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Prediction of complications after partial nephrectomy by RENAL nephrometry score

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ABSTRACT

INTRODUCTION Discussing and planning the appropriate management for suspicious renal masses can be challenging. With the development of nephrometry scoring methods, we aimed to evaluate the ability of the RENAL nephrometry score to predict both the incidence of postoperative complications and the change in renal function after a partial nephrectomy.

METHODS This was a retrospective study including 128 consecutive patients who underwent a partial nephrectomy (open and laparoscopic) for renal lesions in a tertiary UK referral centre. Univariate and multivariate ordinal regression models were used to identify associations between Clavien–Dindo classification and explanatory variables. The Kendall rank correlation coefficient was used to examine an association between RENAL nephrometry score and a drop in estimated glomerular filtration rate (eGFR) following surgery.

RESULTS An increase in the RENAL nephrometry score of one point resulted in greater odds of being in a higher Clavien–Dindo classification after controlling for RENAL suffix and type of surgical procedure (odds ratio [OR]: 1.29, 95% confidence interval [CI]: 1.04–1.64, p=0.043). Furthermore, a patient with the RENAL suffix 'p' (ie posterior location of tumour) had increased odds of developing more serious complications (OR: 2.60, 95% CI: 1.07–6.30, p=0.042). A correlation was shown between RENAL nephrometry score and postoperative drop in eGFR (Kendall's tau coefficient -0.24, p=0.004).

CONCLUSIONS To our knowledge, this is the first study that has shown the predictive ability of the RENAL nephrometry scoring system in a UK cohort both in terms of postoperative complications and change in renal function.

KEYWORDS

Complications – Partial nephrectomy – Renal cancer – RENAL nephrometry

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Nephron sparing surgery (NSS) is the gold standard treatment for small localised renal tumours.[1] NSS achieves equivalent oncological outcome to radical nephrectomy for small renal masses with reduced long-term mortality at the cost of increased short-term morbidity.[2] High volume centres have shown that NSS for larger localised renal tumours (>4cm) can achieve comparable outcomes with those of radical nephrectomy.[1] Minimally invasive partial nephrectomy (PN) is increasingly replacing the open technique because of the potential advantages of shorter hospital stay, reduced intraoperative blood loss and equivalent oncological efficacy.[3] Irrespective of the approach, PN is associated with a higher rate of complications than radical nephrectomy, ranging from 4.5% to 28%.[4,5]

Tumour characteristics on preoperative imaging provide useful information on the complexity of the tumour and have been used to predict the occurrence of postoperative complications after NSS.[6] Several scoring systems based on tumour profile on preoperative imaging have been described in the literature, with the most widely reported being the C-index, the PADUA score and RENAL nephrometry.[7,8] Several groups have reported the use of these scoring systems in predicting perioperative outcomes such as ischaemia time and incidence of complications.[9,10] This study is the first to use the RENAL nephrometry scoring system in a large local UK cohort undergoing NSS in a tertiary referral centre. The aim was to assess its utility in predicting the incidence of postoperative complications.

Methods

This was a retrospective study looking at 128 consecutive patients treated with a PN for a suspicious renal lesion at a single tertiary referral centre. Initially, the case notes of all patients who underwent PN were reviewed (n=152). Of these patients, those who had a PN for stone disease and chronic infection were discarded (n=20), and for those who had more than one PN, the second procedure was also discarded (n=4). All 30-day postoperative complications were stratified using the Clavien–Dindo classification (CDC).[11]

Preoperative computed tomography was reviewed (both axial and coronal planes) and the RENAL nephrometry

score (RNS), as defined by Kutikov and Uzzo in 2009, was calculated for each patient.[6] The five components include: **R**adius (maximal diameter), **E**xophytic/endophytic properties, **N**earness of lesion to the collecting system or sinus, **A**nterior ('a') or posterior ('p') location of lesion and **L**ocation of the lesion relative to the polar lines. If the lesion was in contact with the main renal artery and/or vein, the suffix 'h' (denoting hilar) was added. The lesions were then divided into three groups by complexity, based on the RNS: low complexity (RNS 4–6), moderate complexity (RNS 7–9) and high complexity (RNS 10–12).[12]

In order to investigate whether RNS was a significant predictor of CDC, an ordinal regression method (proportional odds regression) was performed on the CDC outcome variable, using a logit link function. The RNS was treated as a continuous explanatory variable to retain statistical power.

The CDC complications were categorised into three groups: no complications (grade 0), minor complications (grade 1–2) and major complications (grade 3–5). RNS and RENAL suffix were treated as separate variables for the purposes of statistical analysis, and were included in separate univariate ordinal regression models. Age at operation, ASA (American Society of Anesthesiologists) grade and type of procedure (open/laparoscopic) were also included as separate explanatory variables in univariate ordinal regression models to assess their individual associations with the CDC (Table 1). RENAL suffix 'x' and ASA grade 3 were reference categories for this analysis. Next, a multivariate ordinal regression model was fitted, including RNS and all explanatory variables that were previously significant at the 10% level in the univariate analysis (ie RNS, RENAL suffix and surgical procedure [laparoscopic vs open]).

The Kendall rank correlation coefficient was calculated to identify any relationship between RNS and difference in estimated glomerular filtration rate (eGFR) (prior to and following the procedure). In order to test whether there was a significant difference between postoperative and preoperative eGFR, a Wilcoxon signed-rank test was performed. SPSS® version 18.0.3 (SPSS, Chicago, IL, US) was used for all analyses.

Table 1 Univariate analysis assessing the association between the explanatory variables and the Clavien–Dindo classification

Explanatory variable	Odds ratio	95% CI	*p*-value
RNS	1.30	1.04–1.64	**0.023**
RNS suffix			
a	1.30	0.51–3.30	0.577
p	2.59	1.07–6.30	**0.035**
x (reference)			
Age at operation	1.02	0.98–1.05	0.342
Laparoscopic procedure	0.23	0.05–0.98	**0.047**
ASA grade			
1	0.83	0.27–2.54	0.747
2	0.58	0.24–1.41	0.228
3 (reference)			

CI = confidence interval; RNS = RENAL nephrometry score; ASA = American Society of Anesthesiologists

Table 2 Patient demographics (*n*=128)

Median age (range)		66.9 years (20.7–86.0 years)
Sex	Male	83
	Female	45
ASA grade	1	23
	2	77
	3	28
Method of operation	Open	108
	Laparoscopic	20
Median length of stay (range)		5 days (2–35 days)
Median RNS (range)		7 (4–11)
RNS suffix	a	38
	p	36
	x	54
Mean renal mass diameter (SD)		3.69cm (1.62cm)

ASA = American Society of Anesthesiologists; RNS = RENAL nephrometry score; SD = standard deviation

Results

Table 2 outlines the demographics of the study population. The mean tumour size was 3.69cm with the majority of patients undergoing an open PN. There were 15 patients who developed major complications (ie CDC grade 3+). The individual major complications can be found in Table 3. The complications were also stratified by RENAL score complexity (Fig 1).

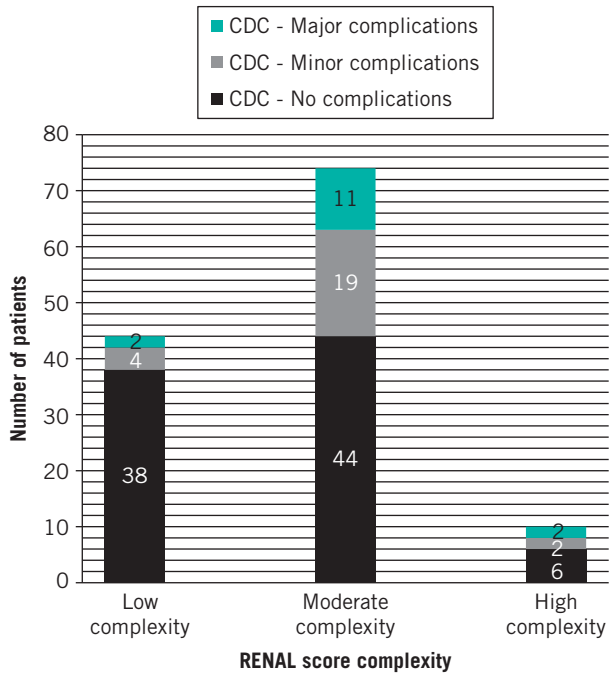
The multivariate analysis (Table 4) showed that an increase in RNS of one point resulted in significantly greater odds of being in a higher CDC after controlling for RENAL suffix and type of surgical procedure (odds ratio [OR]: 1.29, 95% confidence interval [CI]: 1.04–1.64, p=0.043). In addition, the RENAL suffix 'p' increased the odds of developing more serious complications by 2.6 times (95% CI: 1.07–6.30, p=0.042) when compared with those renal masses classed as 'x'. However, those lesions identified with the RENAL suffix 'a' showed insufficient evidence of a difference in complications when compared with lesions with the suffix 'x'. The same applied to patients who underwent a laparoscopic procedure, after adjusting for RNS and RENAL suffix.

The median postoperative eGFR was 72.0ml/min/1.73m^2 (interquartile range [IQR]: 28.0ml/min/1.73m^2) compared with the median preoperative eGFR of 76.0ml/min/1.73m^2

Table 3 Postoperative complications after partial nephrectomy by Clavien–Dindo classification grade. (Note some patients had more than one complication.)

CDC	Complication	Number of patients
Grade 4	Cardiac arrest	1
Grade 4	Renal vein thrombosis	1
Grade 4	Acute kidney injury needing filtration	1
Grade 4	Sepsis/atrial fibrillation needing ICU admission	1
Grade 3	Collection needing ultrasonography/ CT drainage	5
Grade 3	Bleeding needing re-exploration or embolisation	5
Grade 3	Urine leakage	4
Grade 3	Stenting for hydronephrosis (haematoma)	1

CDC = Clavien–Dindo classification; ICU = intensive care unit; CT = computed tomography



Major complications = CDC 3+; Minor complications = CDC 1–2; No complications = CDC 0

Figure 1 The number and grade of Clavien–Dindo complications (CDC) by RENAL score complexity

Table 4 Multivariate analysis assessing the association between the explanatory variables (significant on univariate analysis) and the Clavien–Dindo classification

Explanatory variables	Odds ratio	95% CI	*p*-value
RNS	1.29	1.01–1.66	**0.043**
RNS suffix			
a	1.07	0.41–2.79	0.894
p	2.60	1.04–6.54	**0.042**
x (reference)			
Laparoscopic procedure	0.33	0.07–1.52	0.156

CI = confidence interval; RNS = RENAL nephrometry score

(IQR: 27.0ml/min/1.73m^2) (p<0.0001). There was a weak negative correlation between the difference in post and preoperative eGFR and the RNS (Kendall's tau coefficient -0.24). Nevertheless, this was significant at the 5% level (p=0.004).

Discussion

NSS is now the gold standard for the management of small renal masses. It is well known that chronic kidney disease is an independent risk factor for the development of cardiovascular events and hospitalisation.[13] Recurrence rates and cancer specific survival are comparable between patients undergoing partial or radical nephrectomy.[14,15] Use of PN is increasing and methods to help predict postoperative complications based on preoperative imaging are garnering substantial interest.

With the centralisation of care and video conferencing, the ability to describe a tumour in a clear and concise fashion is paramount. While there are several other objective methods to help describe tumours and predict complications after PN, including the PADUA score and C-index, the RENAL nephrometry method is arguably the most validated in the literature. It has been shown to exhibit good interobserver reliability, which is one of the major concerns about any objective scoring method.[16] In fact, Okhunov *et al* showed better overall interobserver concordance rates for RNS than for those of the PADUA score and C-index.[17]

However, some parts of the scoring method are more easily assessed than others, with the location component only showing 54% concordance between three observers.[15] As a result, Simmons *et al* described the diameter-axial-polar (DAP) nephrometry method, which incorporated well defined reference points to standardise reporting, especially in the presence of varying renal anatomy between patients.[18] They showed that the DAP score was associated with warm ischaemia time (WIT), estimated blood loss and functional volume preservation.

Our cohort consisted of 128 patients, of whom 116 had their PN performed between 2007 and 2012 inclusive. The major complication (CDC grade 3+) rate in our cohort was 12% (n=15) and the median length of stay was 5 days (range: 2–35 days), which is comparable with other

documented literature.[19] As expected, most of our cohort were classified into low and intermediate RENAL complexity groups, with larger complex masses tending to be managed with radical nephrectomy. In our centre, the vast majority of T1a lesions are managed with PN, with a significant proportion of T1b lesions managed in the same way.

Multivariate analysis has shown that RNS and RENAL suffix are significant predictors of complications. Although an association between RENAL complexity score and the development of major (CDC grade 3+) and minor complications (CDC grade 1 or 2) has not been shown, perhaps owing to small cohort numbers, other groups have found that renal masses with a high RNS (>9) were at increased risk of developing major complications.[12] This, however, could not be reproduced in the intermediate RNS (7–9) group.

A significant difference between postoperative and preoperative eGFR was noted at the 5% level. We were also able to show a significant association between the difference in preoperative and postoperative eGFR levels and the RNS. Kendall's tau coefficient was 0.22 (n=107; p=0.002), which indicates a weak correlation but is nevertheless significant. There is varied opinion in the literature regarding this but Cha *et al* found (albeit with a relatively small cohort) that a higher RNS was associated with worse long-term renal function outcomes after PN.[20] This would fit with potentially leaving less functional volume after removing more complex renal masses. A study from 2013 corroborated this and found on multivariate analysis that higher RNS is associated with an increasing risk of developing an eGFR of <60ml/min/1.73m^2 (OR: 1.24, p=0.046).[21]

There are limitations to this study. Owing to its retrospective nature, it was not possible to collate WITs, operative times and estimated blood loss for all patients. As mentioned previously, RNS can predict procedure complexity and therefore ischaemia times. Authors of a similar paper found on multivariate analysis that RNS was the only independent predictor of WIT (p=0.03).[22]

While there were a relatively small number of laparoscopic cases in our cohort, we do not feel that this should have a significant impact on our conclusions as the predictive ability of RNS has been found to be independent of operative approach.[12] However, a study looking at RNS and operative approach noted a large overlap in type of operative approach in renal masses classified as intermediate complexity.[23] They found that the individual RENAL components of decreased radius, anterior and polar location, and non-hilar involvement were associated with the use of minimally invasive surgery. Although our study has shown a lower complication rate in the laparoscopic PN cohort than in the open group, this can be explained partially by the stringent selection criteria that were applied to laparoscopic cases.

The concept of a trifecta as a group of ideal surgical outcomes after surgery has been most reported in the literature describing radical prostatectomy.[24] Recently, the trifecta has been used when referring to outcomes after PN. It is defined currently as a trio of functional renal preservation, negative surgical margins and no perioperative complications.[25] This appears to take into account procedure complexity, oncological safety and surgical quality. A study has shown that each 1cm increase in tumour size increased the chances of not achieving the trifecta twofold.[26] The trifecta unites three important principles of PN, which are individually associated with better prognosis and may increasingly be used to assess surgeon and centre level oncological outcomes.

There is an increasing incidence of small renal masses and, consequently, there are more cases where active surveillance may be more appropriate, especially in elderly patients with co-morbidities. The smaller a renal mass, the higher the likelihood of it being a benign or low grade renal cell carcinoma. It has been shown that a diameter increase of 1cm was associated with a 17% increase in the odds of malignancy.[27]

Kutikov *et al* used RENAL nephrometry to create two predictive models, looking at the likelihood of a lesion being malignant on resection and the likelihood of a lesion being high grade if malignant. The area under the curve for these two models was 0.76 and 0.73 respectively,[28] with the latter being validated externally by another group.[29] Even though we found no correlation in our study between Fuhrman grade and RNS, with further development and external validation, there may be a role for RENAL nephrometry in the decision making process when allocating patients to active surveillance or used alongside percutaneous biopsies for histological diagnosis.

There are further potential roles for the RNS in renal oncological surgery. In a cohort of patients who underwent laparoscopic cryotherapy, multivariate regression analysis confirmed that RNS was associated independently with a higher risk of postoperative complications (OR: 2.23, 95% CI: 1.05–2.11, p=0.008).[30] All tumours with a RNS of >8 developed some type of complication following surgery. Moreover, all patients in the high complexity group (RNS 10–12) had complications while no patients in the low complexity group (RNS 4–6) developed any complications.

Conclusions

There has been much interest in developing and validating nephrometry scoring methods. The RNS is arguably the most widely used currently, and recent literature has shown its usefulness in the management of renal masses and its constantly evolving nature. Our work has confirmed not only its ability to predict complications after PN but also that it correlates with change in renal function postoperatively. Nevertheless, there is still much work to be done in this field to optimise reporting. The potential information obtained from this scoring method is beneficial when counselling patients in the outpatient clinic, especially in deciding when to proceed with a PN or a radical nephrectomy.

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