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ROLE OF DYNAMIC CT SCAN IN DIAGNOSING AND CHARACTERISING THE SOLID RENAL MASSES AND IT'S MIMICS AND COMPARISON WITH HISTOPATHOTHOLOGY.

Radio-Diagnosis

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ABSTRACT

Introduction: Renal tumours are common these days-Benign as well as malignant. Most of the malignant lesions are clear cell carcinoma (ccRCC), followed by papillary RCC (pRCC). It is important to differentiate and characterise renal carcinomas and their mimics. In the present research we did the dynamic evaluation of the renal tumours on CT, differentiated them on the basis of Enhancement pattern and compared with the post-operative histopathological findings as gold standard. **Aims and Objective:** Primary Objective:-To assess the sensitivity and specificity of volume -based enhancement parameters like mean and median enhancement on dynamic contrast enhanced computed tomography (CECT) to diagnose and characterise solid renal masses and compare with histopathology. Secondary Objective:-To assess the sensitivity and specificity of dynamic CT scan in differentiating between Renal cell carcinoma and it's mimics. **Materials and Methods:** Our study was the prospective and multicentric study. We did the study at two centres (MEDANTA hospital, Gurgaon and SRMS institute of medical sciences Bareilly, from: Feb 2015 to June 2016 and November 2020 to June 2023 respectively). Multiphasisc dynamic contrast CT imaging of the 75 patients was done .Images in different phases were transferred to a dedicated workstation .The lesions were segmented and enhancement pattern were displayed as histogram in different phases with the help of the softwere named generic in the Siemens CT scanner .Both quanlitative and quantitative study was done. In the quantitative sections-mean and median enhancement values and parameters like skewness, kurtosis, standard deviation, and interquartile range were calculated for each lesion. Enhacemnet pattern on the histogram were used to differentiate and characterise the solid renal lesions. **Conclusion:** We were able to diagnose different type of renal lesions and differentiate them. Larger number of patient was having renal cell carcinoma predominantly clear cell(ccRCC) and papillary carcinoma(pRCC) on histopathology which showed different enhancement pattern, so we were able to differentiate between clear cell(ccRCC) and papillary carnoma(pRCC) with almost 100 % sensitivity and 98% specificity.

KEYWORDS

INTRODUCTION

Renal tumours in adults constitute a heterogeneous group with characteristic histology and variable clinicobiological profile. Most of them arise from the renal parenchyma, referred to as renal cell tumours, with a much smaller number arising from the collecting system and the mesenchyme.Renal tumours are of Ball type and Bean type. Ball type tumours are more common and usually they enlarge by means of additive expansion.Bean-type lesions grow by infiltration into renal parenchyma. Reniform shape is maintained in bean type of tumour.Ball type lesions are Renal cell carcinoma (RCC), Angiomyolipoma(AML), Oncocytoma ,Metastasis, Lymphoma. Bean type lesions are Transitional cell carcinoma(TCC) ,Metastasis, Infiltrative RCC, Medullary carcinoma, collecting duct carcinoma.(1)

Renal cell carcinoma is the prototype of ball type lesion. Among the primary renal neoplasm renal cell carcinoma accounts for 90% and 3% of all adult malignancy. Peak of RCC is 6th or 7th decades with male predominance.(2,3).

The classification of renal cell carcinoma into subtypes has become of interest because of the association with prognosis.(4)

Conventional renal cell carcinoma (Clear cell renal cell carcinoma) is the most common subtype, approximately 70% of renal cell carcinomas; the overall 5-year survival rate of patients with conventional renal carcinoma ranges from 55% to 60%.(5).

Papillary renal carcinoma, the second most common subtype, comprises from 15% to 20% of renal cell carcinomas and is associated with a high 5-year survival rate (80–90%).(6) Chromophobe renal carcinoma accounts for 6–11% of the cases. Patients with this subtype have the best prognosis: the 5-year survival rate is approximately 90% (7).

Voxel-based whole lesion enhancement parameters can be used as a quantitative tool to differentiate Clear cell RCC (ccRCC) from Papillary RCC (pRCC). Differentiating between the two main types of RCC would provide the patient and the treating physicians more information to formulate the initial approach to managing the patient's renal cancer. (8)

Enhancement parameters can be used as a quantitative tool to differentiate ccRCC from pRCC. Differentiating between the two main types of RCC would provide the patient and the treating physicians more information to formulate the initial approach to managing the patient's renal cancer. (8)

Lipid poor AML and Oncocytoma are the other cortical neoplasm the mimics RCC (9).

The purpose of our study is to evaluate the use of volume -based enhancement parameters like mean and median enhancement on dynamic contrast enhanced computed tomography (CECT) to diagnose and characterise renal masses and compare with histopathology.

MULTIDETECTOR COMPUTED TOMOGRAPHY (MDCT)- it is a faster scan a well as provides better quality of image as compared to normal helical CT (10).Lesser breadth holding is required.Thinner slice sections are acquired for 3D data set and multiplaner reconstruction. Multiple phases of parenchymal enhancement as well as excretion in the collecting system of the kidney can be imaged after intravenous injection of a single bolus of contrast material. Diagnosis and characterisation of renal masses as well as their vascularity can be seen similar to conventional angiography (11). Major advantages of renal MDCT are faster scanning time, better temporal and spatial resolution along with wide range of volume coverage (12).

Aims and Objective

Primary Objective

To assess the sensitivity and specificity of volume -based enhancement parameters like mean and median enhancement on dynamic contrast enhanced computed tomography (CECT) to diagnose and characterise solid renal masses and compare with histopathology.

Secondary Objective

To assess the sensitivity and specificity of dynamic CT scan in differentiating between Renal cell carcinoma and it's mimics.

MATERIALS AND METHODS

Study Site

The study was conducted at Department of Radiology, MEDANTA –THE M EDICITY,GURGAON and SRMS Medical college and hospital,bhojipura,bareilly.UP.

Study Population

The study was conducted on outdoor and indoor patients (national and international)of both sexes, referred to our Department at both places for dynamic CT of abdomen, between the ages of 20 to 80 years with renal problems and associated clinical features of renal mass. Patient who had undergone abdominal CT and incidently detected renal mass were also included.A written, informed consent was taken. All the patients were followed for surgery and histopathology reports.

Study Design: Prospective, Observational study.

Sample Size: 75+17 study subjects (75 patients at MEDANTA hospital and 17 at SRMS medical college).

Duration of Data Collection: Feb 2015 to june 2016 and November 2020 to june 2023

Inclusion Criteria

The study included the following patients in the age group 25-80 years.

1) Referred to our department with suspected renal mass.
2) With incidentally detected renal mass on routine USG, CT and MRI.
3) With known renal mass with their further evaluation and characterisation.
4) Operated cases which comes for follow up during our investigation time for evaluation of development of any new renal lesions.

Exclusion Crieteria

1) Patient who have had any history of allergy to iodinated contrast
2) Patient having severely compromised renal function in which contrast is contraindicated.

METHODOLOGY

History regarding the chief complaints of the patient was obtained. Written informed consent was taken from patient or a close relative before the scan. History of any previous contrast allergy was obtained. Renal function tests (blood urea, serum creatinine) were obtained before commencement of study and eGFR was calculated by creatinine clearance calculator (based on Cockcroft Gault Equation). As and when required, in un-cooperative patients, sedation was given, for which patient was nil by mouth for 7 hours minimum.

75 untreated adult patients of age 25-80 years with suspected, known or incidentally detected renal mass lesions who were referredto our department were examined.

Multidetecter CT Scan Data Were Acquired In 256 Slice Siemens Ct Scanner---

For characterization of a renal mass, the examination were performed before and after administration of IV contrast..The different phases of renal enhancement- arterial (15-20 sec delay) corticomedullary (35-80 sec) nephrographic (85-180 sec) and excretory (3 min or more) were acquired. These multiphase CT acquisitions were transferred to a dedicated three-dimensional workstation.Tumour segmentation and making of histogram were done by an inbuilt application named "generic" in singo via of Siemens console. Mean enhancement along with standard deviation in arterial(CMP),nephrographic and excretory phases were demonstrated by the histogram. Median values were calculated manually from the other data in histogram. On the basis of degree of mean and median enhancement, the solid renal masses were differentiated into types, mainly types of renal cell carcinoma. Correlations were done with the Histopathological evaluation. Follow-up scan were done whenever referred.

DISCUSSION

In our study, we prospectively evaluated 92 patients between 20-80 years of age with untreated, diagnosed or suspicious renal masses by dynamic CT. We did both qualitative as well as quantitative study. Qualitative parameters were tumour consistency, heterogeneity, Intratumoral-calcification, fat, necrosis and hemorrhage, associated congenital or acquired diseases or syndromes, appearance of mass on plain scan relative to renal parenchyma, degree and pattern of enhancement, presence or absence of washout on delayed scan. Quantitative parameters were volume based enhancement values by histogram analysis in different phases like mean, median and standard deviation in arterial, nephrographic and excretory phases.

We evaluated 92 patients. Out of these 88 patients undergone surgery either partial or complete nephrectomy and histopathological evaluation of the post-operative mass were done. Biopsy of the mass and further histopathological evaluation of the biopsy specimen in 4 patients turned out to be benign cortical masses.

Renal masses included in study were clear cell renal cell carcinoma, papillary renal cell carcinoma, Chromophobe renal cell carcinoma, Angiomyolipoma, oncocytoma, renal sarcoma, transitional cell carcinoma, benign cortical neoplasm.

Most common mass found were ccRCC in 50-59 years and 60-69 years age group with no of patients 22 (23.9%) and 14 (12.8%) respectively. The p-RCC were more common in the age group 60-69 years with the number of cases being 5 (5.4%). The chRCC were more common in the age group 30-39 years with the number of cases being 2 (2.2%).

In our study mean age for total renal mass was 53.5 year, for RCC was 55 years, for ccRCC was 56.76 years and for chRCC was 43 years. The observation in our study regarding gender distribution is male to female ratio being 3.5:1.,It was observed that ccRCC were more common in the male with number of cases being 49 (53.33%). The p-RCC were more common in male with the number of cases being 11(12%). The chRCC were seen equally in both sexes.In our study the incidence of ccRCC out of total renal masses noted was 62.6% with the number of patients being 57 and that of p-RCC and ch RCC were 13.3 and 5.3% with number of patients being 12 and 9 respectively. Among all renal masses 8% cases were of AML with number of patients being 7. Oncocytoma and other Benign cortical masses constituted 4% each among all renal masses. The fraction of TCC and renal sarcoma were 1.33 % each.

In our study it was observed that renal masses were more commonly associated with bilateral renal cortical cysts (20%), and Chronic kidney disease (16%). Renal masses associated with syndromes were 10.6%. Syndromes were VHL and Tuberous Sclerosis.

Characteristics Of Renal Mass On CT(Qualitative Analysis)

- In our study it was seen that right sided renal masses (61.33%) are more common than the left sided renal masses (32 %), whereas bilateral masses were less common and constitutes 6.67 %. Bilateral masses were seen in syndromic patients such as tuberous sclerosis and VHL.
- It was also observed that single lesions were more common and seen in 90.67 %. Again multiple masses are seen in syndromic patients.
- On the plain scan most of the masses were heterogenous 73% (67 patients) in appearance and solid-cystic 27% (25 patients) in consistency.
- Most of the masses in our study group were smaller in volume (<100 ml).
- On comparing the density of renal mass on plain scan relative to the normal renal parenchyma ,it was observed that ccRCC showed variable density on plain scan, commonest in our study group were isodense (25%).Most common density of p-RCC and ch-RCC are also isodense. Overall most of the RCC were isodense (39.40%) followed by iso-hypodense (24.60%).
- It has been seen that Intratumoral necrosis was present in most of the patients (72 patients) .Calcification (29 patients), hemorrhage (29 patients) and necrosis was seen in significant number of cases either alone or in combination. Intratumoral fat (12 patients) was mainly seen in AML and few small foci in ccRCC.
- On dynamic study it was observed that most common enhancement degree and pattern was intense and heterogeneous, seen in 46.67% of patients. Among these most of the masses were ccRCC. Oncocytoma and few AML also showed intense and heterogeneous enhancement.
- Regarding characteristics of delayed scan in our study group (washout, no washout and delayed enhancement), Most of the masses showed washout (in71 patients, 77.3%) and most of them are ccRCC, ch RCC and p-RCC. Delayed enhancement was seen in all cases of oncocytoma, other benign cortical masses, renal sarcoma and few cases of p-RCC. In the washout group the masses which becomes isodense on delayed scan were included.

- In our study group it was observed that 30.7% (28 patients) of the masses had associated vascular malformations. The major types of vascular malformation were Intratumoral AV malformation and aneurysms, perirenal ,anterior and posterior pararenal collaterals.
- Most of masses included in our study were localized. In case of late stages of tumour adjacent organ involvement (22 patients) and lymphovascular infiltration (23 patients) were more common.

Statistical Analysis Of Quantitative Study Of Enhancement Degree In Different Phases By Volume Based Tumoral Histogram Evaluation

- We did the calculation of mean and median value in different phases of enhancement in various renal masses. Because of less no of tumours other than the ccRCC and p-RCC, the comparison can be made only between the ccRCC and p-RCC
- The mean and median enhancement of ccRCC were found to be significantly higher than that of p-RCC
- In arterial phase (mean enhancement, 84.66 HU vs 45.70 HU, $p < 0.0001$; median enhancement, 91.87 HU vs 45.60 HU, $p < 0.0001$),
- In nephrographic phase (mean enhancement, 110.60 HU vs 62.20 HU, $p < 0.0001$; median enhancement, 109.81HU vs 62.30 HU, $p < 0.0001$)
- In excretory phase (mean enhancement, 70.94 HU vs 56.90HU, $p < 0.0001$; median enhancement, 69.23 HU vs 52 HU, $p < 0.029$).
- Standard Deviation were higher in ccRCC compared to p-RCC in all the phases because enhancement in ccRCC were more heterogenous than p-RCC.
- In a similar study done by Frank Chen, HannuHuhdanpaa, Bhushan Desai,Darryl Hwang et al (8) ,they demonstrated that the mean and median enhancement of ccRCC were significantly higher as compared to than that of pRCC in the arterial phase (mean 93 HU vs 51 HU, $p < 0.01$; median 91 HU vs 48 HU, $p < 0.01$), in nephrographic phase (mean 111 HU vs 76 HU, $p < 0.01$; median 110 HU vs 72 HU, $p < 0.01$) and in excretory phases (mean 75 HU vs 60 HU, $p < 0.01$; median 71 HU vs 57 HU, $p < 0.01$) .
- Our study reports support their demonstration with more significance and confidence level as our p-value is more significant.
- We calculated the histogram distribution parameters like skewness, SD and interquartile range and kurtosis in different phases of contrast study among all types of renal masses. Again as the significant numbers of patients had ccRCC and p-RCC, so differentiation can be made only between ccRCC and p-RCC.
- Skewness in ccRCC was significantly lower than that of pRCC in the arterial phase (skewness,1.11 vs 1.18)
- Standard deviation and interquartile range of ccRCC were significantly higher than that of pRCC in the arterial phase (standard deviation, 37.64 vs 28.10, $p < 0.0001$, interquartile range, 30 vs17).
- Standard deviation and interquartile range of ccRCC were higher than that of pRCC in the nephrographic phase, (standard deviation, 37.43 vs 23.60, $p < 0.001$; interquartile range, 39 vs 25).
- The studied histogram distribution parameters of ccRCC were not significantly different than that of pRCC on excretory phase.
- Frank Chen, HannuHuhdanpaa, Bhushan Desai,Darryl Hwang et al (8) also differentiated ccRCC and p-RCCby using same statistical parameters. They demonstrated skewness of ccRCC were significantly lower than that of pRCC in the arterial phase (0.29 vs 0.74, nephrographic phase (0.13 vs 1.06), The histogram distribution parameters standard deviation and interquartile range of ccRCC were significantly higher than that of pRCC in the arterial phase (standard deviation, 40 vs 24, interquartile range, 263 vs 166,)
- Result of our study were similar to the above study and support it with more confidence

Accuracy Of Quantitative Study Of Dynamic Ct In Diagnosing And Differentiating Renal Masses As Compared To The Gold Standard (HPE Histopathological Evaluation)

- The value of Weighted Kappa calculated was 0.932
- The strength of agreement is considered to be 'very good'.SE of kappa came out 0.046. Confidence interval was 95%: (0.816 - 0.996)
- Overall accuracy of the quantitative study of dynamic CT in diagnosing renal masses as compared to gold standard (HPE) is 94.7%

Calculated Values Of Sensitivity, Specificity, PPV And NPV Along With Confidence Interval (CI) Of Diagnosing Renal Masses By Quantitative Study Of Dynamic CT.

- Diagnosis of other renal masses like AML, oncocytoma, other benign masses, renal sarcoma, and TCC was done by mainly qualitative study of the masses.
- Types of RCC were diagnosed and differentiated by both qualitative and quantitative study.
- The parameters calculated after comparing the outcome of CT diagnosis and HPE (histopathological evaluation)
- Sensitivity, specificity, PPV, NPV for p-RCC were 100%, 98.4%, 90.9% and 100% respectively.
- Sensitivity, specificity, PPV, NPV for ccRCC were 95.74%, 92.9%, 95.7% and 92.9% respectively.
- Sensitivity, specificity, PPV, NPV for ch-RCC were 75%, 98.6%, 75% and 98.6% respectively.
- Sensitivity, specificity, PPV, NPV for AML were 83.3%, 100%, 100% and 98.6% respectively.
- Sensitivity, specificity, PPV, NPV for other renal masses (like oncocytoma ,benign cortical masses, TCC, renal sarcoma) were 100 %.

Summary and Recommendation

We prospectively evaluated 75 patients between 20-80 years of age with untreated, diagnosed or suspicious renal masses by dynamic CT.

We did both qualitative as well as quantitative study. Qualitative parameters were tumour consistency, heterogeneity, Intratumoral-calcification, fat, necrosis and haemorrhage, associated congenital or acquired diseases or syndromes, appearance of mass on plain scan relative to renal parenchyma, degree and pattern of enhancement, presence or absence of washout on delayed scan.

Quantitative parameters were volume based enhancement values by histogram analysis in different phases like mean, median and standard deviation in arterial, nephrographic and excretory phases. We did the calculation of mean and median value in different phases of enhancement in various renal masses. We also calculated Skewness, Standard deviation and interquartile range. Because of less numbers of tumours other than the ccRCC and p-RCC, the comparison can be made only between the ccRCC and p-RCC by histogram analysis.

Sensitivity and specificity for diagnosing p-RCC came out to be 100%, 98.4% and for ccRCC were 95.74%, 92.9%, by this method.

Sensitivity and specificity for diagnosing ch-RCC by CT came out to be 75%, 98.6%, respectively.

Sensitivity and specificity for diagnosing other renal masses (like oncocytoma, benign cortical masses, TCC, renal sarcoma) by CT came out to be 100 %.

Sensitivity and specificity for diagnosing for AML by CT were 83.3% and 100%,

We demonstrated that enhancement pattern was the most important criteria for differentiating the ccRCC and also diagnosing other types of tumours.

We also demonstrated that quantitative evaluation of dynamic CT by histogram analysis is most accurate in differentiating ccRCC and p-RCC.

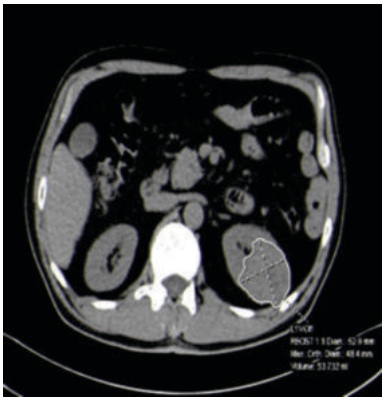
Our study emphasizes the role of volume based quantitative study of dynamic CT in differentiating ccRCC and p-RCC as well as diagnosing other renal masses.

We recommend that both qualitative as well as quantitative dynamic CT study should be done in each and every case of renal masses for diagnosing the mass as well as differentiating the mass.

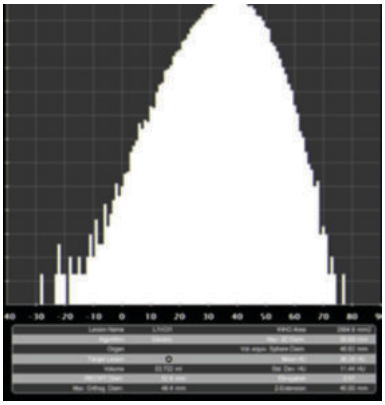
In future we can differentiate more masses by this technique as we know differentiation of masses is very helpful in planning management.

Illustrative Cases

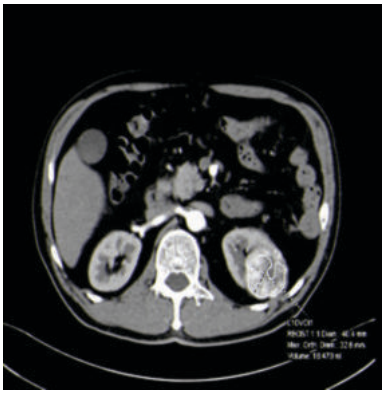
Case 1: A 66 Year Male Presented With Right Flank Pain, Hematuria And Anemia.



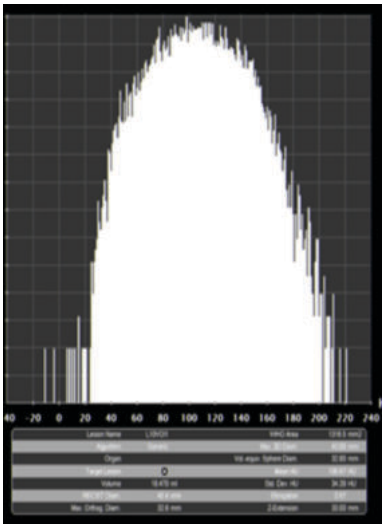
Axial Image Of Plain Scan



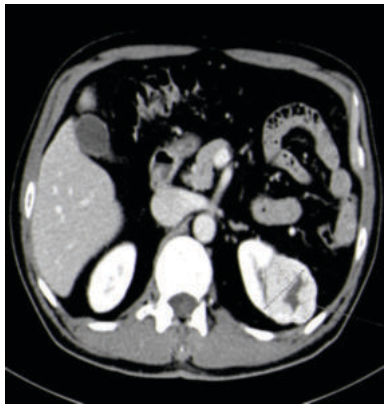
Histogram Of Plain Scan



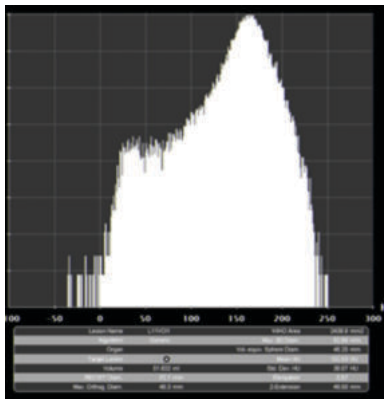
Axial CT Scan Image In Arterial Phase



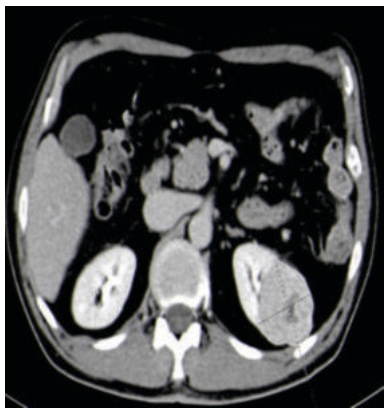
Histogram Of The Renal Mass In Of Arterial Phase



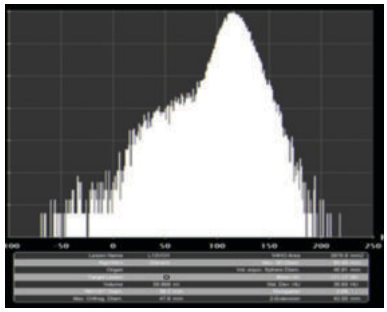
Axial CT Image In Nephrographic Phase



Histogram Of The Tumour In Nephrographic Phase



Axial CT Image In Excretory Phase

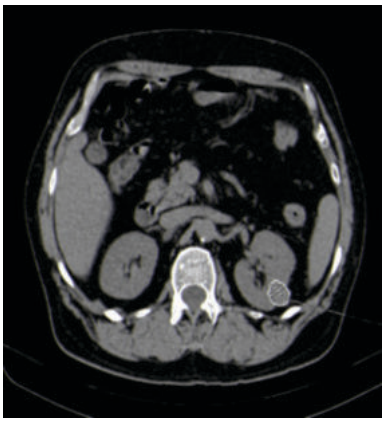


Histogram Of Renal Tumour In Excretory Phase.

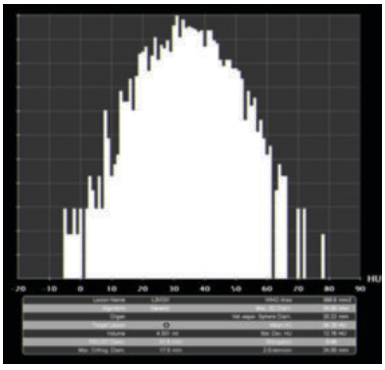
In this case the mass was intensely and heterogeneously enhancing. The value of mean HU in plain, arterial and nephrographic phase were 38,106,152 and 111.The tumour shows washout. The radiological diagnosis was ccRCC. It also came out as ccRCC in HPE result.

Case no-2 A 60 Year Old Male With No Specific Symptoms Was Incidentally Diagnosed As A Case Of Small Renal Mass When He

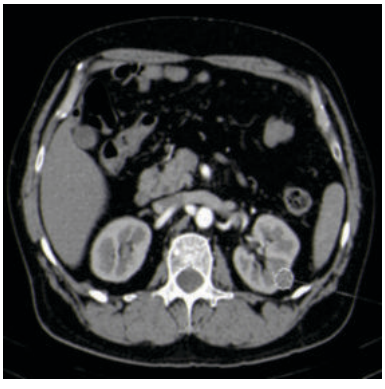
Came For Abdominal CT For Other Region



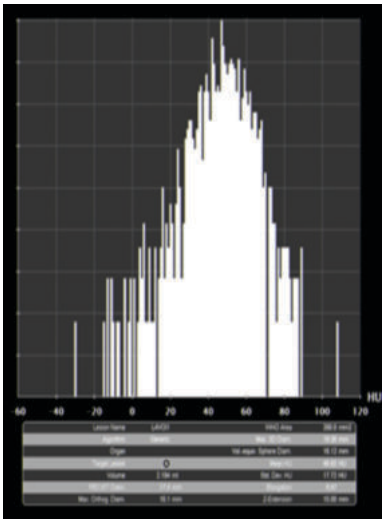
Axial CT Image On Plain Scan.



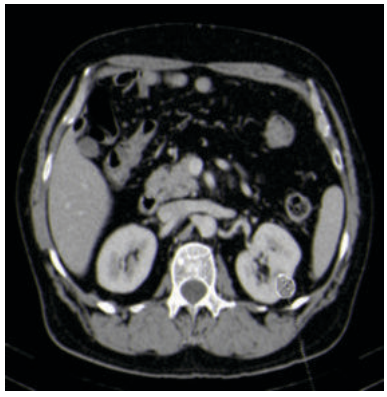
Histogram Of The Mass In Plain Scan



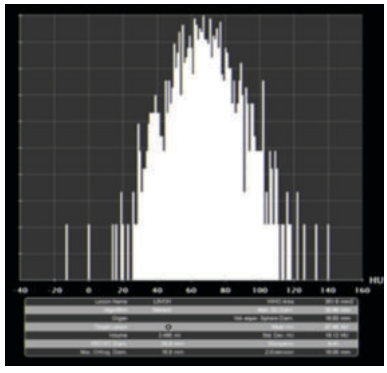
Axial CT Image In Arterial Phase



Histogram Of The Renal Mass In Arterial Phase



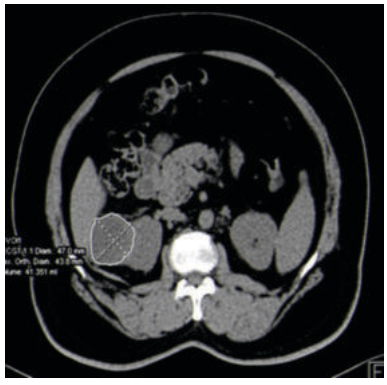
Axial CT Image In Nephrographic Phase



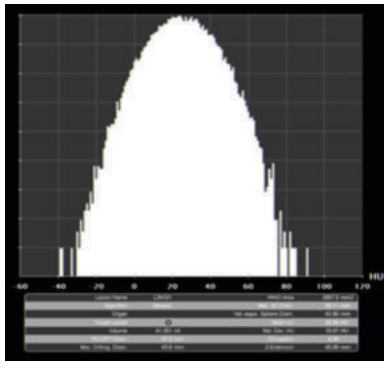
Histogram In Nephrographic Phase

In this case the mass was mildly and homogenously enhancing. The value of mean HU in plain, arterial and nephrographic phase were 34, 48 and 67. The tumour was isodense on delayed scan . The radiological diagnosis of p-RCC was made. It also came out as p-RCC in HPE result.

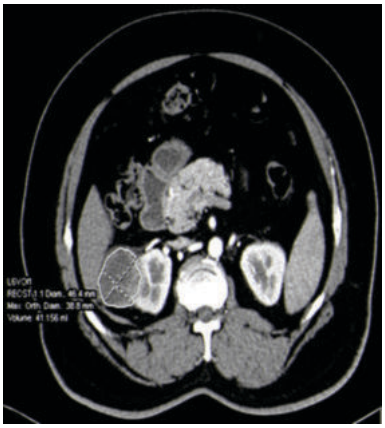
Case No. 3.a 67 Year Old Man Presented With Right Flank Pain And Palpable Mass.



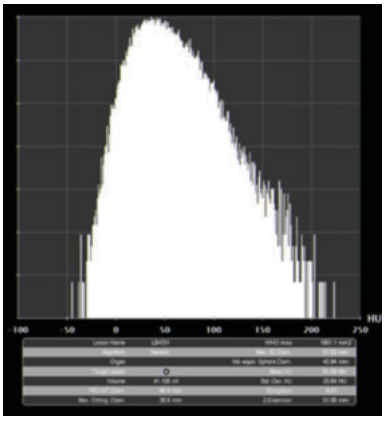
Plain Axial CT Scan



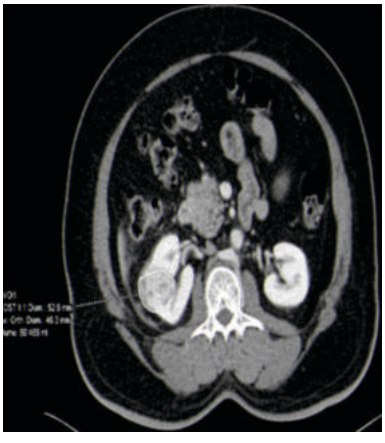
Histogram Of The Mass In Plain Scan



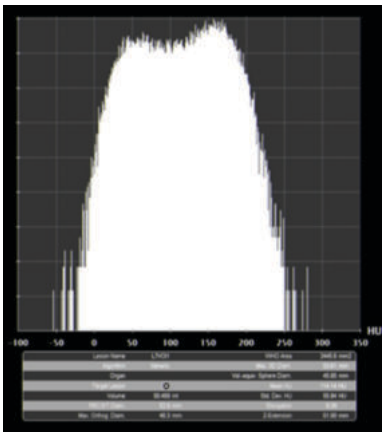
Axial CT Scan In Arterial Phase



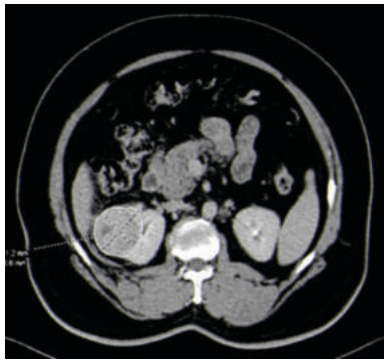
Histogram Of The Tumour In Arterial Phase



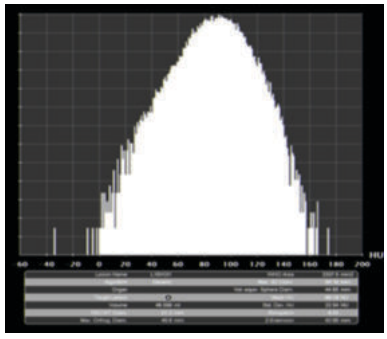
Axial CT Scan In Nephrographic Phase



Histogram Of The Mass In Nephrographic Phase



Axial CT Scan In Excretory Phase



Delayed Phase Histogram

In this case the mass was intensely and homogenously enhancing. The value of mean HU in plain, arterial and nephrographic and delayed phase were 25, 51 ,114 and 88. Delayed enhancement was noted. Central scar was seen The radiological diagnosis of oncocytoma was made. It also came out oncocytoma on histopathology.

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