# "ROLE OF CONTRAST ENHANCED COMPUTED TOMOGRAPHY IN EVALUATION OF SONOGRAPHICALLY DETECTED FOCAL LESIONS IN LIVER"

By

**DR.VINOD**

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In partial fulfilment of the requirements for the degree of

**DOCTOR OF MEDICINE**

**IN**

**RADIO DIAGNOSIS**

Under the guidance of

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HOSPITAL & RESEARCH CENTRE, BIJAPUR

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Date: **DR. VINOD**

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# LIST OF ABBREVIATIONS USED (In alphabetical order)

A: Arterial

AFP: α-fetoprotein

AP: Arterioportal

CCA: Cholangiocarcinoma

CT: Computerized Tomography

CTAP: CT Aortoportogram

CEA: Carcinoembryonic Antigen

DVP: Delayed Venous Phase

EHE: Epitheliohemangioendothelioma

FLC: Fibrolamellar Carcinoma

FNH: Focal Nodular Hyperplasia

GIT: Gastrointestinal Tract

HAP: Hepatic Arterial Phase

HBV: Hepatitis B Virus

HCV: Hepatitis C Virus

HCC: Hepatocellular Carcinoma

HCA: hepatocellular Adenoma

HU: Hounsfield Unit

IUL: Intrauterine Life

IVC: Inferior Venacava

MDCT: Multidetector Computerized Tomography

NASH: Non Alcoholic SteatoHepatosis

N: Number

NRH: Nodular Regenerative Hyperplasia

PVP: Portal Venous Phase

RPV: Right Portal Vein

USG: Ultrasonography

PPV: Positive predictive value,

NNP: Negative predictive value

# ABSTRACT

**Objective of the study:**

To study the spectrum of focal liver lesions and assess the enhancement characteristics in Triphasic CT scan performed in patients with sonologically detected focal liver lesions.

**Materials and methods used:**

**Source of data:**

A prospective correlation study was conducted over a period of one and half years (October 2012 to April 2014) on 50 patients of all age group with sonologically detected focal hepatic lesions. They were evaluated with Triphasic CT and conspicuity and enhancement patterns of individual lesions were noted and these findings were correlated with histopathology/ surgical findings/ USG/ follow-up as applicable.

**Study design**: Hospital based prospective study.

**Sample size:** Sample size wasestimated using N-master software. From the sited reference "Focal Liver lesions: Characterization with Triphasic Spiral computed tomography" proportion of liver lesions detected on spiral CT was considered to be 87% assuming relative precision of 12% and desired confidence interval of 95% (Alpha error of 5%) the minimal sample size required is 40 cases for satisfactory statistical analysis. Our study consists of 50 cases.

**Statistical Methods**: Descriptive statistical analysis has been carried out in the present study. Results on categorical measurements are presented in Number (%).Diagnostic statistics such as sensitivity,specificity, PPV, NPV and Accuracy has been used to find the correlation of CT scan with final diagnosis. A *p* value less than 0.05 was considered statistically significant the 95% confidence interval.

**Results:**

- Total numbers of cases in our study were 50 with 195 lesions.
- There was a male preponderance (56%) when compared to females (44%) of cases.
- Out of 50 patients studied, 31 patients were diagnosed to have malignant (62%) focal liver lesions and 19 patients had benign (38%) focal liver lesions. Of the total 195 focal liver lesions seen in 50 patients, there were 57 benign focal liver lesions accounting for about 29.23% of the total lesions and 138 malignant lesions accounting for about 62% of the total lesions.
- In our study there were 113 hypovascular lesions accounting for 57.95% of the total (n=195) lesions and 82 hypervascular lesions accounting for 42.05% of the total (n=195) lesions.
- The 113 hypovascular lesions, malignant hypovascular lesions included metastases (n=84) accounting for 74.33% of the total hypovascular lesions arising from primary colorectal carcinoma, gastric carcinoma, carcinoma oesophagus and lung malignancy. The benign hypovascular lesions include simple cysts (n=21)18.59%, Abscess (n=8)7.08%.
- The 82 hypervascular lesions, malignant hypervascular lesions were metastases (n=31) 37.80%, from carcinoma pancreas, carcinoma cervix, carcinoma ovary and carcinoma breast. The other malignant lesions included are HCC (n=22)26.82% and Intrahepatic CCA (n=1) 1.21%.
- The benign hypervascular lesions included hemangioma (n=26)31.70%, FNH (n=1) 1.21%, and Adenoma (n=1)1.21%.
- Overall there were 11 enhancing patterns. 5 were hypovascular enhancing patterns and 6 were hyper vascular enhancing patterns.
- The five hypovascular enhancing patterns were hypo/hypo (cyst)/hypo, hyper (rim)/hypo (cyst)/hypo, hypo/hypo/hypo, hyper (rim)/hypo/hypo, and hypo/hypo/hyper.
- The six hypervascular enhancing patterns were A(puddles)/A/A,A/A/A(cleft), A(variegated)/A/A(capsule), hyper(incomplete)/A/A, and hyper/A/A.

**Interpretation and Conclusion:**

- The PVP images acquired at the peak of liver enhancement is essential for detection of hypo vascular lesions.
- HAP images are helpful in detecting hypervascular lesions and are essential for characterization of large proportions of lesions. Equilibrium phase images aid in further lesion characterization.
- Characterization of focal liver lesions based on the 11 enhancement patterns observed and correlation with standard of reference was satisfactory. The Triphasic CT enhancement patterns were 100% sensitive and specific in diagnosing all cases of Abscess, Cysts, hemangioma, FNH and Intrahepatic CCA, however Triphasic CT enhancement patterns in HCC (sensitivity-81.81%), Metastases (sensitivity-93.91%) was sensitive in diagnosing most of the cases and showed 100% specificity in diagnosing in all the cases when there was typical enhancement pattern for the individual lesion concerned.
- Four enhancement pattern observed were always due to benign lesion. Six more enhancement pattern observed was always due to malignant lesion.
- The hypo/hypo/hypo, hypo/hypo/hyper and hyper/A/A enhancement patterns need to be interpreted with caution.
- Triphasic CT of liver is a standardized CT procedure, enables in detection and characterization of vast majority of focal liver lesions, in the presence of different pathological conditions and multilevel disease.

**Keywords: - Triphasic MDCT, Focal Liver Lesions, Detection and Characterization of lesions**.

# CONTENTS

# LIST OF TABLES AND CHARTS

# LIST OF FIGURES

# INTRODUCTION

Focal liver lesions are discrete abnormalities arising within the liver and are increasingly being discovered with the widespread use of diagnostic imaging modalities. Differentiation of various liver lesions is considered to be critical for determining the treatment options. The differential diagnosis (malignant and non malignant lesions) in patients presenting with a focal liver lesion is broad. The high frequency of benign focal liver lesions such as Cysts, Hemangiomas, and Focal nodular hyperplasia etc. make detection and characterization of these lesions essential. In addition, in many of the patients who are referred for CT, one does not know which of these liver abnormalities will be present. Consequently, the preferred liver imaging technique should comprise high sensitivity & specificity for lesion detection with good ability for lesion characterization, and to differentiate lesions that do need further diagnostic tests/treatment from those lesions that do not.

To meet these requirements, a CECT (triphasic) protocol was developed to image the entire liver in arterial, portal, and equilibrium phases.

Triphasic CT has became the primary imaging modality for detection and characterization of focal liver lesions. It is an effective aid in determining the number, location, and nature of such lesions and monitoring their size over time. In patients with cancer, the accurate detection of metastatic disease at the time of diagnosis or during the course of treatment remains crucial for management of the disease.

CT has assumed primary role in evaluating hepatic masses. Despite increased competition from MRI over last decade, role of diagnosis of diseases of liver has not been significantly affected. Besides the general availability of the method, the dominance of CT is primarily due to its excellent visualization of anatomic relationship and of liver position relative to adjacent organs.

This study is an effort to assess the role of triphasic computed tomography in detection and characterization of focal liver lesions and help in deciding further course of management.

# AIMS AND OBJECTIVES

1. To study the spectrum of focal liver lesions and assess the enhancement characteristics in Triphasic CT scan performed in patients with sonologically detected focal liver lesions.
2. To correlate the lesions with clinical, other imaging and histopathological findings wherever necessary.

# REVIEW OF LITERATURE

## EMBRYOLOGY, ANATOMY AND CT IMAGING ANATOMY OF LIVER

### Embryology[1]

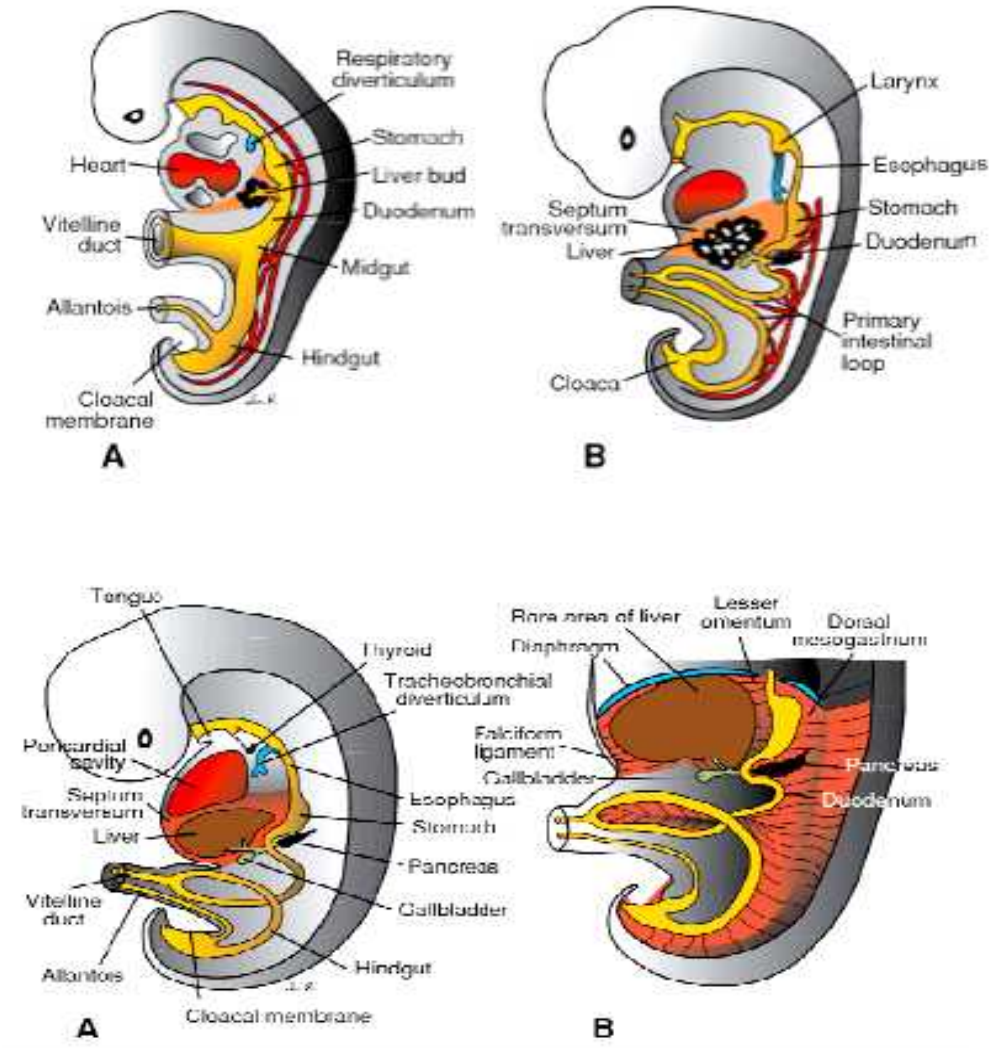
In the middle of third week the liver primordium appears as outgrowth of endodermal epithelium at the distal end of foregut. This outgrowth, called as hepatic diverticulum or liver bud contains rapidly proliferating cells which penetrate the septum transversum, a mesodermal plate between the pericardium and yolk stalk.

While hepatic cells continue to penetrate the septum transversum, the connection between the hepatic diverticulum and the foregut (duodenum) narrows, to form the bile duct. Gall bladder and cystic duct are formed by small out growth in ventral part of bile duct. With further development the epithelial liver cords intermingle with umbilical and vitelline veins which form hepatic sinusoids. The liver cord cells differentiate into parenchymal cells (liver cells) which line the bile ducts. Kupffer cells, hematopoietic cells, and connective tissue cells are derived from the mesoderm of septum transversum. As the organ is formed by continuous penetration of proliferating cells, it bulges caudally into the abdominal cavity, the mesoderm of septum transversum lying between the foregut and the liver, and the liver and anterior abdominal wall become membranous, forming lesser omentum and falciform ligament. They are together known as ventral mesogastrium.

The mesoderm over the surface of liver differentiates into visceral peritoneum, except in its cranial part (which forms the bare area of liver), were it persists to have contact with rest of the remaining septum transversum. This portion of septum forms central tendon of diaphragm.

At 10th week of development, weight of liver is 10% of total body weight, attributed mainly due to hematopoietic function and partly due to sinusoids. At last 2months of IUL weight of liver is 5% of total body weight due to subsidence of hematopoietic activity. At 12th week bile is formed by hepatocytes which enter GIT.

**Fig1: Embryological Development of Liver**

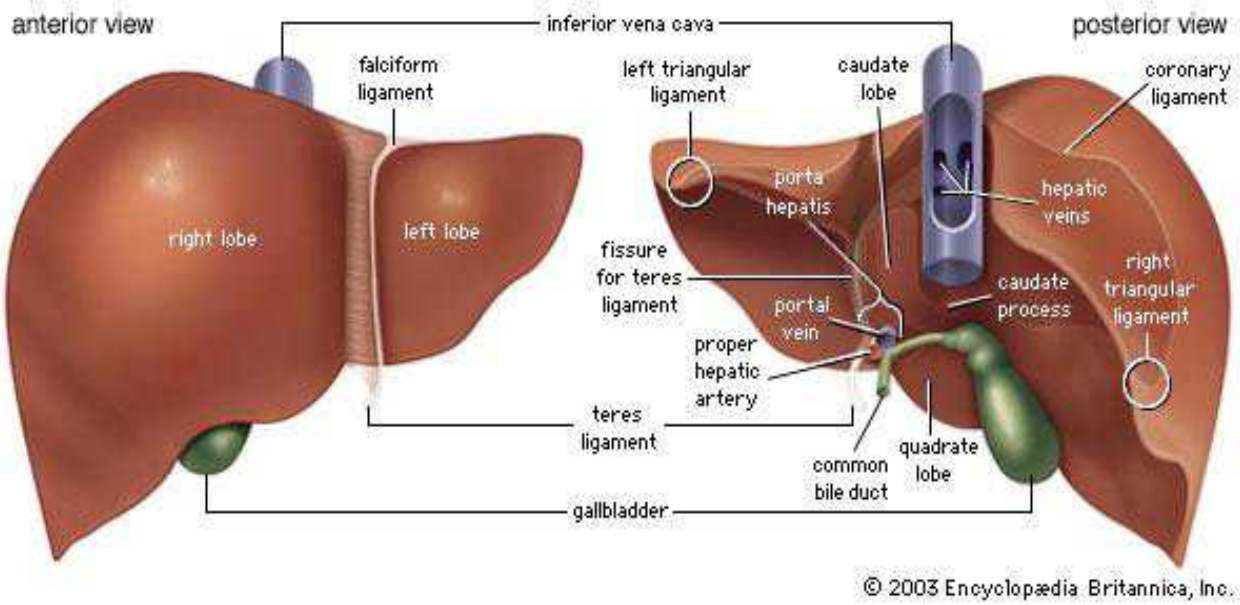



**Anatomy**[2]

The liver is the largest gland in the body, in males it weighs from 1.4 to 1.6kg and in the female from 1.2 to 1.4 kg. Located mainly in the right upper quadrant deep to 7-11th ribs on right side and crosses the midline towards left nipple. The diaphragm separates liver from pleura, lungs, pericardium and heart.

The liver possesses three surfaces: superior, inferior and posterior. A sharp, well-defined margin divides the inferior from the superior in front; the other margins are rounded. The superior surface is attached to the diaphragm and anterior abdominal wall by a triangular fold of peritoneum, the falciform ligament, in the free margin of which is a rounded cord, the ligamentum teres. The line of attachment of the falciform ligament divides the liver into two parts, termed the right and left lobes, the right being much larger. The inferior and posterior surfaces are divided into four lobes by five fossae, which are arranged in the form of the letter H. The left limb of the H marks on these surfaces the division of the liver into right and left lobes; it is known as the left sagittal fossa, and consists of two parts, viz., the fossa for the umbilical vein in front and the fossa for the ductus venosus behind. The right limb of the H is formed in front by the fossa for the gall-bladder, and behind by the fossa for the inferior vena cava; these two fossae are separated from one another by a band of liver substance, termed the caudate process. The bar connecting the two limbs of the H is the porta (transverse fissure); in front of it is the quadrate lobe, behind it the caudate lobe. The liver is connected to the under surface of the diaphragm and to the anterior wall of the abdomen by five ligaments; four of these—the falciform, the coronary, and the two lateral—are peritoneal folds; the fifth, the round ligament, is a fibrous cord, the obliterated umbilical vein. The liver is also attached to the lesser curvature of the stomach by the hepatogastric and to the duodenum by the hepatoduodenal ligament. The porta hepatis is a transverse fissure in the middle posterior and inferior surface of the liver that gives passage to the portal vein, hepatic artery, hepatic nerve plexus, hepatic ducts, and lymphatic vessels.

## Fig2: Normal Anatomy of Liver




**Blood supply**

Liver has dual source of blood supply, nearly 75-80% from portal vein and 20-25% from hepatic artery. The portal vein supplies deoxygenated blood coming from the alimentary tract were as the hepatic artery, branch of celiac artery carries purely oxygenated blood. At the porta hepatis the portal vein and hepatic artery terminate dividing into right and left main branches which in turn divide into segmental branches to supply right and left lobes of the liver respectively. The arterial and venous blood is conducted to the central vein of each liver lobule by the liver sinusoids. The central veins drain into the right, middle and left hepatic veins which in turn drain into IVC.

**Fig3: Blood supply of liver**

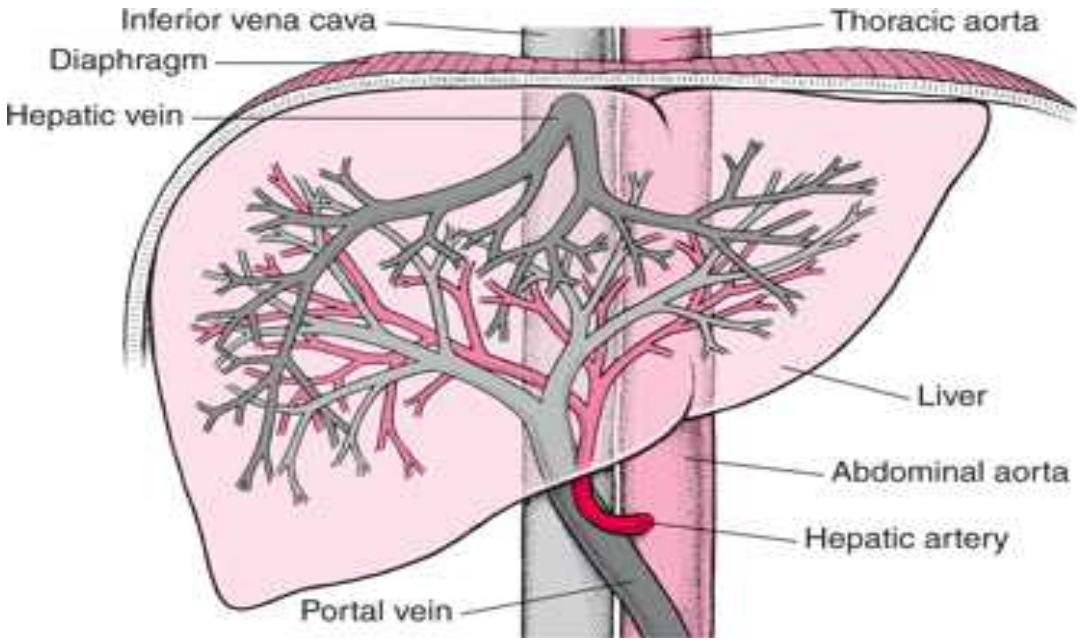
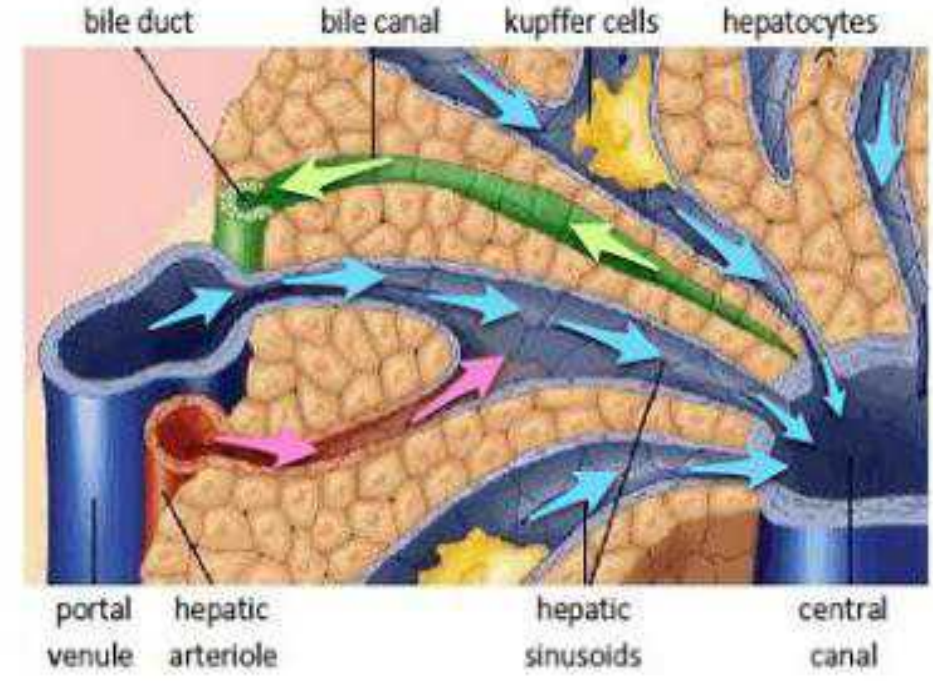



**Fig 4: Blood flow direction in liver**



**Lymphatic drainage**

The liver is a major lymph producing organ. The superficial lymphatics in the sub peritoneal fibrous capsule of the liver (Glisson capsule) and deep lymphatics from the connective tissue that accompany the ramifications of portal vein and hepatic artery drain the anterior aspect of the liver to hepatic nodes noted along the hepatic vessels and ducts in lesser omentum. Efferent vessels from the hepatic nodes drain into celiac lymph nodes, which in turn drain into cisterna chyli. The lymphatics from the posterior aspect of liver drain toward the bare area of liver which drain into phrenic lymph nodes, in turn drain into posterior mediastinal lymph nodes. Liver derives its nerve supply from hepatic plexuses, largest derivative of celiac plexus.

**Segmental anatomy of liver** [3,4,5]

Claude Couinaud French anatomist and surgeon, later modified by bismuth described liver into eight independent and functional units (segments), each with specific vascular and biliary connections. Based on the anatomical landmarks it was possible radiologically to identify the liver segments, so that exact location of the lesion was possible which in turn helped to modern, liver surgery and interventinal radiology.

A simplified version of segmental anatomy of liver assumes that blood enters liver through portal vein (artery and bile duct follow portal vein), which are drained by hepatic veins inserting into IVC. An obliquely oriented vertical cephlocaudal plane passing superiorly from the middle hepatic vein to gall bladder fossa inferiorly divides liver into right and left lobes. The main portal vein divides into right and left at the porta, defining the right and left lobes. The RPV on the right side divide into sectorial and segmental branches. All that is anterior and to the left of the RPV will be right anterior sector (segment 5 & 8), all that is posterior and to the right of RPV will be

right posterior sector (segment 6 & 7). Following the third order division of RPV leads to corresponding segments. The inferior (segments 5 & 6) lie caudal to the portal bifurcation and superior segments (7 & 8) will be cranial to it. On the left side LPV will be the first landmark and left hepatic vein is the second landmark. The smooth arch formed by the umbilical portion of left portal vein from the main birfurcation divides left lobe into two sectors. The liver tissue comprised by the concavity of portal venous arch will be segment 4, and all the liver tissue on the convexity of the portal venous arch will be segment 2 & 3. The distal part of hepatic vein divide segment 2 (posterior superior) and segment 3 (anterior inferior). The liver tissue that lies between the posterior aspect of bifurcation of portal vein and IVC will be segment 1 (caudate lobe).

**Fig 5: Segmental anatomy of Liver**

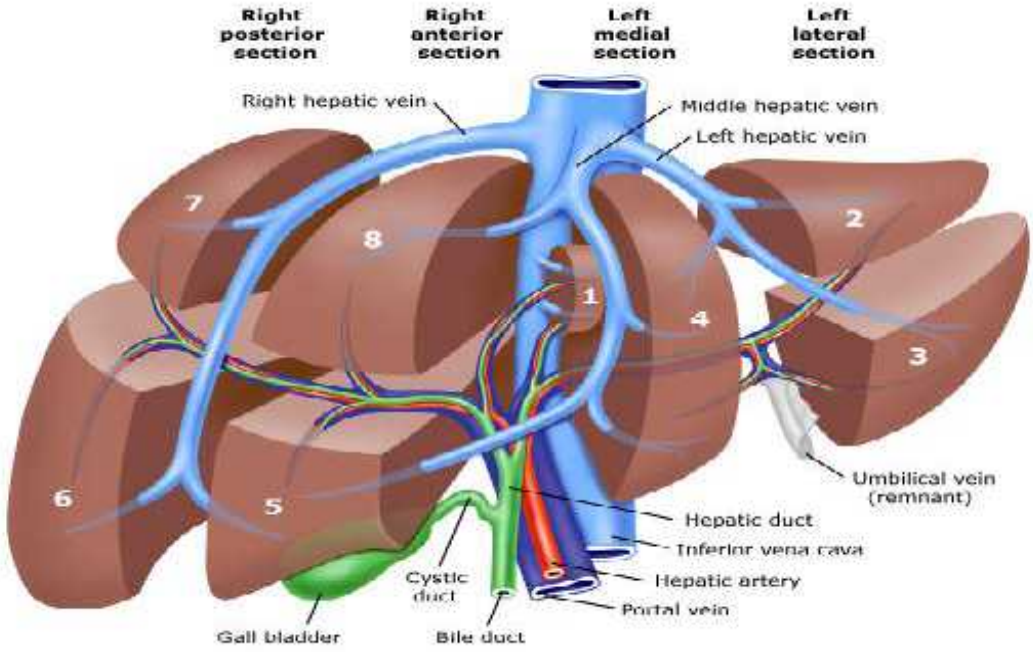
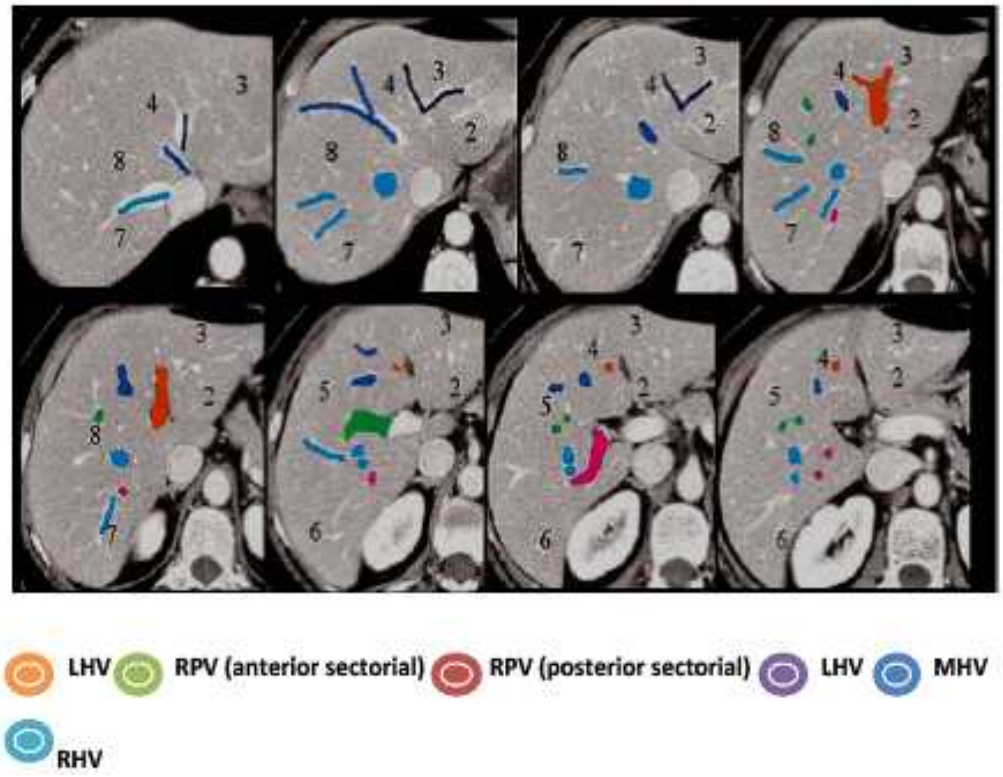


**Fig6: CT segmental Imaging Anatomy of Liver**




### 3.2 IMAGING MODALITY:

**Computed Tomography (CT):**

Techniques: CT provides a global view of the upper abdomen in axial sections enabling clear demonstration of the liver anatomy and adjacent structures. The multidetector row CT scanners can obtain simultaneous multiple acquisitions per each gantry rotation. Thus fast data acquisition is possible over large anatomic areas (entire body with isometric voxels) in less than 30 seconds. The isometric nature of the data facilitates high quality reconstructions in any desirable orientation.

These technical advances have allowed imaging of the entire liver in single breathhold. Short scan times allow the capture of distinct phases (unenhanced, arterial, venous and delayed). These phases provide data concerning the enhancement patterns and hence the possibility of characterization of hepatic neoplasms.

**Non-contrast enhanced CT (NECT):**

NECT imaging is necessary for assessing both diffuse hepatic changes, such as fat infiltration, iron deposition and focal changes such as calcification and hemorrhage. The normal hepatic parenchyma has homogenous appearance on NECT scan with HU value varying between 40 to 70 HU. Liver contains high concentration of glycogen thus has high attenuation value than spleen on NECT. The vascular structures can be identified by their location in NECT and confirmed by enhancement with intravenous contrast. The Intrahepatic biliary tree is not normally visualized although common hepatic duct and common bile duct are normally seen.

Detection of hepatic abnormalities by CT is dependent on differentiating normal from pathologically altered hepatic tissue. Abnormalities in hepatic contour may permit detection of hepatic disease. Most hepatic neoplasms have a lower attenuation value than normal hepatic parenchyma. Generally a difference of atleast 10 HU between the abnormal and normal regions of liver must be present for accurate detection of liver lesions.

**Principle of hepatic contrast enhancement:**

The primary purpose of administering an intravascular contrast agent for hepatic CT is to increase the attenuation value difference between normal hepatic parenchyma and tumours. Diagnostic effectiveness of the study is dependent on dose of contrast agent, route of administration and timing of examination.

Hepatic contrast enhancement is best understood by considering three phases of contrast enhancement. After intravenous contrast administration there is rapid rise of aortic enhancement. During this phase hepatic enhancement increases gradually. Next the contrast diffuses into the extravascular compartment, resulting in rapid decrease in aortic enhancement and concomitant increase in hepatic enhancement. Lastly the

hepatic and aortic enhancement gradually decreases as the contrast diffuses back into the central vascular compartment which continuously loses contrast through glomerular filtration and diffusion into less well perfused organs such as skeletal muscle and fat.

The magnitude of hepatic enhancement is determined by:

1. Technique related factors: rate of injection, dose and concentration.
2. Patient related factors: body weight, cardiac output.

**Single-phase contrast-enhanced Computed Tomography [6] :**

The CT technique that has been most effective for routine depiction of liver abnormalities, including focal lesions, is dynamic contrast -enhanced CT with imaging during the peak of hepatic parenchymal enhancement (portal venous phase). The protocol depends mainly on the type of scanner and the patient's weight. Patients weighing upto 250 pounds receive 125 ml of a 350 mg I/ml and for more than 250 pounds receive 150 ml of a 350 mg I/ml of contrast agent with Injection rate of 3 ml/ sec. Injection of 20 to 50 ml of saline immediately after contrast administration ("saline flush") allows reduction in contrast medium volume of 10% to 20%.

**Multiphase Hepatic Computed Tomography:**

Multiphase hepatic imaging is useful for detection of hypervascular liver lesions, characterization of an indeterminate liver lesion detected on another imaging study and pre-operative planning in a patient planned for hepatic resection. Multiphase hepatic protocols are best performed on MDCT scanners because of their short image acquisition times and excellent spatial resolution.[6,7]

The vascular phase represents the period of intravenous contrast medium injection into the central blood compartment, ideal for the detailed hepatic arterial anatomy for liver resection and intra-arterial chemotherapy, early arterial phase

(approximately 25 sec after the start of the contrast bolus). To detect or characterize vascular liver lesions focus on the late arterial phase (approximately 35 to 40 sec after the start of the contrast bolus). The portal -venous phase, contrast material diffuses from the central blood compartment to the extravascular compartment of the liver for the adequate visualization of the venous anatomy. The equilibrium phase occurs when the contrast medium slowly diffuses from the liver back into the central vascular compartment. Most of the lesions become obscured as there is no substantial difference in attenuation value of the lesion and the normal hepatic parenchyma, except in some HCC's where interstitial enhancement diminishes relative to that of hepatic parenchyma.

**OTHER HEPATIC IMAGING MODALITIES:**

**Plain films:**

Generalized hepatomegaly or a localized bulge in the liver contour caused by the mass lesions may be seen on plain films.

Calcified primary malignant tumors in adults are usually from cholangiocarcinoma or HCC in non-cirrhotic young adults, which is usually of fibrolamellar type. In children calcification is seen in the hepatoblastomas or hemangioendotheliomas.

Air-fluid levels are seen in the hepatic region with hepatic abscess. Plain film of the chest may show pleural effusion, elevation of the domes of the diaphragm, segmental atelectasis and pulmonary secondaries. Skeletal metastases are reported in 2 to 13% of patients with HCC. They were osteolytic and more frequently involve the ribs, spine, femur, pelvis and humerus.

**Barium contrast studies**:

Displacement of the opacified gastrointestinal tract by an enlarged liver or focal displacement of the stomach, duodenum or colon by a localized liver mass is seen. Even detection of primary malignancies like carcinoma stomach, colon on barium studies suggests the possibility of hepatic metastases. Esophageal varices are often present in patients with underlying cirrhosis or HCC induced portal veins obstruction are readily detected.

**Ultrasound:**

The normal liver is homogeneous, contains fine-level echoes, and is either minimally hyperechoic or isoechoic compared to the normal renal cortex. The liver is hypoechoic compared to the spleen.

Both supine and right anterior oblique views are obtained if the patient can move or be moved. Sagittal, transverse, coronal and subcostal views are visualized for complete survey. The liver is examined using 3 to 3.5 MHz transducer. Detection of hepatic abnormalities by ultrasound is dependent on echogenicity differences, between the normal and abnormal hepatic parenchyma.

**Ultrasound contrast agent:**

Microbubble based agents are used as ultrasound contrast media. The gray-scale harmonic contrast enhanced ultrasound has been used for liver tumor characterization. The characteristics of dynamic enhancement pattern of hepatic tumours, such as HCC, metastases, FNH and hemangioma are very similar to those with contrast enhanced CT and MR imaging, despite the fundamental difference that microbubbles are pure intravascular agents.[8]

**Magnetic Resonance Imaging (MRI)**

MRI offers the capability of multiplanar imaging. Axial images, however,

optimally display the intrahepatic mass lesions and the anatomic structures of the liver. It may be used as primary imaging technique in patients who cannot receive iodinated intravenous contrast material e.g. renal failure, allergic to the contrast material. Another advantage of MRI is in evaluation of patients with cirrhosis of liver as they are more prone for malignancy. T1 and T2 weighted images are acquired. T1 weighted images are useful for lesion detection and anatomical details. T2 weighted images are more useful for lesion characterization. Spoiled gradient echo images allow liver scanning in one or two breath holds. In phase and out phase images are acquired after altering TE in T1 weighted images and help in diagnosing focal or diffuse hepatic steatosis.

Contrast enhanced MRI have limited role in lesion characterization, however lesion detection is improved compared to unenhanced MRI.

Use of short T1 inversion recovery (STIR) sequences has maximized contrast-to-noise ratios and subjective liver lesion visibility at all field strengths. The STIR images suppress the fat signal and additive T1 and T2 contrast results in high tumor-liver contrast. In addition, suppression of abdominal wall fat reduces the ghost artifact displayed over the liver from abdominal wall motion.

**Radioisotope scanning:**

The dominant cell population of the liver are hepatocytes (85%), which are also found in the spleen, the bone-marrow and the lymph nodes. These reticuloendothelial cells remove the colloids from the blood, so that liver can be scanned after intravenous injection of 99mTc- colloid particles or mili-micronspheres of albumen (10m). 80 to 90% of this activity is accumulated in liver and spleen are recorded, with atleast 500000 counts per image.

The normal liver is roughly triangular, with curved margins following the contours of

the diaphragm and rib cage. The lower edge is oblique, and often has a gall bladder impression on its lateral third. Also, there is cleft between the left and right lobe, and this is accentuated in the lateral supine projection. The highest activity is over the right lobe and falls gradually towards the margin.

There are many variations of shape, the most common being a Reidel's lobe; variation in position due to alteration of the level of the right dome of diaphragm is common also. Respiratory movement causes some irregularity of the margins, particularly in linear scans. The commonest abnormality is diminished activity, which may be localized or diffuse.

**Radiofrequency ablation (RF ablation):**

Is a lesional heating technique i.e. effects tumour necrosis by hyperthermia. Radiofrequency electrodes are inserted percutaneously into the tumour under ultrasound, CT or MRI guidance. RF waves induce ionic agitation, resulting in frictional heat production within the tissue and causes coagulation necrosis of tumour[9]. Usually done for HCC or metastases [10,11]

Post ablation, recurrence or residual tumour identification is done by hepatic triphasic studies using CT.

**Positron Emision Tomography (PET):**

PET imaging requires specialized detector array and can provide both projection and tomographic images using short lived radionucleides (FDG). The technique (FDG-PET) has high sensitivity in detecting hepatic metastases from different primaries[12].

**Arteriography:**

The hepatic arteries are visualized by selective arterial catheterization. Arterial and parenchymal phases of study are of most diagnostic value. Portal vein is not

normally visualized on DSA (digital subtraction angiography), unless there has been flow reversal or an aorto portal shunt.[9]

Selective hepatic arterial or portal venous embolization is possible for tumour treatment.

**Cavitograms:**

Are usually done by instilling contrast material into the cavities to detect any leakage. More useful while draining hepatic abscesses.

**Fine Needle Aspiration Cytology (FNAC):**

It is an important aid in the diagnosis of malignant hepatic disease, especially in patients with possible neoplastic disease. The aid of radiologic localization can spare such patients the risk of exploratory laprotomy, increased cost and delay of treatment.[13]

**Biopsy:**

Liver biopsy is an invasive procedure where by small pieces of liver tissues are obtained by biopsy needle in order to get accurate pathological diagnosis.

**Laboratory Investigations:**

HEMATOLOGY: Normocytic, normochromic anaemia. Leucocyte and platelet count are reduced. Prothrombin time is prolonged.

URINE ANALYSIS: Urobilinigen levels are increased. Bilirubin is present, if patient has jaundice.

BIOCHEMICAL: In case of gross liver cell damage the following may be seen. Serum bilirubin will be raised. Serum albumin will be reduced and serum globulin is raised. A/G ratio is reversed. SGOT and SGPT values may be increased. Serum alkaline phosphatase is usually raised to about twice normal. SGPT values are of more significant than SGOT, as they are found primarily in the liver. Normal SGPT value is 2 -15 IU/L and normal SGOT value is 2-10 IU/L.

**Plasma proteins**

They are produced by the hepatocytes and variation in these reflects diminished function of the liver. Albumin is synthesized solely in the liver; low plasma albumin indicates severe liver damage.

**Globulins:**

Increased in prolonged viral hepatitis or chronic active hepatitis. Increase in gamma globulin's reflect an increased activity of the immune system.

**Alkaline phosphatase:**

Blood contains alkaline phosphatase drained mainly from the liver, osteoblasts, of bone and to a lesser extent from the intestine and placenta. Alkaline phosphatase is almost always mildly elevated in infiltrative liver diseases.

**Coagulation factors:**

The liver synthesizes six coagulation factors. Fibrinogen (Factor 1), Prothrombin (factor 2), factor V, VIII, IX and X, which require Vit-K as a co-factor. Severe acute or chronic parenchymal liver damage may lead to prolongation of the prothrombin time, due to impaired synthesis of the clotting proteins.

**Serum Alpha-Feto Protein (AFP):**

It is synthesized in fetal life by both the liver and the yolk sac. After the age of 2 years, AFP is barely detectable in normal persons (under 30 ng/ml) and is elevated above 400 ng/ml in more than 80 to 90% of patients with hepatocellular carcinoma.

AFP may also be raised in embryonal teratoblastoma of the gonads, metastatic tumors from the gastric carcinoma and prostatic carcinoma and in Indian childhood cirrhosis. But AFP level of 1000 ng/ml or more in absence of obvious gastrointestinal tract tumor strongly suggest the presence of primary liver carcinoma.

## ETIOLOGY, PATHOGENESIS AND TRIPHASIC CT IMAGING FEATURES OF FOCAL LIVER LESIONS

Hepatic lesions are classified as benign, primary malignant, secondary malignant and infectious lesions.

**Benign liver lesions**

**Hemangioma:**

Hemangioma is the most common benign hepatic tumor. The prevalence ranges from 1% to 20%; the female-to-male ratio varies from 2:1 to 5:1. Hepatic hemangiomas are most often asymptomatic and have a very low rate of complications, thus do not require surgical resection. Therefore, the role of imaging is to help diagnose the lesion. They are usually single and < 4cm, but can be multiple and large in size.[14]

The non-enhanced computed tomography findings consist of a homogenous hypoattenuating lesion. Calcification is seen in 20% of the cases. After intravenous administration of contrast material, arterial-phase CT shows early, peripheral, non-continuous, nodular enhancement of the lesion. Venous-phase shows centripetal enhancement that progresses to uniform filling on delayed-phase. Lesions larger then 10cm are called as Giant Hemangiomas, which is heterogeneous and shows variable amount of calcification and fibrosis. Some of the atypical hemangiomas are calcified hemangiomas, large heterogeneous hemangiomas with fluid-fluid level, hyalinized hemangiomas, pedunculated hemangiomas, cystic or multiloculated haemangiomas. In atypical hemangiomas, the diagnosis will remain uncertain at imaging, and these cases will require histopathological examination.[15]

**Kim et al (2001)**[16] **–** conducted a study on 86 patients with 37 Hemangiomas and 49 malignant liver lesions, to compare and evaluate the accuracy of Tripasic CT for differentiating small hemangiomas from small hyper vascular malignant tumors. It was observed that in the HAP 19%–32% of hemangiomas and 0%–2% of malignant tumors showed enhancement similar to aorta; globular enhancement in 62%–68% and 4%–12%, respectively. At portal venous phase, enhancement similar to blood pool enhancement was observed in 43%–54% of hemangiomas and 4%–14% of malignant tumors; globular enhancement in 46%– 49% and 0%–2%, respectively. Readers diagnosed hemangiomas with 47%– 53% mean sensitivity with all enhancement phases and diagnosed malignant lesions with 95% mean specificity. It was concluded that small hemangiomas frequently show atypical appearances at CT. Triphasic CT showed improved specificity in differentiating small hemangiomas from small hypervascular malignant tumors.

**Focal Nodular Hyperplasia**

FNH is the second most common benign liver tumor after hemangioma having a prevalence of 0.9%. The male-to-female ratio is 1:8, and are seen in relatively young patients.[17] FNH is defined as a nodule composed of benign appearing hepatocytes occurring in a liver that is otherwise histologically normal. It is a regenerative response of hepatic parenchyma to hyper perfusion by vascular malformations in the liver. An association with steroids has been denied more recently.[18 19]

It is often solitary (80%), varying in size from 3-5cms and detected incidentally. Typical FNH may have lobulated contours. At unenhanced CT, the lesions are either hypoattenuating or isoattenuating to the surrounding liver.[20]In approximately 20% of patients, a central hypoattenuating scar may be seen. Related to

the hypervascularity of the tumor, during the arterial phase FNH shows an immediate and intense enhancement (96%), with the exception of the central scar. In portal venous phase there is decreased enhancement of the lesion relative to the normal enhancing hepatic parenchyma, resulting in the lesion being isoattenuating to the liver, with gradual diffusion of the contrast material into the myxomatous stroma of the central scar. Because delayed washout of contrast material from this myxomatous tissue relative to surrounding liver is also found, the central scar may appear hyperattenuating on delayed CT.[21] Distinction between FNH and other hyper vascular liver lesions such as hepatocellular adenoma, hepatocellular carcinoma (HCC), and hyper vascular metastases is critical to ensure proper treatment.[22]

**Andrea J. Ruppert-kohlmayr (2001)** [23]**–** Prospective study of 27 patients with 45 histologically proven FNH and six patients with 18 histologically proven Hepatocellular adenomas were subjected to Triphasic CT evaluation of liver. Quantitative evaluation like: attenuation of lesions, scars, and liver parenchyma during Unenhanced, HAP, and PVP; Relative enhancement of lesions and liver (ratio between attenuation in HAP and PVP, and attenuation in unenhanced phase); prevalence of scar and central vessel in FNH were observed. The study showed no significant difference in attenuation values between FNH and Hepatocellular adenoma in unenhanced phase. In HAP attenuation values were significantly higher in FNH. In PVP no significant differences in attenuation values were detected between FNH and adenoma. Relative enhancement was higher in 100% of FNH and lower than or equal to 1.6 in 87% of Hepatocellular adenomas. Differentiation of visually similar focal liver lesions is possible when Triphasic CT study is combined with quantitative evaluation of lesions.

**Giuseppe Bran Catelli, MD (2001)** [24]**–** in their retrospective study to evaluate the features of FNH at Multiphasic CT study, found that FNH were hyper vascular and hyper attenuating to liver on 106 of 106 arterial phase scans and were isoattenuating to liver on 82 of 89 delayed scans. Of the 124 tumors, 111 enhanced homogeneously, 109 had a smooth surface, 101 were sub capsular, 89 had ill-defined margins, and 62 had a central scar that was observed more often in large lesions (40 of 62 lesions) than in small lesions (22 of 62 lesions). FNH less frequently exerted a mass effect (43 lesions), had vessels around or within the lesion (42 lesions), demonstrated exophytic growth (40 lesions), or showed a pseudo capsule (10 lesions). Only one FNH had calcification. They conclude that Multiphasic CT demonstrates characteristic features that may allow confident diagnosis of FNH. In typical cases, neither biopsy nor further imaging is necessary.

**Hepatocellular adenoma**

Hepatocellular adenoma (HA) is a rare, benign neoplasm of hepatocellular origin that is frequently found in middle-aged women. The use of estrogen-containing or androgen-containing steroids clearly increases the incidence, number, and size of adenomas.[25] May complicate conditions of hepatocellular stimulation such as a glycogenosis type IA or III, Klinefelter's syndrome, familial diabetes or may have a family history.[26,27]

Histologically, HA are made of cords of normal hepatocytes containing variable amounts of glycogen and lipid; arranged in layers without acinar distribution, portal spaces and ductular structures. As this neoplasm has no portal tracts, tumor perfusion occurs solely by peripheral arterial feeders; and hence the hyper vascular nature of adenoma, associated with poor connective tissue support, can lead frequently lead to hemorrhage. Due to this reason it is considered the most dangerous

benign liver disease.[28] Usually solitary in 70–80% of cases, well-circumscribed and vary in size from 1 cm to more than 25 cm. Large adenomas (>5 cm in diameter) are prone to rupture and have potential for malignant transformation.

Liver adenomatosis is characterized by the presence of more than ten adenomas within an otherwise normal liver. It is not associated with glycogen storage disease or chronic anabolic steroid use. They are progressive, symptomatic, and more likely to lead to impaired liver function, hemorrhage, and malignant degeneration.[29]

On unenhanced CT scan HA may appear to be hypo attenuating (due to the presence of lipid, old hemorrhage, and necrosis) or hyper attenuating (due to recent hemorrhage or large amount of glycogen) mass. There is homogeneous moderate enhancement on HAP images with a rapid washout during the portal venous and equilibrium phases. Heterogeneous pattern of enhancement is noted in larger lesions.[30]

The differential diagnosis of HA includes other hyper vascular tumors such as FNH, hepatocellular carcinoma, and hyper vascular metastases. FNH can often be distinguished from HA by the absence of fat, calcification or hemorrhage and by the presence of a central scar and marked hypervascularity. Distinguishing liver adenomatosis from multifocal HCC might be impossible with imaging criteria alone, because HCC lesions are often hyper vascular, partially encapsulated and may contain fat. Clinical evidence of chronic liver disease and elevated serum tumor markers helps in making the diagnosis. Hyper vascular metastases occur in patients with known malignancy, are often multiple and heterogeneous. Metastatic lesions appear hypodense on portal venous and equilibrium phases.[30]

**Tomoaki Ichikawa (2000)** [31]– They analyzed Multiphasic MDCT findings of hepatic adenomas and correlated with histopathologic findings. MDCT was performed in 25 patients with 44 HA. Each case was reviewed for number of detectable lesions in each phase, morphologic features of tumors and degree of enhancement. 13 patients had solitary adenomas, 12 patients had 2-3 adenomas, the detection rate for all 44 adenomas per type of examination was as follows: not enhanced, 86% (38 of 44); HAP, 100% (44 of 44); PVP, 82% (36 of 44), and delayed, 88 %( 21 of 24). Tumor margins were well defined in 38 adenomas (86%) and surface was smooth in 42 adenomas (95%). Hemorrhage, necrosis, fat and calcifications were uncommon. All adenomas showed homogenous enhancement especially on PVP and delayed phase scans and concluded that adenomas have characteristic features that allow their distinction from other focal liver lesions at Multiphase CT.

**Zhou et al (2010)** [32]– In their study, 11 patients with 19 lesions of HA were evaluated for the enhancement characteristics. Quantitative analysis found that there were significant differences in UP, HAP and DP between the attenuation values of HA and hepatic parenchyma, but there were no significant differences in PVP images. They concluded that, its combination with morphologcal features on Triphasic MDCT can help in diagnosing and differentiating the HA from other hepatic tumors.

**Nodular regenerative hyperplasia:**

It is defined as the presence of diffuse, multiple regenerative nodules not associated with fibrosis. The nodules consist of cells that resemble normal hepatocytes. Multiple diffuse, bulging nodules varying in size from 1mm to 10mm.[33]There is no gender predilection and mainly affects patients older than 60years. Symptoms are mainly due to compression causing portal hypertension/ Cholestasis. NRH has been associated with lymphoproliferative disorders, rheumatoid

arthritis, primary biliary cirrhosis, bone marrow transplantation, hereditary hemorrhagic telangiectasia, polyarteritis nodosa, Budd–Chiari syndrome, liver transplantation, amyloidosis, Felty's syndrome and HCC.[34]

Biopsy is required to make a definitive diagnosis of NRH. No definitive imaging features are noted. No enhancement seen in HAP but may show variable enhancement in the PVP and equilibrium phase images.[34]

**Macro regenerative nodule:**

Occurs under the background of cirrhotic liver and acute massive or sub massive necrotic liver. It is a benign but premalignant condition. Biopsy is essential for diagnosis.[34] May show enhancement in the HAP with variable enhancement in the PVP and equilibrium phase images.

**Simple hepatic cysts:**

Simple hepatic cysts are benign developmental lesions that do not communicate with the biliary tree. Originate from hamartomatous tissue. Found in 1%–3% of routine liver examinations, always asymptomatic. Simple hepatic cysts can be solitary or multiple. Their size is very variable, although they are frequently < 5 cm.

On non-enhanced CT scans a hepatic cyst appears as a round or ovoid well-defined lesion, with no evident wall. It is homogeneous and hypoattenuating with attenuation values similar to water (<20 HU). After contrast media injection, both the wall or its contents do not show any enhancement. Higher attenuation values (>20 HU) are present in cyst with hemorrhage or inflammation inside; in these cases complicated cysts are difficult to differentiate from metastases arising from cystic carcinomas.[35]

**Polycystic liver disease:**

An autosomal dominant disorder often found in association with renal polycystic disease. It is due to a ductal plate malformation of the small intrahepatic bile ducts, which loses communication with the biliary tree and is characterized by the presence of multiple cysts of varying sizes. Usually, asymptomatic but in later stages may present with pain, and hepatomegaly due to infection and hemorrhage. Hepatic cysts are found in 40% of cases of autosomal dominant polycystic disease involving the kidneys.[36] Polycystic liver disease typically appears as multiple homogeneous and hypo attenuating cystic lesions with a regular outline on NECT scans, with no wall or content enhancement on contrast-enhanced images.

**Biliary hamartomas:**

Are also called von Meyenburg complexes. They occur due to failure of involution of embryonic bile ducts. They are usually an incidental finding at imaging with an incidence of 0.69%–2.8%. Non-enhanced CT showed hypodense small hepatic nodules, scattered throughout the liver, typically measuring 0.5 to1.0 cm in diameter. The latter feature is the most essential one in differentiating from multiple simple cysts. Furthermore, simple cysts are typically regularly outlined, whereas bile duct hamartomas have a more irregular outline. The other differential diagnosis of Biliary hamartomas include micro- abscesses, carolis disease and metastases.[37]

**Biliary cystadenoma :**

Rare, usually slow growing, multilocular cystic tumors representing less than 5% of intrahepatic cystic masses of biliary origin. They are generally intrahepatic (85%) and range in diameter from 1.5 to 35 cm and occur in middle-aged women. Symptoms are usually related to the mass effect of the lesion and consist of

intermittent pain or biliary obstruction. At CT, a biliary cystadenoma appears as a solitary cystic mass (5–25 HU) with a well-defined thick fibrous capsule, mural nodules, internal septa, and rarely capsular calcification. Polypoid, pedunculated excrescences are seen more commonly in biliary cystadenocarcinoma than in cystadenoma. After contrast media administration, septa, mural nodules, and pedunculated excrescences show enhancement.[38]

**Pseudo-Lesions of the Liver:**

Dual blood supply of liver provides a high intrinsic contrast. Perfusion abnormalities may result in areas of abnormal liver enhancement and is caused by selective impairment of its vascular supply either arterial or venous. The arterial and portal systems, may communicate via intrahepatic anastomosis.[39] Reduction in portal flow results in compensatory increase in arterial flow to the corresponding segment. Connection may also occur between portal vein and the hepatic or systemic veins. Liver may be supplied by accessory hepatic arteries such as the inferior diaphragmatic, capsular or hilar arteries. Accessory network of systemic veins, called as —non-portal venous blood can drain directly into the liver parenchyma via the parabiliary venous plexus, the cystic veins, the veins of Sappey, or the aberrant drainage of the gastric vein.31 All these accessory vessels may mask or mimic liver lesions. Besides these, focal fatty heterogeneities may also mimic as focal liver lesions. Pseudo lesions of liver are broadly divided into three main categories: pitfalls (Parenchymal compression, Pericaval Fat Collection)[40,41] vascular abnormalities and variants, and focal steatosis.

**Portal Venous Inflow Obstruction:**

Reduction in portal venous flow on dynamic scan may show focal area of increase parenchymal enhancement in HAP due to increased compensatory arterial

flow, with rapid return to isodensity in PVP.[42]These areas called as —transient hepatic attenuation differences (THAD), are typically fan-shaped, broad peripheral based and may be lobar, segmental, sub segmental or sub capsular in location. THAD can obscure or artificially increase the size of a focal liver lesion located within the hyper attenuating fan-shaped area.

**Hepatic Vein Obstruction:**

Reduction in the efferent blood flow via the hepatic veins such as seen in Budd-Chiari syndrome causes several liver flow abnormalities which are different in the acute and chronic forms of the disease.[43] In the acute phase on dynamic CT at the HAP of liver enhancement an isolated and vigorous enhancement (due to opening of intrahepatic Arterioportal shunts) of the portal vein is seen. In delayed phase of liver enhancement a mottled parenchymal appearance is the net result of the efferent vessel obstruction, causing stasis and distal accumulation of the intravascular contrast material. In the chronic phase, network of intrahepatic venous collaterals is seen bypassing the obstruction. These abnormal vessels are more peripherally located and most prominent around the caudate lobe due to its separate drainage.

**Intrahepatic Vascular Shunts:**

Intrahepatic shunts can be tumorous or non-tumorous depending on the underlying cause and into Arterioportal, Arteriosystemic or Portosystemic according to the established vascular connection. Arterioportal shunting (AP shunting) is the most common intrahepatic shunts and in general is observed in the context of hepatocellular carcinoma, but it may be seen in post liver biopsy cases. Recently also seen in association with hemangiomas called as —flash-filling hemangiomas.[44]

Intrahepatic portosystemic venous shunts (IPSVS) consist of the direct communication between the portal vein and the systemic veins and they can mimic as

rupture of a portal vein aneurysm into a hepatic vein.[45] In obstruction of superior vena cava, due to collateral circulation intense focal parenchymal enhancement is seen in the early phases of liver enhancement around the round ligament, the left portal vein or remote sub capsular areas, mimicking a true hyper vascular neoplasm.[46]

**Focal Fatty Infiltration and Focal Fatty Sparing**

Fatty infiltration of the liver (FFI) is a common asymptomatic condition present in approximately 10% of the adult population. Usually associated with alcoholism, diabetes and obesity inborn metabolic errors, drug toxicity, glucocorticoid therapy, and infections.[47] Focal fatty infiltration is a frequent source of liver pseudo-lesion, can mimic hypo dense secondary liver deposits or other primaries such as adenoma and HCC, on CT study.

**Primary Malignant Liver Lesions**

**Hepatocellular carcinoma:**

HCC accounts for 90% of primary hepatic malignancies and is one of the ten most common cancers in the world. More frequent with men (M: F ratio of 3:1). Risk factors include cirrhosis (95%), alcohol, HBV, HCV, metabolic liver diseases, environmental carcinogens, hormonal treatments and smoking.[48.49,50] Less than 5% of HCCs do not have a background of chronic liver disease. They present late and usually have poor prognosis. Grossly HCC are classified into nodular, massive and diffuse variety. The growth pattern of HCC may be infiltrative, expanding, multinodular and mixed type. Based on histology, as per WHO, HCC is classified into trabecular, acinar, compact and scirrhous types.[51,52]

The tumor is clinically indolent during the early phases, whereas in the advanced stages it presents with painful hepatomegaly and/or jaundice. In patients with cirrhosis, the progression from RN, to low-grade DN, to high-grade DN, to frank

HCC, one sees development of nontriadal arteries, which become the dominant blood supply in overt HCC[53,54,55]. It is this neovascularity that allows HCC to be diagnosed.

HCC is a vascular tumor and receives its blood supply from hepatic artery and has tendency to invade portal and hepatic veins. Venous invasion is commonly seen in high grade tumors, which are associated with poorer prognosis.[56] Metastases to hepatic hilar nodes, distant metastases to lung followed by bones and adrenals, may occur. Arterioportal shunting, mosaic pattern, central scar, tumor capsule and fatty metamorphosis are few important features of HCC that can be appreciated on diagnostic imaging.[57]

**Staging:**

TNM classification does not accurately predict the patient survival. It is better predicted by criteria combining tumor characteristics, functional status and liver function. Many staging classifications like Barcelona Clinic Liver Cancer staging classification, The Cancer of the Liver Italian Program (CLIP) System, the modified TNM, French score system and scoring system based on expression of estrogen receptors (ER) have been proposed for staging HCC. In recent comparative study, it was concluded that the classification based on ER was a better predictor of survival in patients with inoperable HCC compared to CLIP, Barcelona and French staging scores.[58]

**Table 1: Barcelona Clinic Liver Cancer Staging Classification of patients with Hepatocellular Carcinoma**

| Staging | Performance status | Tumor stage | Child-Pugh |
|---|---|---|---|
| (A) Early | **0** | Single <5 cm 3 nodes <3 cm | A&B |
| (B) Intermediate | **0** | Large/ multinodular | A&B |
| (C) Advanced | **1-2** | Vascular invasion Extra-hepatic spread | A&B |
| (D) End-stage | **3-4** | Any of the above | C |

In the Barcelona Clinic Liver Cancer staging classification the functional status of the patient and the liver status are measured by the Performance Status and Child-Pugh score system, respectively.[59]

Triphasic CT currently plays a fundamental role in the diagnosis and staging of HCC[60,61]. The different blood supply to the lesion, in fact, is the most important CT feature that may help differentiate among small hepatocellular lesions that have emerged in a cirrhotic liver[62],. Indeed, small, overt HCCs show a typical hypervascular pattern, with clear-cut enhancement in the arterial phase and rapid wash-out in the portal venous phase[63,64]. In contrast, early-stage HCCs, RNs or DNs fail to exhibit this feature and appear isoattenuating or hypoattenuating with respect to surrounding liver parenchyma. Nevertheless, high-grade DNs may show increased arterial blood supply and be indistinguishable from a small HCC[65]. Small, nodular type HCC tumor is a sharply demarcated lesion that may or may not be encapsulated.

The CT detection rate of the capsule is low in small tumors because the capsule is thin and poorly developed. The capsule is seen as a peripheral rim that is hypoattenuating on unenhanced and arterial phase and hyperattenuating on delayed phase.

Among the advanced HCC tumors, the typical expansive type of HCC is a sharply demarcated lesion that may be unifocal or multifocal. Typical features of expansive type HCC include tumor capsule and internal mosaic architecture. Most expansive HCC lesions have a well-developed fibrous capsule. The fibrous capsule is demonstrated by CT as a hypoattenuating rim which enhances in the delayed phase. The tumor strands into surrounding tissue, and frequently invades vascular structures, particularly portal vein branches. HCC, in fact, has a great propensity for invading and growing into the portal vein, eliciting tumor thrombi. Identification of neoplastic thrombosis of the portal vein is a crucial staging and prognostic factor[66,67]. Infiltrative HCC may create a massive involvement of the liver, replacing large parts of the parenchyma. The diffuse type is by far the most unusual presentation of HCC. This type is characterized by numerous nodules of small size scattered throughout the liver. The nodules do not fuse with each other and are visualized as diffusely distributed hypodense lesions.[68]

Satellite lesions should be distinguished from multiple small HCC tumors caused by multicentric development. Such a distinction is important since the presence of intrahepatic metastases indicates a more advanced stage and is associated with a worse prognosis. In the case of multicentric development, multiple small tumors may exhibit a different enhancement pattern on CT, reflecting different degrees of tumor differentiation[69]. Calcifications is uncommon in HCC, being detected in about 0.2–1% of tumors. The differential diagnosis of HCC includes focal

nodular hyperplasia, hepatocelluar adenoma, metastatic carcinomas, neuroendocrine carcinoma and Cholangiocarcinoma.

**Karahan (2003)** [70]– in their study, to determine the utility of Triphasic CT in the characterization of HCCs and correlations with histopathologic findings on Thirty patients with hepatocellular carcinomas found that in addition to characterization, Triphasic CT aided in the histopathologic differentiation of HCCs. They also mentioned that hypervascularity in PVP was found to be associated with well-differentiated HCCs and portal vein invasion was frequently seen in tumors >10 cm.

**K.H.Y. Lee (2003)**[71]**–** Described the appearances of HCC including intralesional contrast washout using Triphasic CT. In 35 patients (69%) pathological proof was obtained and in 16patients (31%) HCC was diagnosed on clinical and laboratory findings. In this study they found that the most common enhancement pattern for HCC was hypervascularity on hepatic arterial phase images with mosaic pattern on both arterial and portal venous phase images. These findings were seen in 86% and 78% of lesions by the two observers, respectively. Hyper vascular component was seen in 96% by two observers and 86% and 63% of the lesions showed washout respectively. Objective washout was present with in 76% of lesions.

**C.T. Chou et al, (2011)**[72]- Study performed on 102 patients with solitary HCC to diagnose microvascular invasion from pre-operative CT imaging. These patients who underwent curative hepatectomy were retrospectively included in this study. The pre-operative triphasic CT imaging and laboratory data for the 102 patients were reviewed. Tumour size, tumour margin, peritumoural enhancement, and alpha-fetoprotein level were assessed. Surgical pathology was reviewed; tumour differentiation, liver fibrosis score and microvascular invasion were recorded. The histopathological results revealed that 50 HCCs were positive and other 52 were

negative for microvascular invasion. Univariate analysis revealed tumour size and non-smooth tumour margin showed statistically significant associations with microvascular invasion. The sensitivity, specificity, positive predictive value, and negative predictive value of the non-smooth tumour margin in the prediction of microvascular invasion were 66%, 86.5%, 82.5 %, and 72.6%, respectively. Hence, they concluded that the non-smooth tumour margin in pre-operative CT had a statistically significant association with microvascular invasion. More aggressive treatment should be considered in HCC patients with suspected positive microvascular invasion.

**Fibrolamellar carcinoma**

Fibrolamellar carcinoma (FLC) is a rare neoplasm of hepatocellular origin, considered as independent entity from HCC. FLC occurs predominantly in young people of both sex, usually without preexisting liver disease. FLC does not appear to be related to previous HBV or HCV infection, and is not associated with elevated alpha-fetoprotein levels. Serum unsaturated vitamin B 12 binding capacity and plasma neurotensin may be used as tumoral markers. In a recent study, the survival rates were significantly longer in patients with FLC than HCC: the 5-year relative survival rate was 31% for FLC and 6% for HCC.[73]

The neoplasm usually presents as a large, lobulated and solitary mass with a central fibrous scar that may be calcified. Microscopically, FLC is characterized by cords of tumor cells surrounded by abundant avascular fibrous tissue. Fibrotic lamellae often form a central scar and multiple septa which radiate from the centre of the lesion.

CT demonstrates a well-defined solitary mass with lobulated margins. Central calcific foci with incomplete septae may be seen. On non-enhanced CT images, the

tumor is heterogeneous and hypo dense to adjacent normal liver. On HAP, the tumor is usually heterogeneous and shows strong contrast enhancement. On PVP, the tumor is iso-hypodense to liver, while on delayed-phase imaging the tumor is usually hypo dense. A stellate, central scar with radial septal bands is usually noted on CT scan which appears hypodense on HAP, PVP and delayed phases. Sometimes stellate, central scar and septae may show partial enhancement on delayed images.[74]

**Intrahepatic Cholangiocarcinoma**

Cholangiocellular carcinoma (CCA) is a primary malignancy arising from the bile duct epithelium. The incidence of CCA is around 20%. It generally occurs during the sixth and seventh decades of life[75]. Risk factors are primary sclerosing cholangitis, congenital anomalies of the biliary tree, hepatolithiasis, infection with Clonorchis sinensis, familial polyposis and congenital hepatic fibrosis.[76] Peripheral intrahepatic CCA usually presents with non-specific symptoms, such as anorexia and weight loss, or can be detected as incidental lesion by ultrasound examination. On the other hand perihilar or extrahepatic tumours present signs and symptoms related to the biliary obstruction. In most cases serum α-fetoprotein level is normal but serum CA 19-9 could be an effective tumor marker.[77]

NECT scan shows a predominantly hypodense mass, either solitary or with several satellite nodules. Calcifications may be seen in the central portion of the lesions, especially in mucin-secreting CCA. The most common pattern of mass-forming CCA on CECT is a mild, incomplete and thin, rim-like or thick, band- like enhancement around the periphery of the main tumour on scans obtained at hepatic arterial phase and as gradual centripetal enhancement on subsequent phases.[78]The intra tumoral part of peripheral CCA appears heterogeneous on HAP and PVP. Usually the tumour shows greater enhancement than the surrounding liver

parenchyma on post-equilibrium phases. Biliary ductal dilatation peripheral to the mass, encasement of the portal vein, capsular retraction if the mass is peripherally located, are few of the additional findings. Areas of calcifications may be seen in few percentages of cases.[79]

The important differential diagnoses to be considered are HCC, Fibrolamellar HCC, hemangiomas and hypo vascular metastases.

**Kim et al (2007)[78]**– A study was conducted on 26 patients with 28 histopathologically proven Intrahepatic CCA lesions, to determine whether a particular CT enhancement pattern suggests a correct diagnosis in cirrhotic patients. They found that the prevalent enhancement pattern of CCA differed depending on the size of the tumor. Peripheral rim like enhancement was the most frequent pattern observed in tumors >3cm in diameter. A washout pattern on PVP was the most frequent in tumors <3 cm in diameter. They concluded that the contrast enhancement patterns of CCA in cirrhotic liver on Multiphasic CT scans were found to differ depending on tumor size.

**Cystadenocarcinoma :**

This rare neoplasm is seen predominantly in females in the middle age. It arises from a cystoadenoma or a congenital biliary cyst. Most of the lesions are intrahepatic and only about 10% arise from the extrahepatic biliary ducts.[80]

Microscopically cystoadenocarcinoma consists of epithelial cells arranged in papillary structures circumscribed by an abundant mesenchymal stroma. Biliary cystadenocarcinoma with ovarian stroma is documented only in women developing from a pre-existing biliary cystadenoma and has a good prognosis. In contrast cystadenocarcinoma without ovarian stroma is seen both in men and women and is not associated with a pre-existing cystadenoma.[81]

On all imaging studies it is difficult to distinguish biliary cyst adenoma and Cystadenocarcinoma from other multilocular cystic lesions that occur in the liver, such as abscesses and echinococcal cysts. Correlation with clinical presentation and clinical history is helpful in diagnosing the case. On unenhanced CT scan these appear as hypo dense lesions and on CECT there is enhancement of the wall, thick nodular septae and papillary excrescences.[82]

**Secondary malignant lesions of liver (metastases):**

The most common malignancy of the liver is metastases from other organs, 25–50% patients with a known non-hematological malignancy have liver metastases at the time of diagnosis in colon, gastric, pancreatic, breast and lung cancer. The liver is the most common site of metastasis from the GIT, pancreas, breast, and lung[83].Exact knowledge of number, localization and size of metastases is crucial to determine resectability. Contraindications to resection include: N > 4 liver metastases, extra hepatic spread and involvement of hepatic lymph nodes. Usually present as multiple hepatic lesions. Only 20% of liver metastases present as solitary lesions.

The CT appearance of metastases depends on many factors like histology, vascularity, size, as well as presence of necrosis, fibrosis, calcification, or hemorrhage within the mass. Most hepatic metastases are hypo vascular and primary tumors that seed them are adenocarcinomas from gastrointestinal tract, lung and breast tumors. Hyper vascular metastases are less frequently seen than hypo vascular metastases and typically originate from renal cell carcinomas, carcinoids, pancreatic islet cell carcinomas, sarcomas, pheochromocytomas, melanomas, thyroid carcinomas, and Choriocarcinomas.[84]

Calcified metastases are usually from mucinous colon carcinoma, but can be seen with other primary tumors including leiomyosarcoma, osteogenicsarcoma,

rhabdomyosarcoma, chondrosarcoma, ovarian cystadenocarcinoma, melanoma, pleural mesothelioma, neuroblastoma, and testicular tumors.[85]Occasionally metastases from mucinous adenocarcinomas, such as colorectal or ovarian carcinoma may be cystic with thin wall containing mural nodule within. On NECT scan hypo vascular metastases appear hypodense, show peripheral enhancement in HAP and PVP. Detection of hypo vascular metastases is optimal in PVP. In the delayed phase the outer rim may become isodense/ isointense to surrounding liver parenchyma, so that the lesion appears smaller than it is in reality.[86] Hyper vascular metastases are detected best in HAP which show strong contrast enhancement and become isodense to liver parenchyma in PVP. Cystic metastases show presence of thin discernable wall with enhancing mural nodule within.

Differentials to be considered are multiple benign lesions like simple cysts, hemangiomas, biliary hamartomas, abscesses, FNH, adenomas and multicentric HCC in patients with chronic disease.

**Philippe Soyer (2004)[87] –** In a prospective study on 32 patients, 59 surgically and histopathologically proven hypovascular hepatic metastases underwent Triphasic CT. The CT findings were compared with that of Intraoperative US and Histopathology on lesion-by-lesion basis to determine the sensitivity in each imaging phase. Among the 59 hepatic metastases 39 (66.1%; 95%; CI: 53.3%, 76.8%) were seen on NECT, 44(74.5%; 95% CI: 62.2%, 83.9%) on HAP and 54(91.5%; 95% CI: 81.6%, 96.3%) on PVP respectively. They concluded that PVP imaging depicted hypovascular hepatic metastases more significantly than did unenhanced and HAP.

**Epithelioid Hemangioendothelioma :**

It is a rare primary malignant neoplasm of liver of vascular origin. It is a low-grade malignancy, seen between 20-80 years of age more frequently in middle aged

women. Epithelioid Hemangioendothelioma (EHE) presents with abdominal pain, weakness, anorexia, jaundice, hepatosplenomegaly and rarely haemoperitoneum and Budd-Chiari syndrome[88]. It is associated with oral contraception and exposure to polyvinyl.[89] EHE manifests in two forms, as multiple nodular lesions or as a large mass lesion. Usually are peripherally located. Characteristically have a dense fibrotic hypo vascular central core and a peripheral hyperemic rim. Retraction of adjacent liver capsule is frequently seen. Intra tumoral calcification is seen in 30% of cases. Neoplastic cells invade and obliterate the sinusoids, terminal hepatic veins, and portal veins. On Unenhanced CT scan multiple, round or oval hypo dense lesions are seen, in HAP and PVP contrast scans, peripheral enhancement of the lesions are noted with a surrounding non enhancing hypo dense rim. Marked enhancement of the lesions is seen on delayed images.[90]

**Angiosarcoma:**

It is a rare hepatic malignancy originating from the endothelial cells; accounting for less than 2% of all primary liver neoplasms. It is the most common mesenchymal malignancy in the liver in adults.[91] Angiosarcomas are associated with several toxins including Thorotrast, vinyl chloride, and arsenic ingestion. Occurs predominantly in elderly men.[92] Angiosarcoma is an unencapsulated multinodular lesion, located at the surface of liver. The tumor is characterized by dilated sinusoids lined by malignant cells with hypertrophic or necrotic hepatocytes. On Unenhanced CT scan multiple, hypo dense lesions with feeding vessels are seen, in HAP and PVP, progressive spreading enhancement and puddling of contrast material in different portions of the tumor is seen. The lesions become isodense on post contrast images.[93]

**Infectious lesions:**

**Abscess:**

Intrahepatic single or multiple collections classified based on the etiology, as pyogenic, amebic, or fungal. Clinical symptoms of abscesses are related to the coexistence of sepsis and the presence of one or more space-occupying lesions.[94]

**Pyogenic abscess:**

Most commonly caused by *Clostridium* species and gram-negative bacteria, such as *Escherichia coli* and *Bacteroides* species. Abscesses related to the portal mechanism are usually single, while those related to biliary mechanism are typically multiple and localized in both lobes. At CT the pyogenic abscess appears as an irregular, round, inhomogeneously hypodense area, with HU ranging from 0 to 50. In most cases, the lesion is well demarcated with a thick wall, sometimes with a papillary aspect. After contrast administration, the lesion presents a characteristic rim-enhancement. Presence of a gas or gas fluid level is highly suggestive of abscess.[95]

**Amebic abscess:**

It results from infection with the protozoan *Entamoeba histolytica* and is the most commonly encountered hepatic abscess. Hepatic abscess is the most common extra intestinal complication of amebiasis, occurring in 3-9% of cases. The CT appearance of the amebic abscess is nonspecific, characterized by a homogeneous hypo dense, round or oval, lesion with a slightly hyper dense border, which enhances after contrast media injection, remaining lesion appears hypo dense in relation to the surrounding liver parenchyma. The abscess is usually located in peripheral liver and appears frequently as a multiloculated lesion.[96]

**Fungal abscesses:**

Most often it is caused by *Candida albicans,* but *aspergillus, Cryptococcus, and* other organisms may be found. The CT appearance of fungal abscesses is similar to those of pyogenic ones; In immunosupressed patients multiple small hypo dense lesions less than 1 cm in diameter may be spread throughout the liver. The liquid component is absent and hence detectable as hypo dense lesions.

**Intrahepatic Hydatid Cyst:**

Hepatic echinococcosis is an endemic disease in the Mediterranean basin and other sheep-raising countries. Humans become infected by ingestion of eggs of the tapeworm. Echinococcus granulosus occurs either by eating contaminated food or from contact with dogs. The ingested embryos invade the intestinal mucosal wall and proceed to the liver by entering the portal venous system. Liver filters most of these embryos, those that are not destroyed then become hydatid cysts. Liver is the most frequent site (70%), followed by lung (20%) and other parenchyma's, as spleen, kidney, heart, brain, and muscle. At Histopathological analysis, a Hydatid cyst is composed of three layers: the outer pericyst, which corresponds to compressed liver tissue; the endocyst, an inner germinal layer; and the ectocyst, a translucent thin interleaved membrane. Maturation of a cyst is characterized by the development of daughter cysts in the periphery as a result of endocyst invagination. Peripheral calcifications are not uncommon in viable or nonviable cysts. On NECT, a Hydatid cyst usually appears as a well-defined hypoattenuating lesion with a distinguishable wall. Coarse calcifications of the wall are present in 50% of cases, and daughter cysts are identified in approximately 75% of patients. After contrast media administration, no enhancement is seen.[97]

**Other studies:**

**Marten S. van Leeuwen (1996)[98] –** Prospective study included 105 patients with suspected focal liver disease excluding simple cysts who underwent Triphasic CT. Enhancement pattern of each lesion in each phase were evaluated and were tabulated according to one of the 11 enhancement patterns. It was observed that in 94 patients, 375 lesions were detected. Nature of lesion was confirmed in 326 lesions (87%). Six of the 11 enhancement patterns were always due to benign disease and caused by areas of hyper /hypo perfusion, hemangiomas, cysts, FNH, or benign but non specified lesions. Two of the 11 patterns were always due to malignant disease, and one pattern was due to malignant disease in 38 (97%) of 39 patients with known malignancy elsewhere or with chronic liver disease. Other two patterns were seen in metastases and partly fibrosed hemangiomas. It was concluded that Triphasic CT enables characterization of wide range of focal liver lesions

**Miller et al (1998)[99] –** Prospective study included 102 patients with known or suspected malignant focal lesions who underwent Multiphasic CT. 584 lesions were detected in 102 patients. It was observed that no lesions were detected on unenhanced phase that were not seen on other phases, hyper vascular lesions were best detected on HAP, and hypo vascular lesions were more detected on PVP. However not all the hyper vascular lesions detected on HAP were malignant suggesting that benign lesions may also be hyper vascular (FNH, Hepatic adenoma, Peliosis Hepatis).

**Gualdi GF (1998)[100]**– In their study to evaluate the role of Triphasic CT in characterization of noncystic focal lesions on sixty- six patients with suspected focal liver disease found 11 patterns of enhancement depending on the patterns of enhancement of the lesions in different phases. Four of 11 enhancement patterns (hypo/hyper/hyper, hyper/iso/iso, hyper/hyper/iso, and hyper/hyper/hyper) were

always referable to benign disease. (Hemangioma, FNH-adenoma). Four of 11 enhancement patterns (iso/hypo/hypo, iso/iso/hypo, hyper/hypo/hypo, and hyper/hyper/hypo) were always referable to malignant disease (hepatocellular carcinoma-HCC-metastases). The other three patterns (hypo/hypo/hypo, hypo/hypo/hyper, and hyper/A/A) were seen in both benign and malignant diseases. They concluded that conspicuity of hypo vascular lesions was more in the PVP, and hyper vascular lesions in the HAP, and Triphasic CT improved the characterization of HCC, FNH, adenoma and hemangioma. Patients with unclassified lesions at US or conventional CT suspected HCC and metastases from pancreas neuroendocrine tumors should be submitted to Triphasic CT of the liver.

**Isaac R. Francis (2003)[101] –** Retrospective study of 52 patients with suspected or known hepatic tumors who had underwent Multiphasic CT. Conspicuity with vascular enhancement was rated for each of the three phases by three independent reviewers. It was observed that portal venous phase revealed the highest portal vein and normal hepatic parenchymal attenuation, and maximal tumor -to -parenchymal differences for hypo vascular lesions were superior in portal venous phase.

**Ihab R. Kamel, MD, phD (2003)[102]–**Prospective study on 73 patients with surgically and histopathologically proven liver lesions were evaluated with dual phase helical CT. There were a total of 237 lesions: of which 164 were malignant and 73 were benign. Sensitivity for lesion detection was 69%, 70%, and 71% for three reviewers respectively. Specificity was 91%, 86%, and 90%. It was found that difference in distribution of the lesions classifications between the three reviewers was not statistically significant. It was concluded that dual phase CT evaluation has 69%-71% sensitivity and high specificity of 86%-91% in detecting and characterizing focal liver

lesions and also interpretation is highly reproducible with minimal variation between experienced reviewers.

# MATERIALS AND METHODS

**Objectives of the study:**

To study the spectrum of focal liver lesions and assess the enhancement characteristics in Triphasic CT scan performed in patients with sonologically detected focal liver lesions.

**Method of data collection:**

A prospective correlation study was conducted over a period of one and half years (October 2012 to April 2014) on 50 patients of all age group with sonologically detected focal hepatic lesions. They were evaluated with Triphasic CT and conspicuity and enhancement patterns of individual lesions were noted and these findings were correlated with histopathology/ surgical findings/ USG/ follow-up as applicable.

The patient with suspected liver pathologies was subjected to detailed ultrasound examination. A detailed ultrasound examination was be carried out using one of the equipments in the department i.e. Philips HD 11XE (US with colour Doppler), Siemens ACUSON X300 (US with colour Doppler). In second step patients were evaluated with Triphasic CT by using 6 slice-MDCT scanner (Volume Zoom, Philips Healthcare).

**Duration of study**: October 2012 to April 2014.

**Triphasic CT Imaging Technique of Liver:**

Patients were kept nil orally 4 hours prior to the CT scan to avoid complications while administrating contrast medium. Risks of contrast administration were explained to the patient and consent was obtained prior to the contrast study. Routine anteroposterior topogram of the abdomen was initially taken in all patients in the supine position with the breath held. Axial sections of 5 mm thickness were taken

from the level of lung bases to the level of ischial tuberosities. In all cases plain scan was followed by intravenous contrast scan in suspended inspiration.

For contrast enhancement, 18G Vasofix (indwelling catheter) was placed in antecubital vein and dynamic injection at a rate of about 80-100cc of non ionic contrast material (ultravist: iopromide; 300mg iodine/ml) was given using a power injector. Sections were taken in Hepatic arterial phase (HAP) (40s),Portal venous phase (PVP) (60s) and delayed phases (3-5mins) in craniocaudal direction from the superior margin to the inferior border of the liver. Post study reconstructions were done at 2.5mm. Sagittal and coronal reconstructions were made wherever necessary. Newer techniques in Multi slice CT like curved planar reformatting, volume rendering, Maximum and Minimum Intensity Projections were done as and when necessary.

**Inclusion criteria:**

- Patients of all age groups of both sexes with ultrasound proven cases of hepatic lesions.

**Exclusion criteria:**

- Pregnant women with suspected liver disease.
- Patients with hypersensitivity to CT contrast agents, critically ill patients and in patients in whom CT is contraindicated due to any other reason.

**Image interpretation:**

Viewing of all reconstructed images was done. First the unenhanced, HAP, and PVP images were reviewed for presence of focal liver lesions. Second the CT appearance of each lesion in each phases (unenhanced, HAP, PVP and delayed images) are charecterised based on the enhancement patterns and its attenuation compared with that of the liver parenchyma in that phase.

Lesions were broadly grouped as hypervascular or hypovascular lesions relative to the surrounding parenchyma. Images of different phases were analysed separately and later were reinterpreted together. Later the nature of lesions confirmed by biopsy /surgery /USG/ follow-up as and when required. In some patients with multiple lesions biopsy was performed on only one or two lesions. Rest with similar CT appearance were assumed to be the same lesion. If the lesion did not show any change in size after minimum of six months then the lesion was presumed to be benign.

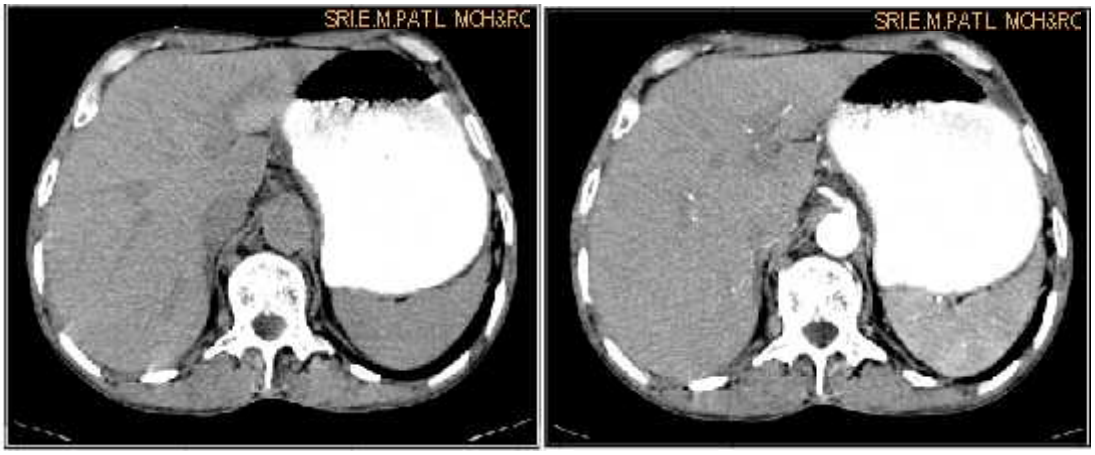
If the number of lesions were more than 10 then analysis of 10 most representative lesions was performed using the combination of all the phases. Appearance of each lesion in each phase was described on the basis of attenuation and homogeneity of the lesion in comparision to the liver parenchyma in that phase and was expressed as one of the five possible states:

1. Area of water attenuation, homogenous: ***hypo*(cyst)**
2. Area of soft tissue attenuation, slightly inhomogemous: ***hypo***
3. Area of mixed attenuation but hypoattenuating than the arterial system: ***mixed***
4. Area of hyperattenuation but less than the arteial system: ***hyper***
5. Isoattenuating compared to the arterial system: ***arterial or A***

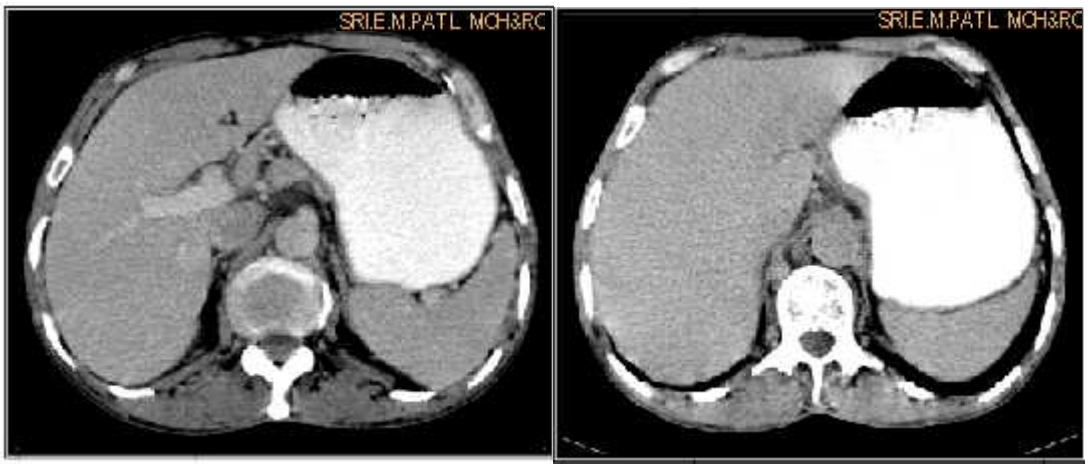
The pattern of enhancment is a three pattern name that includes appearance of lesion in each phase **(eg; *hypo/hypo/hypo*).**

Additional patterns of subtype enhancement in arterial phase like peripheral puddles, variegated, continuous hyperattenuating rim, incomplete rim and cleft were also considered.

## ILLUSTRATIONS



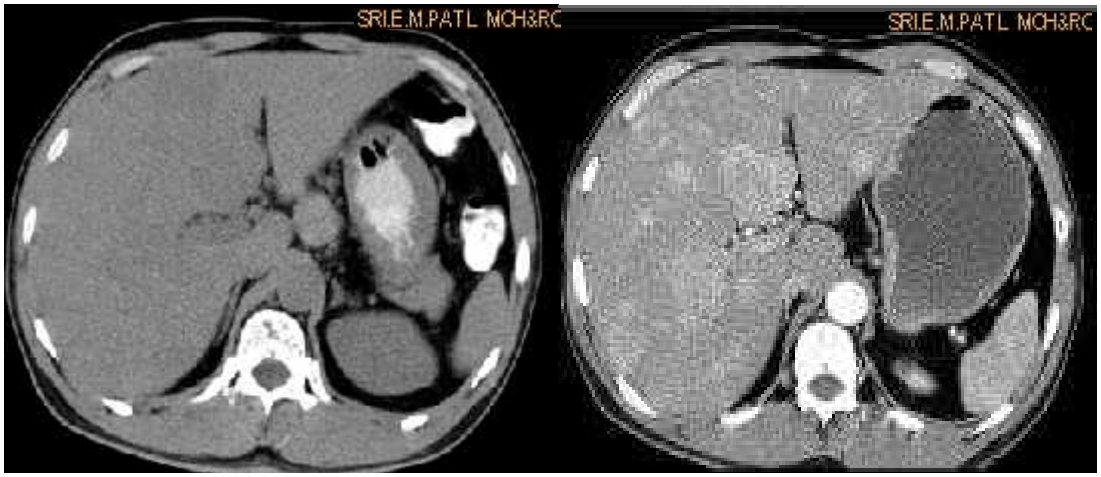

**Unenhanced phase** **HAP**




**PVP** **Delayed phase**

**Fig 7: Normal triphasic CT study of liver with normal enhancement of hepatic parenchyma on different phases.**

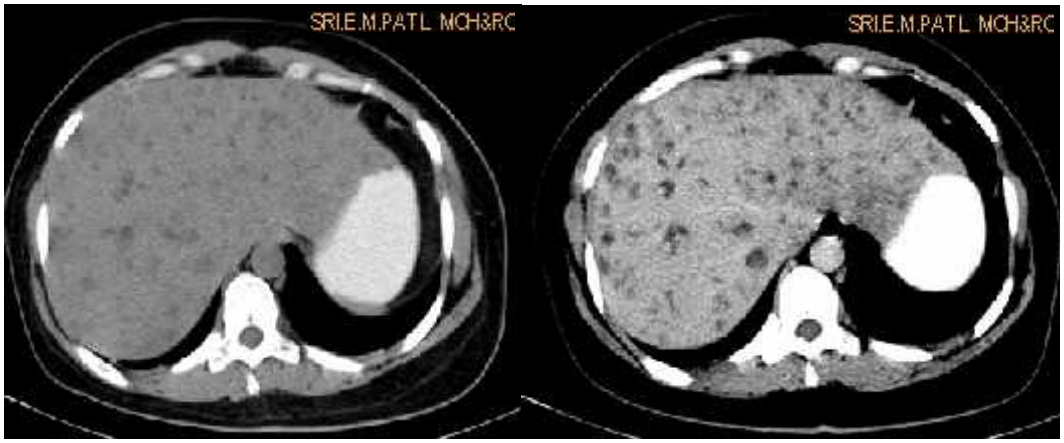
## Hypervascular lesions



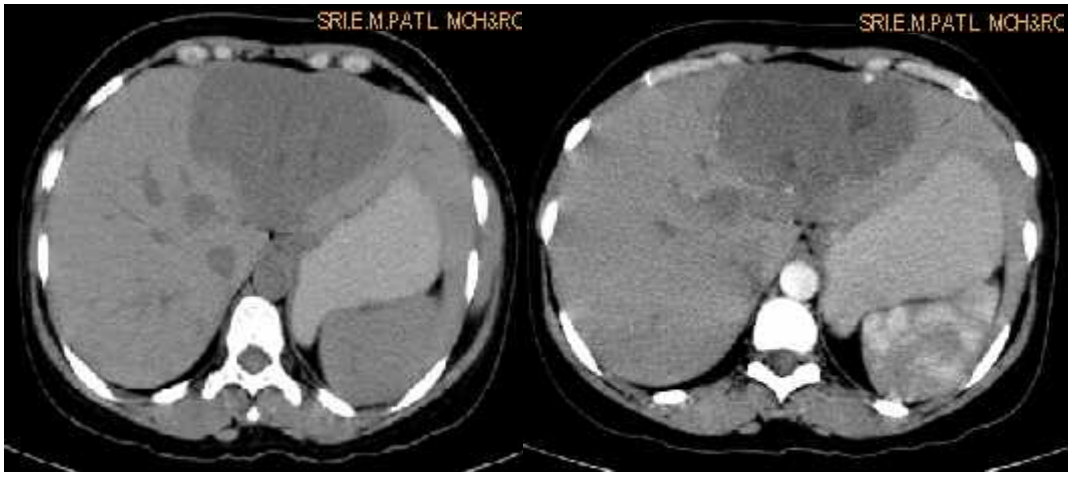

**Unenhanced phase** **HAP**

**Fig 8: Conspicuity of the lesions**

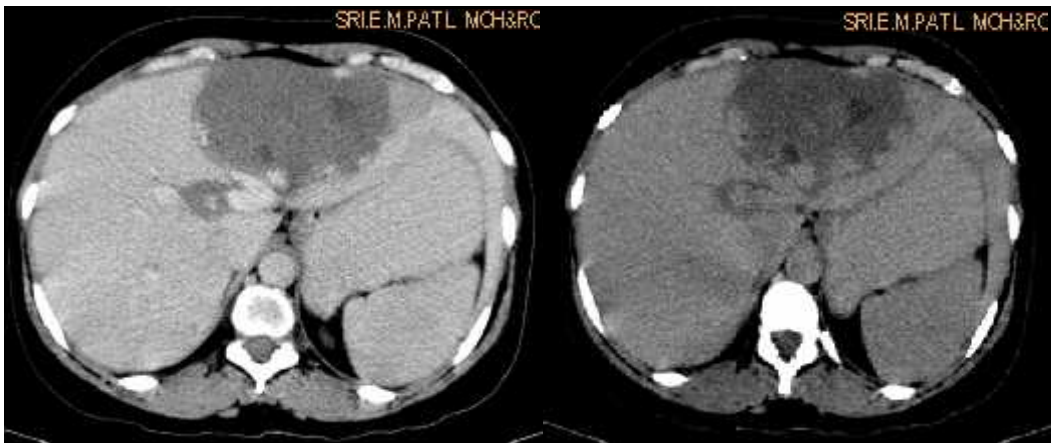
## Hypovascular Lesions




**Unenhanced phase** **PVP**



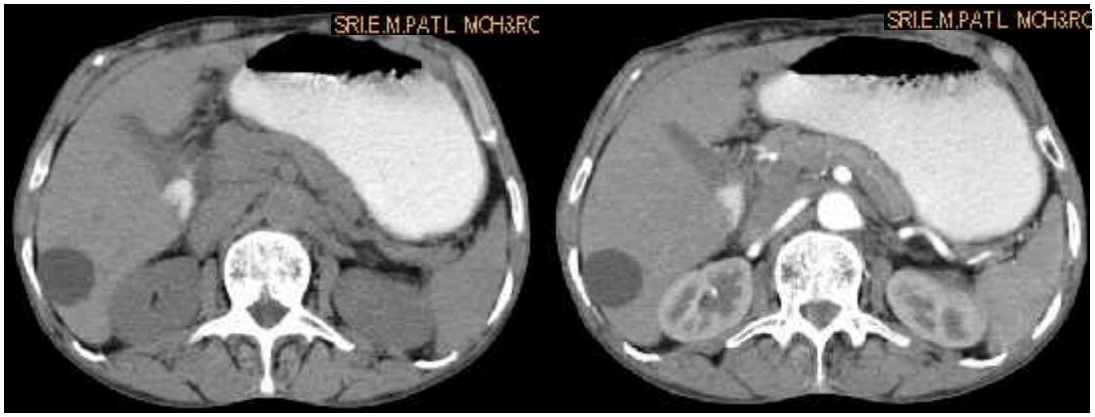

**Unenhanced phase** **HAP**



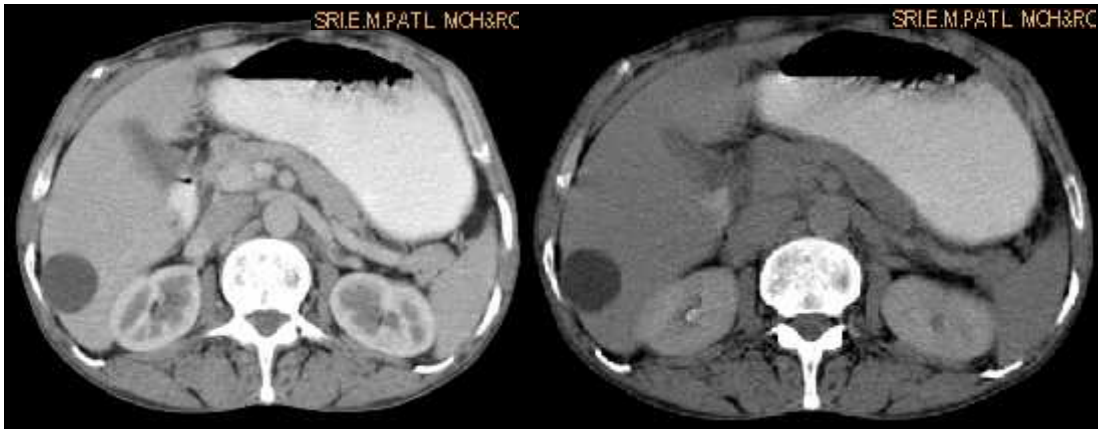

**PVP** **Delayed phase**

**Fig 9: Hemangioma with characteristic peripheral puddles**

**A (puddles)/A/A pattern of enhancement**



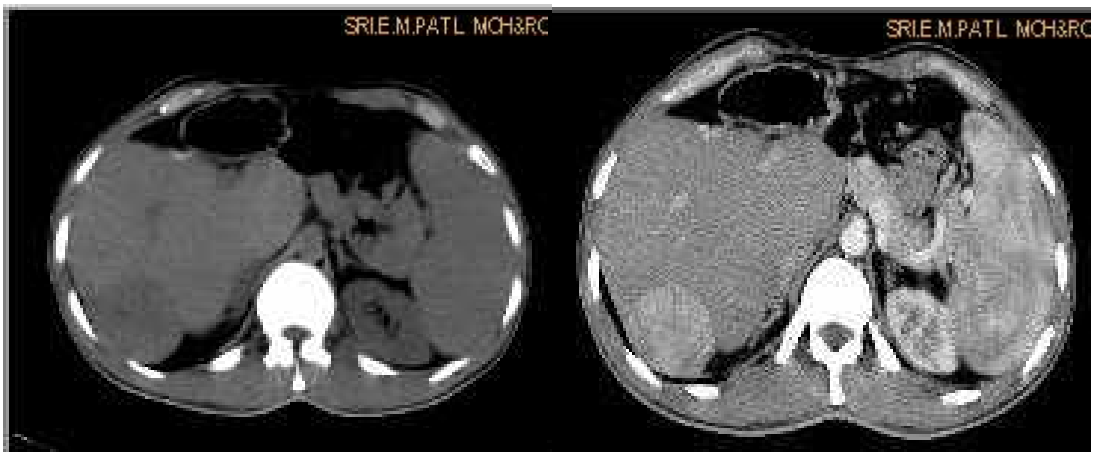

**Unenhanced phase** **HAP**



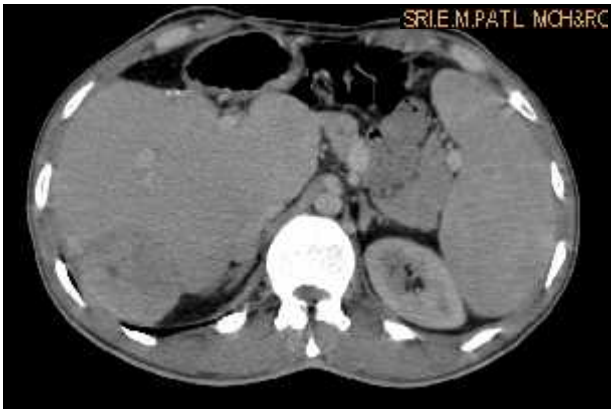

**PVP** **Delayed phase**

**Fig 10: Simple Cyst, sharp margin with homogenous hypo attenuation.**

**hypo / hypo (cyst)/hypo pattern of enhancement**

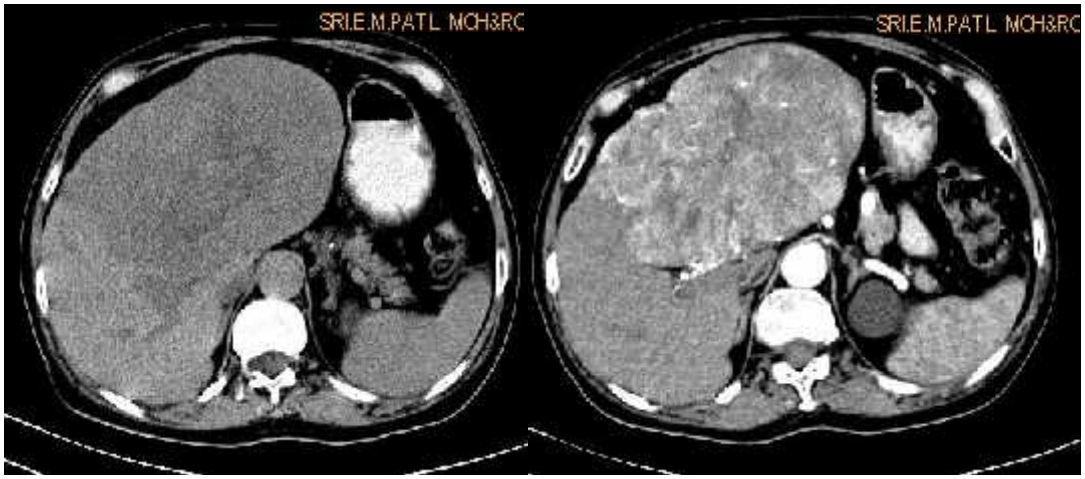



**Unenhanced phase** **HAP**

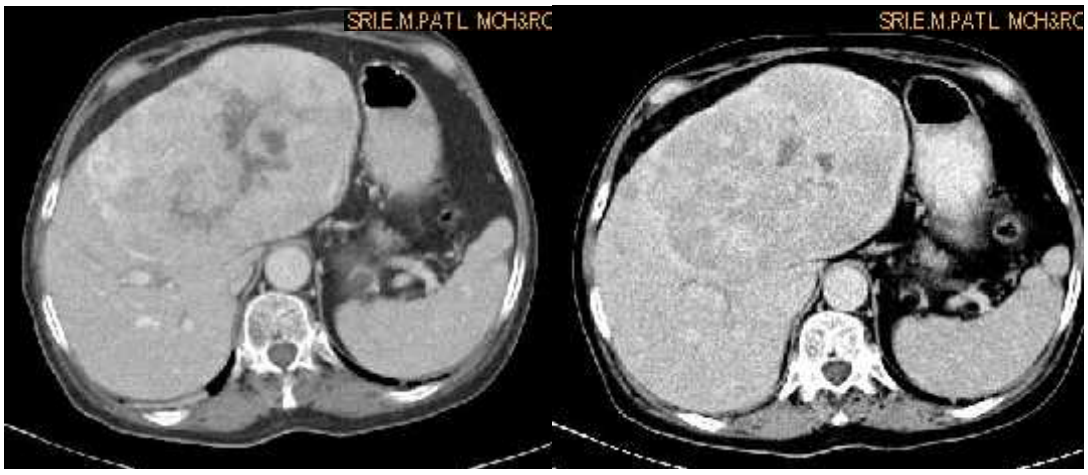



**PVP**

**Fig 11: FNH with early homogenous enhancement and delayed enhancing central scar. A/A/A (cleft) pattern of enhancement**

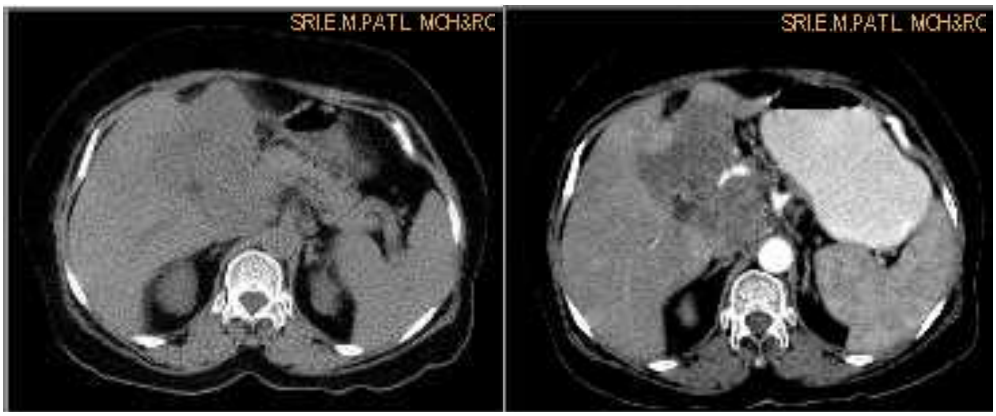



**Unenhanced phase** **HAP**

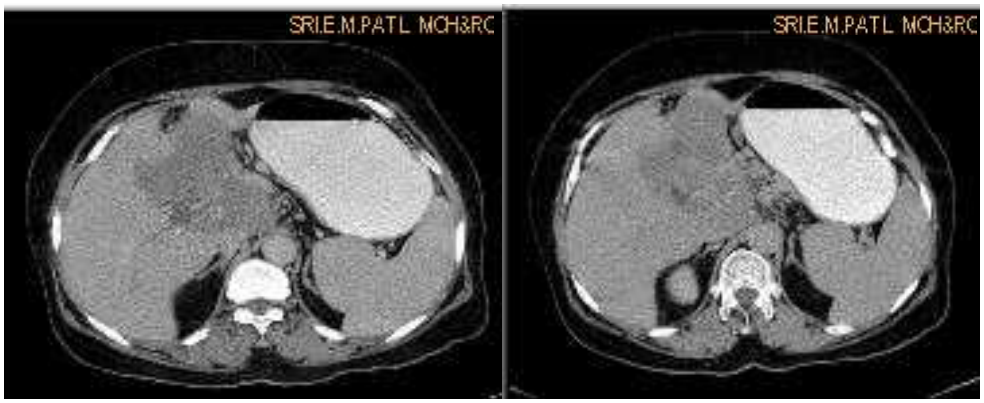



**PVP** **Delayed phase**

**Fig 12: HCC with characterstic variegated pattern of enhancement A (vareigated)/A/A (capsule) pattern of enhancement**

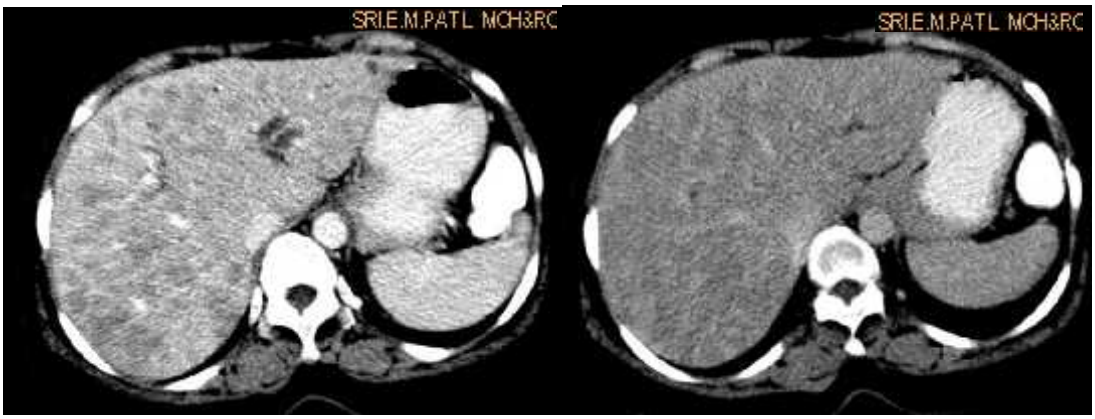



**Unenhanced phase** **HAP**

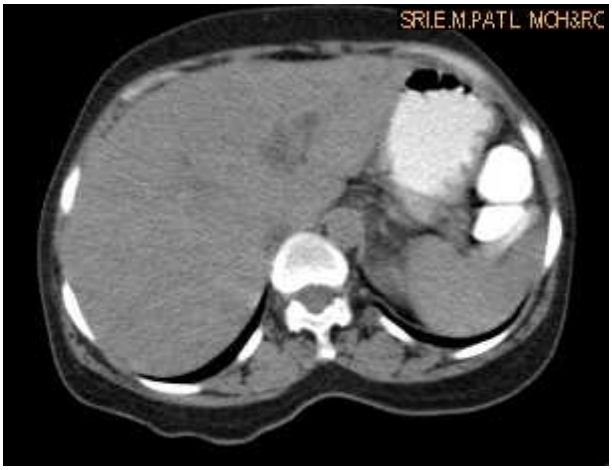



**PVP** **Delayed phase**

**Fig 13: Intrahepatic Cholangiocarcinoma hyper (incomplete)/A/A pattern of enhancement**

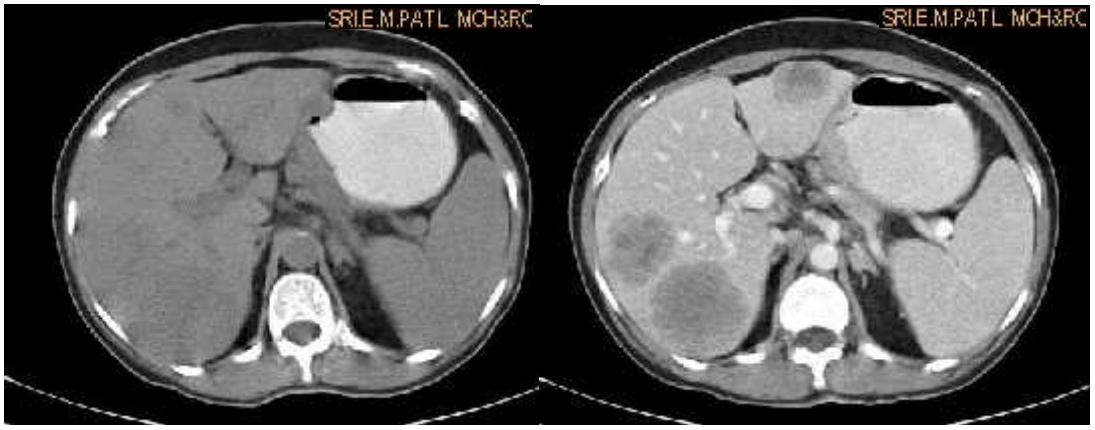



**HAP** **PVP**

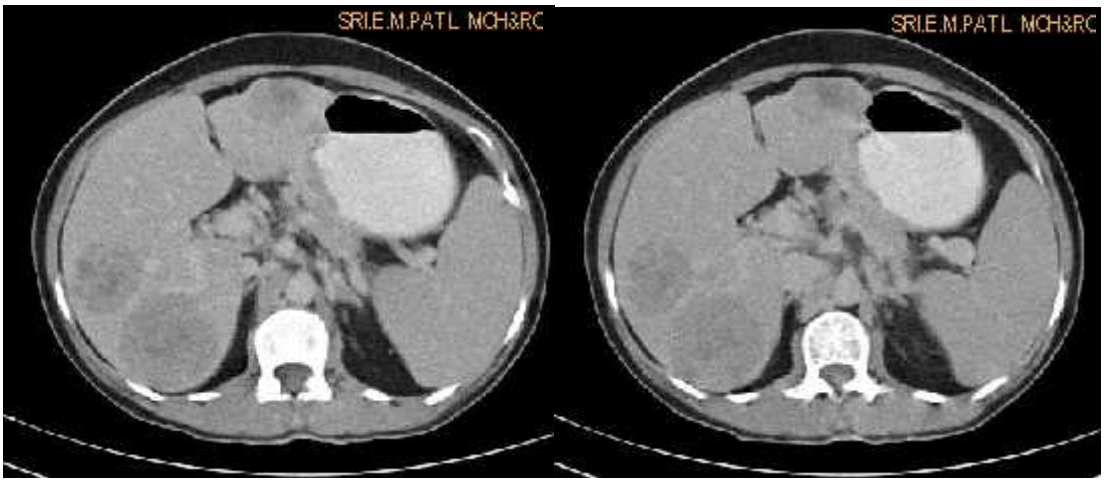



**Delayed phase**

**Fig 14: Metastases hypo/hypo/hypo pattern of enhancement**

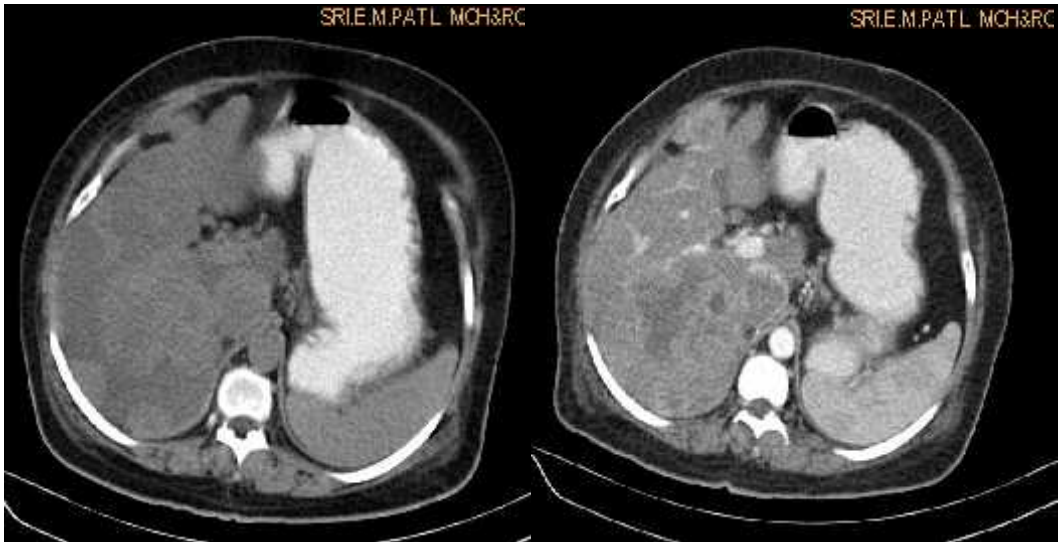



**Unenhanced phase** **HAP**

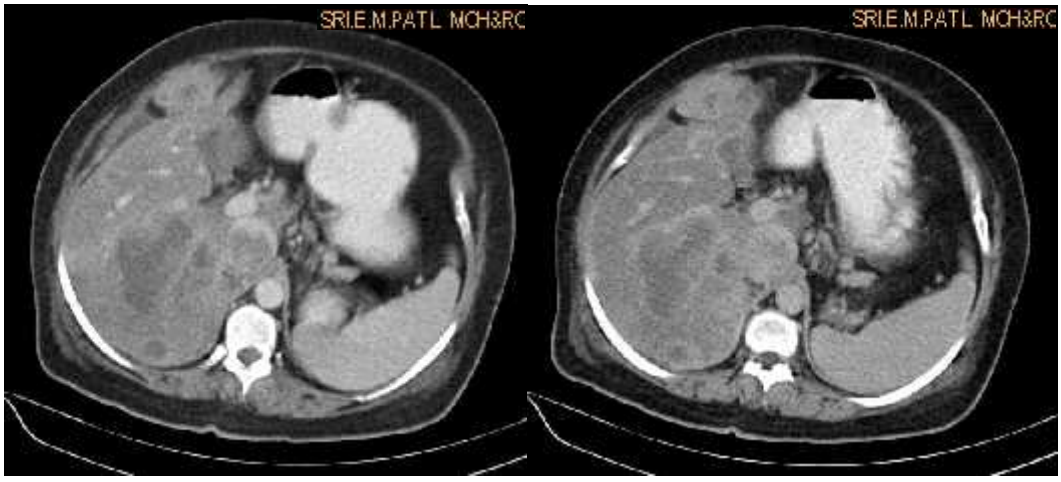



**PVP** **Delayed phase**

**Fig 15: Metastases mixed/mixed/mixed pattern of enhancement**

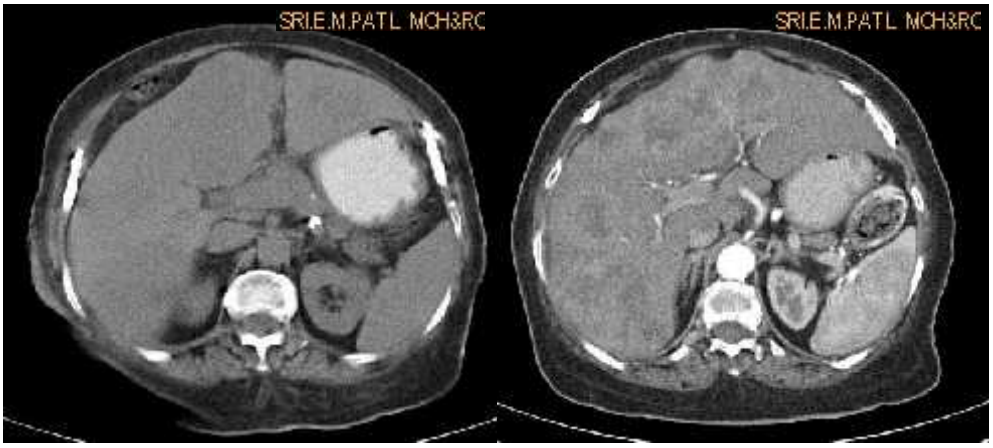



**Unenhanced phase** **HAP**

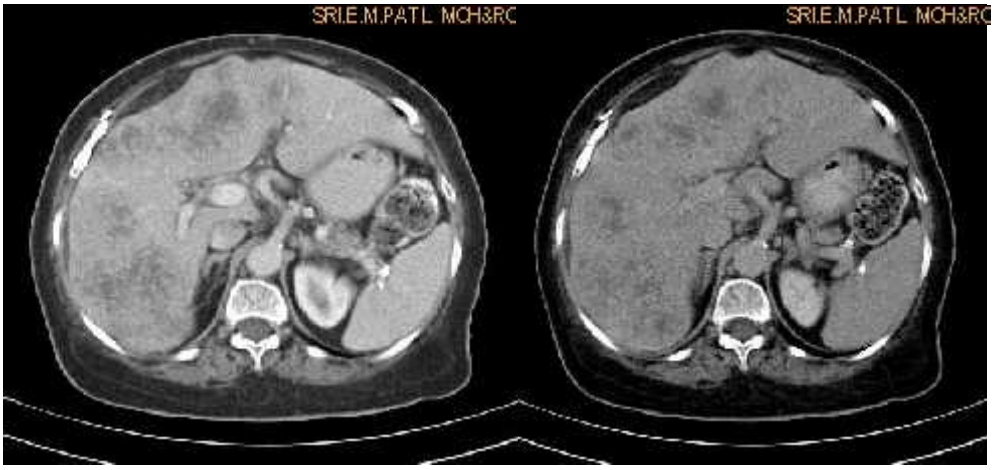



**PVP** **Delayed phase**

**Fig 16: Metastases hyper (rim)/hypo/hypo pattern of enhancement**

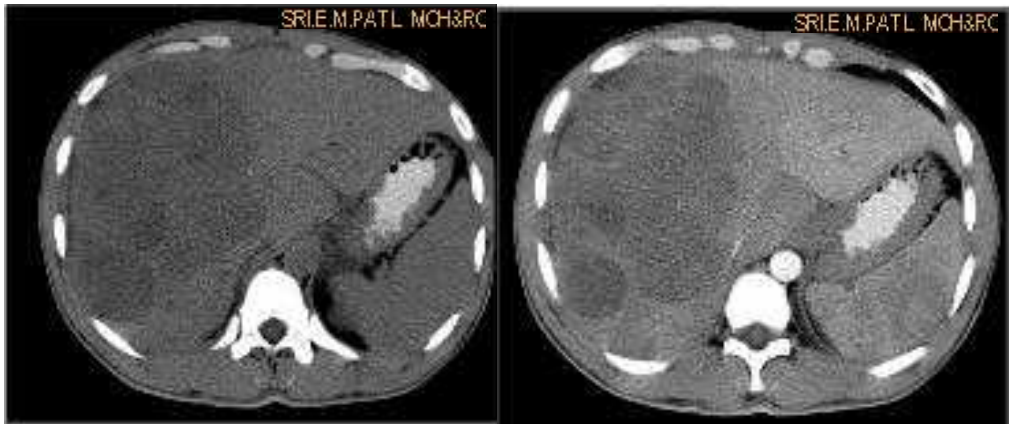



**Unenhanced phase** **HAP**

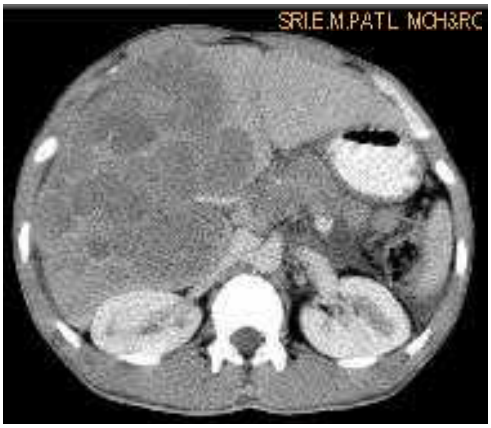



**PVP** **Delayed phase**

**Fig 17: Metastases hyper/A/A pattern of enhancement**

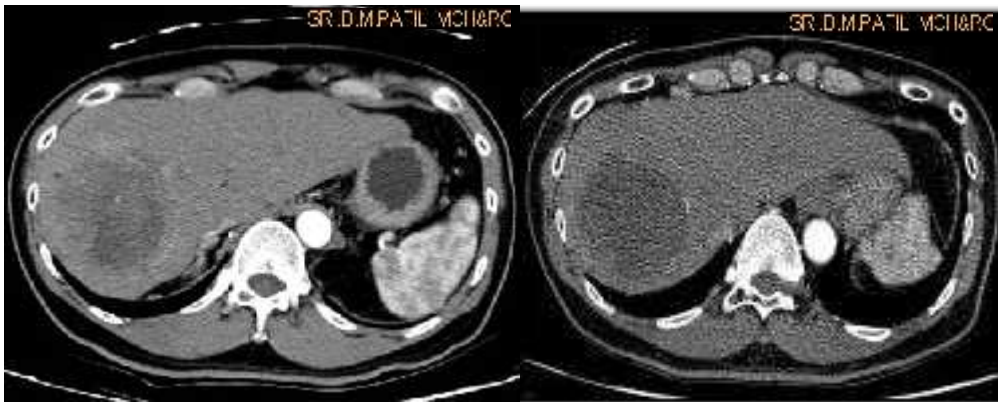



**Unenhanced phase** **HAP**

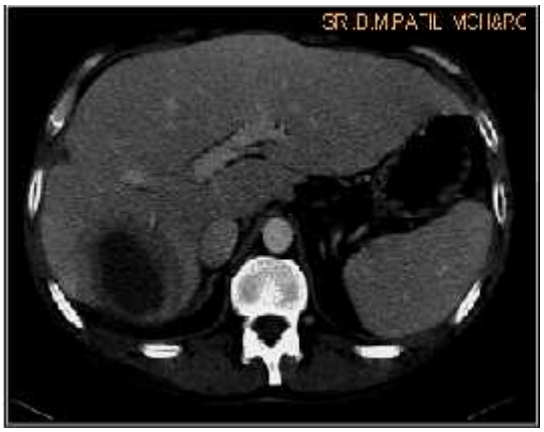



**Early delayed phase**

**Fig 18: Metastases hypo/hypo/hyper pattern of enhancement**



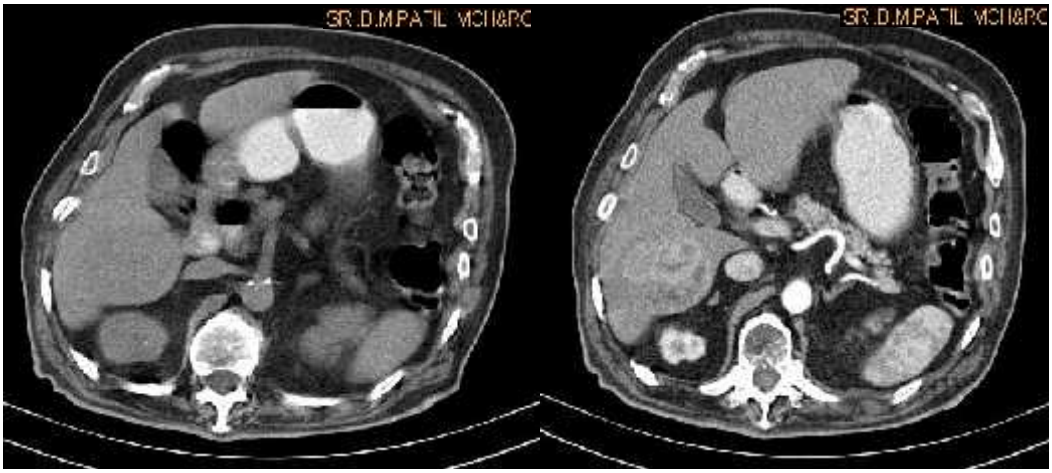

HAP HAP



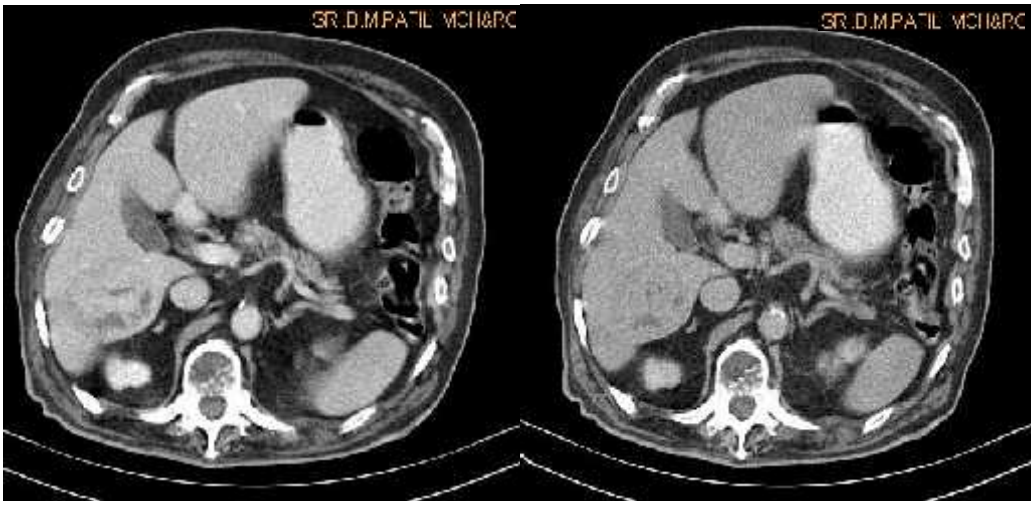

**PVP**

**Fig 19: Abscess with complete peripheral rim Enhancement.**

**hyper (rim)/hypo (cyst)/hypo pattern of enhancement**




**Unenhanced phase** **HAP**



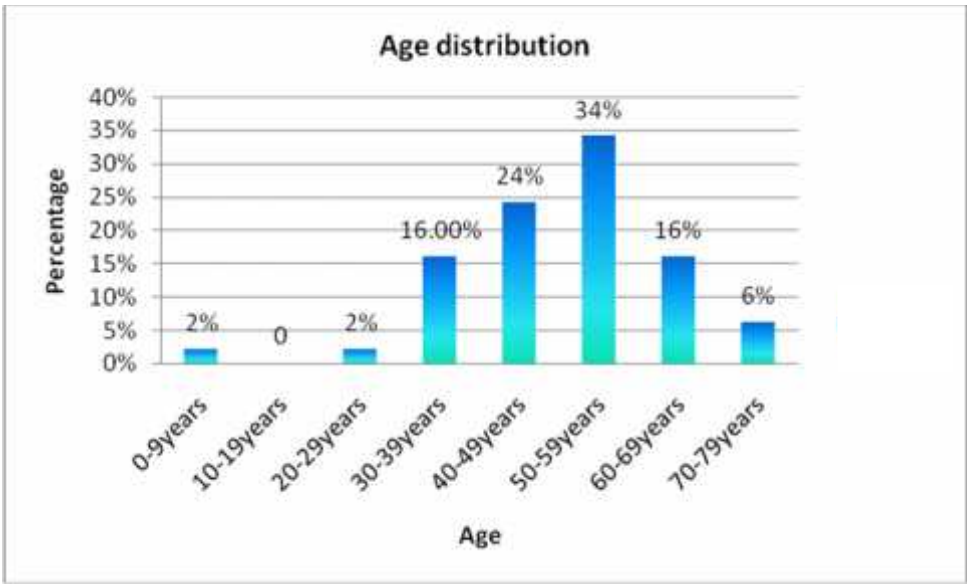

**PVP** **Delayed phase**

**Fig 20: Hepatocellular carcinoma**

## OBSERVATIONS AND RESULTS

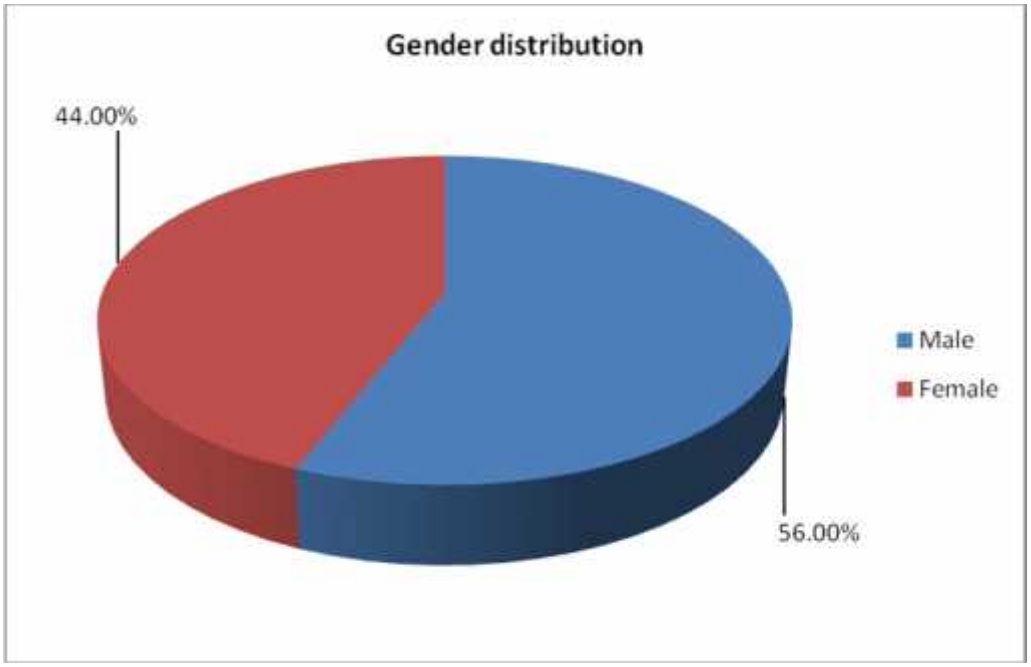
### Table 2: Age distribution of patients studied

| AGE(years) | FREQUENCY | PERCENTAGE |
|---|---|---|
| 0-9years | 01 | 02% |
| 10-19years | 00 | 00 |
| 20-29years | 01 | 02% |
| 30-39years | 08 | 16.% |
| 40-49years | 12 | 24% |
| 50-59years | 17 | 34% |
| 60-69years | 08 | 16% |
| 70-79years | 03 | 06% |
| TOTAL | 50 | 100% |



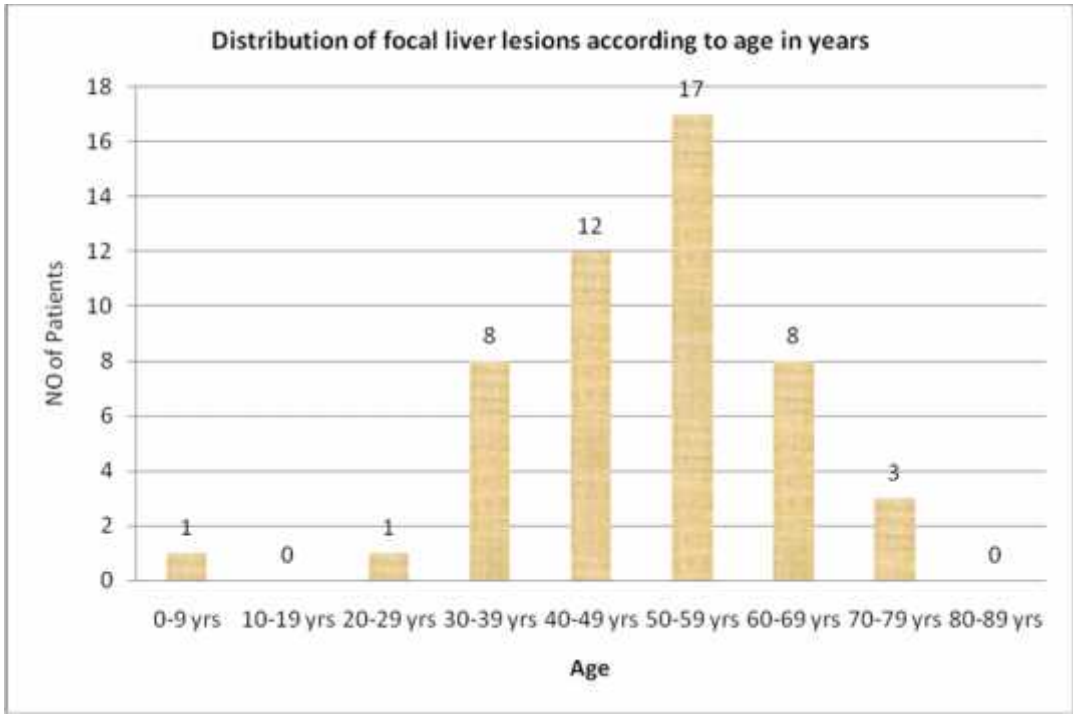
## Table 3: Gender distribution of patients studied

| Gender | Number | Percentage |
|---|---|---|
| Male | 28 | 56.00% |
| Female | 22 | 44.00% |
| Total | 50 | 100% |



## Table 4: Distribution of focal liver lesions according to age in years

| | 0-9 yrs | 10-19yrs | 20-29yrs | 30-39yrs | 40-49yrs | 50-59yrs | 60-69yrs | 70-79yrs | TOTAL | % |
|---|---|---|---|---|---|---|---|---|---|---|
| **Simple Cysts** | 1 | | | 2 | 1 | 2 | | | 6 | 12.00 |
| **Hemangioma** | | | 1 | 2 | 1 | 3 | 1 | | 8 | 16.00 |
| **Adenoma** | | | | 1 | | | | | 1 | 2.00% |
| **FNH** | | | | | 1 | | | | 1 | 2.00% |
| **HCC** | | | | | 3 | 3 | 3 | 1 | 10 | 20.00 |
| **Intrahepatic** | | | | | | 1 | | | 1 | 2.00% |
| **Metastases** | | | | 1 | 5 | 8 | 4 | 2 | 20 | 40.00 |
| **Abscess** | | | | 2 | 1 | | | | 3 | 6.00% |
| **Total** | 1 | 0 | 1 | 8 | 12 | 17 | 8 | 3 | 50 | 100 |



## Table 5: Distribution of focal liver lesions according to Gender

| Diagnosis | Total no of cases | Gender | |
|---|---|---|---|
| | | Male | Female |
| Simple cyst | 06 | 03 | 03 |
| | | 50% | 50% |
| Hemangioma | 08 | 03 | 05 |
| | | 37.50% | 62.50% |
| Adenoma | 01 | 00 | 01 |
| | | 00 | 100% |
| FNH | 01 | 00 | 01 |
| | | - | 100% |
| HCC | 10 | 06 | 04 |
| | | 60% | 40% |
| Intrahepatic CCA | 01 | 01 | 00 |
| | | 100% | - |
| Metastases | 20 | 12 | 08 |
| | | 60% | 40% |
| Abscess | 03 | 03 | 00 |
| | | 100% | - |

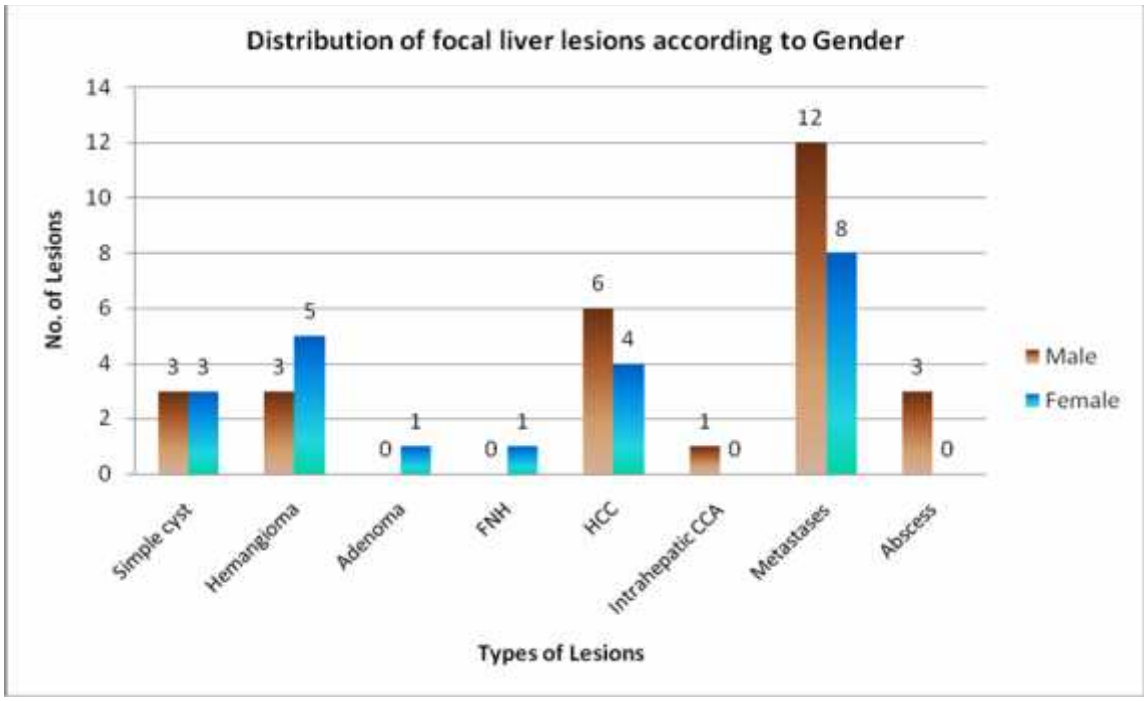


**Table 6: Distribution of Benign/Malignant focal liver lesions of the Total lesions (n=195) in the patients (n=50) studied**

| Groups | No of cases | Number of lesions | Percentage |
|---|---|---|---|
| Benign | 19(38.00%) | 57 | 29.23% |
| Malignant | 31(62.00%) | 138 | 70.77% |
| Total | 50(100%) | 195 | 100% |

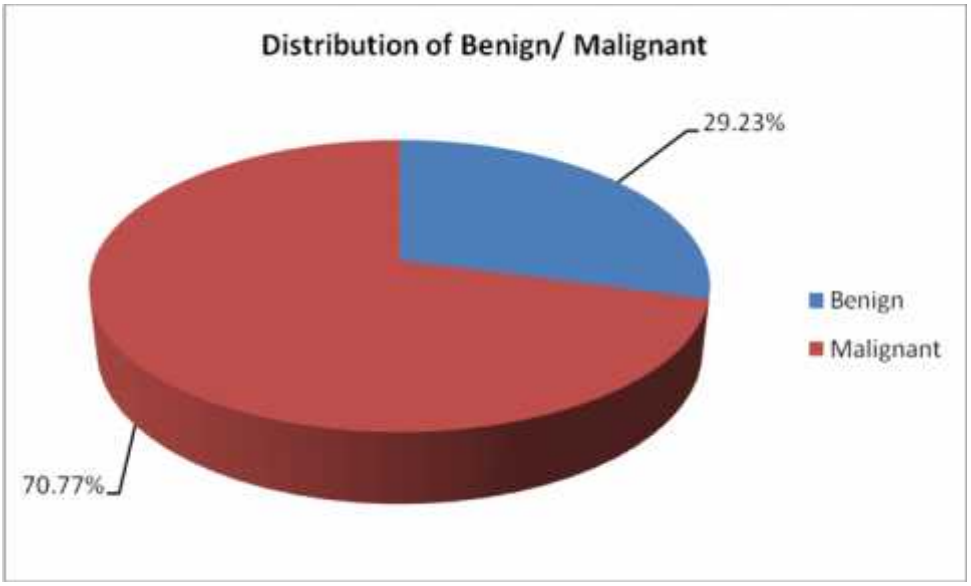
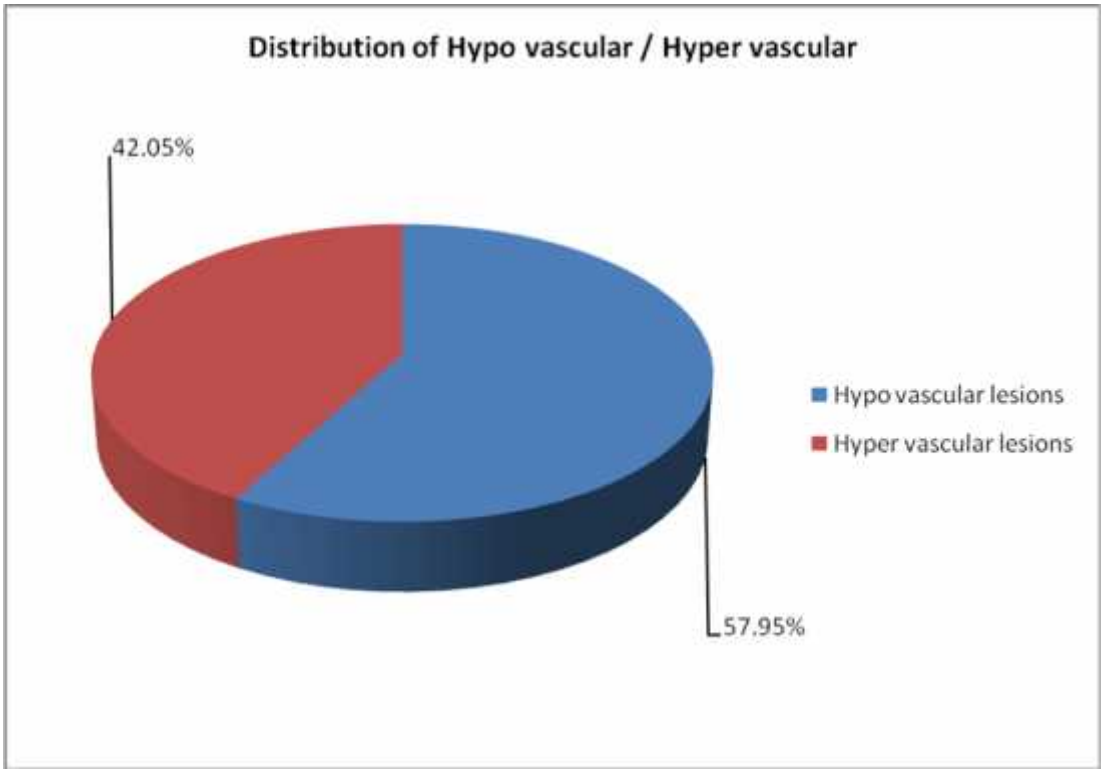


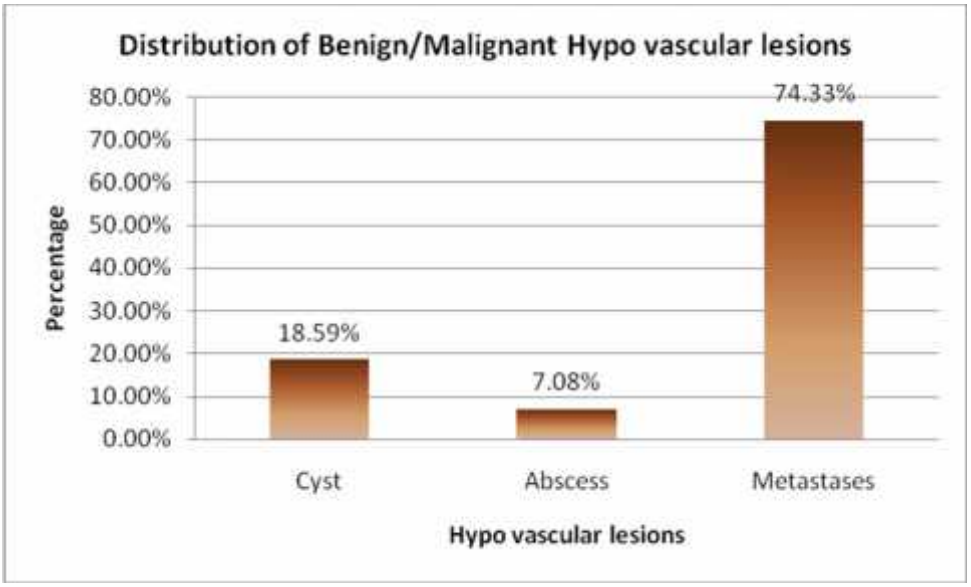
**Table 7: Distribution of Hypovascular / Hypervascular focal liver lesions of the Total lesions (n=195) in the patients (n=50) studied**

| Group | Number of lesions | Percentage |
|---|---|---|
| Hypovascular lesions | 113 | 57.95% |
| Hypervascular lesions | 82 | 42.05% |
| Total | 195 | 100% |



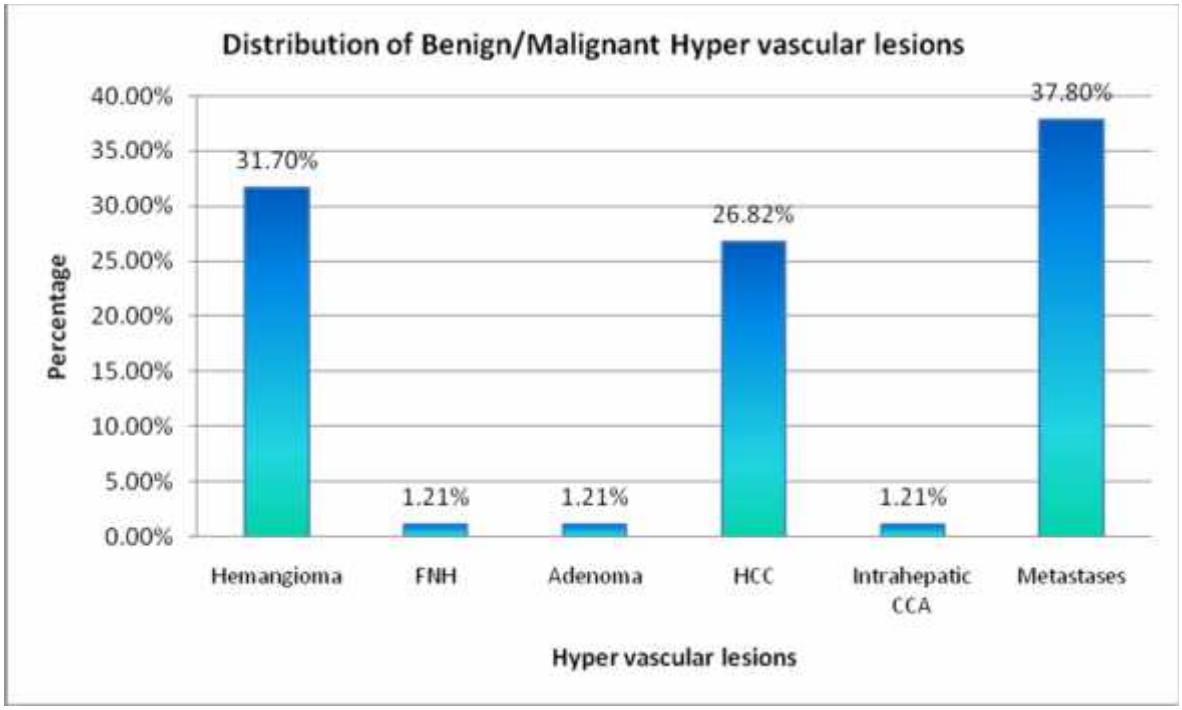
## Table 8: Distribution of Benign/Malignant Hypovascular lesions (n=113)

| Hypovascular lesions | Number of lesions | Percentage |
|---|---|---|
| Cyst | 21 | 18.59% |
| Abscess | 08 | 7.08% |
| Metastases | 84 | 74.33% |
| Total | 113 | 100% |



## Table 9: Distribution of Benign/Malignant Hypervascular lesions

| Hypervascular lesions | Number of lesions | Percentage |
|---|---|---|
| Hemangioma | 26 | 31.70% |
| FNH | 01 | 1.21% |
| Adenoma | 01 | 1.21% |
| HCC | 22 | 26.82% |
| Intrahepatic CCA | 01 | 1.21% |
| Metastases | 31 | 37.80% |
| Total | 82 | 100.00% |



## Table 10: Size wise Distribution of total lesions

| Size of the lesions | Number | Percentage |
|---|---|---|
| <1cm | 46 | 23.59% |
| 1 – 3cm | 104 | 53.33% |
| >3cm | 45 | 23.07% |
| Total | 195 | 100% |

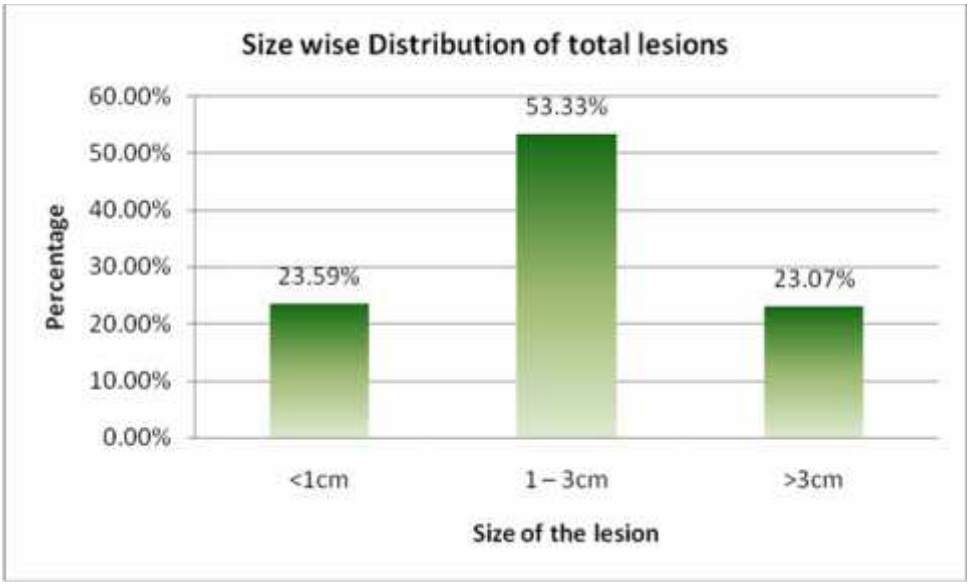


**Table 11: Distribution of hypovascular lesions visualized on each phase relative to size of the lesions**

| Hypovascular lesions (n=113) | PLN | | | HAP | | | PVP | | |
|---|---|---|---|---|---|---|---|---|---|
| | NV | VG | VE | NV | VG | VE | NV | VG | VE |
| <1cm (n=32) | 21 | 11 | 00 | 12 | 17 | 03 | 00 | 23 | 09 |
| 1-3cm (n=68) | 13 | 51 | 04 | 04 | 61 | 03 | 00 | 07 | 61 |
| >3cm (n=13) | 00 | 13 | 00 | 00 | 09 | 04 | 00 | 10 | 03 |

**PLN:plain study, HAP:hepaticarterial phase, PVP:portalvenous phase.**

**NV:not visualized,VG:visualized good, VE:visualized excellent**

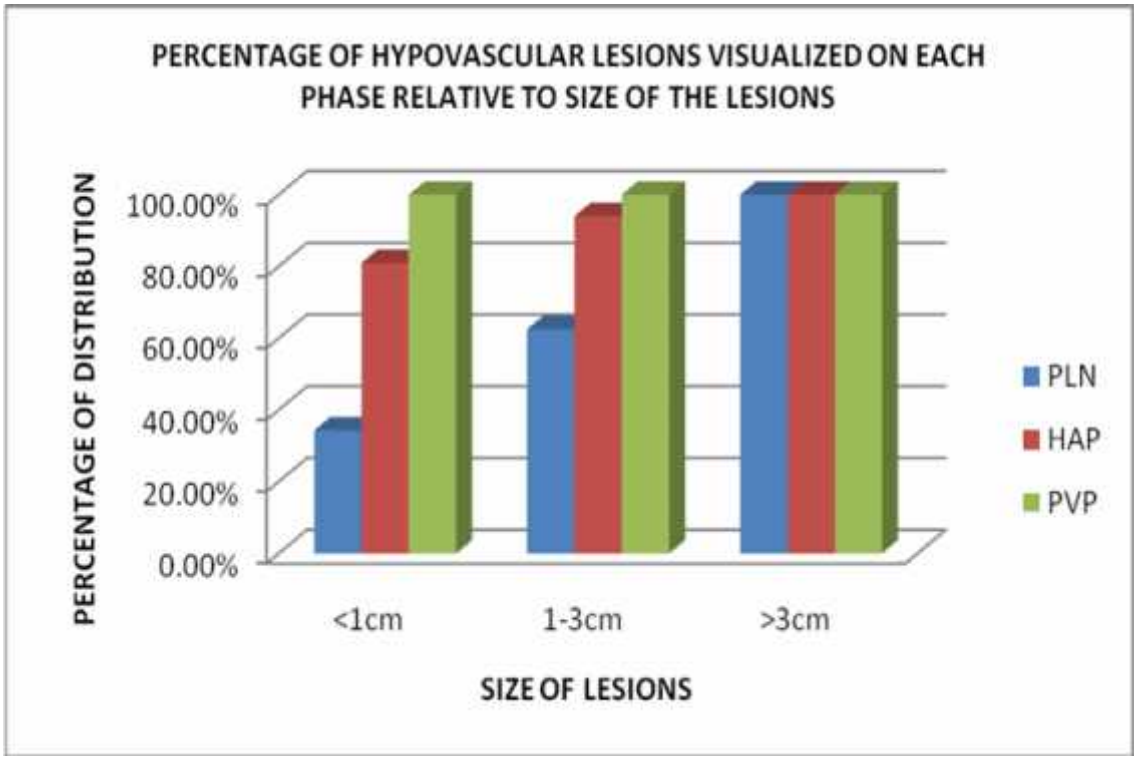
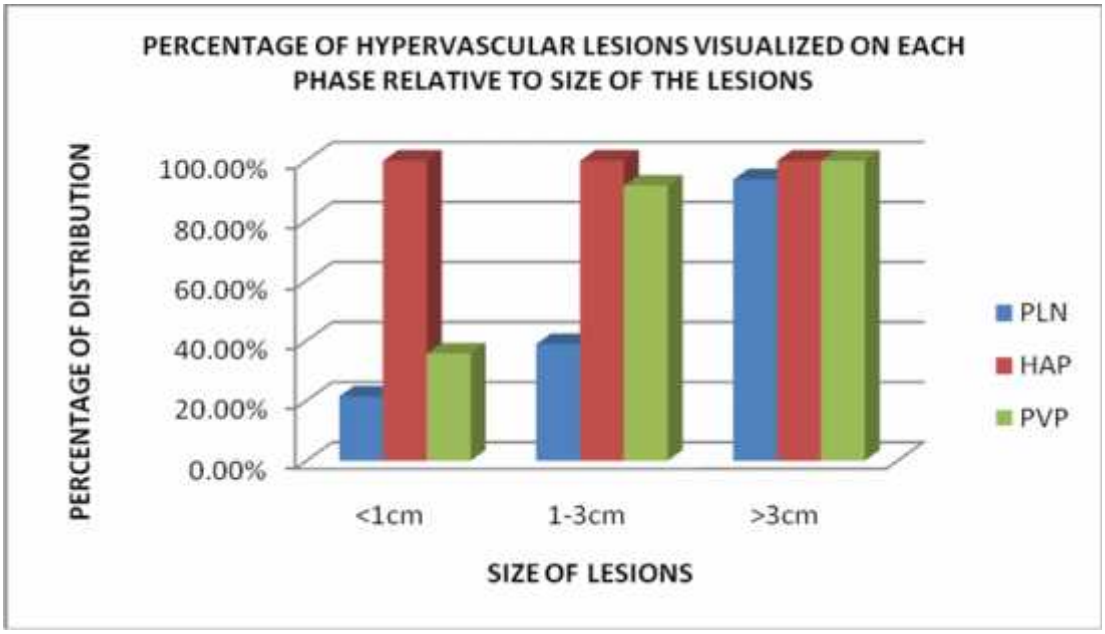


**Table 12: Distribution of hypervascular lesions visualized on each phase relative to size of the lesions**

| Hypervascular lesions(n=82) | PLN | | | HAP | | | PVP | | |
|---|---|---|---|---|---|---|---|---|---|
| | NV | VG | VE | NV | VG | VE | NV | VG | VE |
| <1cm (n=14) | 11 | 03 | 00 | 00 | 02 | 12 | 09 | 05 | 00 |
| 1-3cm (n=36) | 22 | 14 | 00 | 00 | 02 | 34 | 03 | 16 | 17 |
| >3cm (n=32) | 02 | 30 | 00 | 00 | 00 | 32 | 00 | 18 | 14 |

**PLN:plain study, HAP:hepatic arterial phase, PVP:portalvenous phase.**

**NV:not visualized, VG:visualized good, VE:visualized excellent**



## Table 13: Standard of reference in 195 lesions detected with Triphasic CT

| Abnormality | Surgery | Biopsy | US | Follow-up |
|---|---|---|---|---|
| Simple Cysts(21Lesions/6patients) | | | 21/6 | |
| Hemangioma (26Lesions/8patients) | | | 26/8 | 12/5 |
| Adenoma (1Lesion/1patient) | | 1/1 | 1/1 | 1/1 |
| FNH(1Lesions/1patients) | | 1/1 | 1/1 | |
| HCC (22Lesions/10patients) | | 10/10 | | |
| Intrahepatic CCA (1Lesions/1patients) | | 1/1 | | |
| Metastases(115Lesions/20patients) | | 32/8 | 36/6 | 42/5 |
| Abscess(8Lesions/3patients) | | | 8/3 | 8/3 |

## Table 14: The final diagnosis of the lesions (n=113) with Hypovascular enhancing patterns

| Enhancement pattern | | | Total no. of lesions in each pattern | Malignant lesions | | | Benign lesions | | |
|---|---|---|---|---|---|---|---|---|---|
| **HAP** | **PVP** | **DP** | | **No** | **%** | **Final** | **No** | **%** | **Final** |
| hypo | Hypo (cyst) | hypo | n=21 | 00 | | | 21 | 100 | Cyst |
| Hyper (rim) | Hypo (cyst) | hypo | n=8 | 00 | | | 8 | 100 | Abscess |
| hypo | hypo | hypo | n=51 | 51 | 100 | Metastases | | | |
| hyper (rim) | hypo | hypo | n=27 | 27 | 100 | Metastases | | | |
| hypo | hypo | hyper | n=6 | 06 | 100 | Metastases | | | |

**HAP=hepatic arterial phase; PVP=portal venous phase; DP= delayed phase**

1. Area of water attenuation, homogenous: ***hypo*(cyst)**
2. Area of soft tissue attenuation, slightly inhomogemous: ***hypo***
3. Area of mixed attenuation but hypoattenuating than the arterial system: ***mixed***
4. Area of hyperattenuation but less than the arterial system: ***hyper***
5. Isoattenuating compared to the arterial system: ***arterial or A***

## Table 15: The final diagnosis of the lesions (n=82) with Hypervascular enhancing patterns

| Enhancement pattern | | | Total no. of lesions in each pattern | Malignant lesions | | | Benign lesions | | |
|---|---|---|---|---|---|---|---|---|---|
| **HAP** | **PVP** | **DP** | | **No** | **%** | **Final diagnosis** | **No** | **%** | **Final diagnosis** |
| A | A | A | 26 | 00 | 00 | | 26 | 100 | Hemangiomas |
| A | A | A | 1 | 00 | 00 | | 1 | 100 | FNH |
| A (variegated) | A | A (capsule) | 16 | 16 | 100 | HCC | 00 | 00 | |
| hyper (incomplete) | A | A | 1 | 1 | 100 | Intrahepatic CCA | 00 | 00 | |
| Mixed | Mixed | Mixed | 21 | 21 | 100 | Metastases | | | |
| hyper | A | A | 17 | 06 | 35.3 | HCC | 1 | 5.9 | Adenoma |
| | | | | 10 | 58.8 | Metastases | | | |

**HAP=hepatic arterial phase; PVP=portal venous phase; DP=delayed phase**

1. Area of water attenuation, homogenous: ***hypo*** **(cyst)**
2. Area of soft tissue attenuation, slightly inhomogemous: ***hypo***
3. Area of mixed attenuation but hypoattenuating than the arterial system: ***mixed***
4. Area of hyperattenuation but less than the arteial system: ***hyper***
5. Isoattenuating compared to the arterial system: ***arterial or A***

## Table 16: Observed enhancement patterns of 138 malignant lesions

| Final diagnosis | No. of lesions | % | Enhancement pattern | | |
|---|---|---|---|---|---|
| | | | HAP | PVP | DP |
| Metastases(n=115) | 51 | 44.34 | hypo | hypo | hypo |
| | 27 | 23.47 | hyper(rim) | hypo | hypo |
| | 21 | 18.26 | Mixed | mixed | mixed |
| | 10 | 8.70 | hyper | A | A |
| | 06 | 5.21 | hypo | hypo | hyper |
| HCC (n=22) | 16 | 72.73 | A(variegated) | A | A(capsule) |
| | 06 | 27.27 | hyper | A | A |
| IntrahepaticCCA(n=1) | 01 | 100 | Hyper (incomplete) | A | A |

**HAP=hepatic arterial phase; PVP=portal venous phase; DP=delayed phase**

1. Area of water attenuation, homogenous: ***hypo*** **(cyst)**

2. Area of soft tissue attenuation, slightly inhomogemous: ***hypo***

3. Area of mixed attenuation but hypoattenuating than the arterial system: ***mixed***

4. Area of hyperattenuation but less than the arteial system: ***hyper***

5. Isoattenuating compared to the arterial system: ***arterial or A***

**Table 17: Observed enhancement patterns of 57 benign lesions**

| Final Diagnosis | No. of Lesions | % | Enhancement Pattern | | |
|---|---|---|---|---|---|
| | | | HAP | PVP | DP |
| Cysts(n=21) | 21 | 100 | hypo | hypo(cyst) | hypo |
| Abscesses(n=8) | 8 | 100 | hypo(rim) | hypo(cyst) | hypo |
| Hemangiomas(n=26) | 26 | 100 | A(puddles) | A | A |
| FNH(n=1) | 1 | 100 | A | A | A(cleft) |
| Adenoma (n=1) | 1 | 100 | hyper | A | A |

**Table 18: Correlation of CT enhancement patterns in diagnosis of focal liver lesions with final diagnosis–an observation**

| Diagnosis | True positive | False positive | False negative | True negative | Total |
|---|---|---|---|---|---|
| Abscesses | 8 | 0 | 0 | 187 | 195 |
| Adenoma | 0 | 0 | 1 | 194 | 195 |
| Cysts | 21 | 0 | 0 | 174 | 195 |
| Hemangioma | 26 | 0 | 0 | 169 | 195 |
| FNH | 1 | 0 | 0 | 194 | 195 |
| HCC | 18 | 0 | 04 | 173 | 195 |
| Intrahepatic CCA | 1 | 0 | 0 | 194 | 195 |
| Metastases | 108 | 0 | 07 | 80 | 195 |

**Table 19: Correlation of CT enhancement pattern in diagnosis of focal liver lesions with final diagnosis – an evaluation**

| Diagnosis | Sensitivity | Specificity | PPV | NPV | Accuracy | P value |
|---|---|---|---|---|---|---|
| Abscesses | 100 | 100 | 100 | 100 | 100 | <0.001 |
| Adenoma | 00 | 99.48 | 00 | 99.48 | 99.48 | - |
| Simple Cysts | 100 | 100 | 100 | 100 | 100 | <0.001 |
| Hemangioma | 100 | 100 | 100 | 100 | 100 | <0.001 |
| FNH | 100 | 100 | 100 | 100 | 100 | <0.005 |
| HCC | 81.81 | 100 | 100 | 97.74 | 97.94 | <0.001 |
| Intrahepatic CCA | 100 | 100 | 100 | 100 | 100 | <0.005 |
| Metastases | 93.91 | 100 | 100 | 91.95 | 96.41 | <0.001 |

The Triphasic CT enhancement patterns were 100% sensitive and specific in diagnosing all cases of Abscess, Cysts, Hemangioma, FNH and Intrahepatic CCA. The sensitivity of Triphasic CT enhancement patterns in diagnosing most of the cases of focal liver lesion is mentioned in the brackets of the individual lesion concerned, in HCC (sensitivity-81.81%), Metastases (sensitivity-93.91%). There was 100% specificity in diagnosing all the cases only when the individual lesion had typical enhancement pattern. 100% sensitivity and specificity for intrahepatic CCA, Hemangioma, simple cysts Abscesses and FNH observed in our study can be explained by the small sample size.

**Statistical Methods**: Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Diagnostic statistics such as sensitivity, Specificity, Positive predictive value, Negative predictive value and Accuracy has been used to find the

correlation of CT scan with final diagnosis. A *p* value less than 0.05 was considered statistically significant at the 95% confidence interval.

| | Disease | | | | |
|---|---|---|---|---|---|
| Test | Present | n | Absent | n | Total |
| Positive | True positive | a | False positive | c | a+c |
| Negative | False negative | b | True negative | d | b+d |
| Total | | a+b | | c+d | |

The statistical terms used are defined as follows:

- ***Sensitivity*:** probability that a test result will be positive when the disease is present (true positive rate, expressed as a percentage). = a / (a+b)
- ***Specificity*:** probability that a test result will be negative when the disease is not present (true negative rate, expressed as a percentage). = d / (c+d)
- ***Positive predictive value*:** probability that the disease is present when the test is positive (expressed as a percentage). = a / (a+c)
- ***Negative predictive value*:** probability that the disease is not present when the test is negative (expressed as a percentage). = d / (b+d)
- ***Accuracy*** *is the sum of true positive and true negative divided by number of lesions*

# DISCUSSION

This prospective study was carried out in Shri.B.M.Patil medical college hospital and reaserch centre over a period of one and half years (October 2012 to April 2014.) on 50 patients with clinically suspected and detected focal hepatic lesions by using ultrasound. Patients were evaluated with Multidetector Computed Tomography (Volume Zoom, Philips Healthcare). The conspicuity and enhancement patterns of individual lesions after the CT examination were noted and these findings were correlated with histopathology/ surgical findings/ /USG/follow-up as applicable.

In our study the maximum percentage of cases was seen in the age range of 50 -59 years.

- Majority (40%) of the patients with metastases were in the age range of 50-59 years.
- Majority (90%) of the patients with HCC were in the age range of 40-69 years.
- One case (100%) of intrahepatic Cholangiocarcinoma were in the age range of 50-59 years.
- One the case of Adenoma was seen in age group 30-39 years.
- One case of FNH was seen in a female patient of child bearing age, 42 years.
- Hemangiomas and cysts were seen in all age groups.
- Abscesses were seen in patients < 30years.

In our study, there was a male preponderance (56%) as compared to females who accounted for (44%) of the cases.

Regarding gender distribution among individual abnormality in our study

- There was male preponderance in HCC (60%), metastases (60%) and Intrahepatic CCA (100%) and abscess (100%) when compared to females.
- There was female preponderance in hemangioma (62.5%), adenoma (100%) and FNH (100%).
- Simple cysts were seen equally distributed among both sexes.

Even though liver has dual blood supply (nearly 80% from portal vein and 20% from hepatic artery), most of the primary and secondary neoplastic liver lesions receive most of the blood supply from hepatic artery. During HAP hyper vascular lesions are easily identifiable against the background of minimally enhancing liver parenchyma. During PVP most of the hepatic lesions are perceived as hypovascular lesions highlighted by strongly enhancing normal liver parenchyma. Depending upon the vascularity, a lesion will be more conspicuous during HAP or PVP.

With regard to detection of lesions, in the present study

- The total 195 focal liver lesions seen in 50 patients there were 113 hypovascular and 82 hyper vascular lesions.
- Most hypovascular lesions were best detected during PVP and most hyper vascular lesions in HAP.
- In our study a greater number of hypovascular lesions were identified with greater lesion conspicuity on the PVP than on other phases especially when the size of the lesion was less than 3cm in size. When the lesions were >3cm no statistically significant difference was seen between PVP and HAP.
- In our study the number of hyper vascular lesions seen was higher on HAP than on PVP and unenhanced phase when the lesion size was less than 3cm in size. Significant difference in conspicuity was identified between the HAP and other

phases when the lesion size was less than 3cm but no significant difference when the lesion size was greater than 3cm in size.

- In our study unenhanced scan had lower sensitivity for identification of small lesions because of difficulty in differentiating it from unenhanced vessels and biliary dilatation. Most of the differences were seen when the lesion size was less than 3cm, because larger lesions were seen on all phases.
- No patient in our study had a lesion that was detected on unenhanced phase images that was not identified on HAP or PVP images.
- In detection of lesions, our findings were similar to the study done by **Miller et al**[99] on suspected or known case of malignant focal lesions. In our study we grouped the lesion size as <1cm, 1-3cm, and >3cm, **Miller et al** in their study grouped the lesion size as <1cm, 1-2cm, 2-3cm and >3cm. They found that in patients with hypo vascular malignancies, a significant difference was seen in the number of lesions detected between PVP and other phases when the lesion was <2cm. They also detected that the conspicuity of the hypo vascular lesions was higher on the PVP than on other phases when the lesions were <3cm.
- In patients with hyper vascular malignancies, a larger number of lesions in their study, were seen on the HAP than in other phases when the lesions were <2cm. the conspicuity of lesions were higher on HAP and a significant statistical difference was seen between the PVP and HAP, between PVP and unenhanced phases, and between HAP and unenhanced phases when the lesions size were <3cm.

**Isaac R. Francis (2003)**[101] in a prospective study on 52 patients with suspected or known hepatic tumor demonstrated that maximal tumor-to-parenchyma differences are achieved on PVP images.

**Philippe Soyer (2004)**[87] in a prospective study for detection of hypo vascular hepatic metastases at Triphasic liver CT concluded that the PVP images depicted significantly more hypo vascular metastases than in any other phases.

**Miller et al (1998)**[99] **–** Prospective study included 102 patients with known or suspected malignant focal lesions, underwent Multiphasic CT examination of liver. 584 lesions were detected in 102 patients. It was observed that no lesions were detected on unenhanced phase that were not seen on other phases, hyper vascular lesions were best detected on HAP, and hypo vascular lesions were more detected on PVP. However not all the hyper vascular lesions detected on HAP were malignant suggesting that benign lesions may also be hyper vascular (FNH, Hepatic adenoma, Peliosis Hepatis)

**Table 20: Comparison of hypo vascular/hyper vascular lesions with Marten S. van Leeuwen, et al study**

| Lesions | Current study (n=195 lesions) | vanLeeuwen, MD, et al (n=326 lesions) |
|---|---|---|
| Hypo vascular | 113(57.95%) | 196(61%) |
| Hyper vascular | 82(42.05%) | 130(39%) |

**Note data are presented as no. of lesions and in the bracket as %**

## Table 21: Comparison of hypovascular benign/malignant lesions with Marten S. van Leeuwen, et al study

| Hypovascular lesions | Current study (n=113) | van Leeuwen, MD, et al (n=196) |
|---|---|---|
| Cysts | 21(18.59%) | 51(26%) |
| Abscess | 08(7.1%) | 00 |
| Hemangioma | 00 | 08(4%) |
| Metastases | 84(74.33%) | 118(60%) |
| Others (benign) | 00 | 19(10%) |

**Note: data are presented as no. of lesions and in the bracket as %**

## Table 22: Comparison of hyper vascular benign/malignant lesions with Marten S. van Leeuwen, MD, et al study

| Hypervascular lesions | Current study (n=82) | van Leeuwen, MD, et al (n=130) |
|---|---|---|
| Hemangioma | 26(31.70%) | 51(39.23%) |
| FNH | 01(1.21%) | 07(5.38%) |
| Adenoma | 01(1.21%) | 04(3.10%) |
| HCC | 22(26.82%) | 18(13.84%) |
| Intrahepatic CCA | 01(1.21%) | 00 |
| Metastases | 31(37.80%) | 48(36.92%) |
| Others (benign) | 00 | 02(1.53%) |

**Note: data are presented as no. of lesions and in the bracket as %**

**Table 23: Comparison of enhancement pattern and its final diagnosis with Marten S. vanLeeuwen, MD, et al study**

| Enhancement patterns | Current study | | | vanLeeuwen, MD, et | | |
|---|---|---|---|---|---|---|
| | No. | % | Final diagnosis | No. | % | Final |
| hypo/hypo(cyst)/hypo | 21 | 100 | Cysts | 51 | 100 | Cysts |
| hyper(rim)/hypo (cyst)/hypo | 8 | 100 | Abscesses | 00 | 00 | |
| hypo/hypo/hypo | 51 | 100 | Metastases | 84<br>05 | 94<br>6 | Metastases<br>Hemangiomas |
| hyper(rim)/hypo/hypo | 27 | 100 | Metastases | 29 | 100 | Metastases |
| hypo/hypo/hyper | 06<br>53 | 100 | Metastases | 62<br>38 | | Metastases<br>Hemangiomas |
| A(puddles)/A/A | 26 | 100 | Hemangiomas | 51 | 100 | Hemangiomas |
| A/A/A(cleft) | 01 | 100 | FNH | 5 | 71 | FNH |
| A(variegated)/A/A (capsule) | 16 | 100 | HCC | 00 | 00 | |
| hyper(incomplete)/A/A | 1 | 100 | Intrahepatic CCA | 00 | 00 | |
| mixed/mixed/mixed | 21 | 100 | Metastases | 28 | 100 | |
| hyper/A/A | 06<br>10<br>01 | 35<br>58.8<br>5.1 | HCC<br>Metastases<br>Adenoma | 18<br>20<br>02<br>04 | 40<br>44<br>4<br>8 | HCC<br>Metastases<br>FNH<br>Adenoma |

In characterization of hypovascular lesions the first distinction was made between cysts and hypovascular solid lesions.

- All the 21(100%) lesions with hypo/hypo (cyst)/hypo enhancement pattern were confirmed to be cysts because of sharp margins and homogenous hypo vascular pattern.
- When enhancing rim was observed, with hyper (rim)/hypo (cyst) /hypo enhancing pattern, all the lesions (8) were abscess.
- In non-cystic hypo vascular lesions, when the lesions demonstrated hypo/hypo/hypo enhancing pattern, 51(100%) lesions were metastases.
- When an enhancing rim in arterial phase was observed with hyper (rim)/hypo/hypo pattern, all the lesions (27 of 27) were metastases. hypo/hypo/hyper enhancing pattern, was seen in 6(100%) lesions, were metastases.

In characterization of hypervascular lesions:

- All the 26 (100%) lesions with A (puddles)/A/A enhancement pattern were hemangiomas.
- A/A/A (cleft) enhancement pattern, was seen in 1 case of FNH and hyper (incomplete)/A/A enhancement pattern, were seen in 1 case of Intrahepatic CCA.
- 16 of 22 HCC presented as A (variegated)/A/A (delayed), enhancing pattern.
- With mixed/mixed/mixed enhancement pattern, all the lesions (21 of 21) were metastases.
- Most (58.8%) of the malignant hyper/A/A lesions were metastases and rest of the lesions (35%) were HCC. The benign lesions were Adenoma (5.1%).
- Interpretation of hyper/A/A enhancing pattern, should be done in clinical context,

biopsy is essential for differentiating these lesions.

In characterization of lesions the present study was similar and correlated well with the study done by **Marten S. van Leeuwen, MD, PhD et al** on 94 patients. They found 11 patterns of enhancement and demonstrated that six of the 11 enhancement patterns were always due to benign disease, three of the 11 patterns were always due to malignant disease and the other two patterns was due to metastases and hemangiomas.

In the present study we had 11 patterns of enhancement. Four of the 11 enhancement patterns were always due to benign lesions, another five of 11 enhancement patterns were always due to malignant lesions, and other two of the 11 enhancement patterns were due to both malignant and benign lesions. We found two different enhancement patterns one for the abscess and another for intrahepatic CCA which were not included in the study conducted by **Marten S. vanLeeuwen, et al**.

The present study also correlated well with the study conducted by **Gualdi GF, Casciani E, D'agostino A, Polettini E (1998)[100]** In their study to evaluate the role of Triphasic CT in characterization of noncystic focal lesions on sixty- six they found, 11 patterns of enhancement of the lesions in different phases. Four of 11 enhancement patterns (hypo/hyper/hyper, hyper/iso/iso, hyper/hyper/iso, and hyper/hyper/hyper) were always referable to benign disease. (hemangioma, FNH-adenoma). Four of 11 enhancement patterns (iso/hypo/hypo,iso/iso/hypo,hyper/hypo/hypo, and hyper/hyper/hypo) were always referable to malignant disease (hepatocellular carcinoma-HCC-metastases). The other three patterns (hypo/hypo/hypo, hypo/hypo/hyper, and hyper/A/A) were seen in both benign and malignant

diseases. They concluded that conspicuity of hypo vascular lesions was more in the PVP, and hyper vascular lesions in the HAP, and Triphasic CT improved the characterization of HCC, FNH, adenoma and hemangioma. Patients with unclassified lesions at US or conventional CT, suspected HCC and metastases from pancreas neuroendocrine tumors should be submitted to Triphasic CT of the liver.

The present study was also comparable to the study conducted by **Matilde Nino-Murcia,(2000).** Retrospective analysis of the arterial contrast images of 100 consecutive patients with focal liver lesions were reviewed. Enhancement patterns of a dominant lesion (in multiple lesions) or a representive lesion in each patient classified into one of the five categories of enhancement: homogenous, abnormal internal vessels or variegated, peripheral puddles, complete ring or incomplete ring. Lesions without enhancement were recorded separately. Histologic examination, correlative imaging, or clinical or imaging follow up were used as the standards of reference. It was observed that 92% of the 100 lesions demonstrated arterial phase enhancement. The patterns associated with PPV of 82% or more and specificity of 80% or more included abnormal internal vessels or variegated (HCC), peripheral puddles (Hemangiomas), and complete ring (Metastases). It was concluded that focal hepatic lesions in arterial phase of enhancement has potential use in determination of specific diagnosis.

# CONCLUSION AND SUMMARY

- In 50 patients there were 28 male and 22 female patients.
- 195 focal liver lesions were detected. 138 lesions were malignant and 57 lesions were benign. The most common malignant lesion was Metastases (n=115) followed by Hepatocellular carcinoma (n=22) and Intrahepatic CCA (n=1). The most common benign lesion was Hemangiomas (n=26), followed by Cysts (n=21), Abscesses (n=8), F N H (n=1) and adenoma (n=1).
- Total focal liver lesions were broadly classified into, hypovascular or hyper vascular lesions, based on the enhancing pattern of the individual lesions.
- There were 113 hypo vascular lesions accounting for 57.95% and 82 hyper vascular lesions accounting for 42.05% of the total 195 lesions.
- The portal venous phase (PVP) images acquired at the peak of liver enhancement is essential for detection of hypo vascular lesions.
- Hepatic arterial phase (HAP) images are helpful in detecting hyper vascular lesions and are essential for characterization of large proportions of lesions. Equilibrium phase images aid in further lesion characterization.
- Characterization of focal liver lesions based on the 11 enhancement patterns observed and correlation with standard of reference was satisfactory. The Triphasic CT enhancement patterns were 100% sensitive and specific in diagnosing all cases of Abscess, Cysts, hemangioma and Intrahepatic CCA, however Triphasic CT enhancement patterns in HCC (sensitivity-81.81%), FNH (sensitivity-100%), Metastases (sensitivity-93.91%) was sensitive in diagnosing most of the cases and

showed 100% specificity in diagnosing in all the cases when there was typical enhancement pattern for the individual lesion concerned.

- Four enhancement patterns observed were always due to benign lesion. Five more enhancement pattern observed was always due to malignant lesion.
- The hypo/hypo/hypo, hypo/hypo/hyper and hyper/A/A enhancement patterns need to be interpreted with caution.
- Triphasic CT of liver is a standardized CT procedure plays a very important role as a diagnostic imaging modality in detection, characterization and follow up of vast majority of focal liver lesions, in the presence of different pathological conditions and multilevel disease. Despite increased competition from MRI over last decade, role of diagnosis of diseases of liver has not been significantly affected. Triphasic CT scores over availability, affordability, ease and speed of operation. The advantages offered by computed tomography are far beyond its limitations and hence we recommend Triphasic computed tomography as the initial imaging modality for imaging focal liver lesions.
- Few of the limitations in our study are; lesion by lesion pathological evaluation, ultrasound evaluation or follow up was not performed; in defining CT pattern of enhancement an objective criteria is taken into consideration; in some patients with multiple lesions, biopsy was performed on only one or two lesions, rest with similar CT appearance were assumed to be the same lesion; technical factors like amount of contrast injected, concentration of the contrast and physiological status of the patients.

# BIBILIOGRAPHY


1. T.W. sadler; langman's medical embryology 10th edition. Twin bridges: Montana,Lippincott Williams & Wilkins; 2007
2. Henry Gray, Anatomy of human body; The liver, 5th edition.1821-1865
3. Bismuth H, Houssin D, Castaing D Major and minor segmentectomies —reglees‖ in liver surgery. World J Surg 1982; 6:10–24.
4. Bismuth H (1982) Anatomical surgery and surgical anatomy of the liver. World J Surg 6:3–9.
5. Fasel JH, Selle D, Evertsz CJ Segmental anatomy of the liver: poor correlation with CT. Radiology 1998;206:151–56.
6. Lee JKT, Stanley RJ, Sagel SS, Heiken JP. Computed Body Tomography with MRI Correlation. Chapter 12, 4th edition: volume 2 : Lippincott-Raven ; 2006
7. Oto A, Tamm EP, Szklaruk J. Multidetector Row CT of the Liver. Radiol Clin N Am 2005 ; 43: 827-848.
8. Kono Y, Mattrey RF. Ultrasound of Liver. Radiol Clin N Am. USA: Elsevier; 2005 ;43: 815-816.
9. Grainger RG, Allison DJ, Adam A, Dixon AK. Diagnostic Radiology 4th edition : Churchill Livingstone ; 2004.
10. Mc Cahan JP, Dodd GD. Radiofrequency ablation of the liver. AJR;2001;176: 3-16.
11. Chhabra DG, Shah RC, Parikh V, Jagannath P. Radiofrequency ablation of liver tumours: experience with open and Percutaneous approach. Indian Journal of Gastroenterology 2006 ; 25 : 66-70.
12. Khandani AH, Wahl RL. Applications of PET in liver imaging .Radiol Clin N Am. USA: Elsevier; 2005 ;43: 849-860.

13. Zornosa J , Wallace S, Ordonez N , Lukeman J .Fine Needle Biopsy of the Liver :AJR 1980; 134 : 331-334.
14. Jang HJ, Kim TK, Lim HK, Hepatic hemangioma: atypical appearances on CT, MR imaging, and sonography.AJR Am J Roentgenol 2003; 180:135–41.
15. Valerie Vilgrain, Leila Boulos, Marie Pierre Vullimerme, Imaging of atypical hemangiomas of the liver with pathological correlation.Radiographics 2000; 20:379-397.
16. Tonsok Kim, MD, Michael P. Federle, MD, Richard L. Baron, MD, Mark S. Peterson, MD, Yasuhiro Kawamori, MD. Discrimination of Small Hepatic Hemangiomas from Hyper vascular Malignant Tumors Smaller than 3 cm with Three-Phase Helical CT. Radiology 2001; 219:699–706.
17. Karhunen PJ Benign hepatic tumor and tumor-like conditions in man. J Clin Pathol 1986; 39:183–88.
18. Mathieu D, Kobeiter H, Maison P, et al. Oral con- traceptive use and focal nodular hyperplasia of the liver. Gastroenterology 2000; 118:560 –564.
19. Nguyen BN, Flejou JF, Terris B, et al. Focal nodular hyperplasia of the liver: a comprehensive pathologic study of 305 lesions and recognition of new histologic forms. Am J Surg Pathol 1999; 23: 1441–1454.
20. Shahid M Hussain, Turkan Terjivatan, Pieter E. Zondervan, Focal Nodular Hyperplasia: Findings at state-of-the-art MR imaging,US,CT and pathologic analysis. Radiographics 2004; 24:3-19.
21. K.J. Mortelt,M.Praete, H.Van Vierberghe, CT and MR imaging findings in focal nodualar hyperplasia: Radiologic pathologic correlation,AJR 2000;175:687-692.

22. Heiken JP, Liver. In: Lee JKT, Sagal SS, Stanley RJ, et al. Computed body tomography with MRI correlation;1998
23. Ruppert-kohlmayr JA, Uggowitzer MM. Kugler C, Schaffler G, Ruppert SG. Focal Nodular Hyperplasia and Hepatocellular Adenoma of the Liver: Differentiation with Multiphasic Helical CT.AJR 2001; 176:1493-98.
24. Giuseppe Brancatelli, MD, Michael P. Federle, MD, Luigi Grazioli, MD, Arye Blachar, MD, Mark S. Peterson, MD, Leland Thaete, MD. Focal Nodular Hyperplasia: CT Findings with Emphasis on Multiphasic Helical CT in 78 Patients. Radiology 2001; 219:61–68.
25. Soe K.L, Soe M, Gluud S, Liver pathology associated with the use of anabolic-androgenic steroids. Liver 1992; 12:73–79.
26. Lerut JP, Ciccarelli O, Sempoux C, Glycogenosis storage type I diseases and evolutive adenomatosis: an indication for liver transplantation. Transpl Int 2003; 16:879–84.
27. Reznik Y, Dao T, Coutant R, Hepatocyte nuclear factor-1alpha gene inactivation: cosegregation between liver adenomatosis and diabetes phenotypes in two maturity- onset diabetes of the young (MODY) 3 families. J Clin Endocrinol Metab 2004; 89:1476–1480.
28. Ishak K, Anthony P, Sobin L Histological typing of tumors of the liver. In: WHO International Histological Classification of Tumors, 2nd edition. Springer-Verlag, Berlin;1992.
29. Grazioli L, Federle MP, Ichikawa T, et al (2000) Liver adenomatosis: clinical, pathologic, and imaging findings in 15 patients. Radiology 216:395–402.

30. R.Lencioni, D.Cioni, C. Bartolozzi, Focal liver lesions, Detection, Characterization and Ablation, Medical radiology, Diagnostic Imaging, Springer Verlag Berlin Heildberg; 2005.
31. Tomoaki Ichikawa, MD, Micheal P. Federele, Luigi Grazioli, MD, Micheal Nalesnik, MD Hepatocellular adenoma: Multiphasic CT and Histopathologic findings in 25 patients. Radiology 2000; 214:861-68.
32. Jian-shou Zhou Yi Huan and Meng-qi Wei Quantitative analysis of hepatocellular adenomas with triphasic contrast enhanced multislice spiral computed tomography (MSCT). African Journal of Biotechnology 2010; Vol. 9(23): 3448-3457.
33. Federele MB, Brancatelli G. Imaging of benign hepatic masses. semin liver Dis 2001; 21: 237- 49.
34. Reshamwala PA, Kleiner DE, Heller T.Nodular regenerative hyperplasia: not all nodules are created equal. Hepatology 2006; 44: 7.
35. Mergo PJ, Ros PR Benign lesions of the liver. Radiol Clin North Am,1998;36:319– 331.
36. Van Sonnenberg E, Wroblicka JT, D'Agostino HB, Symptomatic hepatic cysts: percutaneous drainage and sclerosis. Radiology 1994; 190:387–92.
37. Mortelé K, Ros PR (2001) Cystic focal liver lesions in the adult: differential CT and MR Imaging features. Radiographics 2001; 21:895–910.
38. Korobkin MT, Stephens DH, Lee JKT et al (1989) Biliary cyst-adenoma and cystadenocarcinoma: CT and sonographic findings. AJR Am J Roentgenol 153:507–511.
39. Itai Y, Matsui O Blood flow and liver imaging. Radiology 1997; 202:306–14.

40. Yoshimitsu K, Honda H, Kuroiwa T, et al Pseudo lesion of the liver possibly caused by focal rib compression: analysis based on hemodynamic change. AJR Am J Roentgenol 1999; 172:645–49.
41. Han BK, Im JG, Jung JW, et al Pericaval fat collection that mimics thrombosis of the inferior vena cava: demonstration with use of multi-directional reformation CT.Radiology 1997; 203:105–08.
42. Chen WP, Chen JH, Hwang JI, et al Spectrum of transient hepatic attenuation differences in biphasic helical CT.AJR Am J Roentgenol 1999;172:419–24.
43. Mathieu D, Vasile N, Menu Y, et al Budd-Chiari syndrome. Dynamic CT. Radiology 1987;165:409–413.
44. Yu JS, Rofsky NM Magnetic resonance imaging of arterioportal shunts in the liver. Top Magn Reson Imaging 2002; 13:165–76.
45. Lane MJ, Jeffrey B, Katz DS Spontaneous intrahepatic vascular shunts. AJR Am J Roentgenol 2000; 174:125–31.
46. Maldjian P, Obolevich A, Cho K Focal enhancement of the liver on CT. A sign of SVC obstruction. J Comput Assist Tomogr 1995; 19:316–18.
47. Alpers DH, Sabesin SM, White HM Fatty liver: biochemical and clinical aspects. In: Schiff L,Schiff E (eds) Diseases of the liver, 7th edn. Philadelphia : JB Lippincott; 1993.
48. Sherman M. Screening for hepatocellular carcinoma. Hepatol Res 2007; 37 Suppl 2: S152-65.

49. Bralet MP, Regimbeau JM, Pineau P, et al Hepatocellular carcinoma occurring in non fibrotic liver: epidemiologic and histopathologic analysis of 80 French cases. Hepatology 2000; 32:200– 204.
50. Simonetti RG, Cammà C, Fiorello F, Politi F, D'Amico G, Pagliaro L. Hepatocellular carcinoma. A worldwide problem and the major risk factors. Dig Dis Sci 1991; 36:962-72.
51. Gibson JB, Sobin LH Histological typing of tumors of the liver, biliary tract and pancreas. Geneva: WHO; 1978.
52. Kojiro M Pathology of hepatocellular carcinoma. In Okuda K, Tabor E, (eds) Liver Cancer. New York: Churchill Livingston; 1997(pp 165–187).
53. Arakawa M, Kage M, Sugihara S, et al Emergence of malignant lesions within an adenomatous hyperplastic nodule in a cirrhotic liver. Gastroenterology 1986; 91:198–08.
54. Brancatelli G, Federle MP, Grazioli L, et al Hepatocellular carcinoma in non cirrhotic liver: CT, clinical, and pathologic findings in 39 U.S. residents. Radiology 2002; 222:89–94.
55. Bugianesi E, Leone N, Vanni E, et al Expanding the natural history of nonalcoholic steatohepatitis: from cryptogenic cirrhosis to hepatocellular carcinoma. Gastroenterology 2002; 123:134–40.
56. Stevens WR, Johnson CD, Stephens DH, et al. CT findings in hepatocellular carcinoma: correlation of tumor characteristics with causative factors, tumor size, and histologic tumor grade. Radiology. 1994; 191:531-37.
57. Stevens WR, Gulino SP, Batts KP, et al. Mosaic pattern of hepatocellular carcinoma: histologic basis for a characteristic CT appearance. J Comput Assist Tomogr. 1996; 20:337-42.

58. Villa E, Colantoni A, Camma C, et al Estrogen receptor classifi cation for hepatocellular carcinoma: comparison with clinical staging systems. J Clin Oncol 2003; 21:441–446.
59. Llovet JM, Bru C, Bruix J Prognosis of hepatocellular carcinoma: the BCLC staging classifi cation. Semin Liver Dis 1999; 19:329–38.
60. Awai K, Takada K, Onoshi H, et al , Aortic and hepatic enhancement and tumor-to-liver contrast: analysis of the effect of different concentrations of contrast material at multidetector row helical CT. Radiology 2002; 224:757–763.
61. Kawata S, Murakami T, Kim T, et al Multidetector CT: Diagnosis impact of slice thickness on detection of hyper vascular hepatocellular carcinoma. AJR Am J Roentgenol 2002; 179:61–66.
62. Choi BI (2004) The current status of imaging diagnosis of hepatocellular carcinoma. Liver Transpl 10:S20–S25.
63. Ichikawa T, Kitamura T, Nakajima H, et al Hyper vascular hepatocellular carcinoma: can double arterial phase imaging with multidetector CT improve tumor depiction in the cirrhotic liver? AJR Am J Roentgenol 2002; 179:751–58.
64. Lee KHY, O'Malley ME, Haider MA, et al (2004) Triple-phase MDCT of hepatocellular carcinoma. AJR Am J Roentgenol 182:643–649
65. Freeny PC, Grossholz M, Kaakaji K, et al (2003) Significance of hyperattenuating and contrast-enhancing hepatic nod- ules detected in the cirrhotic liver during arterial phase helical CT in pre-liver transplant patients: radiologic-his-topathologic correlation of explanted livers. Abdom Imag- ing 28:333–346

66. Karahan OI, Yikilmaz A, Isin S, et al Characterization of hepatocellular carcinoma with triphasic CT and correlation with histopathologic findings.Acta Radiol 2003; 44:566–71.
67. Yoshikawa J, Matsui O, Kadoya M, et al Delayed enhancement of fibrotic areas in hepatic masses: CT-pathologic correlation. J Comput Assist Tomogr 1992; 16:206– 11.
68. Choi BI, Lee HJ, Han JK, et al Detection of hyper vascular nodular hepatocellular carcinomas: value of Triphasic helical CT compared with iodized-oil CT. AJR Am J Roentgenol 1997; 168:219–24.
69. Ueda K, Kitigawa K, Kadoya M, et al Detection of hyper vascular hepatocellular carcinoma by using spiral volumetric CT: comparison of US and MR imaging. Abdom Imaging 1995; 20:547– 54.
70. Karahan OI, Yikilnaz A, Lsin S, Orhan S. Characterization of Hepatocellular Carcinoma with Triphasic CT and Correlation with Histopathologic Findings. Acta Radiological 2003; 44(6):566- 571.
71. K.H.Y. Lee,M.E. O' Malley, M.A. Haider, A. Hanbidge Triple-phase MDCT of HCC AJR 2004;182:643-649.
72. C.T. Chou et al,Prediction of microvascular invasion of hepatocellular carcinoma by preoperative CT imaging.British journal of radiology 2011; 126:1-6.
73. El-Serag HB, Davila JA Is fibrolamellar carcinoma different from hepatocellular carcinoma? A US population based study. Hepatology 2004; 39:798-03.
74. Mitchell T. Smith et al, Fibrolamellar hepatocellular carcinoma, Radiographics 2008; 28:609 – 613.

75. Okuda K, Nakanuma Y, Miyazaki M Cholangiocarcinoma: recent progress. Part 1: epidemiology and etiology.J Gastroenterol Hepatol 2002; 17:1049–55.
76. Abdel-Rahim AY et al,Parasitic infections and hepatic neoplasia. Dig Dis 2001;19:288-291.
77. Qin XL, Wang ZR, Shi JS, et al (2004) Utility of serum CA 19-9 in diagnosis of cholangiocarcinoma: in comparison with CEA. World J Gastroenterol 10:427-432.
78. Kim TK, Choi BI, Han JK, et al Peripheral cholangiocarcinoma of the liver: two-phase helical CT findings. Radiology 1997; 204:539–43.
79. Lacomis JM, Baron RL, Oliver JH, et al Cholangiocarcinoma: delayed CT contrast enhancement patterns. Radiology 1997; 203:98–104.
80. Devaney K, Goodman ZD, Ishak KG Hepatobiliary cystadenoma and cystadenocarcinoma. A light microscopic and immunohistochemical study of 70 patients. Am J Surg Pathol 1994; 18:1078–91.
81. Gourley WK, Kumar D, Bouton MS, et al (1992) Cystadenoma and cystadenocarcinoma with mesenchymal stroma of the liver. Immunohistochemical analysis. Arch Pathol Lab Med 116:1047-1050.
82. Agildere AM, Haliloglu M, Akhan O Biliary cyst adenoma and cystadenocarcinoma. AJR Am J Roentgenol 1991; 156:1113.
83. El-Serag HB, Mason AC. Rising incidence of hepatocellular carcinoma in the United States. N Engl J Med 1999; 340: 745-50.
84. Edmunson H, Craig J Neoplasms of the liver. In: Schiff L (ed) Diseases of the liver, 8th edn. Philadelphia: Lippincott; 1987(p 1109).

85. Wee A. Fine needle aspiration biopsy of the liver: Algorithmic approach and current issues in the diagnosis of hepatocellular carcinoma. *Cytojournal* 2005; 2: 7.

86. Semelka RC, Worawattanakul S, Kelekis NL Liver lesion detection, characterization and effect on patient management: comparison of single-phase spiral CT and current MR techniques. J Magn Reson Imaging 1997; 7:1040-1047.

87. Philippe Soyer, MD, PhD, Marc Poccard, MD, Mourad Boudiaf, MD, Martine Abitbol,MD, Lounis Hamzi, MD, Yves Panis, MD, phD et al Detection of Hypovascualar Hepatic Metastases at Triple- phase helical CT: Sensitivity of phases and Comparison with Surgical and Histopathologic Findings. Radiology 2004; 231:413-420.

88. Ishak KG, Sesterhenn IA, Goodman ZD, et al Epithelioid hemangioendothelioma of the liver: a clinicopathologic and follow-up study of 32 cases. Hum Pathol 1984; 15:839–52.

89. Dean PJ, Haggitt RC, O'Hara CJ. Malignant Epithelioid hemangioendothelioma of the liver in young women. Relationship to oral contraceptive use. Am J Surg Pathol 1985; 9: 695-704.

90. Miller WJ, Dodd GD 3rd, Federle MP, et al Epithelioid hemangioendothelioma of the liver: imaging findings with pathologic correlation. AJR Am J Roentgenol 1992; 159:53–57.

91. Buetow PC, Buck JL, Pantongrag-Brown L, et al Undifferentiated (embryonal) sarcoma of the liver: pathologic basis of imaging findings in 28 cases. Radiology 1997; 203:779–83.

92. Almogy G, Lieberman S, Gips M, et al Clinical outcomes of surgical resections for primary liver sarcoma in adults:results from a single centre. Eur J Surg Oncol 2004; 30:421–27.
93. Itai Y, Teraoka T () Angiosarcoma of the liver mimicking cavernous hemangioma on dynamic CT. J Comput Assist Tomogr 1989; 13:910–12.
94. Mergo PJ, Ros PR MR imaging of inflammatory disease of the liver. Magn Reson Imaging Clin N Am 1997; 5:367–376.
95. Mortele K, Ros PR Cystic focal liver lesions in the adult: differential CT and MR Imaging features. Radiographics 2001; 21:895–910.
96. Radin RD, Ralls PW, Colletti PM, et al CT of amebic liver abscesses. AJR Am J Roentgenol 1988; 150:1297–1301.
97. De Diego Choliz J, Lecumberri FJ, Francquet T, et al Computed tomography in hepatic echinococcosis. AJR Am J Roentgenol 1982; 13:699–702.
98. Van Leeuwen MS, Noordzij J, Felberg MAM, Hennipman AH, Doornewaard H Focal liver lesions: Characterization with triphasic spiral CT. Radiology 1996; 201:327-36.
99. Frank H. Miller, Reni S. Butler, Frederick L. Hoff, Steven W Fitzgerald, Albert A. Nemcek, Jk, Richard M. Gore, et al using Triphasic helical CT to detect focal liver lesions in patients with neoplasms.AJR 1998; 171:643-49.
100. Gualdi GF, Casciani E, D'Agostino A, Polettini E Triphasic spiral computerized tomography of the liver: vascular models of non-cystic focal lesions. RadiolMed.1998 Oct; 96(4):344-52.

101. Isaac R. Francis, Richard H. Cohan, Nancy J.McNulty, Joel F. Platt, Melvyn Korobkin, Achamyeleh Gebremariam, et al, Multidetector CT of Liver and Hepatic Neoplasms: Effect of Multiphasic Imaging on Tumor Conspicuity and Vascular Enhancement. AJR 2003; 180:1217-24.

102. Ihab R. Kamel, MD, PHD, Micheal A. Choti, MD, Karen M. Horton, MD, H.J.V.Braga, MD, Bernard A. Birnbaum, MD, Elliot K. Fishman, MD, et al surgically staged focal liver lesions: accuracy and reproducibility of dual-phase helical ct for detection and characterization. Radiology 2003; 227: 752-57.

# ANNEXURE-I

# ETHICAL CLERANCE CERTIFICATE


B.L.D.E. UNIVERSITY'S
SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103
INSTITUTIONAL ETHICAL COMMITTEE

## INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 18-10-2012 at 3-30pm to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.

Title "Role of Contrast enhanced computed tomography in evaluation of Sonographically detected focal lesions in liver"

Name of P.G. student Dr. Vinod.
Radiodiagnosis

Name of Guide/Co-investigator Dr B.R. Dhamangaonkar.
Prof of Radiodiagnosis

DR.TEJASWINI. VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

# CONSENT BY PARTICIPANT

The whole study and its procedure has been well explained in the language I can understand best.

I hereby consent voluntarily to participate as a study subject in "**Role of contrast enhanced Computed Tomography in evaluation of Sonographically detected focal lesions in liver".**

**(Signature/Thumb Print of Patient)**

Full name of the patient.....

Signature of Candidate.....

Date: .....

Place: .....

# SAMPLE INFORMED CONSENT FORM

B.L.D.E.U's SHRI B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, BIJAPUR – 586103, KARNATAKA

**TITLE OF THE PROJECT:** ROLE OF CONTRAST ENHANCED COMPUTED TOMOGRAPHY IN EVALUATION OF SONOGRAPHICALLY DETECTED FOCAL LESIONS IN LIVER

**PRINCIPAL INVESTEGATOR:** DR.VINOD
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**PG GUIDE:** DR.B R DHAMANGAONKAR M.D.
Professor of Radiodiagnosis
Department Of Radiodiagnosis
B.L.D.E. University's
Shri B.M. Patil Medical
College & Research Centre,
Sholapur Road,
Bijapur - 586103

**PURPOSE OF RESEARCH:**

Assess the role of triphasic computed tomography in detection and characterization of focal liver lesions and help in deciding further course of management.

**PROCEDURE:**

I have been explained that I will be subjected to a contrast enhanced computed tomography scan.

**RISKS AND DISCOMFORTS:**

I understand that my/my wards participation in this study, there will be risk of radiation exposure and contrast adverse reaction.

**BENEFITS:**

I understand that my/my wards participation in this study will help in finding out the role of contrast enhanced computed tomography in evaluation of sonographically detected focal lesions in liver.

**CONFIDENTIALITY:**

I understand that medical information produced by this study will become a part of this Hospital records and will be subjected to the confidentiality and privacy regulation of this hospital. Information of a sensitive, personal nature will not be a part of the medical records, but will be stored in the investigator's research file and identified only by a code number. The code key connecting name to numbers will be kept in a separate secure location.

If the data are used for publication in the medical literature or for teaching purpose, no names will be used and other identifiers such as photographs and audio or video tapes will be used only with my special written permission. I understand that I may see the photograph and videotapes and hear audiotapes before giving this permission.

**REQUEST FOR MORE INFORMATION:**

I understand that I may ask more questions about the study at any time. Dr. Vinod is available to answer my questions or concerns. I understand that I will be

informed of any significant new findings discovered during the course of this study, which might influence my continued participation.

If during this study, or later, I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me. And that a copy of this consent form will be given to me for careful reading.

**REFUSAL OR WITHDRAWL OF PARTICIPATION:**

I understand that my participation is voluntary and I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice to my present or future care at this hospital.

I also understand that Dr. Vinod will terminate my participation in this study at any time after he has explained the reasons for doing so and has helped arrange for my continued care by my own physician or therapist, if this is appropriate.

**INJURY STATEMENT:**

I understand that in the unlikely event of injury to me/my ward, resulting directly to my participation in this study, if such injury were reported promptly, then medical treatment would be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study, I am not waiving any of my legal rights.

I have explained to _____ the purpose of this research, the procedures required and the possible risks and benefits, to the best of my ability in patient's own language.

Date: Dr. B R Dhamangaonkar Dr.Vinod

(Guide) (Investigator)

**PROFORMA**

NAME:

AGE: SEX: OCCUPATION:

ADDRESS:

HOSPITAL NO:

PRESENTING COMPLAINTS:

PAST HISTORY:

Jaundice/blood transfusion/surgery/others.

FAMILY HISTORY:

Similar complaints/any deaths due to similar complaints.

PERSONAL HISTORY:

Habits:

GENERAL EXAMINATION:

LOCAL EXAMINATION:

PER ABDOMEN:

CLINICAL DIAGNOSIS:

INVESTIGATIONS:

RADIOLOGICAL INVESTIGATIONS:

Ultrasound abdomen and pelvis:

TRIPHASIC CT:

Liver size:

Liver contour:

Liver attenuation:

Focal /diffuse liver lesion:

Focal lesion:

1. Number:

2. Size:

3. Site:

4. Density (HU)

5. Enahncement pattern: Arterial phase:

Portal venous phase:

Equilibrium phase:

6. Calcification:

Any other associated findings:

Other investigations:

MRI:

Biopsy:

Histopathological diagnosis:

Radiological diagnosis:

FINAL DIAGNOSIS:

# KEY TO MASTER CHART

| | | |
|---|---|---|
| HM | - | Hepatomegaly |
| NECT | – | Non-enhanced computed tomography |
| HAP | - | Hepatic arterial phase |
| PVP | - | Portal venous phase |
| DVP | - | Delayed phase |
| FNAC | – | Fine needle aspiration cytology. |

# MASTER CHART

| Serial no | Names | CT no | Age | Sex | HM | NECT | HAP | PVP | DP | No of lesions | Necrosis | Calcification | Lobes involved | Diagnosis | Other finding | FNAC/Biopsy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Parvathi | 10 | 65 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Metastases | Right adrenal metastases | - |
| 2 | Laxmibai | 24 | 69 | F | Present | Iso -hyper | Hyper | A | A | Solitary | Present | Present | Right | HCC | Portal vein thrombosis, Cirrhosis of liver | HCC |
| 3 | Sangappa | 176 | 56 | M | Absent | Iso | Hypo | Hypo | Hypo | Multiple | Absent | Present | Both | Metastases | Ca stomach | |
| 4 | Safeena | 199 | 40 | F | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Both | Hemangioma | Bulky uterus | - |
| 5 | Mahadevi | 267 | 45 | F | Absent | Hypo | Hypo | Hypo | Hyper | Multiple | Absent | Absent | Both | Metastases | Ca Breast with nodal metastases | |
| 6 | Jamilnasi | 298 | 32 | M | Present | Hypo | Hyper(rim) | Hypo | Hypo | Solitary | Absent | Absent | Right | Abscess | Right sided effusion | - |
| 7 | Sangappa | 324 | 60 | M | Present | Iso | A | A | A | Multiple | Present | Present | Both | HCC | Portal venous thrombosis ,Splenomegaly | HCC |
| 8 | Lakappa S S | 520 | 42 | M | Present | Hypo | Hypo | Hypo | Hyper | Solitary | Present | Absent | Right | Metastases | Ca rectum | - |
| 9 | Suleman | 755 | 52 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Simple cysts | Chronic Pancreatitis with dilated MPD | - |
| 10 | Gangappa | 757 | 60 | M | Present | Iso | Hyper | A | A | Solitary | Present | Present | Right | HCC | Splenomegaly with dilated portal vein, ascites | HCC |
| 11 | Hanamawwa a | 917 | 56 | F | Present | Hypo | Hyper | A | A | Solitary | Present | Present | Both | HCC | IHBRD , ascites , splenomegaly | HCC |
| 12 | Girimalla | 1453 | 65 | M | Absent | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Metastases | Lung, bone metastases , CA Pyriform fossa | - |
| 13 | Meherunissa | 1515 | 41 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | absent | Both | Simple cysts | Calcified granuloma in right lower lobe | |
| 14 | Shivappa | 1636 | 48 | M | Present | Iso-hypo | A | A | A | Solitary | Present | Absent | Right | HCC | Cirrhosis of liver with ascites | HCC |
| 15 | Shinabailamani | 1639 | 45 | F | Present | Iso | A | A | A | Solitary | Present | Absent | Right | HCC | Multiple lung nodules | HCC |
| 16 | Vittal | 1702 | 50 | M | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Both | HCC | Portal splenic vein thrombosis , mild ascites | HCC |
| 17 | Imambee | 2048 | 55 | F | Absent | Iso-hypo | Hyper(rim) | Hypo | Hypo | Multiple | Absent | Absent | Right | Metastases | Ca cervix with pelvic nodes | - |
| 18 | Channamma | 2345 | 53 | F | Present | Hypo | Hyper | Hyper | Hyper | Multiple | Absent | Present | Right | HCC | Right portal vein obstruction, small right lobe | HCC |
| 19 | Peerappa | 2787 | 45 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Present | Absent | Both | Metastases | Lung ,bone metastases | - |
| 20 | Huda inamdar | 2867 | 32 | F | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Both | Hemangioma | Left renal staghorn calculus | - |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Rafeeq | 2906 | 53 | M | Absent | Iso | Hypo | Hypo | Hyper | Multiple | Absent | Absent | Right | Metastases | Ca pancrease | - |
| 22 | Bagamma | 2928 | 45 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Metastases | Mass in sigmoid colon. | - |
| 23 | Bhimabai | 3010 | 58 | F | Present | Hypo-iso | Mixed | Mixed | Mixed | Multiple | Absent | Absent | Both | Metastases | Ca cervix with pelvic nodes metastases | |
| 24 | Pandappa | 3494 | 58 | M | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Left | Hemangioma | Right mild hydroneprosis with ureteric calculus. | - |
| 25 | Basappa | 3552 | 50 | M | Absent | Hypo | Hyper | Hypo | Hypo | Multiple | Absent | Absent | Right | Metastases | Ca oesophagus with mediastenal nodes | - |
| 26 | Ilahi | 3555 | 36 | M | Absent | Hypo | Hypo | Hypo | Hypo | Solitary | Absent | Absent | Right | Simple cyst | Umbilical hernia | - |
| 27 | Shekawwa | 3616 | 55 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Right | Metastases | Ca recto-sigmoid junction with nodal metastases | |
| 28 | Shantabai | 3723 | 72 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Present | Right | Metastases | Right adnexal neoplastic mass with omental metastasis | - |
| 29 | Danamma | 3867 | 60 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Metastases | Ca ovary,Vertebral metastases, | - |
| 30 | Basangouda | 3909 | 37 | M | Present | Hypo | Hyper(rim) | Hypo | Hypo | Multiple | Absent | Absent | Right | Abscess | Mild splenomegaly, renal abscess | - |
| 31 | Bhimasingh R | 4189 | 46 | M | Present | Hypo | Hyper(rim) | Hypo | Hypo | Multiple | Absent | Absent | Both | Abscess | Pneumobilia, cystitis | - |
| 32 | Gurusiddappa | 4236 | 38 | M | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Right | Hemangioma | Bilateral renal calculi | - |
| 33 | Meenakshi | 4317 | 30 | F | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Present | Both | simple cysts | Serous cystadenoma and, hydrosalpinx | - |
| 34 | B k sushila | 4853 | 58 | F | Present | Iso | Hypo | Hypo | Hyper | Multiple | Absent | Present | Both | Metastases | Ca ovary ,Mild ascites | - |
| 35 | Muragawwa | 4875 | 56 | F | Absent | Hypo | A | A | A | Multiple | Absent | Absent | Both | Hemangioma | Small Epigastric Hernia , Urinary Bladder Diverticulae | - |
| 36 | Shivalingappa | 4955 | 72 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Present | Right | Metastases | Ca lung with pleural deposits | |
| 37 | Revansidda | 5117 | 68 | M | Absent | Hypo | Hypo | Hypo | Hyper | Multiple | Absent | Absent | Both | Metastases | Ca colon | - |
| 38 | Channagond | 5257 | 31 | M | Present | Iso-hyper | Mixed | Mixed | Mixed | Multiple | Absent | Absent | Right | Metastases | Carcinoma pancreas | - |
| 39 | Balesh bijjaragi | 5532 | 50 | M | Present | Hypo | A | A | A | Multiple | Absent | Absent | Right , caudate | Hemangioma | prostatomegaly | - |
| 40 | Vittal | 5596 | 55 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Right | Metastases | Ca stomach | - |
| 41 | Mahadev | 5661 | 8 | M | Present | Hypo | Hypo | Hypo | Hypo | Solitary | Absent | Absent | Left | Simple cysts | Inflammed appendix | - |
| 42 | Pushpavati | 5864 | 36 | F | Absent | Iso | Hyper | A | A | Solitary | Absent | Absent | Right | HCC | Uterine fibroid | Adenoma |
| 43 | Ningappa | 6070 | 42 | M | Present | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Both | Metastases | Carcinoma colon | - |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 | Sangappaangadi | 6348 | 52 | M | ABSENT | HYPO | hyper(Incomplete) | Hyper | A | A | Absent | Absent | Both | ICCA | IHBRD , mild ascites | ICCA |
| 45 | Shantagouda P | 6675 | 71 | M | Present | Hypo | Hyper | A | A | Multiple | Absent | Absent | Both | HCC | Portal venous thrombosis | HCC |
| 46 | Rukamawwa | 7008 | 68 | F | Present | Hypo | A | A | A | Multiple | Absent | Absent | Both | Hemangioma | cholecystitis and cholelithiasis | |
| 47 | Indira patil | 7123 | 56 | F | Absent | Hypo | Hypo | Hypo | Hypo | Multiple | Absent | Absent | Left | Simple Cysts | Ca cervix with pelvic nodes | - |
| 48 | Shankerjadhav | 7124 | 55 | M | Present | Hypo | A(variegated) | A | A(capsule) | Solitary | Absent | Present | Right | HCC | Cirrhosis with ascites | HCC |
| 49 | Lalithabai | 7290 | 42 | F | Present | Iso | A | A | A | Solitary | Absent | Absent | Right | FNH | Right renal simple cysts | FNH |
| 50 | Shoba | 7486 | 25 | F | Present | Hypo | A | A | A | Multiple | Absent | Present | Both | Hemangioma | Right moderate hydroneprosis -PUJ obstruction | |