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Role of Computed Tomography in Characterisation of Renal Masses with Clinical and Histopathological Correlation

Dr. Nihar Ranjan Mohanty[1*], Dr. Madhusmita Mohanty[2]
[1]Consultant Radiology, Apollo Hospital, Bhubaneswar, Odisha, India
[2]Assistant Professor, Department of Pathology, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India

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***Corresponding author**
Dr. Nihar Ranjan Mohanty

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Abstract: Multi detector Helical CT is accepted as the preferred imaging technique for diagnosis of renal tumor ,tumor staging and detecting metastases. This study was performed to evaluate the role of computed tomography in the detection and characterisation of renal masses and its correlation with clinical findings and histopathology. This study was a prospective study conducted from March. 2016 to February 2018 with 50 patients who were referred for characterisation of indeterminate renal masses that did not meet the criteria for simple cyst on previous ultrasound. MDCT scans of patients were conducted with plain scan followed by contrast scan and image analysis in console. Mean age of patients is 55 years with male: female ratio 2.33:1.Most common clinical feature of mass is flank mass. Most common renal mass in the study is renal cell carcinoma followed by renal cysts. Number of cases of renal cell carcinoma diagnosed by CT is 26. On histopathology 23 came out to be renal cell carcinoma and 3 came out to be transitional cell carcinoma. Again in 1 case of CT diagnosis of Wilm's tumor came out to be renal cell carcinoma on histopathology. CT findings show significant association with reference to diagnosis of renal cell carcinoma (p=0.016) with accuracy of 88%.CT diagnosis of renal cysts is adequate. In the present study among other miscellaneous solid masses accuracy of CT in diagnosing Wilm's tumor is 50%.In all other miscellaneous masses histopathological diagnosis was same as CT diagnosis. CT was found to be 100% accurate in diagnosing lymphoma, angiomyolipoma, Xanthogranulomatous pyelonephritis and multi locular cystic nephroma, but p value was not significant.(p=0.991). Multi detector helical CT enables excellent detection of renal masses and differentiation between cystic, complex cystic and solid masses.
Keywords: Renal mass, Multi detector helical CT, histopathology.

INTRODUCTION

Helical CT is widely accepted as the state of the art technology for evaluation of abdomen [1]. It is widely accepted as the preferred imaging technique for diagnosis of renal tumor, tumor staging and detecting metastases, because of its low cost, high accuracy and ready accessibility.

Multi detector computed tomography (MDCT)promises to provide even more rapid assessment of the kidneys and a higher accuracy in the evaluation of renal masses and of renal blood vessels than is provided by single detector helical CT. MDCT can image kidneys during each of three phases of contrast enhancement due to its high speed of image acquisition. The elimination of respiratory misregistration ensures that the entire lesion is imaged and that chance of identifying small enhancing lesion is maximised. The acquisition of volumetric data during a single breath hold allows a comparison of identical levels on scans obtained before and after administration of contrast material. Partial volume averaging is minimised because a section through the centre of a lesion is assured with MDCT when overlapping sections are reconstructed.

Another advantage is that raw data can be reconstructed at any level. This improves accuracy of region-of-interest measurement and the imager's ability to characterise a lesion. So subtle features within cystic lesion such as septation, wall thickening and nodularity can be evaluated. Thus MDCT is the best technique for characterisation of renal masses. Detection rate of renal masses has increased in the last decade owing to widespread use of CT and MRI [2].

AIM AND OBJECTIVES

- To evaluate the role of computed tomography in the detection and characterisation of renal masses.

- To correlate the clinical findings of patients with renal masses.
- To correlate the computed tomography findings of renal masses in comparison to histopathological evaluation obtained by open biopsy, guided biopsy.

MATERIALS AND METHODS

This study was a prospective study conducted from March 2016 to February 2018 at the Department of Radiology, Apollo hospital Bhubaneswar and in the Department of Pathology, KIMS; Bhubaneswar .The study population comprised 50 patients -35 males and 15 females. Patients were referred for characterisation of indeterminate renal masses that did not meet the criteria for a simple cyst on previous ultrasonography.

Multi-detector 64 slice tomography: Toshiba aquilion 64 at Apollo hospital, Bhubaneswar was used. Patients with at least 6 hours of empty stomach underwent contrast enhanced CT scan abdomen with informed consent about possible contrast reaction. Axial sections of 5 mm thickness taken from the level of lung bases to the level of ischeal tuberosities. In all cases plain scan was followed by contrast scan in suspended inspiration.

Scans were obtained with MDCT parameters as slice thickness-5mm,slice interval-5mm, reconstruction interval 1-10 (slice thickness for reconstruction -0.5-10mm) ,gantry rotation-0.5 second, field of view-365mm. For contrast enhancement dynamic injection of contrast done at a rate of 3.5 to 4 ml/sec of about 80-100cc of non-ionic contrast material (omnipaque, iohexol; 360 mg iodine/ml) was given. Sections were taken in non-contrast phase, cortico-medullary phase (25-70 sec),nephrographic phase (80-180 sec), excretory phase (after 180 sec) and delayed phase. Cortico-medullary phase is useful for getting information about renal vasculature or when there is possibility that a detected renal mass may be an aneurysm or vascular malformation or fistula [2]. This phase is also better for diagnosis of tumor extension to vein. Nephrographic phase is valuable for characterising renal masses and characterising indeterminate lesions [3-5]. Excretory phase is helpful to better delineate relationship of centrally located mass with collecting system [6] and also useful for evaluating urothelial masses.

Post study reconstructions were done at 0.625mm.Sagittal and coronal reconstruction were made whenever necessary .Newer techniques in Multi slice CT like 3D volume rendering and Maximum and Minimum intensity projections were used as and when necessary. All cases were comprehensively evaluated and correlated with relevant history and clinical findings.

Image analysis was done in the console. The size and location of the mass was obtained from contrast enhanced images. The mass is then characterised by its features and by presence or absence of enhancement .The attenuation values were measured in unenhanced, contrast enhanced images by the region-of-interest technique. Enhancement parameters that were calculated include renal mass enhancement and renal cortical enhancement. These were analysed and compared for each patient. All solid lesions with attenuation similar to other soft tissue abdominal structures and if the lesion shows tissue enhancement 20 HU or greater were classified as malignant.

For characterisation of cystic renal lesions, the Bosniak criteria [7, 17] were used. A lesion was considered simple cyst if it appeared to be well marginated with thin smooth walls; was internally homogeneous; demonstrated attenuation less than 20 HU and similar to other fluid controls; was not enhancing after administration of intravenous contrast material. A lesion was considered minimally complicated ,radiologically benign cyst if it met a criteria for a category II cyst as defined by Bosniak, like one or more thin internal septations or minimal mural or septal calcification. Hyper attenuating cysts were also included in this category if they meet the other criteria of simple cysts. Category II F lesions includes lesions which are well defined and have multiple septa with minimal thickening of wall and septa. Class III cysts were moderately complicated showing nodular and thick calcification in wall or septa and abnormal enhancement of wall or septa. Class IV cysts were cystic carcinomas.

Statistical analysis was done from data collected from 50 cases of renal masses were analysed with the help of SPSS 16.0 software. Chi-square test of independence was used for test of association, p value <0.05 was taken as significant.

RESULTS AND DISCUSSIONS

In this study 50 patients of renal mass lesions were observed. Of these, thirty-five lesions are solid mass lesions and fifteen lesions were cystic lesions. Age range of presentation was 16- 94 years, mean age of 55 years. Male to female ratio of 2.33:1.

Clinical features of renal masses (Table-1)

24 cases (48%) of renal masses presented with lump in abdomen or flank mass most common clinical feature and pertains to side of kidney involved and size of the lesion. Fever, a constitutional symptom is second most common clinical feature presented in 19 cases (38%). Hematuria presented in 18 cases (36%) is the third most common symptom. Flank pain, malaise and night sweat and weight loss were seen in 5 cases each corresponding to 10% of cases each. Dysuria, oliguria, hypertension, varicocele seen in 2 cases (4%),

3 cases (6%), 4 cases (8%), 2 cases (4%) respectively. Cough and dyspnea is least common seen in 1 case (2%) a case of metastasis of renal mass to chest presenting as lymphangitis carcinomatosa. 12 cases were asymptomatic corresponding to24% and they comprise mostly of simple renal cysts (Bosniak[7] grade I,II and early renal cell carcinoma). These findings are in accordance with study undertaken by Higgins *et al*. 2001 [8].

Table-1: Clinical features of renal masses (n=50)

Clinical Features	No.of Cases	Percentage
Hematuria	18	36%
Flank pain	5	10%
Lump in the abdomen	24	48%
Dysuria	2	4 %
Oliguria	3	6%
Fever	19	38%
Malaise & night sweat	5	10%
Weight loss	5	10%
Cough &Dyspnea	1	2%
Hypertension	4	8%
Varicocele	2	4%
Asymptomatic	12	24%

Distribution of renal masses (table-2)

In the present study the most common renal mass is renal cell carcinoma (RCC) present in 24 cases (48%). Renal cysts including autosomal dominant polycystic kidney disease comes second with 12 cases (48%).Most common renal masses should be renal cysts [9] but as this study is undertaken for CT evaluation of suspicious renal masses after ultrasonography and intra venous pyelography examination, many more simple cysts are not taken into consideration in this study. Transitional cell carcinoma(TCC) present in 3 cases(6%), lymphoma 1 case(2%), Wilm's tumor in 1 case(2%), angiomyolipoma 3 cases(6%), Xanthogranulomatous pyelonephritis(XGPN) 2 cases (4%) and multi locular cystic nephroma(MLCN) 1 case (2%).The solid renal masses occupy 3/4thof renal masses. Renal cell carcinoma occupies 2/3rd of solid renal masses and nearly 83% of all malignant solid renal masses. These findings match with the study given by Landis S H *et al.* [10].

Table-2: Distribution of renal masses

Renal Mass	No. of cases	Percentage
RCC	24	48%
TCC	3	6%
Lymphoma	1	2%
WILM'S	1	2%
XGPN	2	4%
Angiomyolipoma	3	6%
MLCN	1	2%
ADPKD	3	6%
Renal cysts	12	24%

Abbreviation-RCC-Renal cell carcinoma: TCC-Transitional cell carcinoma

XGPN-xanthogranulomatous pyelonephritis: MLCN-multi locular cystic nephroma: ADPKD-autosomal dominant polycystic kidney disease.

Clinical features of Renal cell carcinoma-In the present study most common clinical presentation is hematuria seen in 14 cases(58%) followed by flank mass seen in 12 cases(50%) and also fever which is a constitutional symptom is seen in 12 cases(50%). Flank pain is seen in 5 cases (21%).Classical triad of symptoms i.e. hematuria, flank mass and flank pain seen in 5 cases corresponding to 21% of cases, patients have disease in its late phase i.e, distant metastasis and vascular invasion. Malaise, night sweat seen in 5 cases (21%), weight loss seen in 5 cases (21%). Hypertension seen in 1 case (4%) and cough and dyspnea seen in 1 case (4%).Varicocele seen in 2 cases (8%). Asymptomatic cases i.e. incidentally discovered renal masses seen in 5 cases (21%).This study does not correlate with the study given by Amendola *et al*. [11] and Jayson *et al*. [12] where asymptomatic cases are most common to be detected. This discrepancy is due to late presentation of patients and larger size of masses at the time of presentation and also depends on size of population studies.

Size of the lesion

Variable	Present Study	Birbaum *et al*. [3]	Welch *et al*. [13]
Size range	5-20 cms	1.4-8cms	1.5-19 cms
Mean size	8cms	4.3+- 1.8 cms	7cms

The size of lesion in present study has a range of 5-20 cms and mean size 8 cms and this correlates with the study conducted by Welch *et al.* [13] and the size of lesion in present study is slightly greater than the study conducted by Birbaum *et al.* [3].This explains the discrepancy of clinical features in this study and other studies.

CT FINDINGS OF RENAL CELL CARCINOMA DIAGNOSED BY CT

Table-3- The present study shows that renal cell carcinomas are predominantly hypodense on non-contrast CT seen in 73% (19 cases) and 19% are isodense. The rest are hyperdense. This finding correlates with work done by Mc Clennan and Deyoe *et al*. [14]. Renal cell carcinomas show enhancement of solid portion of the mass (>20 HU) in all cases but this enhancement is less than normal cortical enhancement. This finding is in accordance with Yuh *et al.* [15]. Calcification is noted in 27% of cases of renal cell carcinoma in the present study. This matches with the study conducted by Zagoria *et al.* [16]. Necrosis is seen in renal cell carcinoma in 81% of cases. Cystic areas noted in renal cell carcinoma in 27% of cases and these are termed cystic renal cell carcinomas. They represent Bosniak grade IV cysts and are low grade tumors. This finding matches with study conducted by Bosniak MA [17] and Curry NS *et al.* [9].

Tumor extension to perinephric space that means braeching of fascia of gerota seen in 54% cases and this finding differentiates between low grade and high grade renal cell carcinoma and is important in staging renal cell carcinoma. This finding correlates with the study done by Johnson CD *et al*. [18]. Vascular invasion that is renal vein and inferior vena cava invasion is seen in 27% of cases and this finding is in accordance with the work done by Mc Clennan and Deyoe *et al*. [14] and Johnson CD *et al*. [18]. Local lymph node enlargement is seen in 50% cases taking the size criteria i.e. the size of lymph node ,if >1.5 cm is considered malignant and this finding matches with the study done by Mc Clennan and Deyoe *et al*. [14].

Distant metastasis noted in 50% cases. They represent stage IV disease which is clearly in excess of the number of patients with distant metastasis as given in MC Clennan and Deyoe *et al*. [14] and this may be explained by fact that patients in this part of country present late with larger masses. In one case the metastatic focus from renal cell carcinoma primary manifests as lymphangitis carcinomatosa of bilateral lung fields [19]. The number of cases of renal cell carcinoma diagnosed by CT is 26.On histopathology 23 came out to be renal cell carcinoma and 3 came out to be transitional cell carcinoma. Again in 1 case we gave diagnosis of Wilm's tumor on CT, came out to be renal cell carcinoma on histopathology.

Table-3: CT findings of CT diagnosed RCC (n=26)

Mass character	No. of Cases	Percentage
Hypodense	19	73%
Isodense	5	19%
Hyperdense	2	8%
Enhancement of solid portion >20 HU	26	100%
Calcification	7	27%
Necrosis	21	81%
Cystic areas(cystic RCC)	7	27%
Hemorrhage	2	7.7%
Perinephric infiltration	14	54%
Lymphadenopathy	14	54%
Vascular spread	7	27%
Distant Metastasis	13	50%

CT CHARACTERISATION OF MISCELLANEOUS MASSES-Table-4

The present study evaluated 1 patient with lymphoma of left kidney. The mass appears homogeneously hypodense and mild enhancement of solid portion of the mass by 10HU. Necrosis, cystic change, calcification and fatty density are absent in the mass. Perirenal infiltration by mass is present. Lymphadenopathy is present. Distant metastasis to liver is present. This is a form of lymphoma in which

renal parenchyma is affected through direct infiltration by involvement of perirenal tumor or renal hilar mass .These findings match with study done by El-Sharkawy MS *et al.* [20].

This study evaluated 3 cases of angiomyolipoma, 2 in left kidney and 1 in right kidney. This came out to be only renal mass with female predominance. The mass is heterogenous with patch of fatty density of CT HU (< -30 HU) is seen interposed with solid tissues. Out of 3 angiomyolipoma 1 has hemorrhagic component and these findings correlate with the study done by Elenon O *et al*. [21].

2 cases of Xanthogranulomatous pyelonephritis found in the study, 1 in left kidney and other in right .The mass is heterogenous in density with multiple low attenuating areas (CT HU -10 to +30) showing rim enhancement and a large central calculus(Staghorn calculus)with enlarged non-functioning kidney. Perirenal extension of mass is present and there is psoas abscess in the same side psoas muscle. These finding correlate with study by Parker MD *et al.* [22]

One case of multilocular cystic nephroma (MLCN) of left kidney was included which shows a predominantly cystic mass of water attenuation with thick solid septae and interspersed solid areas .The solid areas and septae take enhancement but less than normal renal parenchyma. The mass came out to be benign on histopathology and this finding correlates with the study done by Dalla-Palma L *et al*. [23].

The study evaluated 2 cases in which CT diagnosis was given as Wilm's tumor of right kidney. The mass shows heterogenous density i.e. predominantly hypodense with areas of calcification and necrosis.Solid areas of mass enhanced but less than renal parenchyma. There was presence of perilesional infiltration, lymphadenopathy and local vascular invasion. Out of 2 cases one came out to be Wilm's tumor and other came out to be renal cell carcinoma on histopathology. Both the patients were males and aged 16 years. These findings match with study by Reiman TA *et al*. [24].

Table-4: CT characterisation of miscallaneous masses (n=9)

	Lymphoma(n=1)	Angiomyo-lipma(n=3)	XGPN(n=2)	MLCN(n=1)	Wilms'(n=2)
Mass appearance	Hypodense	Heterogenous	Heterogenous	Heterogenous	Heterogenous
Enhancement	Homogeneous	Heterogenous	Marginal,mild	Septal,mild	Heterogenous
Necrosis/cystic change	Absent	Absent	Present	Present	Present
Calcification	Absent	Absent	Present	Absent	Present
Hemorrhage	Absent	+/-	Absent	Absent	Absent
Fat density	Absent	Present	Present	Absent	Absent
Perirenal fat infiltration	Present	Absent	Present	Absent	Present
Lymphadenopathy	Present	Absent	Absent	Absent	Present
Local vascular invasion	Absent	Absent	Absent	Absent	Present
Distant metastasis	Present	Absent	Absent	Absent	Absent

CT FINDINGS IN RENAL CYSTS: Table-5

Total number of patients with cystic disease in this study is 15. 3 cases of present study show autosomal dominant poly cystic kidney disease which present as bilateral enlarged kidneys showing multiple cysts (>4 in number in each kidney).Calcification is seen in 1 of the 3 cases. Hepatic cysts are found in all the 3 cases, pancreatic cysts are found in 2 cases and all the three i.e.hepatic, pancreatic and splenic cysts are seen in 1 case. All the findings correlate with the study conducted by Ravine D *et al*. [25].

Rest of 12 cases of study include 4 cases of parapelvic cysts and 8 cases of simple renal cysts. The parapelvic cysts are located in renal hilum showing water attenuation and have imperceptible wall .On enhanced scans there is neither enhancement nor communication to the renal collecting system, but the contrast filled infundibula are seen effaced or compressed by parapelvic cysts. These findings correlate with study by Meyer DP *et al*. [26].

All the simple renal cysts are simple cysts i.e. they show water attenuation and imperceptible wall and no contrast enhancement. Out of these cases 1 case is given the diagnosis of acquired cystic renal disease, has multiple cysts in both kidneys and the patient has a history of dialysis for last 3 years .These findings correlate with the study done by Bosniak MA [17] and Curry NS *et al.* [9].

Table-5: CT findings in renal cysts (n=15)

Case	Site	Cortical/ medullary	Parapelvic	Number of cysts	Internal Attenuation (water)	Solid component	Enhance-ment	Associated findings
1	B/L	+	-	Multiple	+	-	-	Calcification seen Cysts in liver, pancreas and spleen (ADPKD).
2	B/L	+	-	Multiple	+	-	-	Cysts in liver and pancreas(ADPKD)
3	B/L	+	-	Multiple	+	-	-	Liver cysts(ADPKD)
4	LK	-	+	Single	+	-	-	
5	LK	-	+	Single	+	-	-	
6	LK	+	-	Single	+	-	-	
7	LK	+	-	Single	+	-	-	
8	LK	+	-	Single	+	-	-	
9	RK	+	-	Single	+	-	-	
10	B/L	+	-	Multiple	+	-	-	Acquired cystic Kidney Disease
11	RK	+	-		+	-	-	
12	RK	+	-		+	-	-	
13	RK		+		+	-	-	
14	RK	+			+	-	-	

HISTOPATHOLOGICAL CORRELATION OF CT DIAGNOSED MALIGNANT MASSES: Table-6

This table shows the accuracy of CT in diagnosis of renal cell carcinoma .Out of total 29 cases of renal malignancy as diagnosed by CT with distribution as renal cell carcinoma 26 cases and non-renal cell carcinoma(malignant renal lesion other than renal cell carcinoma)3 cases with 2 cases of Wilm's tumor and 1 case of lymphoma. But on histopathology out of 26 renal cell carcinoma(as given by CT),23 came out to be renal cell carcinoma and 3 cases came out to be transitional cell carcinoma.1 of the 2 cases given as Wilm's tumor came out to be renal cell carcinoma in histopathology. Thus the accuracy of CT diagnosis of renal cell carcinoma is 88% and this matches with the study conducted by Szolar *et al*. [5], Kopka *et al*. [27]. CT findings show significant association with reference to diagnosis of renal cell carcinoma (p=0.016).

Table-6: Histopathological correlation of ct diagnosed malignant masses

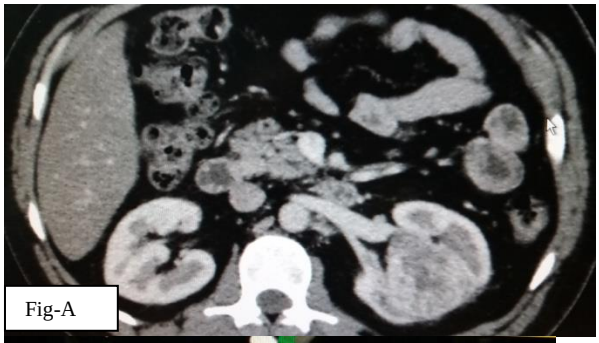
CT diagnosed	HISTOPATHOLOGY		Chai square test P value
	Renal Cell Carcinoma	Non Renal Cell Carcinoma	
Renal Cell Carcinoma	23	3	x^2= 5.73
Non Renal Cell Carcinoma	1	2	p=0.016

HISTOPATHOLOGICAL CORRELATION OF CT DIAGNOSED MISCALLANEOUS MASSES: Table 7

In the present study 2 cases were given the diagnosis of Wilm's tumor on CT, out of which 1 came out to be renal cell carcinoma. So the accuracy of CT in diagnosing Wilm's tumor is 50%.In all other miscellaneous masses histopathological diagnosis was same as CT diagnosis. CT was found to be 100% accurate in diagnosing lymphoma, angiomyolipoma, Xanthogranulomatous pyelonephritis and multi locular cystic nephroma, but p value was not significant.(p=0.991).

Table-7: Histopathological correlation of ct diagnosed miscellaneous masses

Case	CT	Histopathology	Accuracy	Chai square test P value
Wilm's Tumor	2	1	50%	
Lymphoma	1	1	100%	
Angiomyolipoma	3	3	100%	x^2=0.275
Xantho granulomatous pyelonephritis	2	2	100%	p=0.991
Multilocular cystic nephroma	1	1	100%	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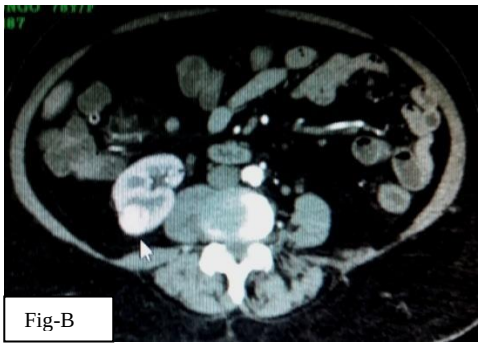
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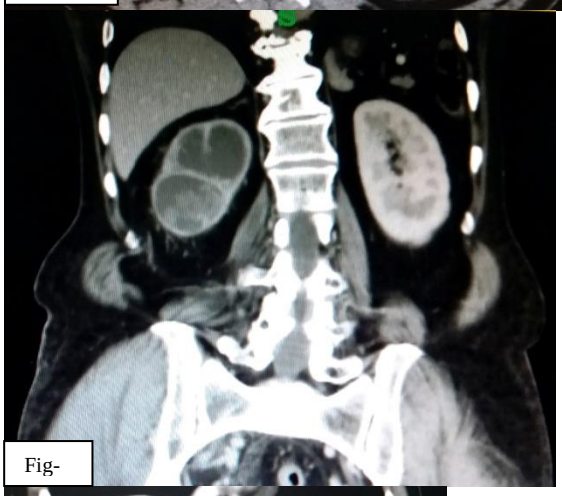
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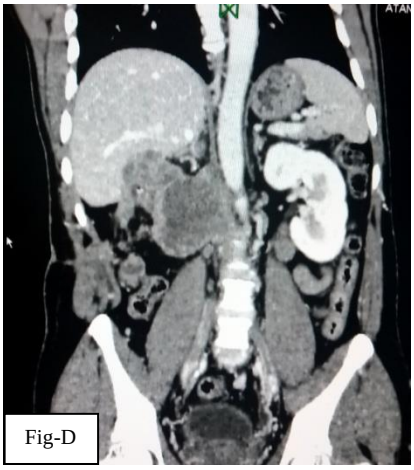
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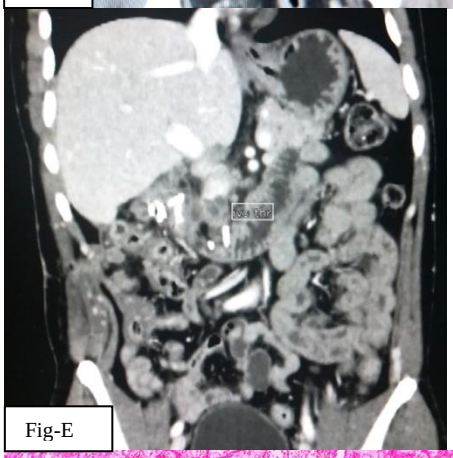
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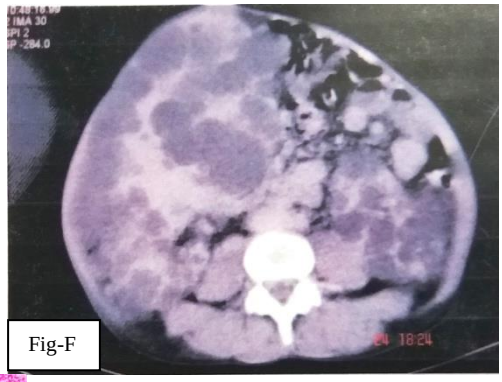
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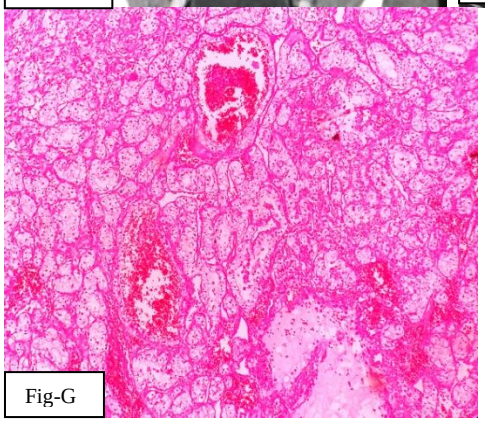
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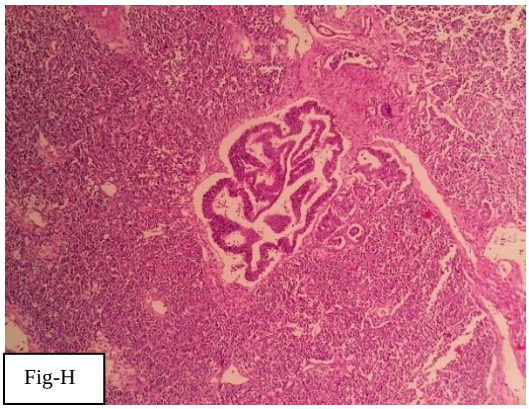
Fig-H

Fig A- RCC of midpole of left kidney on CECT, Fig B-Small RCC lower pole of right kidney on CECT, Fig-C-Transitional cell carcinoma with hydronephrosis of right kidney on CECT, Fig-D-Post operative case with recurrent RCC on CECT, Fig-E-Tumor thrombosis in a case of RCC on CECT, Fig-F-Autosomal dominant poly cystic kidney disease with both renal and hepatic cysts on CECT. Fig-G- Clear cell variant of RCC histopathology, Fig-H- Wilm's tumor histopathology.

CONCLUSION

The technical developments in CT scanning with use of multi slice helical CT enable an excellent detection of renal masses. Contrast enhanced images allow differentiation between cystic and solid renal masses. Complex cystic and solid lesions can be characterised further. Clinically most of patients with renal mass in our study presented with lump abdomen while hematuria was the commonest symptom in renal cell carcinoma cases. Incidentally detected renal cell carcinoma constitute only 21% cases .Classic triad of clinical features hematuria, flank mass and flank pain seen in 21% of cases and is seen in patients in its late phase i.e., distant metastasis and vascular invasion. Pre-treatment percutaneous biopsy in suspicious cases can significantly decrease the number of unnecessary surgeries for benign disease and assist the urologist in clinical decision making.

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