A DISSERTATION ON

"THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION"

Submitted to

THE TAMIL NADU Dr.M.G.R.MEDICAL UNIVERISTY
CHENNAI

In Partial Fulfillment of the Regulations
For the Award of the degree

M.D. DEGREE BRANCH VIII
RADIODIAGNOSIS

MADRAS MEDICAL COLLEGE,
CHENNAI.

APRIL-2017

CERTIFICATE

This is to certify that the dissertation titled **"THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION"** submitted by **Dr.AMARNATH.S ,** appearing for **M.D.RADIODIAGNOSIS** degree examination in April 2017, is a bonafide record of work done by him under my guidance and supervision in partial fulfillment of requirements of The Tamilnadu Dr. M.G.R Medical University, Chennai. I forward this to The Tamilnadu Dr. M.G.R Medical University, Chennai.

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DECLARATION

I, **Dr. AMARNATH .S,** certainly declare that this dissertation titled, "**THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION**", represent a genuine work of mine done at the Barnard Institute of Radiology, Madras Medical College and Government General Hospital, under the supervision of the **Prof.N.Kailasanathan,M.D.,D.M.R.D.,** Director, Barnard Institute of Radiology, Madras Medical College and Rajiv Gandhi Government General Hospital.

I, also affirm that this bonafide work or part of this work was not submitted by me or any others for any award, degree or diploma to any other university board, neither in India or abroad. This is submitted to The Tamil Nadu Dr.MGR Medical University, Chennai in partial fulfilment of the rules and regulation for the award of Master of Radiodiagnosis Branch VIII

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ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude to **Prof.Dr.M.K.Muralidharan MS,MCH.,**the Dean, Madras Medical College and **Prof.Dr.N.Kailasanathan, M.D.R.D** ,Director, Barnard Institute of radiology, MMC & RGGGH, for allowing me to undertake this study on "**THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION"**

I was able to carry out my study to my fullest satisfaction, thanks to guidance, encouragement, motivation and constant supervision extended to me, by my beloved Head of the Department **Prof.Dr.R.Ravi**. Hence my profuse thanks are due for him.

I would like to express my deep gratitude and respect to my guide **Professor Dr.S.Kalpana** whose advice and insight was invaluable to me. This work would not have been possible without her guidance, support and encouragement.

I am also extremely indepted to **Professor Dr.K.Malathi** for her valuable suggestions, personal attention, constructive cricticism during my study.

My sincere thanks to **Professor Dr.S.Babu peter** for his practical comments and guidance especially at the inception of the study and I also wish to thank **Prof.D.Ramesh** for his valuable support through out the study.

I am bound by ties of gratitude to my respected Associate Professors, **Dr.Manimekala** and **Dr.Kasi Visalakshi** and Assistant Professors, **Dr.Chezhian, Dr.Geetha.K, Dr.Geetha.G, Dr.Iyengaran, Dr.Mohideen Ashraf, Dr.Saranya, Dr.Balan** in general, for placing and guiding me on the right track from the very beginning of my career in Radiodiagnosis till this day.

I am fortunate to have my postgraduate colleagues Dr.Gomathi, Dr.Satheesh Kumar, Dr.Bharathi Priya for their valuable suggestions, relentless help for shouldering my responsibilities. Simply words cannot express its depth for their unseen contributions. My lovable thanks to my parents and my friends for their moral support.

I would be failing in my duty if I don't place on record my sincere thanks to those patients who inspite of their sufferings extended their fullest co-operation.

Dr.AMARNATH.S

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“ THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION “

INTRODUCTION

A discrete abnormality arising within the liver is defined as a space occupying lesion in the liver. Space occupying lesions of the liver can be divided into developmental, neoplastic, inflammatory and miscellaneous.

Currently, there is no consensus concerning the optimal strategy for imaging the liver for space occupying lesions. Various imaging modalities for liver are often used based on the availability of equipment and experience of the radiologists and the requests of referring physicians.

The main goals of liver imaging are to assess:

(1)The number and size of the liver abnormalities

(2) The location of abnormalities relative to the liver vessels

(3) The nature of the lesions i.e. benign versus malignant

(4) The origin of abnormalities i.e. primary versus secondary

(5) The liver parenchyma surrounding the lesions

Most commonly used imaging techniques for liver space occupying lesions includes ultrasound (US) with or without contrast, computed tomography (CT) with or without contrast, MRI with or without contrast and US-guided biopsy.

In addition, other techniques , such as CT arterioportography (CTAP), CT hepatic arteriography (CTHA), Positron Emission Tomography (PET), and laparoscopy with or without intraoperative US, are also used depending on the availability and experience of the clinicians and radiologists.

Although multiple such imaging modalities are available among these, CT is currently the most commonly used first line imaging modality for staging and monitoring of the diseases because of its wide availability.

Perfusion Computed Tomography (CTP) has a great potential in determining the hepatic and portal blood flow. It offers the advantages of quantitative determination of the lesion hemodynamics thus distinguishing the malignant and the benign process, as well as providing the morphological data.

RATIONALE OF THE STUDY

In the current field of Gastrointestinal Radiology , accurate imaging of the liver is clinically important for the appropriate management of the liver disease especially of the cancer patients since the liver is the second most common site for the metastatic disease after the lymph node metastasis and the most common site for metastasis from colorectal cancers.

Primary liver neoplasms are also common with hepatocellular carcinoma being the most common primary malignant tumour and the third most common cause of cancer related mortality worldwide. For these patients, accurate imaging techniques for the early detection ,staging ,and for monitoring of the disease are of utmost importance

Apart from the malignant tumours from the liver, benign conditions like hemangioma, focal nodular hyperplasia, hepatic adenomas and other rare conditions like hepatic lipoma ,mesenchymal hamartoma and angiomyolipoma are also to be studied in detail so that any chance of the malignancy should not be missed which will cause a serious morbidity or mortality in such patients.

Few other cystic lesions of the liver like simple cyst, hydatid cyst, pyogenic or amoebic liver abscess, bilioma and few neoplastic cystic lesions like biliary cystadenoma or cyst adenocarcinoma, lymphangioma and cystic metastasis are to be differentiated so that their treatment protocols are formulated accordingly

Emerging functional and molecular imaging techniques using MRI, CT, US, Positron Emission Tomography (PET) and optical based technologies are being developed and have shown promising results for monitoring the liver lesions more accurately than the traditional morphologic imaging.

By CT Perfusion ,the measurement of blood flow characteristics through dynamic CT acquisitions following intravenous administration of contrast agents can be easily be integrated into routine CT imaging protocols within the same imaging session.

Several studies also have shown that CT perfusion parameters correlate well with the presence and the extent of tumour vessels (in malignant cases) which could be leveraged for earlier detection of liver malignancies and more individualised monitoring of patients during treatment.

In addition ,CT Perfusion can also be integrated with PET examinations ,allowing assessment of both the hemodynamic and metabolic status of the liver lesions

Herein ,the basic principles ,current acquisition protocols and interpretation of the lesion using perfusion parameters are reviewed. Potential clinical applications of CT Perfusion imaging for earlier detection and treatment monitoring of hepatic lesions and current challenges and potential solutions for this technique are discussed.

GROSS ANATOMY OF THE LIVER:

The largest organ of the human body is the liver, weighing nearly 1.5 kg and is situated in the right upper quadrant which is closely associated with the small intestine , that process the nutrient enriched venous blood which leaves the digestive tract.

Liver is made of soft, pinkish-brown tissues and is encapsulated by a connective tissue capsule and this capsule is covered and reinforced by the peritoneum, which protects the liver and holds it in place within the abdomen.

The peritoneum connects the liver in four locations: the coronary ligament, the left and right triangular ligaments, and the falciform ligament.

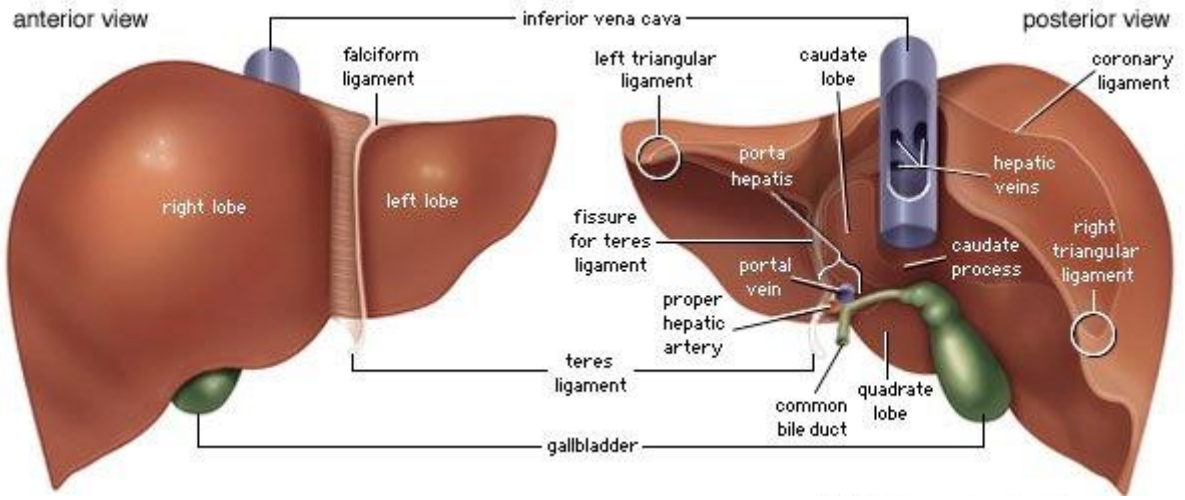

Fig 1 Anatomy of liver anterior & posterior view

The liver consists of four distinct lobes – the left, right, caudate, and quadrate lobes. The left and right lobes are the largest lobes and are separated by the falciform ligament.

The right lobe is about 5 to 6 times larger than the tapered left lobe. The small caudate lobe extends from the posterior side of the right lobe and wraps around the inferior vena cava. The small quadrate is inferior to the caudate lobe and extends from the posterior side of the right lobe and wraps around the gallbladder.

BileDucts

The tubes that carry bile through the liver and gallbladder are known as bile ducts and form a branched structure known as the biliary tree. Bile produced by liver cells drains into microscopic canals known as bile canaliculi. The countless bile canaliculi join together into many larger bile ducts found throughout the liver.

These bile ducts next join to form the larger left and right hepatic ducts, which carry bile from the left and right lobes of the liver. Those two hepatic ducts join to form the common hepatic duct that drains all bile away from the liver.

The common hepatic duct finally joins with the cystic duct from the gallbladder to form the common bile duct, carrying bile to the duodenum of the small intestine. Most of the bile produced by the liver is pushed back up the cystic duct by peristalsis to arrive in the gallbladder for storage, until it is needed for digestion.

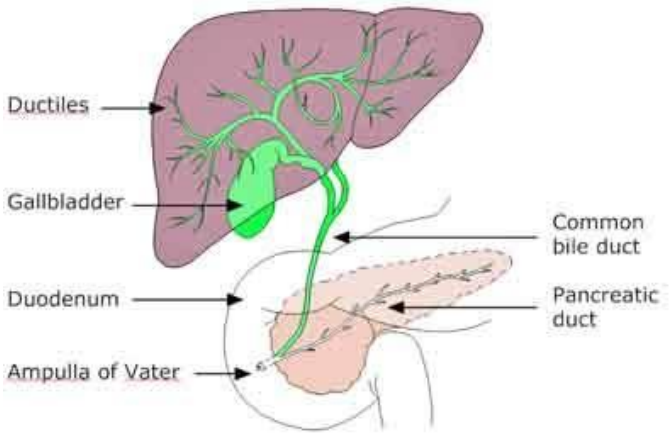

Fig 2 : Normal biliary drinage of liver

BloodVessels:

The blood supply of the liver is unique among all organs of the body due to the dual supply (hepatic portal vein and arterial system).The portal vein supplies 75% of the liver and remaining 25% is supplied by hepatic artery. Blood traveling to the spleen, stomach, pancreas, gallbladder, and intestines passes through capillaries in these organs and is collected into the hepatic portal vein.

The hepatic portal vein then delivers this blood to the tissues of the liver where the contents of the blood are divided up into smaller vessels and processed before being passed on to the rest of the body.

Blood leaving the tissues of the liver collects into the hepatic veins that lead to the vena cava and return to the heart. The liver also has its own system of arteries and arterioles that provide oxygenated blood to its tissues just like any other organ.

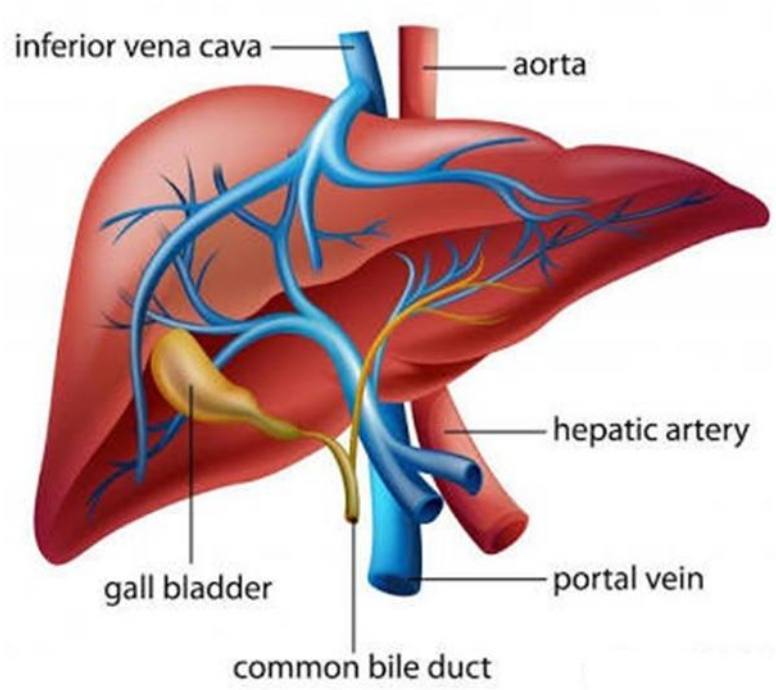

Fig 3: Normal blood supply of liver

Lobules

The internal structure of the liver is made of around 100,000 small hexagonal functional units known as lobules. Each lobule consists of a central vein surrounded by 6 hepatic portal veins and 6 hepatic arteries.

These blood vessels are connected by many capillary-like tubes called sinusoids , which extend from the portal veins and arteries to meet the central vein like spokes on a wheel. Each sinusoid passes through liver tissue containing 2 main cell types: Kupffer cells and hepatocytes.

Kupffer cells are a type of macrophage that capture and break down old, worn out red blood cells passing through the sinusoids. Hepatocytes are cuboidal epithelial cells that line the sinusoids and make up the majority of cells in the liver. Hepatocytes perform most of the liver's functions – metabolism, storage, digestion, and bile production.

Tiny bile collection vessels known as bile canaliculi run parallel to the sinusoids on the other side of the hepatocytes and drain into the bile ducts of the liver.

FUNCTIONS OF THE LIVER:

The liver performs over 500 metabolic functions, resulting in synthesis of products that are released into the blood stream or that are excreted to the intestinal tract (bile).Also, several products are stored in liver parenchyma. Some of the major functions of the liver are

1)Helps in digestion by production of bile.

2)Metabolism of carbohydrates, proteins & lipids

3)Detoxification of drugs, alcohol and hormones

4)Storage of nutrients ,vitamins, minerals ,glycogen & triglycerides

5)Production of prothrombin, fibrinogen, and albumins

6)Helps in immunity through Kupffer cells (Liver macrophages)

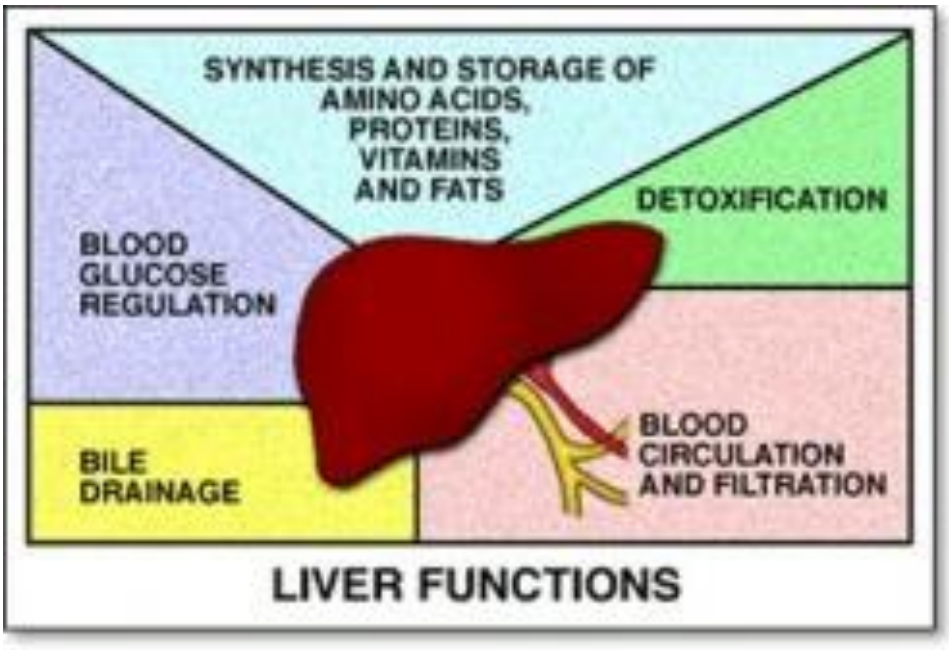

Fig 4: Normal functions of the liver

CLASSIFICATION OF LIVER LESIONS:

- **Primary Benign tumors**
- **Primary Malignant tumors**
- **Infections**
- **Trauma**
- **Liver Secondaries**
- **Other lesions**

PRIMARY BENIGN LIVER TUMORS:

A. EPITHELIAL TUMORS

(a) hepatocellular

1. Hepatic adenoma
2. Focal nodular hyperplasia
3. Nodules in cirrhosis: regenerative nodule & dysplastic nodule
4. Nodular regenerative hyperplasia

(b) cholangiocellular

1. Bile duct hamartoma

2. Peribiliary cyst

3. Biliary cystadenoma

4. Caroli disease

5. Biliary papillomatosis

B. MESENCHYMAL TUMORS

(a) tumor of adipose tissue

I. Hepatic lipoma

2. Hepatic myelolipoma

3. Hepatic angiomyolipoma

(b) tumor of muscle tissue

I. Leiomyoma

(c) tumor of blood vessels

1. Infantile hemangioendothelioma

2. Hemangioma

3. Peliosis hepatis

(d) tumor of neural crest

1. Hepatic paraganglioma

(e) mesothelial tumor

1. Benign mesothelioma

C. MIXED TISSUE TUMOR

1. Mesenchymal hamartoma
2. Hepatoblastoma
3. Benign teratoma

D. MISCELLANEOUS

1. Adrenal rest tumor
2. Pancreatic rest

E. PSEUDO-LESION

1. Focal fatty infiltration
2. Focal fat sparing

PRIMARY MALIGNANT TUMORS:

A. EPITHELIAL TUMOR

(a) hepatocellular

I. Hepatoblastoma (7%)

2. Hepatocellular carcinoma (75%)

(b) cholangiocellular (6%)

I. Cholangiocarcinoma

2. Biliary cystadenocarcinoma

B. MESENCHYMAL TUMOR

(a) tumor of blood vessels

I. Angiosarcoma

2. Epithelioid hemangioendothelioma

3. Kaposi sarcoma

(b) other tumor

1. Embryonal sarcoma

2. Fibrosarcoma

C. TUMOR OF MUSCLE TISSUE

1. Leiomyosarcoma

2. Embryonal rhabdomyosarcoma of the biliary tree

D. MISCELLANEOUS

1. Carcinosarcoma

2. Teratoma

3. Yolk sac tumor

4. Carcinoid

5. Squamous carcinoma

6. Primary lymphoma

INFECTION:

1.Pyogenic /Amoebic Liver Abscess

2.Echinococcal Cyst

3.Inflammatory Pseudotumour

TRAUMA:

1.Hematoma

2.Traumatic cyst

LIVER SECONDARIES

OTHER LESIONS:

1.Simple Hepatic Cyst

2.Sarcoidosis

3.Langerhans Cell Histiocytosis

HEPATIC ADENOMA (HEPATOCELLULAR ADENOMA/LIVER CELL ADENOMA**)**

The most frequent hepatic tumor in young women after long term use of oral contraceptives[1]. Peak age is around 40 years in young women in childbearing age (90%). Not seen in males unless on anabolic steroids & rare in children. Associated with oral contraceptives ,anabolic steroids & pregnancy. Clinically present as RUQ pain as sign of mass effect or intratumoral or intraperitoneal hemorrhage and hepatomegaly .Mean size is around 3-5cm in diameter and is commonly located in right lobe of liver and in subcapsular location. It can be multiple in up to 21% of cases .Can present as a round well-circumscribed mass with pseudocapsule which can be intraparenchymal or pedunculated with occasional eccentric dystrophic calcifications .Treatment includes hormone therapy. Screening for malignant degeneration is done with a-fetoprotein and treatment is surgical resection

FOCAL NODULAR HYPERPLASIA (FNH)

It is the second most common benign tumor of liver after hemangioma[1]. Peak age is around 3rd-4th decade and commonly associated with: hepatic hemangioma ,meningioma, astrocytoma, arterial dysplasia of other organs**.** Initial clinical symptom is often asymptomatic and may present as vague abdominal pain due to liver capsule stretching or distention. Few patients may present with mild hepatomegaly . It is commonly Located in right lobe more than left lobe and multiple in 5-20% of cases. Size is usually less than 5 cm with mean diameter of 4

cm **.**Presents as a well-circumscribed non-encapsulated nodular cirrhotic like mass in an otherwise normal liver. Treatment includes discontinuation of oral contraceptives, resection of pedunculated mass and diagnostic excisional biopsy for extensive tumor.[1]

MESENCHYMAL HAMARTOMA OF LIVER

It's a rare developmental cystic liver tumor and histologically has disordered arrangement of primitive fluid-filled mesenchyme, bile ducts, hepatic parenchyma; stromal and cystic contents .Peak age group is 15-24 months and show progressive abdominal enlargement with or without respiratory distress and lower extremity edema. Commonly located in right lobe more than left lobe and in 20% of cases it present as pedunculated mass and grossly discernible cysts in 80% of cases .Size of the lesion usually ranges 0.5-2.9 cm (mean 1.6cm) [1]

BILIARY CYSTADENOMA (BILE DUCT CYSTADENOMA)

It is a rare benign multilocular cystic tumor originating in bile ducts as premalignant form of biliary cystadenocarcinoma. Peak Age group is above 30 years. Commonly located in intrahepatic more than extrahepatic bile ducts and right lobe involved in 48% cases left lobe in 20-35% and both lobes in 15-30% [1]. Patients presents with chronic abdominal pain, dyspepsia, anorexia, nausea vomiting, jaundice and abdominal swelling with palpable mass. Size of the lesion is

around 1.5-35 cm. It can present as well-defined cystic mass containing clear or cloudy, serous or mucinous or gelatinous, purulent or hemorrhagic or bilious fluid containing hemosiderin with thick fibrous capsule and papillary excrescences with mural nodules. Septations may be seen between the cysts. Treatment is usually surgical resection and recurrence is common.

CAROLI DISEASE (COMMUNICATING CAVERNOUS ECTASIA OF INTRAHEPATIC BILE DUCTS)

It's a rare congenital autosomal recessive disorder characterized by multifocal segmental saccular cystic dilatation of the large intrahepatic bile ducts, which retain their communication with the biliary tree. Peak Age group is childhood and 2nd-3rd decade. Clinically may present as recurrent cramp like upper abdominal pain, fever (cholangitis),transient jaundice (biliary stasis secondary to sludge or stones) and cirrhosis with portal hypertension (very rare).It can be diffuse or segmental with two subtypes: (1) pure form: presents as attacks of cholangitis with intra-ductal stone formation and (2) complex form (more common) which is associated with other ductal plate malformation. Imaging wise seen as multiple cystic structures converging towards the porta hepatis as either localized or diffusely scattered cysts communicating with bile ducts and sometimes sludge/pus/calculi can be seen in dilated ducts [(1)]

HEPATIC HEMANGIOMA (Cavernous Hemangioma of Liver)

It is the most common solid benign liver tumor (78%) and the second most common liver tumor after metastases [(1)] and is rarely seen in young children. It is frequently associated with hemangiomas in other organs, focal nodular hyperplasia, Rendu-Osler-Weber disease, Klippel-Trenaunay-Weber syndrome and von Hippel-Lindau disease. Clinically patient may be asymptomatic if tumor is small and it may enlarge during pregnancy. These lesions are frequently peripheral / subcapsular in posterior right lobe of liver and may be pedunculated and multiple in 10-20% of cases. Size of the lesion is usually less than 4 cm. Very small and very big lesions have the most atypical imaging features. Most lesions appear as well-circumscribed lobulated mass with blood supply from hepatic artery with arterial enhancement characteristics. Lesions may have central area of fibrosis nothing but areas of non-enhancement. Some lesions may show central septal calcifications within areas of fibrosis or phleboliths. Giant Hepatic Cavernous hemangioma are hemangioma with size more than 5 cm with atleast one dimension exceeding 8-10 cm

HEPATIC ABSCESS (LIVER ABSCESS) :

It is a localized collection of pus in the liver resulting from any infectious process with destruction of the hepatic parenchyma and stroma It is of three types : 1) pyogenic 2) fungal and 3) amoebic **.** A pyogenic abscess tends to be centrally located, and an amoebic abscess peripherally.

Amoebic abscess is caused by Entamoeba histolytica and mode of spread is spread of amoebae from colon to liver via portal system with common age group between 3rd-5th decade. Clinically patients present as hepatomegaly, elevation of right hemidiaphragm, pleural effusion, right lower lobe atelectasis/infiltration and gas within abscess (especially seen in Klebsiella).Location wise amoebic liver abscess is common on right lobe and systemic dissemination by invasion of lymphatics /portal system (rare). Size ranges from 2-12 cm and multiple liver abscesses seen in 25% cases. The lesions may have nonspecific variable appearance with nodularity of abscess wall , internal septations with or without disruption of diaphragm

Pyogenic Liver Abscess is the most common type of liver abscess and is caused by Escherichia coli, aerobic streptococci, Staphylococcus aureus, anaerobic bacteria with commonly involved age group between 6th-7th decade. Clinically patients may have pyrexia ,abdominal pain ,nocturnal sweating vomiting, malaise, and jaundice. Usually located in both lobes of the liver as multiple abscesses and these are more often of biliary than hematogenous origin.

HYDATID DISEASE (Echinococcus Granulosus & E. cysticus)

Liver is the most commonly affected organ [(1)] and is commonly located in right lobe than left lobe and multiple cysts seen in 20% of cases with maximum size may reach upto 50 cm (average size of 5 cm) [(2).] Clinically patient may present with abdominal pain or can be asymptomatic. Some may have recurrent jaundice with biliary colic ,blood eosinophilia and urticaria with anaphylaxis . It may be of three types (a) Unilocular cyst, (b) Cyst with daughter vesicles or daughter cysts and (c) Partially or completely calcified. Treatment includes (1) Surgery (2) Anthelmintics (albendazole, mebendazole) and (3) Percutaneous aspiration and injection of antiscolicidal agents.

HEPATOBLASTOMA:

It is the third most common abdominal tumor in children and most frequent malignant hepatic tumor in infants and also in children <3 years of age [(1)] with peak age between 18 and 24 months. Clinically patients presents with upper abdominal mass, weight loss, nausea, vomiting, jaundice, pain , precocious puberty (production of endocrine substances) and persistently with markedly elevated a-fetoprotein .

It is commonly located in the right lobe of the liver and is usually a solitary mass with an average size of 10-12 cm . It is multifocal in 20% of cases and coarse calcifications / osseous matrix may be seen in some patients and metastases commonly to the lung .

HEPATOCELLULAR CARCINOMA (HEPATOMA)

It is the most common primary malignancy of the liver & 80- 90% of all primary liver malignancies and the most frequent primary visceral malignancy in the world [(1).] .It is the second most frequent malignant hepatic tumor in children after hepatoblastoma [(1)]**.** Peak age group in industrialized world is around 6th to 7th decade however it is also seen in children above 5 years of age. It can arise as a solitary massive mass in one lobe (most often right) with satellite nodules. It can also present as multifocal small nodules of usually less 2 cm (up to 5 cm) in both hepatic lobes. Some cases present as diffuse microscopic infiltrating form with tiny indistinct nodules closely resembling cirrhosis**.** Metastases to lung is most common and can also involves adrenal, lymph nodes and bone .It can cause portal vein invasion and also hepatic vein invasion .Occasionally causes invasion of bile ducts

and IVC. Calcifications can also be seen in ordinary HCC however it is common in fibrolamellar and sclerosing HCC. Patients presents with hepatomegaly and ascites.

CHOLANGIOCARCINOMA

It is a malignant tumor arising from biliary tract. It can occur as either 1. Intrahepatic, 2.Hilar/central at bifurcation 3.Extrahepatic and 4. Gallbladder. Average age group is between 50 to 60 years. Patients present with abdominal pain, painless jaundice ,palpable mass and weight loss. It can spread locally along the duct and cause local infiltration of liver. Sometimes metastatic spread to regional lymph nodes can also be seen. Biliary and vascular obstruction are typical. It usually present as a mass of 5-20 cm in diameter with satellite nodules and punctate / chunky calcifications can also be seen. Sometimes calculi can be seen in biliary tree.

BILIARY CYSTADENOCARCINOMA (BILE DUCT CYSTADENOCARCINOMA)

It is a rare malignant multilocular cystic tumor originating from biliary cystadenoma. Histologically it may have ovarian stroma and these patients have a good prognosis and these subtype is seen in females only. Other groups without ovarian stroma usually have a bad prognosis. It presents as hemorrhagic internal fluid with nodularity with septations which suggest the possibility of malignancy. Some lesions may have coarse calcifications

HEPATIC ANGIOSARCOMA(HEMANGIOENDOTHELIAL SARCOMA / KUPFFER CELL SARCOMA / HEMANGIOSARCOMA)

Etiology is due to exposure to thorotrast (thorium dioxide),arsenic and polyvinyl chloride. Common age group is between 6th-7th decade. Patients present with abdominal pain, weakness, fatigue, weight loss, spontaneous hemoperitoneum jaundice, microangiopathic hemolytic anemia ,thrombocytopenia and DIC . There will not be elevation of a-fetoprotein. Early metastases can be seen to lung , spleen, porta hepatis nodes, portal vein, thyroid, peritoneal cavity and bone marrow. It has more Predilection for splenic metastases. Portal vein invasion can be seen with unifocal or multifocal or infiltrative lesion with hemorrhagic ascites [(1)]

LYMPHOMA OF LIVER

It can occur as either a primary lymphoma or a secondary lymphoma. Primary lymphoma is very rare and usually present as a solid solitary mass**.** Secondary lymphoma which is the common type of which Hodgkin disease is more common than non-Hodgkin lymphoma. It can occur as an (1) infiltrative or diffuse type without any alteration in hepatic architecture or as (2) focal nodular type which can be detectable by cross-sectional imaging or as (3) combination of diffuse and nodular types.

METASTASES TO LIVER

It is the most common malignant lesion of the liver and the liver is the most common metastatic site after regional lymph nodes [(1)] . Incidence of metastatic carcinoma is 18-20 times greater than primary carcinoma .Metastases represent 22% of all liver tumors in patients with a known malignancy [(1)]. Some of the common causes of metastasis with their primary organ of origin are colon > stomach > pancreas > breast > lung. Involvement of liver along with spleen are typically seen in patients with leukemia, lymphoma and melanoma in adults. Neuroblastoma and Wilms tumor in pediatric age group can present in similar manner. Patients usually present with hepatomegaly and abnormal liver enzymes. Lesions are located in both lobes of the liver with right lobe being common than the left lobe . Lesions are usually multiple however solitary lesions can also be seen in

few cases and size of the lesion can be variable and size smaller than 2 cm can be seen in 1/3rd of the patients.

HEPATIC CYST

It is the second most common benign hepatic lesion after hemangioma [(1)]. It can be of (1) acquired hepatic cyst usually secondary to trauma, inflammation, parasitic infestation & neoplasia and (2) congenital hepatic cyst due to the defective development of aberrant or an obstructed intrahepatic bile ducts. Usual age group is between 5th to 8th decade. Patients may have hepatomegaly ,abdominal pain or jaundice (rare). Size of cyst ranges from microscopic (< 1 cm) to maximal size of 20 cm (average size is between 1.2 – 4 cm) .Number of cysts may vary from solitary to multiple cysts which can be seen throughout liver. With more than 10 cysts, polycystic liver disease should be considered. It presents as well-circumscribed round or ovoid unilocular lesion with imperceptible wall with or without a rim calcification.

CONVENTIONAL IMAGING IN LIVER LESIONS

ULTRASOUND (US)

US is widely available, and is the initial imaging modality for the assessment of the liver to narrow down the differential diagnosis in a relatively quick and cost-effective manner. The initial US, may be followed by CT or MRI imaging or an US-guided biopsy

US is useful in evaluating for the presence of bile duct obstruction and also is useful in distinguishing between cystic and solid lesions. US with Doppler is also useful in identifying the presence or absence of thrombus in portal vein and hepatic veins in cases of HCC.

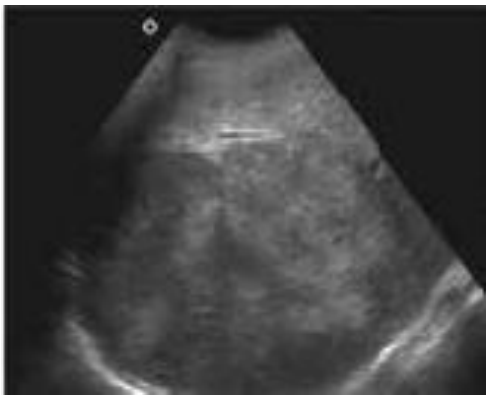

Fig 5: USG reveals a large heterogeneously hyperechoic lesion in right lobe –HCC

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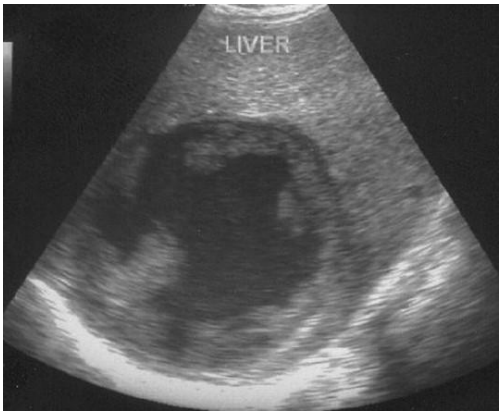


Fig 6 : USG shows a large heterogeneous cystic lesion with thick walls in right lobe – abscess

COMPUTED TOMOGRAPHY (CT)

The development of multi detector row CT MDCT technology has helped CT to continue to excel in its already established indication i.e., hepatic lesion detection

For multiphasic hepatic imaging, non-ionic contrast material is administered at a rate of 4 mL/sec for 20 seconds. The scans are acquired prior to contrast administration (Non-Contrast scans), one each during the early arterial phase (15 seconds after injection of contrast medium), Late arterial phase (25 seconds after the initiation of injection), and hepatic venous phase (60 seconds after the start of injection). In some cases delayed scanning is also done after 3 to 5 minutes of contrast administration.

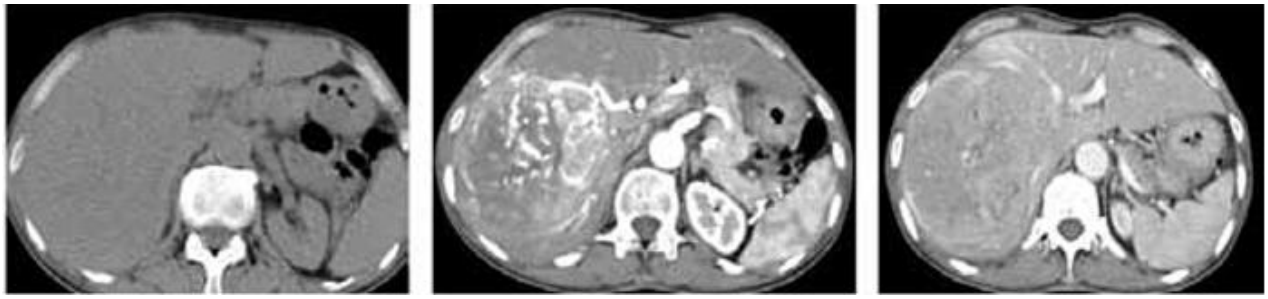


Fig 7 :Triphasic study reveals a large iso to hypodense lesion in right hepatic lobe showing intense enhancement in arterial phase , with relative washout in portal venous phase- HCC

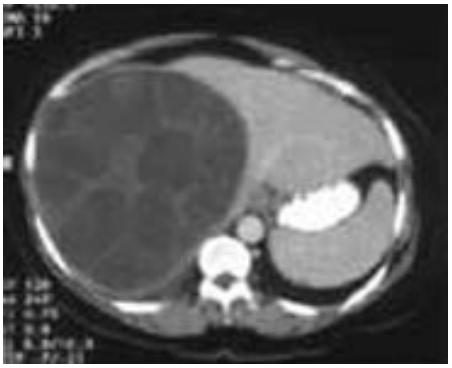


Fig 8:CECT showing characteristic appearance of cysts enclosed within a cyst giving rise to honeycomb/spokewheel pattern -hydatid cyst

MAGNETIC RESONANCE IMAGING (MRI)

MRI has a wider range of contrast mechanisms than other imaging techniques. Although primarily used for lesion detection and characterization, the biliary system anatomy and hepatic vascular patency can also be assessed during the same examination

A wide range of protocols is available due to the numerous combinations of field strength, pulse sequence implementation and interdependent sequence parameters, all of which can influence image quality

The major classes of contrast agents currently used for MRI of the liver include extracellular agents (eg, low molecular- weight gadolinium chelates), reticuloendothelial agents (eg, ferumoxides), hepatobiliary agents (eg, mangafodipir), blood pool agents (ultrasmal superparamagnetic iron oxide), and combined agents (Gadobenate dimeglumine)

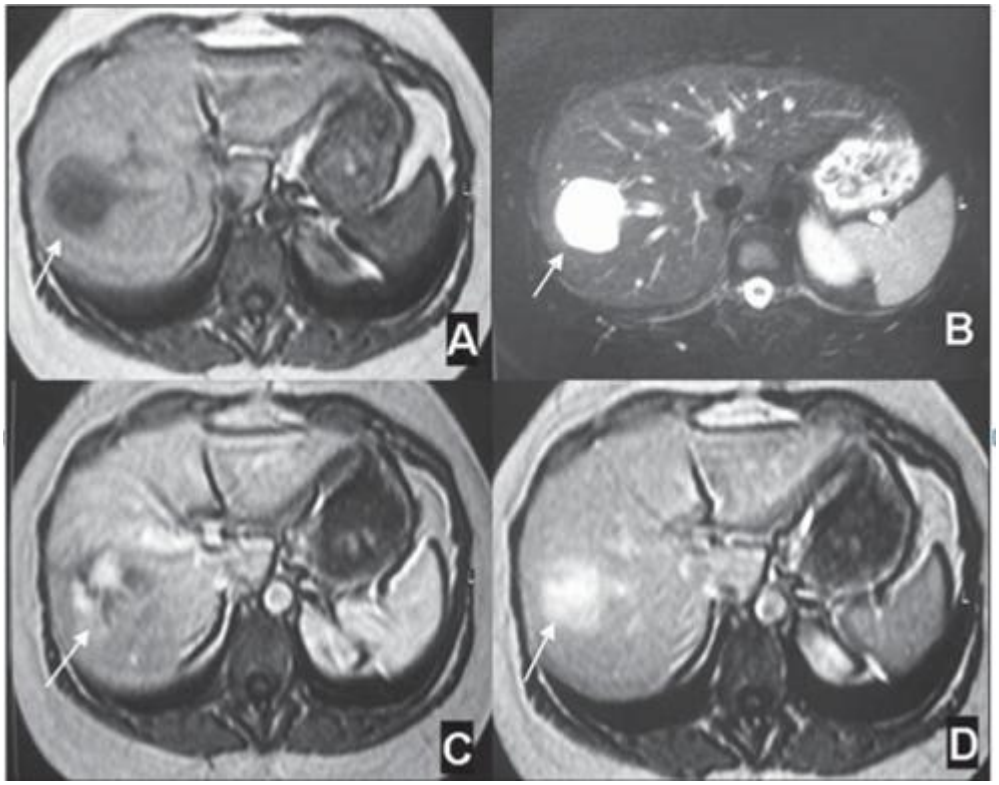


Fig 9:Hepatic hemangioma (arrow): hypo intense on T1weighted (A) ; hyper intense on T2 weighted image (B) ; early globular enhancement (C) ; and late homogeneous enhancement (D) after intravenous contrast injection

PERFUSION IMAGING

Perfusion is the transport of blood to a unit volume of tissue per unit of time and usually refers to the blood transport at the capillary level. Perfusion imaging provides the ability to detect regional and global alterations in organ blood flow.

Perfusion imaging helps in non-invasive assessment of tumor grade depending upon its vascularity. It helps in biopsy planning and in evaluation of response to treatment. It also helps to differentiate between post treatment changes and residual tumor.

Primary goal of perfusion imaging is resolution of arterial and portal venous components of hepatic blood flow on a global and regional basis.

As normal liver receives majority of blood supply from portal vein, in primary and metastatic hepatic malignancies and cirrhosis, there is relative increase in hepatic arterial blood flow which can be demonstrated by perfusion imaging. This new field of liver imaging may have profound implications for the diagnosis and surveillance of liver diseases in the future.

In large vessels, blood flow is measured as a velocity, but in the capillary bed perfusion is calculated as the volume of blood delivered to a volume of tissue at a given time (mL/min/100 mL)

CT PERFUSION

Dynamic contrast-enhanced imaging techniques using CT have been used to obtain measures of tumour vascular physiology and hemodynamics

After the rapid administration of a contrast agent and the acquisition of serial images at short intervals (seconds), an analysis that uses a pharmacokinetic model of the time dependence of contrast can produce imaging biomarkers such as tumor blood volume, blood flow, vascular permeability, and size of extravascular extracellular space. Many of these parameters have been correlated with tumor grade, aggressiveness, and prognosis

BASICS PRINCIPLES OF CT PERFUSION

CT perfusion analysis is based on several fundamental requirements. One is sequential CT scanning of the same volume over time, performed before, during, and after intravenous administration of contrast agents to trace the temporal changes in CT attenuation in the tissue volume of interest.

The tissue enhancement measured after contrast material injection can be divided into two phases based on the distribution of contrast agent in the intravascular or the extravascular-extracellular (interstitial) compartment

In the first phase, the enhancement is mainly due to the contrast material within the intravascular space. Later, in the second phase, tissue enhancement results as contrast material passes from the intravascular to the extravascular (extracellular) space across the capillary basement membrane .Therefore, in the first phase, the enhancement is determined to a great extent by the blood flow, while in the second phase, the enhancement depends on the blood volume and the permeability of capillaries to the contrast agent

The contrast agent present in the volume of interest reflects the summed amount of contrast agent within the blood vessels and the contrast agent that has moved to the interstitial space by passive diffusion

Another requirement for perfusion CT analysis is the selection of a vessel (usually an artery) supplying the tissue of interest to obtain a time-intensity curve (the arterial input function) by placing a region of interest (ROI) into the lumen of the vessel. Unlike in other organs, for which ROI is usually placed only onto the artery, ROIs for hepatic CT perfusion should be placed on both artery and portal

vein because the liver has a dual blood supply from the hepatic artery and the portal vein.

ACQUISITION PROTOCOLS

The dynamic image acquisition includes first an intravascular phase study, second a delayed phase study, or both because the tissue enhancement seen following contrast agent administration can be divided into two phases based on its distribution in the intravascular or the extravascular compartment

The first phase study is composed of images acquired during the initial phase of contrast agent administration within 40 to 60 seconds. In this phase, the tissue enhancement is mainly due to the contrast agent within the intravascular space and is determined to a great extent by the blood flow.

Later in the second phase, as contrast material passes from the intravascular to the extravascular component across the basement membrane of capillary, enhancement results from contrast agent distribution in both intravascular and extravascular components. Thus, tissue enhancement in this phase largely depends on the blood volume and capillary permeability The second delayed phase study can be added 2–10 minutes after the first phase study.

CALCULATION OF CT PERFUSION PARAMETERS

After CT data acquisition, various CT perfusion parameters can be calculated by using either a model-free or a model-based approach, with the former being easier to implement. Regardless of the algorithm used, several imaging processing steps should be performed for the calculation of CT perfusion parameters.

The imaging processing includes motion correction or image alignment, selection of arterial (and/or portal) input functions, ROI definition, and voxel wise computation of perfusion parameters.

The perfusion analysis of the liver is calculated differently from other organs because the liver has a dual blood supply—the hepatic artery and the portal vein. The effective time intensity curve obtained from liver tissue is therefore a result of an overlay of both the arterial and the portal venous components.

The normal liver is predominantly supplied by the low-pressure portal vein (75%) and supplemented by high-pressure hepatic artery (25%). However, several diseases such as liver cirrhosis and primary and metastatic liver tumors lead to

global or regional perfusion changes toward increased hepatic arterial blood flow and decreased portal venous flow, although the underlying mechanism is different among the diseases.

In liver cirrhosis, deposition of collagen in the space of Disse and subsequent increased resistance to incoming sinusoidal blood flow are known to be responsible for the decreased portal flow, which is counteracted by an increase in hepatic arterial flow through the hepatic arterial buffer response

In HCC, however, increased hepatic arterial flow is mainly derived from the appearance are of unpaired arteries that are not associated with portal vein branches. In the case of hepatic metastasis, proliferation of sinusoidal endothelial cells which is assisted by vascular endothelial growth factor expression primarily results in increased hepatic arterial flow.

Therefore, dedicated methods that allow a separation of the arterial and portal venous components are required for liver perfusion image analysis as well as for the diagnosis of various liver diseases.

CT PERFUSION PARAMETERS

Hepatic perfusion CT facilitates the analysis of liver function through the measurement of various perfusion parameters like

1)Blood Volume (BV),

2)Blood Flow (BF) ,

3)Permeability surface area (PERM) ,

4)Arterial Liver Perfusion(ALP),

5)Portal Venous Perfusion (PVP),

6) Mean Transit Time (MTT), and

7) Hepatic Perfusion Index (HPI)

Blood volume is the volume of blood within the vasculature that is actually flowing (expressed in units of mL/100 mL).

Blood flow refers to the volume flow rate of blood through the vasculature (expressed as mL/min/100 mL).

Permeability surface area product is the product of permeability and the total surface area of capillary endothelium in a unit mass of tissue or tumor (measured as mL/min/100 mL).

Mean Transit Time is average time it takes for blood to traverse between the arterial inflow and the venous outflow, measured in seconds.

Hepatic Perfusion Index is the ratio of the arterial liver perfusion to the total hepatic perfusion HPI = arterial liver perfusion/(arterial liver perfusion + portal venous perfusion)

Miles et al [10] and **Blomley et al** [11] on CT perfusion imaging of liver metastases showed increased arterial perfusion in liver metastases, which was confirmed by other investigators, regardless of the modality (CT and MR imaging), pharmacokinetic model, or whether the subjects studied were human or animals.

Leggett et al [12] and **Reiner et al** [13] also reported significantly increased ALP and decreased PVP in patients with metastatic diseases mainly from colorectal cancer when compared with adjacent normal parenchyma

Guyennon et al [20] demonstrated that metastatic neuroendocrine tumor showed significantly higher HPI, blood flow, blood volume, and permeability surface area product, and significantly shorter MTT, than adjacent parenchyma in 16 patients.

Lefort et al [21] reported that metastatic neuroendocrine tumor showed significantly higher HPI, blood flow, blood volume, and permeability surface area product similar results in 16 patients with biopsy-proven liver metastases from neuroendocrine tumor.

Ippolito et al [9] demonstrated significantly increased ALP and HPI with significantly decreased PVP in HCCs compared with adjacent normal parenchyma by using a maximum slope model

Sahani et al [14] and **Zhu et al** [15] reported that HCC demonstrated higher blood flow, blood volume, and permeability surface area product and shorter MTT than the background liver parenchyma on CT perfusion images

Zang et al.,([19] studied the role of perfusion CT in HCC and showed increase in BF, BV, and PERM with decrease in MTT.

Wang et al., [18] studied perfusion parameters in hemangiomas and showed increase in ALP at the periphery of hemangiomas

Tsushima et al [16] and **Shi et al** [17] also demonstrated increased HAP and HPI with decrease of PVP in apparently normal liver tissue with occult metastases on CT perfusion images, when compared with liver in patients without metastases and in controls, respectively

AIM OF THE STUDY

PRIMARY OBJECTIVES

Acquire CT perfusion parameters Blood Volume (BV), Blood Flow (BF), Permeability (PERM), Arterial Liver Perfusion (ALP), Portal Venous Perfusion (PVP) and Hepatic Perfusion Index (HPI) within the liver lesion and in normal liver parenchyma.

1) To compare the imaging diagnosis of liver lesions (especially the atypical lesions) using CT perfusion parameters with the histopathological diagnosis.

2) To analyse the correlation between CT perfusion parameter values of normal liver parenchyma with various benign and malignant lesions of the liver

SECONDARY OBJECTIVES

- To analyse the correlation between CT perfusion parameter values of normal liver parenchyma with some of the common benign and malignant lesions of the liver in these study group

Study Area : Barnard Institute of Radiology, Madras Medical College, Chennai.

Study Period : 6 months (March 2016- August 2016)

Sample Size : 50

Study Design : Prospective observational study

Inclusion Criteria:

- Age between 10 and 80 years , both sexes.
- The presence of liver space occupying lesion diagnosed by US / Conventional CT /MRI.

Exclusion Criteria:

- Lactating and pregnant females whatever the gestational age.
- Patients with impaired renal function (serum creatinine level higher than 1.3 mg/100 ml).

METHODOLOGY (MATERIALS AND METHODS)

This prospective study was performed after obtaining clearance from our institutional ethical committee and institutional informed consent guidelines were observed.

Patients referred from Surgical gastroenterology department with suspected liver lesion on US / CT /MRI, who are willing for CT perfusion are included in this study during the period from March 2016 to August 2016. The patients were screened using the drawn inclusion/ exclusion criteria. Relevant entries in the proforma for each patient were made after reviewing his/her case sheet & previous medical records.

The population enrolled in this study was composed of 50 patients diagnosed as having liver space occupying lesion by conventional and contrast enhanced US / CT / MRI. All patients were required to provide written informed consent before study participation.

All CT perfusion studies were done using 16 SLICE CT scanner (SOMATOM EMOTION , SIEMENS HEALTHINEERS) with syngo® Body Perfusion CT (Body PCT) software . The technique is based on a cine mode continous accusition of dynamic flow of contrast.. The imaging parameters were 80-120 kVp and 50-120 mAs, 24 spiral images were obtained.

A bolus of 50 ml of low osmolar non-ionic contrast material Iohexol 350 (Omnipaque 350) was injected through a 18-gauge cannula placed in the volar aspect in the cubital vein at a flow rate of 5 ml/s .

After motion correction and automatic segmentation ROI within proximal abdominal aorta is drawn to obtain arterial input function . A second ROI is drawn within the portal vein to determine portal venous input function addressing unique character of dual blood supply in liver . A third ROI is drawn over spleen, which allows separation of arterial and portal venous blood flow in the liver.
Time-intensity curves are generated from abdominal aorta , portal vein , and spleen

By applying the perfusion software, quantitative parameter images were generated from the time-attenuation curves. For each patient, seven types of parameter maps were calculated for each section:

- Temporal maximum intensity projection (MIP) in Hounsfield units (HU),
- Blood Volume -BV (ml/100 ml),
- Blood Flow -BF (ml/100 ml/min)
- Permeability -PERM (ml/100 ml/min)
- Arterial Liver Perfusion -ALP (ml/100 ml/min)
- Portal Venous Perfusion -PLP (ml/100 ml/min) and
- Hepatic Perfusion Index -HPI in percentage (%)

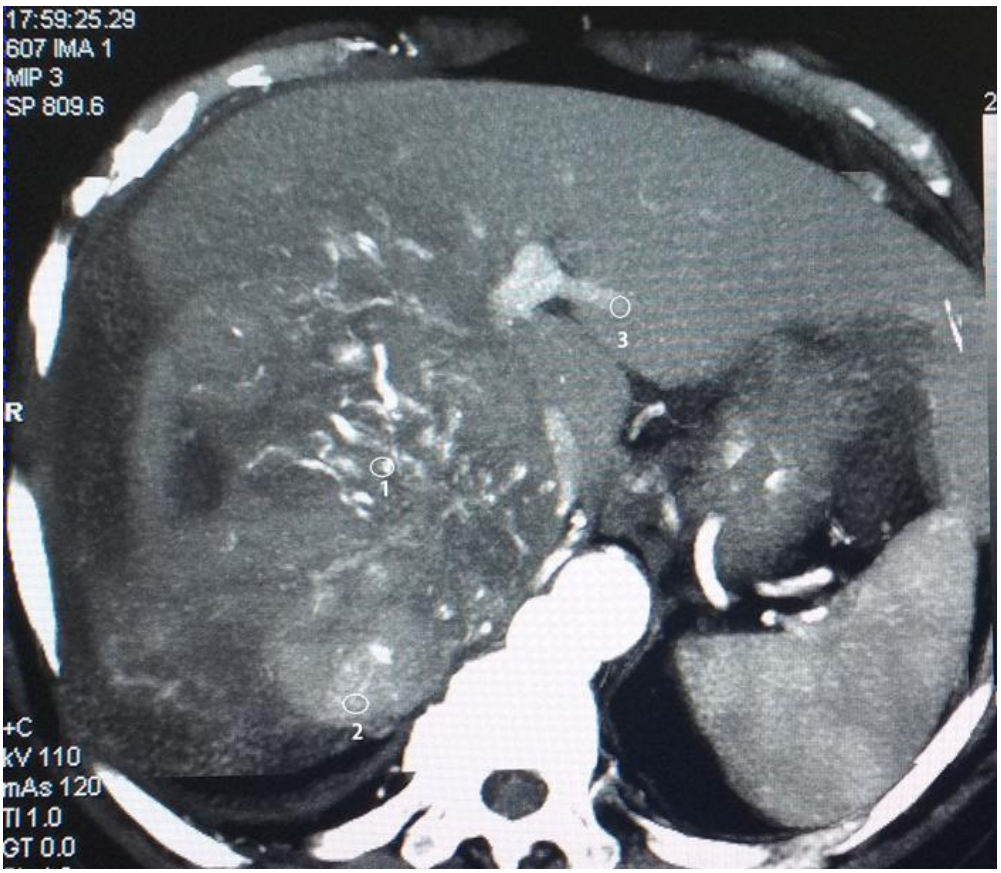
Initially, ROIs were drawn on the MIP images, on the centre part of lesion (C) and periphery of the lesion (P) excluding the areas with necrosis or vessels. The ROIs were then automatically copied onto the perfusion maps and corresponding BV, BF, PERM, ALP, PVP and HPI values were acquired.

For every patient, reference ROIs were also drawn on the healthy adjacent liver parenchyma (N) and perfusion parameters were obtained as control values. All the patients were followed up and histopathological reports were collected from the pathology

REPRESENTATIVE CASES

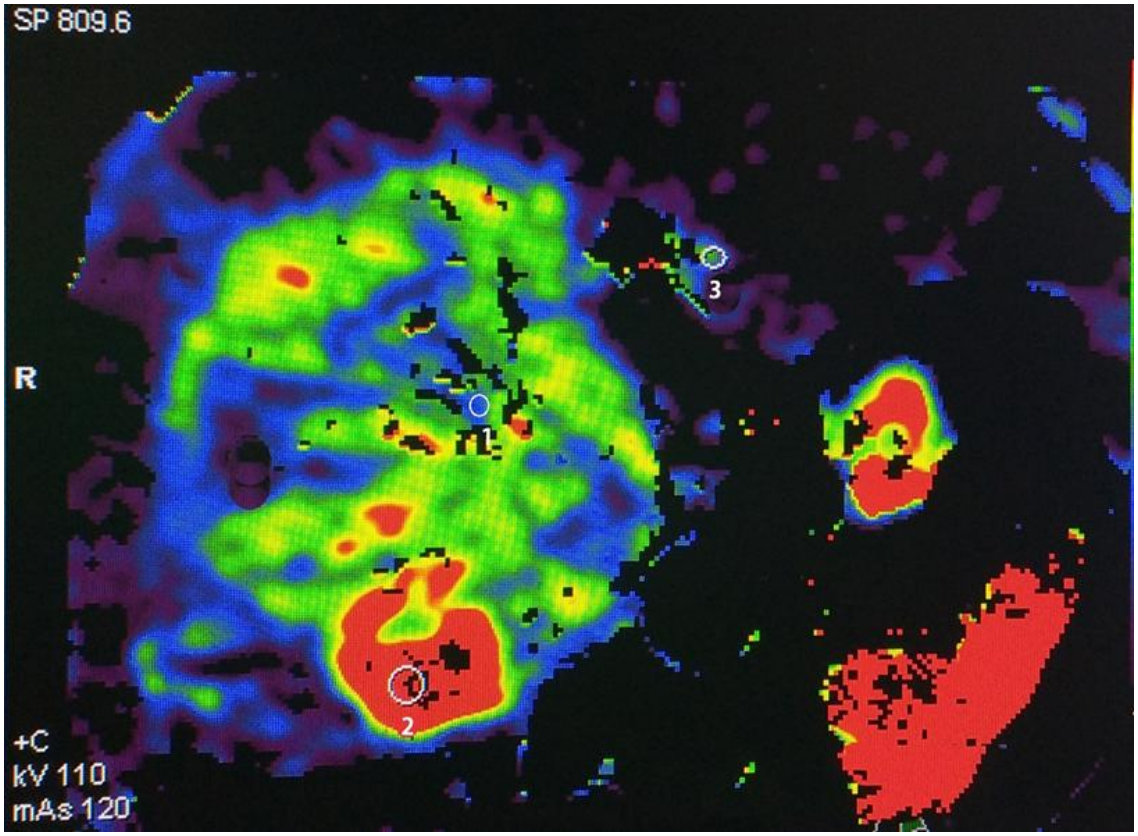
CASE 1

65 year old HbsAg positive male with upper abdomen pain and jaundice diagnosed as hepatocellular carcinoma on US. Histopathology – trabecular hepatocellular carcinoma



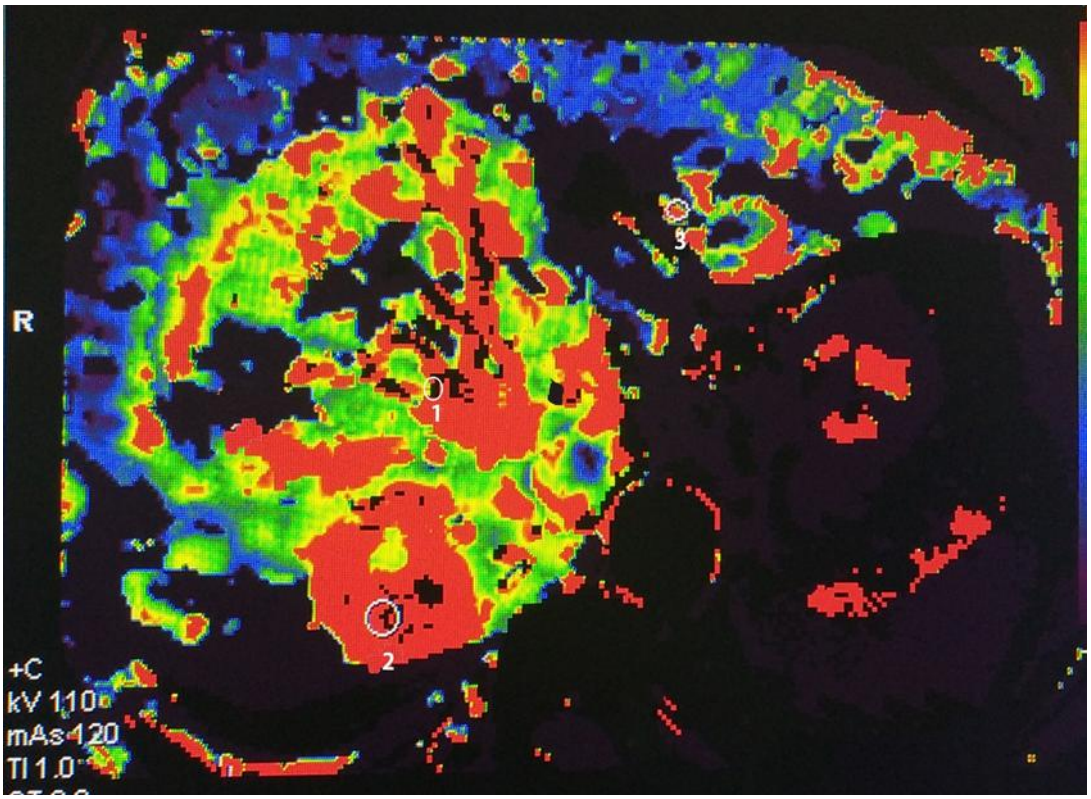
MIP PERFUSION CT (HU)

MIP image shows heterogeneously enhancing lesion with necrotic areas in the right lobe of the liver displacing the portal vein



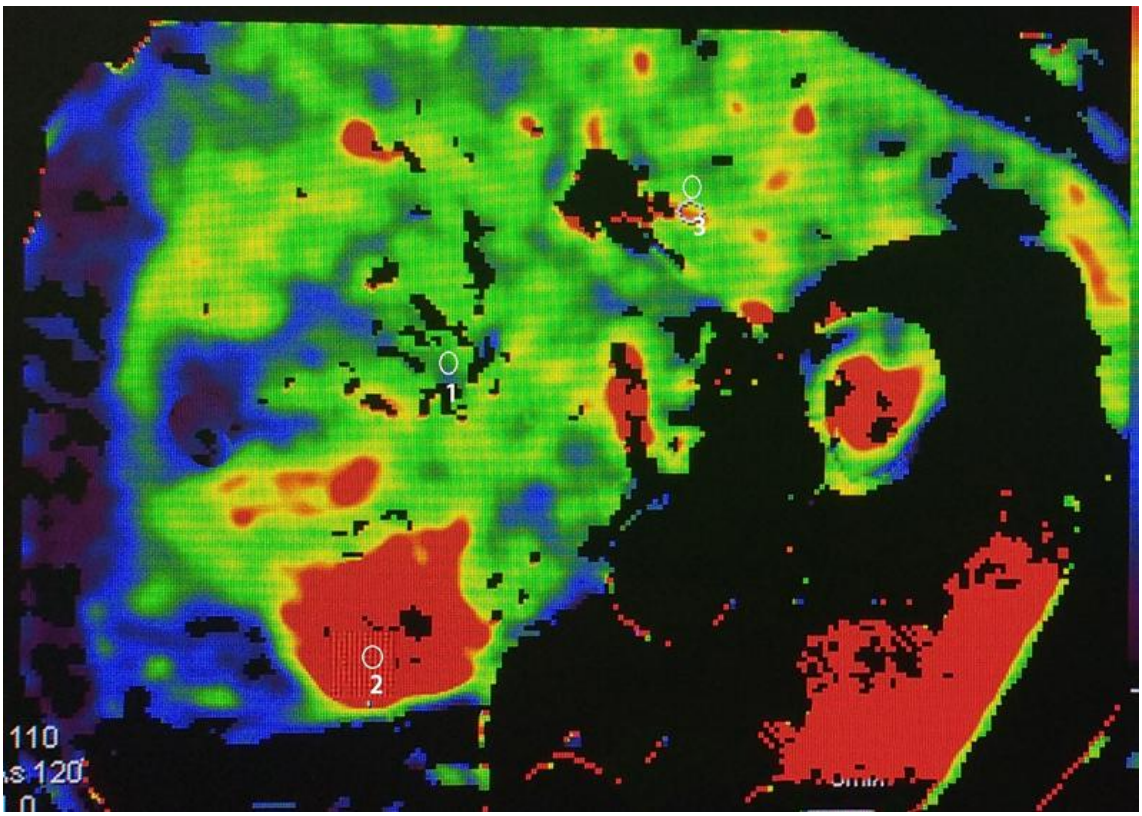
BLOOD VOLUME

Blood volume map shows increased values in both the centre and the periphery of the lesion (centre > periphery)



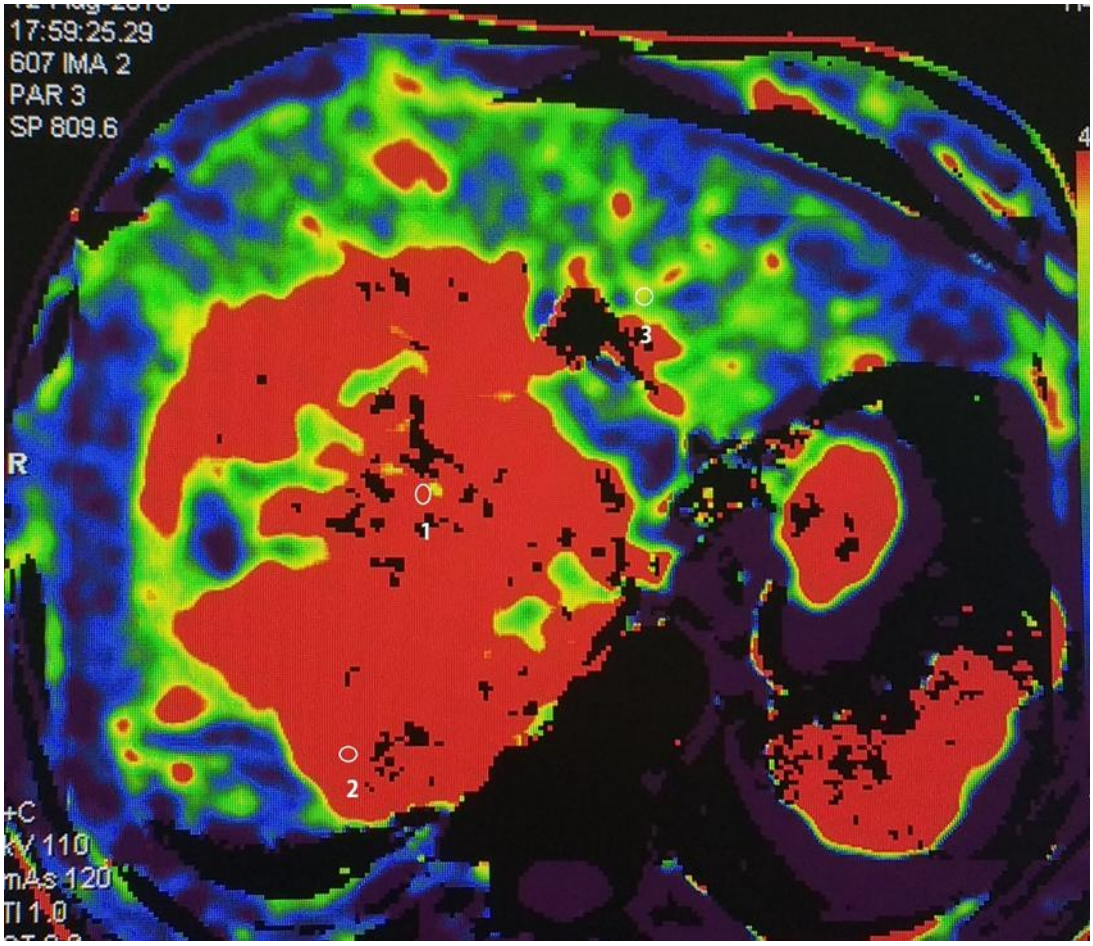
BLOOD FLOW

Blood flow map shows increased values in both the centre and the periphery of the lesion (centre > periphery)



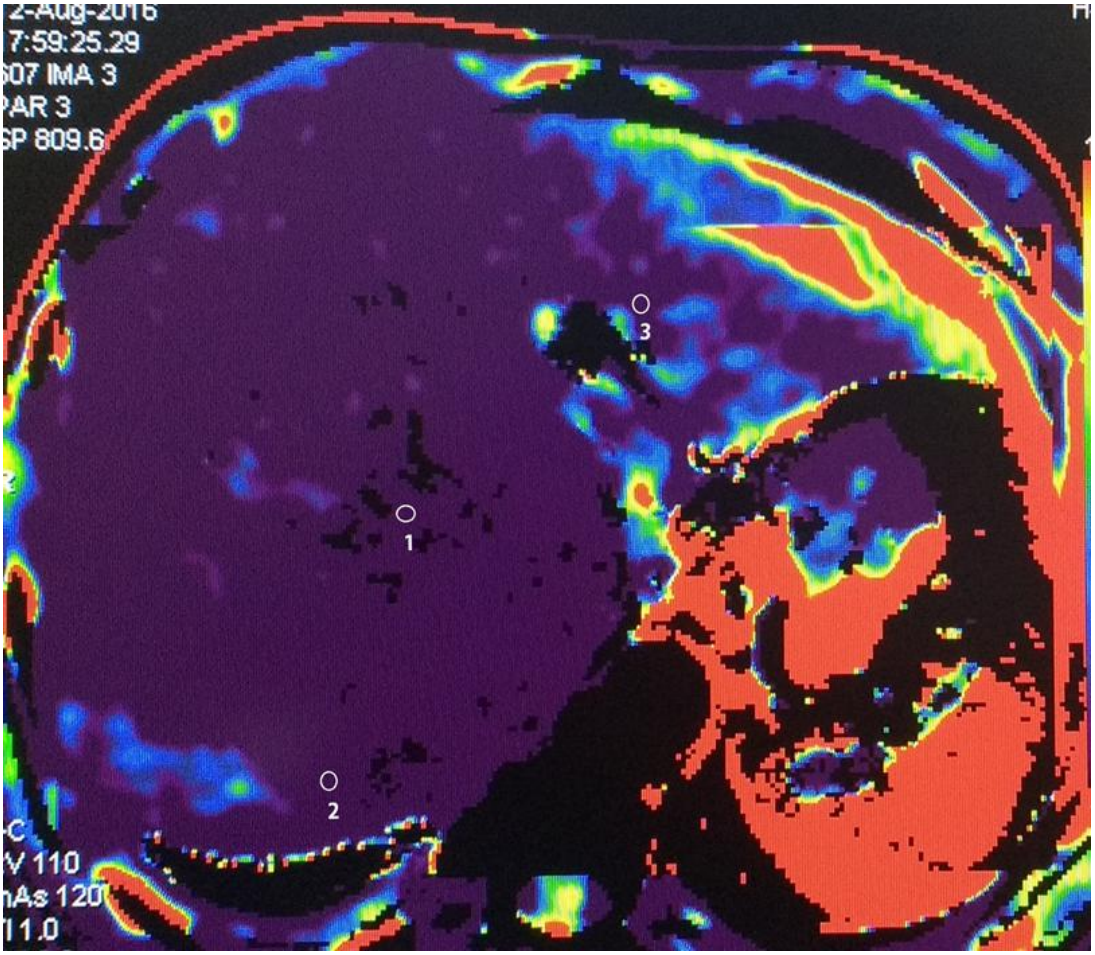
PERMEABILITY

Permeability map shows increased values in both the centre and the periphery of the lesion (centre > periphery)



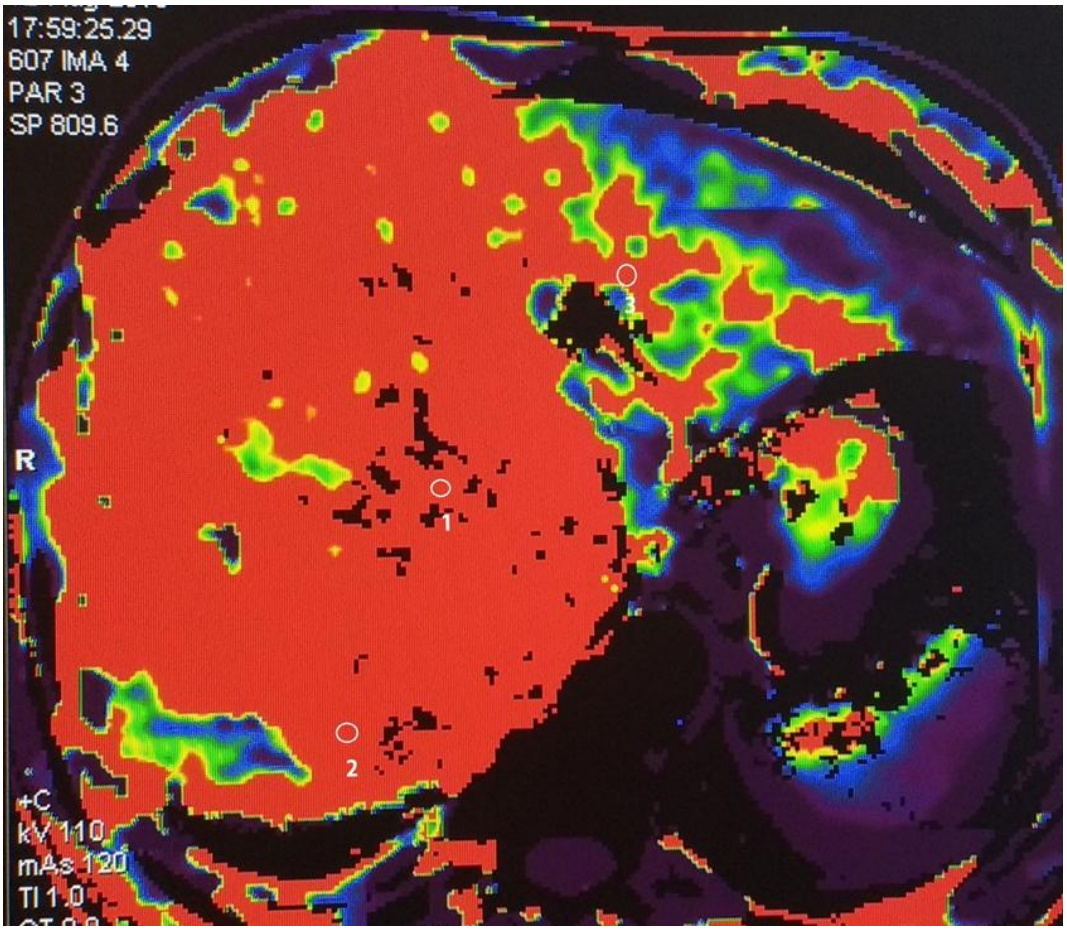
ARTERIAL LIVER PERFUSION

Arterial liver perfusion map shows increased values in both the centre and the periphery of the lesion (centre > periphery)



PORTAL VENOUS PERFUSION

Portal venous perfusion map shows relatively reduced values in both the centre and the periphery of the lesion



HEPATIC PERFUSION INDEX

Hepatic perfusion index shows increased values in both the centre and the periphery of the lesion (centre > periphery)

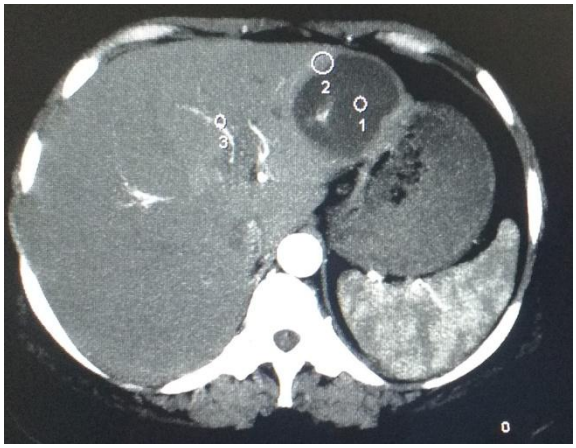
CT Perfusion Interpretation:

Parameters		ROI-1 Centre of the lesion (C)	ROI -2 Periphery of lesion (P)	ROI-3 Normal liver parenchyma (N)
MIP	HU	144	100	60
BV	ml/100 ml	35	15	5.1
BF	ml/100ml/min	64	37.2	20.8
PERM	ml/100ml/min	80	36	34.8
ALP	ml/100ml/min	40	28	7.4
PVP	ml/100ml/min	6.1	6.3	20.6
HPI	%	90	80	26

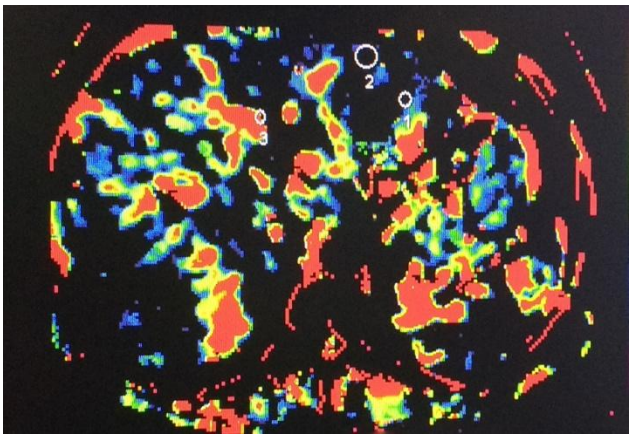
Significant increase of CT perfusion parameters such as BV,BF,PERM ALP & HPI noted in tumor compared to normal liver parenchyma (centre >periphery)

CASE 2

50 year old female with upper abdominal pain diagnosed as hydatid cyst left lobe of the liver on US. Histopathology/Fnac - Hydatid cyst

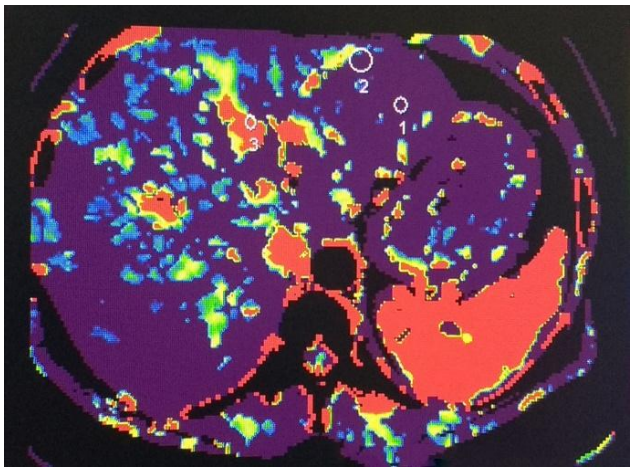


MIP PERFUSION CT (HU)

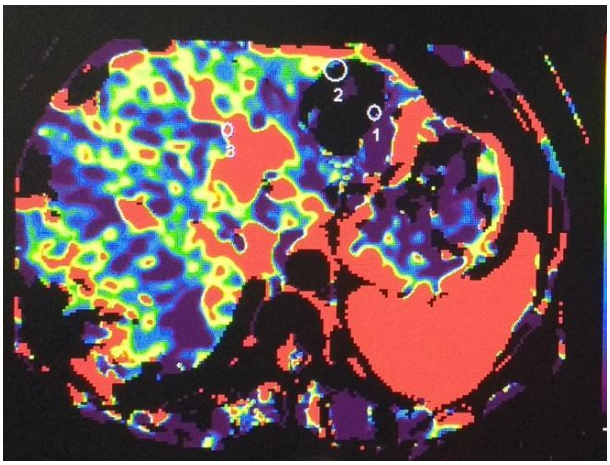


BLOOD VOLUME

MIP image and blood volume map shows relatively reduced values in both centre and periphery of the lesion

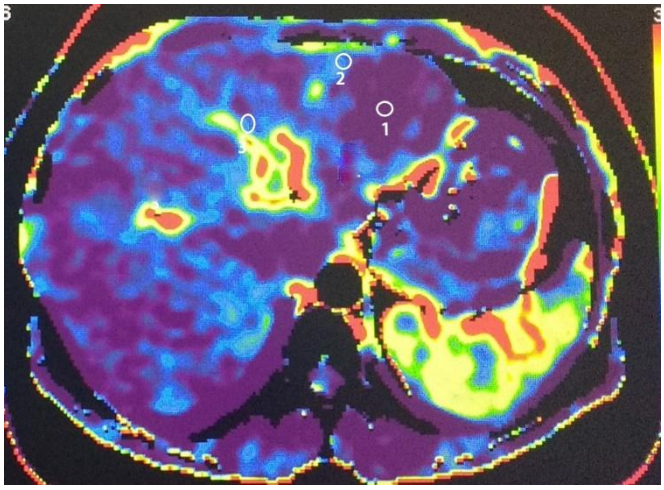


BLOOD FLOW

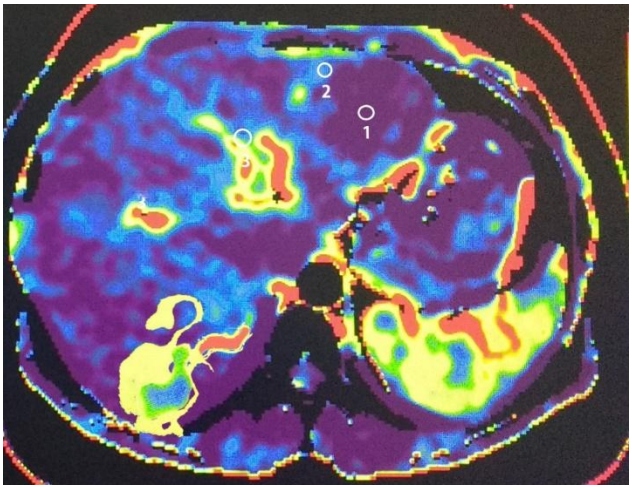


PERMEABILITY

Blood flow and permeability map shows relatively reduced values in both centre and periphery of the lesion

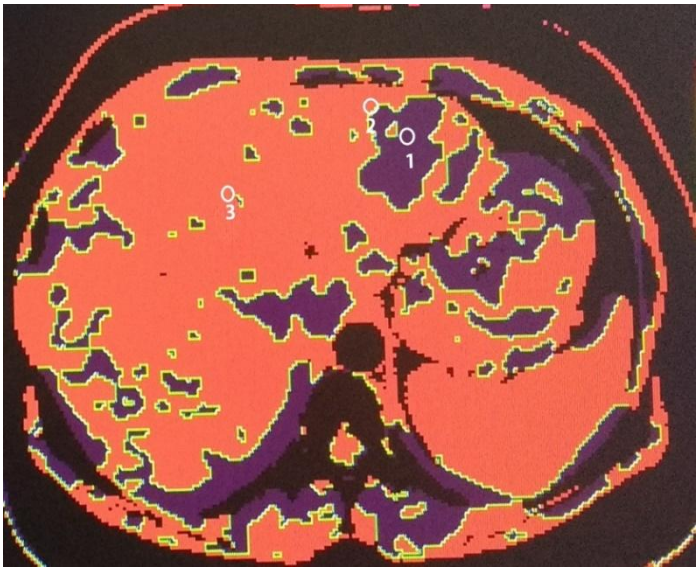


ARTERIAL LIVER PERFUSION



PORTAL VENOUS PERFUSION

Arterial liver perfusion and portal venous perfusion map shows relatively reduced values in both centre and periphery of the lesion



HEPATIC PERFUSION INDEX

Hepatic perfusion index map shows relatively reduced values in both centre and periphery of the lesion

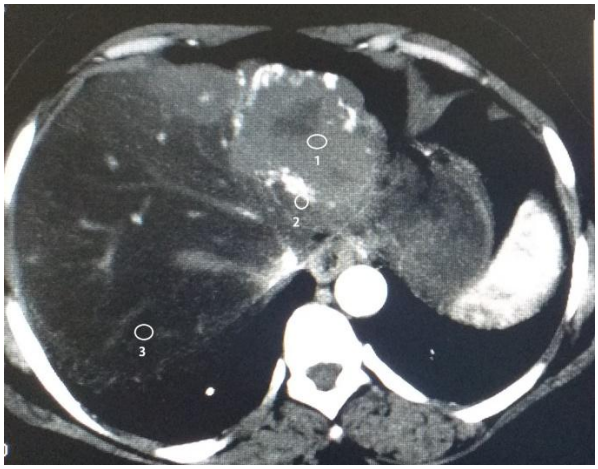
CT Perfusion Interpretation:

Parameters		ROI-1 Centre of the lesion (C)	ROI -2 Periphery of lesion (P)	ROI-3 Normal liver parenchyma (N)
MIP	HU	38	50	69
BV	ml/100 ml	3	3.8	5.5
BF	ml/100ml/min	8	16	38.4
PERM	ml/100ml/min	20	37.4	45.8
ALP	ml/100ml/min	3	4.8	6.9
PVP	ml/100ml/min	12	20	30.1
HPI	%	18	20	37

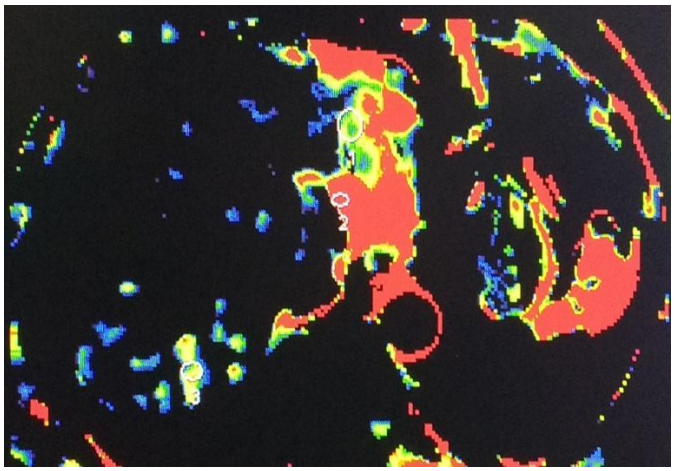
Minimal decrease in the values of CT perfusion parameters noted in lesion compared to normal liver parenchyma.

CASE 3

50 year old female with upper abdominal pain diagnosed as hemangioma left lobe of the liver on Conventional CT. Histopathology - cavernous hemangioma

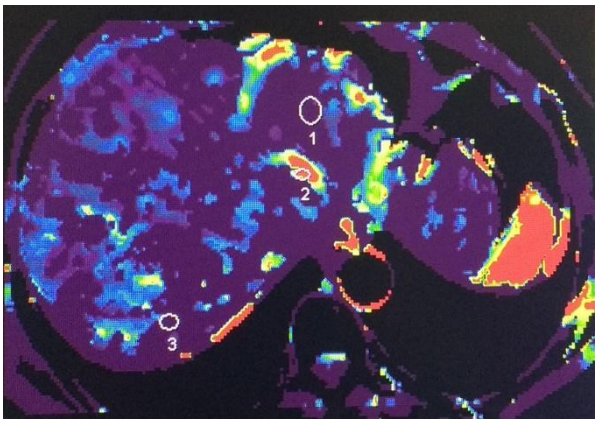


MIP PERFUSION CT (HU)

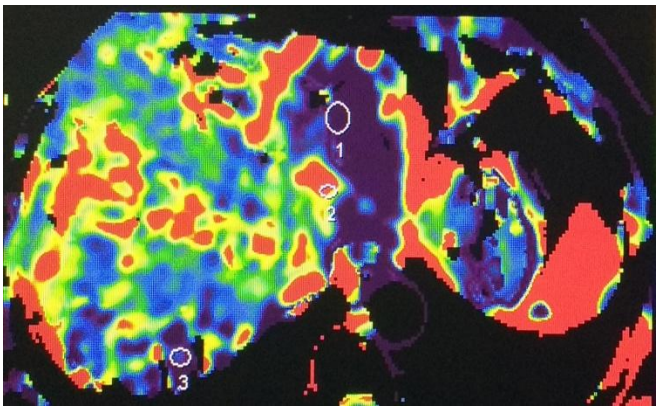


BLOOD VOLUME

MIP image and blood volume map shows relatively increased values in both the centre and the periphery of the lesion (periphery > centre)

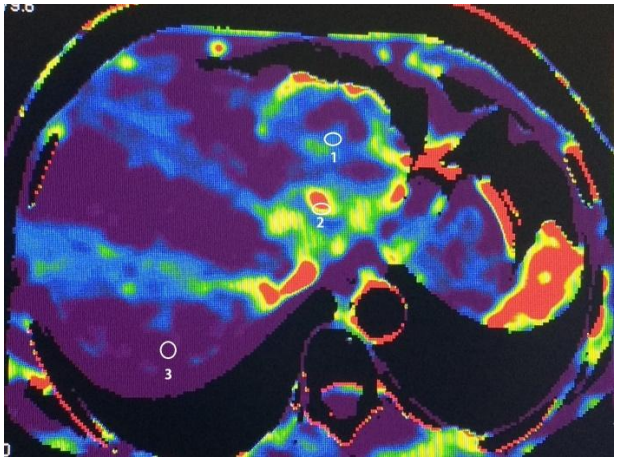


BLOOD FLOW

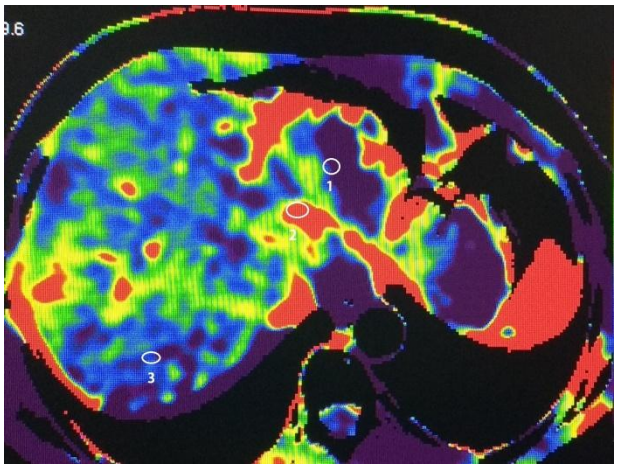


PERMEABILITY

Blood flow map and permeability map shows relatively increased values in both the centre and the periphery of the lesion (periphery > centre)

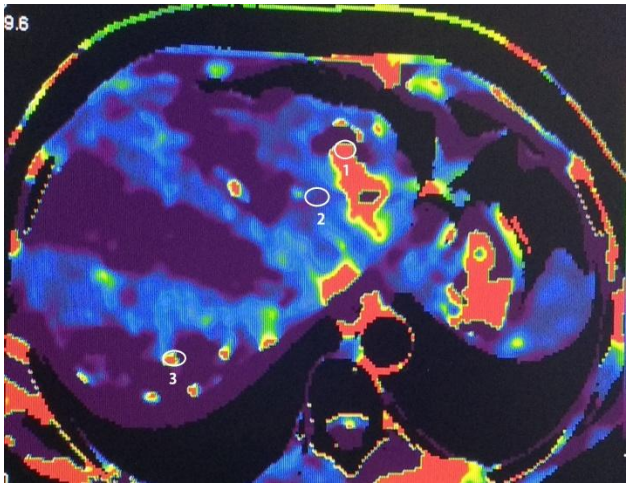


ARTERIAL LIVER PERFUSION



PORTAL VENOUS PERFUSION

Arterial liver perfusion map shows relatively increased and portal venous perfusion map shows relatively reduced values in both the centre and the periphery of the lesion (periphery > centre)



HEPATIC PERFUSION INDEX

Hepatic perfusion index map shows relatively increased values in both the centre and the periphery of the lesion (periphery > centre)

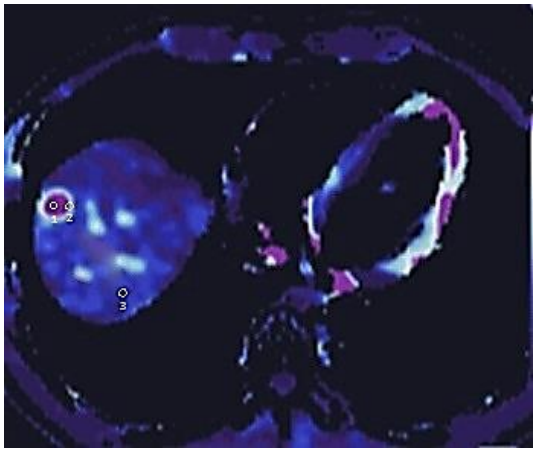
CT Perfusion Interpretation:

Parameters		**ROI-1 Centre of the lesion (C)**	**ROI -2 Periphery of lesion (P)**	**ROI-3 Normal liver parenchyma (N)**
MIP	**HU**	**50**	**144**	**18**
BV	**ml/100 ml**	**6.4**	**10**	**6**
BF	**ml/100ml/min**	**40**	**52**	**24.7**
PERM	**ml/100ml/min**	**30**	**36**	**32.9**
ALP	**ml/100ml/min**	**15**	**25.6**	**5.7**
PVP	**ml/100ml/min**	**14**	**12**	**24.3**
HPI	**%**	**16**	**20**	**19**

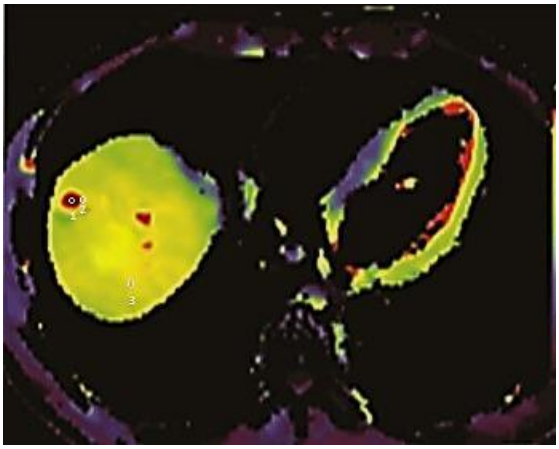
Significant increase of CT perfusion parameters noted in lesion compared to normal liver parenchyma (periphery > centre)

CASE 4

45 year old male with right upper abdominal pain diagnosed as metastasis on Conventional CT. Histopathology- well differentiated adenocarcinoma metastasis

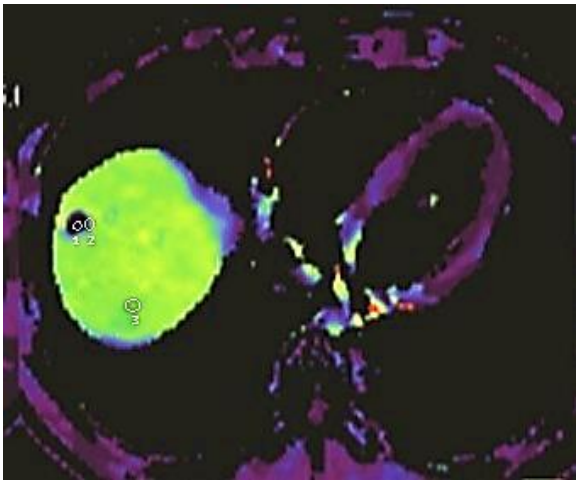


BLOOD VOLUME

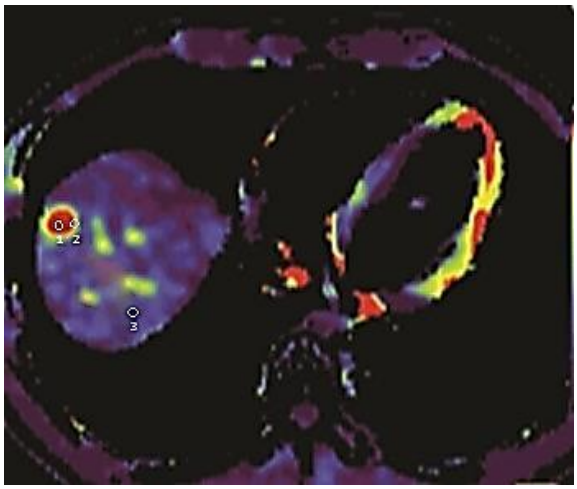


BLOOD FLOW

Blood volume and Blood flow map shows relatively increased values in both the centre and the periphery of the lesion (centre > periphery)



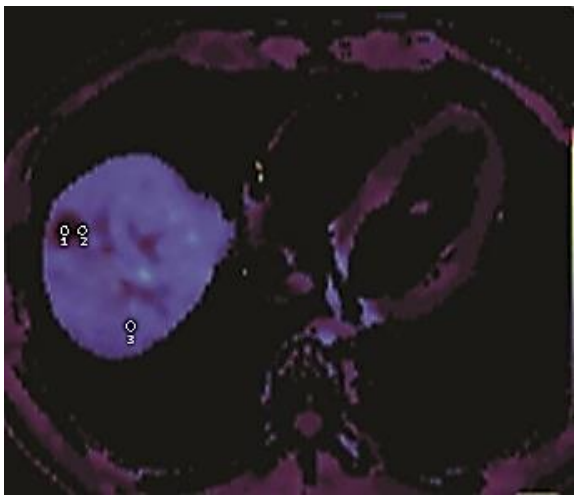
PERMEABILITY



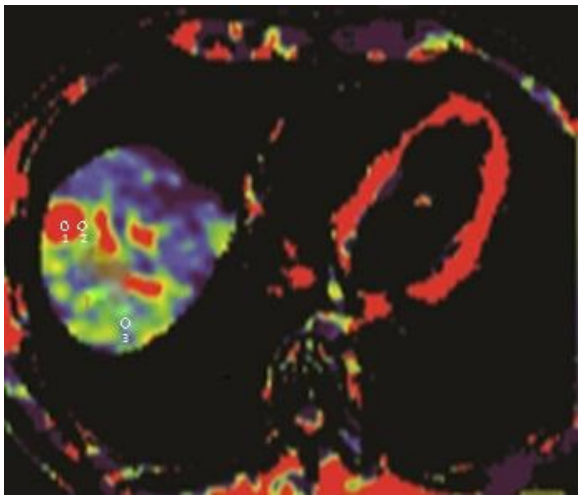
ARTERIAL LIVER PERFUSION

Permeability & Arterial liver perfusion map shows relatively increased values in both the centre and the periphery of the lesion (centre >periphery)

\



PORTAL VENOUS PERFUSION



HEPATIC PERFUSION INDEX

Portal venous perfusion map shows decreased & Hepatic perfusion index map shows relatively increased values in both the centre and the periphery of the lesion (centre > periphery)

CT Perfusion Interpretation:

Parameters		ROI-1 Centre of the lesion (C)	ROI -2 Periphery of lesion (P)	ROI-3 Normal liver parenchyma (N)
MIP	HU	98	80	65
BV	ml/100 ml	20	16	11.3
BF	ml/100ml/min	50.2	47.2	38.6
PERM	ml/100ml/min	56.2	40	50
ALP	ml/100ml/min	32.2	28.2	8
PVP	ml/100ml/min	8	10	32
HPI	%	100	52	20

Significant increase of CT perfusion parameters noted in lesion compared to normal liver parenchyma (centre >periphery)

STATISTICAL ANALYSIS

The collected data were analysed with IBM.SPSS statistics software23.0 Version. To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and the mean & S.D were used for continuous variables

To find the significant difference between the bivariate samples in Independent groups the Unpaired sample t-test was used. The Receiver Operator Characteristic (ROC) curve analysis was used to find the Sensitivity, Specificity ,PPV and NPV on comparison of Imaging Diagnosis with HPE.

To find the association in the categorical variables Chi-square test was used. In all the above statistical tools the probability value .05 is considered as significant level.

AGE DISTRIBUTION

In this study, benign liver lesions are more common in 2nd to 5th decade (~80%) , whereas malignant liver lesions are more common in 4th to 8th decade(~88%).

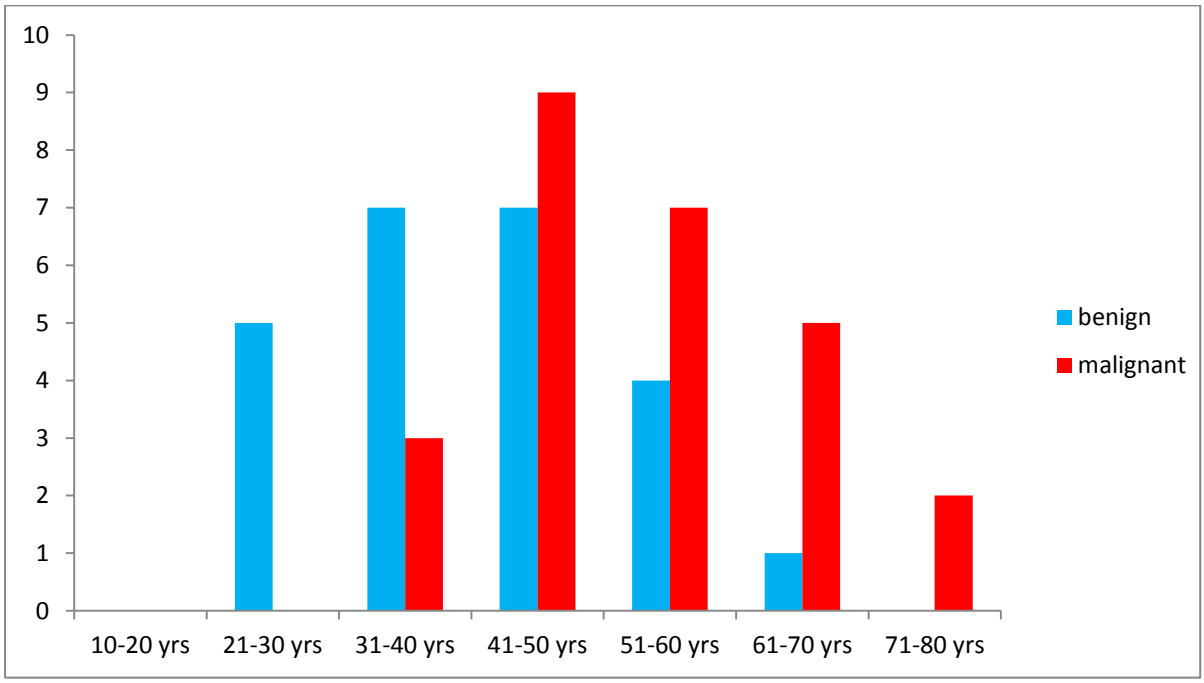
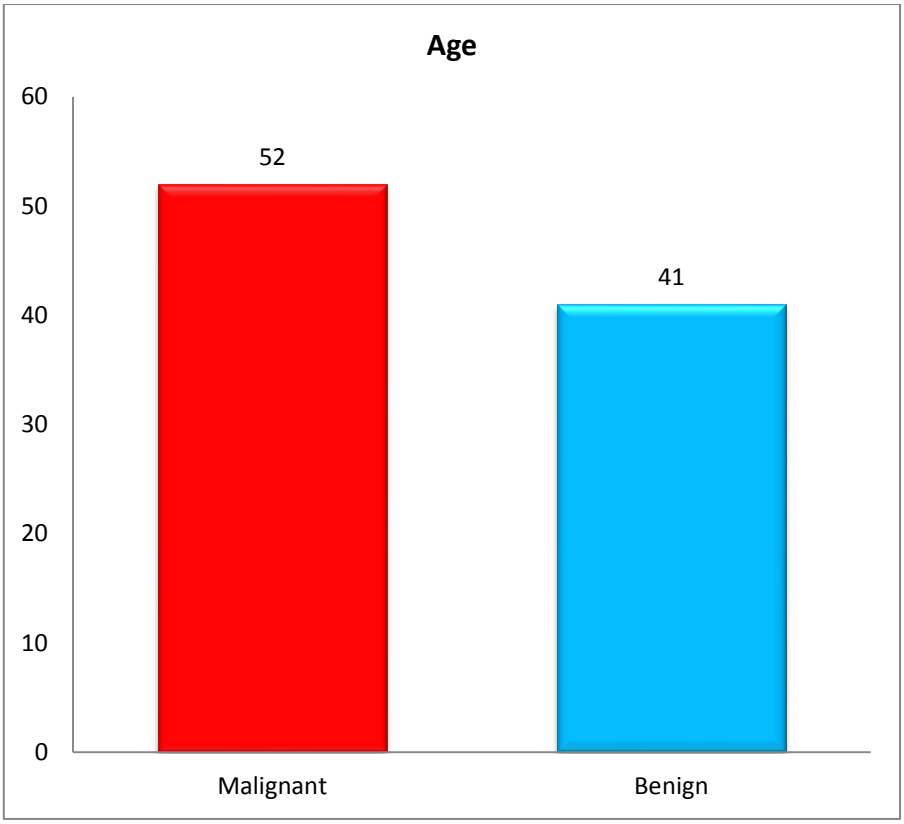


Fig 10: Bar diagram shows age range distribution of benign and malignant liver lesion among the study group



	Sample (n)	Mean Age
Malignant lesion	26	52
Benign lesion	24	41

Fig 11: Bar diagram shows mean age range distribution of benign and malignant liver lesion among the study group

GENDER DISTRIBUTION

In this study, out of 50 patients , 29 (58%) were males and 21 (42%) were females. Out of 26 patients of malignant liver lesion 18(69.23 %) were males and 8 were females (30.76 %). Out of 24 patients of benign liver lesion 11 (45.83 %) were males and 13 (54.17%) were females

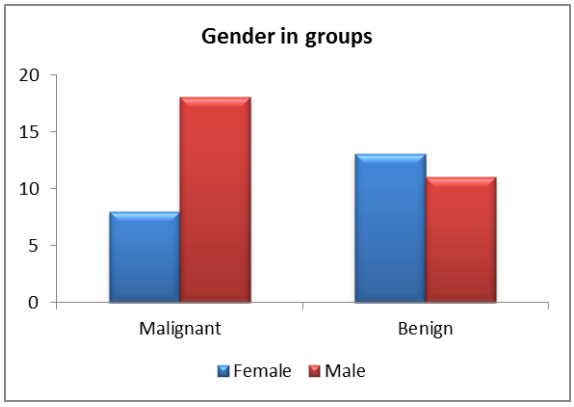


Fig : 12 Bar diagram shows gender distribution of benign and malignant liver lesion among the study group

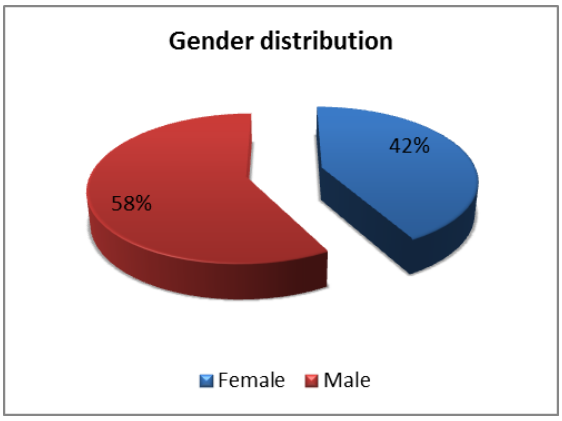


Fig :13 Pie chart shows gender distribution of liver lesions

Table 1 : Gender Crosstabulation

			ID		
			Malignant	Benign	Total
SEX	FEMALE	Sample	8	13	21
		% within female	30.8%	54.2%	42.0%
	MALE	Sample	18	11	29
		% within male	69.2%	45.8%	58.0%
Total		Sample	26	24	50
		% within sample	100.0%	100.0%	100.0%

MEAN VALUES OF CT PERFUSION PARAMETERS

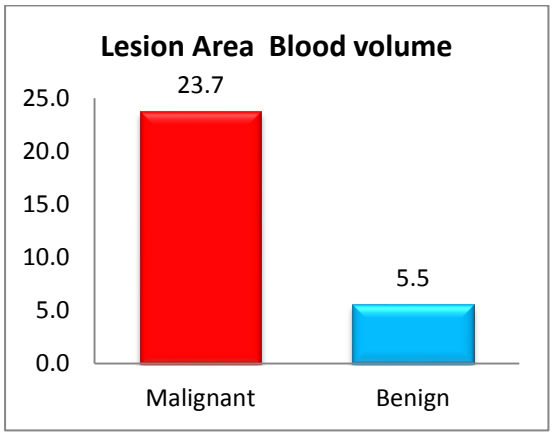
GROUP STATISTICS

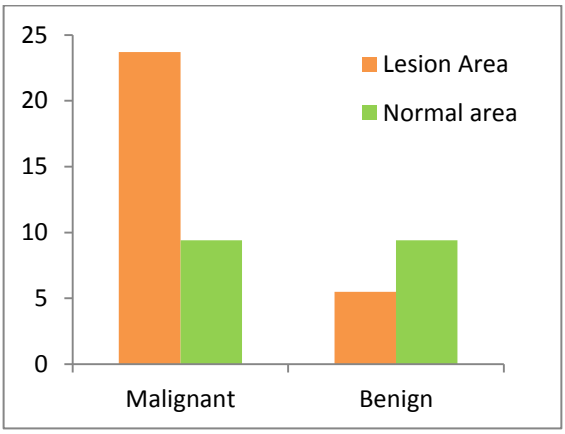
Table -2

Parameters		Mean	Standard deviation	t value	p value
BV	Malignant	23.7	5.1	14.6	.0005
	Benign	5.5	3.3		
BF	Malignant	48.8	7.07	8.3	.0005
	Benign	22.7	14.1		
PERM	Malignant	47.5	9.2	5.7	.0005
	Benign	33.2	8.1		
ALP	Malignant	28.9	6.6	9.9	.0005
	Benign	9.2	7.3		
PVP	Malignant	7.8	1.6	-7.6	.0005
	Benign	13.9	3.6		
HPI	Malignant	78	5.9	9.4	.0005
	Benign	36	21.9		

Table shows the Mean, Standard Deviation, 't ' value and 'p 'value of parameters BV,BF,PERM,ALP,PVP and HPI shows statistically significant 'p' value

BLOOD VOLUME



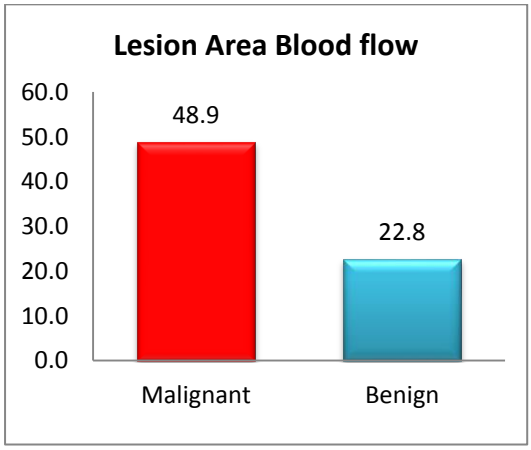


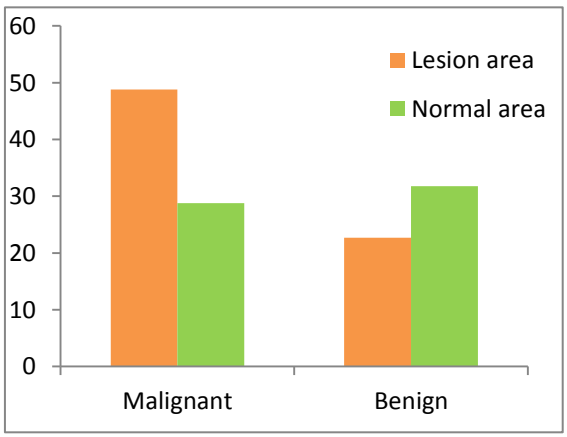
14 (a) **14 (b)**

Fig: 14(a) Shows mean values of intra lesional BV in malignant & benign liver lesion among the study group

14 (b) Shows comparision of intra lesional and normal parenchymal mean BV

BLOOD FLOW



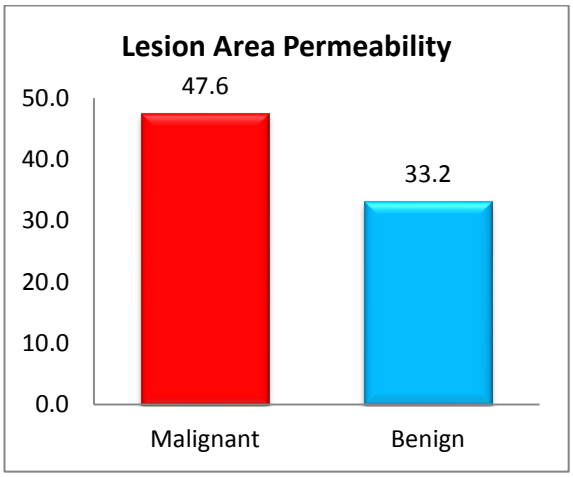


15(a) **15(b)**

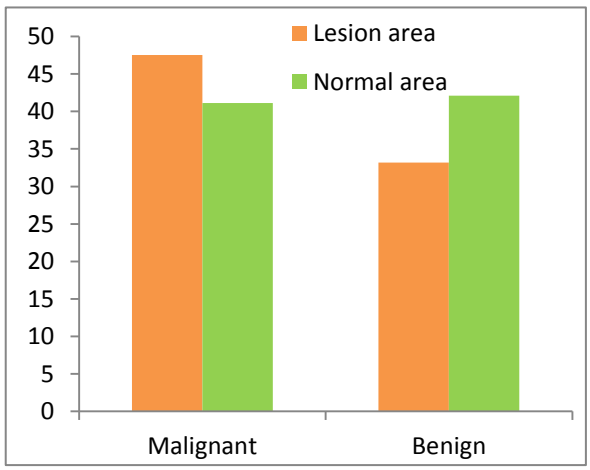
Fig: 15(a) Shows mean values of intra lesional BF in malignant & benign liver lesion among the study group

15 (b) Shows comparision of intralesional and normal parenchymal mean BF

PERMEABILITY



16(a)

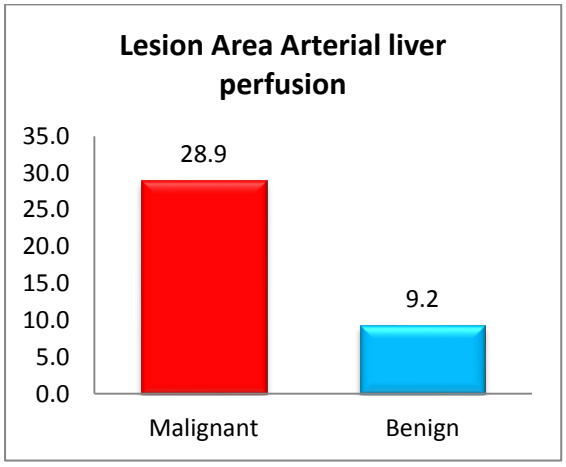


16 (b)

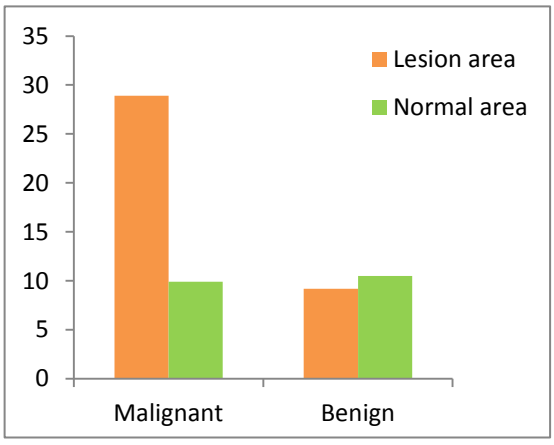
Fig: 16 (a) Shows mean values of intra lesional PERM in malignant & benign liver lesion among the study group

16 (b) Shows comparision of intra lesional and normal parenchymal mean PERM

ARTERIAL LIVER PERFUSION



17 (a)

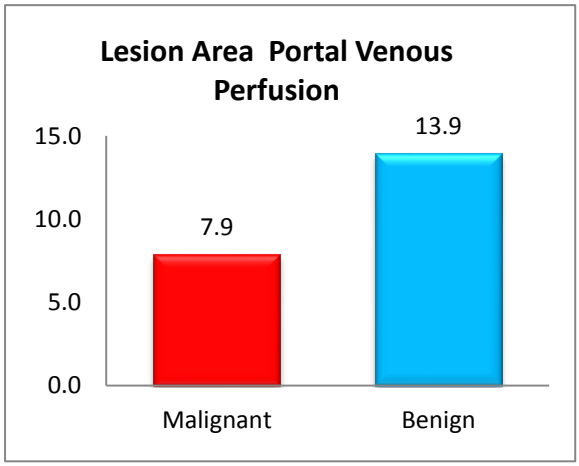


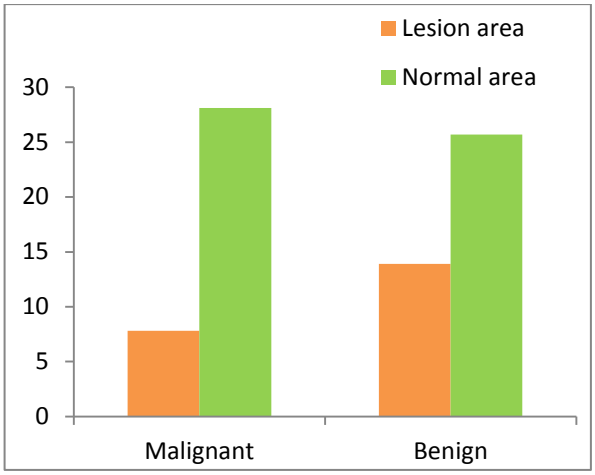
17 (b)

Fig: 17(a) Shows mean values of intra lesional ALP in malignant & benign liver lesion among the study group

17(b) Shows comparision of intralesional and normal parenchymal mean ALP

PORTAL VENOUS PERFUSION



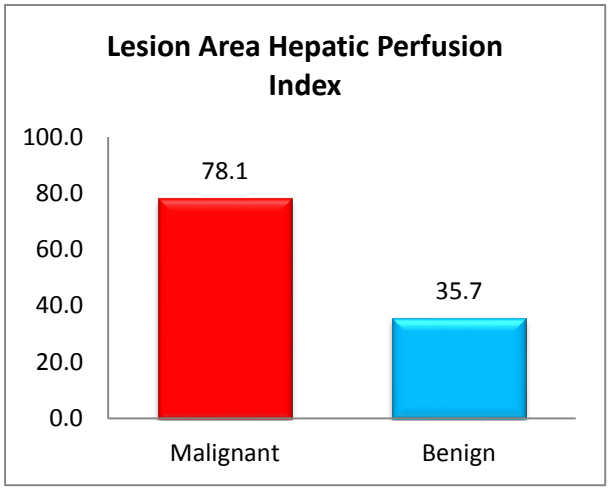


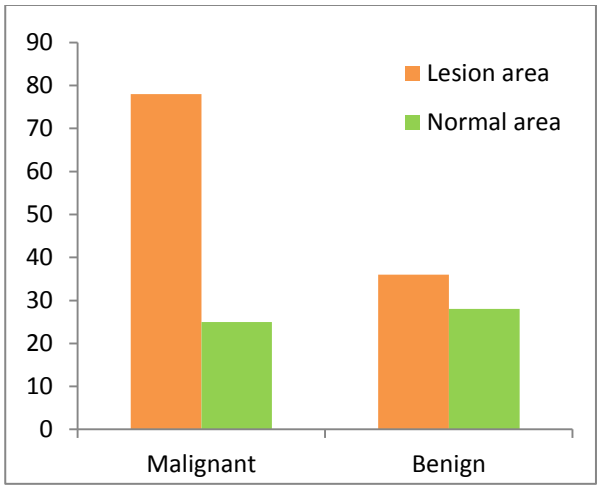
18(a) **18(b)**

Fig: 18(a) Shows mean values of intra lesional PVP in malignant & benign liver lesion among the study group

18(b) Shows comparision of intralesional and normal parenchymal mean PVP

HEPATIC PERFUSION INDEX



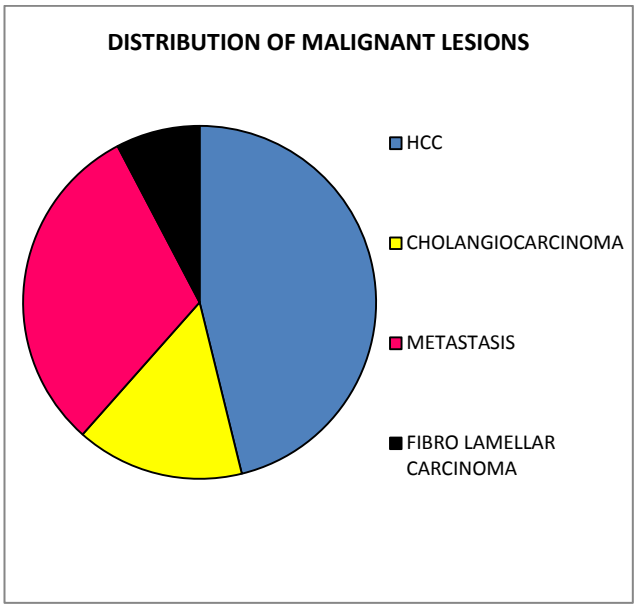


19(a) **19(b)**

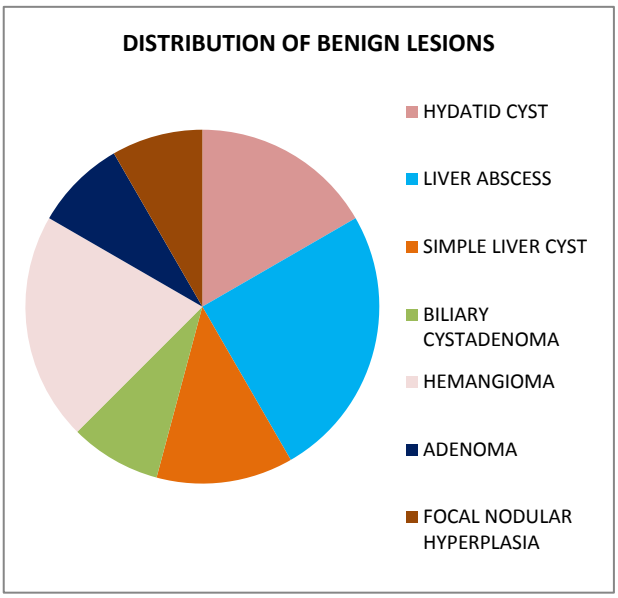
Fig: 19(a) Shows mean values of intra lesional HPI in malignant & benign liver lesion among the study group

19(b) Shows comparision of intralesional and normal parenchymal mean HPI

DISTRIBUTION OF LESIONS

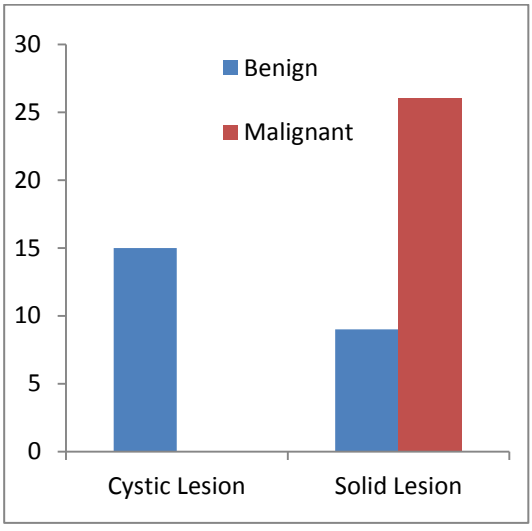


20 (a)

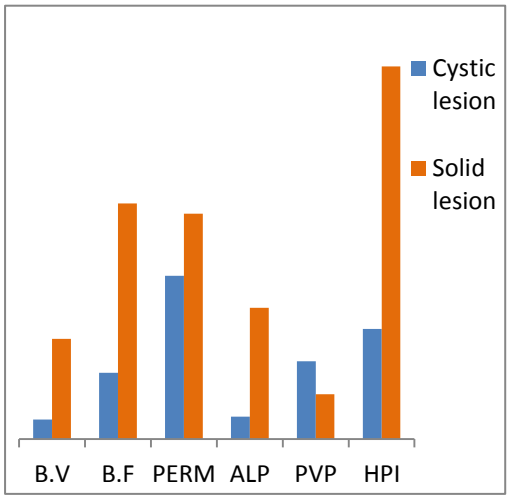


20 (b)

Fig: 20 (a) & (b)Shows the distribution of malignant & benign liver lesion among the study group respectively



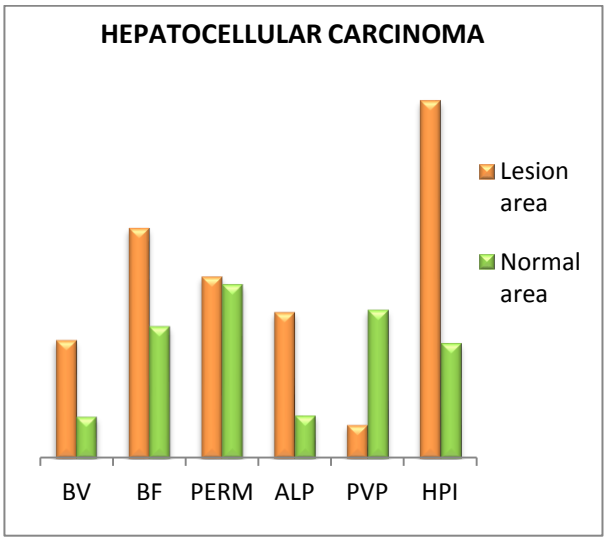
21 (a)



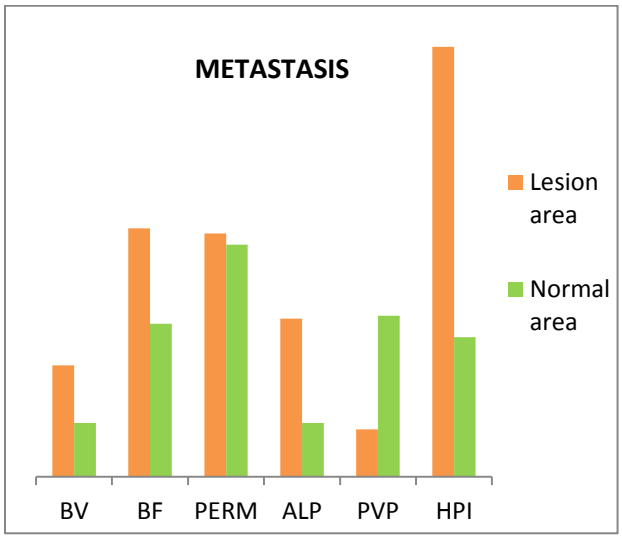
21 (b)

Fig: 21(a) Shows cystic and solid lesion distribution of malignant & benign liver lesion among the study group

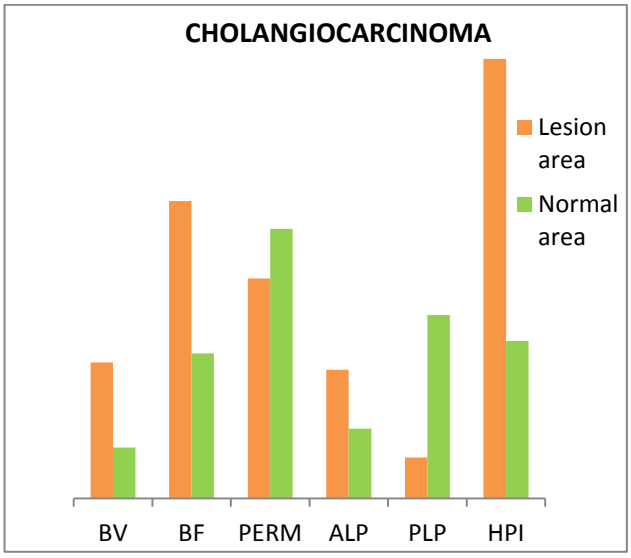
21(b) Shows comparision of parameters in solid & cystic liver lesions



22(a)

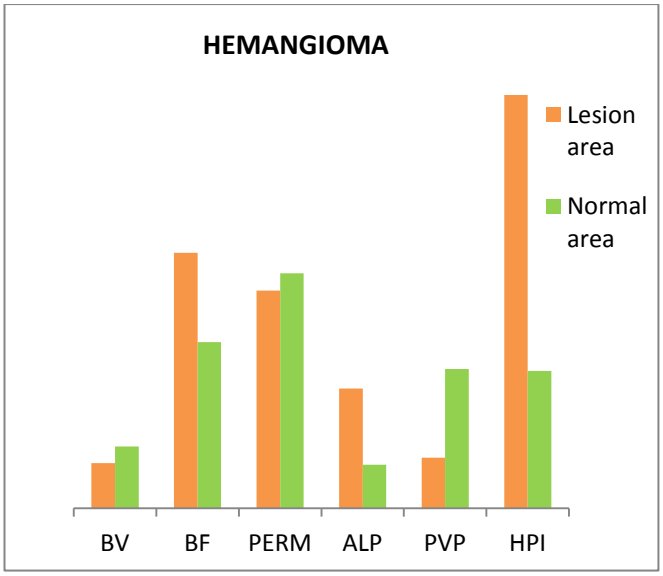


22(b)

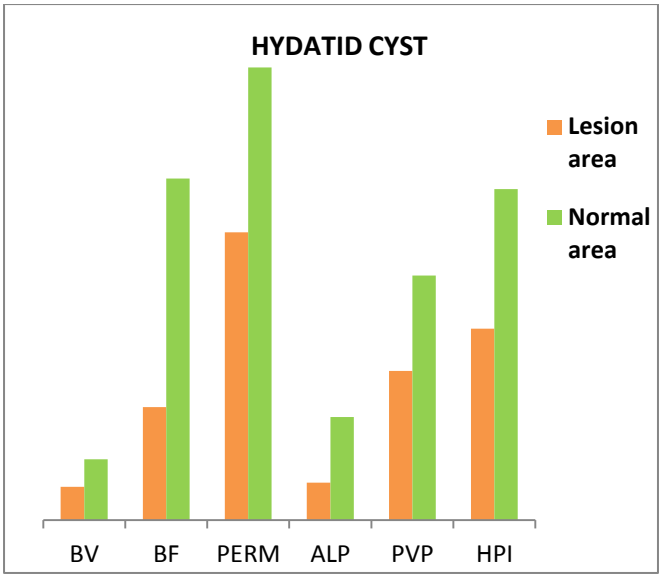


22(c)

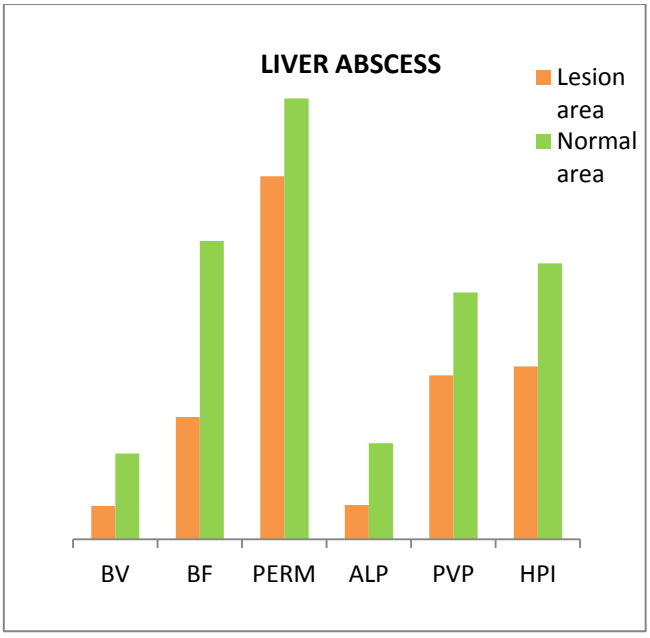
Fig 22 (a), (b) & (c) shows comparision of intra lesional and normal parenchymal mean perfusion parameter values in Heptocellular carcinoma, metastasis & cholangiocarcinoma respectively



23(a)



23(b)



23(c)

Fig 23 (a), (b) & (c) shows comparision of intralesional and normal parenchymal mean perfusion parameter values in Hemangioma, Hydatid cyst & Liver abscess respectively

Table -3 HPE crosstabulation

Lesion in CT perfusion imaging		HPE		Total
		Positive	Negative	
	Malignant lesion	25	1	26
	Benign lesion	23	1	24
Total		48	2	50

CT Perfusion imaging Comparision of the Malignant and Benign liver lesion with HPE shows

Sensitivity of the study- 96.2%

Specificity of the study -95.8%

Positive Predictive Value-96.2%

Negative Predictive Value-95.8%

Accuracy % of the study-96%

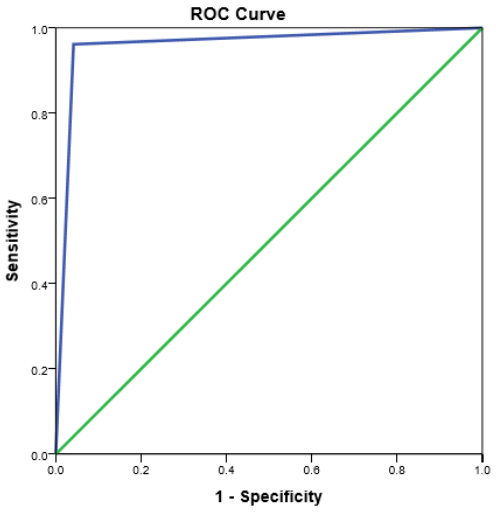


Fig 24 shows ROC curve analysis to find the Sensitivity ,Specificity ,PPV and NPV on comparison of Imaging Diagnosis with HPE.

RESULTS

For statistical analysis the average value of the parameters (C+P/2) are taken from the lesion area and are compared with normal liver. Among 50 patients in the study group 26 patients had malignant lesion and 24 patients had benign on histopathology . The most common tumors in these study groups were hepatocellular carcinoma and liver abscess respectively

The CT perfusion parameters were analysed and the mean values of BV, BF, PERM, ALP, PVP & HPI were calculated for the malignant and benign lesions of the Liver

On Comparing the CT perfusion parameters between the malignant and benign liver lesions showed that there is a highly significant increase in BV,BF, PERM, ALP and HPI among malignant versus benign ($p = 0.0005$) whereas the PVP is significantly reduced.($p=0.0005$)

Comparison of the CT perfusion parameters of malignant group versus normal liver parenchyma showed that there is an increase in intralesional BV, BF,

PERM, ALP and HPI among the malignant liver lesion and a relatively reduced PVP.

Comparison of the CT perfusion parameters of the benign lesion group versus normal liver parenchyma showed that there is a slight reduction of intralesional BV,BF, PERM, ALP, PVP among benign lesion group with a slight increase in the HPI

On comparing the perfusion parameters in few common malignant lesions (in these study group)such as hepatocellular carcinoma, metastasis and cholangiocarcinoma versus normal liver parenchyma showed that there is an increase of intra lesional BV, BF, ALP and HPI among these malignant liver lesions with a relatively reduced PVP.

On comparing the perfusion parameters in few common benign lesions(in these study group) such as liver abscess, hydatid cyst versus normal liver parenchyma showed that there is a reduction of intralesional BV, BF, PERM, ALP, PVP and HPI among these benign liver lesions indicating the cystic content of the lesion and in case of hemangioma there is relatively an increase in intralesional BF, ALP and HPI when compared with normal liver parenchyma.

DISCUSSION

Space occupying lesions in the liver can be classified into developmental, neoplastic, inflammatory and miscellaneous. Accurate imaging of the liver is clinically important for the appropriate management of the liver disease so that the various liver lesions can be differentiated and their treatment protocols are formulated accordingly.

Perfusion Computed Tomography (CTP) has a great potential in determining the hepatic and portal blood flow. It offers the advantages of quantitative determination of the lesion hemodynamics thus distinguishing the malignant and the benign process, as well as providing the morphological data.

In this study , we studied 50 patients diagnosed by conventional and contrast enhanced US / CT /MRI with proposed inclusion and exclusion criteria , of which 26 patients were found to have malignant lesion and 24 patients were found to have benign lesion on histopathology . Patients in the study were diagnosed based on biopsy /FNAC and/or surgical excision. Multi-parametric assessment of the malignant and benign lesion was done including assessment of BV , BF ,PERM ,ALP, PVP and HPI.

The aim of this study was to compare the imaging diagnosis of liver lesions (especially the atypical lesions) using CT perfusion parameters with the histopathological diagnosis and to analyse the correlation between CT perfusion parameter values of normal liver parenchyma with various benign and malignant lesions of the liver .

On comparing malignant and benign liver lesions with the CT perfusion parameters according to the results, it was clear that BV, BF, PERM ,ALP and HPI were relatively above the normal reference values (taken from normal liver parenchyma) in patients with malignant lesions and were relatively below the normal reference values (taken from normal liver parenchyma) in patients with benign lesion.

Comparision of the perfusion parameters in few common malignant lesions (in these study group) such as hepatocellular carcinoma, metastasis and cholangiocarcinoma versus normal liver parenchyma showed that there is an increase of intra lesional BV, BF, ALP and HPI among these malignant liver lesions with a relatively reduced PVP.

Comparision of the perfusion parameters in few common benign lesions(in these study group) such as liver abscess, hydatid cyst versus normal liver parenchyma showed that there is a reduction of intra lesional BV, BF, PERM,

ALP, PVP and HPI among these benign liver lesion indicating the cystic contents of the lesion .

Ippolito et al [9] demonstrated that in hepatocellular carcionoma there is increase in BV, BF, ALP, HPI and a reduction in PVP. Sahani et al [14] and Zhu et al [15] **r**eported that HCC demonstrated higher BV, BF, and PERM than the background liver parenchyma on CT perfusion images. In addition to these parameters, HCCs also demonstrated a higher ALP and HPI as they specifically reflect the growth of new unpaired arterial blood vessels and a blood supply most exclusively derived from arterial circulation in HCC nodules which supports the current study.

Early works by Miles et al [10] ,Blomley et al [11] on CT perfusion imaging of liver metastases showed increased ALP in liver metastases, which was confirmed by other investigators. Leggett et al [12] and Reiner et al [13] also reported significantly increased ALP and decreased PVP on CT perfusion imaging in patients of liver metastases when compared with adjacent normal parenchyma.

Tsushima et al [16] and Shi et al [17] also demonstrated increased ALP and HPI with decrease of PVP in apparently normal liver tissue with occult metastases on CT perfusion images, when compared with liver in patients without metastases and

in controls, respectively. These results suggest that CT perfusion may be used to predict the presence of micro-metastases in an otherwise morphologically normal-appearing liver, potentially altering management of patients. All the above mentioned studies are supporting the current study.

Although ALP and HPI can increase in both metastasis and HCC compared with adjacent normal parenchyma, total blood flow and ALP are much higher in HCC than in metastases.

Another interesting finding in this study is that in cases of hemangioma there is increased BV, BF, ALP and HPI. Similar such observation is noted in the malignant liver lesions. However on careful and detailed evaluation it is noted that there is an increase in BV, BF, ALP and HPI at the periphery of hemangiomas as compared with malignant liver lesions like hepatocellular carcinoma and metastasis.

Wang et al.,[18] studied perfusion parameters in hemangiomas and showed increase in ALP at the periphery of hemangioma thus differentiating hemangioma from other malignant hepatic lesions

CONCLUSION

CT perfusion is a non-invasive, quantifiable, and feasible technique allowing quantitative assessment of hemodynamic changes in normal and diseased liver which is difficult to detect accurately with conventional CT.

CT perfusion imaging of the liver provides functional information about the microcirculation of normal parenchyma and can be used to differentiate focal lesions of the liver with the perfusion parameters It is a promising technique for diagnosing primary or metastatic tumors.

CT perfusion imaging of the liver also helps in assessing the efficacy of systemic or local tumor therapy, for predicting early response to anticancer treatments, and for monitoring tumor recurrence after therapy..

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ABBREVIATIONS

US-Ultrasound

CT- Computed Tomography

MDCT-Multi Detector Computed Tomography

MRI-Magnetic Resonance Imaging

CTAP - Computed TomographyArterio Portography

CTHA- Computed TomographyHepatic Arteriography

PET-Positron Emission Tomography

CTP- Perfusion Computed Tomography

RUQ-Right Upper Quadrant

IVC-Inferior Vena Cava

HCC-HepatoCellular Carcinoma

DIC-Disseminated Intravascular Coagulation

ROI-Region Of Interest

BV-Blood Volume

BF-Blood Flow

PERM-Permeability surface area/Permeability

ALP-Arterial Liver Perfusion

PVP-Portal Venous Perfusion

HPI-Hepatic Perfusion Index

MTT-Mean Transit Time

MIP-Maximum Intensity Projection

HPE-Histopathological Examination

n-Sample

PPV-Positive Predictive Value

NPV- Negative Predictive Value

ROC-Receiver Operator Characteristic Curve

C-Centre of the lesion

P-Periphery of the lesion

N-Normal Liver Parenchyma

PATIENT PROFORMA

"THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION"

SI.No :

Name :

Age/Sex :

Occupation :

Address :

Phone no :

Presenting Complaints:

Past H/O:

Clinical Examination :

USG /CT/MRI Findings:

CT Perfusion Interpretation:

Parameters	**ROI-1 Centre of the lesion (C)**	**ROI -2 Periphery of lesion (P)**	**ROI-3 Normal liver parenchyma (N)**
MIP HU			
BV ml/100 ml			
BF ml/100ml/min			
PERM ml/100ml/min			
ALP ml/100ml/min			
PVP ml/100ml/min			
HPI %			

Histopathological Examination :

PATIENT INFORMATION SHEET

We are conducting a study on "**THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION".** A research is underway at the madras medical college on patients with suspected space occupying lesions of liver on USG/CT/MRI .

Patients with suspected space occupying lesions of liver on USG/CT/MRI are evaluated with CT perfusion imaging . CT perfusion parameters are correlated with post operative histopathology for its usefulness in categorising the benign & malignant lesions of the liver especially the atypical lesions as treatment strategies, prognosis and response to therapy depend on accurate diagnosis .

Your cooperation would be valuable to us for the same.

The privacy of patients in the research will be maintained through out the study. In the event of publication or presentation your identity will be kept confidential . Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at anytime.

The result of your study may be intimated to you at the end of the study period or during if anything found abnormal which may aid in management or treatment.

Signature of the investigator Signature of the participant

Dr.Amarnath.S

Date:

PATIENT INFORMED CONSENT FORM

Title of the study**:** "**THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION"**

Name of the Participant: Date :

Age : Sex : ID No:

I have read the information in this form (or it has been read to me).

I have read and understood this consent form and the information provided to me.

I have had the consent document explained to me.

I have been explained about the nature of the study.

I have been explained about my rights and responsibilities by the investigator.

I have been explained that there are no risks associated with my participation in this study.

I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital.

I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent.

I hereby give permission to the investigators to release the information obtained from me as result of participation in this study . I understand that they are publicly presented.

I have understand that my identity will be kept confidential .

I have had my questions answered to my satisfaction.

I have decided to be in the research study.

By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

Name_____

Signature_____

<u>ஆராய்ச்சி ஒப்புதல் கடிதம்</u>

ஆராய்ச்சி தலைப்பு :

<u>“கல்லீரல் கட்டியின் தன்மையையும் அதன் வீரியத்தையும் சி.டி. பர்ப்யூசன் ஸ்கேன் மூலம் அதன் இரத்த உள்ளோட்டத்தை வைத்து கணக்கிடுதல்”</u>

பெயர் :

வயது :

பாலினம் :

இந்த ஆய்வு , சி.டி. பர்ப்யூசன் ஸ்கேன் மூலம் , கல்லீரல் கட்டியின் இரத்த உள்ளோட்டத்தை வைத்து , அதன் தன்மையையும் (சாதாரண கட்டி / கேன்சர் கட்டி / நீர் கட்டி /சீழ் கட்டி) மற்றும் அதன் வீரியத்தையும் அறுவை சிகிச்சைக்கு முன்னரே அறிய உதவும் என்பதை அறிவேன் .

இந்த ஆராய்ச்சியின் விவரங்களும் அதன் நோக்கங்களும் முழுமையாக எனக்கு தெளிவாக விளக்கப்பட்டது . எனக்கு விளக்கப்பட்ட விஷயங்களை நான் புரிந்துகொண்டு எனது சம்மதத்தை தெரிவிக்கிறேன் .

இந்த ஆராய்ச்சியில் பிறரின் நிர்பந்தமின்றி என் சொந்த விருப்பத்தின்பேரில் பங்கு பெறுகின்றேன் .

நான் என்னுடைய சுய நினைவுடனும் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் என்னை சேர்த்துக்கொள்ள சம்மதிக்கிறேன் .

தேதி : **பங்கேற்பாளர்**

கையொப்பம்

ஆராய்ச்சி தகவல் தாள்

"கல்லீரல் கட்டியின் தன்மையையும் அதன் வீரியத்தையும் சி.டி. பர்ப்யூசன் ஸ்கேன் மூலம் அதன் இரத்த உள்ளோட்டத்தை வைத்து கணக்கிடுதல்

மேற்கண்ட ஆராய்ச்சியானது, சென்னை மருத்துவக் கல்லூரியில், அல்ட்ரா சவுண்ட் ஸ்கேன் / சிடி ஸ்கேன் /எம். ஆர். ஐ ஸ்கேன் மூலம் கண்டறியப்பட்ட கல்லீரல் கட்டி இருக்கும் நபர்களிடம் மேற்கொள்ளப்படுகிறது.

அல்ட்ரா சவுண்ட் ஸ்கேன் / சிடி ஸ்கேன் /எம். ஆர். ஐ ஸ்கேன் மூலம் கல்லீரல் கட்டி இருப்பதாக கண்டறியப்பட்ட நபர்கள், சி.டி. பர்ப்யூசன் ஸ்கேன் எனப்படும் பரிசோதனைக்கு உட்படுத்தப்படுவர். அதன் மூலம் பெறப்படும் துப்புகள், ஊசி /சதை டெஸ்ட் / அறுவை சிகிச்சைக்குப் பின்னர் கட்டியின் திசுத்தன்மைகளோடு ஒப்பிட்டுப்பார்க்கப்படும். இந்த தகவல்கள் கல்லீரல் கட்டியின் தன்மையையும் அதன் வீரியத்தையும்_பற்றி அறிய உதவும். கல்லீரல் கட்டியின் தன்மையையும் (சாதாரண கட்டி / கேன்சர் கட்டி / நீர் கட்டி /சீழ் கட்டி) மற்றும் அதன் வீரியத்தையும் முன்னரே அறிவதன் மூலம் அதற்கான சிகிச்சை முறைகளையும், சிகிச்சை பலன்களையும் முன் கணிக்க முடியும். தங்களுடைய பங்களிப்பும் ஒத்துழைப்பும் ஆராய்ச்சி நன்முறையில் வெற்றி பெற பெரிதும் உதவியாக அமையும்.

நீங்களும் இந்த ஆராய்ச்சியில் பங்கேற்க நாங்கள் விரும்புகிறோம் . இந்த ஆராய்ச்சியில் உங்களுக்கு பரிசோதனைகள் செய்து அதன் தகவல்களை ஆராய்வோம் .அதனால் தங்களது நோயின் ஆய்வறிக்கையோ அல்லது சிகிச்சையோ பாதிப்பு ஏற்படாது என்பதையும் தெரிவித்துகொள்கிறோம் .

முடிவுகளை அல்லது கருத்துகளை வெளியிடும்போதோ அல்லது ஆராய்ச்சியின் போதோ தங்களது பெயரையோ அல்லது அடையாளங்களையோ வெளியிட மாட்டோம் என்பதையும் தெரிவித்து கொள்கிறோம் .

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில் தான் இருக்கிறது . மேலும் நீங்கள் எந்நேரமும் இந்த ஆராய்ச்சியிலிருந்து பின்வாங்கலாம் என்பதையும் தெரிவித்துக் கொள்கிறோம் .

இந்த சிறப்பு பரிசோதனையின் முடிவுகளை ஆராய்ச்சியின்போது அல்லது ஆராய்ச்சியின் முடிவின் போது தங்களுக்கு அறிவிக்கப்படும் என்பதையும் தெரிவித்துக் கொள்கிறோம் .

ஆராய்ச்சியாளர் கையொப்பம் **பங்கேற்பாளர் கையொப்பம்**

நாள் :

இடம் :

MASTER CHART

NAME	AGE/SEX	IMAGE DIAGNOSIS	PARAMETERS IN LESION						PARAMETERS IN NORMAL LIVER						HPE
			B.V	B.F	PERM	ALP	PVP	HPI	B.V	B.F	PERM	ALP	PVP	HPI	
datchanamoorthy	65/m	HCC	25	55.6	58	34	6.2	85	5.1	20.8	34.8	7.4	20.6	26	HCC
selvi	50/f	Hydatid cyst ©	3.4	12	28.7	3.9	16	19	5.5	38.4	45.8	6.9	30.1	37	hydatid cyst
nagamma	50 /f	hemangioma	8.2	46	33	20.3	9.1	69	6	24.7	32.9	5.7	24.3	19	hemangioma
geetha	24/f	simple liver cyst ©	2.8	18	26.7	2.9	13	18	11.9	34.2	45.8	14.9	31.1	32	simple liver cyst
balan	32/m	Hydatid cyst ©	4.1	10.5	34	3.4	14.9	18	7	34	45.6	14.2	23.8	37	hydatid cyst
godhavari	51/f	liver abscess ©	2.9	10	27.2	2	18	10	7.2	36.7	39.8	8.8	22.2	28	liver abscess
malarvannan	45/m	cholangiocarcinoma	20	53.5	40	18	4.8	79	13.8	29.2	45.9	13.6	34.4	28	cholangiocarcinoma
vasuki	65/f	HCC	22	50	54.8	30.2	7.9	78	8.7	23.4	43	12.3	30.7	30	HCC
lavanya	29/f	adenoma	10.2	42	33	17	13.1	56	11.2	34.6	34.6	6.2	20.8	22	adenoma
ramesh	41/m	metastasis	14	45	34.2	28.1	8	77	9.6	23.9	45.2	12	38	24	metastasis
vani	34/f	biliary cystadenoma	6	14	26.8	10	18.2	35	10.2	38.9	48.9	11.3	38.7	22	biliary cystadenoma ©
suresh	28/m	liver abscess ©	3.8	12	29	2.9	17.1	15	5.6	28.3	37.9	6.7	24.3	21	liver abscess
babu	45/m	metastasis	18	48.7	48.1	30.1	9	76	11.3	38.6	50	8	32	20	metastasis
ranganathan	62/m	HCC	28.7	58	60	38	5.6	88	11.8	23.5	34.9	6.7	24.3	21	HCC
kala	36/f	HCC	24	48.6	52	29	9.1	76	6.7	28.9	39	7.9	27.1	22	hemangioma
krishnakumar	29/m	simple liver cyst ©	3.4	17	22.3	3.2	17	18	12.9	32.5	34.5	13.8	22.2	38	simple liver cyst
loganayaki	38/f	biliary cystadenoma	8	15.6	30	12	16.3	42	13.3	33	33.9	13.9	27.1	33	biliary cystadenoma ©
sangeetha	52/f	HCC	22.3	46	50	27.2	8	77	8.8	34.7	45.7	5.8	23.2	20	HCC
rani	56/f	metastasis	16	47.8	35.3	30	7.2	81	14.2	24.9	39.8	10.2	34.8	22	metastasis
sugavanesh	32/m	hemangioma	4.8	44	35	22	10	68	14.8	29.5	47.3	7.4	22.6	24	hemangioma
sakthivelu	49/m	liver abscess ©	3.1	10	27.1	2.8	16.2	15	5.7	34.9	49.5	13.4	31.6	29	liver abscess
sivakolundhu	59/m	HCC	28.6	56	42	26.2	6	86	6.9	40	45.2	9.5	22.5	29	HCC
vijay	61/m	metastasis	18	43.8	52.3	32	7	82	7.4	23.7	34.5	13.4	29.6	31	metastasis
chella durai	52/m	cholangiocarcinoma	22.3	52	42	20.8	7.2	74	8.2	28.7	47.9	10.7	32.3	24	cholangiocarcinoma
suganthi	42/f	FNH	6	22	36	7	18	28	11.8	34.5	34.8	8.9	22.1	28	FNH
sivaraman	52/m	HCC	29.1	60	54.8	34.1	5.9	85	12.9	23.6	29.1	7.8	26.2	22	HCC
annamalai	38/m	FLC	20	45	52	20	8	71	6.9	34.5	43.1	11.2	24.8	31	FLC
chockalingam	51/m	hemangioma	4.1	40	46.8	18	8.2	69	9.7	29	31	9.3	25.7	26	hemangioma
rakkamma	78/f	metastasis	20	47.8	56	35.2	9	79	6.9	23.5	43.6	5.6	20.4	21	metastasis
viswanathan	50/m	HCC	20.3	52	58.1	39	7.4	84	13.9	34.8	34.5	11.3	28.7	28	HCC
chitti babu	38/m	liver abscess ©	3.4	11.9	57.9	3.1	15.9	16	12.9	26	45	7.8	22.2	26	liver abscess
vinayagam	61/m	HCC	27	45.7	60	42	10	81	5.6	34.5	34.8	10.5	34.5	23	HCC
kesavan	32/m	FLC	22.4	43	50.2	21.3	9	70	14.2	40.1	39.4	6.7	24.2	20	FLC
kaviarasan	42/m	Hydatid cyst ©	3.8	11.5	22	3.2	15.1	17	8.9	38.9	48.4	7.6	24.4	23	hydatid cyst
vani	45/f	cholangiocarcinoma	25	46.7	38	23	8	74	6.8	20.1	47.3	13.5	25.5	34	cholangiocarcinoma
palani	52/m	metastasis	18.8	22	24.7	17.2	12	59	12.5	23	45.8	9.4	24.6	27	metastasis
pushpa	42/f	hemangioma	12	44.8	38	20	7.9	72	8.3	34.8	45.9	6.5	22.5	22	hemangioma
kasiyammal	48/f	HCC	28	53.6	49.3	32.1	10	76	7.8	31.9	39.3	15.3	34.7	30	HCC
kaviyashree	29/f	FNH	8.7	24	25	10	17.9	36	5.9	28.9	37.2	7.9	25.1	23	FNH
karuppaiah	72/m	metastasis	23.2	47	52	32.2	10	76	6.3	32	34.5	8.4	22.6	27	metastasis
guna	41/m	liver abscess ©	3.7	12.9	31.8	4.9	16.1	23	8.2	27.6	50	11.6	22.4	34	liver abscess
thangam	33/f	adenoma	12	46.5	35	18	12	60	11.9	34	45.3	12.8	40.2	24	adenoma
vigneshwaran	42/m	HCC	32.9	47	50.4	32.8	8.9	79	13.4	27	44.3	13.9	23.1	37	HCC
marakathavalli	56/f	hemangioma	13.8	42	32.8	22.1	7.9	74	14.1	23.5	36.9	8.4	23.6	26	hemangioma
komalavalli	48/f	metastasis	30.1	49.9	42	19.9	5.1	79	7.8	27.8	37.9	9.4	26.6	26	metastasis
sivakumar	54/m	cholangiocarc carcinoma	26.7	53.4	32	27.2	8.2	76	6.7	22.3	45.3	10.5	34.5	23	cholangiocarcinoma
suresh	50/m	HCC	33.9	52.9	48.1	32.8	7.2	82	12.2	34.9	45.9	8.9	32.1	21	HCC
geetha	39/f	Hydatid cyst ©	2.3	12.3	32.8	4.9	15.1	24	3.4	28	44.7	13.5	21.5	38	hydatid cyst
ettiyappan	63/m	simple liver cyst ©	3.4	11.4	43.2	3.4	7.3	30	7.9	34.8	49.3	14.8	26.2	36	metastasis
mani	54/m	liver abscess ©	2.9	16.3	42.8	4.6	14.4	24	11.9	23.7	39.4	8.9	24.12	26	liver abscess

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To
Dr.S.Amarnath
Post Graduate in Radiology
Madras Medical College
Chennai 600 003

Dear Dr.S.Amarnath,

The Institutional Ethics Committee has considered your request and approved your study titled **"THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION " - NO.17022016.**

The following members of Ethics Committee were present in the meeting hold on **02.02.2016** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
2.Dr.R.Vimala,MD.,Dean,MMC,Ch-3	:Deputy Chairperson
3.Prof.Sudha Seshayyan,MD., Vice Principal,MMC,Ch-3	: Member Secretary
4.Prof.B.Vasanthi,MD.,Inst.of Pharmacology,MMC,Ch-3	: Member
5.Prof.P.Raghumani,MS, Dept.of Surgery,RGGGH,Ch-3	: Member
6.Dr.Baby Vasumathi, Director, Inst. of O&G,Ch-8	: Member
7.Dr.K.Ramadevi,MD,Director, Inst.of Bio-Chem,MMC,Ch-3	: Member
8.Prof.M.Saraswathi,MD.,Director, Inst.of Path,MMC,Ch-3	: Member
9.Prof.Srinivasagalu,Director,Inst.of Int.Med.,MMC,Ch-3	: Member
10.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
11.Thiru S.Govindasamy, BA.,BL,High Court,Chennai	: Lawyer
12.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary - Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

" THE VALUE OF PERFUSION CT IMAGING IN SPACE OCCUPYING LESIONS OF LIVER WITH HISTOPATHOLOGICAL CORRELATION "

INTRODUCTION

A discrete abnormality arising within the liver is defined as a space occupying lesion in the liver. Space occupying lesions of the liver can be divided into developmental, neoplastic, inflammatory and miscellaneous.

Currently, there is no consensus concerning the optimal strategy for imaging the liver for space occupying lesions. Various imaging modalities for liver are often used based on the availability of equipment and experience of the radiologists and the requests of referring physicians.

The main goals of liver imaging are to assess:

(1)The number and size of the liver abnormalities

(2) The location of abnormalities relative to the liver vessels

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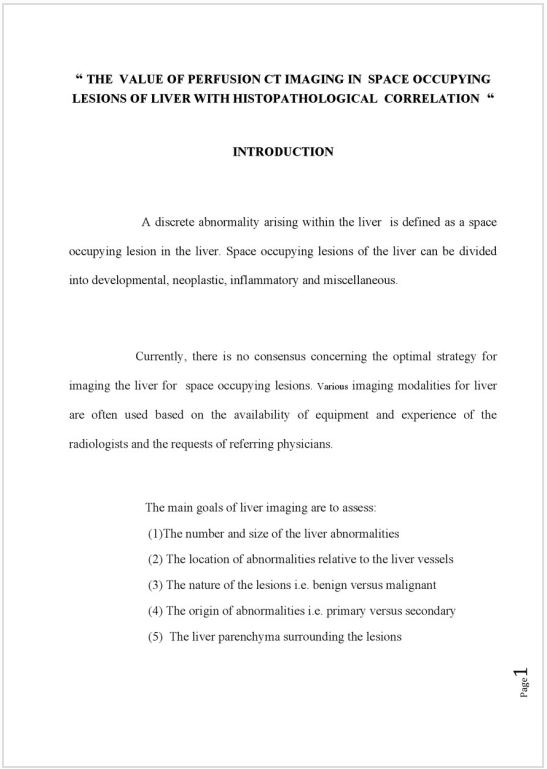

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The main goals of liver imaging are to assess:

(1)The number and size of the liver abnormalities

(2) The location of abnormalities relative to the liver vessels

(3) The nature of the lesions i.e. benign versus malignant

(4) The origin of abnormalities i.e. primary versus secondary

(5) The liver parenchyma surrounding the lesions

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