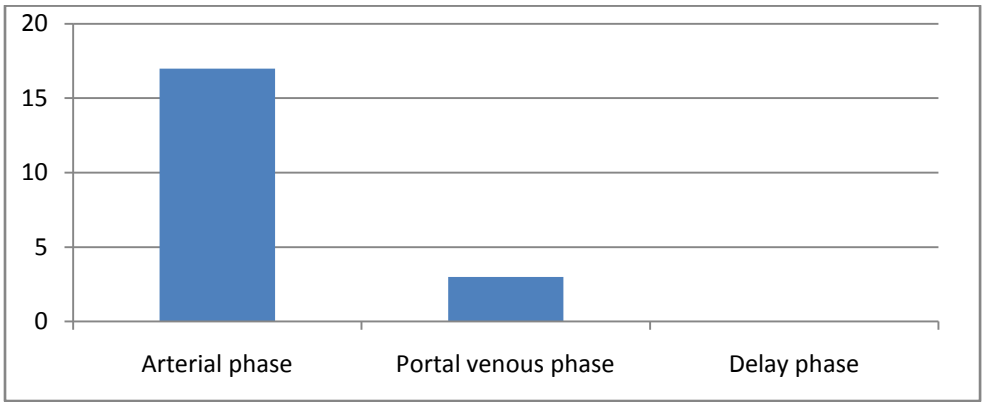


Figure 4.23 Distribution of the appearance of in Mass Phase of Acquisition

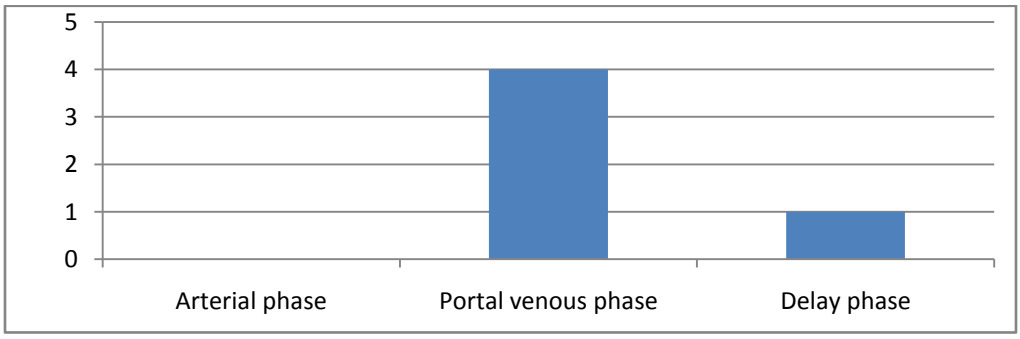


Figure 4.24 Distribution of the appearance of Cirrhosis in Phase of Acquisition

Chapter Five

Discussion, Conclusion and Recommendation

5.1 Discussion

Triphasic spiral liver Computed Tomography (CT) is a standardized procedure for the detection and characterization of a large variety of benign and malignant liver 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 of liver parenchyma during a single breath hold. 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 (Ji H, 2010).

This was clearly seen in the result of study which showed that (3) cases was liver abscess, which make the incidence of abscess among the Sudanese population in Khartoum state, 10 cases was liver cysts, 20 cases was liver masses, 20 cases was liver metastases, 5 cases was liver cirrhosis and (2) case was fatty liver.

Most metastatic lesions were hypo vascular with more lesions being detected on portal venous phase and most of the primary malignancies were hyper vascular and detected on hepatic arterial phase, however haemangiomas, focal nodular hyperplasia and hepatocellular adenoma are benign lesions which are seen to enhance in the arterial or hyper vascular phase. In our study, 14 metastatic lesions were hypervascular and 6 lesions

were hypovascular. Most of the hypervascular metastatic lesions (n =20) were best visualized on arterial phase images rather than on port venous phase. Most of them become iso or hypodense on portovenous and equilibrium phases making it difficult to diagnose on single phase thus signifying the importance of additional arterial phase images (Maarten, 2006).

Advanced or poorly differentiated hepatocellular carcinomas are usually hypervascular lesions that derive most of their blood supply from the hepatic artery with the portal venous contribution decreasing as the grade of malignancy increases. Similarly, cirrhosis and its associated altered portal venous blood flow may help reveal more lesions on the hepatic arterial phase than on the portal venous phase. In our study, all the 60 hepatomas presented as hyper/mixed; 31 detected only in the arterial phase; 21 were hypoattenuating in the portal phase and 8 were better seen in portal phase. These findings are in keeping with the well-known hypervascularity of HCC. All hyper/mixed/mixed lesions occurring in patients with chronic liver disease truly represent HCC lesions. Therefore; lesions seen during only the hepatic arterial phase may require biopsy. In patients with hypervascular malignancies such as hepatoma, detection of small lesions especially if solitary is important because these lesions are more likely to be respectable or respond to therapy than the larger lesions (Heiken, 2008).

Focal nodular hyperplasia and adenomas may appear hyperdense during the hepatic arterial phase and may rapidly become isodense to the liver or invisible during the portal venous phase and equilibrium phase, simulating hepatomas or hypervascular metastases. In this study, very few cases of focal nodular hyperplasia (FNH) and adenomas diagnosed in our study and

all of them were hyper enhancing on arterial phase. Three lesions labeled as adenomas became isodense on portovenous and equilibrium phase. Similarly, one case of FNH was more conspicuous on portovenous images. These lesions could have been easily overlooked if only single phase imaging was acquired (Vilgrain, 2003)

The triphasic helical CT examination can create certain diagnostic dilemmas, including the inability to specifically characterize some lesions seen only on the hepatic arterial phase and not on the equilibrium or portal venous phase. Although high accuracy (95%) was noted in our results, we had 2 false positive results.

These lesions were labeled as malignant because of hypervascularity and patient\'s history of renal cell carcinoma and gastrointestinal malignancy. These lesions proved to be focal nodular hyperplasia and haemangioma and not metastases. Hepatomas, hypervascular metastases, focal nodular hyperplasia and adenomas may all appear similar on triphasic helical CT examination. In spite of this, our study showed sensitivity of triphasic helical CT scan to be hundred percent for differentiation of benign and malignant liver lesions (Camera, 2006).

Our study has some limitations like small sample size especially for benign lesions. Interobserver agreement for interpretation of CT images was not calculated. In cases of multifocal lesion, only biopsy of largest and most approachable lesion was performed. Other potential limitation is that scans were performed on three different CT Scanners with two different make.

5.2 Conclusion

Triphasic CT scan is a good non-invasive tool and can be used as first line imaging modality for differentiating benign and malignant focal liver lesions. Benign lesions like haemangioma can be reliably differentiated from malignant liver lesion; therefore unnecessary biopsies can be avoided. It is also particularly useful for hypervascular lesions which can be easily missed on routine CT scanning.

5.3 Recommendations

- Standard protocol should be followed for accurate detection of small liver lesions.
- 3D protocol should be available in all diagnostic centers for liver pathology whenever possible.
- Proper training for the operating technologist.
- Use the dual head Computed Tomography (CT) because it's has a high contrast resolution.

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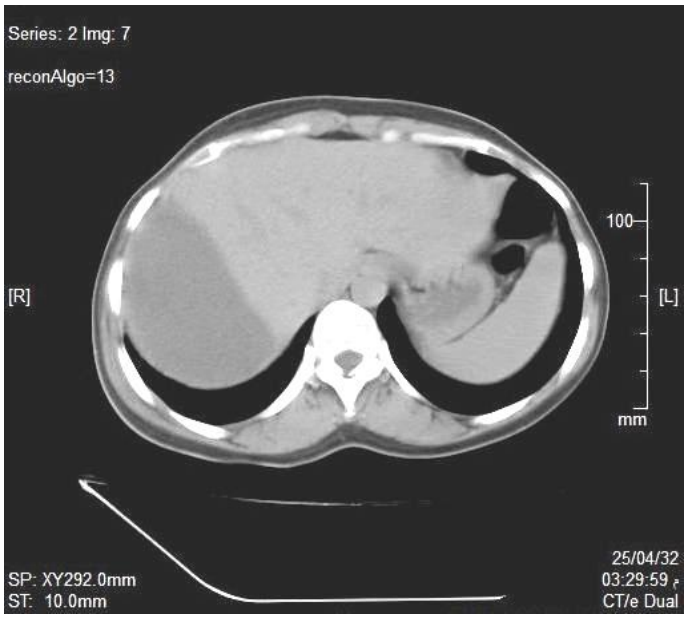
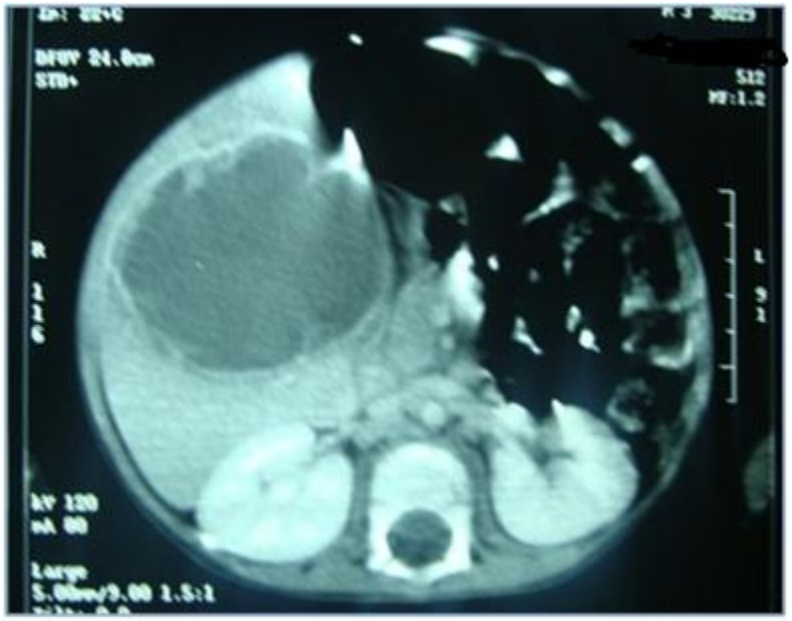
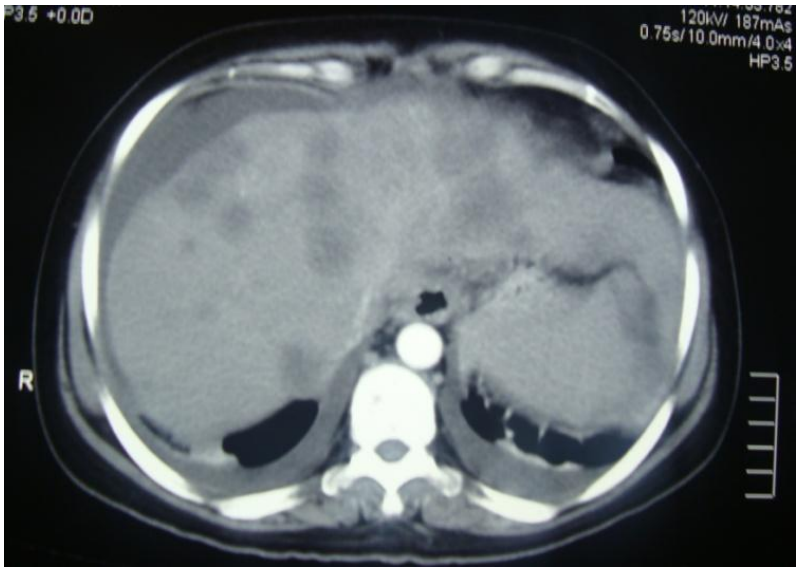
APPENDICES



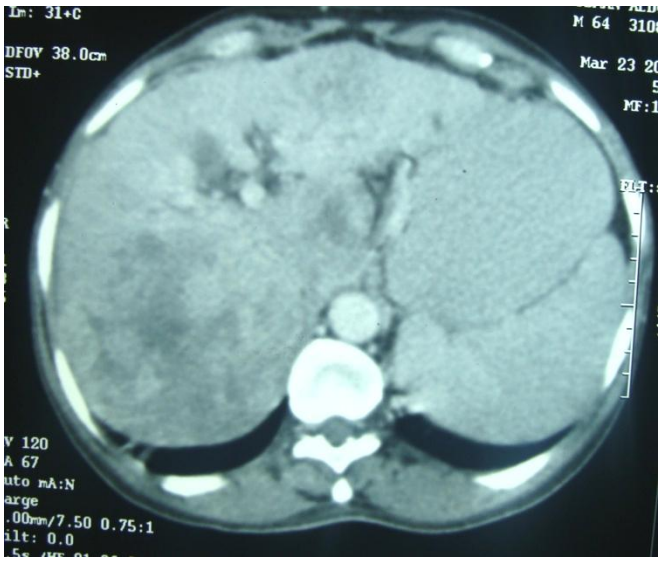
An axial CT image for (44) years old female, appeared well define hypo dense area in right lobe of the liver, indicated liver cyst.



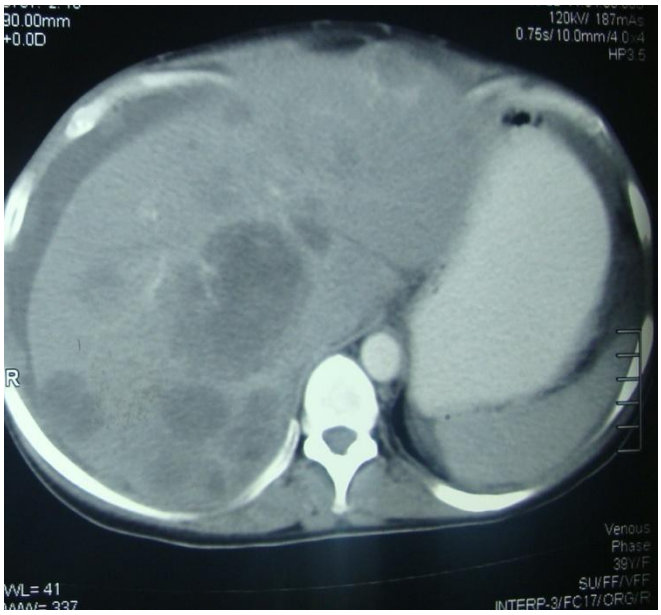
An axial CT image for male, (2) years old, appeared as will defined hypo dense lesion with thick enhanced wall at the left lobe of the liver indicated liver abscess



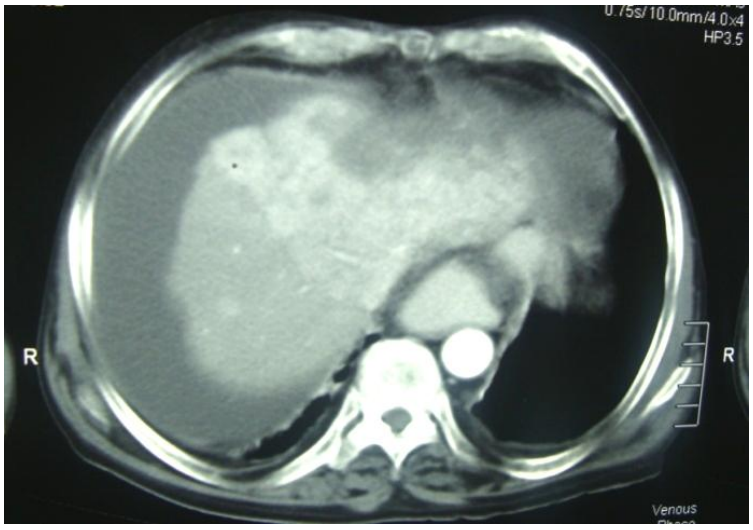
An axial CT image for an axial ct image for Female, (32) years old, appeared as hypo dense lesions in both lobes of the liver. Indicated liver metastasis.



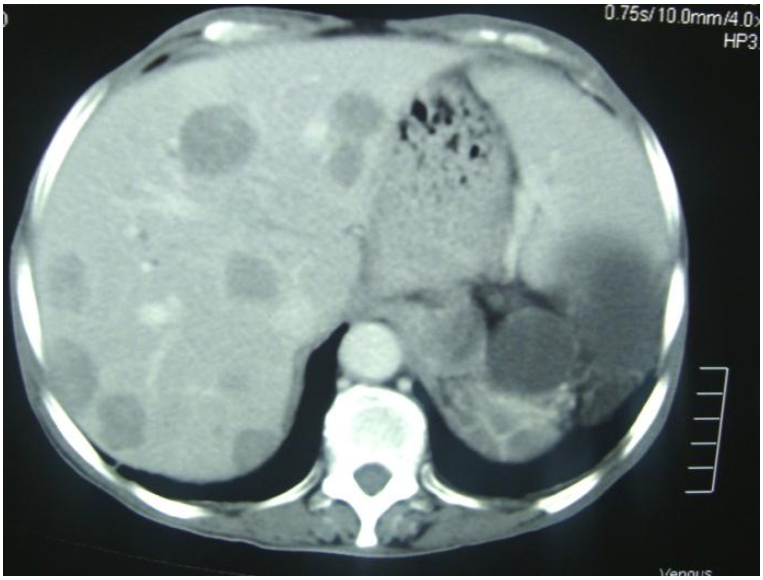
An axial CT image for Male, (64) years old, appeared as hypo dense lesions in both lobes the largest seen in the right lobe (9.5 cm), indicated liver metastasis.



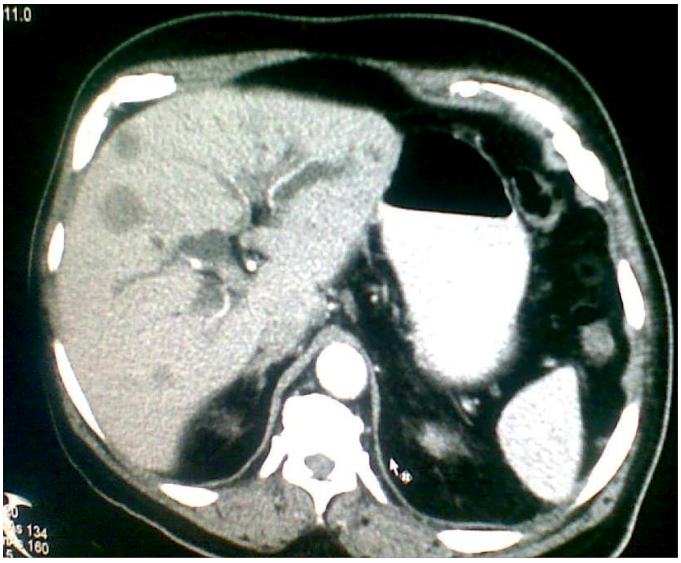
An axial CT image for Female, (50) years old, appeared as hypo dense lesions in the left lobe of the liver measure (8.5x7cm), indicated liver mass.



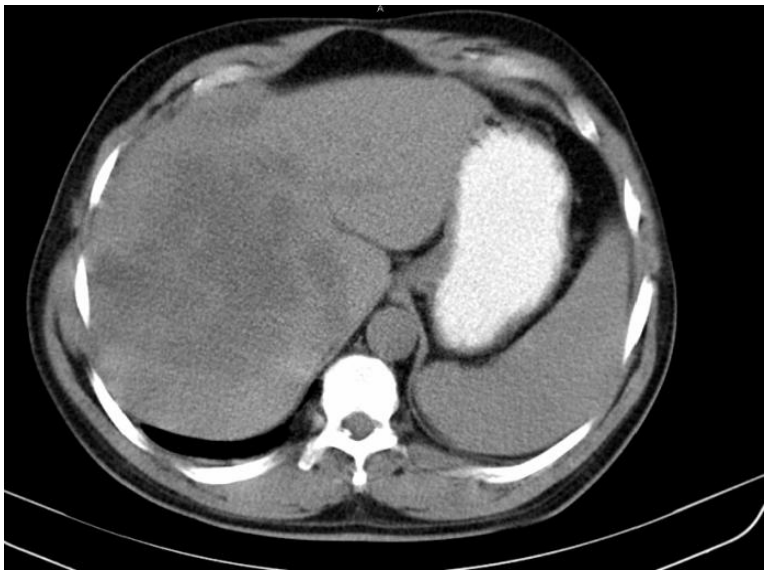
An axial CT image for Male, (70) years old, appeared as hypo dense lesions in the left lobe of the liver , indicated liver mass.



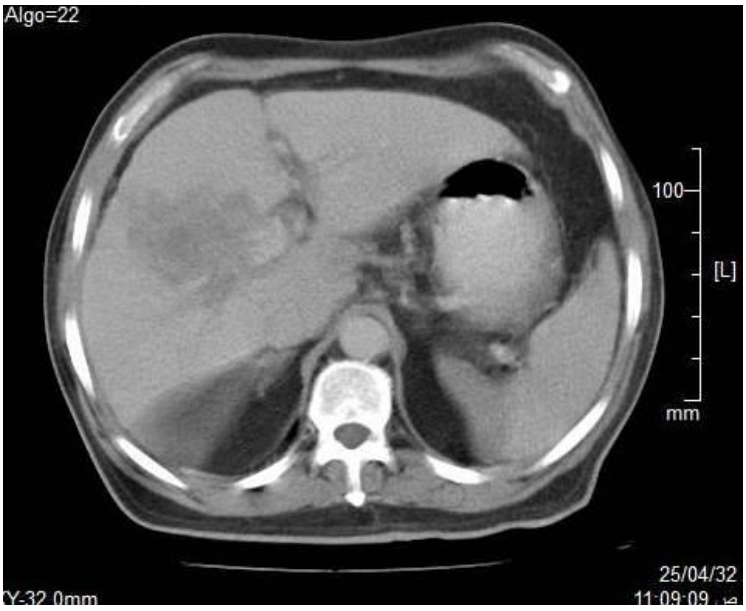
An axial CT image for Female, (75) years old, appeared as multiple hypo dense lesions, indicated liver mass.



An axial CT image for Male, (70) years old, appeared as multiple hypo dense lesions scattered in liver, indicated liver mass.



An axial CT image for Male, (50) years old, appeared as hypo dense in the right lobe, indicated liver mass.



An axial CT image for Male, (60) years old, appeared as hypo dense in the right lobe, indicated liver mass.