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Multi-detector Computed Tomography Evaluation of Renal Masses with Histopathological Correlation

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Abstract:
Introduction: The highest burden of renal cancer is seen in developed countries. As more countries adopt western lifestyle, incidence of renal cancer is predicted to increase in the future. Kidney cancer (KC) is estimated to cause 400 000 new cases worldwide each year, and it kills over 175 000 people worldwide each year.
Materials and Methods: A prospective hospital-based study was carried out on 64 patients of various ages with clinically suspected renal masses at the Radiodiagnois department of the National Academy of Medical Sciences, Bir Hospital, and Kanti Children Hospitals Kathmandu. The Department of Pathology performed pre- and post-operative histopathology examinations on all patients with renal masses identified by Multi-detected Computed Tomography (MDCT). The histological results and diagnosis were then compared with the MDCT results and diagnosis in the pre-made proforma.
Results: The results of the MDCT showed that 82.8 percent of the cases had malignant renal masses, while only 17.2 percent had benign renal masses. The results of the histopathological analysis also revealed malignant renal masses in over three-quarters (79.70%) of the cases, while only 20.30 percent had benign renal masses. More than half of the cases were male participants. 96.2%, 100%, 100%, 84.6%, and 96.8% were the sensitivity, specificity, PPV, NPV, and accuracy of MDCT for malignant masses renal, respectively. In the case of benign renal mass, the MDCT's sensitivity, specificity, PPV, NPV, and accuracy were 84.6%, 100%, 100%, 96.2%, and 96.8%, correspondingly.
Conclusion: MDCT showed excellent sensitivity and specificity for both benign and malignant kidney cancers. Thus, we came to the conclusion that MDCT is helpful in assessing renal mass and distinguishing between benign and malignant masses.

Keywords: Evaluation; Histopathological Correlation; MDCT; Renal mass.

INTRODUCTION

The vast majority of renal masses are discovered by accidentally when using magnetic resonance imaging (MR), computed tomography (CT), and ultrasound (US). The good news is that the majority of these are simple kidney cysts that are easy to identify and don't need to be treated. Nevertheless, solid and complex cystic renal masses are also found; some of them may not require surgery, while many are obviously malignant and must be removed. Therefore, it is important to properly characterize these masses in order to implement the necessary management [1]. Metastatic disease to the kidney typically manifests as multiple bilateral renal masses, often associated with metastatic disease to other organs. Often they are poorly defined and infiltrate the renal parenchyma [2–4]. There are a group of renal “masses” that superficially may be difficult to differentiate from a renal neoplasm. This group includes congenital anomalies and inflammatory masses, as well as vascular structures.

In almost every case, an accurate evaluation using an excellent MDCT scan, the clinical background of the case, and knowledge of this particular set of "lesions" should reveal their real origin [5]. The imaging characteristics of renal cell carcinoma are extremely varied, with masses ranging from cystic to solid, from homogeneous to heterogeneous and necrotic, from small to large, and from localized to extensive. Renal cell carcinomas can range from small, slow-growing, incidentally discovered lesions to aggressive neoplasms that may metastasize. Ensuring renal cell carcinomas are accurately diagnosed and distinguishing them from lesions that don't need surgery is the radiologist's responsibility [2, 3]. An estimated 400 000 new cases of kidney cancer (KC) are reported worldwide each year, and the disease's global fatality rate is close to 175 000 fatalities annually [6]. Despite making just 2% of all cancer diagnoses and deaths worldwide, renal cell carcinoma (RCC) has more than doubled in incidence in the developed world over the last 50 years and is currently the ninth most prevalent neoplasm in the US [7]. Developed nations, mostly in North America and Europe, have the largest disease burden. Future incidence is expected to rise as more nations adopt Western lifestyles. Gender, age, and genetic illnesses are fixed risk factors for RCC, while smoking, obesity, high blood pressure, diabetes, food and alcohol use, and occupational exposure are intervening risk factors [8]. Renal malignancy is the third most common urologic malignancy and represents 4% of all malignancies. Over 90% of renal tumors are renal cell carcinomas, making them the 13th most common malignancy worldwide. However, few data are available on renal cell carcinoma in Nepal [9–12]. There were lack of sufficient published articles regarding multi-detector computed tomography evaluation of renal masses with histopathological correlation in Nepal. The aim of the study was to find out whether Multi-detected Computed Tomography (MDCT) is useful in the evaluation of renal mass and differentiating benign and malignant mass lesions taking the histopathological findings and diagnosis as the gold standard.

METHOD AND MATERIALS

Study design and setting

The study was prospective hospital-based observational type conducted at National Academy of Medical Sciences, Bir Hospital and Kanti Children Hospitals Kathmandu at Radiodiagnois department. On average, 150 patients visited daily in the radiodiagnosis department at Bir Hospital, whereas 80 patients were visited daily in the radiodiagnosis department at Kanti Children Hospital. Patients of all age groups with clinically suspected renal mass (with hematuria, pain abdomen) after being examined in OPD/ward in department of urosurgery, general surgery and those diagnosed to have renal masses after ultrasound examination in department of radiodiagnosis were included in the study. Patients with post-renal trauma, simple cystic lesions, extra renal mass invading kidney, pregnancy, known cases of contrast allergy, deranged renal function and renal pseud-tumors were excluded from the study.

Study variables

Study variables were age, gender, side of renal mass, size of renal mass, number of lesions, solid and complex cystic renal masses, necrosis and calcification of renal mass, renal outline, regional lymphadenopathy, renal vein/IVC thrombus, local invasion, distant metastasis and histopathological subtypes.

CT Examination

After the patients entered into study from the portal of entries like OPDs of General Surgery, Uro-surgery and Ultrasound departments, informed consent was obtained, detailed clinical history, general and systemic examination of patients were done prior to proceed for the CT scan. Images were acquired by Philips MX16 slice multidetector CT, with machine's tube current of 355 mA, tube voltage of 140 kV, acquisition time 16 slices per second, pitch of 1, slice thickness of 5 mm, images taken helically. CT evaluation of the kidneys was done in both non-enhanced and contrast-enhanced scans obtained in suspended respiration, to overcome the motion artifact. The pre-contrast and post-contrast scans were performed with the same peak kilovoltage, milliampere-second setting, section thickness, and field-of-view in order to prevent artifactual variations in attenuation values. Contrast medium was administered rapidly with a mechanical injector through an antecubital vein as a 150-mL bolus containing 40 to 45 g of iodine at a rate of 2 to 4 mL per second. The corticomedullary phase occurs between 25 and 70 seconds after the start of contrast administration.

In corticomedullary phase, images were obtained to get information about the renal vasculature or when there is a possibility that a detected renal mass may represent an aneurysm or an arteriovenous malformation or fistula or vascular invasion by renal mass. The nephrographic phase starts about 80 seconds and lasts up to 180 seconds after the start of injection, and it offers the best opportunity for discrimination between the normal renal medulla and a renal mass. For identifying renal masses and clarifying unclear lesions, the nephrographic phase is the most useful. The excretory phase starts about 180 seconds after the contrast infusion starts. The contrast material is excreted into the collecting system, so the attenuation

of the nephrogram progressively decreases. This stage can sometimes be useful in clarifying the association between a central mass and the collecting system. Thus, images were acquired in all these phases. Newer techniques like 3D reconstruction and angiograph were also used during the study. CT findings and diagnosis made by an experienced radiologist were entered in the predesigned proforma for analysis of data. All patients diagnosed of having renal masses on MDCT were subjected to pre/post-operative histopathological examination in Department of Pathology. Then, the histopathological findings and diagnosis were entered in the pre-designed proforma and correlated with the MDCT findings and diagnosis.

Statistical analysis and data management

Data obtained were entered into the computer using Stastistical Package for Social Science (SPSS) program version 21. Data were presented using tables and pie charts. MDCT diagnosis of renal mass and pathological diagnosis of renal was tested using sensitivity, specificity, PPV and NPV.

Ethical consideration

Approval of the study was obtained from the Institutional Review Board (IRB) of National Academy of Medical Sciences (Ref. no. R-29, 2070/071). Participant or guardian were explained about the disease, the study, the procedure and its significance, consequences, the expected benefit to them and to the community.A written informed consent indicating that the participant or guardian (if the patient is a minor) has understood all the information in the consent form and is willing to participate in the research was obtained from all guardians of patients included in this study. They were assured of full confidentiality during and after the study period. Participants were informed that they could withdraw from study at any time without giving any reason.

RESULTS

A total of 64 cases were included in the study considering inclusion and exclusion criteria. Among total cases (64 cases), most of the cases (40.6%) were from more than 60 years of age. 32.8% cases were from 30-60 years of age while more than one fourth (26.6%) of cases were below 30 years of age. We found mean age of the cases was 56 years. More than half of the cases were male (62.5%) but only 37.5% were female cases in the study (Table 1).

Table 1| Age and gender distribution of the respondents (n=64).

Age (yrs)	Number	Percentage
<30	17	26.6
30-60	21	32.8
>60	26	40.6
Median age	56 years	
Gender		
Male	40	62.5
Female	24	37.5

Table 2| Side of renal mass of the respondents *(n=64)*

Kidney	Number	Percentage
Right	34	53.1
Left	28	43.8
Isthmus	1	1.6
Both	1	1.6
Total	64	100.0

Table 3| Number of cases with maintenance of renal outline (n=64)

Regional Lymphadenopathy	Number	Percentage
No	54	84.4
Yes	10	15.6
Total	64	100

Table 4|Number of cases with histopathological diagnosis *(n=64)*

Diagnosis	Number	Percentage
Angiomyolipoma	3	4.7
CP	2	3.1
Malignant Round Cell Tumor	1	1.6
Oncocytoma	3	4.7
RCC	24	37.5
RCC (clear cell type)	3	4.7
RCC (mixed cell type)	2	3.1
RCC (papillary type)	1	1.6
Renal Abscess	3	4.7
TCC	4	6.3
Wilm's Tumor	16	25
Xanthogranulomatous pyelonephritis	2	3.1
Total	64	100.1

Side of renal mass

As shown in table 2, more than half (53.1%) of the cases had right sided renal mass followed by 43.8% cases had left sided renal masses. Cases who had renal mass on both kidney and isthmus of horseshoe kidney is equal (1.6%). Among malignant mass lesions, 27 were in right kidney, 23 in left kidney and one in isthmus of a horseshoe kidney. Among benign cases, 6 were found in right kidney and 5 in left kidney. No significant difference between the laterality of malignant lesions were seen.

Size of renal mass

This study included the renal masses of maximum diameter/size ranging from 4.0 cm to 13.5 cm. Mean lesion size in the study population was 6.7 cm. Mean diameter of benign lesion was 5.6 cm and for malignant lesions mean diameter of lesion was 7.9 cm. There was significant difference between the mean diameter size of benign and malignant lesion in our study.

Number of lesions

Of total 64 cases in our study, most of the cases i.e. 93.75 % (60 cases) had a single lesion in a kidney and only 6.25% cases (4 cases) had two lesions one in each kidney. Among malignant mass, RCC had one lesion each in both kidneys. Among benign entities, one case of renal abscess had one lesion in each kidney and another one case of angiomyolipoma had one lesion in each kidney.

Solid/complex cystic

Both solid and complex cystic renal masses were included in the study. From total 64 patients, 53 had solid renal masses and 11 had complex cystic masses, of whom 13 cases (20%) had benign masses and 51 cases (80%) had malignant masses. The complex cystic tumors in all 11 cases were malignant.

Necrosis

60 cases (93.8%) of the 64 renal mass patients that were part of the study displayed necrosis, whereas 4 cases (6.3%) did not exhibit necrosis on MDCT. Of the 60 cases with necrosis, 7 had benign masses and 53 had malignant masses. Necrosis was present in every RCC, Wilm's, and TCC patient.

Calcification

In this study, 39 cases (60.9%) had calcification and 25 cases (39.1%) did not have calcification. 36 cases among all malignant cases had calcification and 3 benign cases had calcification. Malignant ones had central calcification and benign mass had peripheral calcification in our study.

Enhancement

Enhancement is one of the most significant imaging finding which is used to differentiate benign and malignant renal masses. In our study, Hounsfield Unit (HU) of renal mass was taken in unenhanced phase, corticomedullary phase (CMP), nephrographic phase (NP) and excretory phase. Mean HU in Nephrographic phase in benign masses is +56 HU and +105 HU in malignant mass. Mean difference of HU between enhanced (NP) and unenhanced phase were +12 HU and +63 HU in benign and malignant masses respectively. In RCC, the mean difference of HU between enhanced (NP) and unenhanced phase was +63 HU.

Maintenance of renal outline

Renal outline is one of the important radiological features to differentiate the focal and infiltrative types of renal masses. In this study, out of 64 cases, 50 cases (78.1%) had their renal outline not maintained and 14 cases (21.9%) had maintained renal outline. Among the cases where renal outline was not maintained were RCC and Wilm's tumor cases. Benign renal mass with not maintained renal outline were RCC. Malignant lesion with maintained renal outline were TCC.

Regional lymphadenopathy.

In this study, 10 cases (15.6%) had regional lymphadenopathy and 54 cases (84.4%) did not haveregional lymphadenopathy as shown in table 3.

Renal vein/IVC thrombus

Renal vein/IVC malignant thrombus is one of the bad prognostic factors associated with malignant renal tumors, mostly in RCC and Wilm's tumor. In our study, 25 cases (39.1%) had renal vein or IVC thrombus and 39 cases (60.9%) did not have renal vein thrombosis. The cases having renal vein or IVC thrombus were malignant renal masses of which 20 cases were of RCC and 5 cases were of Wilm's tumor**.**

Local invasion

Of 64 cases in the study, 8 cases had local invasion. All of them were malignant in pathology-5 cases of RCC and 3 cases of Wilm's tumor. In 2 cases adrenal gland was invaded, 1case of splenic invasion, 3 cases of large bowel invasion and 2 cases of posterior abdominal wall invasion was found in the study.

Distant metastasis

In this research, 9 cases out of 64 had distant metastasis whereas 55 did not have metastasis. 5 RCC cases and 4 Wilm's tumor cases were the tumors which metastasized. The organs/sites where metastasis of renal mass occurred were lungs, liver and vertebrae.

CT diagnosis

Of the total 64 cases included in the study, the MDCT diagnosis was made according to the standard imaging findings of the renal mass.

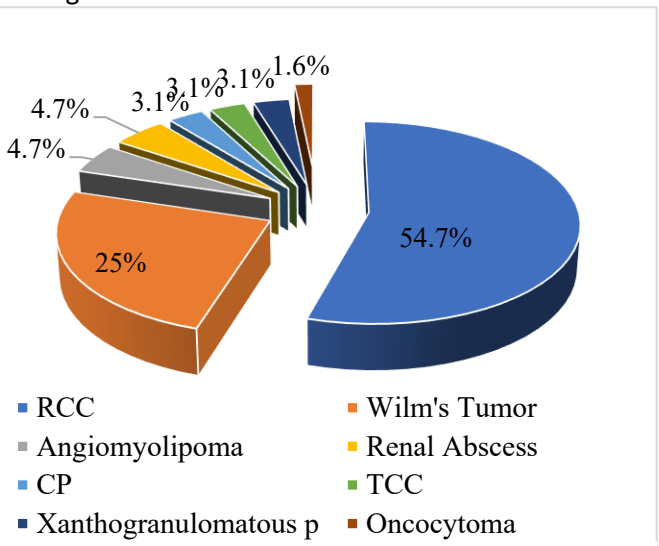

Figure 1| CT diagnosis of respondents (n=64)

As presented in figure 1, more than half (54.7%) of the cases had RCC and one fourth (25%) of cases had Wilm's tumor. The number of cases who had Angiomyolipoma and renal abscess was equal (4.7%). The same number

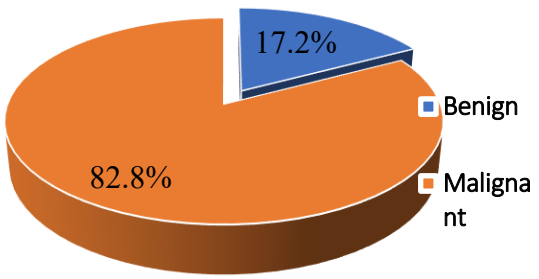

Figure 2|Benign and malignant masses from MDCT findings (n=64)

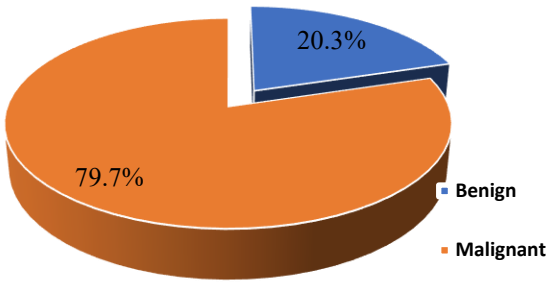

Figure-3| Benign vs malignant as Histopathological Findings (n=64)

(3.1%) of cases had chronic pyelonephritis (CP), TCC and Xanthogranulomatous Pyelonephritis. Only 1.6% of cases had oncocytoma.

Benign vs malignant as MDCT Findings

As shown in figure 2, more than three fourth (82.8%) of the cases had malignant renal mass and very few (17.2%) cases had benign renal mass according to the MDCT findings.

Histopathological Diagnosis

Histopathological analysis of 64 cases revealed the following diagnoses: RCC (n = 30), Wilm's tumor (n = 16), TCC (n = 4), malignant round cell tumor (n = 1), oncocytoma (n = 3), angiomyolipoma (n = 3), renal abscess (n = 3), chronic pyelonephritis (n = 2), and xanthogranulomatous pyelonephritis (n = 2), shown in table 4.

Benign vs malignant as Histopathological Findings

As shown in figure 3, more than three fourth (79.7%) of the cases had malignant renal mass and very few (20.30%) cases had benign renal mass according to the histopathological examination that is gold-standard for our study.

Benign/Malignant MDCT vs Histopathological Findings

After comparing MDCT diagnosis with histopathological findings in terms of benignity or malignancy of renal masses in the study, sensitivity, specificity, PPV, NPV and Accuracy of MDCT for malignant mass are 96.2%, 100%, 100%, 84.6% and 96.8% respectively. Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for benign renal mass are 84.6%, 100%, 100%, 96.2% and 96.8% respectively. For the commoner malignant renal masses like RCC and Wilm's tumor seen in this study, statistical analysis shows the following results. Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for RCC are 100%, 75%, 85.7%, 100% and 90% respectively. Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for Wilm's tumor are 100%, 100%, 100%, 100% and 100% respectively (Table 5).

Table 5| Benign/Malignant cases diagnosed from MDCT and histopathological findings (n=64)

MDCT Finding	Histopathological Finding		
	Benign	Malignant	Total
Benign	11	0	11
Malignant	2	51	53
Total	13	51	64

DISCUSSION

More than one-third (40.6%) of the total cases in this study were from the age group over 60. This finding is consistent with a study conducted in Nepal by Sidharth et al [10]. The median age of the patients was 56 years which is similar to other studies done in Nepal [13, 14]. More than half (62.5%) of the cases were male. This finding is similar to the study done by Sharmin et al. in Bangladesh [15]. Among malignant renal mass, the most common entity in adult cases i.e. RCC was seen among the age group of 60-90 yrs. Among malignant renal mass, the most common entity in children i.e.Wilm's tumor was seen among the age group of 3-4 yrs. Our findings are similar to the findings of Gudbjarston et al. who have described the incidence and distribution of renal cell cancer in a large population and have found that RCC peaks in 6th through the 8th decade and the incidence and distribution of Wilm's tumor in the mean age group of 45 months in male and 48 months in female [16]. Mean lesion size in the study population was 6.7 cm. Mean diameter of benign lesion was 5.6 cm and for malignant lesions mean diameter of lesion was 7.9 cm . There was significant difference between the mean diameter size of benign and malignant lesion. As described by Thompson RH et al that size of renal mass correlates with the malignant potential and higher grade in malignancy, our results also showed similar type of results [17]. There were 53 solid cases and 11 complex cystic cases out of 64 total, with 13 cases (20%) benign masses and 51 cases (80%) malignant masses identified. All 11 complex cystic mass cases were found to be malignant. Our findings are similar to other studies that showed majority of the solid and complex cystic

lesions were malignant [18, 19]. In this study, 10 cases (15.6%) had regional lymphadenopathy and 54 cases (84.4%) did not have regional lymphadenopathy. Generally, lymph node involvement occurs in about 15% of patients in the absence of other metastasis. CT used to be insensitive for identifying nodal metastases in nodes of normal size. There have been reports of a 10% false negative rate with a cutoff node size of 1 cm because of reactive hyperplasia [20]. The false positive rate from reactive hyperplasia was reduced to 6.3% in Catalano's study, however, as 13 of 14 real positive cases for nodal metastases were found using MDCT [21]. Currently, regional lymph node dissection is considered of no clinical benefit to patients with clinically negative lymph nodes; however, in patients with positive lymph nodes suggested preoperatively or those with progressive disease, lymph node dissection is associated with improved survival [22].

In our study, 25 cases (39.1%) had renal vein or IVC thrombus and 39 cases (60.9%) did not have renal vein thrombosis. The cases having renal vein or IVC thrombus were malignant renal masses of which 20 cases were of RCC and 5 cases were of Wilm's tumor which findings were similar to the study done by Kallman et al which proved the malignant nature of tumors with renal vein and IVC thrombi [23]. The study showed that, out of total cases (64) more than three fourth (82.8%) of the cases had malignant renal mass and very few (17.2%) cases had benign renal mass according to the MDCT findings. Our results were similar to the findings of the study carried out by Kim et al who obtained the incidences of benign tumors versus malignant tumors, renal cell carcinoma (RCC) versus non-RCC, and asymptomatic RCCs versus symptomatic RCCs and showed the MDCT accuracy for detection of renal mass [24]. The current study revealed that, more than three fourth (79.7%) of the cases had malignant renal mass and very few (20.30%) cases had benign renal mass according to the histopathological examination that is gold-standard for our study. This findings were also similar to previous studies done on renal masses [25, 26]. After comparing MDCT diagnosis with histopathological findings in terms of benignity or malignancy of renal masses in the study; sensitivity, specificity, PPV, NPV and Accuracy of MDCT for malignant mass are 96.2%, 100%, 100%, 84.6% and 96.8% respectively. Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for benign renal mass are 84.6%, 100%, 100%, 96.2% and 96.8% respectively. For the commoner malignant renal masses like RCC and Wilm's tumor seen in this study, statistical analysis shows the following results: Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for RCC are 100%, 75%, 85.7%, 100% and 90% respectively. Sensitivity, specificity, PPV, NPV and Accuracy of MDCT for Wilm's tumor are 100%, 100%, 100%, 100% and 100% respectively. These findings are consistent with those of other studies conducted by Sharmin et al., Sundeep et al., and Siddiqui et al. in Bangladesh, India, and Pakistan, respectively [15, 27, 28].

CONCLUSION

Renal cell carcinoma (RCC) was the commonest malignant tumor in the kidney. The results of the histological and MDCT diagnoses revealed that the most of the cases had malignant kidney masses. Excellent sensitivity and specificity for both benign and malignant renal tumors were demonstrated by MDCT. So, we concluded that, MDCT is useful in the evaluation of renal mass and differentiating benign and malignant mass. The MDCT findings were evaluated by single radiologist, the inter-observer variation of interpretation of findings could not assessed in this study. There were 3 patients with renal abscess, the sample examined by pathology was pus /aspirate rather than the renal tissue in contrast to the tissue samples taken in other cases. However pathological diagnosis of renal abscess was given. This study included only 64 lesions which appears to be smaller size of study population to draw a definite conclusion. So, further study in larger population is recommended for better detection and characterization of renal masses by using MDCT.

ADDITIONAL INFORMATION AND DECLARATIONS

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Declaration of conflict: None

Author Contributions: Concept and design: SD and AC, statistical analysis: AC and MG, writing of the manuscript: SD, revision and editing the manuscript: AC and MG. All the authors read and agreed with the contents of the final manuscript.

Data Availability: The data sets used and analyzed for the study are available from the corresponding author upon reasonable request.

ABBREVIATIONS:

MDCT: Multi-detected Computed Tomography
CMP: Corticomedullary Phase
CP: Chronic Pyelonephritis
IRB: Institutional Review Board
IVC: Inferior Vena Cava
NP: Nephrographic Phase
NPV: Negative Predictive Value
PPV: Positive Predictive Value
RCC: Renal Cell Carcinoma
TCC: Transitional Cell Carcinoma

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