Received:
22 August 2018

Revised:
21 September 2018

Accepted:
16 October 2018

<https://doi.org/10.1259/bjr.20180738>

Cite this article as:

Kumar P, Singh A, Deshmukh A, Phulware RH, Rastogi S, Barwad A, et al. Qualitative and quantitative CECT features for differentiating renal primitive neuroectodermal tumor from the renal cell carcinoma and its subtypes. *Br J Radiol* 2019; **91**: 20180738.

FULL PAPER

Qualitative and quantitative CECT features for differentiating renal primitive neuroectodermal tumor from the renal cell carcinoma and its subtypes

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Objective: To identify important qualitative and quantitative clinical and imaging features that could potentially differentiate renal primitiveneuroectodermal tumor (PNET) from various subtypes of renal cell carcinoma (RCC).

Methods: We retrospectively reviewed 164 patients, 143 with pathologically proven RCC and 21 with pathologically proven renal PNET. Univariate analysis of each parameter was performed. In order to differentiate renal PNET from RCC subtypes and overall RCC as a group, we generated ROC curves and determined cutoff values for mean attenuation of the lesion, mass to aorta attenuation ratio and mass to renal parenchyma attenuation ratio in the nephrographic phase.

Results: Univariate analysis revealed 11 significant parameters for differentiating renal PNET from clear cell RCC (age, $p = < 0.001$; size, $p = < 0.001$; endophytic growth pattern, $p < 0.001$; margin of lesion, $p = < 0.001$; septa within the lesion, $p = < 0.001$; renal vein invasion, $p = < 0.001$; inferior vena cava involvement, $p = 0.014$; enhancement of lesion less than the renal parenchyma, $p = 0.008$; attenuation of the lesion, $p = 0.002$; mass to aorta attenuation ratio, $p = < 0.001$; and mass to renal

parenchyma attenuation ratio, $p = < 0.001$). Univariate analysis also revealed seven significant parameters for differentiating renal PNET from papillary RCC. For differentiating renal PNET from overall RCCs as a group, when 77.3 Hounsfield unit was used as cutoff value in nephrographic phase, the sensitivity and specificity were 71.83 and 76.92 % respectively. For differentiating renal PNET from overall RCCs as a group, when 0.57 was used as cutoff for mass to aorta enhancement ratio in nephrographic phase, the sensitivity and specificity were 80.28 and 84.62 % respectively.

Conclusion: Specific qualitative and quantitative features can potentially differentiate renal PNET from various subtypes of RCC.

Advances in knowledge: The study underscores the utility of combined demographic and CT findings to potentially differentiate renal PNET from the much commoner renal neoplasm, i.e. RCC. It has management implications as if RCC is suspected, surgeons proceed with resection without need for confirmatory biopsy. On the contrary, a suspected renal PNET should proceed with biopsy followed by chemoradiotherapy, thus obviating the unnecessary morbidity and mortality.

INTRODUCTION

Primitive neuroectodermal tumor (PNET) is also known as Ewing's sarcoma of bone. Extrasosseus/extraskeletal Ewing's sarcoma is a rare, highly aggressive small round cell tumor of neural crest origin, commonly encountered in young adults and children.¹ Initially, extrasosseus Ewing's sarcoma was regarded as a distinct clinical entity, separate from Ewing's sarcoma of the bone. Now, it is recognized that they also exhibit the same balanced translocation (11;

22) (q24; q12) and are hence reclassified as Ewing's sarcoma family of tumors (ESFT).² PNETs arising from the kidney is a rare entity and account for less than 1% of all pediatric renal neoplasms, due to which limited literature about this entity is available.^{2,3} Historically, renal neoplasms have been treated with either partial or complete nephrectomy. The pre-operative diagnosis of the renal PNET is crucial because they usually present in the advanced stage with metastatic disease due to their aggressive nature, and thus

carry dismal prognosis as compared to the renal cell carcinoma (RCC).^{4–6} The management of renal PNET is multidisciplinary, comprising of surgery, chemotherapy and radiotherapy.⁷ Recent studies have shown that neo-adjuvant chemotherapy for ESFT could improve the rates of surgical local control and possibly, negate the recommendation for adjuvant radiotherapy, which is often reserved for patients with positive surgical margins.⁸

To the best of our knowledge, there is no study available in literature that compares the imaging features of renal PNET and RCC. The purpose of this study was to identify the important clinical and contrast-enhanced CT imaging features that can potentially be used to differentiate renal PNET from the various subtypes of RCC.

METHODS AND MATERIALS

Patient selection

The institute ethics committee approved our retrospective study and patients' consent was waived-off due to retrospective nature of the study. We reviewed the data of 143 patients with pathologically proven RCC and 21 cases of renal PNET admitted to our institute over a 6 year period from January 1, 2011 to December 31, 2017. Of these 143 RCC cases, 14 patients had bilateral RCC (diagnosed to have Von Hippel-Lindau and Birt-Hogg-Dube syndromes). We could not acquire pre-op images in 58 RCC patients and 2 renal PNET patients since they were scanned outside All India Institute of Medical Sciences and images could not be procured for analysis. Thus, 71 patients having RCC (47

male and 24 female) and 19 patients having renal PNET (11 male and 8 female) were included in the study. Among the 71 patients with RCC, 59 patients had clear cell RCC, 9 had papillary RCC and 3 had chromophobe RCC [Figure 1](#). Out of the 19 patients with renal PNET who were included for analysis, quantitative analysis was performed only in 13 patients as 6 patients underwent imaging outside All India Institute of Medical Sciences and these cases were excluded from quantitative analysis.

CT examination

The CT examinations were performed using a helical multislice CT scanner, either on a 64-slice single source MDCT-scanner Somatom definition AS (Siemens AG, Germany) or on a 256-slice dual source MDCT-scanner Somatom Definition Flash (Siemens AG, Germany). CT scans were obtained during patient breath-holding with the following parameters for imaging acquisition and reconstruction. Protocol for 64-slice single source MDCT-scanner: enhanced 1.5 mm image with increment of 1.0 mm, pitch:1.0 and rotation time : 0.5 s. The thickness of the sagittal and coronal reformation was 5 mm. Protocol for 256-slice dual source MDCT-scanner: enhanced 1.5 mm image with increment: 1.5 mm, pitch: 0.6 and rotation time : 0.5 s. The thickness of the sagittal and coronal reformation was 5 mm. All patients received 1000 ml of water orally, 30 min before the CT acquisition, and 70–100 ml of i.v. contrast agent (iohexol 300 mg ml⁻¹). i.v. contrast material was injected with the help of a mechanical injector at the rate of 4 ml s⁻¹. 62 RCC patients underwent multiphasic CT, which included corticomedullary, nephrographic

Figure 1. Algorithm showing distribution of the patients with renal mass in the study. HPE, histopathology examination; PNET, primitive neuro ectodermal tumor; RCC, renal cell carcinoma.

Table 1. Patient and renal mass lesion characteristics

Parameter	Renal PNET (19)	Clear cell RCC (59)	p-value	Papillary RCC (9)	p-value	Overall RCC (71)	P value
Age (in years)	24.2 ± 7.55	56.2 ± 11.5	<0.001 ^a	51.66 ± 12.8	<0.001 ^a	55.6 ± 12.2	<0.001 ^a
Male sex	11	41	0.351 ^b	6	1.0 ^c	47	0.502 ^b
Left laterality	9	27	0.9 ^b	7	0.223 ^c	34	0.968 ^b
Size (in cm)	13.76 ± 5.335	7.39 ± 3.34	<0.001 ^a	8.2 ± 3.77	0.0073^a	7.4 ± 3.35	<0.001 ^a
Exophytic lesion	03	43	<0.001 ^c	6	0.013^c	49	<0.001 ^c
Margin of the lesion	Circumscribed = 12 Indistinct = 7	Circumscribed = 56 Indistinct = 3	<0.001 ^b	Circumscribed = 8 Indistinct = 1	0.2 ^c	Circumscribed = 67 Indistinct = 4	<0.001 ^b
Septae with in the lesion	16	11	<0.001 ^c	02	0.003^c	13	<0.001 ^c
Necrotic component present with in the lesion	19	54	0.327 ^c	08	0.32 ^c	64	0.338 ^c
% Necrotic component with in the lesion (>30%)	13	36	0.561 ^b	06	1.0 ^c	43	0.530 ^b
Calcification with in the lesion	01	10	0.278 ^c	00	1.0 ^c	11	0.448 ^c
Renal vein involvement	17	17	<0.001 ^c	02	0.001^c	19	<0.001 ^c
IVC involvement	8	9	0.014^b	0	0.029^c	9	0.004^b
Presence of retroperitoneal nodes	5	15	1.0 ^b	3	1.0 ^c	18	0.984 ^b
Metastatic lesion in the lung	07	22	0.982 ^b	02	0.66 ^c	24	0.746 ^c
Metastatic lesion in the bone	01	9	0.436 ^c	1.0	1.0 ^b	10	0.446 ^c
Homogenous enhancement	01	03	0.578 ^c	01	1.0 ^c	05	0.449 ^c
Enhancement of lesion less then renal parenchyma	19	43	0.008^c	08	0.321 ^c	54	0.018^c
Attenuation of the lesion	72.0 ± 15.5	103 ± 31.3	0.0002^a	69.7 ± 30.0	0.7134 ^a	97.75 ± 32.9	0.0018^a
Mass/aorta attenuation ratio	0.432 ± 0.116	0.7669 ± 0.160	<0.001 ^a	0.512 ± 0.183	0.27 ^a	0.726 ± 0.184	<0.001 ^a
Mass/renal parenchyma attenuation ratio	0.460 ± 0.145	0.741 ± 0.185	<0.001 ^a	0.4896 ± 0.160	0.173 ^a	0.700 ± 0.20	0.0001^a
Presence of perinephric stranding	16	39	0.159 ^c	05	0.165 ^c	45	0.103 ^c
Presence of parasitic vessels	17	40	0.079 ^c	08	1.0 ^c	49	0.086 ^c

IVC, inferior vena cava; PNET, primitive neuroectodermal tumor; RCC, renal cell carcinoma;

^aMann-Whitney test.^bPearson χ^2 test.^cFisher exact test.

Figure 2. 14-year-old male with renal PNET. (A) Coronal CT scan nephrographic phase image showing heterogeneously hypoenhancing shaped endophytic infiltrating mass lesion involving the right kidney. Diameter of mass is 14 cm. (B) Axial contrast-enhanced CT scan images showing necrosis and septation within the lesion (white arrows). (C) Coronal contrast-enhanced CT scan images showing contiguous extension of the mass lesion in the right renal vein and in the IVC (black arrows). Attenuation of the lesion in nephrographic phase was 73.6 h. Mass/ aorta ratio was 0.4 and Mass/ renal cortex ratio was 0.6. IVC, inferior vena cava; PNET, primitive neuroectodermal tumor; RCC, renal cell carcinoma.

and excretory phase scanning. The other nine patients underwent monophasic CT that included nephrographic phase only. Similarly, among the patients with renal PNET nine underwent multiphasic CT and four of those underwent monophasic CT.

Image analysis

Two experienced radiologists (SC, AS) with 10 and 5 years of experience in reporting who were not aware of the pathologic results analyzed the radiological findings. They reviewed the nephrographic phase (*i.e.* scan acquired after the delay of at least 80 s post-contrast injection) images of the patients at the picture archiving and communication system workstation (SyngoVia; Siemens AG, Germany). The following imaging features were analyzed and recorded for each patient by consensus-side (right or left) of the lesion, size (largest diameter of tumor), tumor morphology (predominantly exophytic or endophytic) and margin of the lesion. We categorized margin of the lesions into two types: circumscribed and infiltrative.

The pattern of enhancement of the mass lesion was categorized into homogeneous and heterogeneous. The degree of enhancement was categorized into either less than, equal to or more than renal parenchyma. To measure the attenuation, the radiologists selected three

regions of interest for each lesion and recorded the mean value. Each region of interest was more than 1 cm² in size and placed over the most enhancing solid area in the nephrographic phase. The attenuation of the aortic lumen at the level of origin of the ipsilateral renal artery and attenuation of the ipsilateral renal parenchyma (contralateral renal parenchyma in cases where the renal parenchyma was completely replaced by the tumor) was also noted.

We assessed the presence of the septa and necrosis within the lesion and we graded the necrotic component within the tumor into the two categories: whether less or more than 30% of the whole tumor, by subjective assessment. The following other parameters were assessed: presence of calcification within the mass lesion, extent of venous thrombosis, nodal spread (renal hilar, para-aortic, and paracaval lymph nodes measuring >1 cm in the short-axis diameter were considered metastatic), perinephric change (evidence of strands of soft-tissue attenuation or parasitized vessels in the perinephric area), distant metastases in lungs and bones.

Statistical analysis

Statistical analysis was performed for identifying clinical and imaging features that could potentially be used to differentiate

between renal PNET, RCC subtypes (clear cell and papillary) and overall RCCs. We compared the values for each parameter using the χ^2 test and Fisher exact test for categorical variables, and Mann–Whitney test for continuous variables. *p*-value less than 0.05 was considered significant. We performed all analyses with the help of STATA/SE v. 14.2 (STATA Corp LP, College Station, TX) software. To evaluate the diagnostic validity of the mass to aorta Hounsfield unit (HU) ratio, mass to renal parenchyma HU ratio and mean HU of the lesion in differentiating these masses, we generated and analyzed receiver operating characteristic (ROC) curves to determine the cutoff value with highest accuracy.

RESULTS

In our study, 143 patients with RCC and 21 patients with renal PNET underwent surgical treatment. The study sample included 71 patients with RCC and 19 with renal PNET. The subtypes of RCC were: clear cell in 59 (83.09%) papillary in 9 (12.67%) and chromophobe in 3 (4.2%). Table 1 summarizes the results of the univariate analysis comparing the clinical and imaging parameters between renal PNET, the two RCC subtypes viz. clear cell and papillary (chromophobe RCC was not analyzed

separately due to small number of patients), and all RCCs as a whole.

Age and sex

The renal PNET group had a significantly younger age compared with the clear-cell RCC group, papillary RCC group and all RCC group ($p = < 0.001$). The mean age with range was 24.2 ± 7.55 years (12–37 years) for renal PNET, 56.2 ± 11.5 years (28–73 years) for clear cell RCC, 51.66 ± 12.8 years (34–70 years) for papillary RCC and 55.6 ± 12.2 years (27–75 years) for overall RCCs. There was no significant difference between the groups among both genders.

Morphologic CT image parameters

The mean tumor size was 13.76 ± 5.335 cm (range, 6–23.2 cm) for renal PNETs, 7.39 ± 3.34 cm (range, 2–14 cm) for clear cell RCCs, 8.2 ± 3.77 cm (range, 3–115.3 cm) for papillary RCCs and 7.4 ± 3.35 cm (range, 2–15.4 cm) for overall RCCs.⁹ Compared with clear cell RCCs, the following features were significantly more common in renal PNETs: endophytic location (84.2 vs 27.11%, $p < 0.001$), indistinct margins (36.84 vs 5.08%, $p < 0.001$) (Figures 2a–5a), septa within the lesion (84.2 vs 18.64%, $p <$

Figure 3. 24-year-old female with renal PNET. (A) Coronal CT scan nephrographic phase image showing heterogeneously hypoenhancing bean shaped endophytic infiltrating mass lesion involving the right kidney. Diameter of mass is 16 cm. (B) Axial contrast-enhanced CT scan images showing necrosis and septation within the lesion (white arrows). (C) Coronal contrast-enhanced CT scan images showing left renal vein and in the IVC are not involved by the mass lesion (black arrows). Attenuation of the lesion in nephrographic phase was 81.3 h. Mass/ aorta ratio was 0.3 and Mass/ renal cortex ratio was 0.27. IVC, inferior vena cava; PNET, primitive neuroectodermal tumor.

Figure 4. 22-year-old female with renal PNET. (A) Coronal CT scan nephrographic phase image showing heterogeneously hypoenhancing bean shaped endophytic infiltrating mass lesion involving the right kidney. Diameter of mass is 19.3 cm. (B) Axial contrast-enhanced CT scan images showing necrosis and septation within the lesion (white arrows). (C) Coronal contrast-enhanced CT scan images showing contiguous extension of the mass lesion in the right renal vein and in the IVC (black arrows). Attenuation of the lesion in nephrographic phase was 56.0 h. Mass/ aorta ratio was 0.509 and Mass/ renal cortex ratio was 0.533. IVC, inferior vena cava; PNET, primitive neuroectodermal tumor; RCC, renal cell carcinoma.

Figure 5. 62-year-old female with conventional (clear cell) renal carcinoma. (A, B) Coronal and axial contrast-enhanced CT scan nephrographic phase images showing heterogeneously hyperenhancing exophytic circumscribed mass lesion arising from the upper pole of the left kidney (black arrows). Few necrotic areas are also seen within the lesion. Diameter of mass is 6.5 cm. Left renal vein and IVC are not involved by the lesion (not shown in the figure). Attenuation of the lesion in nephrographic phase was 197.6 h. Mass/ aorta ratio was 0.88 and mass/ renal cortex ratio was 0.8233.

Figure 6. 40-year-old male with papillary renal carcinoma. (A, B) Coronal and axial contrast-enhanced CT scan nephrographic phase images showing heterogeneously hypoenhancing exophytic circumscribed mass lesion arising from the interpolar region of the left kidney. Lesion is predominantly necrotic and have enhancing component in the periphery (white arrows). Diameter of mass is 8 cm. Left renal vein and IVC are not involved by the lesion (not shown in the figure). Attenuation of the lesion in nephrographic phase was 47 h. Mass/ aorta ratio was 0.57 and Mass/ renal cortex ratio was 0.465. IVC, inferior vena cava.

0.001) (Figures 2b–5b), vascular invasion in the form of tumor thrombus extension into the renal vein and inferior vena cava (IVC) ($p < 0.001$ and $p = 0.014$ respectively) and lesser degree of contrast enhancement ($p < 0.008$) (Figures 2c–4c). There was no statistically significant difference noted between the renal PNET and the clear cell RCC for the presence of necrosis, calcification, retroperitoneal nodes, metastatic lesions in the lung, bones and perinephric changes.

Compared with the papillary RCCs, the following features were significantly more in renal PNETs: endophytic location (84.2 vs 33.33%, $p < 0.013$) (Figures 2A–4A and 6A), septa (84.2 vs 22.22%, $p < 0.003$) (Figures 2B and 3B), vascular invasion in the form of tumor thrombus extension into the renal vein and IVC ($p = 0.001$ and $p = 0.029$ respectively) (Figures 2C and 3C). There was no significant difference noted between renal PNETs and papillary RCCs for appearance of margin of the lesion, presence of necrosis, calcification, retroperitoneal nodes, metastatic lesions in the lung, bones, perinephric changes and the degree of enhancement.

Compared with overall RCCs, the following features were significantly more in renal PNETs: endophytic location (84.2 vs 30.98%, $p < 0.001$), indistinct margins (36.84 vs 5.63%, $p < 0.001$), septa within the lesion were 84.2 vs 18.30%, $p < 0.001$, vascular invasion in the form of tumor thrombus extension into the renal vein and IVC ($p < 0.001$ and $p = 0.004$ respectively) and lesser degree of enhancement ($p < 0.018$). There was no significant difference between the renal PNETs and the RCCs for presence of necrosis, calcification, retroperitoneal nodes, metastatic lesions in the lung, bones and perinephric changes.

Quantitative contrast enhancement characteristics
All quantitative measurements were done in the nephrographic phase. The mean HU of renal PNETs (72.0 ± 15.5 HU) was significantly lower than clear cell RCCs (103 ± 31.3 HU, $p = 0.0002$) and overall RCCs (97.75 ± 32.9 h, $p = 0.0018$) (Figures 2B–5B).

There was no significant difference between renal PNETs and papillary RCCs for the HU of the lesion, $p = 0.713$ (Figures 2B and 6B). The mass to the aorta enhancement ratio in the renal PNETs was 0.432 ± 0.116 , which was significantly lower than the clear cell RCCs (0.7669 ± 0.160 , $p < 0.001$) and overall RCCs (0.726 ± 0.184 , $p < 0.001$). There was no significant difference between the renal PNET and papillary RCC group for mass to aorta enhancement ratio ($p = 0.27$). The mass to renal parenchyma ratio in renal PNETs was 0.460 ± 0.145 which was significantly lower than the clear cell RCCs (0.741 ± 0.185 , $p < 0.001$) and overall RCCs (0.700 ± 0.20 , $p = 0.0001$).

The ROC curves for the mass to aorta enhancement ratio, for the mass to renal parenchyma enhancement ratio and attenuation of the lesion enhancement in differentiating renal PNET and clear cell RCC group are illustrated in Figure 7 (A–C). The area under the curve (Az value) for the attenuation of the lesion enhancement was 0.8344. In the ROC analysis, the cut-off value was 77.3 HU with the sensitivity 79.366% and specificity 76.92% (Figure 7A). The area under the curve (Az value) for the mass to aorta enhancement ratio was 0.9557. In the ROC curve analysis, the cut-off value was 0.595 with the sensitivity 88.14% and specificity 92.31% (Figure 7B). The area under the curve (Az value) for the mass to renal parenchyma enhancement ratio was 0.9035. In the ROC curve analysis, the cutoff value was 0.537 with the sensitivity 91.53% and specificity 84.62% (Figure 7C).

The ROC curves for the mass to aorta enhancement ratio, for the mass to renal parenchyma enhancement ratio and attenuation of the lesion enhancement in differentiating renal PNET and overall RCC group are illustrated in Figure 8 (A–C). The area under the curve (Az value) for the attenuation of the lesion enhancement was 0.8483. In the ROC curve analysis, the cutoff value was 77.3 HU with the sensitivity 71.83% and specificity 76.92% (Figure 8A). The area under the curve (Az value) for the mass to aorta enhancement ratio was 0.90. In the ROC curve

Figure 7. Graphs show ROC curves for differentiation of renal PNET from clear cell RCC on the basis of mean attenuation of the mass lesion (A), mass to aorta attenuation ratio (B) and mass to renal parenchyma attenuation ratio (C). PNET, primitive neuroectodermal tumor; RCC, renal cell carcinoma; ROC, receiver operating characteristic.

analysis, the cutoff value was 0.57 with the sensitivity 80.28% and specificity 84.62% (Figure 8B). The area under the curve (Az value) for the mass to renal parenchyma enhancement ratio was 0.773. In the ROC curve analysis, the cutoff value was 0.537 with the sensitivity 80.28% and specificity 84.62% (Figure 8C).

DISCUSSION

Most of the renal PNET patients present in the second to third decade of life.^{5,10} This is in concordance with our study in which the mean age of the renal PNET patient was 24.2 ± 7.55 years. On the other hand, patients with RCC are usually older as evident in our study (mean age 55.6 ± 12.2 years). There is also slight male preponderance as described in the previous studies, which is also noted in our study.^{5,11} However, no significant difference is noted for male preponderance between the renal PNETs and RCCs. The most common presenting symptoms in renal PNETs are abdominal pain, abdominal distension, palpable mass and hematuria.¹²

Morphologic characteristics

Renal PNET patients usually have advanced and bulky disease at initial presentation as evident in our study (mean size 13.76 ± 5.335 cm) as compared to the clear cell RCCs and overall RCCs (mean size 7.39 ± 3.34 cm and 7.4 ± 3.35 respectively). This finding is similar to the study by Murgan et al and Rowe et al in

which the median size of the renal PNET masses was 11 and 12 cm respectively.^{2,5,13} This may be attributed to the delay in the diagnosis and aggressive nature of the renal PNET that leads to unhindered tumor growth in the retroperitoneum.²

In our study, renal PNETs most commonly presented as an infiltrative endophytic mass, while RCCs presented as an exophytic mass with circumscribed margins. This difference in the morphologic appearance is statistically significant and similar observations were also reported in the previous studies.¹⁴ One of the most important finding in our study was the presence of multiple irregular septae in the renal PNET lesions. Out of 19 renal PNET lesions, septae were present in 16 (84.2%) patients; in contrast, only 13 (18.30%) out of 71 RCC lesions had septae. In the RCC lesions that did have septae, the septations were present in the necrotic portion; however, in the renal PNET lesions, these septae were present in the necrotic as well as in the solid portion of the lesions. This finding is similar to the study by Wu et al and Lee et al.^{11,15}

As reported in the previous studies, renal PNET shows aggressive behavior in the form of vascular invasion, which is confirmed in our study. In our study, contiguous extension of the tumor in the renal vein is noted in 89.4% and in the IVC is noted in the 42.1% of the renal PNET patients. In contrast, in all RCC lesions, tumoral extension in the renal vein is present in 26.7% and into

Figure 8. Graphs show ROC curves for differentiation of renal PNET from all RCC on the basis of mean attenuation of the mass lesion (A), mass to aorta attenuation ratio (B) and mass to renal parenchyma attenuation ratio (C). PNET, primitive neuroectodermal tumor; RCC, renal cell carcinoma; ROC, receiver operating characteristic.

the IVC in 12.6% of patients, which is statistically significant.^{11,16} With regards to the local infiltration of the tumor in the form of peri-nephric stranding and parasitic vessels, there is no significant difference, suggesting that renal PNET and all RCC have local aggressive infiltrating behavior.

Contrast enhancement characteristics

The present study shows that contrast enhancement characteristics of the lesion viz. attenuation of the lesion, mass/aorta enhancement ratio and mass/renal parenchyma enhancement ratio in the nephrographic phase could be very useful quantitative parameters in differentiating renal PNET from overall RCCs (A_z values > 0.8483, 0.90 and 0.773 respectively) and clear cell RCCs (A_z values > 0.8344, 0.9557 and 0.9035 respectively). These findings are similar to other studies, which showed that conventional/ clear cell RCCs show strong enhancement than non-conventional RCCs.¹⁷ Clear cell RCCs show hyperenhancement likely due to the presence of rich vascular network and alveolar architecture.¹⁸ To the best of our knowledge, this is the first study presenting the data for the differentiation of renal PNET from RCC with the help of above-mentioned quantitative parameters. However, these quantitative enhancement parameters may not be very useful for differentiating renal PNET from the papillary RCC as the latter are usually hypovascular and show mild enhancement. Nevertheless, a combination of the qualitative

characteristics may be helpful in differentiating renal PNET from the papillary RCC. For example, hypoenhancing bulky tumor in a young patient having endophytic growth pattern with vascular involvement is strongly suggestive of renal PNET over papillary RCC. For the patients with surgically treatable RCC, nephrectomy is the standard of the treatment. However, renal PNETs usually require multimodality treatment including surgery, chemotherapy and radiotherapy because of its highly aggressive nature with early stage metastasis and higher tendency for local recurrence.

There are several limitations to this study. Small number of PNET cases may not accurately reflect the full imaging spectrum of renal PNET. Therefore, further studies with a larger number of patients will be necessary in the future to support our results. Attenuation values were measured only in the nephrographic phase and comparison with attenuation value in the unenhanced phase and in the corticomedullary phase was not done. Average size of the papillary and clear cell RCCs in our study was quite large (7.4 and 8.2 cm respectively) relative to other series in the literature.¹⁹ This may reflect a bias in the nature of patients referred to a cancer center.

CONCLUSION

Renal PNET is a rare neoplasm of neural crest origin occurring in young adults. It has a very aggressive clinical course with poor survival. Therefore, in a young patient presenting with large bulky necrotic, hypoenhancing tumor showing endophytic growth pattern with internal septae, renal PNETs should be considered in the differential diagnosis. Quantitative parameters

like mean attenuation of the lesion, mass to aorta and mass to renal parenchyma attenuation ratio in the nephrographic phase can be used as adjunct parameters for the radiological diagnosis. A pre-operative biopsy with immunohistochemistry and cytogenetic analysis should be done so that neo-adjuvant therapy can be given in the timely fashion which may result in the improve survival of these patients.

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