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ORIGINAL ARTICLE

Correlation between Renal Tumor Nephrometry Score and Tumor Morphological Characteristics: How Can It Help Surgeons to Choose the Type of Partial Nephrectomy?

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ABSTRACT

Background: Low complexity renal tumors would be good indications for partial laparoscopic nephrectomy (PLN) while partial open nephrectomy (PON) or even radical nephrectomy is indicated for higher grades. Many factors are associated with tumor complexity including tumor size, nearness to the sinus, endophyticity, polar location, inside description and hilar designation. This study aimed to investigate the potential value of nephrometry score as well as the solid renal masses morphology that help the urologist to decide the type of partial nephrectomy. **Methods:** All patients had initial ultrasound examination that demonstrated renal mass suspicious of RCC. All patients underwent CT with contrast for staging. **Results**: Current prospective study included 40 patients according to the inclusion/exclusion criterion of the study. Postoperative histopathological examination revealed renal cell carcinoma (RCC) in 36 patients; 26 patients had papillary RCC and 10 cases had clear cell RCCs, angiomyolipoma in was present in one case, and oncocytoma was found in 3 patients. Males (33 patients) were affected more than females (7 patients), and left side (24 patients) were affected more than the right side (16 patients). Significant statistical differences were noted regarding the tumor size, tumor endophyticity, tumor distance from the renal sinus, and R.E.N.A.L. nephrometry score in partial laparoscopic nephrectomy vs open partial nephrectomy patient groups. The R.E.N.A.L mean score was 6.3± 1.4 for PLN and 8.1± 1.9 for partial open nephrectomy groups. **Conclusion**: R.E.N.A.L nephrometry score, tumor size, endophyticity and distance from the sinus are important factors that affect surgical decision-making regarding laparoscopic or open partial nephrectomy.

Key words: R.E.N.A.L nephrometry score; Partial nephrectomy; Renal cell carcinoma.

INTRODUCTION

Renal cell carcinoma is a common malignant tumor showing high mortality rate [1]. Low complexity renal tumors would be good indications for partial laparoscopic nephrectomy (PLN) while partial open nephrectomy (PON) or radical nephrectomy is indicated for higher grades. Many factors are associated with tumor complexity including tumor size, nearness to the sinus, endophyticity, polar location, inside description and hilar designation [2,3].

The predictive role of post nephrectomy surgical outcomes carried out by the preoperative aspects and dimensions used for anatomic (PADUA) [4], centrality index (C-index) [5] and the R.E.N.A.L nephrometry scoring systems [3] had been evaluated, yet there are few reports regarding their comparative dominance. These scores aimed to predict surgical outcomes so they may have potential role to affect surgical treatment selection. PADUA and the R.E.N.A.L nephrometry scoring systems involve comparable constituents and methodology. They offer an inclusive report of the tumor size, intimacy to the renal collecting system, polar locations, and posterior or anterior locations and each component is assigned a score. The centrality index (C-Index)

score measures and illustrates renal mass centrality depending on the ratio of the distance between kidney center and the tumor as well as the tumor radius [6].

The Nephrometry score based on imaging modalities (CT or MRI) frequently utilized by Urology surgeons to systematize solid renal masses reporting by allowing quantification of anatomical features [3,7]. The nephrometry score correlate with operative complication rates, operative ischemic period, postoperative outcomes and show a significant role in surgery planning [8–11].

This study aimed to investigate the potential value of nephrometry score as well as the solid renal masses morphology that help the Urologist to decide the type of partial nephrectomy.

METHODS

This prospective study included 40 consecutive patients (33 males and 7 females), who underwent laparoscopic (8 patients), open partial nephrectomy (32 patients), the age range of the patients was 40 to 80 years, the mean age for laparoscopic partial nephrectomy group was 54.1 ± 9.3 years and was 64.36 ±12.3 for open partial nephrectomy group. This study was conducted between Jan 2018 to Dec 2019. Written informed consents were obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

All patients were referred from Urology Department after initial ultrasound examination that demonstrated renal mass suspicious of RCC. All patients performed CT with contrast for staging according to the inclusion criteria that included adult patients with initial ultrasound examination that demonstrated renal mass suspicious of RCC. Exclusion criteria of the study were renal impairment, allergy to contrast medium, solitary kidney, multiple tumors, previous partial open or laproscopic nephrectomy. Consequently, a total of 40 patients were selected and underwent CT then surgery within 7 days after CT.

All patients were subjected to contrast enhance CT study using 16 slice multi-detector CT scanner (Somatom Balance, Siemens Medical Solutions) machine. The exam included: non-contrast, arterial, venous and delayed phases at scan delay about 30, 60 and 300 seconds respectively following automatic intravenous injection of non-ionic (Iopromide 350 mg/ml) contrast medium injected automatically through 18-gauge IV antecubital line at a rate of 3–4 ml/s and the contrast dose about (1 ml/kg).

Image parameter: slice thickness = 0.5 mm, kV/mAs = 120/350, collimation = 0.625-mm, 1.4 pitch, scan was done from the diaphragmatic dome to symphysis pubis

Images were then reconstructed at 2.5 mm thickness and reformatted on a dedicated workstation to have coronal, sagittal and oblique multi-planar reformatted images (MPR).

Image interpretation:

Analysis of the source and reformatted images was done by three experienced radiologists with more than 10 years' experience in abdominal imaging on dedicated workstation. The aim was evaluate the characteristic tumor morphology that influences the surgeon's choice of surgery. In case of mismatch in the CT findings, conjoint reading was held between the 3 radiologists and solved in consensus.

CT images were assessed for:

- R.E.N.A.L nephrometry score with stratification into mild, moderate and high complexity summarized in table 1 [3].
- Adhesions to surroundings.
- Endophyticity (length from the tumor bottom to the renal surface in mm).
- Distance in (mm) from the deepest tumor portion to the renal sinus.
- Distance between tumor's nearest edge to the equatorial kidney plane, tumor's polar position, internal description (for tumors located inside the kidney), hilar designation (applied for renal tumors in contact with the vessels of the kidney).
- Regarding R.E.N.A.L nephrometry score assessment; Radius of the tumor was measured in any plane (axial, coronal, sagittal or oblique) to measure the tumor maximum diameter. The exophytic/endophytic tumor location was assessed better in axial plane. Nearness of the tumor to the renal collecting system was assessed better in delayed images in coronal or oblique planes. Anterior or posterior location of the tumor was better assessed in the axial plane. Location relative to the renal poles was better assessed in coronal plane. The suffix (h) to check if the mass touches the main renal artery or vein was assessed in arterial and venous phases."
- Then a panel of urological surgeon and the radiologists reviewed the CT findings. R.E.N.A.L score below 7, endophyticity (up to 16 mm) and renal sinus distance (up to 4 mm) were the top upper values to decide PLN in the current study.
- Surgical planning was determined depending on CT findings before the surgery and the clinical data of

the patient. Correlation between imaging features and results of surgery were done. Post-operative histopathological examination done to all patients.

Statistical Analysis

- Data collection, tabulation and statistical analysis of the study data was done using the Statistical Package for the Social Sciences (SPSS) Version 21. Current study also performed descriptive statistics in the form of number and percentage for qualitative data. Sensitivity, specificity and accuracy were also calculated.

RESULTS

Forty selected patients were included in the current prospective study. Successful removal of renal masses was done to all patients without major perioperative complications. Postoperative hemorrhage occurred in 1 patient, and was conservatively managed; 1 patient showed urine leakage postoperatively and was managed by stenting. Both complications occurred in open partial nephrectomy.

Histopathological examination of the renal mass was done postoperatively. It revealed renal cell carcinoma in 36 (26 patients were papillary RCC and 10 were clear cell RCCs), angiomyolipoma in 1, and oncocytoma in 3 patients.

Males (33 patients) were affected more than females (7 patients), and left side (24 patients) were affected more than the right side (16 patients). Significant statistical differences were seen regarding the tumor size, tumor endophyticity, tumor distance from the renal sinus, and R.E.N.A.L. score noted between the partial laparoscopic nephrectomy, and partial open nephrectomy groups [table 2].

R.E.N.A.L score complexity stratifications in the current study group revealed that low complexity was found in 8 patients [figure 1], moderate complexity in 20 patients [figure 2] and high complexity in 12 patients [figures 3-4]. All patients with low complexity underwent PLN while those with moderate and high complexity underwent open partial nephrectomy [table 3].

The R.E.N.A.L mean score was 6.3± 1.4 for PLN and was 8.1± 1.9 for open nephrectomy groups. Among R.E.N.A.L score, regarding the tumor Radius, score 1 was the most common, found in 26 patients, Exophytic/Endophytic score 1 was found in 24 patients, Nearness to collecting system/sinus score 1 was found in 25 patients, Anterior/Posterior tumor's location each was reported in 15 patients while 10 patients were polar. Location relative to polar lines; score 1 was found in 24 patients and ''h'' score was found in 2 patients as the tumor was touching the renal artery (figure 3), [table 4].

Statical analysis revealed that the size of the tumor, tumor endophyticity, tumor distance from the renal sinus, and R.E.N.A.L. score were determinants of surgery type selection (table 2). Masses with fewer endophyticity, masses situated away from the renal sinus as well as those with R.E.N.A.L low score were more often chosen to undergo PLN than open partial nephrectomy.

Table 1: R.E.N.A.L. nephrometry score of solid renal tumors.

Component	1 point	2 points	3 points
Radius (max. in cm)	⩽4	>4 but <7	⩾7
Exophytic/endophytic	⩾50% exophytic	< 50% exophytic	100% endophytic
Nearness to collecting system or the renal sinus measured in mm as the shortest distance from the deepest point of the tumor	⩾7	>4 but <7	⩽4
Anterior/posterior location. Assessed on the axial view, no points are allocated	Tumor location assigned a letter added at the end of the score; ''A'' for anterior tumor to the renal sinus, ''P'' posterior, and ''X'' if neither.		
Location relative to the polar lines ''h'' assigned as a suffix if the tumor touches the main renal vein or artery	Entirely above upper polar (UPL) or below lower polar lines (LPL)	The tumor crosses polar lines	>50% of the tumor is across the polar line, mass completely between polar lines, or crosses the renal axial midline (RAM)

Nephrometry score grading: score of 4-6: low complexity, score of 7-9: moderate complexity and score of 10-12: high complexity. Polar lines describe two parallel lines tangential to the upper and lower renal cortical lips at the renal hilum

Table 2: Study group patients' characteristics

	PLN (8 patients)	PON (32 patients)	P value
Gender (M/F)	6/2	27/5	0.372
Laterality (R/L)	4/4	12/20	0.787
Mean age (years)	54.1± 9.3	64.36 ±12.3	0.256
Mean RENAL score	6.3± 1.4	8.1± 1.9	<0.001
Mean size (mm)	22.3± 5.1	30.1± 8.4	0.001
Adhesions to surroundings	0/8	10/32	0.787
Mean endophyticity (mm)	14.5 ± 4.3	22.1± 5.2	<0.001
Mean distance in (mm) from the renal sinus	7.5 ± 6.1	2.7 ± 7.1	<0.001

Table 3: RENAL complexity stratifications in the study group patients

	PLN	PON
Low complexity (4-6 points)	8	--
Moderate complexity (7-9 points)	--	20
High complexity (>9 points)	--	12
Total	8	32

Table 4: Correlation between RENAL score and choice of surgical approach

RENAL score points	PLN (8 patients)	PON (32 patients)
R		
1	8	18
2	--	2
3	--	12
E		
1	7	17
2	1	3
3	--	12
N		
1	7	18
2	1	4
3	--	10
A		
A	3	12
P	3	12
X	2	8
L		
1	7	17
2	1	3
3	--	11
h	--	2
Mean RENAL score points	6.3± 1.4	8.1± 1.9

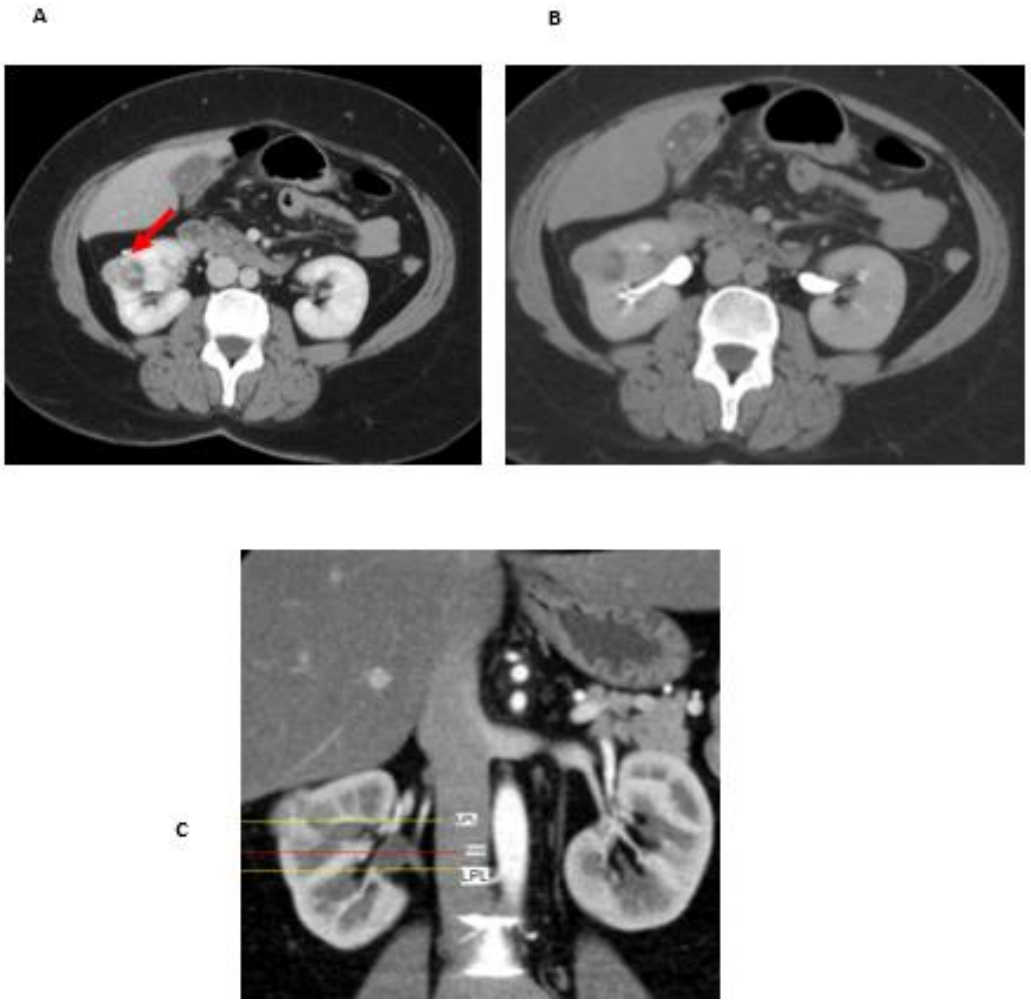

Figure 1: Female patient, 41year-old with right renal mass, 6X nephrometry score (low complexity). Axial CT (A) venous (B) delayed phases. (C) coronal. CT venous phase reveals well defined right renal heterogeneously enhanced mass (red arrow) showed **R**adius of 29 x 33 mm (**1**P), > 50% of the mass **E**xophytic (**2**P), the inner tumor margin **N**earness to the collecting system about 7.8 mm (**1**P) (B excretory phase), **Polar** in location (X), and crossing the upper polar line (yellow line in C) but not touching the renal axial midline (**2**P , red line in C). Endophyticity measures 14.5 mm and length from renal sinus 18.9 mm.

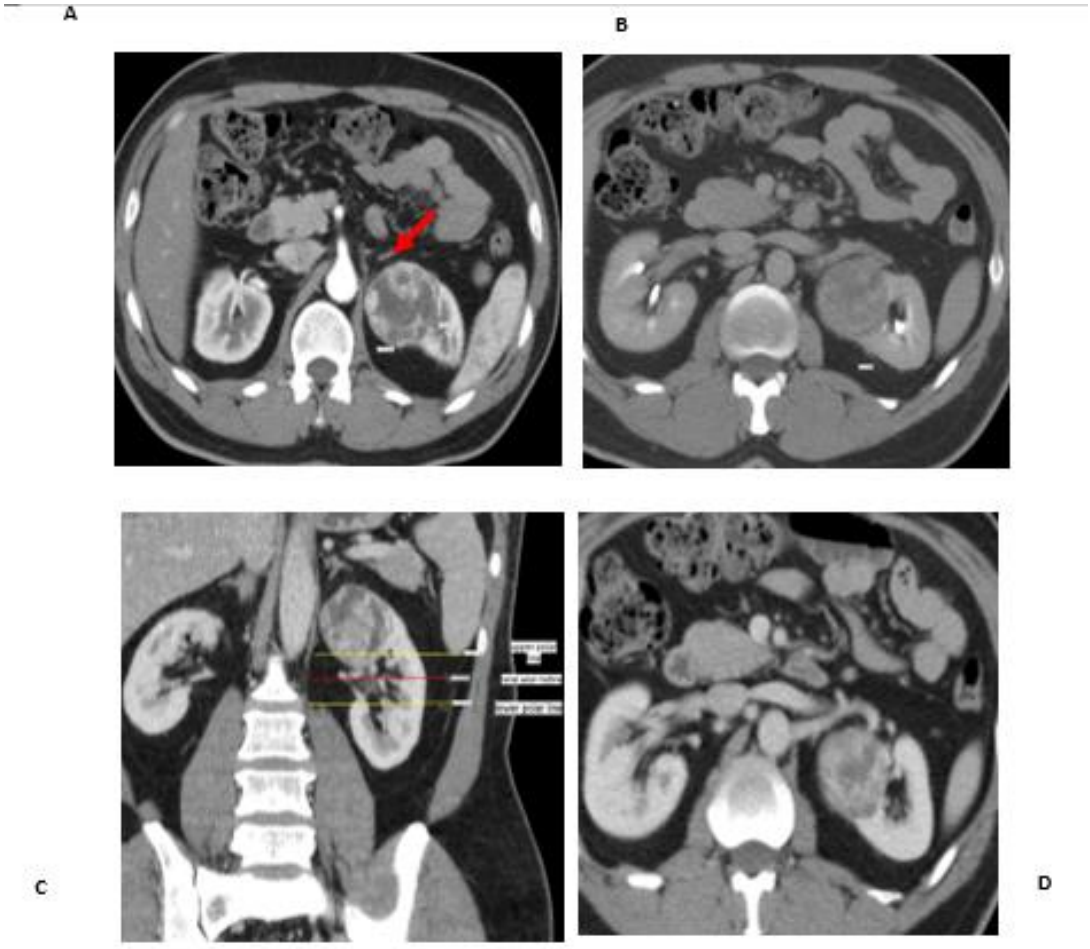

Figure 2: Male patient, 52 year-old with left renal mass, **9A nephrometry score** (moderate complexity). Axial CT (A,D) venous (B) delayed phases. (C) coronal CT venous phase reveals well defined left renal solid heterogeneously enhanced mass (red arrow) showed **R**adius of 55 x 52 mm (**2**P), < 50% of the mass **E**xophytic (**2**P), the inner tumor margin **N**earness to the collecting system about 2mm (**3**P) (B excretory phase)), **A**nterior in location, and crossing the upper polar line (yellow line in C) but not touching the renal axial midline (**2**P, red line in C). Endophyticity measures 24 mm and length from renal sinus 7 mm.

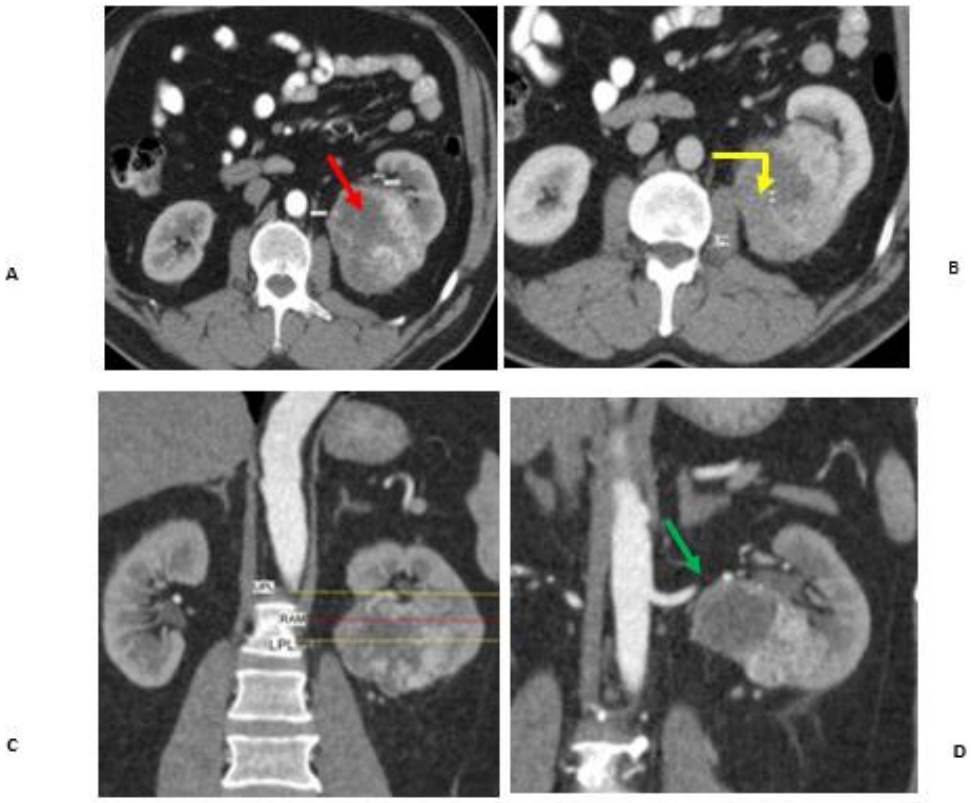

Figure 3: Male patient, 58 year-old with left renal mass, 11P "h" nephrometry score (high complexity). Axial CT (A) arterial (B) venous phases. (C,D). coronal CT arterial phase reveals well defined left renal solid heterogeneously enhanced mass (red arrow) showed **R**adius of 74 x 51 mm (**3**P), < 50% of the mass **E**xophytic (**2**P), the inner tumor margin **N**earness to the collecting system about 1mm (**3**P), **Pos**terior in location, and crossing the upper polar line (yellow line in C) and the renal axial midline (**3**P , red line in C). Poor fat planes between the mass and left psoas muscle (yellow arrow in B). The mass touches left renal artery (h) (green arrow in D). Endophyticity measures 32 mm and length from renal sinus 1mm.

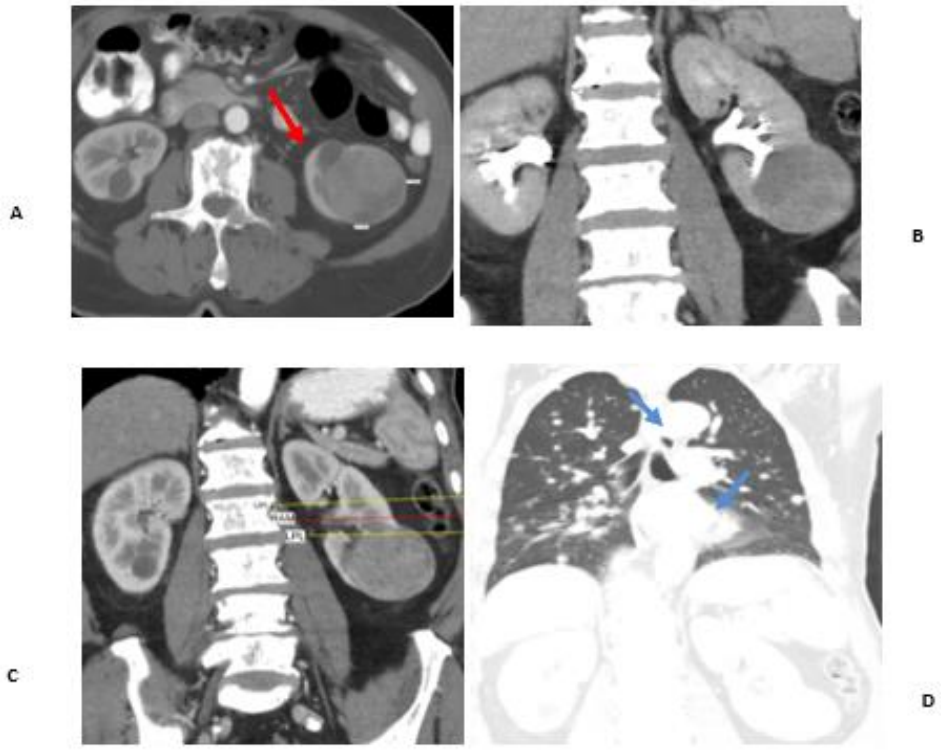

Fig. 4: Male patient, 77 year-old with metastatic left RCC, **8** X **nephrometry score** (moderate complexity). Axial CT (A) arterial (B) delayed phases. Coronal CT (C) arterial phase, lung window (D), reveals well defined left renal solid heterogeneously enhanced mass (red arrow) showed **R**adius of 47 x 55 mm (**2**P), > 50% of the mass **E**xophytic (**2**P), the inner tumor margin amputates the related collecting system (**3**P) (B excretory phase)), Polar in location, and crossing the lower polar line and sparing renal axial midline (**1** P). Endophyticity measures 31.6 mm and length from renal sinus 27 mm. Diffuse lung metastasis noted (blue arrows in D).

DISCUSSION

With frequent use of imaging modalities; 66% of renal masses are currently incidentally noticed thus increasing the number of diagnosed RCC patient's [3,12]. As a consequence of increased number of diagnosed renal tumors; minimally invasive surgical options have also increased particularly the surgery that spares the nephron (nephron-sparing) that might reduce the renal insufficiency resultant morbidity or mortality [13]. More difficult surgeries are performed by surgeons on complex renal masses with wide range of choices, including observation, open/laparoscopic surgery, single-site laparoendoscopic surgery, robotic assisted surgery and percutaneous/laparoscopic ablation of the tumor [14].

The characteristics of tumor resected using PON or PLN had been reported in many studies, but few studies mentioned the features affecting decision of Urologist for PON or PLN, or the cut-off value determining the choice for both processes [2,3] .

Current prospective study included 40 selected patients with more affection of males (73.5%) than females (26.5%), and the left kidney (60%) was affected more than the right side (40%) in agreement with Funahashi et al. [2].

R.E.N.A.L score complexity stratifications in the selected patients revealed that low complexity tumors were found in (20%), moderate complexity were present in (50%) of the patients and high complexity were reported in (30%) of the patients. All patients with low complexity underwent PLN while moderate and high complexity patients underwent open partial nephrectomy (PON) in concordance with Alsaikhan et al [3] who stated that many studies [15-18] reported that tumors with less complexity are commonly resected using partial laparoscopic nephrectomy, while tumors showing high-complexity more probable to underwent partial open nephrectomy or radical nephrectomy (RN) and added that size of the tumor and nephrometry score were independent factors for planning of PLN, PON and radical nephrectomy.

Current study revealed that significant statistical differences regarding the tumor size, tumor endophyticity, distance away from the renal sinus, and R.E.N.A.L. score were observed among the partial open nephrectomy and partial laparoscopic nephrectomy patients which is in concordance with several studies [2, 15-19].

Gill et al. [16] evaluated the tumor's characteristics and reported that the size of the tumor size about 2.6 cm in partial laparoscopic nephrectomy and 3.3 cm in partial open nephrectomy as well as endophyticity of the tumor were significantly different between the two surgeries [12] which is agreement with current study.

Naya et al. [17] assessed the tumor's morphological features and stated that nephrometry score and tumor size were important features determining selection of surgery type where nephrometry score of 8 was recommended as a cut-off value for choosing partial laparoscopic nephrectomy which is in agreement with current study where R.E.N.A.L score was 6.3 for partial laparoscopic nephrectomy and 8.1 score for partial open nephrectomy.

Esen et al. [18] assessed tumor factors; distance from the renal sinus and endophyticity (cut-off value of 16 mm) in 23 and 32 patients subjected to open partial nephrectomy and robot-assisted nephrectomy, respectively as well as high R.E.N.A.L. score (cut-off value of 6.5) and stated that these factors were important predictors to select robotic over open surgical procedures which is concordance with the current study .

Cha et al. [19] noticed that patients with elevated nephrometry score "(R) and (E) variables" could experience more renal postoperative complications which was in concordance with current study surgery type selection.

Broughton et al. [15] and Funahashi et al. [2] stated that the size of the tumor and R.E.N.A.L. score were determinant factors for choosing PLN over PON or radical nephrectomy which was in disagreement with the present study regarding the tumor size and the RENAL score.

In the current study, the R.E.N.A.L mean score was 6.3± 1.4 for choosing PLN and was 8.1± 1.9 for PON groups in disagreement with Broughton et al. [15] and Funahashi et al. [2] studies who concluded that the size of the tumor was not a significant predicting factor influencing the choice of surgery type and that R.E.N.A.L score was not a statistically significant factor in selecting the type of surgery. The aforementioned studies were retrospective and whether the judgment criterion is universal or not was not clear. The surgeons in the present study selected laparoscopic surgery in exophytic tumors with low R.E.N.A.L score and far away from the renal sinus and avoided laparoscopic surgery in large size tumors.

Dahl et al. [10] stated that patients with Nephrometry score with low complexity infrequently experienced postoperative bleeding or urinary fistula compared to moderate or high complexity tumors, while higher scores (< 7) were more likely to experience postoperative urological complications. Another publication states that each elevation in the nephrometry score lead to increased risk of postoperative urine leakage, taking the ''E'' score as an important predictor of that risk [20] in concordance with the present study as 1 patient had postoperative urine leakage and his ''E'' score was 3. Another patient had postoperative hemorrhage which was managed conservatively and his nephrometry score was 11P "h".

Post-operative histopathological study of the current study patients showed renal cell carcinoma in 36 patients (26 were papillary RCC, 10 were clear cell RCCs), angiomyolipoma occured in 1pateint and oncocytoma was reported in 3 patients. High R.E.N.A.L score was found in clear cell RCC with post-operative hemorrhage in one patient and low score was present in other groups in concordance with Alsaikhan et al [3] who stated that there was good correlation between the tumor grade and the nephrometry score (P .0001) and histologic characteristics (P. 0001) and they concluded that papillary RCC show low nephrectomy score while clear cell RCC show higher nephrectomy score. Additionally, benign tumors were usually smaller, away from the hilum and more endophytic. They determined that higher nephrometry scores usually correlate with nuclear grade, pathologic stage, and death from RCC.

To our knowledge, little number of prospective studies were done to evaluate the size of the tumor, tumor endophyticity, tumor distance from the renal sinus, and R.E.N.A.L. score as determinants of surgery selection ; either PLN or open partial nephrectomy. Although RENAL scoring system is usually used by urologists as it has implications for surgical planning but still RENAL score is less familiar to radiologists.

The current study shows some limitations, including small sample size but this can be explained by prospective nature of the study. The current study didn't evaluate, robotic partial nephrectomy as it is

not available in our institution. Robotic partial nephrectomy has been developed and gradually spread and it can minimize the difficulties in partial laparoscopic nephrectomy. Several studies stated that robotic partial nephrectomy might be done for more complicated masses; [21] so it could be a substitute to PON and PLN in selected patients. Further multicenter studies with larger sample size in an attempt to assess the cut-off points are recommended.

CONCLUSION

Nephrometry R.E.N.A.L score, tumor's size, endophyticity and distance from the sinus are important factors that affect surgical decision-making regarding laparoscopic or open partial nephrectomy

Conflict of Interest: None.

Financial Disclosures: None.

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