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# Focal hepatic lesions in adults-A correlative study of imaging features on Ultrasound, Triple phase Contrast Enhanced Computed Tomography, Diffusion Weighted Sequence on Magnetic Resonance Imaging with histopathological findings.

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***Abstract:*** ***Objectives***
*1. To study the imaging features of Focal hepatic lesions on Ultrasound, Computed Tomography and Magnetic Resonance Imaging(DWI sequence) in correlation with histopathology findings.*
*2. To characterize enhancement patterns of various hepatic lesions on Contrast enhanced triphasic Computed Tomography.*
*3. Correlation between type of arterial enhancement and histopatholgy.*
*4. To assess cut off value between benign and solid malignant lesions.*
*5. To assess cut off between infective and cystic malignant lesions.*

***Keywords:****Contrast Enhanced Computed Tomography,Liver lesions, Magnetic Resonance Imaging, Ultrasound*

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## I. Introduction

Liver is the largest organ of the body, located in the right upper quadrant of abdominal cavity. It is one of the vital organs of the body, performing a variety of functions. A wide variety of focal lesions affect the liver, ranging from benign to malignant to metastatic. Hence it is important to accurately localize and characterize the lesions for appropriate surgical or non-surgical management.

In the present era, wide array of imaging modalities are available for detection of focal liver lesions, such as Ultrasound, Computed tomography, MRI, Nuclear imaging and Positron emission tomography.

Ultrasound was first introduced to the medical world in the 1960s, since then its popularity has increased. Being easily available, cost effective and quick to perform, it is used as the initial screening modality of choice for liver pathology. It helps in detection and localization of a lesion, but cannot accurately characterize the lesion and that is where computed tomography plays an important role.

Computed Tomography (CT) imaging is also known as "CAT scanning" was invented in 1972 by British engineer Godfrey Hounsfield of EMI Laboratories. CT has evolved at tremendous pace from initial single slice CT scanners taking several minutes to scan a single region, to present day 16, 62 and 124 slice scanners taking only few seconds to scan a region which allows for multiphasic scanning. It is the best imaging modality for detecting, localizing and accurately characterizing the liver lesion. It allows multiphase imaging of liver in after a single IV bolus of contrast which allows for better characterizing the lesion as arterial phase enhancing such as HCC, adenoma and hypervascular metastasis, portal venous phase such as hypovascular metastasis, HCC , adenomas and FNH and delayed phase enhancing like capsule and central scar.

Recently MRI is fast gaining pace in detection of focal liver lesions with its ability for molecular level of detection. There are multiple sequences for detecting and characterizing the focal liver lesions namely T1WI, T2WI, GRE imaging, diffusion weighted imaging and dynamic contrast enhanced imaging. Diffusion weighted imaging is based on the restriction of random movement of water molecules called "Brownian movement" within and outside the cells.

Diffusion is expressed in an Apparent diffusion coefficient (ADC), which reflects the diffusion properties unique to each type of tissue.

With assessment of ADC values, DWI proved to be helpful in characterization of focal liver lesions. Highly cellular tissues provide a short path of diffusion, resulting in diffusion restriction and low ADC values, as is seen in solid liver lesions and abscesses. Low cellularity means that there are fewer structural barriers, making the diffusion path longer. This results in high ADC values as is seen in cysts and necrotic lesions. In summary, ADC maps, derived from DWI provide a non-invasive measure of cellularity. This makes DWI a potential tool in diagnosis, treatment planning and monitoring, especially in oncology. In our study we have chosen diffusion weighted sequence for lesion detection and characterization based on ADC values, as this is one of the fastest sequence and very sensitive in detecting focal liver lesions. To our knowledge there are not much studies done comparing DWI and CECT.

## II. Materials and methods

**Study area and duration:**

This study was conducted in the Department of Radio-diagnosis, Dr B R Ambedkar Medical College, Bangalore, during the period of September 2012 to May 2014. The study was approved by scientific and ethical committee of the hospital.

**Study design and patients:**

This was a prospective observational study, in which 50 patients who met the inclusion criteria were taken and underwent triphasic contrast enhanced CT. Patients also underwent diffusion weighted MRI and ultrasound abdomen, if not done before CT.

**Inclusion criteria:**

1. All patients with Focal Liver lesions(neoplastic and non neoplastic) detected by ultrasound abdomen.
2. All patients of extra hepatic primaries with suspected liver metastasis.
3. In case of multiple focal liver lesions only the two largest will be included in the study.

**Exclusion criteria:**

1. Patients with traumatic liver lesions and patients with features suggestive of haemangioma, simple / hydatid cyst after triphasic CT.
2. Patient with allergy to intravenous contrast.
3. Patients with metallic implants.
4. Claustrophobic patients
5. Patients <18years of age.
6. Cochlear implant and cardiac pacemaker

**Data collection:**

Clinical data, including demographic, clinical and laboratory data were collected for all the patients, who were diagnosed to have focal liver lesions in radiology department. Ultrasound, CECT feature were noted and ADC values were calculated for the largest two lesions.

**Imaging protocols**

Patients were subjected to Triphasic Computed Tomography, ultrasound, Magnetic Resonance Imaging.

**Computed Tomography**

Equipment: Toshiba 64 slices MDCT:

Patient preparation and scanning technique:

• Once the patient agrees to participate in the study, informed consent was taken prior to CT examination, followed by detailed history and brief clinical examination.
• Patients were kept nil by mouth for at least 4 hours prior to examination.
• The protocol included image acquisition in precontrast, post contrast hepatic arterial, portal venous and delayed phases.
• Patient was cannulated with 18G venous cannula.
• Contrast was injected using an automatic pressure injector, approximately 120-150 ml of non ionic contrast material was injected at of 4.5ml/sec.
• Arterial phase was imaged using bolus tracking system with threshold of 150 HU in lower thoracic aorta.
• Porta-venous phase acquired with a 60-70sec from the time of contrast injection.

• Delayed phase acquired after 180sec and if required delayed scan was repeated at 5minutes.
• For all phases slice thickness, slice interval and reconstruction thickness was 0.5mm
• Contrast material used is Iohexol 300mg/ml.

**Ultrasound:**
Equipment: Phillips IU22
GE Volusion 730

**Magnetic Resonance Imaging:** Equipment: Philips Acheiver 1.5 tesla.
Protocol:

All study population will be undergoing MRI on 1.5Tscanner(PHILIP,Achiva) maximum gradient strength 45 $mTm^{-1}$,maxm. Slew rate $200mTm^{-1}s^{-1}$using a phased array body coil with the patient in supine position. Two EIGHT-element body matrix coils will be placed anteriorly and used in conjunction with two posterior spine clusters (three channels each) to optimize the signal-to-noise ratio (SNR). The imaging protocol will include True Fast Imaging and Steady Precession (True FISP) axial and coronal sequences, which will serve as localizer for planning furthersequences. Then conventional MRI sequences, T1W axial (in and opposed phase) and fat-suppressed (FS) T2W axial and coronal sequences, will be acquired.

Respiratory triggered FS (fat suppression) spin echo-echo planar imaging axial diffusion weighted sequence at b-values of 0,50 and 500 $s/mm^2$ will be done . The following parameters were used: EPI factor = 51, TR/TE = 2097/56 ms, flip angle = 90 degrees, slice thickness = 5 mm, number of averages = 6, receiver bandwidth =26275.5 Hz/pixel, field of view = 330× 295×209, matrix = 112 × 96, acquisition time = 2-4 min (depending on patient's respiratory cycle). The DW sequence was respiratory triggered. Trace DW images and ADC maps were derived automatically on a voxel-by-voxel basis.

**Image analysis:**
**USG Images:** Entire liver was scanned for focal lesions through intercostal, subcostal and epigastricwindows.

Echo pattern of the liver was assessed. Focal lesions were evaluated for echogenicity, vascularity on power Doppler with lowest possible PRF and central cleft evaluation. Liver surface was evaluated for nodularity. Liver was also evaluated for patency of hepatic and portal veins. Portahepatis was assessed for CBD dilatation and lymphadenopathy. Presence or absence of ascitis was also noted.

**CT images:** They were viewed using CT console (enzol) and PACS (Barco monitors). Mean HU was calculated

by placing the ROI at 5 separate areas of the lesion, on plain scans for all cases. All the phases were simultaneously viewed by dividing the monitor in 2x2 boxes. In doubtful cases of enhancement, especially in hypoenhancing lesions, HU was calculated and enhancement was confirmed by a difference of >10HU compared with NECT.

Images in all phases were classified into hypoenhancing, isoenhancing or hyperenhancing in comparison to the adjacent liver parenchyma. Arterial phase hyper enhancement was further subdivided into homogenous pattern, variegated pattern, open rings or closed rings. The ‘‘homogeneous’’pattern was defined as diffuse uniform enhancement with no more than 10% central low attenuation with any evident vessels having normal contour and branching. The ‘‘abnormal internal vessels or variegated’’ pattern was defined as either visible internal vessels that were irregular in contour and branched in a distorted fashion unlike normal progressive anatomic arborization or randomly distributed hyperattenuating and hypoattenuating regions The ‘‘complete ring’’ pattern was defined as circumferential ring enhancement surrounding a predominant central region with low attenuation. The ‘‘incomplete ring’’ pattern was defined as non-circumferential ring enhancement.

Central cleft was evaluated as cystic, scar tissue, air, fat, thrombus, calcification. Cystic was defined as hypoenhancing area with either HU being less than 10HU or persistent central hypoenhancement on delayed phase or both. Thrombus was said to present when the area was non enhancing and hyperdense on plain scan. Air was said to present when HU was < -150 or dark appearance on bone window. Lipid is said to be present when the HU is around -40 and not less than -150HU. Scar tissue was defined as hyperenhancing central area on delayed phase imaging. Portal and hepatic vein thrombosis was assessed in portalvenous and delayed phases.

**DW MRI images:** Images were viewed on Phillips console. ADC map was generated. Images with b=0, b-50,

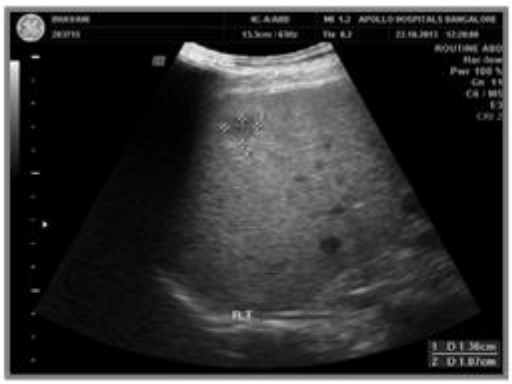
b-500 were viewed simultaneously with ADC map. Lesions that were assessed on CECT were assessed here as well. ADC values were calculated by drawing round to oval ROI on the ADC maps covering at least ½ of the lesion. Both cystic and solid components were covered in the ROI. At least three ROIs were drawn and mean value was taken. We used link point marker to localize the lesion on ADC map.

**Statistical Analysis**

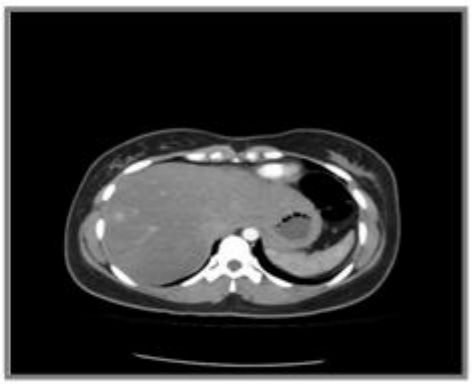
Statistical analyses were performed by using software programs [SPSS software version 17.0, SPSS for Windows (Microsoft)], [Stata (version 11) for windows (Microsoft)] and Microsoft Office Excel 2007(Microsoft Corporation, Redmond, WA). Variables were expressed as Mean ± SD and percentage. We used the chi- square test or Fisher exact test for comparisons of categorical variables and the t-test for comparisons in the distributions of continuous variables. Using receiver-operator characteristic (ROC) curves the area under the curve (AUC), ADC cut off values were calculated between abscess and cystic malignant group and between benign and solid malignant with sensitivity and specificity.

## III. Figures And Tables

**Hepaticadenoma**



**USG**



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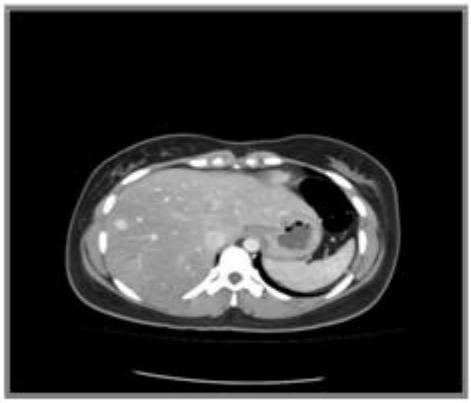
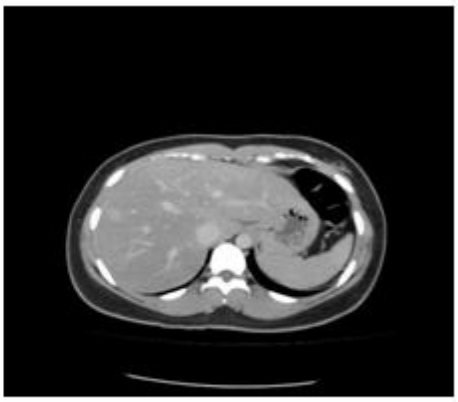
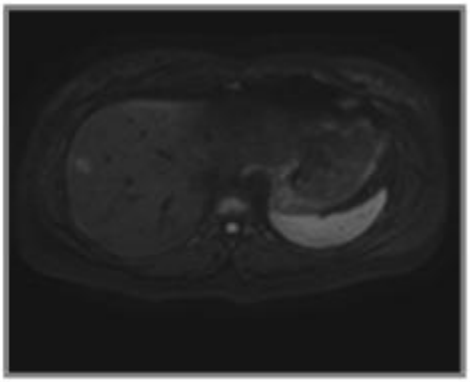


**PortalvenousphaseCT**



**DelayedphaseCT**



**DWI–b500**

**Figure 8:** This was an incidentally detected case of hepatic adenoma detected on routine USG seen as hypoechic lesion. CECT shows Homogenously enhancing lesion in arterial, portalvenous and delayed phase images. DWI with b500 shows mild restriction.

**Abscess**

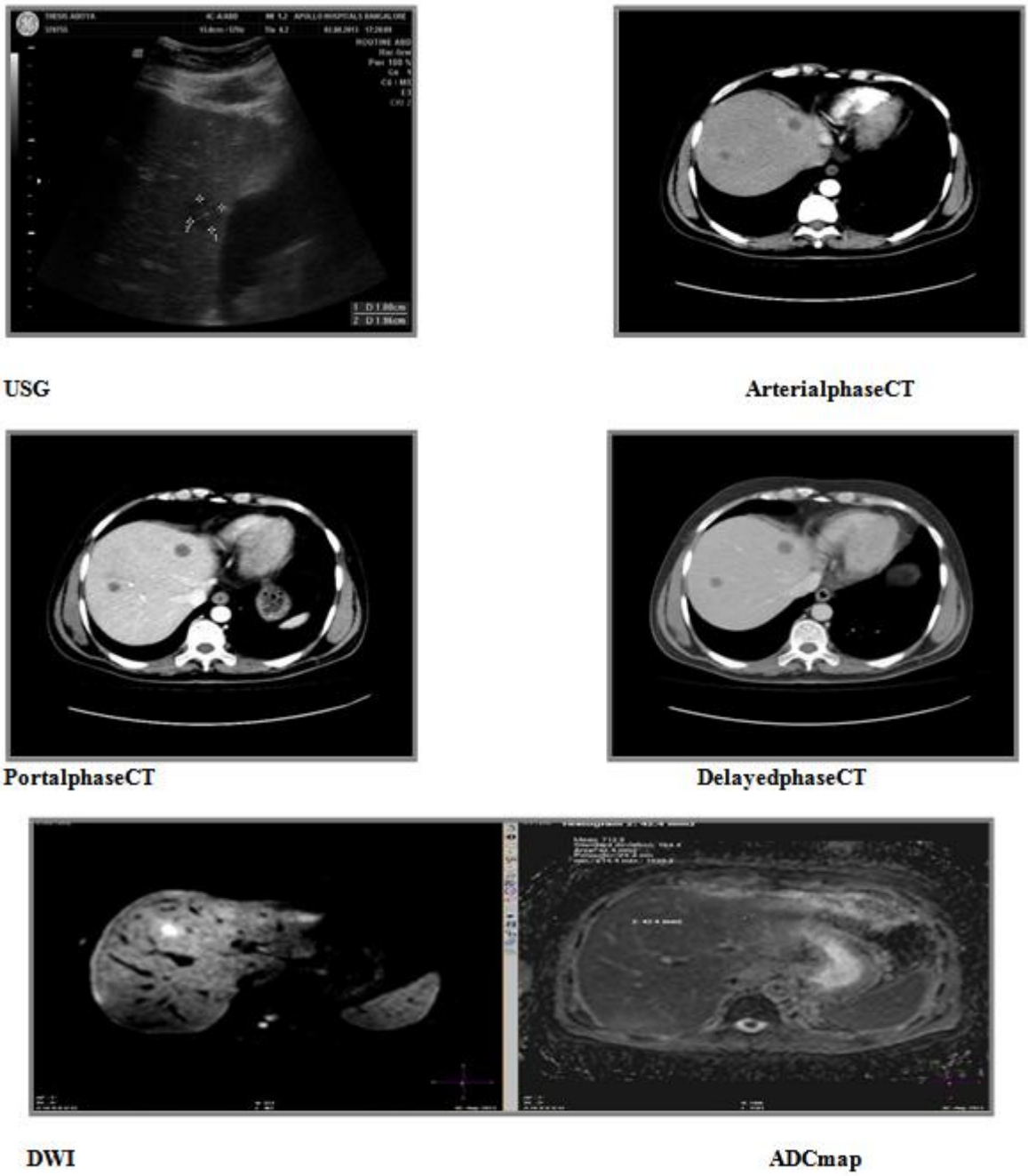
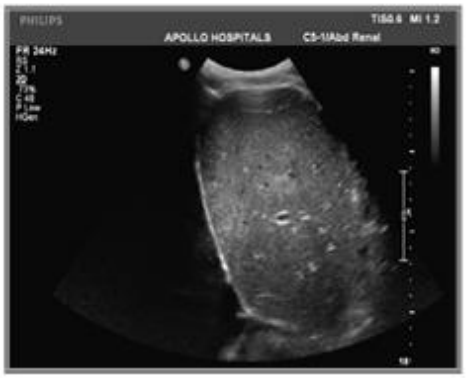
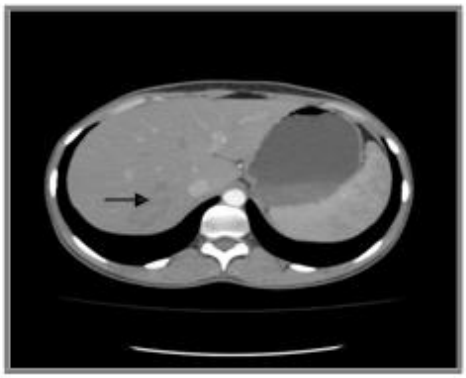



**Figure 9 :** This was a follow up case of hepatic abscess. USG showing a well defined hypoechoic lesion. CECT shows 2 well defined hypoechoic lesions with hyperenhancing walls in all the phases. DWI shows diffusion restriction with ADC of 0.712x10-3.

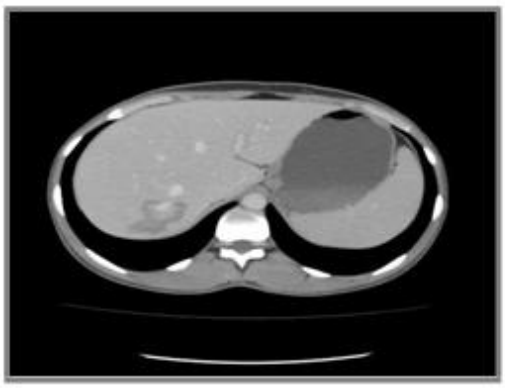
**Focalgranulomatoushepatitis**




**USG**



**ArterialphaseCT**



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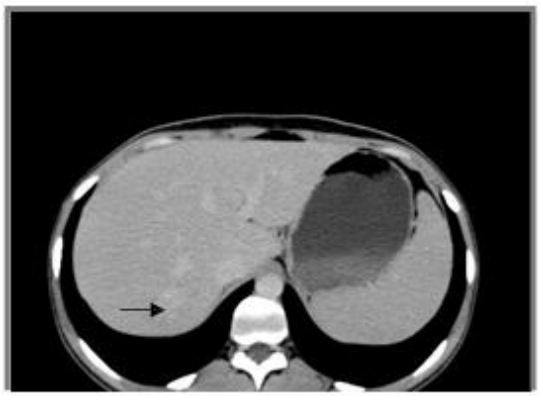
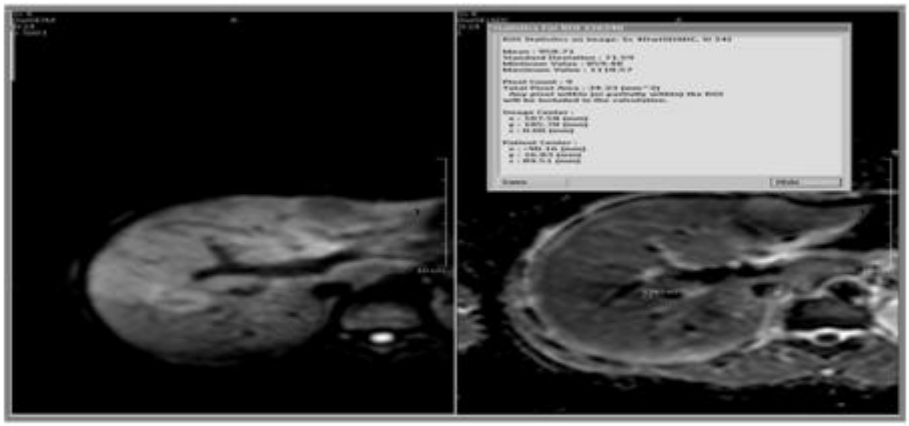


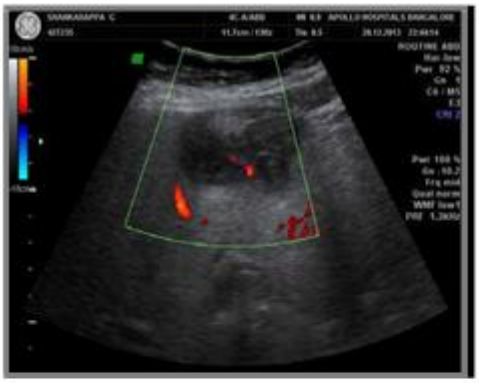
**DelayedphaseCT**



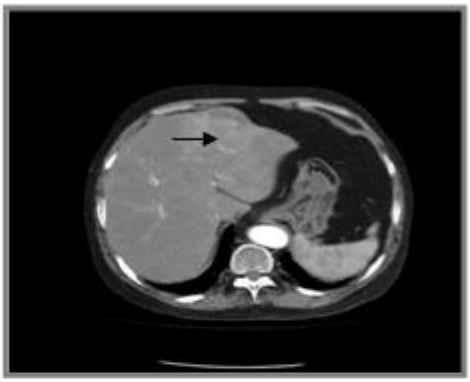
**DWI** **ADCmap**

**Figure 10:** Case of focal granulomatous hepatitis. USG showing ill defined areas of hyperechogenicity in segment 6 and 7. Arterial phase CT shows Illdefined hypoenhancing lesion. On portal venous phase it is seen as well defined hypoenhancing lesion.

**Hepatocellularcarcinoma**



**USG**



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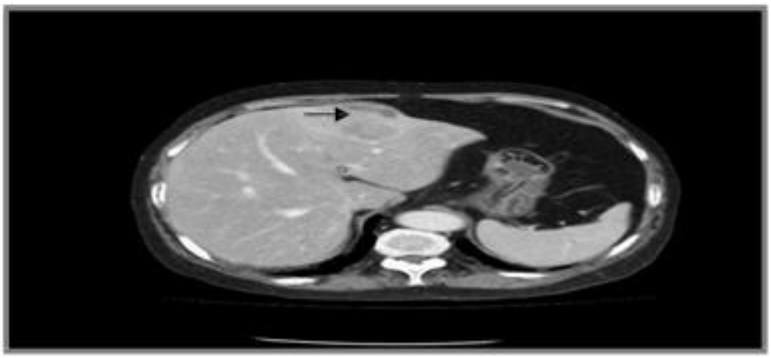

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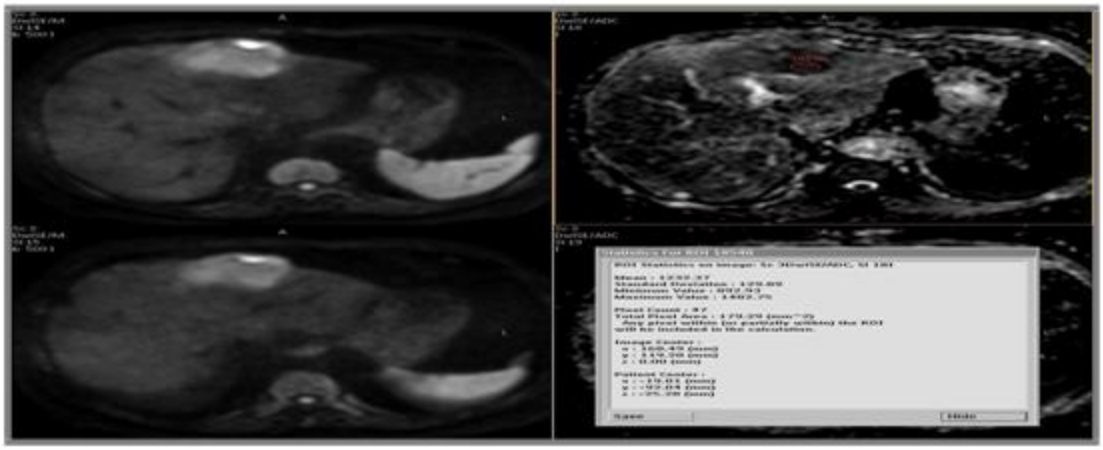
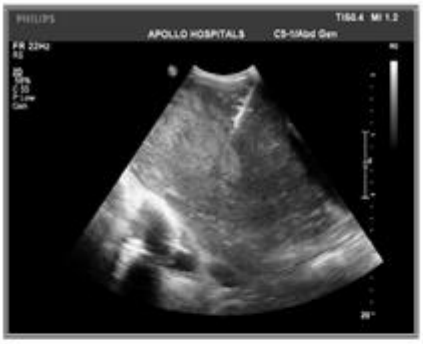


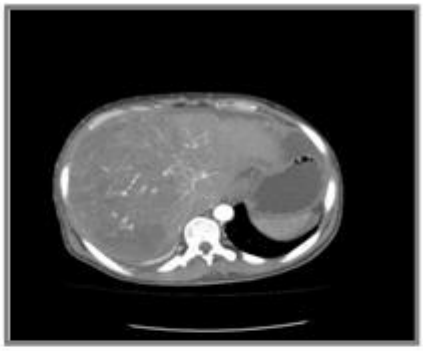
**DWI** **ADC**

**Figure 11:** This was a case of HCC detected on USG, triphasic CT was referred and showed variegated type of arterial enhancement with areas of contrast washout in portal venous phase. DWI showing diffusion restriction with ADC value of 1.23x10-3.

**Multicentrichcc**




**USG**



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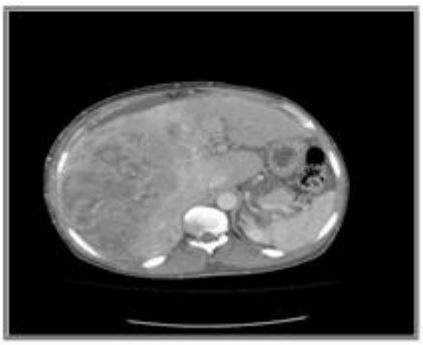

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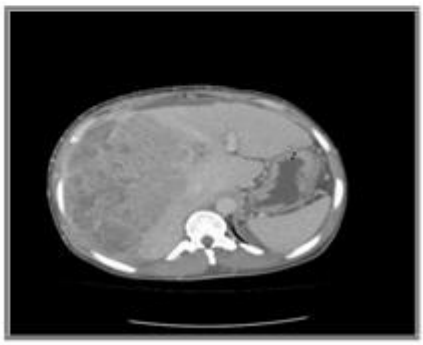
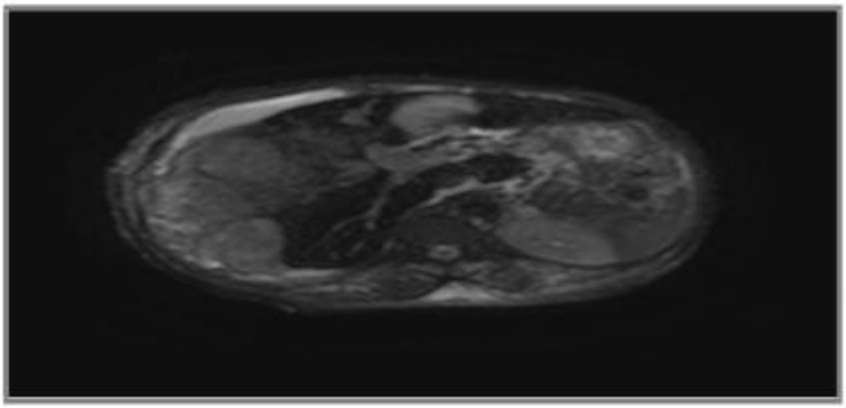


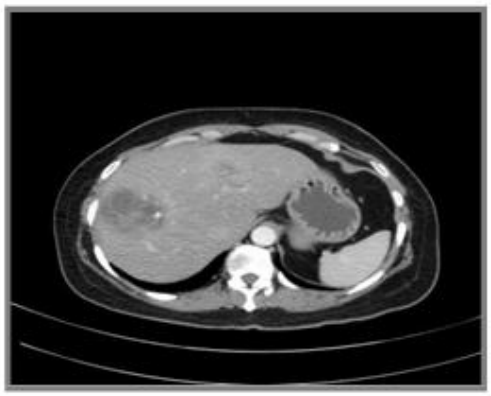
**DelayedphaseCT**



**DWI**

**Figure 12:** This was a known case of CLD due to hepatitis C, ultrasound shows a large heterogenous hyperechoic mass lesion. CECT shows variegated hyperenhancing mass in arterial phase with hypoenhancement in portalvenous and delayed phase suggestive of washout. DWI showing restriction.

**Hepaticmetastasisofrcc**



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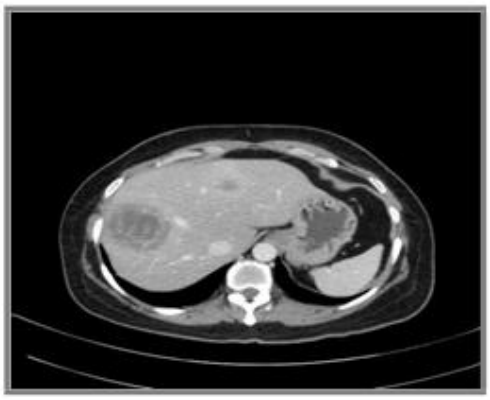

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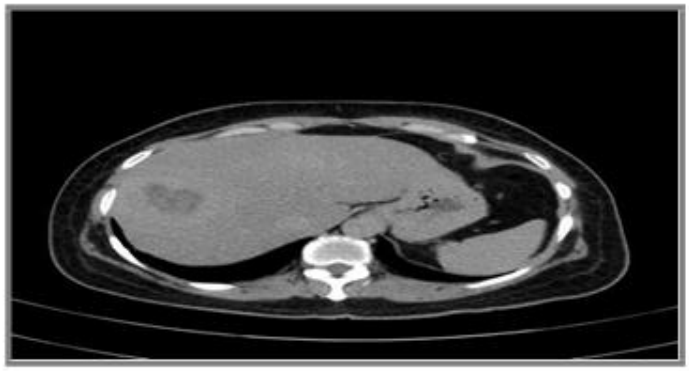

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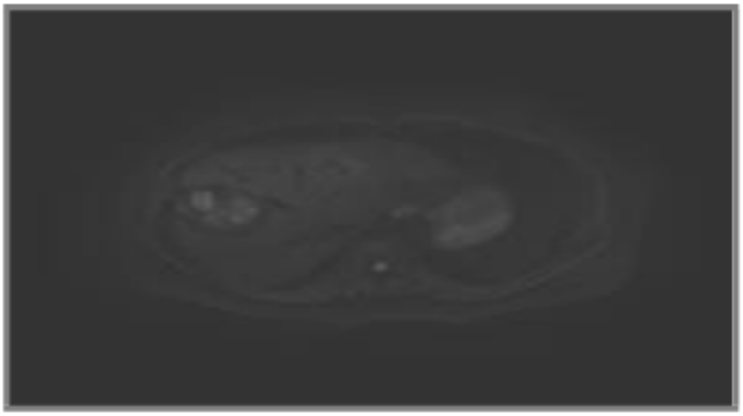
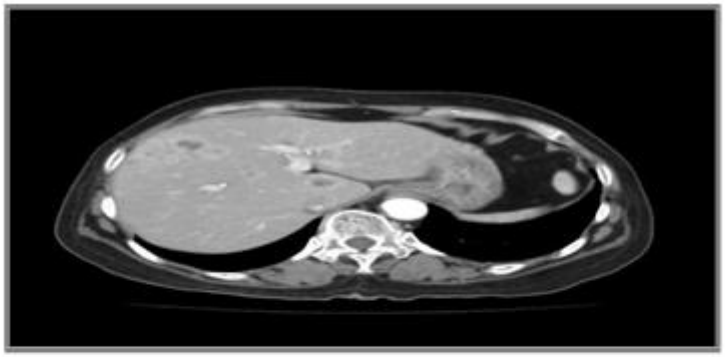


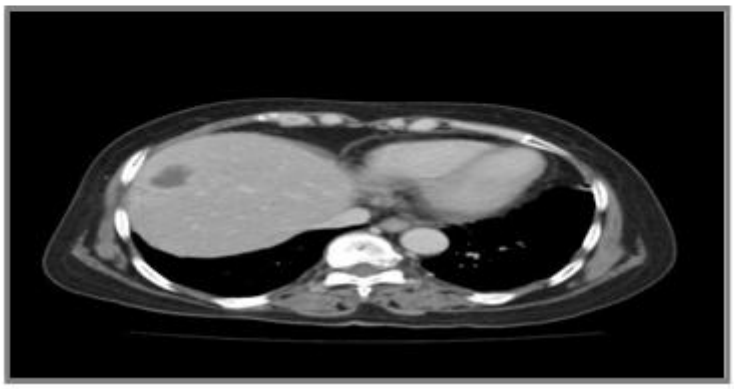
**DWI**

**Figure 13:** Case of RCC on follow up shows variegated type of enhancing lesion with prominent vessels in arterial phase in segment 8 of liver. Portal venous and delayed phase shows mild persistent centripetal enhancement.

**HEPATIC METASTASIS OF CARCINOMA BREAST**



**PortalvenousphaseofCT**



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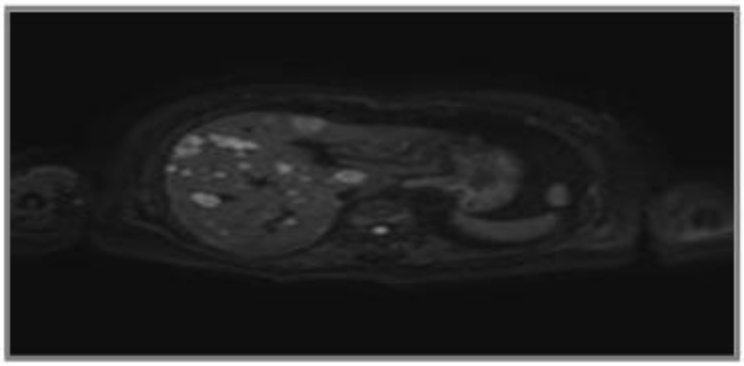
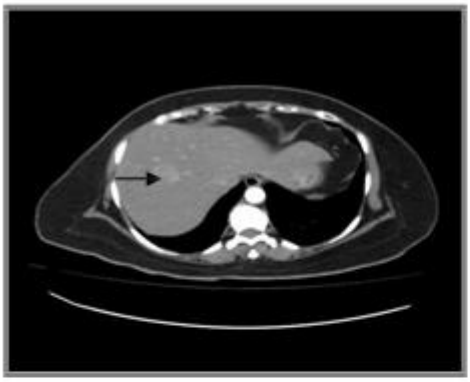


**DWI**

**Figure 14:** Case of carcinoma breast, CECT showing ring enhancing lesions in portalvenous and delayed phases. DWI showing multiple foci of diffusion restriction.

**HEPATIC METASTASIS OF CARCINOMA ENDOMETRIUM**



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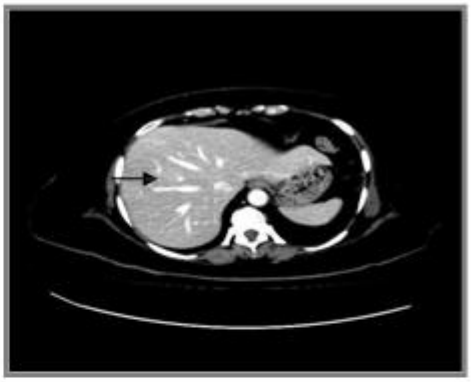

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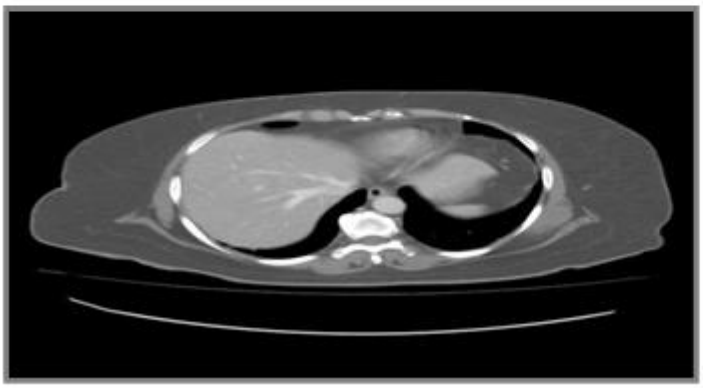

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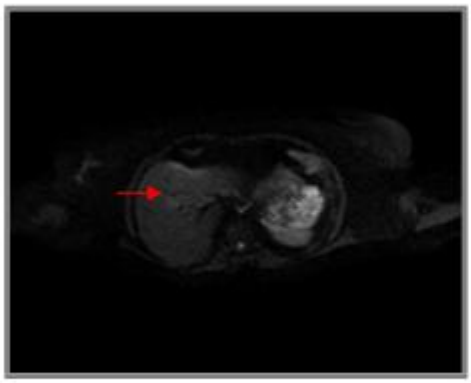
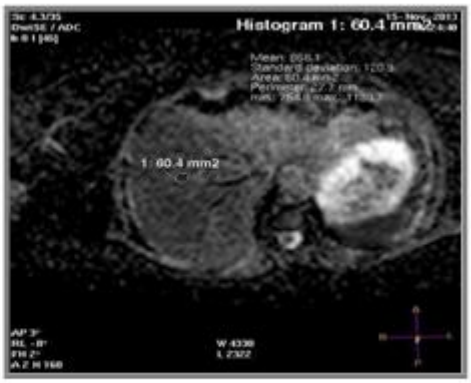


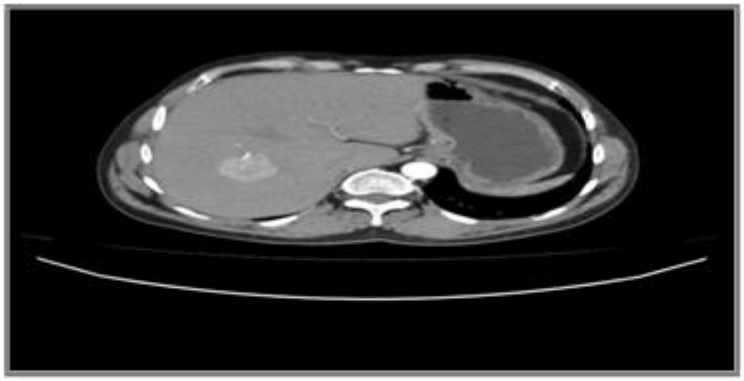
**DWI**



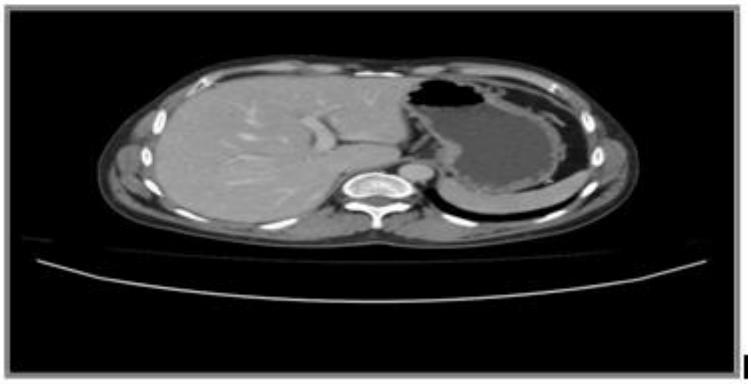

**ADC**

**Figure 15 :** Case of Ca. Endometrium, CECT arterial phase shows well defined homogenous enhancing lesion, in portal venous phase the lesion is mildly hyperenhancing with illdefined border and in delayed phase the lesion is inconspicuous. DWI shows restriction with ADC of 0.868x10-3 suggesting highly cellular tissue.

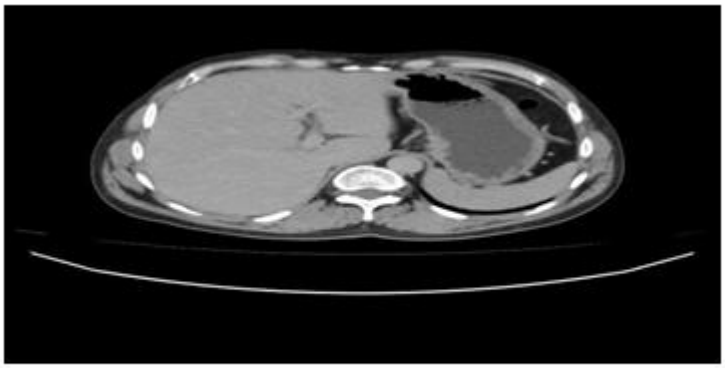
**Focalnodularhyperplasia**



**ArterialphaseCT**



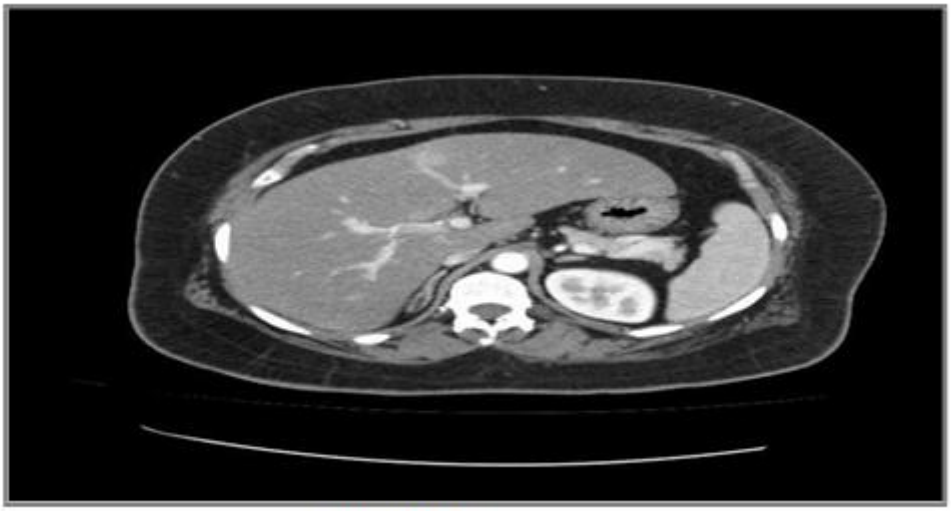
**PortalvenousphaseCT**



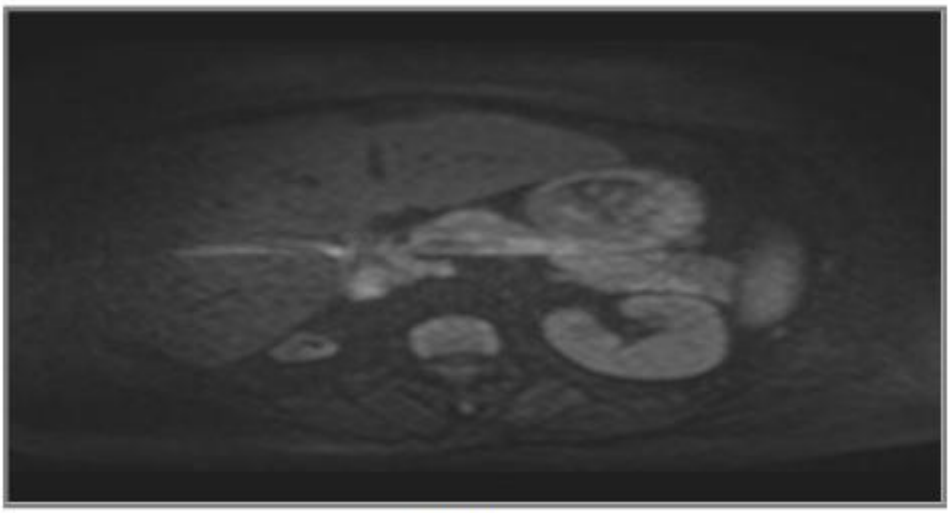
**DelayedphaseCT**

**Figure 16:** case of FNH. CECT arterial phase shows homogenously enhancing lesion in segment 8, the lesion is becoming inconspicuous in portalvenous and delayed phase suggesting contrast hold up.

**Vascularmalformation**



**PortalphaseCT**



**DWI**

**Figure 17:** An ill defined area of hyperenhancement seen in segment 2 of liver, corresponding section on DWI shows no obvious lesion.

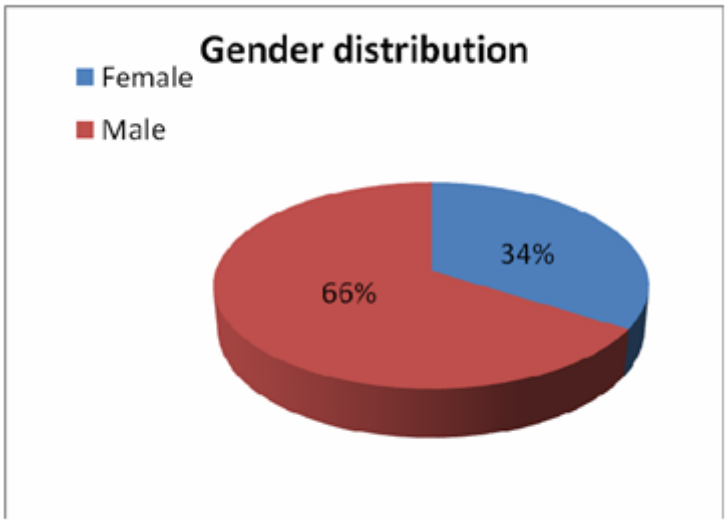
## IV. Observation and Results

Out of 50 patients in our study, 33 were male and 17 female patients. Mean age of total study group was 54 with mean age of presentation for males being 55yrs and female being 51yrs.

**Table1:AgeandGenderdistributionofpatientsstudied**

| AgeGroup | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | # | % | # | % | # | % |
| **20-29** | 3 | 9.1 | 1 | 5.9 | 4 | 8.0 |
| **30-39** | 3 | 9.1 | 3 | 17.6 | 6 | 12.0 |
| **40-49** | 3 | 9.1 | 3 | 17.6 | 6 | 12.0 |
| **50-59** | 8 | 24.2 | 4 | 23.5 | 12 | 24.0 |
| **60-69** | 9 | 27.3 | 6 | 35.3 | 15 | 30.0 |
| **70-80** | 6 | 18.2 | | 0.0 | 6 | 12.0 |
| **>80** | 1 | 3.0 | | 0.0 | 1 | 2.0 |
| **Total** | **33** | **100.0** | **17** | **100.0** | **50** | **100.0** |
| **Mean±SD** | **55.7±15.31** | | **51.1±12.68** | | **54.2±14.52** | |

**Chart1:Genderdistribution**

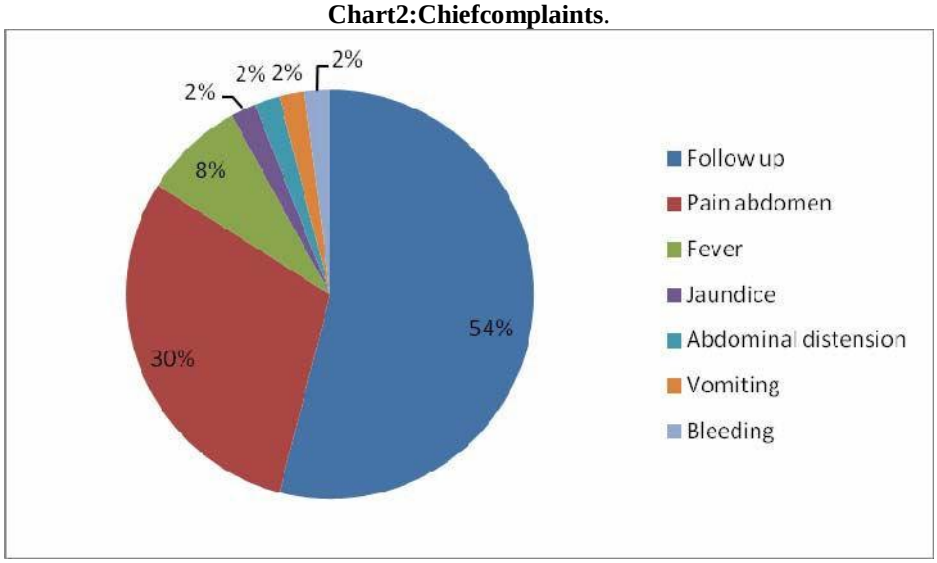



Most of the patients were follow up cases out of which maximum were follow up cases of known primaries followed by HCC and abscess. 1 patient in the follow up group was diagnosed to have THAD. 15 patients presented with pain abdomen, 4 with fever and 1 each with jaundice, abdominal distension, vomiting and bleeding (hematemesis, melena).

**Table2:Chiefcomplaints**

| **Chiefcomplaints** | **No.ofpatients** | **%** |
|---|---|---|
| **Followup/nocomplaints** | 27 | 54% |
| **Painabdomen** | 15 | 30% |
| **Fever** | 4 | 8% |
| **Jaundice** | 1 | 2% |
| **Abdominaldistension** | 1 | 2% |
| **Vomiting** | 1 | 2% |
| **Bleeding** | 1 | 2% |
| **Total** | **50** | **100%** |

**Chart2:Chiefcomplaints**.




Comparison was made between ultrasound, NECT, CECT and DW MRI in terms of lesion detection rate. It was found that diffusion weighted MRI had the maximum lesion detection rate followed by CECT, NECT and ultrasound being the least.

**Table3:NumberofLesionsseenindifferentimagingmodalities**

| NUMBEROFLESIONS | UltraSound | CTScan | CECT | MRI |
|---|---|---|---|---|
| **Lesionsnotseen** | 13 | 5 | 2 | 1 |
| **Onelesion** | 19 | 26 | 26 | 22 |
| **Twolesion** | 18 | 19 | 22 | 27 |
| **Total** | **55** | **64** | **70** | **76** |

**Chart3:NumberofLesionsseenindifferentimagingmodalities**

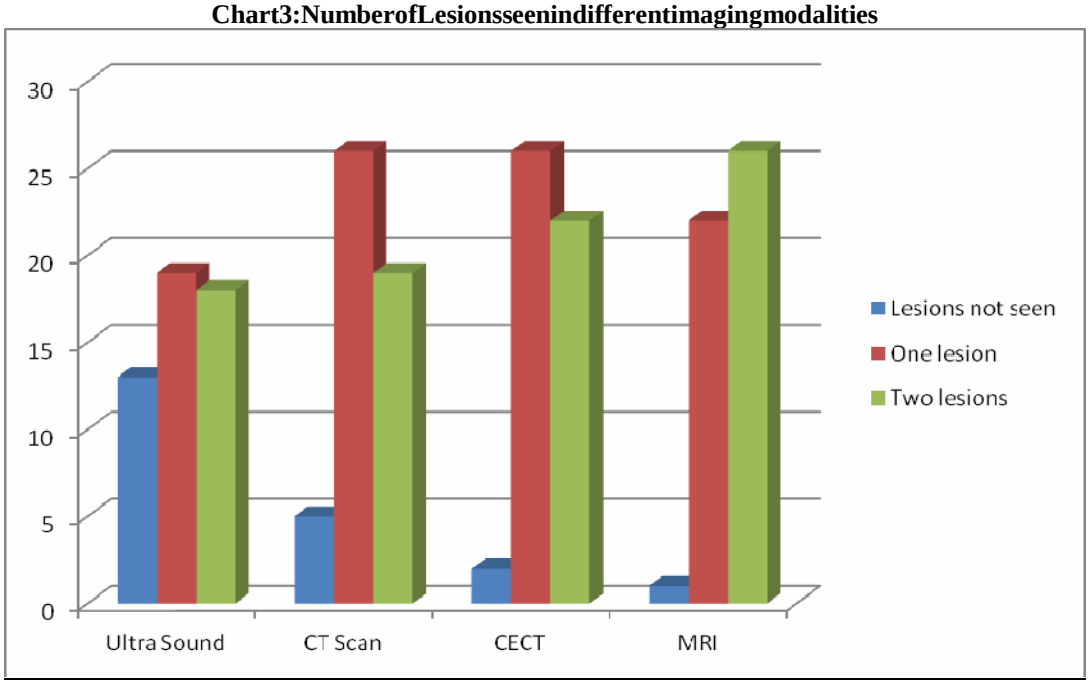



**Table4:Associationbetweennumberoflesionsindifferentimagingmodality**

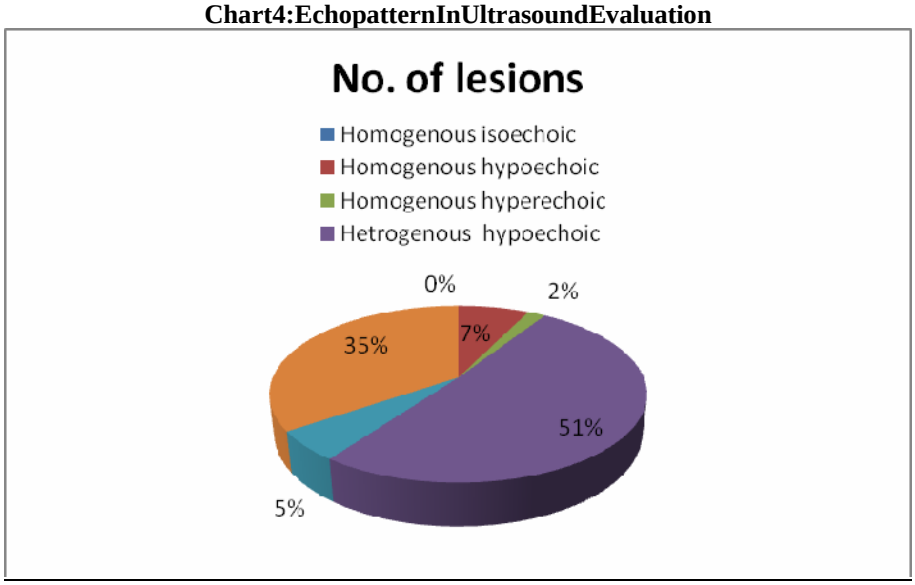
| | UltraSound | | CT | | CECT | | MRI | |
|---|---|---|---|---|---|---|---|---|
| **NoofLession** | # | % | # | % | # | % | # | % |
| **One** | 19 | 38.0 | 26 | 52.0 | 26 | 52.0 | 21 | 42.0 |
| **Two** | 18 | 36.0 | 19 | 38.0 | 22 | 44.0 | 27 | 54.0 |
| **NotSeen** | 13 | 26.0 | 5 | 10.0 | 2 | 4.0 | 1 | 4.0 |
| **TOTAL** | **55** | **100.0** | **64** | **100.0** | **70** | **100.0** | **26** | **100.00** |
| **Chi-Square** | **18.65** | | | | | | | |
| **P-Value** | **0.011** | | | | | | | |

Out of 50 cases, ultrasound was able detect 55 lesions from 37 cases. In 13 cases ultrasound was not able to detect any lesion. Echopattern on ultrasound was grouped broadly as homogenous and heterogenous, which was further subcategorized as hypoechoic, isoechoic and hyper echoic in comparison to the adjacent liver parenchyma. Heterogenous echopattern was the most common echopattern seen, with heterogenous hypoechoic lesions being commonest followed by heterogenous hyperechoic lesions. Isoechoic lesions were the least in both the groups. No cases of homogenous isoehoic seen in our study.

**Table5:EchopatternInUltrasoundEvaluation**

| ECHOPATTERN | No.oflesions | % |
|---|---|---|
| Homogenousisoechoic | 0 | 0 |
| Homogenoushypoechoic | 4 | 7.3 |
| Homogenoushyperechoic | 1 | 1.8 |
| Hetrogenoushypoechoic | 28 | 50.9 |
| Hetrogenousisoechoic | 3 | 5.5 |
| Hetrogenoushyperechoic | 19 | 34.5 |
| **Total** | **55** | **100.0** |

**Chart4:EchopatternInUltrasoundEvaluation**

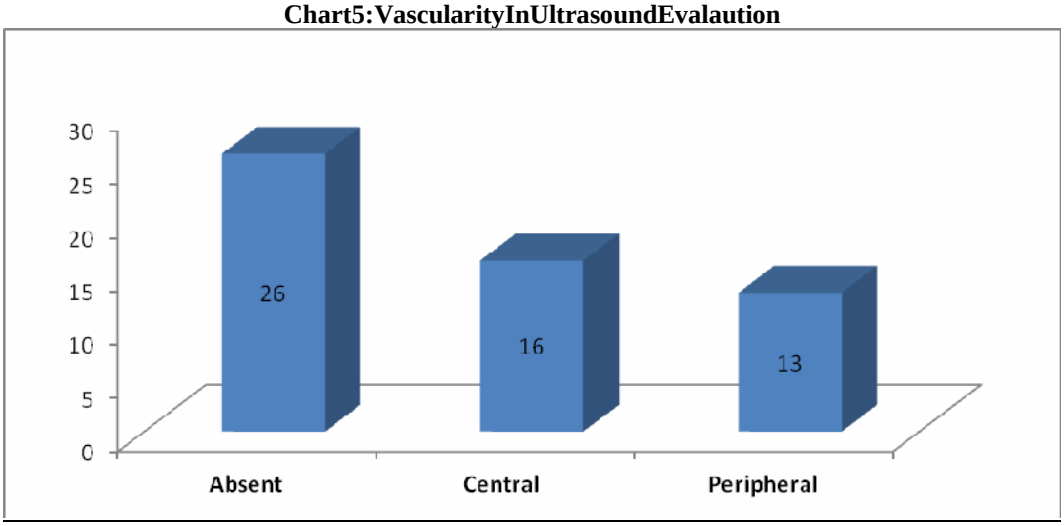



Vascularity was assessed using power Doppler ultrasound with lowest possible PRF. It was found that 26 lesions did not show any vascularity, 16 showed central vascularity and 13 peripheral

**Table6:VascularityInUltrasoundEvalaution**

| VASCULARITY | No.oflesions | % |
|---|---|---|
| **Absent** | 26 | 47.3 |
| **Central** | 16 | 29.1 |
| **Peripheral** | 13 | 23.6 |
| **Total** | **55** | **100.0** |

**Chart5:VascularityInUltrasoundEvalaution**




Out of 70 lesions detected on CECT 38 lesions showed hypervasclarity on arterial phase among which 15 lesions showed variegated pattern, 15 showed closed ring pattern, 5 were open rings and 3 were homogenous pattern. 24 were hypoenhancing and 8 were isoenhancing to the liver parenchyma

**Table7:ArterialphaseevaluationinCECT**

| ARTERIAL | No.oflesions | % |
|---|---|---|
| Hypoenhancing | 24 | 34.3 |
| Isoenhancing | 8 | 11.4 |
| Hypervascular-homogenous | 3 | 4.3 |
| Hypervascular- variegated | 15 | 21.4 |
| Hypervascular–closedring | 15 | 21.4 |
| Hypervascular–openring | 5 | 7.1 |
| **Total** | **70** | **100.0** |

**Chart6:ArterialphaseevaluationinCECT**

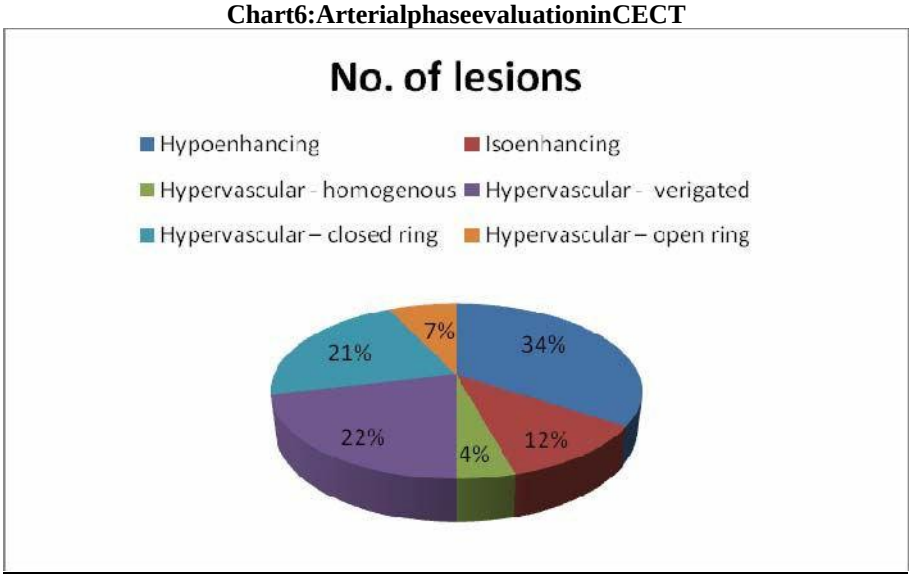



**Table8:AssociationbetweenvascularityoflesionsonultrasoundandarterialphaseCT**

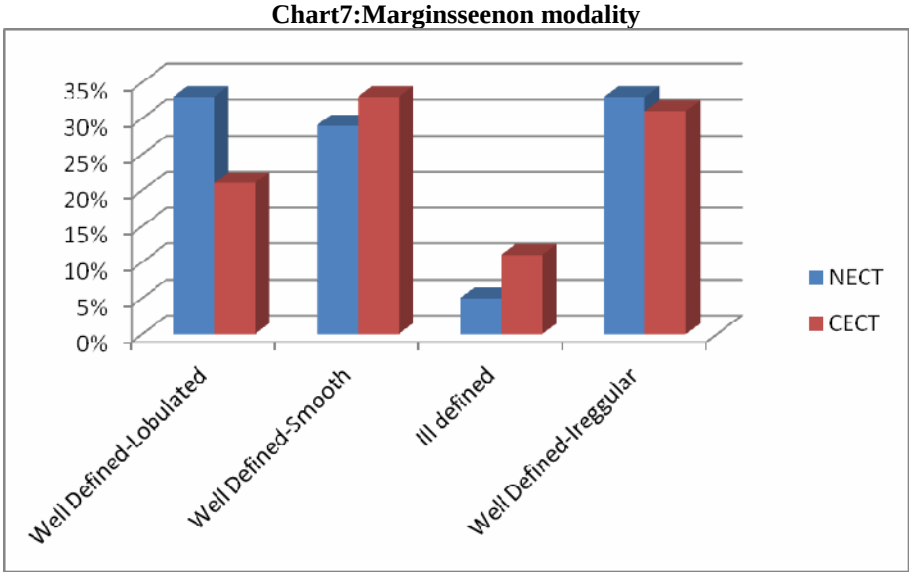
| | UltraSound | | CECT | |
|---|---|---|---|---|
| **Vascularity** | **#** | **%** | **#** | **%** |
| **0** | 26 | 47 | 32 | 46 |
| **1** | 29 | 53 | 38 | 54 |
| **Total** | 55 | 100 | 70 | 100 |
| **Chi-Square** | **0.03** | | | |
| **P-Value** | **0.8623** | | | |

Margin of the lesions were assessed in NECT and CECT. Well defined lobulated and irregular margins were more commonly found on NECT and well defined smooth on CECT.

**Tabe9:MarginsseeninNECTandCECT.**

| **Margins** | **NECT** | **CECT** |
|---|---|---|
| **WellDefined-Lobulated** | 33% | 21% |
| **WellDefined-Smooth** | 29% | 33% |
| **Illdefined** | 5% | 11% |
| **WellDefined-Ireggular** | 33% | 31% |

**Chart7:Marginsseenon modality**




Most of the lesions were well seen on portal venous phase. Hypoenhancing lesions were seen in 41% of the lesions followed by hyperenhancing and isoenhancing

**Table10:CECTevalautioninportalvenousphase**

| PORTAL | No.oflesions | % |
|---|---|---|
| **Hypoenhancing** | 29 | 41.4 |
| **Isoenhancing** | 13 | 18.6 |
| **Hyperenhancing** | 28 | 40.0 |
| **Total** | 70 | 100.0 |

**Table11:CECTevalautionindelayedphase**

| Delayed | No.oflesions | % |
|---|---|---|
| **Hypoenhancing** | 33 | 47.1 |
| **Isoenhancing** | 28 | 40 |
| **Hyperenhancing** | 9 | 12.9 |
| **Total** | 70 | 100.0 |

Type of arterial hyperenhancement pattern was compared with that of the histopathology groups and it was found that homogenous hyperenhancement was seen in 3 lesions, 2 of which were RCC metastasis and 1 was in benign group(adenoma),

15 lesions showed variegated pattern and were seen in solid malignant, cystic malignant and benign group, with HCC being the commonest diagnosis.

Complete rings were seen15 lesions with 7 lesions in solid malignant group, 5 in cystic malignant and 3 in infection group with maximum lesions being of metastatic origin. Incomplete rings were seen in 5 patients with 3lesions in infection group, 1 in cystic malignant and 1 in solid malignant, with abscess being the most common lesion.

**Table12:Comparisonbetweenarterialhyperenhancementwithhistopathologygroup**

| ArterialHyperenhancement | INFECTION | BENIGN | CYSTIC MALIGNANT | SOLID MALIGNANT | Total |
|---|---|---|---|---|---|
| | # | # | # | # | |
| **Homogenous** | - | 1 | - | 2 | 3 |
| **Verginated** | - | 4 | 7 | 4 | 15 |
| **CompleteRing** | 3 | - | 5 | 7 | 15 |
| **IncompleteRing** | 3 | - | 1 | 1 | 5 |
| **Total** | **6** | **5** | **11** | **12** | **38** |
| **Chi-Square** | **18.7689** | | | | |
| **P-Value** | **0.02** | | | | |

No of lesions with most common CECT enhancement pattern and number of each lesion were compared

**Table 13:** Most common CECT enhancement pattern and number of lesion in each type of histopathological diagnosis

| Histopathology | nooflesions | Mostcommonpattern | | |
|---|---|---|---|---|
| | | Arterial | portalvenous | delayed |
| **HCC** | 14 | Hyperenhancing | Hyperenhancing | hypoenhancing |
| **Adenoma** | 3 | Hyperenhancing | Hyperenhancing | Hyperenhancing |
| **FNH** | 1 | Hyperenhancing | isoenhancing | isoenhancing |
| **Abscess** | 12 | Hyperenhancing | Hyperenhancing | isoenhancing |
| **Metastasis** | 32 | Hyperenhancing | hypoenhancing | hypoenhancing |
| **NHL** | 3 | hypoenhancing | hypoenhancing | hypoenhancing |
| **Benignlesion** | 2 | Hyperenhancing | isoenhancing | hypoenhancing |
| **Granulomatoushepatitis** | 2 | hypoenhancing | hypoenhancing | hypoenhancing |
| **Vascularmalformation** | 1 | isoenhancing | Hyperenhancing | isoenhancing |

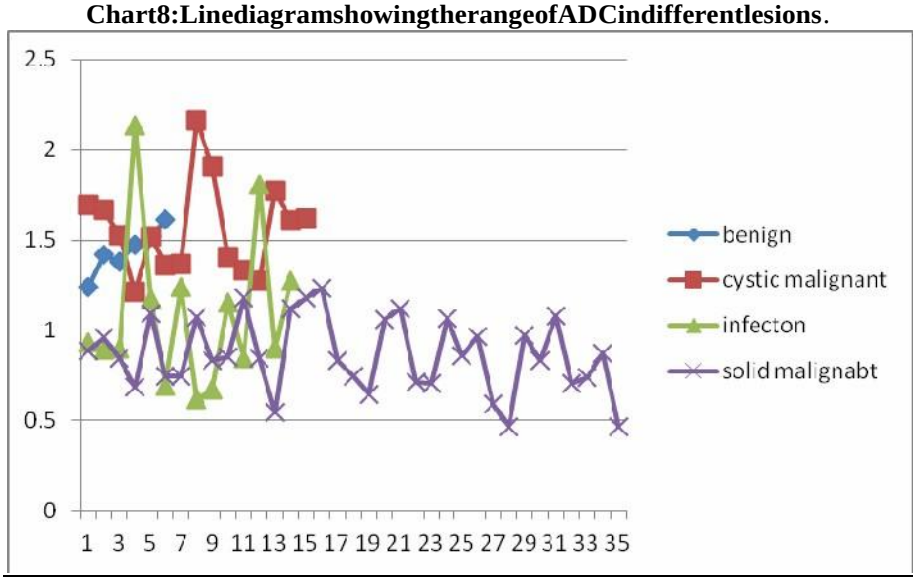
Lesions were grouped into benign, infection, cystic malignant and solid malignant. Their minimum and maximum values were noted and line diagram was made for the range of values in the each category. From the graph it is noted that there is overlap of values of all the categories between 1.1x10-3 to 1.3x10-3.

**Table14:Numberoflesionsineachgroupwithminimumandmaximum ADCvalues.**

| Group | nooflesions | % | Range | |
|---|---|---|---|---|
| | | | Min | Max |
| **Benign** | 6 | 7.8 | 1.23 | 1.98 |
| **Infection** | 14 | 18.4 | 0.61 | 2.13 |
| **Cysticmalignant** | | | | |

| | | | | |
|---|---|---|---|---|
| | 18 | 23.6 | 1.21 | 2.16 |
| **Solidmalignant** | 38 | 50 | 0.54 | 1.23 |

**Chart8:LinediagramshowingtherangeofADCindifferentlesions**.




Groups were divided into two groups of two each. Infection and cystic malignant were grouped as one and solid and benign lesions were grouped in another and cut off values were calculated for each group. The ADC cut off in infection and cystic malignant group was 1.07 with values below the cut off being common for infection and above being common in cystic malignant, with sensitivity of 100% and specificity of 67%. In benign and solid malignant group the cut off was 1.23, values below 1.23 indicating towards malignancy and values above 1.23 indicting benignity with sensitivity of 100% and specificity of 92.7%.

**Table15:Cutoffvalueswithsensitivityandspecificityinvariousgroups.**

| Study | CADCValue | CutoffValue | Sensitivity(%) | Specificity(%) | AUC |
|---|---|---|---|---|---|
| **Infection** | 1.0±0.42 | 1.07 | 100 | 67 | 0.86 |
| **CysticMalignant** | 1.5±0.23 | | | | |
| **Benign** | 1.5±0.26 | | | | |
| **SolidMalignant** | 0.9±0.15 | **1.233** | 100 | 92.7 | 0.96 |

## V. Discussion

A variety of focal lesions affect the liver, among which commonest are hemangioma, simple cysts, hepatocellular carcinoma, hepatic adenoma, FNH and metastaticdeposits. Since liver is the largest organ and highly vascular, there is high rate of occurrence of metastatic deposits. Most common ones are from carcinoma lung, breast and gastrointestinal malignancies. HCC is the most common primary malignancy ofliver, predisposing factors include macronodularcirrhosis. A variant of HCCoccurring in young patients called fibrolamellar HCC occurs denovo, doesn't showany rise in AFP and has better prognosis than the typical HCC.

There are various modalities to image FLL, most commonly and widely usedamong them is the ultrasonography. Ultrasonography is a very sensitive tool indetecting the focal liver lesions, however due to observer dependency the sensitivity can come down especially for detecting lesions less than 1cm. Ultrasound candiagnose FLL with some accuracy, however lacks specificity. Multiphase CECT hasrapidly gained popularity due to high accuracy in characterizing FLL and vascular anatomy. It has become the gold standard in imaging focal liver lesions.

Diffusion weighted MRI works on principle of restriction of diffusion of watermolecules. Highly cellular tissues show restriction of water movement and appearsbright on DWI. DWI can be quantified using ADC maps. In our study we are trying to establish a similar cut off between cystic malignancy and abscess and between benign lesions and solid malignancy.

Our study is a prospective observational study involving 50 patients, out ofwhich 33 were male(66%) and 17 female(34%) patients. Mean age of total studygroup was 54 with mean age of presentation for males being 55yrs and female being51yrs. 27(54%) of patients belong to the follow up with prior history of either a known primary, HCC or abscess. 15(30%) patients had chief complaint as pain abdomen,4(8%) presented with fever, 1(2%) each with vomiting, abdominal distention,jaundice and bleeding tendencies(hemoptysis).We

compared three imaging modalitiesi.e., ultrasound, CT (plain and contrast) and MRI with each other and with histopathology. We noticed that there was significantly higher number of lesionsdetected by diffusion weighted MRI when compared with CECT, NECT andultrasound. On ultrasound there were 13 cases, were lesion was not picked up. This can be attributed to lesions being smaller in size, isoechoic to the adjacent liverparenchyma and observer dependency. In 5 cases NECT was not able to pick up thelesion. There were 2 cases were CECT was not able to pick up he lesions, both thesecases were of metastasis group on chemotherapy, and in these cases DW MRI was able to detect the lesion. This can be attributed to smaller size <5mm with decreasedenhancement following chemotherapy.

There was one case where CECT showed an ill defined nodular enhancingarea in segment 4a in portal venous phase, the lesion was not well seen on otherphases, ultrasound and MRI. Ultrasound scan was repeated in this case and T2 SPIRsequence was done and showed no obvous lesion. It was finally concluded as Vascularmalformation. H.Ravikumar, et al. has described polymorphous THAD as usuallynot following the portal vein branches and show various shapes and sizes without astraight border sign. They may be caused by an aberrant blood supply, inflammationor parenchymal injuries from physical or chemical agents[1].

There were 6 extra lesions detected on DW MRI among which 2 were casesof metastasis and 2 of HCC. In all the cases it was found that the lesion size was ~5mm and all the patients were on treatment. Changes in attenuation of liver metastatic lesions from gastrointestinal stromal tumors after imatinibmesylate therapy have beenpredictive of tumor response at 18F-FDG PET, and lesions responding according toattenuation criteria have had a significantly longer time to progression[2,3]. Tochettoand colleagues reported that the change in attenuation of liver metastatic lesions of colon cancer at MDCT and metabolic activity at FDG PET 1 month after 90Yradioembolization are highly correlated[4,5]. In one study[6], DW MR imaging wasfound to be more sensitive than SPIO-enhanced MR imaging in detection ofcolorectal hepatic metastases. SPIO-enhanced MR imaging was less sensitive for metastases of less than 1 cm in diameter[6].

On ultrasound we noticed that the common echopattern was heterogenoushypoechoic i.e., 28(51%) lesions followed by heterogenoushypoechoic pattern19(34%) lesions. Of the 55 lesions seen on ultrasound there were 29(52.7%) lesionswhich showed vascularity out of which 16(29.1%) showed central vascularity and 13(23.6%) showed peripheral vascularity. Since most of the pattern showed arterial spectrum we compared it with that of the arterial phase of CECT, and we found that,tough ultrasound detected less number of lesions compared to CECT but there was nostatistical significant difference in detecting vascularity within the lesion when compared with arterial phase of CECT.

Central cleft of the lesion was evaluated in both ultrasound and CECT as cystic, fat, air, calcium, thrombus or scar. In our study we found ultrasound was equal in detecting intralesional air of abscesses as compared to CECT. There were 20lesions where central cystic component was detected on USG as compared to 30 lesions on CECT. This can be correlated to higher lesion detection rate of CECT. Ultrasound was found to be on par with CT in detecting ascites, portal and hepatic vein thrombosis.

CECT was used as the modality for characterizing FLLs. We used arterial,portal venous and delayed phase images to characterize the lesions. In arterial phaseout of 70 lesions there were 38(54.2%) lesions showing hyperenhancement,24(34.3%) hypoenhacement and 8(11.4%) lesions that show enhancement similar to the liver parenchyma.Hyperenhancement was further categorized into homogenous,variegated , open ring and closed ring pattern. There were 3(4.3%) lesions ofhomogenous patter, 15(21.4%) lesions with variegated appearance, 15(21.4%) lesionswith closed ring and 5(7.1%) lesions with open ring pattern. We compared vascularity on ultrasound with that of arterial phase hyperenhancement. Chi square test was usedfor this purpose and it showed no statistically significant difference betweenvascularity on ultrasound and arterial phase enhancement indicating both are equally good in assessing vascularity of lesion, but however CECT is should be considered as better modality as it can detect more number of lesions as compared USG.Margins were evaluated in NECT and CECT. In NECT margins appear morelobulated(33%) as compared to CECT where the margins were smooth(33%).

On portal venous phase 29(41.4%) lesions showed hypoenhancement,28(40%) hyperenhancement and 13(18.6%) isoenhancement. On delayed phaseisoenhancing were 28(40%), hypoenhancing were 33(47.1%) and 9(12.9%) showedpersistanthypervascularity. Comparison between type of arterial enhancement andhistopathology group was. Homogenous pattern was seen in 3 lesions, 1 in benigngroup(adenoma) and 2 in solid malignant group(RCC). 15 lesions had variegated appearance out of which 4 were in benign group(FNH and adenoma), 7 in cystic malignant group(HCC) and 4 in solid malignant group(HCC). 15 lesions had closedring pattern with 3 in infectious group, 5 in cystic malignant group and 7 in benigngroup. 5 Lesions were seen to have open ring pattern out of which 3 were in infectious group, 1 in cystic malignant and 1 in solid malignant. Chi square test was done to establish association between the arterial hypervascularpattern withhistopathology group. We found significant association between the 2 groups with pvalue of 0.02. This was correlating with the study of Matilde Nino-Murcia, et al. in in their study found arterial patterns to have positive

predictive value of 82% andspecificity of 80% and concluded that the appearance of hepatic lesions in the arterialphase of enhancement has potential use in the determination of specific diagnoses[7].

There were 11 cases of HCC out of which 2 cases were of multicentric HCC detected by CECT. On CECT all the lesions showed hyper enhancement withvariegated patter except for one which showed isoenhancement. Most of the lesionsshowed persistent contrast enhancement and few showed washout in portal venous and most of the lesions were hypoenhancing on delayed phase.Jae Hoon Lim et al., intheir study concluded that addition of delayed phase imaging to dual-phase helical CTis valuable for the detection and characterization of hepatocellular carcinoma as fewof the HCC which showed washout in delayed phase especially the lesions whichwere hyperenhancing in portalvenousphase[8].

There were 9 cases in infectious group out of which 7 were well formed abscesses, one was resolving abscess and one was case of focal granulomatoushepatitis. 6 cases showed early arterial enhancement cases showed early open/closedring hyperenhancement on arterial phase with most of the lesions showing persistanthyperenhancement in portalvenous and delayed phase, 2 lesions showedhypoenhancement in portal venous phase which remained the same in delayed phase.Lesions in granulomatous hepatitis were hypoenhancing in arterial and portal venous phase and isoenhancing in delayed phase.

There were 23 cases of metastasis, out of which 4 cases were cystic, 17 were solid malignant and 3 cases showed both solid and cystic malignant. On arterialphase most of the lesions were hyperenhancing with all of them showing closed ringenhancement with one showing homogenous enhancement(RCC metastasis), these cases remained hyper to isoenhancing in portalvenous and delayed phases. 2 caseswere isoenhancing on arterial phase, both of them showing hypoenhancement onportal venous phase.

7 lesions were diagnosed under benign group out of which 3 were hepatic adenomas, one was FNH, two as benign lesion on HPE and 1 was inferred as vascularmalformation. All hepatic adenomas showed early arterial enhancement withpersistence of contrast in portalvenous and delayed phase. This is in contradiction to the findings of Luigi Grazioli et al., where they have found adenomas to beisoenhancing in portalvenous or delayed phase[9]. One case of FNH showed arterialvariegated pattern of hyperenhancement which remained isoenhancing in portal venousand delayed phases. In comparison Mathieu D et al., in their study also found FNH to be hyperenhancing on arterial phase and isoenhancing on portalvenous and delayedphases[10]. One case of Vascular malformation showed only nodular enhancement inportalvenous phase.

MRI was able to detect 76 lesions. ADC was calculated. There were two groups made, one group containing infective lesions vs. cystic neoplasms, and anothergroup containing benign lesions vs. solid malignant lesions. In our study we foundsome overlap of lesions in the range of $1.1x10^{-3}$ $mm^2$/sec to 1.3x10-3 $mm^2$/sec.Hencefor lesions in this grey zone, conventional MRI sequences and triphasic CT wouldhelp in establishing the diagnosis.

We found the cut off value in the cystic vs. infective group to be 1.07x10-3mm2/sec with sensitivity of 100% and specificity of 67%, with values less than$1.07x10^{-3}$ $mm^2$/sec indicating towards infection. In second group i.e., benign vs. solidmalignant we found the cut off value of 1.23x10-3 mm2/sec with sensitivity of 100% and specificity of 92% with values less than 1.23x10-3 mm2/sec indicatingmalignancy. In comparisionTejasparikh et al., in his study found that the area underthe curve for diagnosis of malignancy was 0.839, with sensitivity of 74.2%, specificity of 77.3%, positive predictive value of 85.5%, negative predictive value of 62.3%, and accuracy of 75.3%, by using a threshold ADC of less than 1.60x10-3 mm2/sec[11].

## VI. Summary

1. Ultrasound did not show any statistical difference in picking up the vascularity and central cleft features of focal liver lesions as compared to CECT, however CECT detected significantly more number of lesion.
2. Ultrasound was equally accurate in picking up hepatic vein thrombosis, portal vein thrombosis and ascitis as compared to CECT.
3. Characterization using CECT based on type of arterial pattern with portal venous phase and delayed phase imaging is accurate in diagnosing the lesion
4. Diffusion weighted MRI is the better modality at detecting smaller lesion.
5. DWI with ADC values is helpful in characterizing lesions where CECT gives indeterminate results.
6. Cystic vs. infective group was found to have cut off of 1.07x10-3 mm2/sec with sensitivity of 100% and specificity of 67%, with values less than 1.07x10-3 mm2/sec indicating towards infection
7. Benign vs. solid malignant was found to have a cut off value of 1.23x10-3 mm2/sec with sensitivity of 100% and specificity of 92%. Lower values signifying solid malignant and higher values indicating benign nature.

## VII. Limitations:

1. Most important limitation to our study was small study population.
2. .Since few were on treatment, their enhancement pattern would change and wouldn't have correlated with the actual pattern of the lesion.

3. Only two largest lesions were considered, immaterial of weather they were benign or malignant.
4. Only respiratory triggered DW MRI was done, hence we could not compare it with other techniques.
5. ADC data varies from manufacturer to manufacturer. We have not compared it with other MR system, so this value cannot be generalized on all the MR systems.
6. Even when the same MR system is used, DW MR imaging studies have inherently lower SNR and are susceptible to a range of artifacts, which could increase the variability of the calculated ADC.
7. ADC was calculated from the most restricting region on B500 only.
8. Histopathological diagnosis of all the lesions could not be done .
9. Biopsy was not done in a known case of primary.

## VIII. Conclusion

In our study we concluded that CECT is the modality of choice for characterizing focal liver lesions, for preoperative localization of the lesion and vascular anatomy assessment. Diffusion weighted imaging has high sensitivity in detecting smaller lesions and characterization of lesion is possible with ADC values. DWI should be routinely included in all the MRI studies of liver. In doubtful cases of CECT, DW MRI can help in establishing the diagnosis.

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