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ROLE OF TRIPHASIC CONTRAST-ENHANCED CT IN CHARACTERISATION OF LIVER LESIONS

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Abstract

Introduction:
The liver, a vital organ responsible for digestion, detoxification, and receiving rich blood supply from the hepatic artery and portal vein, is susceptible to various diseases, both benign and malignant. The alteration in blood supply patterns serves as the foundation for the triple-phase scan of the liver. Contrast-enhanced triphasic CT, evaluating the organ in arterial, portal venous, and delayed phases, proves instrumental in identifying a spectrum of abnormalities.

Methodology:
This cross-sectional investigation, conducted at a private medical college and tertiary hospital in Hyderabad, involved administering non-ionic contrast medium to patients with suspected liver illnesses. Arterial phase measurements were taken 35-40 seconds post-contrast administration, showcasing peak hepatic artery-supplied lesions. The portal phase, obtained 70-80 seconds later, proved optimal for evaluating hypo-vascular lesions, while the delayed or equilibrium phase, acquired 5-7 minutes post-contrast injection, offered comprehensive insights.

Results:
The study revealed that 57% of lesions were hypovascular, more discernible in the portal venous phase, while 43% were hypervascular, exhibiting prominence in the arterial phase. Lesions smaller than 3 cm constituted 43% of cases, those between 3 and 5 cm accounted

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for 16%, and lesions larger than 5 cm comprised 40%. Notably, lesions smaller than 3 cm demonstrated metastases, predominantly hypo-vascular and visible in the portal phase.

Comparisons with Miller et al.'s study on malignant focal lesions corroborated the current findings, particularly in lesion detection concerning size and phase variability. Marten S. van Leeuwen et al. identified 11 enhancement patterns, categorizing six as benign, three as malignant, and two as metastases and hemangiomas. Gualdi GF et al. presented 11 enhancement patterns, with four always indicative of benign disease and four of malignant disease. The rest were observed in both benign and malignant cases.

The study showcased that 50% of metastatic lesions originated from colorectal carcinoma, 20% from pancreatic malignancy, and 10% each from stomach, ovary, and lung cancers. Gastrointestinal tract malignancies predominantly contributed to liver metastasis.

Conclusion:
Triphasic contrast-enhanced CT emerged as an optimal modality for characterizing focal liver lesions, revealing diverse enhancement patterns in different phases. Metastasis, particularly from colorectal carcinoma, dominated in the age group of 50-59 years. Hepatic arterial phase excelled in identifying hyper-vascular lesions, while the portal venous phase exhibited superior conspicuity for hypo-vascular lesions. This non-invasive tool, serving as the first line of differentiation between benign and malignant lesions, minimizes unnecessary biopsies for lesions like hemangiomas and certain infective pathologies with distinctive enhancing patterns. The study's findings align with previous research, emphasizing the robustness and clinical relevance of triphasic contrast-enhanced CT in liver lesion characterization.

INTRODUCTION

Liver is prone to various diseases including benign and malignant because of its major function of digestion, detoxification and rich blood supply by hepatic artery and portal vein. Most primary and metastatic liver lesions, receives their blood from the hepatic artery, thus reverses the normal proportion of hepatic blood supply which is mainly supplied by portal vein (70%) to hepatic artery which becomes the prime source of blood supply 1. These difference in pattern of blood flow forms the basis of triple phase scan of liver. This technique has helped to elucidate the imaging features of primary and metastatic liver lesions. Triple phase CT is very crucial in distinguishing a benign lesion from malignant to avoid unnecessary invasive procedures especially in benign tumor’s like hemangioma. Improved detection and characterization can help determine which hepatic tumor’s may be amenable to aggressive surgical techniques and which indicate palliative treatment.

This study significances to evaluate the triple phase CT features of common hepatic lesions with emphasis on the role of different phase imaging in characterization of these lesions, so

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that diagnosing, staging and management of patients with liver pathology could be performed more effectively.

Contrast enhanced triphasic CT evaluates the liver in 3 different phases (arterial, portal venous and delayed phases) to help identify a wide variety of abnormalities. The unenhanced images provide more consistent lesion measurement; hepatic arterial images help detect hyper vascular lesions; and the portal venous images are better at identifying hypo vascular malignancies. Studies have reported the value of this technique in establishing the diagnosis of hepatic lesions based on their appearances during the different phases of enhancement.

METHODOLOGY:

This observational study was carried out on thirty patients who had suspicions or were being evaluated for liver lesions in a medical college with a tertiary care hospital attached in Hyderabad. The study used nonionic contrast media (iopamide 350 mg) and a multidetector CT scan (TOSHIBA SYSTEM-HI SPEED 16 SLICE CT). Written consent was obtained from the patient or legal guardian. In order to prevent complications from contrast, patients were instructed to fast for four to six hours before consuming solid foods. Additionally, water was advised to be consumed in small sips at regular intervals, as it acts as a negative contrast medium for the bowels

Following the initial NCCT, 100ml of iopamide 350mg (the amount of contrast to be injected was determined based on body weight, -1.5ml of contrast /kg body weight) were delivered using an IV cannula in a calibrated power injector at a rate of 3-3.5ml/sec to generate CECT scan images. Sections were obtained in the craniocaudal direction during the delayed (3-5 minutes), portal venous (40 seconds), and hepatic artery (25 seconds) phases.

Lesions were classified into two categories: those that were hypovascular in comparison to the surrounding parenchyma, or those that were hypervascular in relation to it.

The appearance of each lesion in each phase was stated as one of the five potential states and was described based on the lesion's homogenicity and attenuation in comparison to the liver parenchyma in that phase.Homogeneous area of water attenuation: hypo(cyst). Slightly attenuated soft tissue area in homogemous: hypo. Area with hypoattenuation compared to the arterial system but mixed attenuation. High attenuation area, but smaller than arterial system: hyper As opposed to the arterial system, which isoattenuating: arterial or A. The pattern of enhancement is a three-phase pattern name (e.g., hypo/hypo/hypo) that incorporates the lesion's appearance in each phase. Additional patterns of subtype enhancement in arterial phase like peripheral puddles, variegated, continuous hyperattenuating rim , incomplete rim and cleft were also considered.

Pregnant woman with suspected liver lesions, hypersensitivity to ct contrast agents, abnormal renal parameters, hemodynamically unstable patients were excluded.

OBSERVATION AND RESULTS

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•To characterize the focal liver lesions on plain CT and comparison with triphasic contrast enhanced ct.
•To study the size, distribution and anatomical localization of lesions of liver
•To study the enhancement patterns of lesions in all three phases.
•To differentiate between benign and malignant lesions by analyzing the enhancement and washout patterns.
•To detect small lesions which are not detected on ultrasonography but with clinical and biochemical suspicion.
•To detect the patency of portal vessels in portal phase.

AGE	NUMBER	PERCENTAGE
<20	2	7%
20-29	4	13%
30-39	4	13%
40-49	5	17%
50-59	8	27%
60-69	4	13%
70-79	3	10%

Table 01: Showing percentage distribution

Chart 01: Showing percentage distribution in pie representation

SEX	NUMBER	PERCENTAGE
MALE	18	60%
FEMALE	12	40%

Table 02: Showing number and percentage of sex distribution

Chart 02: Showing anatomical distribution of lobes involved

GROUP	NUMBER	PERCENTAGE%
BENIGN	12	40%
MALIGNANT	18	60%

Table 03: Showing percentages of benign and malignant

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Chart 04: Showing distribution and number of various liver lesions

LESION	NUMBER	PERCENTAGE
HEMANGIOMA	4	13%
ABSCESS	5	17%
CYST	2	7%
ADENOMA	1	3%
HCC	4	13%
CHOLANGIOCARCINO	2	7%
HEPATOBLASTOMA	2	7%
METASTASIS	10	33%

Table 04: Distribution of various liver lesions

Table 05: Showing distribution of various patterns of enhancement

PLAIN CT	NUMBER
HYPO	21(70%)
ISO	5(16%)
HYPER	3(10%)
HETEROGENOUS	1(4%)

GROUP	NUMBER	PERCENATGE %
HYPOVASCULAR	17	57%
HYPERVASCULAR	13	43%

Table 06: Showing distribution of hypovascular and hypervascular lesions

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LESION	NUMBER	PERCENTAGE	ENHANCEMENT PATTERN
HEMANGIOMA	3	75%	A(puddles)/A/A
	1	25%	hypo/hypo/hypo
ABSCESS	5	100%	hypo(rim)/hypo(cyst)/hypo
CYSTS	2	100%	hypo/hypo(cyst)/hypo
ADENOMA	1	100%	hyper/A/A

Chart 05: Showing distribution of hypovascular and hypervascular lesions

Table 07: Showing distribution of benign liver lesions

LESION	NUMBER	PERCENTAGE	ENHANCEMENT PATTERN
METASTASIS	7	70%	hypo/hypo/hypo
	2	20%	hypo(rim)/hypo/hypo
	1	10%	hyper/A/A
HEPATOCELLULAR CARCINOMA	3	75%	A(variegated)/A/A
	1	25%	hyper/A/A
CHOLANGIO CARCINOMA	2	100%	hyper/A/A
HEPATOBLASTOMA	2	100%	A(variegated)/A/A

Table 08: Showing distribution of malignant liver lesions

SITE OF PRIMARY	NUMBER	PERCENTAGE
CA COLON/RECTUM	5	50%
CA PANCREAS	2	20%
CA STOMACH	1	10%
CA OVARY	1	10%
CA LUNG	1	10%

Table 09: Shows distribution of secondaries in malignant liver lesion

DISCUSSION

This observational study was conducted in medical college over a period of one and half year on 30 patients with clinically suspected focal liver lesions which are evaluated on ultrasound and subjected to 16 slice MDCT with plain and triphasic study.

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The enhancement patterns of various focal liver lesions have been studied and compared with the previous studies in literature as standard to characterize the type of lesion and to come to final diagnosis.

The enhancement patterns are also correlated with histopathological examination in some cases with equivocal enhancement patterns.

Demographic data: In this study most of the cases were in the age group of 50-59yrs comprising 27% (n=8) followed by 5 cases in the age group of 40-49yrs (17%). (Table-1).

These results are seen correlating with the study conducted by Hasaneen et al[39] in which the most common age group was 41-60yrs (40%).

Lesions were more common in males (60%) than in females (40%). (Table-2)

This data is seen in concordance with study by Rani.S et al[38] in which the incidence in males is 55%.

Clinical symptoms: Most of the lesions this study presented with complaint of pain abdomen(n=19) around 63% followed by weight loss(n=13) 43% followed by jaundice(n=9)30%. (Table-4)

Distribution of pathologies: The maximum number of lesions involved right lobe (43%) followed by both lobes (40%) and left lobe (17%). (Table-3)

The maximum number lesions are noted in right lobe of liver due to its bigger size and maximum distribution of portal flow.

This is in concordance with the distribution of focal liver lesions more common on the right lobe as seen in the observations by Rani.S et al.[38]

Most of the cases showed single lesion (60%) and 12 % of cases showed multiple lesions.

In this study majority of lesions are malignant(n=18) around 60% and 40%(n=12) of lesions are benign. (Table-7)

The most common lesion found in this study is metastasis(n=10)33% followed by abscess(n=5)17%,hepatocellularcarcinoma(n=4)13%,hemangioma(n=4)13%,cysts(n=2)7%,cholangiocarcinoma(n=2)7%,hepatoblastoma(n=2)7%, and adenoma(n=1)3%.

In malignant lesions the most common lesion is metastasis(n=10) and in benign lesions the most common is abscess(n=5). (Table-8)

On plain CT majority of lesions around 70%(n=21) are hypodense followed by isodense 16%(n=5), hyperdense10%(n=3), and heterogenous 4%(n=1). (Table-9). 1 case of HCC showed heterogenous density and 1 hemangioma and 2 cases of metastasis showed hyper density due to hemorrhagic component.

During hepatic arterial phase hyper vascular lesions are easily identified against the background of minimally enhancing liver parenchyma and during portal venous phase most of the lesions are identified as hypo vascular lesions against the background of strongly enhancing liver parenchyma. Most of the hypo vascular lesions are best identified in portal venous phase and most hyper vascular lesions in arterial phase.

In this study majority of lesions are hypo vascular lesions 57%(n=17) which are identified with greater conspicuity in portal venous phase and hyper vascular lesions around 43%(n=13) best identified in arterial phase.

In this study plain ct had lower detection rate for identification of small lesions because of difficulty in differentiating it from unenhanced vessels and biliary dilatation. Most of the differences were seen when the lesion size was less than 3cm, because larger lesions were seen on all phases.

In the current study lesions less than 3cm are around 43%(n=13),between 3-5cm are 5 cases(16%),more than 5cm are 12 cases(40%).

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Out of the above 13 cases which are less than 3cm 8 cases are of metastasis and out of these 6 cases are hypo vascular metastasis prominently seen in portal phase.

No patient in this study had a lesion that was not detected on plain ct images that was not identified on with hepatic arterial or portal venous phase images.

In detection of lesions, the findings of this study were similar to the study done by Miller et al[52] on suspected or known case of malignant focal lesions, they found that in patients with hypo vascular malignancies, a significant difference was seen in the number of lesions detected between portal venous phase and other phases when the size of the lesion was <2cm. They also detected that the conspicuity of the hypo vascular lesions was higher on the portal venous phase than on other phases when the lesions were <3cm.

In patients with hyper vascular malignancies, a larger number of lesions in their study, were seen on the hepatic arterial phase than in other phases when the lesions were <2cm,the conspicuity of lesions were higher on hepatic arterial phase .

Philippe Soyer et al [49] in a prospective study for detection of hypo vascular hepatic metast3ases at Triphasic liver CT concluded that the PVP images depicted significantly more hypo vascular metastases than in any other phases.

Comparison of hypo vascular/hyper vascular lesions with Marten S. van Leeuwen, MD, et al[53] study

Lesions	Current study	Van Leeuwen, MD, et al[53]
Hypo vascular	57%	61%
Hyper vascular	43%	39%

The current study showed maximum number of lesions which are hypo vascular which seen corresponding to the study conducted by Van Leeuwen, MD, et al[53] . Out of these hypo vascular lesions majority (23%) of lesions are metastasis.

Characterization of Lesions Based On Enhancement Patterns On Triphasic Ct:

In the current study seven patterns of enhancement have been observed in 30 patients and of these 4 of the 7 patterns were found in benign lesions and 2 patterns in malignant lesion and 1 pattern in both benign and malignant lesions

- Majority of hemangiomas 75%(n=3) showed A(puddles)/A/A pattern and 25%(n=1) showed hypo/hypo/hypo pattern of enhancement.
- All cysts 100%(n=2) showed hypo/hypo(cyst)/hypo pattern of enhancement.
- All abscess100%(n=5) showed hypo(rim)/hypo(cyst)/hypo pattern of enhancement.
- Adenoma (n=1) showed hyper/A/A type of enhancement
- All cholangiocarcinoma's 100%(n=2) showed hyper/A/A pattern of enhancement.
- 75%(n=3) of HCC's showed A(variegated)/A/A pattern and 25%(n=1) showed hyper/A/A pattern of enhancement.
- 100%(n=2) hepatoblastomas showed A(variegated)/A/A pattern of enhancement .
- Of all metastatic lesions 70%(n=7) showed hypo/hypo/hypo pattern,20% showed hypo(rim)/hypo/hypo pattern ,10% showed hyper/A/A pattern of enhancement.

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In the current study 4 cases of hemangiomas noted, all were detected incidentally when the patient with symptoms of pain abdomen. The most common pattern of enhancement observed is peripheral discontinuous nodular enhancement/puddles of contrast in arterial phase followed by centripetal filling in delayed phase in 3 cases.
1 case is hypo vascular which is hypoattenuating in all three phases and on follow up the lesion is of same size showing its benign nature.
5 cases of hepatic abscess noted, all came with main complaints of fever and pain abdomen.
4 cases out of these were amoebic liver abscess which on aspiration of fluid revealed anchovy sauce pus and are seen in right lobe of liver and 2 out of these showed rupture in to pleura and lung parenchyma with formation of an abscess. On contrast the characteristic pattern is double target appearance with central hypo enhancing component and enhancement of inner rim in arterial phase and outer rim in delayed phase.

1 case is of pyogenic liver abscess noted in right lobe showing the double target appearance on triple phase CT and associated with cholecystitis.

2 cases of simple hepatic cysts are noted which are detected incidentally and are non enhancing in all three phases.

1 case of hepatic adenoma noted in a female patient referred for complaint of pain abdomen. It showed homogenous enhancement in arterial phase and is isodense on both portal and delayed phases.

10 cases of metastasis were detected with a known primary. Majority are in the age group of Out of these 7 cases are hypo vascular lesions which are seen hypo enhancing in all three phases and 2 cases showed peripheral rim enhancement in arterial phase and one case is seen hyper enhancing in arterial phase.
In majority of metastasis the primary is from gastrointestinal tract and one case which is hyper enhancing the primary is from neuroendocrine tumor of pancreas.

2 cases of hepatoblastoma were noted in pediatric age group (1 yr and 3yrs) came with complaints of abdominal distention and jaundice showed heterogenous enhancement in arterial and portal phases and hypo enhancement in delayed phase.

In characterization of lesions the current study was compared with the study done by
Marten S. van Leeuwen, MD, PhD et al [53]100 on 94 patients, found 11 patterns of enhancement. They demonstrated that six of the 11 enhancement patterns were always due to benign disease, three of the 11 patterns were always due to malignant disease, and the other two patterns were due metastases and hemangiomas.

Gualdi GF, Casciani E, D'agostino A, Polettini E **[51]**In their study to evaluate the role of Triphasic CT in characterization of non cystic focal lesions on sixty- six patients with suspected focal liver disease they found, 11 patterns of enhancement depending on the enhancement patterns of the lesions in different phases. Four of 11 enhancement patterns (hypo/hyper/hyper, hyper/iso/iso, hyper/hyper/iso, and hyper/hyper/hyper) were always referable to benign disease. (hemangioma, FNH-adenoma). Four of 11 enhancement patterns (iso/hypo/hypo, iso/iso/hypo, hyper/hypo/hypo, and hyper/hyper/hypo) were always referable to malignant disease (hepatocellular carcinoma-HCC-metastases). The other three patterns (hypo/hypo/hypo, hypo/hypo/hyper, and hyper/A/A) were seen in both benign and malignant diseases.

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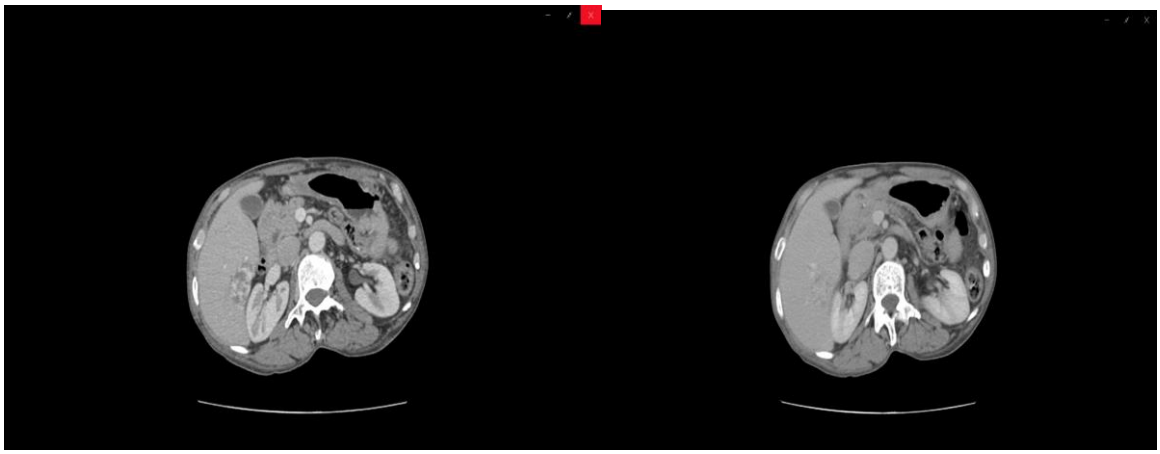
In this study seven patterns of enhancement patterns were only detected as the study population is small.

KNOWN PRIMARY IN METASTASIS:

Site of primary	CURRENT STUDY[n=10]	Matilde et al[50] [53]	Leeuwen et al[53] [58]
Carcinoma rectum /colon	5(50%)	17(32%)	36(62%)
Ca. Pancreas	2(20%)	11(20%)	3(5%)
Ca. stomach	1 (10%)	1(2%)	-
Ca ovary	1 (10%)	1	-
Ca lung	1(10%)	-	-

In the current study out of 10 metastatic lesions majority 50% of cases the primary carcinoma is from CA colon and ca rectum and in 20 % cases is from ca pancreas and 10% each from `CA stomach, CA ovary, CA lung.
The most common primary for liver metastasis is from gastrointestinal tract.

The current study group spectrum is correlating with Matilde et al[50] study, in which 53 metastases were included, majority from colorectal carcinoma (17) followed by pancreatic malignancy (11). This study group spectrum is also correlating with study group of 58 patients by Leeuwen et al[53].



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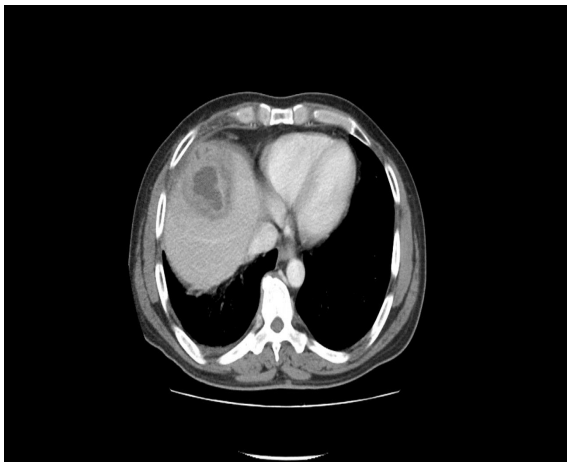

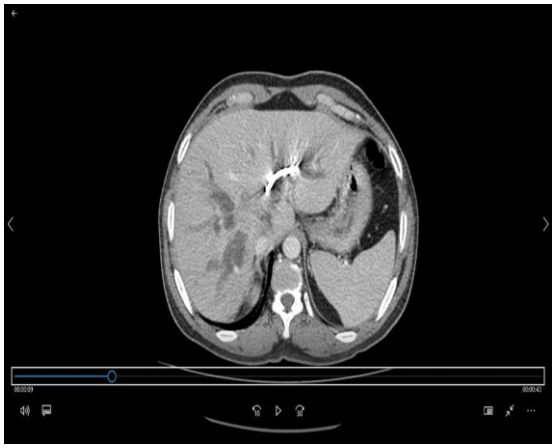

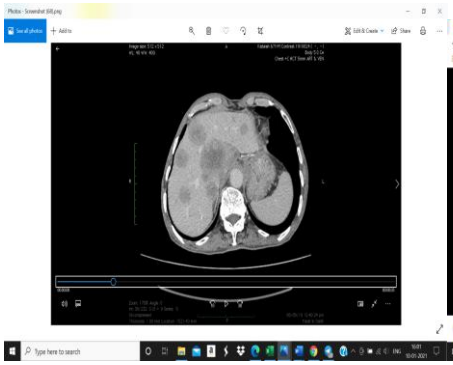

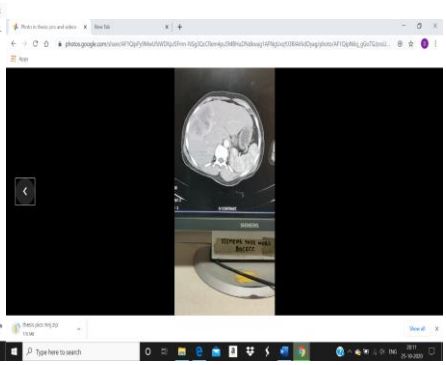

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Limitations for current study: Due to small sample size the various types of enhancement patterns as described by other study groups could not be detected in this study.Biopsy could not be done for each and every case. As the study involves imaging in three different phases there is increased radiation dose to the patient

CONCLUSION AND SUMMARY

- Triphasic contrast enhanced CT is an ideal modality in characterization of focal liver lesions by studying various patterns of enhancement in arterial, portal venous and delayed phases.
- Metastasis is the most common malignancy detected in this study in the age group of 50-59yrs
- Hyper vascular lesions are better identified on hepatic arterial phase and the conspicuity of hypo vascular lesions is better in portal venous phase indicating the necessity of triphasic study.
- It is a good non invasive and first line tool for differentiating between benign and malignant lesions ,thus avoiding unnecessary biopsies as in hemangiomas and infective pathologies with their characteristic enhancing patterns.

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