DISSERTATION ON

THE STUDY OF DENSITY VARIATIONS IN COMPUTED TOMOGRAPHIC IMAGES OF THE LIVER AND ITS CLINICAL IMPORTANCE

Submitted in partial fulfillment of the requirement for the award of the degree of

M.S. ANATOMY
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CERTIFICATE

This is to certify that ***T. Vasantha Kumar*** *PG student of 2004-2007 Batch in the Department of Anatomy, Govt. Stanley Medical College, Chennai-600 001 has done this dissertation on* “**THE STUDY OF DENSITY VARIATIONS IN COMPUTED TOMOGRAPHIC IMAGES OF THE LIVER AND ITS CLINICAL IMPORTANCE**” *under my guidance and supervision in partial fulfillment of the regulation laid down by the Tamil Nadu Dr. M.G.R. Medical University, Chennai for M.S. Anatomy degree examination to be held in March 2007.*

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DECLARATION

I solemnly declare that this dissertation on “**THE STUDY OF DENSITY VARIATIONS IN COMPUTED TOMOGRAPHIC IMAGES OF THE LIVER AND ITS CLINICAL IMPORTANCE**” *was prepared by me in the Department of Anatomy in collaboration with the Department of Radiology, Stanley Medical College and Hospital, Chennai-1 under the guidance and supervision of* ***Dr. Sudha Seshayyan,*** *Professor and HOD, Department of Anatomy, Stanley Medical College, Chennai-1 between 2004-2007.*

This dissertation is submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the University requirements for the award of degree of M.S. in Anatomy.

Place:
Date:

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CONTENTS

AIM OF THE STUDY

Computed tomography has been applied to the liver since the introduction to body imaging. In each instance, the liver has become the organ most often studied in the truncal body, predominantly because the liver is a common site of metastatic disease.

CT techniques to evaluate the liver have advanced during the past decade and undoubtedly will continue to evolve.

CT provides a global view of the upper abdomen in axial sections enabling clear demonstration of the liver anatomy and adjacent structure. The ability to selectively reconstruct small subsets of data retrospectively may allow confirmation of lesions such as cysts. This is done with thinner sections.

For more than 15 years computed tomography (CT) has been widely used for evaluating both focal and diffuse hepatic diseases. It has become established as the imaging method of choice for routine screening of the liver.

CT is the imaging technique of choice for hepatic trauma. It can reliably diagnose and stage significant hepatic and extrahepatic injuries, document interval healing of hepatic injuries, and diagnose early and delayed complications.

The advent of computed tomography has made the cross-sectional study on liver very easy. This has helped the surgeons in planning surgeries more accurately and in a conservative manner.

In this study I have made an attempt, to study the fluctuations in density of computed tomographic images of the liver.

To study the various factors and reason for the fluctuations in the density.

To enable anatomists to assist the clinicians in arriving at a proper diagnosis.

To give first hand information to the students about the fluctuations.

To create a general interest in CT and its advantages.

NORMAL ANATOMY

COMPUTED TOMOGRAPHY

Gross Morphology

The liver is the largest organ in the body lying in the right upper quadrant of the abdomen. Cross sectional CT images readily display most border forming perihepatic structures, including the anterior abdominal wall, posterior diaphragm, right kidney, right colon, stomach, inferior vena cava, and right adrenal gland.

The liver is covered by peritoneum, except for the fossa for the inferior vena cava, the fossa for the gall bladder, and the bare area of the liver, where the posterior surface of the liver comes in direct contact with the diaphragm. This lack of a peritoneal surface against the diaphragm can be used to aid in differentiating the origins of fluid collections. Pleural fluid collections are seen throughout the entire posterior aspect of the posterior perihepatic space, whereas peritoneal fluid stops medially at the bare area of the liver[1].

The shape of the liver is complex, superiorly it is dome shaped, conforming to the undersurface of the diaphragm. This surface is usually smooth, although accessory fissures containing fort and slip of the diaphragm can cause peripheral indentation and scalloping of the liver margin or liver and simulate a peripheral lesion[2]. Inferiorly, the undersurface of the liver is concave and slopes downward to a sharp border.

The complex hepatic shape accounts for the varied appearance of the liver on CT scans obtained at different levels. Sections obtained near the diaphragm reveal that the liver occupies nearly the entire right half of the abdomen. More caudally located images reveal that the volume of the liver gradually decreases, the right lobe becoming indented by the kidney and assuming a more anterior and lateral position.

The gall bladder lies on the visceral surface of the liver in a fossa between the right hepatic lobe and medial segment of the left hepatic lobe. Caudally the gall bladder is located more laterally and anteriorly and at times may reach the anterior abdominal wall or press on the duodenal sweep, colon, or gastric antrum.

The liver is composed of a large right hepatic lobe, a smaller left hepatic lobe, and an anatomically distinct caudate lobe. A total of four intrahepatic fissures define the margins of the intrahepatic lobes and the principal lobar segments.

The left intersegmental fissure contains fat and the ligamentum teres and produces a vertical cleft in the anterior surface of the left hepatic lobe. This fissure separates the medial and lateral segments of the left hepatic lobe.

The fissure of the ligamentum venosum courses obliquely from the posterior aspect of the left intersegmental fissure deeply into the liver anterior to the caudate lobe and contains the two layers of the lesser omentum. It separates the posteriorly positioned caudate lobe from the posterior aspect of the medial and lateral segments of the left hepatic lobe. At its lower end, it comes laterally in front of the papillary process of the caudate lobe to reach the left extremity of the porta hepatis.

The sagitally oriented interlobar fissure separating the right and left hepatic lobes, is approximated by a plane extending from the superior recess of the gall bladder through the fossa of the inferior vena cava. This fissure is an incomplete structure, occasionally present inferiorly above the gall bladder as a fat-filled cleft containing the main portal vein and smaller accompanying portal triad structures. Superiorly, the same vertical plane runs through the plane of the middle hepatic veins, the superior landmark delineating the right and left hepatic lobes[3].

The right intersegmental fissure is ill defined and is best seen by examining hepatic casts; it cannot be visualized directly by computed tomography, because it produces no detectable surface alterations. An approximation of its location may be made by drawing a line that bisects the liver parenchyma between the anterior and posterior branches of the right portal vein and extends superiorly to run in the plane of the right hepatic vein.

Congenital absence of either the right or the left lobe of the liver is a rare anomalous variant without clinical significance, usually with hypertrophy of the contralateral lobe and the caudate lobe[4]. It is important to recognize this variant so as not to mistake the lack of lobar tissue as atrophy from cirrhosis or chronic biliary obstruction, which may have similar apperance[5]. Although in the latter condition, crowded bile ducts and vessels in the atrophied lobe may be a clue to the diagnosis[6]. Another normal structure occasionally mistakes for an abnormal mass, is the inferior process of the caudate lobe, the papillary process. On transverse images below its attachment to the caudate lobe, it may appear separate from the liver and simulate an abnormal, extrinsic mass[7].

An appreciation of the landmarks of the segmental anatomy of the liver is important as an aid for planning surgical resection of malignant liver lesions[8]. Surgical approaches are limited by the fact that there are no functional intersegmental anastomosis for the vascular and biliary channels, thus requiring procedures more extensive than a wedge resection to be performed along intersegmental/ interlobar planes.

Segmental and vascular Anatomy:

Intrahepatic vascular structures are well delineated as enhancing structure following intravenous contrast administration. They also are generally seen on non-contrast enhanced images as slightly hypodense to liver parenchyma. When fatty infiltration of the liver is present, the vessels often have higher attenuation than liver parenchyma, even on non-contrast enhanced scans. Conversely, in severely anaemic patients, the vascular structures can be easily seen as significantly lower in attenuation than the liver parenchyma.

The hepatic veins comprise the efferent vascular system of the liver. The three major hepatic vein trunks - the right, middle and left are routinely displayed as CT as they drain into the inferior vena cava at the posterior superior margin of the liver. The hepatic veins are all intersegmental or interlobar in posterior and provide CT and MR landmarks for distinguishing the segments of the liver.

The right hepatic vein runs in a coronal plan at the superior aspect of the right intersegmental fissure, which separates the anterior and posterior segments of the right lobe, and enters the right lateal margin of the inferior vena cava.

The middle hepatic veins is located at the top of the interlobar fissure separating the right and left hepatic lobes and enters the left anterior aspect of the inferior vena cava.

The left hepatic veins courses in the left intersegmental fissure separting the medial and lateal egments of the left lobe and enters the anterior left parties of the inferior neva cava either alone or after joining with the middle hepatic vein[9].

Smaller accessory veins may also enter directly into the inferior vena cava. The caudate lobe drains separately in multiple short hepatic veins emptying directly into the inferior vena cava from the posterior margin of the caudate lobe[10].

The main portal vein extends in a relatively straight course from its retropancreatic origin at the influence of the superior mesenteric vein and splenic vein, through the hepatoduodenal ligament (free edge of the lesser omentum) at the anterior margin of the inferior vena cava, and into the porter hepatis, where it bifurcates into the right and left portal vein[11]. The main hepatic artery and the common hepatic and bile ducts also course within the hepatoduodenal ligament and lie anterior to the main portal vein.

At its origin the initial portion of the left portal vein, or pars transversa, extends anteriorly, leftward and cranially over the anterior surface of the caudate lobe, giving off small caudate lobe branches. At the left intersegmental fissure, the left portal vein turns sharply cranially and ascends as the second portion, or umbilical segment, of the left portal vein within the left intersegmental fissure. The umbilical segment gives horizontal branches to the medial and lateral segments of the left hepatic lobe.

The undivided right portal vein courses rightward and cranially, giving several small caudate lobe branches. Within the substance of the right hepatic lobe, the right portal vein divides into anterior and posterior branches that supply the corresponding segments of the right hepatic lobe.

Unlike the hepatic venous trunks, which course between segments, the portal veins branches run within segments. The angulations of the venous branches relative to the axial plane appears to determine the likelihood of visualization of these, vessels on transverse CT images. Horizontally oriented vessels (right portal vein) and vertically oriented vessels (right hepatic vein, inferior vena cava, and the umbilical segment of the left portal vein) are more readily identified on axial CT sections, than are obliquely directed vessels (middle hepatic veins and pass transversa of the left portal vein).

The proper hepatic artery usually arises from the celiac axis, continues as the common hepatic artery after giving rise to the gastroduodenal artery, and branches into the right and left arteries in the porta hepatis. Within the hepatoduodenal ligament, the artery lies anterior to the portal vein and medial to the common hepatic duct. Unlike the proximal portal veins, the initial hepatic arterial trunks display considerable variability in their origins and proximal course.

In upto 45 percent of cases, anomalous origins of the common, left and other hepatic arteries are present with replacement either to the superior mesenteric or left gastic arteries. Smaller intra hepatic arteries are identified only infrequently as they course in the portal triad. As with the portal venous system, every distal hepatic artery supplies a definite hepatic segment and courses within the segment parenchyma.

The intra hepatic peripheral bile ducts course in the portal triad with the portal veins and hepatic arteries. The high resolution CT scanners allows visualization of intrahepatic biles ducts on CT in upto 40 percent of patients. Therefore the mere presence of small intrahepatic ducts on CT does not indicate biliary obstruction[12]. These small intrahepatic bile ducts typically measure 1 to 3 mm in diameter and out seem adjacent to contrast enhancing portal venous radicals. The course of these structures is toward the line hilus, where the right and left hepatic ducts are usually visualized. These two main bile ducts exit from the liver and joints in the right side of the porta hepatis to form the common hepatic duct.

HEPATIC PARENCHYMA:

The CT attenuation measurements of normal adult livers vary between 38 and 80 Hounsfield unit (H) on non-contrast-enhanced images[13]. However, the range in the individual patient is much narrower, causing the normal liver to appear relatively homogeneous. The broad range of reported heportic CT numbers is largely the result of attenuation values being obtained on different CT scanners, using different scanning energies and methods of calibration. In addition, varying amounts of liver glycogen in fasting and recently fed patients may affect hepatic CT attenuation values[14] and CT numbers vary with variations in fat content.

The non-contrast enhanced liver parenchyma has a higher density than that of the pancreas, kidneys or spleen. The average liver-spleen difference is 7 to 8H, with high normal hepatic CT numbers always associated with high normal splenic attenuation values; the converse is also true. The relatively higher attenuation value of liver parenchyma compared with other organs is a result of the high concentration of glycogen within the liver[15].

Usually the hepatic parenchyma has a greater attenuation than that of blood, and the portal and hepatic venous systems are seen as lower attenuations branching structures within the liver on non-contrast-enhanced CT scans. Delineation of the status of the intrahepatic biliary tree is difficult without the use of intravenous contrast to enhance the liver parenchyma and portal vascular structures, allowing for accurate evaluation of the bile ducts, which remain near water density.

REVIEW OF LITERATURE

Detections of hepatic abnormalities by computed tomography is dependent on differentiating normal from pathologically altered hepatic tissue. Abnormalities in hepatic contour may permit detection of hepatic disease, but most abnormalities are identified on CT by visualizing regions of altered hepatic density. Generally, a difference of at least, 10H between the abnormal and normal regions of liver must be present for accurate detection of liver lesion.

FOCAL DECREASED ATTENUATION MASSES IN THE LIVER:

Disease entities with decreased attenuation mashes in the liver are,

Cyst:

Simple cyst:

Murphy BJ et al[16] has stated that non-parasitic cysts of the liver are most commonly congenital, although they may be secondary to previous inflammation or trauma. A non-parasitis cyst appears on CT san as a sharply delineated, round or oval, near-water attenuation lesion with an imperceptive or thin smooth wall and no septation or internal structures[16]. Although some necrotic meastases, abscess, and chronic hematoma may have near - water attenuation values, only a simple cyst has no enhancement of the wall after contrast administration. The attenuation value of cysts range from 0 to 15H.

ii) Polycystic Liver Disease:

Multiple low-attenuation cysts of various sizes and without contrast enhancement can be detected in the livers of about one third of patients with adult polycystic kidney disease. Although pathologically identical to simple liver cysts, the cysts in polycystic liver disease occasionally have calcification in their walls and more frequently contain blood and fluid levels.

ABSCESS

i) Pyogenic Abscess:

Jeffrey R.B. et al[17] has stated that on CT scans, pyogenic abscess typically appear as relatively well-defined homogenous areas with an attenuation value that usually is greater than that of a benign cyst but lower than that of a solid neoplasm[17]. Most have a peripheral rim or capsule of contrast enhancement. In some cases, several small abscess appear to aggregate in a pattern that suggests coalescence into a single large cavity (cluster sign). The presence of central gas in a low-attenuation hepatic mass, either as air bubbles or an air-fluid level, is a specific sign of an abscess but occurs in fewer than 20% of cases.

ii) Amoebic abscess:

Radin DR et al[18] noted that two development of a liver abscess is the most common extra-colonic complication of amoebiasis, occurring in about one third of patients with amoebic dysentery. About two thirds of amoetic liver abscess are solitary. Most amoebic liver abscesses are located in the posterior portion of the right lobe.

The CT appears of amoebic abscesses is variable and non-specific. Generally, an amoebic abscess presents as a sharply defined, homogeneous area having an attenuation that usually is greater than that of a benign cyst but lower than that of a solid neoplasm.

Iii) Fungal Abscess:

Fungal abscesses usually occur in immunocompromised patients and have became increasingly prevalent in patients who have AIDS and in patients with lymphoma and leukemia who are treated with intensive chemotherapy. The classic CT appearance of fungal abscess is multiple small, round, law-attenuation lesions that are diffusely scartted in a somewhat uniform pattern throughout the liver (and spleen). Rarely, some lesions have a central focus of higher density (thought to represent hyphae) that produces a target appearance.

Echinocorcal cyst

Pandolfo I et al[19] stated that echiococcal (hydatid cyst) disease present on CT as unilocular or multilocular well-defined, low attenuation cysts with thin or thick walls[19]. Daughter cysts generally appears as areas of even lower attenuation that typically are located in the periphery of the larger mother cyst. Because daughter cysts frequently float free in the lumen of the mother cyst alteration of the patients position during scanning can demonstrate a change in position of the daughter cysts, a virtually pathognomonic sign of hydatid disease.

Dense calcification may occur either peripherally or centrally within septations. Gas may form in the cyst because of superimposed infection or communication with the intestinal lumen through the bile duct. The rare finding of a fat-fluid level in an echinococcal cyst has been reported as an indication of communicating rupture into the biliary tree.

HEMANGIOENDOTHELIOMA

Lucaya J, Enriquely G, Amat L[22] state that on non-contrast CT scan, hemangioendotheliomas appear as single or multiple well-demarcated masses of decreased attenuation. After bolus injection of contrast material, early peripheral enhancement of the lesion is seen. On delayed scans, a variable degree of centripetal enhancement is shown and may became completely isodense with normal liver.

This tumour of vascular origin usually becomes clinically evident before 6 months of age and is the most common hepatic lesions producing symptoms during infancy.

HEPATOCELLULAR CARCINOMA

Ros PR Murphy BJ, Buck JL[23] reveal that this primary malignant tumour of the liver most frequently produces single or multiple low-attenuation masses on non-contrast CT. In Asia, the disease is more prevalent and it may be associated with parasitic infestation. Most hepatocellular carcinomas are hypervascular and characteristically show rapid wash-in and wash-out on dynamic studies. The presence of an tumour capsule and mosaic appearances are often observed[23].

OTHER MALIGNANT TUMOURS:

Most primary malignant tumors of the liver appear as low attenuation masses on non-contrast CT scan and show enhancement after contrast administration. Fibrolamaellar carcinoma often contains an area of decreased attenuation corresponding to the central scar. Intra hepatic cholangio carcinoma typically appears as a homogeneous low-attenuation mass[25] that may have small satellite nodules.

Angiosarcomas classically arise in a liver that demonstrate the homogeneous or reticular pattern of thorotrast deposition in the liver they appear as single or multiple masses that are predominantly of low attenuation.

Hepatic AIDS related Kaposi's sarcoma produces multiple small nodules of low attenuation on non-enhanced and dynamic contrast-enhanced CT scans[26]. Because the vascular spaces within the tumour are slow both to fill with contrast and to clear it, on delayed images Kaposi's sarcoma may demonstrate prolonged enhancement relative to the surrounding liver parenchyma.

METASTASES

Katyal S and colleagues[27] have demonstrated that the Ct appearance of metastases generally correlates with the degree of vascularities of the tumour. Most metastases of the liver appear as single or (more commonly) multiple low-attenuation masses on non-contrast Ct scans.

Amorphous punctuate deposit of calcification in an area of diminished attenuation may be seen in metastases from mucin-producing tumour of the stomach or colon[27]. Metastases may rarely have an attenuation value higher than that of liver parenchyma because of diffuse calcification, recent haemorrhage, or fatty infiltration of surrounding hepatic tissue.

CIRRHOSIS:

Cirrhosis can result from a variety of causes and results in morphologic changes seen at CT. the fibrous deposition with nodular regeneration of liver parenchyma results in distortion of the normally smooth liver architecture and often results in a grossly nodular appearance to the liver.

In the study, by Harbin et al[28], CT demonstrates characteristic morphologic appearances to the liver. These typically reflect a nodular appearance to the contour of the liver, often with atrophy of the right lobe, and hypertrophy of the caudate lobe and lateral segment of the left lobe.

HEPATIC INFARCTION

Because of the liver's dual blood supply (hepatic artery, portal vein) and the tolerance of hepatocytes for low levels of oxygen, hepatic information is relatively uncommon. Hepatic infarcts typically appear on CT scans as well circumscribed, peripheral, wedge shaped areas of low attenuation that are best seen on contrast - enhanced images. At times, hepatic infarcts may have a round or oval configuration and be centrally located.

HYPERENHANCING FOCAL LIVER LESIONS ON CONTRAST-ENHANCED COMPUTED TOMOGRAPHY

Haemodynamics of contrast material is a key to the diagnosis of focal liver lesions. Lesions with arterial dominant vascularity show brisk enhancement during the arterial dominant phase (20 to 30 seconds after contrast injection), whereas those with portal veins blood supply can appear as hyperenhancing lesions in the portal veins dominant phase (60 to 70 seconds after contrast injection). Moreover, some lesions with dense fibrous stroma show persistent inhancement in the equilibrium phase (2 to 5 minutes after contrast injection.

HYPERENHANCING LIVER LESIONS IN THE ARTERIAL PHASE

Hepatocellular carcinoma

Itai Y, et al[29] in his study stated that in the early arterial phase after contrast administration, non-necrotic areas of an hepatocellular carcinoma appear hyperdense, as does any enhancing capsule. However, this is generally a transient phenomenon, and the lesion rapidly becomes isodense or hypodense, infrequently, these tumours persist as hyperenhancing lesions during the portal vein phase.

HYPERVASCULAR METASTESES

Foley WD, Jochem RJ[31] state that metastases that are hyperdense during the arterial phase are uncommon lesions that usually reflect a hypervascular underlying tumour. The differential diagnosis of hyperintense metastases includes carcinoid, melanoma, pancreatic islet cell tumour, hypernephroma, pheochromocytoma, choriocarcinoma and carcinoma of the breast and thyroid. These hypervascular metastases generally become isodense with liver before the equilibrium phase begins. Therefore, patients with these primary neoplasms should always undergo multiphasic contrast CT studies to avoid missing a metastatic liver lesion.

HYPERENHANCING LIVER LESIONS IN THE PORTAL VEIN AND/OR EQUILIBRIUM PHASES

Valls C et al[30] observed that although typically hyperenhancing during the arterial phase, hemangioma, hepatocellular carcinoma, and focal nodular hyperplasia may show increased contrast enhancement relative to surrounding liver parenchyma during the portal vein phase (or equilibrium phase, in the case of hemangioma).

Solitary fibrous tumours is an unusual neoplasm of mesenchymal origin that typically affects the pleura. Several cases have been reported of liver involvement in which this highly vascular tumour demonstrated heterogeneous and amorphaous contrast enhancement during the portal vein phase and striking hyperenhancement in the equilibrium phase.

Angiolipoma is a rare benign lipomatous tumour that may show globular or linear areas with strong enhancement within a hypodense mass on CT scans obtained during the portal vein phase.

In cases of obstruction of the superior vena cava, venous collaterals to the inferior vana cava may be detected on portal vein phase CT as geographic areas of liver parenchyma with intense opacification (hot-spot lesion), or pattern mimicking hypervascular lesion such as hemangioma.

Cholangiocrcinoma characteristically shows hyperenhancement in the equilibrium phase, related to slow diffusion of contrast material to the extensive fibrous stroma of the tumour. A similar mechanism also accounts for the delayed hyperenhancement in inflammatory pseudotumour, a rare liver tumour consisting of a proliferation of inflammatory cells, spindle cells and fibro elastic tissue, occasionally, intense desmoplastic changes in and around liver metastasis in patients treated with systemic chemotherapy can produced lesions that are densely hyperenhancing during the equilibrium phase.

GENERALIZED ABNORMAL ATTENUATION OF THE LIVER

Disease entities with increased attenuation:

Haemochromatosis:

Haemochromatosis is a disorder in which excessive deposition of iron in body tissues leads to fibrosis and dysfunction of the involved organs. Primary haemochromatosis is an inherited condition in which there is excessive intestional absorption of iron. Secondary haemochromatosis primarily develops in patients who have higher iron intake (multiple blood transfusions or prolonged consumption of medicinal iron) or chronic hemolytic anaemia.

Foley Wd, Jochem RJ[31] stated that the liver is the first organ to be damaged in hemochromotosis, and hepatomegally is present in almost all symptomatic cases. On non-contrast CT scans, the attenuation of the liver parenchyma is homogeneously increased. The normal hepatic and portal veins stand out in bold relief as prominent low attenuation structures against the background of the diffusely hyperdense liver. Interruption of the diffuse increase in parenchymal attenuation can be seen with malignant involvement of the liver, either by metastases or by hepato cellular carcinoma (a known complication of hemochromatosis).

GLYCOGEN STORAGE DISEASE

Doppman J L et al[33] observed that in these autosomal genetic disorder, various enzymatic defects leads to abnormalities in carbohydrate metabolism. The most common type affecting the liver is Von Gierke’s disease (Type I). In this condition, a deficiency of glucose-6-phosphatase in the liver and kidneys leads to excessive deposition of glycogen in the hepatocytes and proximal renal tubules.

The CT findings in Von Gierke’s disease can reflect either of two conflicting processes occurring in the liver. When excessive glycogen storage predominates, there is generalized increase in the attenuation of the liver. When fatty infiltration is more prominent, the hepatic parenchyma has a diffusely decreased attenuation. At times, the areas of fatty infiltration are non homogeneous. In such cases, foci of normal hepatic parenchymal attenuation scattered throughout the liver may be difficult to distinguish from malignant disease.

DISEASE ENTITIES WITH DECREASED ATTENUATION:

Fatty Infiltrations:

Gale ME et al[36] stated that regardless of the precise underlying toxic, ischemic, or infectious, insults, diffuse fatty, infiltration results in a generalized decreased in the attenuation value of the liver on non-contrast CT scan. In normal persons, the mean liver CT number is never lower than that of the spleen, whereas in fatty infiltration the hepatic density is much lower. In fatty infiltration, the portal and hepatic veins commonly appear as high-attenuation structures surrounded by a background of low density caused by the excessive hepatic fat (the reverse of the normal pattern of portal and hepatic veins as low-density channels coursing through the liver). When fatty infiltration of the liver is due to cirrhosis, there often is prominence of the caudate lobe associated with shrinkage of the right lobe.

AMYLOIDOSIS

Hepatic infiltration and enlargement is a common finding in patients with systemic amyloidosis, although significant liver disease rarely occurs.

Suzuki et al[38] stated that diffuse hepatic involvement may produce a generalized pattern of decreased attenuation throughout the liver. More commonly, amyloid deposits appear as discrete areas of low-attenuation within an enlarged liver.

MATERIALS AND METHODS

This study of computed tomography attenuation variation of liver was done at the Department of Anatomy, Stanley Medical College, Chennai-1.

Venue of study:

1. Department of Anatomy, Stanley Medical College, Chennai-1.

2. Department of Radiology, Stanley Medical College, Chennai-1.

METHOD OF SELECTION

Sixty patients who visited Stanley Medical College hospital at various periods of time with complaints of pain in the right hypochondrium were selected for this study. There was no age criteria and the patients were in all age groups.

INSTRUMENT USED:

Toshiba - Asteion spiral CT scanner

TSX - O21A series

Omnipaque - Iodinated contrast material.

METHOD OF STUDY

- Noncontrast study
- Contrast study

PATIENT PREPARATION

All patients were asked not to take anything by mouth from the previous night and were asked to come on empty stomach.

Bowel preparation was done with Bisacodyl suppositories on the day of examination.

The patients were advised to take small amounts of water at regular intervals. Taking small amounts of water at desired intervals allowed to keep the patient hydrated.

NONCONTRAST STUDY

Patients were asked to lie down supine. Then serial axial section were taken. Exposure level 120-135 k.volts.

This exposure level was adjusted according to the build of the patient.

Upper most sections were taken from the level of the diaphragm and the study completed at the level of the inferior surface of the liver.

For some patients (as in secondaries) the study was extended to the whole abdomen.

Couch movement fixed at 10 mm and thickness of slice fixed at 10mm.

Reconstruction done when required at 5mm interval.

CONTRAST STUDY

The patients were selected after enquiring for allergy to iodinated contrast material and other history of Asthma and renal failure ruled out.

20ml of iodinated contrast mixed to one litre of water and given to the patient by mouth at frequent intervals to opacify the bowel.

100-150ml (hundred to hundred and fifty milli litre) omnipaque was given through the intravenous route, 2-3ml/second as bolus injection.

Then 10 mm (millimeter) interval axial section images were taken starting at 70 seconds after the injection and completed at 100 seconds.

Then reconstruction at 5mm (5 millimeter) interval done as and when required.

In this method the lesion detected in plain (non contrast) study was evaluated for their type of enhancement.

OBSERVATIONS

I. ***A well defined hypodense lesion with rounded contour seen in the right lobe of the liver.***

Density of the lesion varies from 8-13 Hounsfiled units.

On contrast administration non enhancement was noted.

II. ***A homogenous well defined hypodense rounded lesion seen in the right lobe of the liver. The lesion was without any intralesional septation.***

There was no evidence of wall calcification

Density of the lesion varies from 16-24 Hounsfield units.

On contrast administration the wall shows enhancement of more than 20 Hounsfield units from the noncontrast value.

III. ***Multiple hypodense lesions of varying sizes and shapes were seen occupying both the lobes of the liver.***

The above lesions were with density variations from 20-28 Hounsfield units.

No evidence of solid elements seen.

No evidence of calcification seen.

Post contrast images showed wall enhancement of 15 Hounsfield units more than that of non-contrast study.

IV. ***A well defined rounded hypodense lesion with multiple septations was seen in the right lobe of the liver.***

The density of the lesion varies from 19-32 Hounsfield units.

The lesion does not show any solid contents.

There was no evidence of calcification.

In post contrast images the wall and septations showed enhancement of more than 20 Hounsfield units.

V. ***The liver contour showed nodularity***

Density of the liver varies from 65-80 Hounsfield unit.

The size of the liver was decreased. The caudate lobe was enlarged in size.

The ratio of caudate lobe: right lobe was one.

On contrast administration non homogenous enhancement was noted.

Evidence of free intraperitoneal fluid was noted.

VI. A relatively ill defined inhomogenous lesion was seen.

The lesion had a density variation of 30-68 Hounsfield units.

There was no evidence of calcification.

No evidence of vascular invasion was seen in non-contrast study. The above findings were seen in a child aged 6 years.

In this case contrast study could not be performed as the child had contraindication for contrast study.

VII. A well defined relatively homogenous hypodense lesion occupying the left lobe of the liver was seen.

The lesion was capsulated with rounded margin.

The density varies from 40 to 75 Hounsfield units.

There was no evidence of calcification.

No evidence of necrosis was seen.

On contrast administration the lesion showed good enhancement. The variation was 60-90 Hounsfield units.

VIII. ***Multiple hypodense lesion of varying size and shapes were seen occupying both the lobes of the liver***

The density variation ranges from 30 to 50 Hounsfield units.

There was no evidence of calcification.

No evidence of necrosis was seen.

On contrast administrative a relatively homogenous mild enhancement of the lesion was seen.

The density range was 40-62 Hounsfield units. The liver showed usual enhancement.

IX. ***Multiple hypodense lesions of varying sizes and shapes which are relatively hemogenous in density were seen.***

Density variation shows a range of 35-45 Hounsfield units.

No evidence of necrosis was seen.

No evidence of calcification was seen.

There was no evidence of vascular invasion.

On post contrast images there was normal opacifications of portal and hepatic veins.

The lesion shows mild hemogenous enhancement.

Remaining normal parenchyma of the liver showed good enhancement.

X. There was two calcific lesions seen in the right lobe of the liver.

Density of the lesion varies from 160-200 Hounsfield units.

One lesion shows central hypodense area of density 30-40 Hounsfield units.

The post contrast images showed no significant variations in the density of the lesions.

The remaining normal liver parenchyma shows normal enhancement.

XI. Linear hypodensities seen in both the lobe of the liver which are consistent with intra hepatic biliary radicles.

Confluence of both hepatic ducts were not visualized.

Common hepatic duct region shows ill-defined osodense lesion.

The density range is 60-75 Hounsfield units.

On postcontrast images the lesion is isoattenuating with that of the normal liver.

XII. The liver appears homogenous.

- The size, shape and contour of the liver appears normal.
- No specific lesion is visualized.
- Computed Tomographic attenuation measures between 38 and 80 Hounsfield units.
- No evidence of calcification seen.
- No evidence of necrosis seen.

Observation of the following patients had features of the some of the observations of the above listed.

a) ***Observations of seven of the patient had the following features:***

- A homogenous well define & hypodense lesion rounded in shape seen.
- No intra lesional septation was found.
- No evidence of wall calcification.
- Density of the lesion varied from 14-26 Hounsfield units.
- On contrast administration the wall showed enhancement of more than 20 Hounsfield units from the non-contrast value.
- These above findings were similar to observation II.

b. ***Three patients had the following features in the observations***

- Multiple hypodense lesions of varying sizes and sharpes seen occupying both the lobes of the liver.
- Density varied from 20-30 Hounsfield units.
- No evidence of calcification seen.
- No evidence of solid elements seen.

- Post contrast images showed wall enhancement of 15 Hounsfield units more than that of non-contrast study.

- These above findings were similar to observation III.

c. ***The following features were observed in three of the patients:***

- Well defined rounded hypodense lesion with multiple septation were seen in the right lobe of the liver.

- Density varied from 18-34 Hounsfield units.

- The lesions did not show any solid contents.

- No evidence of calcification was seen.

In post contrast images the wall and septations showed enhancement of more than 20 Hounsfield units.

These findings were similar to observation IV.

d) ***Six patients had the following features as observation:***

- Liver contour showed nodularity.

- Density of the liver varied from 55-75 Hounsfield units.

- The size of the liver was decreased. Caudate lobe was enlarged in size.
- Caudate lobe: right lobe ratio was 1 (one).
- On contrast administration inhemogenous enhancement noted.
- Evidence of free intraperitoneal fluid was noted.

These features were similar to observation V.

e) *The following features were observed in eight patients*

- A well defined relatively hemogenous hypodense lesion seen.
- Lesion was capsulated with rounded margin.
- Density variation was 42-77 Hounsfield units.
- No evidence of calcification seen.
- No evidence of necrosis seen.
- On contrast administration the lesion showed good enhancement.

- The variation was 60-90 Hounsfield units.

The above features were similar to observation VII.

F) The following features were observed in eleven patients

- Multiple hypodense lesions of varying sizes and shapes seen.
- They were relatively homogenous.
- Density variation range 35-47 Hounsfield units.
- No evidence of calcification seen.
- No evidence of necrosis seen.
- There was no evidence of vascular invasion.
- On post contrast images there was normal opacification of portal and hepatic veins.
- The lesions showed mild homogenous enhancement.
- Remaining normal parenchyma of the liver showed good enhancement.

The above features observed were similar to observation IX.

g) Observation of seventeen patients had the following features:

- The liver appeared homogenous.
- The size, shape and contour of the liver appeared normal.
- No specific lesion was visualized.
- Computed tomographic attenuation measured between 38 and 80 Hounsfield units.
- No evidence of calcification seen.
- No evidence of necrosis seen.

The above features observed were similar to observation XII.

The above observations were done at the Department of Radiology, Stanley Medical College, Chennai-1.

All the patients of various age groups were observed at different periods of time.

DISCUSSION

Computed tomography has been widely used for evaluating both focal and diffuse hepatic diseases. It has become established as the imaging method of choice for routine screening of the liver.

CT provide a global view of the upper abdomen in axial sections. This enables clear demonstration of the liver anatomy and adjacent structures.

CT is a very good method of deciding whether a mass is present. It may be possible to predict the nature of the mass, as for example with cysts or haemangiomas. Sometimes, the diagnosis can be suggested, as in the case of multiple metastases, but frequently the definitive diagnosis depends on biopsy.

Murphy BJ et al has stated that a non-parasitic cyst appears on Ct scans as a sharply delineated round or oval near water attenuation lesion with an imperceptible or thin smooth wall and no septations or internal structures. A simple cyst has no enhancement of the wall after contrast administration.

A well defined hypodense lesion with rounded contour was seen in the right lobe of the liver in observation I. Density varies from 8-13 Hounsfield units. On contrast administration no enhancement was noted.

There features were consistent with simple liver cyst.

Jeffery R.B. et al has stated that on CT scans pyogenic abscess typically appear as relatively well-defined homogenous areas with an attenuation value that usually is greater than that of a benign cyst but lower than that of a solid neoplasms.

Most have a peripheral rim or capsule of contrast enhancement.

A homogenous well defined hypodense rounded lesions seen in the right lobe of the liver without intralesional septation was featured in observation II. Density of the lesion varies from 16-24 Hounsfield units. No evidence of wall calcification.

On contrast administration the wall showed enhancement of more than 20 Hounsfield units from the non-contrast value.

These features were consistent with liver abscess. This case was proved to be bacterial liver abscess in pathological examination.

Radin DR et al noted that the CT appearance of amoebic abscesses is variable and non specific. Generally, an amoebic abscess presents as a sharply defined, hemogenous area having an attenuation that usually is greater than that of an benign cyst but lower than that of a solid neoplasm. Rim enhancement mimicking a necrotic neoplasm often occurs.

About two thirds of amoebic liver abscess are solitary. The remainder are multiple but often coalese into a single large liver abscess.

Multiple hypodense lesions of varying sizes and shapes occupying both the lobes of the liver were seen in observation III.

Density variation from 20-28 Hounsfield units.

No evidence of solid elements was seen.

No evidence of calcification was seen.

Post contrast images showed wall enhancement of 15 Hounsfield units more than that of non contrast study.

These features are suggestive of multiple liver abscesses. This was proved to be amoebic liver abscess in pathological examination.

Pandorfo I et al has stated that hydatid cyst (Elinococcal cyst) presents on Ct as unilocular or multi-locular, well-defined, low-attenuation cysts with thin or thick walls. Daughter cysts appear as areas of even lower attenuation that typically are locate in the periphery of the larger mother cyst. Dense calcification may occur either peripherally or centrally within septation.

A well defined rounded hypodense lesion with multiple septations seen in the right lobe of the liver was observed in observation IV.

Density varied from 19-32 Hounsfield unit. The lesion does not show any solid contents.

No evidence of calcifications seen.

In post contrast images the wall and septation showed enhancement of more than 20 Hounsfield units.

These features are consistent with hydatid cyst liver liver. Pathology proved the same.

In the study by Harbin et al CT demonstrates characteristic morphologic appearances to the liver. These typically reflect a nodular appearance to the contour of the liver, often with atrophy of the right lobe, and hypertrophy of the caudate lobe and lateral segment of the left lobe.

The liver contour showed modularity in more than fine cases in observation V.

Density of the liver varied from 65-80 Hounsfield units.

The size of the liver decreased.

Caudate lobe enlarged in size.

Caudate lobe: right lobe ration is 1 (one).

On contrast administration in hemogenous enhancement noted.

Evidence of free intra-peripheral fluid noted.

These features are consistent with cirrhosis of the liver.

Lucayar J et al observed that an non-contrast CT scans, hemangioendotheliamas appear as single or multiple well-demarcated masses of decreased attenuation. After bolus injection of contrast material, early peripheral enhancement of the lesion is seen. On delayed scans, hemangioendotheliomas show a variable degree of centripetal enhancement and may become completely isodense with normal liver.

A relatively ill defined inhemogenous lesion with density variation of 30-68 Hounsfield units in a child aged 6 years was seen in observation VI.

No evidence of calcification was seen.

No evidence of vascular invasion seen in non contrast study.

In this case contrast study could not be performed, as the child has contra indication for contrast study.

This observed image showed features consistent with haemangio endothelioma.

Ros PR et al stated that hepatocellular carcinoma, a primary malignant tumour of the liver most frequently produces single or multiple low attenuation masses on non contrast CT. The appearance of hepetocellular carcinoma often contrast administration depends on the vascularity of the tumour. Most hepato cellular carcinoma are hypervascular. The presence of a tumour capsule and mosaic appearances are often observed.

However, some hepatocellular carcinomas (usually well-differentiated) are hypovascular and minimal contrast enhancement.

A surrounding capsule that appears as low attenuation as non-contrast scans may exhibit prolonged contrast enhancement.

i) A well defined relatively hemogenous hypodense lesions with capsulated rounded margin was seen in observation VII occupying the left lobe of the liver.

- Density variation from 40-75 Hounsfield units.
- There was no evidence of calcification.
- No evidence of necrosis seen.
- On contrast administration the lesion shows good enhancement, the variations is 60-90 Hounsfield units.

The above features are consistent with hepatocellular carcinoma.

ii) Multiple hypodense lesions of varying sizes and shapes seen occupying both lobes of liver, was features in observation VIII.

- Density variation ranging from 30-50 Hounsfield units.
- There was no evidence of calcification.
- No evidence of necrosis.

On contrast administration relatively, homogeneous mild enhancement of the lesion, density range of 40-62 Hounsfield units. The liver shows visual enhancement.

The above features are consistent with multicentric hepatocellular carcinoma.

Katyal S and colleagues have demonstrated that the CF appearance of metastases generally correlated with the degree of vascularity of the tumour. Most metastases of the liver appear as single or (more commonly) multiple low-attenuation masses on non-contrast CT scans. Because they typically are hypovascular, most metastases are more easily distinguished from adjacent normally enhancing hepatic parenchyma after contrast administration.

Rim enhancement of a hypodense metastasis represents a vascularised viable tumour periphery contrasted with a hypovascular or necrotic center.

Amorphous punctuate deposits of calcification in an area of diminished attenuation may be seen in metastases from mucin-producing tumour of the stomach or colon. Metastases may rarely have an attenuation value higher than that of liver parenchyma because of diffuse calcification, recent haemorrhage, or fatty infiltration of surrounding hepatic tissue.

i) Multiple hypodense lesions of varying sizes and shapes which are relatively homogenous were seen in observation IX density variation range 35-45 Hounsfield units.

- No evidence of necrosis.
- No evidence of calcification.
- There was no evidence of vascular invasion.

On post contrast images there was normal opacification of portal and hepatic veins. The lesion shows mild homogenous enhancement. Remaining normal parenchyma of liver shows good enhancement.

The above features are consistent with secondaries liver. The patient was a proved case of rectal carcinoma.

ii) Two calcific lesion were seen in the right lobe of the liver in observation X.

Density of the lesion varies from 160-200 Hounsfield units.

One lesion shows central hypodense area of density 30-40 Hounsfield units.

The post contrast images show no significant variations in the density of the lesion. The remaining normal liver parenchyma shows normal enhancement.

The patient was a known case of carcinoma colon. These above imaging features with the given clinical background are consistent with calcific secondaries, liver which are common in mucinous carcinoma of gastrointestinal tract. Pathological examination proved the same.

Lee JW et al stated that most primary malignant tumours of the liver appear as low attenuation masses on non-contrast CT scans and show enhancement after contrast administration. Fibrolamellar carcinoma often contains an area of decreased density attenuation corresponding to the central scar, about half of the tumour contain calcification, which usually is punctuate and central.

Intrahepatic cholangiocarcinoma typically appears as a homogenous low attenuation mass that may have small satellite nodules. Multiple large dense areas of calcification commonly occur, an appearance that is rare in untreated hepatocellular carcinoma. CT often shows extension of tumour through the hepatic capsule and invasion of organs adjacent to the liver.

Linear hypodensities were seen in both lobes of the liver which are consistent with intrahepatic biliary radicles were observed in observation XI.

Confluence of both hepatic ducts not visualized.

Common hepatic duct region shows ill-defined osodense lesion.

The density range in 60-75 Hounsfield units.

On contrast images the lesion is isoattenuating with that of the normal liver.

The postoperative pathological image proved the case to be a variety of cholangiocarcinoma, known as klatskin tumour.

In observation XII the images of the liver appeared homogenous. The size, shape and contour of the liver appeared normal. Density variation range 38-80 Hounsfield units.

No specific lesion visualized.

No evidence of calcification.

No evidence of necrosis.

The above features are consistent with the normal CT image of the liver.

SUMMARY

The liver which is a common site of metastatic disease has prompted the researches to select it as the organ most often studied in the truncal body with recent advanced techniques.

Computed tomography has become established as the imaging method of choice for routine screening of the liver.

This study of density variations in computed tomographic images of the liver was done on sixty patients in the department of anatomy and the department of radiology, Stanley Medical college, Chennai.

The study was done by two methods.

- Non contrast study
- Contrast study

The fluctuations of the CT images of the liver were observed as

- Focal decreased attenuation masses.

- Hyper enhancing focal liver lesions on contrast enhanced computed tomography and
- Generalized abnormal attenuation of the liver.

The following disease entities with different density range was observed in this study.

- Liver cyst - simple cyst
- Liver abscess.
- Multiple abscesses
- Hydatid cyst
- Cirrhosis
- Hemangioendothelioma
- Hepatocellular carcinoma - solitary
- Multicentric hepatocellular carcinoma.
- Secondaries liver - Hypodense
- Hyperdense secondaries liver
- Cholangiocarcinoma
- Normal anatomy

Seventeen cases were observed with normal anatomy of the liver. Diseases like hypodense secondaries, solitary hepatocellular carcinoma, liver abscess and cirrhosis of the liver were observed in majority of the patients.

One rare case of hemangioendothelioma was observed in a six year old child, one case of cholangiocarcinoma was also observed.

These observations of the density of the liver in CT is of much value to the surgeons in planning an accurate and conservative surgery.

CT techniques to evaluate the liver have advanced during the past decade and continues to evolve. We now have a better definition of when and how to utilize these examination to review liver anatomy and disease processes for prompt diagnosis and treatment.

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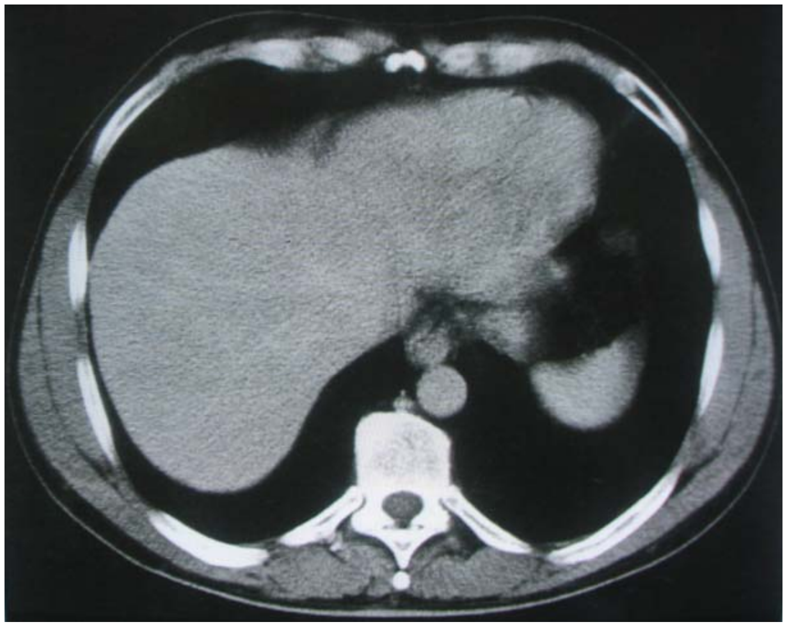
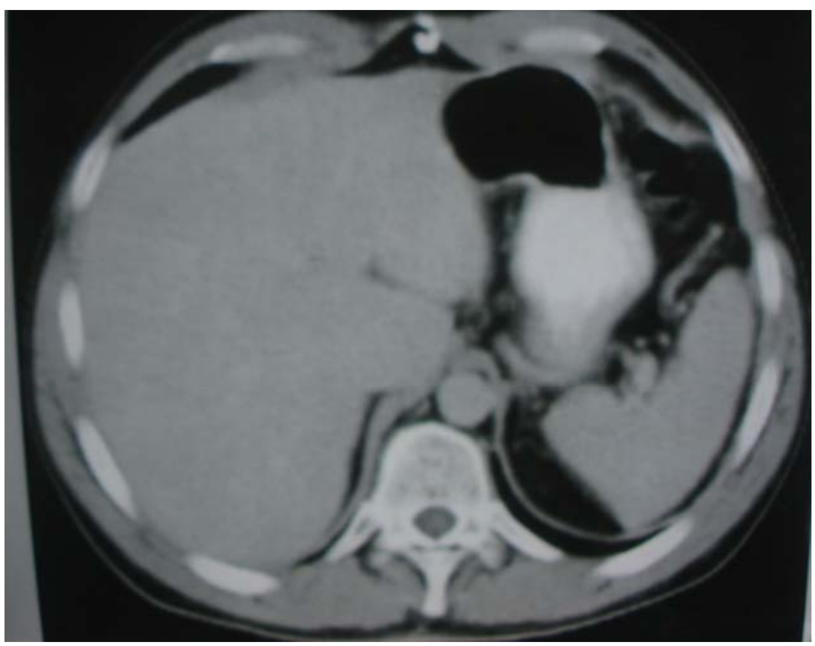
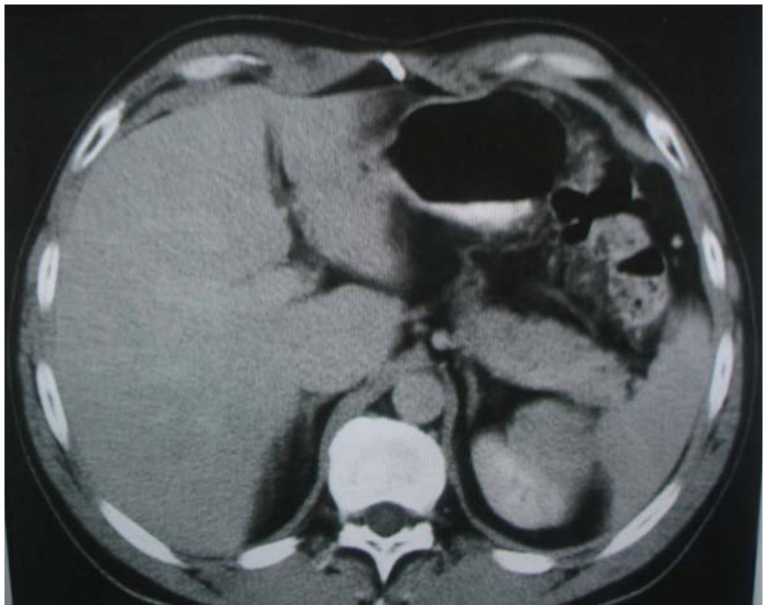
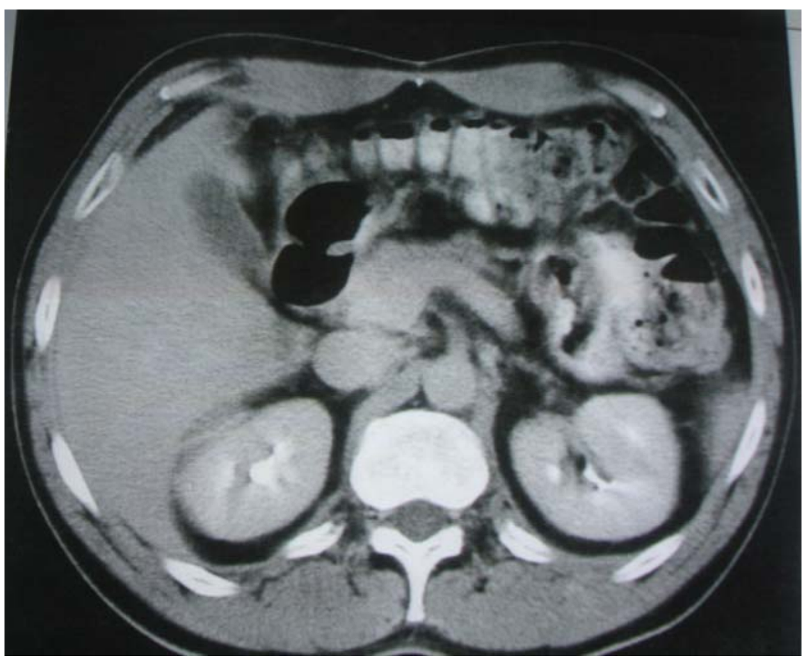
NORMAL ANATOMY

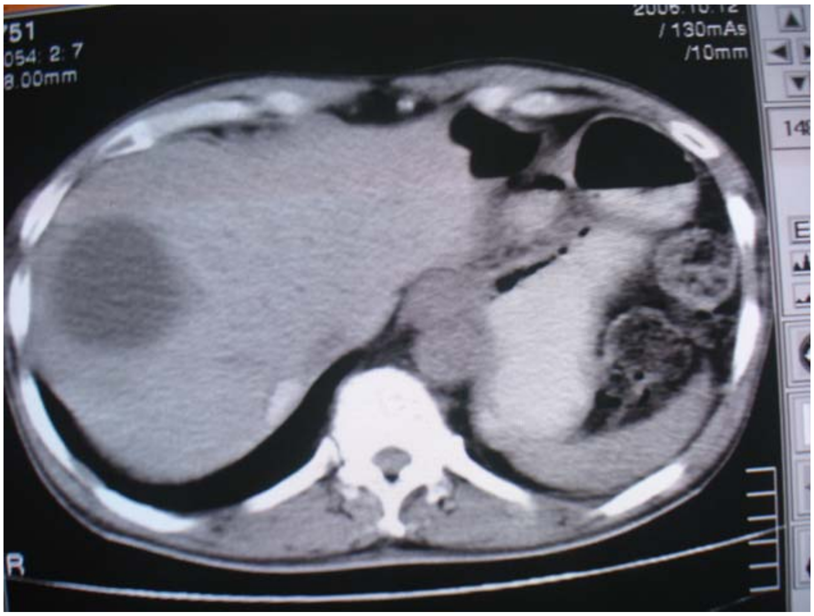








LIVER CYST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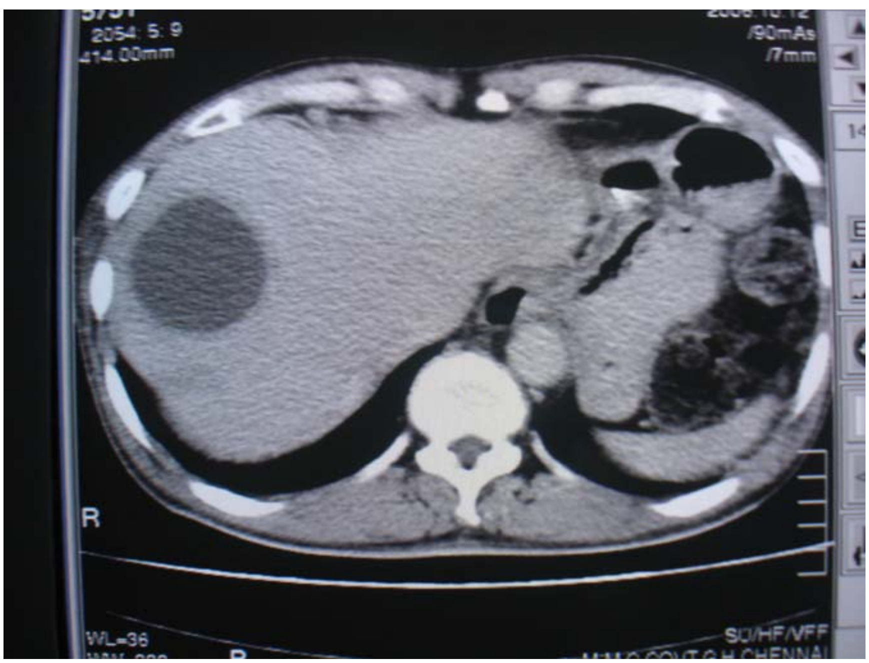
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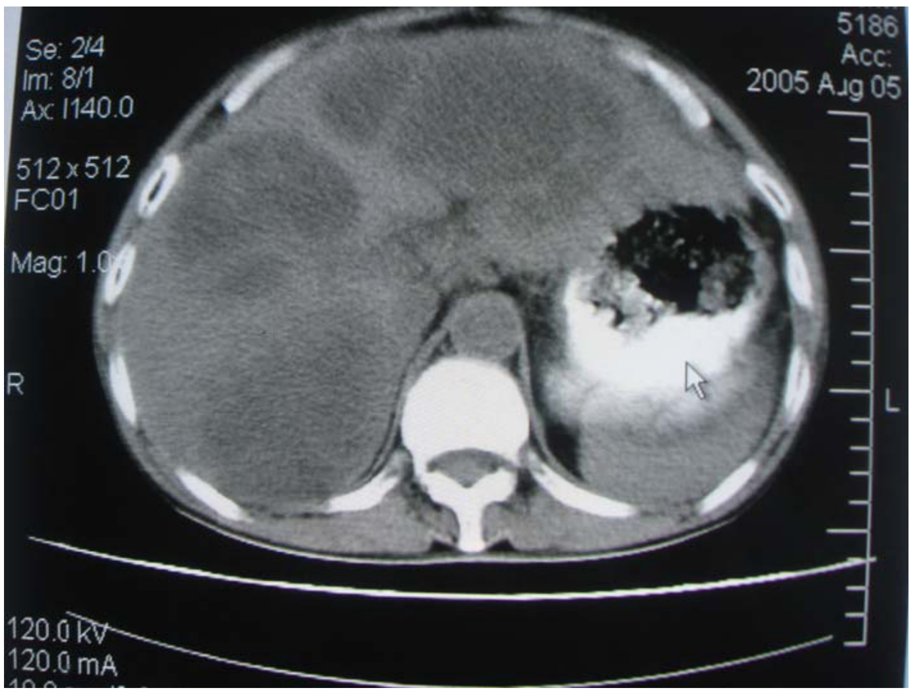
LIVER ABSCESS (BACTERIAL)

LIVER ABSCESS (AMOEBIC)



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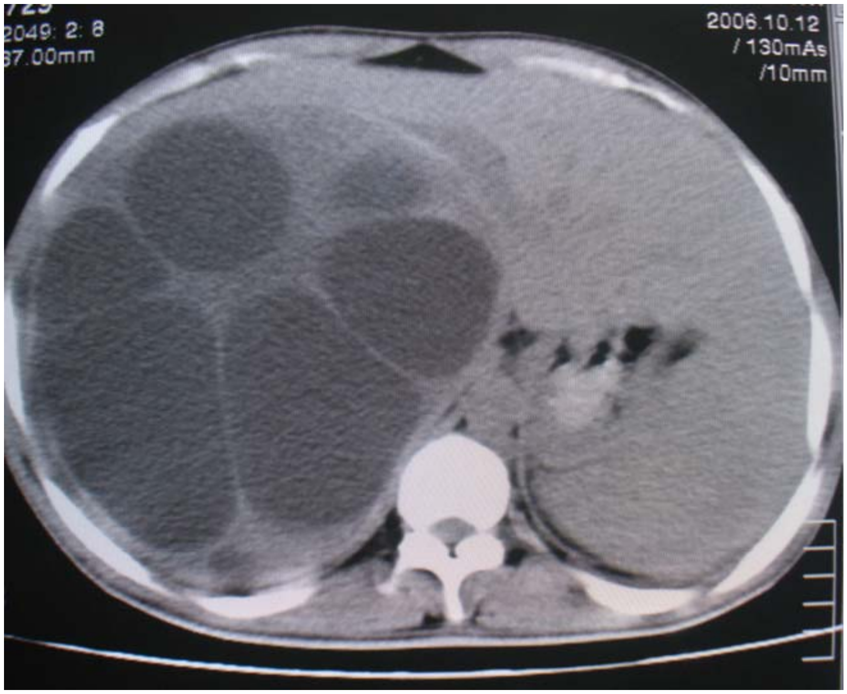

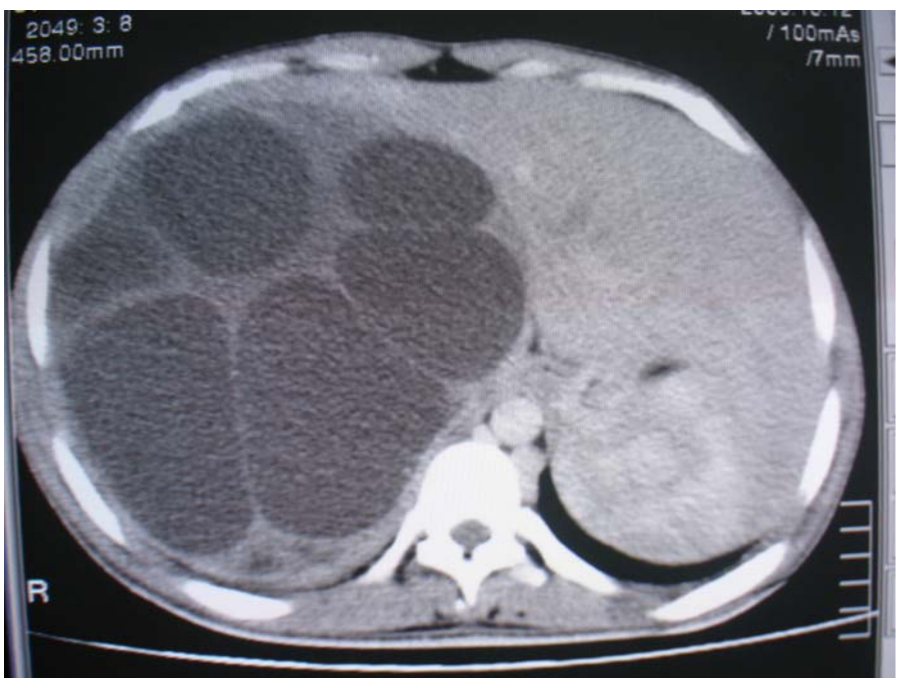

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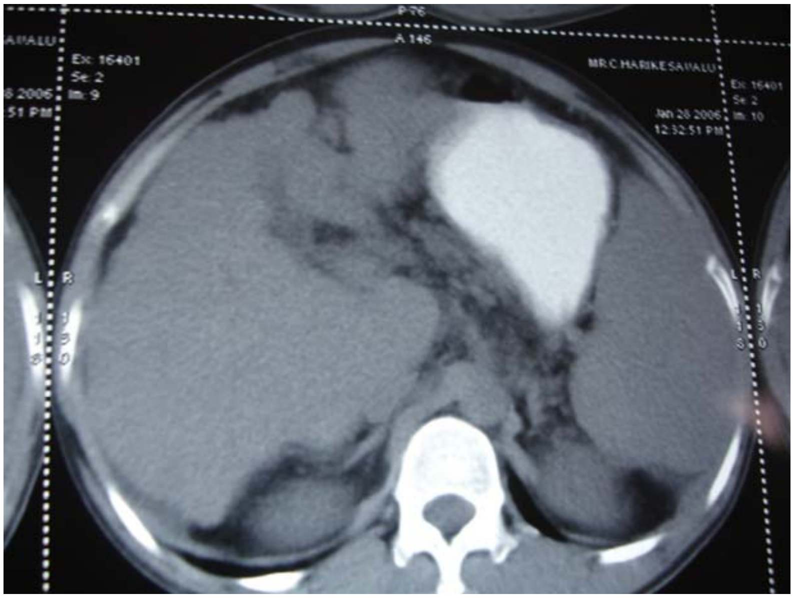

HEMANGIOENDOTHELIOMA

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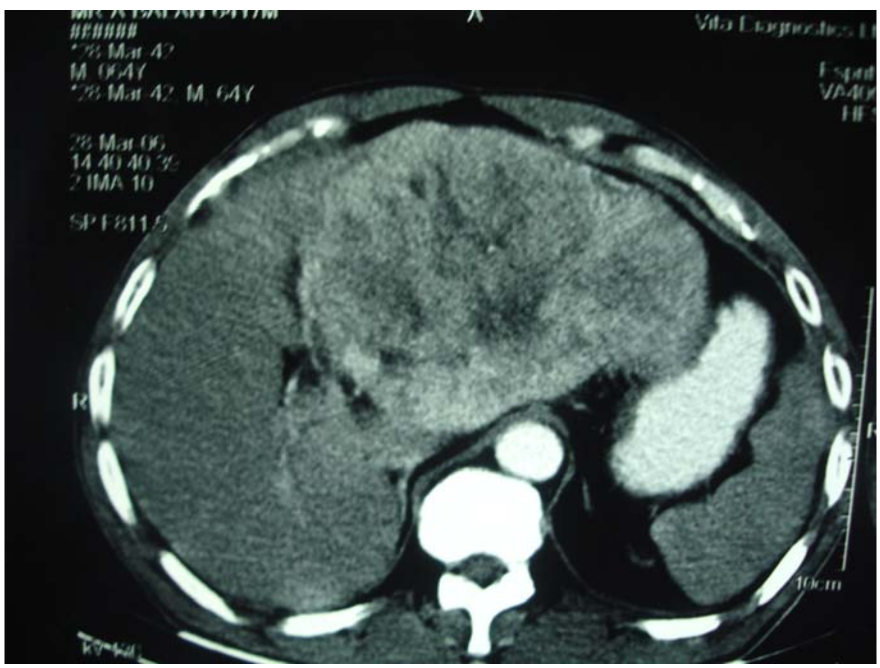

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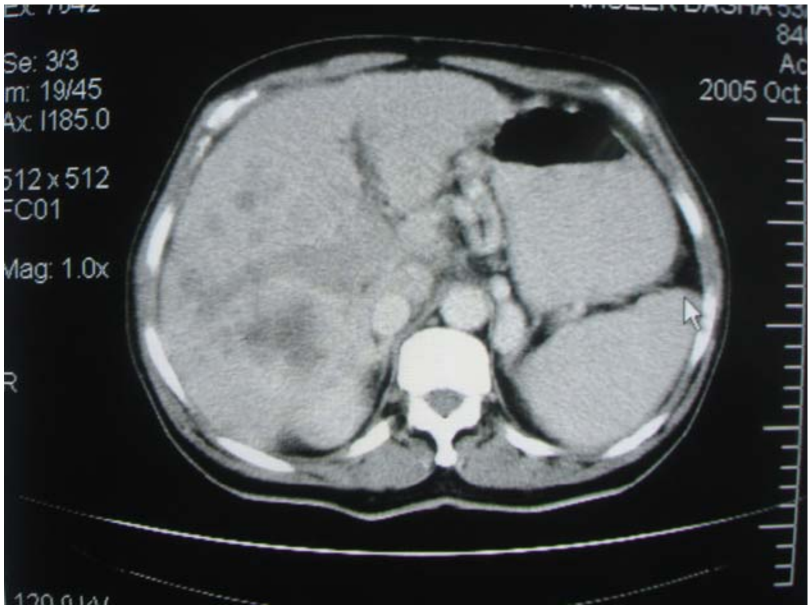

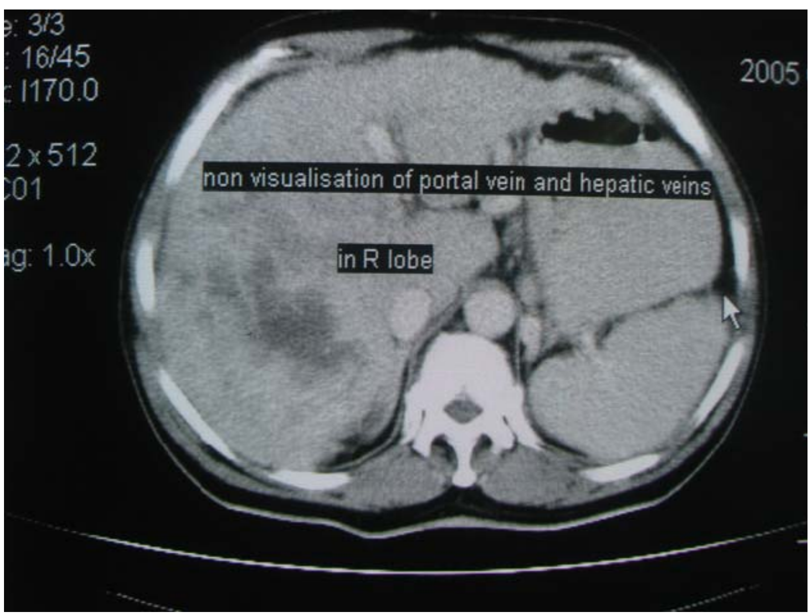

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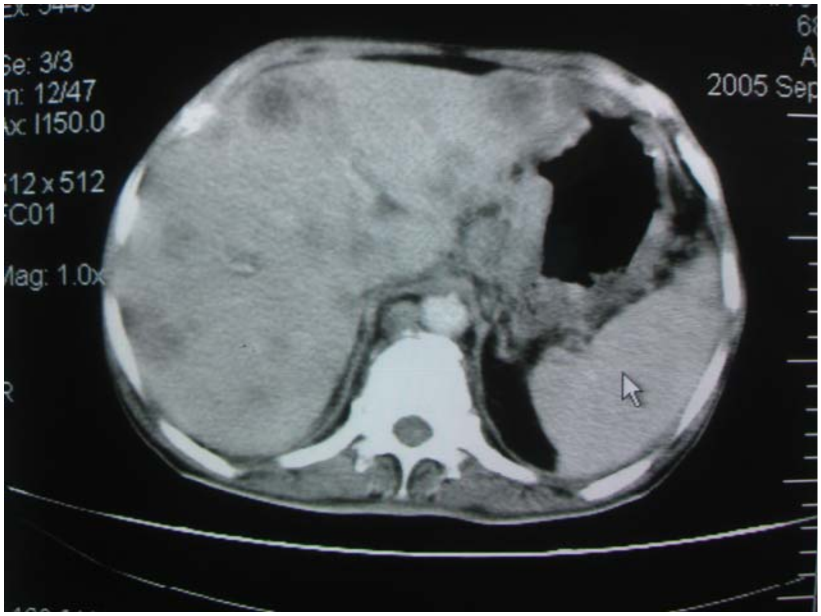

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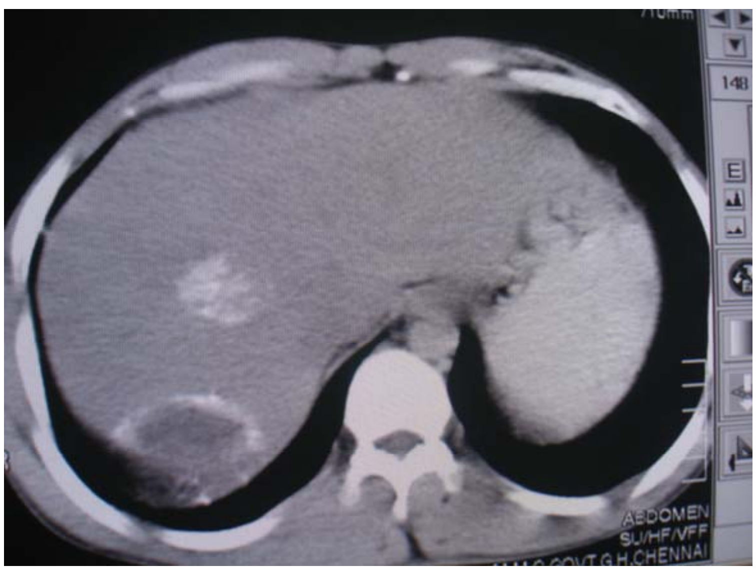

CHOLANGIO CARCINOMA