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Multidetector Computed Tomographic Evaluation of Renal Masses

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Abstract: ***Background and Objectives: MDCT plays a significant role in the characterization and detection of renal masses which are considered indeterminate or malignant on ultrasonography. MDCT plays a major role in comparision of the enhancement patterns of renal neoplasm, renal cysts and renal cortex during a corticomedullary and nephrographic phase. Methods: This research was done for a period of 10 months in the department of Radio-diagnosis in Great Eastern Medical School& Hospital, ragolu, srikakulam on patients referred from urology and surgery were evaluated through detailed history, ultrasonography and computed tomography was carried out using GE 16 SLICE CT Scanner. CT Scans obtained with single breath hold time from the level of diaphragm to the level of iliac crest. Results: The present study included 33 cases of renal masses between age group of 22-82 years. There were twenty males and thirteen females with one patient showing left kidney upper pole hypoechoic mass on USG, which turned out to be dromedary hump and was thus excluded from study. 16 patients presented with hematuria, eleven patients with loin pain, four patients with weight loss, one with fever and one patient was asymptomatic. For the final analysis thirty two patients were included (19 males and 13 females). Thirty three lesions were detected in thirty two patients. Of these, thirty lesions were neoplastic lesions of which majority of the neoplastic lesion comprised of Renal cell carcinoma (22 cases), Transitional cell carcinoma (3 cases), Angiomyolipoma (1 case), Renal oncocytoma (1 case), Renal metastasis (1 case), Renal abscess (1 case) and three lesions were cystic lesions. Interpretation and Conclusion: 1) Renal neoplasm showed greater enhancement in the nephrographic phase compared with that in corticomedullary phase. 2) Renal cortex also showed greater enhancement in the nephrographic phase compared with that in corticomedullary phase.***

Keywords: Renal mass, Computed tomography, Renal cell carcinoma

1. Introduction

The Introduction of Helical CT has many important advances in the detection and characterization of renal masses and is accepted as a imaging technique for suspected renal tumors, renal staging and detecting metastases because of its high accuracy and ready accessibility and low cost.

The commonest renal lesion is a simple cyst with an incidence of 26% - 50% after the age of 50 years. Benign renal masses outnumber the malignant ones. RCC accounts for 3.7% of all solid malignancies and is more common among men (1.6:1, M:F). Patients with localized disease have 92% 5-year survival, while this decreases to 65% for those with regional metastasis, and 12% for patients with distant metastatic disease[1].

CT has largely replaced angiography and to certain extent ultrasound in the evaluation of renal masses. The diagnostic accuracy of properly performed CT for separating cyst from neoplasm is extremely high. CT has been used to image a wide spectrum of renal diseases and masses. Renal CT scanning is easy to perform, fast, and free of operator dependence and has met with ready clinical acceptance. The most commonly used method to evaluate indeterminate renal masses is contrast-enhanced CT[2]. It is also considered the method of choice to stage renal cell carcinoma with high accuracies in both early and advanced stages[3]. Helical CT has many potential advantages over conventional axial CT. Rapid and continuous scanning allows an entire sequence to be obtained during a single breath hold. At the most commonly used pitch of 1:1, most kidneys can be scanned using narrow (5 mm) image collimation in less than 30 seconds. Although collimation and pitch must be determined at the time that scans are acquired, raw data can be reconstructed at any level. The rapid scanning time of helical CT also permits renal imaging during any of the three phases of renal parenchymal contrast material enhancement: the cortical phase, nephrographic phase, or excretory phase.

2. Methodology

Source of Data
A prospective observational study was performed in the department of radiodiagnosis, GEMS & HOSPITAL, Ragolu, on patients referred from surgery and urology department over a period of ten months.

Sample size: thirty three cases

Inclusion criteria:
The study includes

- All patients clinically suspected to have Renal mass lesions.
- All patients with incidentally diagnosed renal masses by ultrasound.
- Cases of all ages irrespective of sex.

Exclusion criteria:

The study will exclude

- Patient having history of trauma

Imaging Protocol Used

Patients were kept nil by mouth four hrs before the procedure to the avoid complications of contrast medium administration. Contrast administration risks were explained to the patient and consent was obtained prior to the contrast study. Routine anterio-posterior topogram of the abdomen was initially taken in all patients in the supine position with the breath held. Axial plain sections of 5 mm thickness were taken from the level of lung bases to the level ischial tuberosities. plain scan was followed by intravenous contrast scan in suspended inspiration Post study reconstructions were done at 2.5 mm. Sagittal and coronal reconstructions were made wherever necessary. Newer techniques in Multislice CT like curved planar reformatting, volume rendering, Maximum and Minimum Intensity Projections were done as and when necessary. The magnification mode was commonly employed, and the scans were reviewed on a direct display console at multiple window settings (i.e. abdomen window at 320/40; Lung window 1400/-600; Bone window of 2400/200)

The lesions were evaluated with respect to pre and post contrast attenuation values, the size , location of the mass , presence of fat presence of calcification , and extension into the adjoining structures.

3. Results

33 cases were studied. One case is excluded from study with dromedary hump on USG.

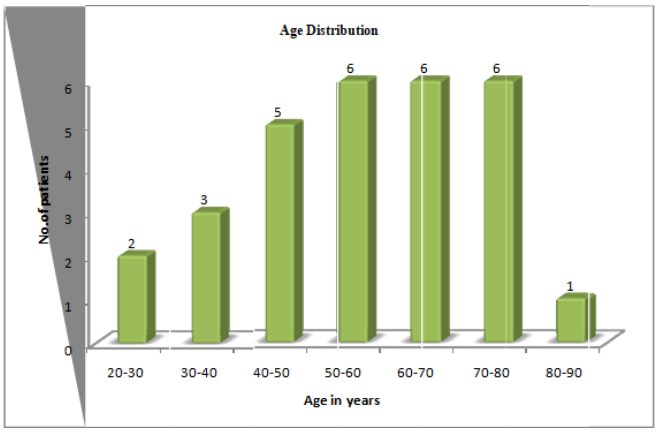

Table 1: Age Distribution of Renal Neoplasms

Age group (years)	*No. of patients*
20-30	2
30-40	3
40-50	5
50-60	6
60-70	6
70-80	6
80-90	1

Table 2: Enhancement Data for Renal Neoplasms

Variable	HU
Unenhanced attenuation	23±7
CMP attenuation	49±22
NP attenuation	68±26
CMP enhancement	23±14
NP enhancement	47±19

CMP-Corticomedullary phase, NP-Nephrographic phase, HU-Hounsfield units

On unenhanced CT scans, neoplasms demonstrated a mean attenuation of 23±7 HU. Renal neoplasms showed average enhancement of 26±14 HU during corticomedullary phase and 45±19 HU during nephrographic phase. One tumor, which showed greater degree of enhancement during corticomedullary phase, showed fewer enhancements during nephrographic phase.

Table 3: Attenuation Values and Enhancement of Renal Neoplasms

Tumor	Unenhanced attenuation (HU)	CMP attenuation (HU)	NP attenuation (HU)	CMP enhancement (HU)	NP enhancement (HU)
1	30	55	84	25	54
2	29	45	105	16	75
3	24	57	106	23	82
4	28	51	82	23	54
5	22	50	75	28	53
6	27	84	52	57	25
7	31	46	70	15	39
8	34	53	90	19	56
9	27	44	65	17	38
10	26	44	67	18	40
11	28	47	86	19	58
12	33	50	80	17	47
13	30	70	80	40	50
14	27	50	54	22	26
15	28	48	56	23	31
16	28	53	58	15	20
17	26	47	71	21	55
18	26	54	60	26	23
19	30	44	48	14	18
20	26	44	50	18	24
21	30	70	80	40	50
22	27	84	52	57	25
23	30	55	84	25	54
24	31	46	70	15	39
25	26	44	50	18	24
26	31	41	65	17	44
27	28	50	75	28	52
28	32	46	100	19	75
29	26	44	67	18	40
30	24	70	84	26	38

CMP-Corticomedullary phase. NP –Nephrographic phase. HU-Hounsfield units.

Table 4: Renal Cysts

Variable	Present study
No.of patients	3
Age range	22-65y
Mean age	45y
Average size	6.3cm ±1.4
Range	5-8cm
Unenhanced mean attenuation (HU)	12 ± 2
Unenhanced attenuation Range (HU)	-5 to 28
CMP enhancement (HU)	1 ±2
NP enhancement (HU)	2-±3

CMP- Corticomedullary phase. NP-Nephrographic phase. HU-Hounsfield Units

Table 5: Summary of Enhancement Data

Region Studied	Unenhanced attenuation (HU)	CMP Attenuation (HU)	NP Attenuation (HU)	CMP enhancement (HU)	NP enhancement (HU)
Neoplasms	232±7	49±22	68±26	26±14	45±19
Cortex	32±3	137±30	163±36	105±29	131±40
Cysts	12±2	13±1	14±2	1±2	2±3

The statistical significance of both renal neoplasms and normal renal cortex enhancement in the nephrographic and corticomedullary phases were calculated using student t test. Both renal neoplasms and renal cortex showed significantly greater enhancement in the nephrographic phase compared with that in the corticomeduallry phase (p=.001and p=.001 respectively).

4. Discussion

Accurate differentiation of a renal neoplasm and a simple cyst or minimally complicated cyst has become an increasingly important CT application. The Helical CT scanner permits imaging kidneys during various phases of parenchymal enhancement, including corticomedullary, nephrographic and excretory phase. Previous studies[4,7] have shown that nephrographic and excretory phase images are superior to corticomedullary phase in the detection of renal masses. Cohan et al[5] demonstrated that small medullary lesions may be missed on corticomedullary phase and that false-positive medullary pseudolesions may be detected due to disparate enhancement of medulla compared with that of the adjacent cortex.

The purpose of the present study is to compare corticomedullary and nephrographic phases in the characterization of a renal mass and to evaluate the characteristics of renal parenchymal enhancement during these two phases.

CT attenuation values

Mean attenuation values were measured in Hounsfield Units for each renal neoplasm in unenhanced, corticomeduallary and nephrographic phase images. The mean attenuation values were calculated from the absolute attenuation values in each phase images. Lesion enhancement was then determined by measuring the difference in mean attenuation numbers between unenhanced and enhanced images.

Renal neoplasms

Age distribution

Age	Present study	Cohan et al [5]	Birnbaum et al [6]	Szolar et al[7]	Welch et al[8]
No.of patients	32	33	30	93	73
Age range	22-82y	37-82y	41-80y	28-85y	14-80y
Mean age	52y	58.4y	62y	59y	63.7y

Sex distribution

Sex	Present study	Cohan et al[5]	Birnbaum et al[6]
No. of males	19	20	21
No. of females	13	13	9
Male /Female ratio	1.75:1	1.5:1	2.3:1

Clinical presentation

Variable	Present study	Amendola et al[9].	Jayson et al[10].
No.of patients	22	39	131
Hematuria	16	9	31
Flank pain	11	2	13
Distant metastases	0	3	-
Asymptomatic	1	25	80

Size of the lesion

Variable	Present study	Birnbaum et al[6]	Welch et al[7]
Range	2.4 to 15cm	1.4 to 8 cm	1.5 to 19cm
Mean size	7.3±4cm	4.3±1.8 cm	7cm

Comparison of enhancement of renal neoplasms

Neoplasms	Present study	Birnbaum et al[6]
Unenhanced attenuation (HU)	23±7	19±8
CMP attenuation (HU)	49±22	40±17
NP attenuation (HU)	68±26	65±18
CMP enhancement (HU)	23±14	21±15
NP enhancement (HU)	47±19	46±14

The mean attenuation of renal neoplasms in unenhanced phase is 23±7 HU. The mean attenuation of neoplasms in corticomeduallary phase is 49±22 HU and in nephrographic pahse is 68±26HU. Neoplasm enhancement during corticomedullary phase is 23±14HU and during nephrographic phase is 47±19HU.

These findings correlated with the study conducted by Birnbaum et al[6]., who studied the enhacement characteristics

of 15 neoplasms and demonstrated that renal neoplasms show progressive enhancement over time and the mean enhancement is statistically significantly greater in nephrographic phase than in corticomedullary phase.

Renal cysts:
Three radiolgocally benign cysts were diagnosed in three patients who ranged in size from 22-65 years (mean, 45 years). The average cyst size was 6.3 cm ± 1.4 (range, 5-8 cm). Cysts demonstrated a mean attenuation of 12 ± 2 HU. The mean cyst enahcement was 1 ± 2 HU during corticomedullary phase and 2 ± 3 HU during nephrographic phase. These findings correlated with the study conducted by Birnbaum et al[6]., who studied 30 patients and discovered 16 radiologically benign cysts.

Variable	Present study	Birnbaum et al[6]
No. of patients	3	15
Age range	22-65y	51-80y
Mean age	45y	63y
Average size	6.3cm ± 1.4	3.1 cm ± 2.1
Range	5-8 cm	1.1-10 cm
Unenhanced mean attenuation (HU)	12 ± 2	11 ± 13
Unenhanced attenuation Range (HU)	-5 to 28	-5 to 34
CMP enhancement (HU)	1 ± 2	1 ± 3
NP enhancement (HU)	2 ± 3	3 ± 3

Comparison of enhancement of renal cortex

The mean attenuation of renal cortex is measured in all phases in all patients. The renal parenchymal enhancement is determined by measuring the difference in cortical attenuation numbers between the contrasts enhanced and unenhanced images.

Enhancement of renal cortex

Renal cortex	Present study	Birnbaum et al [6]
Unenhanced attenuation (HU)	32 ± 3	19 ± 5
CMP attenuation (HU)	137 ± 30	72 ± 34
NP attenuation (HU)	163 ± 36	135 ± 29
CMP enhancement (HU)	105 ± 29	53 ± 34
NP enhancement (HU)	131 ± 40	116 ± 29

Cohan et al[5] studied cortical enhancement in corticomedullary and nephrographic phases. Mean attenuation of renal cortex in their study was 147 ± 41 HU on corticomedullary phase images and 117±41 HU on nephrographic phases.

Summary of enhancement data

Region studied	Unenhanced Attenuation (HU)	CMP Attenuation (HU)	NP attenuation (HU)	CMP enhancement (HU)	NP enhancement (HU)
Neoplasms	23 ± 7	49±22	68±26	26±14	45±19
Cortex	32±3	137±30	163±36	105±29	131±40
Cysts	12±2	13±1	14±2	1±2	2±3

5. Conclusion

1) Renal neoplasm showed greater enhancement in the nephrographic phase compared with that in corticomedullary phase (p=.001).
2) Renal cortex also showed greater enhancement in the nephrographic phase compared with that in corticomedullary phase (p=.001).

To conclude, if dedicated renal CT is requested for a suspected renal mass, the three helical scan series to be obtained are unenhanced, corticomedullary and nephrographic phase images.

6. Summary

This study was done to show that majority of the renal masses was better detected , characterized and staged on Multiphasic Helical CT compared to other imaging modalities like intravenous pyelography, ultrasound and MRI.

Analysis of summary enhancement data revealed that both renal neoplasms and normal renal cortex demonstrated significantly greater enhancement in the nephrographic phase compared with that in the corticomedullary phase (p =.001 and 0.001 respectively). No statistically significant differences (p > 0.5) in enhancement were noted for the radiologically benign cysts when the two phases are compared.

The enhancement values of Renal masses on contrast enhanced CT in nephrographic phase, corticomedullary phase determines the vascularity of the mass and hence determines the nature of the lesion.

Therefore, this study proves that Multiphasic Helical CT is a first line of investigation for determining the indeterminate

lesion in comparison to other modalities.

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Image Gallery

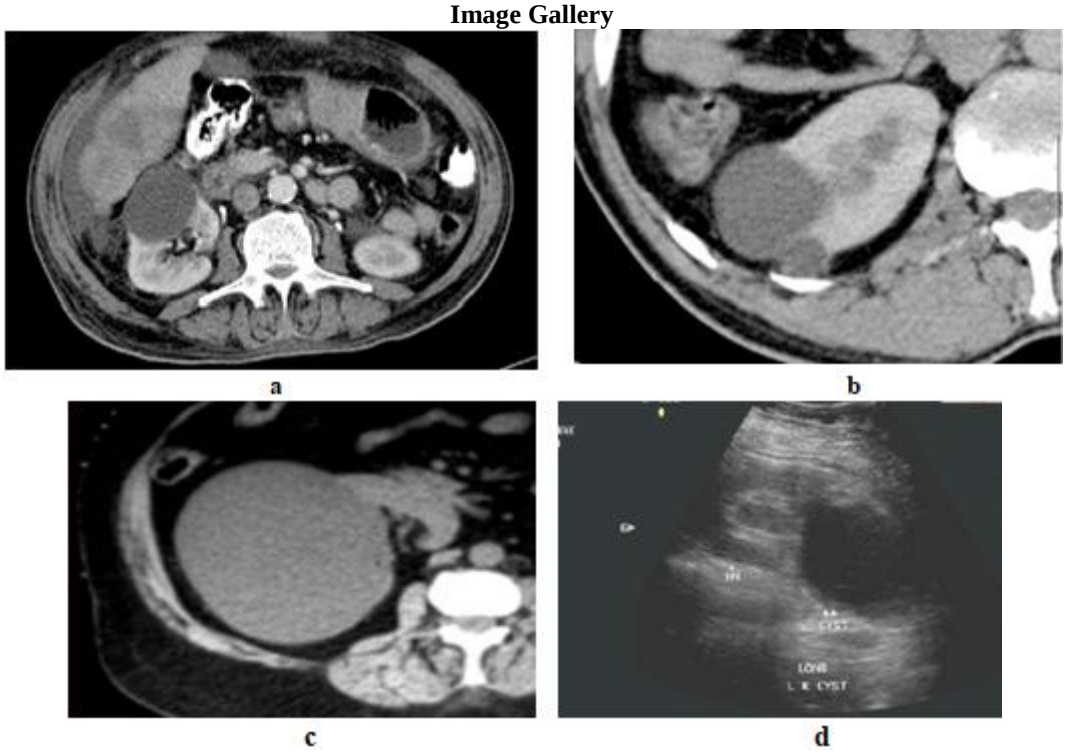
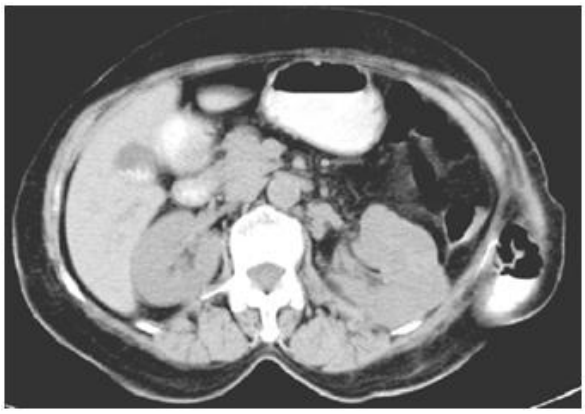


Figure 2: Types of Renal cysts on MDCT

a) Bosniak type I cyst with uniform low attenuation and thin non enhancing wall.
b) Bosniak type I cyst with pseudoseptations
c) Bosniak type II cyst with uniform high attenuation,no enhancement is seen.
d) A well defined focal anechoic lesion in lower pole of left kidney-USG



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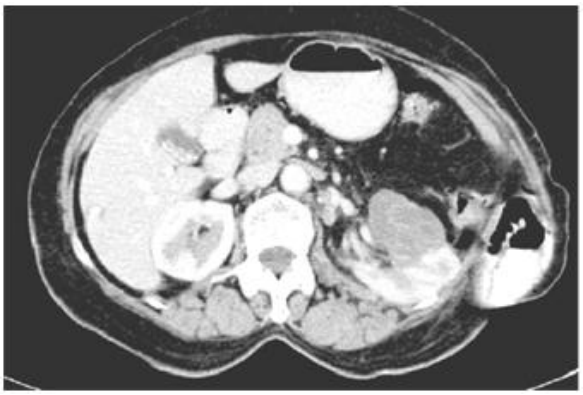

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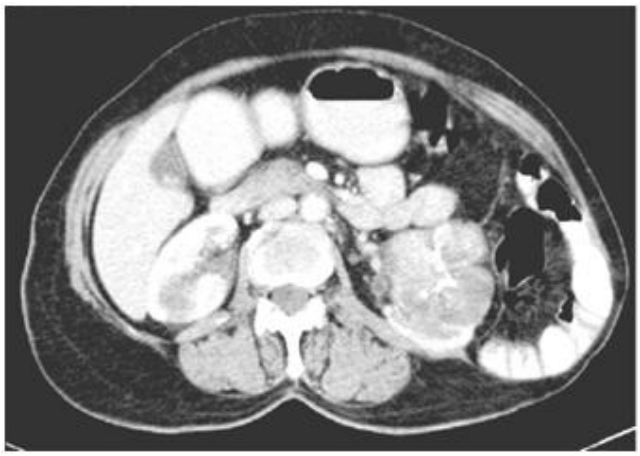
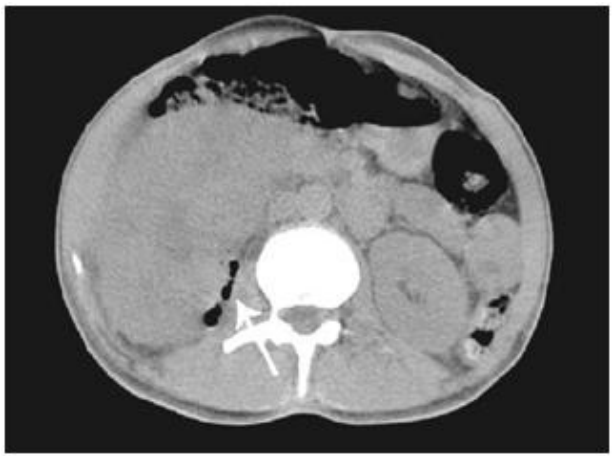


(c)

Figure 3: Renal cell carcinoma – CT

a) NECT showing soft tissue exophytic mass in left kidney
b) Lesion shows enhancement on contrast administration
c) Another case of RCC showing areas of calcification



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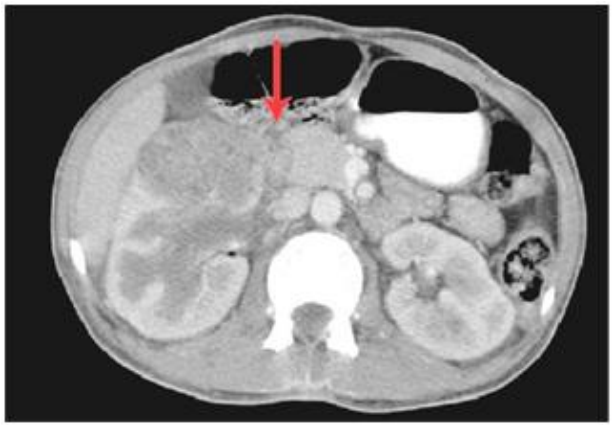

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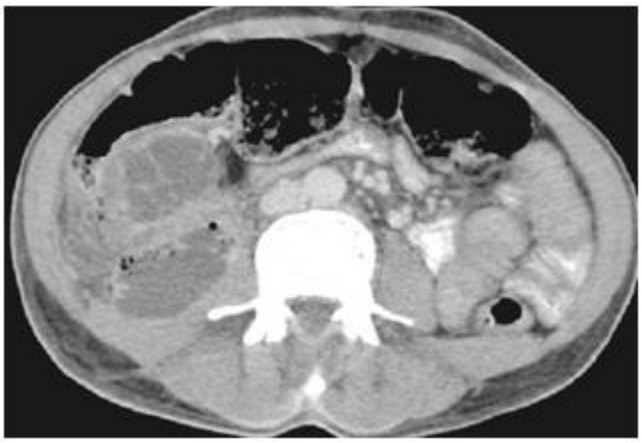
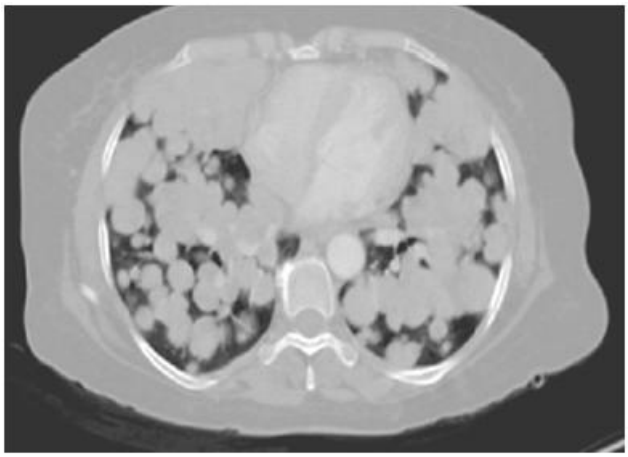


(c)

Figure 4: Stage III Renal cell carcinoma

a) NECT showing soft tissue mass in right kidney with pockets of air(arrow) in the posterior pararenal space
b & c) Lesion shows enhancement with infiltration in the 2nd part of duodenum(red arrow) and right psoas.



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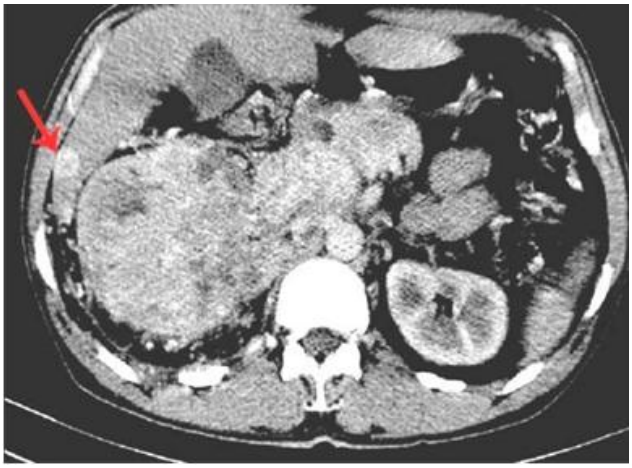
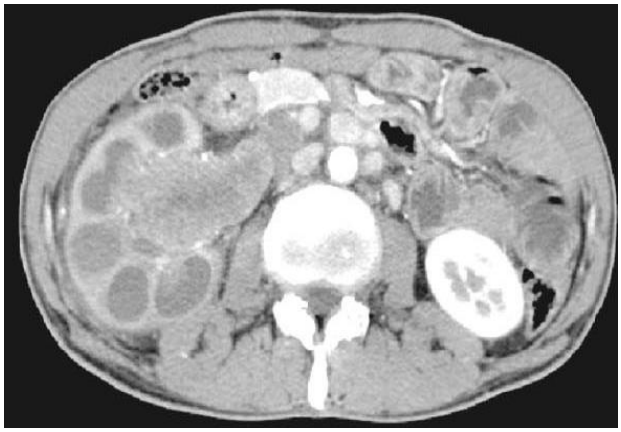


(b)

Figure 5: Stage IV Renal cell carcinoma

a) Renal cell carcinoma with canon ball pulmonary metastases.
b) RCC with hypervascular metastases to right lobe of liver (red arrow).



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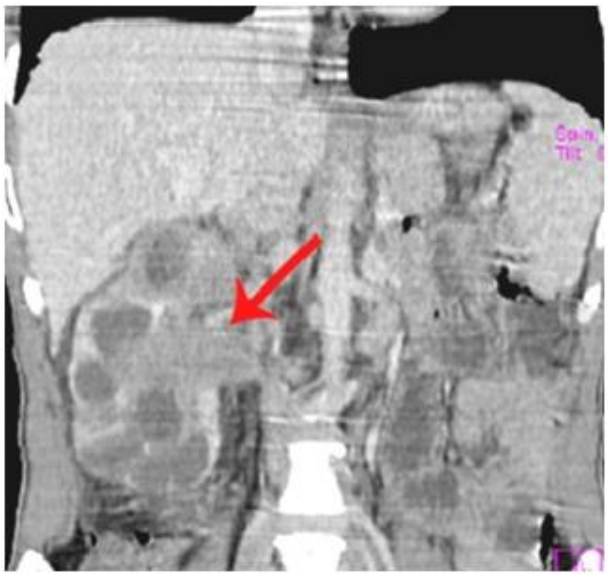
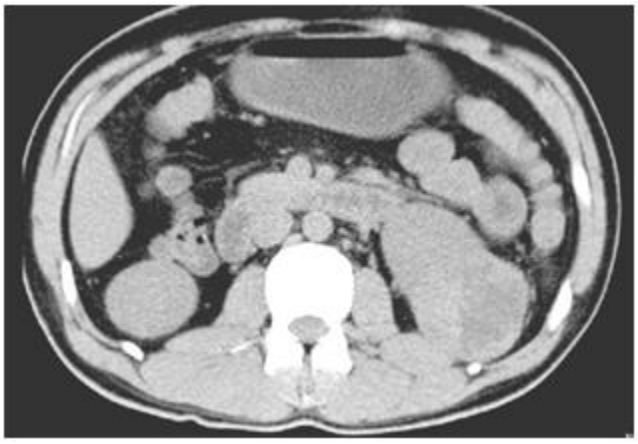


(b)

Figure 6: CT appearance of Renal pelvic TCC
(a & b): CECT shows enhancing soft tissue density mass filling the entire right pelvicalyceal system(red arrow) causing proximal hydronephrosis.



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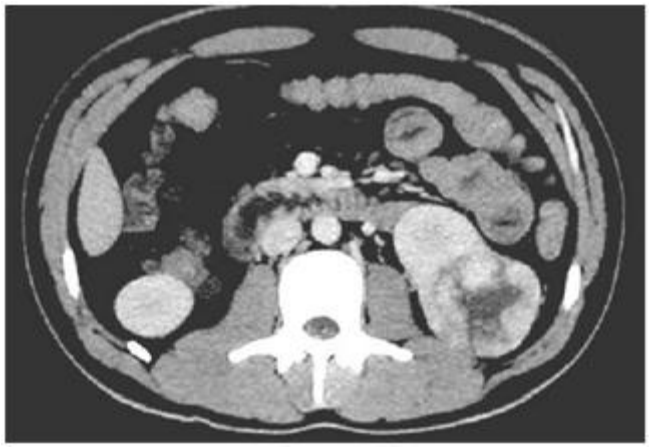

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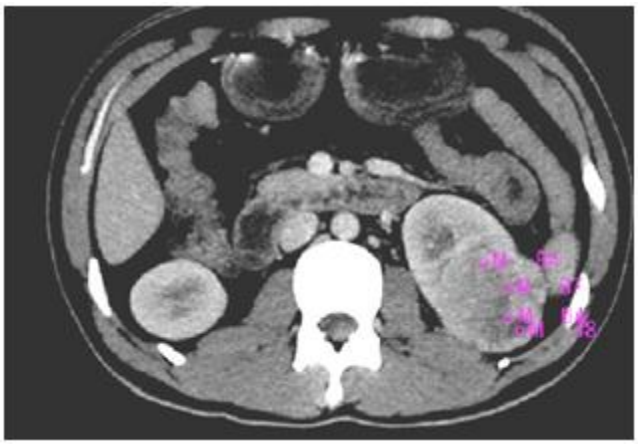

(c)

Figure 7: CT appearance of oncocytoma
a) NECT shows soft tissue exophytic mass with hypodense areas in left kidney.
b & c) CECT shows enhancing soft tissue mass with non enhancing hypodense area representing central scar.

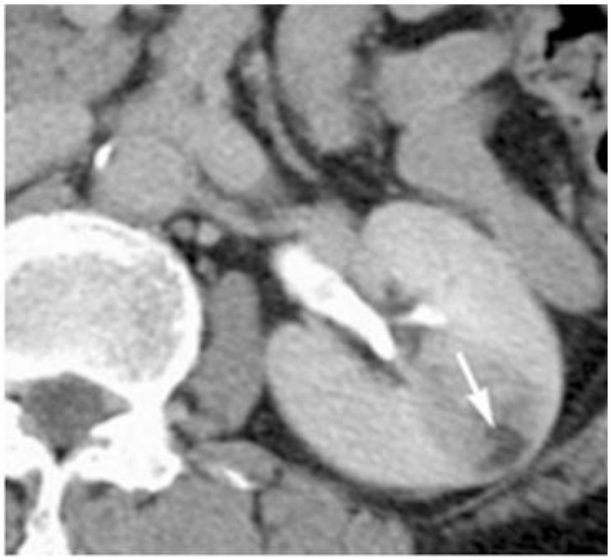

Figure 8: Angiomyolipoma
CT feature suggestive of hypodense lesion of -20 HU involving the cortex of left kidney showing minimal enhancement.