ROLE OF COMPUTED TOMOGRAPHY IN THE EVALUATION OF RENAL MASSES

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ABSTRACT

BACKGROUND

In recent years, Computed Tomography (CT) has been found to be extremely useful in the diagnosis and treatment of renal masses. It provides an accurate morphologic picture of the renal mass. The precise contrast resolution makes identification of the characteristic attenuation values possible.

Aims and Objectives - To characterise benign vs. malignant renal lesions based on CECT image analysis and to stage wherever possible.

MATERIALS AND METHODS

60 patients with suspected renal mass underwent CECT in Gauhati Medical College for a period from June 2014 to August 2015; patients who were diagnosed to have renal mass on ultrasound and referred for a CT scan for further evaluation. The images were analysed in unenhanced, corticomedullary, nephrographic and excretory phases after administration of non-ionic intravenous contrast. The lesion detection, enhancement pattern, local invasion and distant metastasis were assessed in pre- and post-contrast studies.

RESULTS

There were 45 malignant and 15 benign lesions in our study; the radiological diagnoses of malignant mass was confirmed by histopathology, whereas benign lesions were followed up to confirm their benignity. We had two false positive cases in our study, one was an oncocytoma and another was an angiomyolipoma. MDCT was 100% sensitive, 88.2% specificity and reached an accuracy rate of 96.7%.

CONCLUSION

As a result of the study, the following conclusions can be stated: CT has excellent accuracy in the diagnosis, characterisation and differentiating benign and malignant renal masses and for the characterisation of small renal mass the degree of enhancement on the corticomedullary phase is the most valuable parameter.

KEYWORDS

RCC, CECT, Wilms' Tumour, Lymphoma, Abscess.

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BACKGROUND

In recent years, Computed Tomography (CT) has been found to be extremely useful in the diagnosis and treatment of renal masses. It provides an accurate morphologic picture of the renal mass. The precise contrast resolution makes identification of the characteristic attenuation values possible.[1]

Renal Cell Carcinoma (RCC) is the most common malignant tumour of the kidney, accounting for 85% - 90% of adult renal malignancies, and 1% - 2% of all malignancies. Although radical surgery remains the only efficient and curative treatment both in localised and advanced RCC, surgical techniques have evolved over the years.

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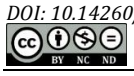


Currently, less invasive surgical techniques such as laparoscopic and nephron-sparing surgery are used in the treatment of renal tumours. Therefore, detailed preoperative imaging and exact renal tumour staging are important for planning the surgical approach and strategy and for providing accurate prognostic information for the patient. The evolution of CT technology and the introduction of Multi-Detector Computed Tomography (MDCT) have provided a higher spatial resolution and faster acquisition.[2]

Aims and Objectives

To find out the role of computed tomography in the evaluation of renal masses with respect to -

a. To characterise benign vs malignant renal lesions based on CECT image analysis.
b. To stage wherever possible.

MATERIALS AND METHODS

Data for the study was collected from patients attending the Department of Radiodiagnosis, Gauhati Medical College, Guwahati, with clinically suspected renal mass.

A prospective study was conducted over a period from June 2014 to August 2015 on 60 patients with clinically suspected renal mass or patients who were diagnosed to

have renal mass on ultrasound and were referred for CT for further characterisation. They presented with symptoms of abdominal pain, mass, haematuria, fever or weight loss. Patients were evaluated with Multidetector Computed Tomography (Philips MX 16). A provisional diagnosis was suggested after the CT examination and these findings were correlated with histopathology/surgical findings as applicable.

Inclusion Criteria

The study includes renal masses, which need further evaluation after USG examination.

Exclusion Criteria

1. Simple cysts are not included in the study.
2. Extrarenal masses invading the renal parenchyma are excluded from the study.
3. Hydronephrosis due to any obstructive cause is excluded from the study.

RESULTS

Sl. No.	Age	No. of Cases	Percent
1	< 10 yrs.	9	15.0
2	10 - 19 yrs.	2	3.33
3	20 - 29 yrs.	3	5.0
4	30 - 39 yrs.	5	8.3
5	40 - 49 yrs.	3	5.0
6	50 - 59 yrs.	13	21
7	> 60 yrs.	25	41.6
	Total	**60**	**100.0**

Table 1. Distribution of Cases according to Various Age Groups

In our study, the maximum percentage of patients were in the age older than 60 years (41.6%). Out of 60 cases, 45 were diagnosed to be malignant (75%) and 15 cases were diagnosed as benign (25%); 23 out of 34 patients (67.6%) of renal cell carcinomas were more than 60 years old, the youngest patient with RCC was 35 years old male patient and the oldest was 72 years old male patient.

Sl. No.	Gender	No. of Cases	Percent
1	Male	36	60%
2	Female	24	40%
	Total	**60**	**100**

Table 2. Gender Distribution of Patients Studied

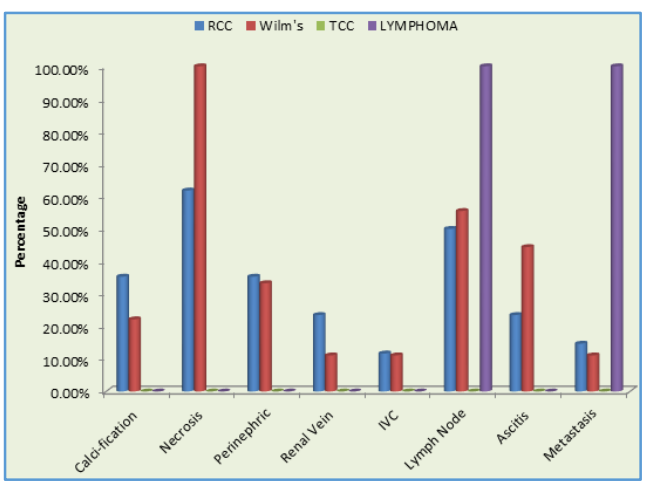
- In our study, there was a male preponderance (60%) when compared to females (40%). Overall, male-to-female ratio is 1.5:1.
- There was male preponderance (64.7%) in case of RCC when compared to females (35.3%). Male-to-female ratio is 1.8:1.
- 5 out of 9 cases of Wilms' tumour (55.6%) were males. Male-to-female ratio is 1.25:1.

Malignant Lesions													
Renal Mass (No)	**Calcification**	**Hydronephrosis**	**Necrosis**	**Ureter Involvement**	**Perinephric Extension**	**Renal Vein Involvement**	**IVC Involvement**	**Adrenal Involvement**	**Liver Involvement**	**LN Involvement**	**Lungs Involvement**	**Ascitis**	**Long Bones Involvement**
RCC (34)	12	00	21	00	12	08	04	03	01	17	05	08	02
	35.3%		61.8%		35.3%	23.5%	11.7%	8.8%	2.9%	50%	14.7%	23.5%	5.8%
Wilms' Tumour (09)	02	00	09	00	03	01	01	01	00	05	01	04	00
	22.2%		100.0%		33.3%	11.1%	11.1%	11.1%		55.5%		44.4%	
Renal TCC (01)	00	01	00	01	00	00	00	00	00	00	00	00	00
		1000.0%		100.0%									
Lymphoma (01)	00	00	00	00	00	00	00	00	00	01	01	00	00
										100%	100%		

Table 3(a). Different CT Features of Malignant Renal Masses

Benign Lesions													
Renal Mass (No)	**Calcification**	**Hydronephrosis**	**Necrosis**	**Perinephric Extension**	**Ureter Involvement**	**Renal Vein Involvement**	**IVC Involvement**	**Adrenal Involvement**	**Liver Involvement**	**LN Involvement**	**Lungs Involvement**	**Ascitis**	**Long Bones Involvement**
Focal pyelonephritis (02)	00	00	00	02	00	00	00	00	00	00	00	00	00
				100%									
Complex Cyst (01)	01	00	00	00	00	00	00	00	00	00	00	00	00
	100%												
Abscess (03)	00	00	03	02	00	01	00	00	00	02	00	01	00
			100%	100%		33.3%				66.6%		33.3%	
AML (03)	00	00	00	00	00	00	00	00	01	00	00	00	00
									33.3%				
Oncocytoma (02)	00	00	00	00	00	00	00	00	00	00	00	00	00
PCKD (02)	00	00	00	00	00	00	00	00	00	00	00	00	00
Lymphangiectasia (01)	00	00	00	01	00	00	00	00	00	00	00	01	00
				100%								100%	
Calyceal Diverticulum (01)	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 3(b). Different CT Features of Benign Renal Masses



Graph 1. Histogram showing CT Features of Malignant Mass

The most common calcified renal mass in our study was renal cell carcinoma. Calcification was seen in 12 out of 34 cases of RCC (35.3%). Malignant renal masses showed more amount of necrosis when compared to the benign renal masses (61.8% of RCC and 100% of Wilms' tumour).

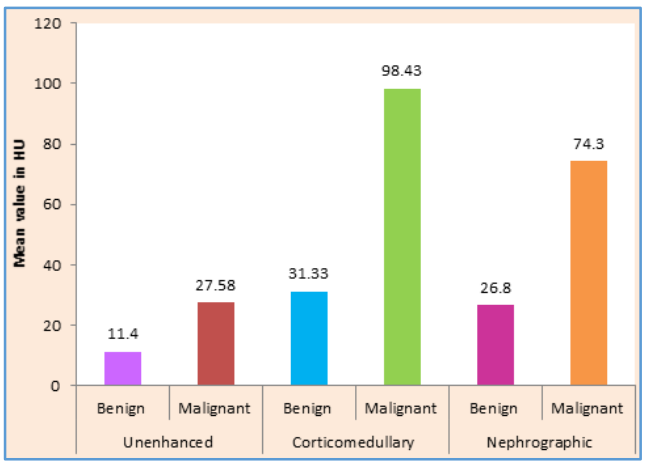
The most common site of metastases from renal cell carcinoma was to Lymph nodes (50%) and Lungs (14.7%).

		Unenhanced	**Corticome-Dullary**	**Nephro-Graphic**
Benign N = 15	Mean HU	11.4467	31.34	26.7933
	Std. Deviation	21.56091	25.7306	22.2532
	Minimum	-32	-11	-10
	Maximum	28	82	62
Malignant N = 45	Mean HU	27.5911	98.4756	74.3489
	Std. Deviation	2.8595	18.21459	13.25477
	Minimum	19.8	57.6	44
	Maximum	34.2	126.8	100.6
Total N = 60	Mean HU	23.555	81.6917	62.46
	Std. Deviation	12.88819	35.55198	26.07207
	Minimum	-32	-11	-10
	Maximum	34.2	126.8	100.6
F Value		24.763	123.223	100.636
P Value		P < 0.01	P < 0.01	P < 0.01

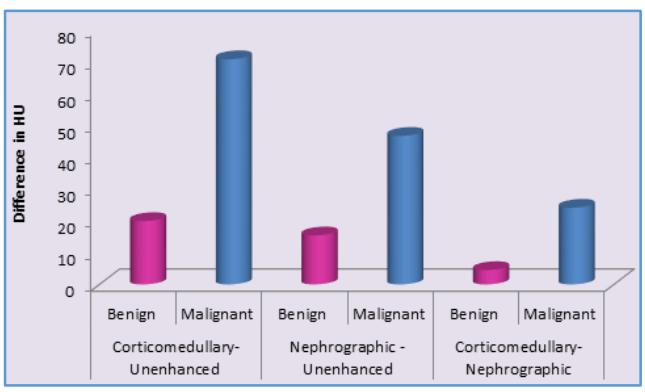
Table 4(a). Characteristics of Renal Masses on MDCT with Respect to Attenuation Values on Pre- and Post-Contrast Scan, a Comparison

Difference		**N**	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**	**'F' value**	**'P' value**
Corticomedullary-Unenhanced	Benign	15	19.9	15.8	0.6	54	98.001	<0.01
	Malignant	45	70.8	17.7	34.2	103.2		
Nephrographic - Unenhanced	Benign	15	15.4	9.8	1.4	34	75.322	<0.01
	Malignant	45	46.7	12.8	22.7	74.2		
Corticomedullary-Nephrographic	Benign	15	4.5	11.01939	-24.8	20	60.973	<0.01
	Malignant	45	24.1	7.38962	3.7	39.1		

Table 4(b). Characteristics of Renal Masses on MDCT with Respect to Attenuation Values on Pre- and Post-Contrast Scan, a Comparison



Graph 2(a). Histogram showing Comparison of Renal Masses on MDCT with Respect to Attenuation Values on Pre- and Post-Contrast Scan



Graph 2(b). Histogram showing Comparison of Renal Masses on MDCT with Respect to Attenuation Values on Pre- and Post-Contrast Scan

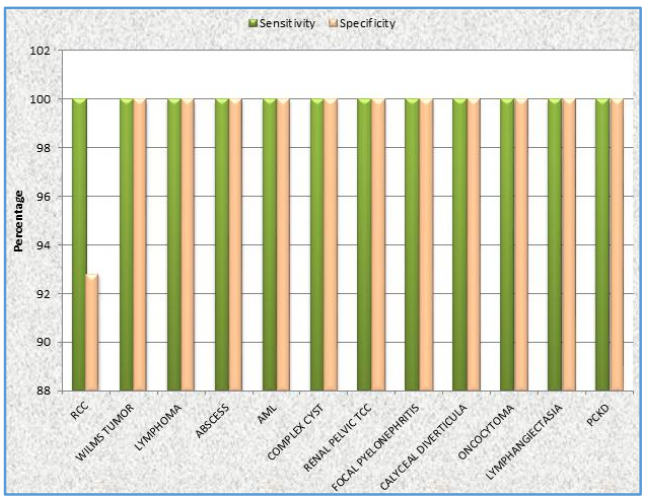
- In our study, the benign renal masses had an attenuation value of 11.4 HU on pre-contrast scans, whereas the malignant renal masses showed a higher attenuation value of 27.6 HU.
- Mean attenuation value of benign renal masses in corticomedullary phase was 31.3 HU and that of malignant masses was 98.4 HU.
- Mean attenuation value of benign renal masses in nephrographic phase was 26.8 HU and that of malignant masses was 74.3 HU.
- Benign renal masses showed a mean increase of 19.9 HU in the corticomedullary phase, whereas malignant renal masses showed a significant increase of 70.8 HU.
- Benign renal masses showed a mean increase of 15.4 HU in the nephrographic phase, whereas malignant renal masses showed increase of 46.7 HU.

Diagnosis	True +Ve	False +Ve	False -Ve	True -Ve	Total
Renal cell carcinoma	32	2	0	26	60
Wilms' tumour	9	0	0	51	60
Lymphoma	1	0	0	59	60
Abscess	3	0	0	57	60
AML	3	0	0	57	60
Complex cyst	1	0	0	59	60
Renal pelvic TCC	1	0	0	59	60
Focal pyelonephritis	2	0	0	59	60
Calyceal diverticula	1	0	0	59	60
Oncocytoma	2	0	0	58	60
Lymphangiectasia	1	0	0	59	60
PCKD	2	0	0	58	60

Table 5. Sensitivity and Specificity of MDCT for Renal Masses

Diagnosis	Sensitivity	Specificity	PPV	NPV	Accuracy	P value
Renal cell carcinoma	100.0	92.8	94.1	100.0	96.7	<0.001
Wilms' tumour	100.0	100.0	100.0	100.0	100.0	<0.001
Lymphoma	100.0	100.0	100.0	100.0	100.0	<0.001
Abscess	100.0	100.0	100.0	100.0	100.0	<0.001
AML	100.0	100.0	100.0	100.0	100.0	<0.001
Complex cyst	100.0	100.0	100.0	100.0	100.0	<0.001
Renal Pelvic TCC	100.0	100.0	100.0	100.0	100.0	<0.001
Focal pyelonephritis	100.0	100.0	100.0	100.0	100.0	<0.001
Calyceal diverticula	100.0	100.0	100.0	100.0	100.0	<0.001
Oncocytoma	100.0	100.0	100.0	100.0	100.0	<0.001
Lymphangiectasia	100.0	100.0	100.0	100.0	100.0	<0.001
PCKD	100.0	100.0	100.0	100.0	100.0	<0.001

Table 6. Sensitivity, Specificity, PPV, NPV, Accuracy and the P value of MDCT for Renal Masses



Graph 3. Histogram showing Sensitivity and Specificity of Individual Renal Masses

Final Diagnosis

Final Diagnosis	CT Diagnosis		Total
	Malignant	Benign	
Malignant	43 (TP)	0 (FN)	43
Benign	02 (FP)	15 (TN)	17
Total	**45**	**15**	**60**

Sensitivity: 100%, Specificity = 88.2%, PPV = 95.5%, NPV = 100%, Accuracy = 96.7%.

In our study, out of 34 cases of RCC 10 cases are in stage I, 7 cases are in stage II, 12 cases are in stage III and 5 cases are in stage IV. Out of 10 stage I cases, 2 cases are false positive.

In our study, out of 09 cases of Wilms' tumour, 2 cases are in stage I, 2 cases are in stage II, 4 cases are in stage III, 1 case is in stage IV and no case in stage V.

DISCUSSION

In our study, out of total 60 cases studied, 36 males and 24 females (age range from 2 to 72 years); there were 45 (75%) malignant and 15 (25%) benign renal masses. Renal cell carcinoma (n = 34) accounted for 56.7% of all renal masses and 75.5% of malignant renal masses. Other renal masses include Transitional cell carcinoma (n = 01), Wilms' tumour (n = 09), Lymphoma (n = 1), Complex renal cyst (n = 01), Abscess (n = 03), PCKD (n = 2), Focal pyelonephritis (n = 2), Calyceal diverticulum (n = 1), Renal lymphangiectasia (n = 1), Angiomyolipoma (n = 03) and Oncocytoma (n = 02). The one case of bilateral angiomyolipoma was diagnosed as tuberous sclerosis after further investigations of other systems by different imaging modalities. Our findings correlate well with the findings of Taryn Hodgdon et al,[3] who found the mean age of RCC and AML was 59 +/- 13 years and 53 +/- 12, whereas in our study it was 60.03 years and 37.3 years. Verhoest G et al[4] in their study have found that the incidence of renal cell carcinoma was 6% in < 40 years, 38.5% in 40 - 60 years, 52.3% in 60 - 80 years and 3.2% in > 80 years. This correlates well with our study, where the maximum percentage of patients were seen in 60 - 69 years. Manal H. Wahba et al[5] studied 61 patients. Renal masses were confirmed by surgery, renal biopsy or followup. Their final diagnosis includes renal cell carcinoma (n = 39), transitional cell carcinoma (n = 3), Wilms' tumour (n = 3), angiomyolipoma (n = 7), Lymphoma (n = 6) and metastasis (n = 1). Our study is well correlated with this study.

9 patients (100%) with Wilms' tumour were < 10 years, the youngest was 2 years old male patient and oldest was 5 years old female patient. The mean age was 2.9 years. Our findings are similar to the findings of A. Adegboyega et al,[6] who found peak incidence of Wilms' tumour is at 37 months.

In our study, 5 out of 60 cases are bilateral; 2 cases of PCKD, 1 case of angiomyolipoma, 1 case of lymphangiectasia and 1 case of lymphoma is bilateral. The one case of bilateral angiomyolipoma was diagnosed as tuberous sclerosis after further investigations of other systems by different imaging modalities; 18 out of 34 cases of RCC are located on right side and 5 out of 9 cases of Wilms' tumour are located on right side. In the study done by Manal H. Wahba et al,[5] 51 cases had unilateral masses (91%) and 5 cases had bilateral masses (9%).

The findings of our study is similar to that of Manal H. Wahba et al.[5] Study regarding CT characteristics of renal masses, in their study among 39 masses of RCC 9 cases had lymph node metastasis, 8 cases had perinephric extension, 4 cases had distant metastasis and 2 cases had renal vein thrombosis; whereas in our study among 34 masses of RCC, 15 cases had lymph node metastasis, 12 cases had perinephric extension, 5 cases had distant metastasis and 8 cases had renal vein thrombosis.

	Adegboyega et al[6] Study		Our Study	
	No. of Case	%	No. of Case	%
Calcification	02	17%	02	22.2%
Vascular involvement	03	25%	01	11.1%
Lymph node involvement	06	50%	05	55.5%
Bone involvement	0	0%	0	0%

Table 7. Comparison with A. Adegboyega et al[6] Study (CT Characteristics of Wilms' Tumour)

Our study shows very similar findings regarding CT characteristics of Wilms' tumour, e.g. calcification, vascular involvement, lymph node involvement and bone involvement.

In our study, the benign renal masses had an attenuation value of 11.4 HU on unenhanced scans, whereas the malignant renal masses showed a higher attenuation value of 27.6 HU. Mean attenuation value of benign renal masses in corticomedullary phase was 31.3 HU and that of malignant masses was 98.4 HU. Mean attenuation value of benign renal masses in Nephrographic phase was 26.8 HU and that of malignant masses was 74.3 HU. Benign renal masses showed a mean increase of 19.9 HU in the corticomedullary phase, whereas malignant renal masses showed a significant increase of 70.8 HU (P value < 0.01). Benign renal masses showed a mean increase of 15.4 HU in the nephrographic phase, whereas malignant renal masses showed increase of 46.7 HU (P value < 0.01). Difference between corticomedullary and nephrographic phase was 4.5 HU in benign lesion and 24.1 HU in case of malignant lesion. ln our study, out of two false positive cases one oncocytoma was

misdiagnosed as renal cell carcinoma due to its heterogeneous pattern with increased density on unenhanced scan and significant enhancement in the corticomedullary and nephrographic phase. The other case was of angiomyolipoma, which was again mistaken for malignant lesion due to its higher attenuation value of on unenhanced scan and significant contrast enhancement and lack of macroscopic fat, the diagnosis of angiomyolipoma was confirmed on histological examination by FNAC. In our study Sensitivity = 100%, Specificity = 88.2%, PPV = 95.5%, NPV = 100% and Accuracy = 96.7% was achieved for differentiating benign from malignant renal masses on pre- and post-contrast images.

The findings of prior studies are consistent with the results of this study. A study reported by Kim et al[7] showed that RCC had strong enhancement on biphasic CT with a contrast enhancement of over 100 HU on the CMP at 115 ± 48 HU.

In the study done by Ghazi Alshumrani et al,[8] absolute nephrographic phase enhancement (nephrographic minus unenhanced phase) was clear cell renal cell carcinomas 65 HU (34 - 120), oncocytomas 80 HU (51 - 111). In our study, nephrographic phase enhancement was renal cell carcinomas 52.3 HU and oncocytomas 30.1 HU.

Our findings correlate well with findings of the Zagoria et al[9] study, wherein the author has found that the vascular solid renal neoplasms showed mean attenuation value of 104 ± 46 and 90 ± 37 in CMP and NP respectively, whereas benign lesions showed 19 ± 8 and 20 ± 8 in CMP and NP respectively, the difference in attenuation between CMP and NP was 22 for solid masses and 1 for benign masses. Keeping a cut-off value of 20 HU as the significant enhancement to distinguish between the vascular neoplasms and the benign lesions, we achieved Sensitivity = 100%, Specificity = 88.2%, PPV = 95.5%, NPV = 100% and Accuracy = 96.7% compared to Zagoria et al[9] who achieved Sensitivity of 95.2%, Specificity of 100%, PPV of 100%, NPV of 95.8% and Accuracy of 97.2%.

In our study, all the renal cell carcinomas displayed soft tissue attenuation on pre-contrast scan and HU of 106.9 ± 10.3 and 80.2 ± 8.8 on CMP and NP respectively. S. K. Choi et al[10] have also described similar findings, wherein they have demonstrated that RCC being very vascular tumour shows significant enhancement (> 20 HU) in CMP and NP. They found 67 RCCs had a mean attenuation value of 29.5 ± 10.5 HU on the unenhanced scan (range, 5 to 50 HU). All carcinomas showed significant contrast enhancement (more than 20 HU) after intravenous injection of contrast.

	Current Study	Kopka et al Study
Sensitivity (%)	100	100
Specificity (%)	88.2	95
PPV (%)	95.5	96
NPV (%)	100	100
Accuracy (%)	96.7	96

Table 8. Comparison with Kopka et al[11] Study; Analysis of Different Helical CT Phases in revealing Histologically Proven Malignancies

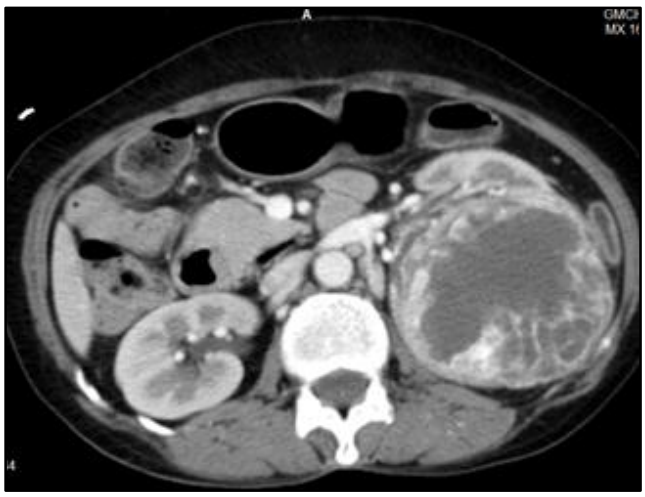
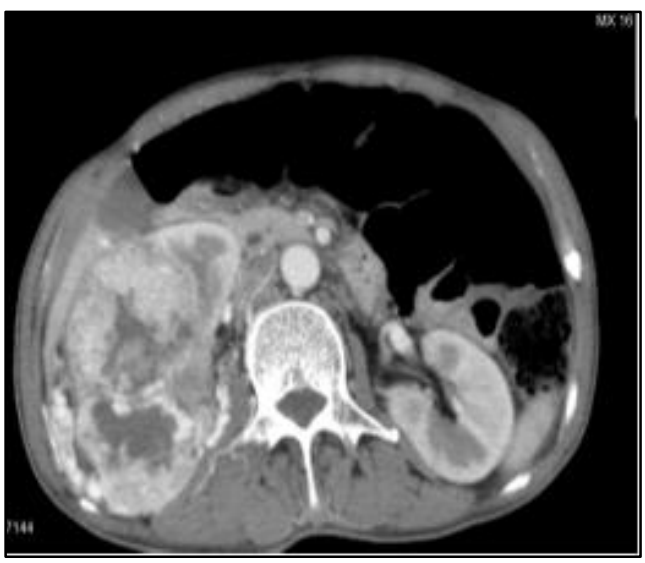
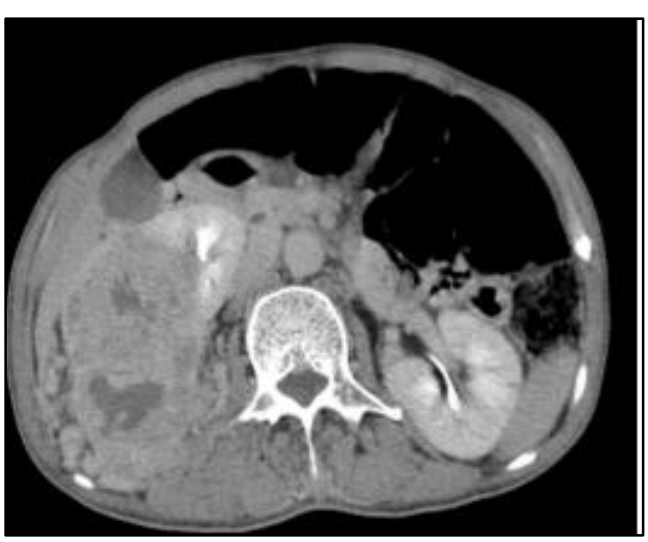
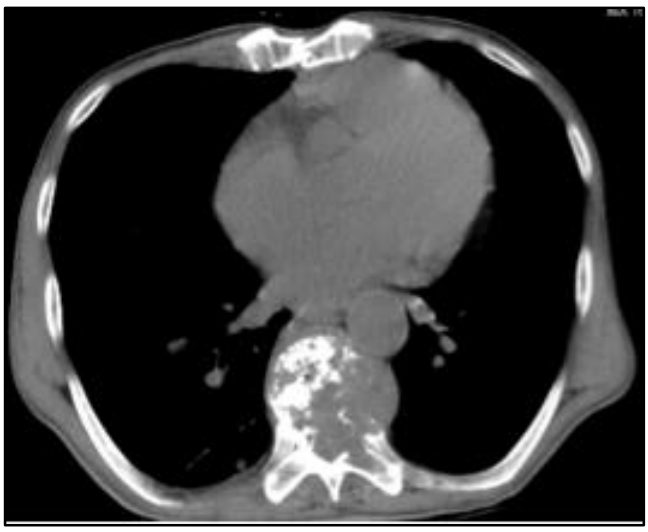


Figure 1. Stage II RCC. CECT Image shows Heterogeneously Enhancing Lesion with Internal Necrosis involving the Left Kidney







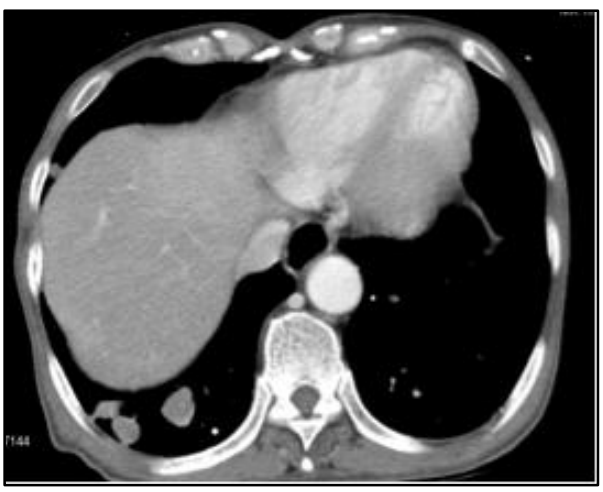


Figure 2. Stage IV Renal Cell Carcinoma. CT showing Large Soft Tissue Density Heterogeneously Enhancing Mass with Necrosis and Perirenal Neovascularity involving Right Kidney with Skeletal and Pulmonary Metastasis

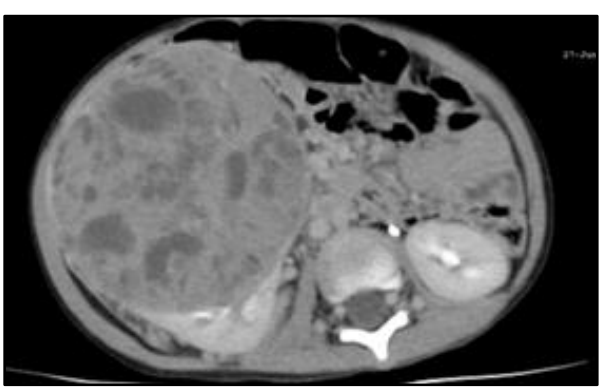


Figure 3. Wilms' Tumour

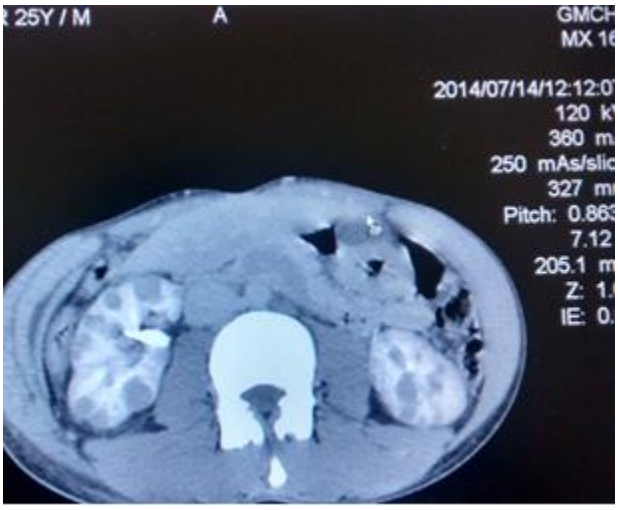


Figure 4. Lymphoma Multiple Hypoenhancing Lesions involving Both Kidneys

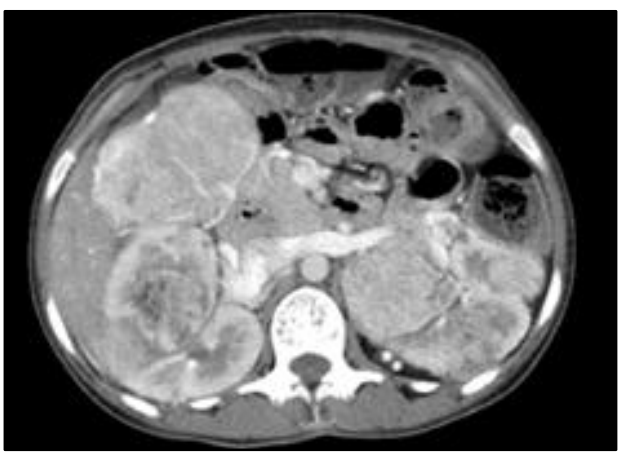


Figure 5. CT of Bilateral Angiomyolipoma in a Case of Tuberous Sclerosis

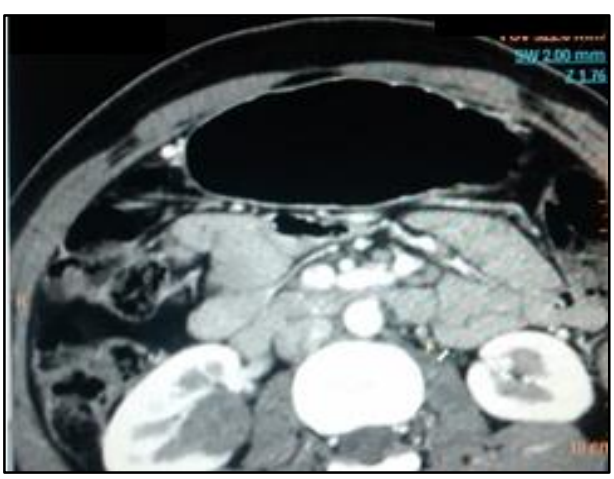


Figure 6. CT appearance of Oncocytoma. CECT Axial Image showing Well-Defined Soft Tissue Density Mass in the Right Kidney

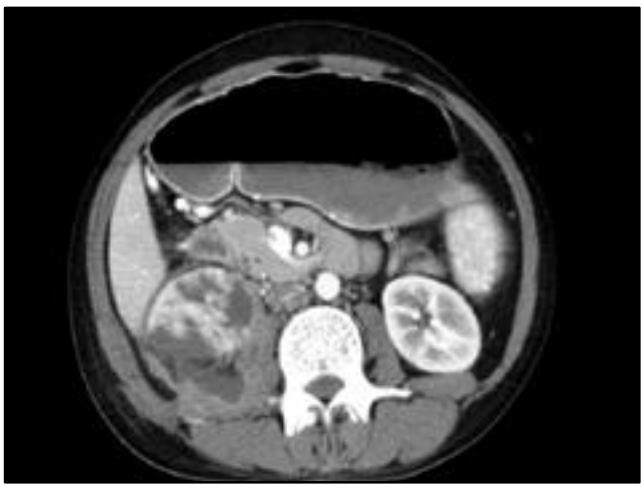


Figure 7. CECT Axial Image of Right Renal Abscess with Perinephric Extension

CONCLUSION

As a result of the study, the following conclusions can be stated:

1. CT has excellent accuracy in the diagnosis, characterisation and differentiating benign and malignant renal masses.
2. For the characterisation of small renal mass, the degree of enhancement on the corticomedullary phase is the most valuable parameter.

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