ARCHIVIO ISTITUZIONALE
DELLA RICERCA

Alma Mater Studiorum Università di Bologna
Archivio istituzionale della ricerca

PADUA and R.E.N.A.L. nephrometry scores correlate with perioperative outcomes of robot-assisted partial nephrectomy: analysis of the Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database

This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

Published Version:
Schiavina, R., Novara, G., Borghesi, M., Ficarra, V., Ahlawat, R., Moon, D.A., et al. (2017). PADUA and R.E.N.A.L. nephrometry scores correlate with perioperative outcomes of robot-assisted partial nephrectomy: analysis of the Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database. BJU INTERNATIONAL, 119(3), 456-463 [10.1111/bju.13628].

Availability:
This version is available at: https://hdl.handle.net/11585/590177 since: 2017-05-22

Published:

DOI: http://doi.org/10.1111/bju.13628

Terms of use:

Some rights reserved. The terms and conditions for the reuse of this version of the manuscript are specified in the publishing policy. For all terms of use and more information see the publisher's website.

This item was downloaded from IRIS Università di Bologna (https://cris.unibo.it/).
When citing, please refer to the published version.

(Article begins on next page)

11 September 2026

This is the peer reviewed accepted manuscript of the following article:

Schiavina R, Novara G, Borghesi M, Ficarra V, Ahlawat R, Moon DA, Porpiglia F, Challacombe BJ, Dasgupta P, Brunocilla E, La Manna G, Volpe A, Verma H, Martorana G, Mottrie A.

PADUA and R.E.N.A.L. nephrometry scores correlate with perioperative outcomes of robot-assisted partial nephrectomy: analysis of the Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database.

BJU Int. 2017 Mar;119(3):456-463

Final peer reviewed version available at: https://doi.org/10.1111/bju.13628

Rights / License:

The terms and conditions for the reuse of this version of the manuscript are specified in the publishing policy. For all terms of use and more information see the publisher's website.

This item was downloaded from IRIS Università di Bologna (https://cris.unibo.it/)

When citing, please refer to the published version.

PADUA and RENAL nephrometry scores correlates with perioperative outcomes after robot-assisted partial nephrectomy: analysis of the Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database.

Authors: R. Schiavina[1,3], G. Novara[2,13], M. Borghesi[1,3], V. Ficarra[4], R. Ahlawat[5], D. Moon[6], F. Porpiglia[7], Challacombe B[8], Dasgupta P[8], E. Brunocilla[1,3], G. La Manna[3,9], A. Volpe[10], Hema Verma[11], G. Martorana[1,3], A. Mottrie[12,13]

Affiliations:

1.Department of Urology, S. Orsola-Malpighi Hospital, University of Bologna, Bologna, Italy;

2. Department of Surgery, Oncology, and Gastroenterology - Urology Clinic, University of Padua, Padua, Italy.

3. Cardio-Nephro-Thoracic Sciences PhD, University of Bologna, Bologna, Italy.

4. Department of Experimental and Clinical Medical Sciences, University of Udine, Udine, Italy.

5. Division of Urology and Renal Transplantation, Medanta Kidney and Urology Institute, Medanta, the Medicity, Gurgaon, India.

6. Dept Surgery, Peter MacCallum Cancer Centre, University of Melbourne, Melbourne, Vic., Australia.

7. San Luigi Gonzaga Hospital, University of Turin, Orbassano, Italy.

8 Guy's & St Thomas' NHS Foundation Trust and NIHR Biomedical Research Centre, King's College London, London, UK.

9. Department of Nephrology and Experimental, Diagnostic and Specialty Medicine, University of Bologna, Bologna, Italy.

10. University of Eastern Piedmont, Novara, Italy.

11. Departments of Radiology, Guy's and St. Thomas' NHS Foundation Trust, King's College London, London, UK.

12. Department of Urology, Onze-Lieve-Vrouw Hospital, Aalst, Belgium.

13.OLV Vattikuti Robotic Surgery Institute, Aalst, Belgium.

Corresponding author:

Dr. Riccardo Schiavina, Department of Urology, University of Bologna, S. Orsola-Malpighi Hospital, Bologna, Italy, Address: Palagi 9, 40134, Bologna, +393494447896, fax: +390516362747, mail: rschiavina@yahoo.it

Key words: Renal cell carcinoma; Robot-assisted partial nephrectomy; Nephrometry score; PADUA score, RENAL score; Perioperative complications.

Conflict of interests:

Possible conflicts of interest in the manuscript, including financial, consultant, institutional and other relationships that might lead to bias or a conflict of interest: none declared.

Abstract

Objectives

To evaluate and compare the correlations between PADUA and RENAL scores and perioperative outcomes and postoperative complications in a multicenter, international series of patients undergoing Robot-assisted partial nephrectomy (RAPN) for masses suspicious of RCC.

Patients and methods

We retrospectively evaluated the clinical records of patients who underwent RAPN between 2010 and 2013 for clinical N0M0 renal tumours in four international Centers that completed all the data required for the Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database. All patients underwent pre-operative computed tomography or magnetic resonance imaging to define the clinical stage and anatomic characteristics of the tumors. PADUA and RENAL scores were retrospectively assessed in each Center. Univariate and multivariate analyses were performed to evaluate the correlations between age, gender, Charlson comorbidity index, clinical tumor size, PADUA and RENAL complexity group categories and warm ischemia time >20 minutes, urinary calyceal system closure and grade of postoperative complications.

Results

Overall, 277 patients have been evaluated. The median tumor size was 33.0 millimeters (22.0-43.0). The median PADUA and RENAL score were 8 and 7 respectively; 112 (40.4%), 86 (31.0%) and 79 (28.5%) patients were classified in the low, intermediate or high-complexity group according to PADUA score, while 118 (42.5%), 139 (50.1%) and 20 (7.2%) were classified in the low, intermediate or high-complexity group according to RENAL score, respectively. Both nephrometric tools significantly correlated with perioperative outcomes at univariate and multivariate analyses..

Conclusion

A precise stratification of patients before partial nephrectomy is recommended, allowing to balance the potential threats and benefits of nephron-sparing surgery. In our analysis, both PADUA and RENAL were significantly associated with prolonged WIT and high-grade postoperative complications after RAPN.

Introduction

Partial nephrectomy (PN) has become the standard of care for the conservative management of clinically localized RCC for many years [1,2], as it demonstrate equivalent oncological results [3,4] but reduced renal function impairment [5,6] in comparison with radical nephrectomy (RN). Despite the functional benefits offered by conservative surgery, patients undergoing PN are at higher risk of postoperative complications compared with those undergoing RN, especially in the case of complex renal tumors [7-10]. In complex cases, laparoscopic PN generally represents a more challenging procedure, with longer warm ischemia times (WIT), a higher rate of urinary calyceal system (UCS) entry, and more frequent postoperative complications rates than those reported for easier and smaller lesions. [8]. In this scenario, the utilization of the da Vinci® platform has been increasing over time [9]. Proposed as the natural evolution and simplification of the traditional laparoscopy, the robotic approach allows

surgeons to perform a very precise tumor excision, with easier parenchymal reconstruction, especially in those patients with more complex renal masses [10,11]. These important advantages could lead to a reduction in the hilar clamping time in comparison with laparoscopic approach, allowing minimization of renal function impairment [12].

Recently, in order to categorize and stratify patients into different anatomical complexity groups and allow urologists to estimate the potential perioperative outcomes, several standardized anatomical classification-scoring systems have been described [11-16]. The most frequently used are the RENAL nephrometry and the PADUA classifications [13,14]. Despite several differences between these two nephrometric scores, both have been demonstrated to effectively correlate with perioperative outcomes after partial nephrectomy, as well as useful tools for strategic surgical planning [17-20]. However, studies comparing the different predictive value of these two nephrometry scores are limited. In this study, we sought to evaluate the role of both the PADUA and RENAL scores in the association with perioperative outcomes and postoperative complications in a multicenter, international series of patients undergoing RAPN for masses suspicious of RCC.

Patients and methods

The Vattikuti Global Quality Initiative in Robotic Urologic Surgery (GQI-RUS) database is an Institutional Review Board-approved database including data of 10 worldwide centres. In this institutional review board–approved report all participating centres provided the necessary institutional data sharing agreements before initiation of the study. A computerized databank was generated for data transfer. After combining the data sets, reports were generated for each variable to identify data inconsistencies and other data integrity problems. Through regular communication with all centres, resolution of all identified anomalies was achieved. Before final analyses, the database was frozen, and the final data set was produced for the current study.

In this multicenter, international study, we evaluated retrospectively the clinical records of patients who underwent RAPN between 2010 and 2013 for clinical N0M0 renal tumours in four centers that completed all the data required for the study. All the clinical and pathological data were prospectively evaluated for each patient: age, gender, clinical tumor size, anatomic tumor parameters according to PADUA and RENAL classifications; WIT,

urinary calyceal system (UCS) closure, pathological results, console time, blood loss, transfusion rate, intraoperative and postoperative complications. Before surgery all patients underwent three-dimensional computed tomography scans or magnetic resonance imaging to define the clinical stage and anatomic characteristics of the tumors. All the radiologic images were retrospectively reviewed by each participant center with the aim of assigning the PADUA and the RENAL scores (13-14). Tumors were stratified into low-complexity (score 6–7), intermediate-complexity (score 8–9), and high-complexity groups (score >9) according to the PADUA score and into low-complexity (score 3-6), intermediate-complexity (score 7-9), and high-complexity groups (score >9) according to the RENAL score.

Partial nephrectomy was performed according to the standard criteria for RAPN. Regional lymph node dissection was not routinely performed. Surgeons with extensive prior robotic experience, including robotic radical prostatectomy, robotic radical nephrectomy, and radical cystectomy, performed all the procedures. Three-months postoperative complications were classified according to the Dindo modification of the Clavien system [21]. Then, postoperative complications were distinguished as minor (grade 1–2) and major (grade 3–4).

Pathologic Evaluation

All surgical specimens were processed according to standard pathologic procedures at each institution. Tumors were staged according to the 2010 American Joint Committee on Cancer–Union Internationale Contre le Cancer TNM classification [22]. Histological subtype was defined according to the Heidelberg classification [23]. Tumor grade was assessed according to the Fuhrman system [24]. Positive surgical margin (PSM) status was defined as the presence of tumor tissue on the inked surface of the tumor on final pathologic assessment.

Statistical Analysis

T-test was used for normally distributed continuous variables, and results are shown as mean with standard deviation (SD); Wilcoxon rank sum testing was used for non-normally distributed variables, and results are shown as median and interquartile range (IQR). Categorical variables are shown as number and percentage and associations were tested with Pearson Chi-square, linear by linear association or Anova test.

Clinical parameters, including age, gender, Charlson comorbidity index (CCI), clinical tumor size, PADUA (6-7 vs. 8-9 vs. >9) and RENAL (3-6 vs. 7-9 vs. >9) scores were evaluated to estimate WIT>20 minutes, UCS closure, any grade and grade 3-4 postoperative complications with univariable and multivariable logistic regression models. The multivariable models included only the variables significant at univariable analysis and considered PADUA score or RENAL score separately; as clinical tumor size is part of the nephrometry scores, it was not included in the multivariable model. Statistical significance was set as $p \leq 0.05$. All reported p values are two-sided. Analyses were performed with SPSS version 20.0 (SPSS Inc, Chicago, IL, USA).

Results

Overall, 277 patients with complete perioperative data have been evaluated. Clinical and pathological characteristics are summarized in Table 1. Of the entire cohort, 243 (87.7%) subjects were operated in elective condition, with median clinical tumor size of 33.0 millimeters (22.0-43.0).

Preoperative median Padua and RENAL score were 8 and 7 respectively; 112 (40.4%), 86 (31.0%) and 79 (28.5%) were classified in the low, intermediate or high-complexity group according to PADUA score, while 118 (42.5%), 139 (50.1%) and 20 (7.2%) were classified in the low, intermediate or high-complexity group according to RENAL score, respectively.

Table 2 shows the distribution of the 277 patients according to PADUA and RENAL scoring systems, which were concordant in 171 (61.7%) patients.

Table 3 shows the incidence of perioperative and postoperative outcomes according to PADUA and RENAL complexity groups: longer WIT, need for UCS closure, higher console time and grade 3-4 postoperative complications significantly raised with the increasing of both PADUA and RENAL complexity group, while any grade of postoperative complications was correlated only with RENAL score. On the contrary, intraoperative blood loss was not correlated to the scoring systems.

A detailed report of intraoperative and postoperative complications, as well as the related Clavien grade and specific treatment are showed in table 4. Globally, 12 (4%) intra-operative complications occurred and 43 (15.5%) postoperative complications have been reported with four (1%) re-interventions. Overall, 25 (9.0%) and 18 (6.4%) patients experienced low grade (grade 1-2) and high grade (grade 3-4) postoperative complications according to Clavien-Dindo classification respectively.

Table 5 summarizes the correlations between PADUA and RENAL scores and perioperative and postoperative outcomes at univariate and multivariate analysis.

On univariable analysis, the clinical tumor size as well as PADUA score was significantly correlated to both WIT (table 5a) and grade 3-4 postoperative complications (table 5d), with differences being recorded between intermediate and high complexity groups. Conversely only the high complexity group according to RENAL score was significantly correlated to WIT and grade 3-4 postoperative complications, with no difference between low and intermediate complexity groups. Similarly, gender, clinical tumor size and intermediate vs. high complexity groups according to both PADUA and RENAL scores were significantly correlated to UCS closure in univariable analysis (table 5b). At multivariate analysis gender and intermediate vs. high complexity groups according to both PADUA and RENAL remained significant but the OR of high complexity group according to RENAL was inferior to the OR of intermediate one (table 5b). Finally, only high-complexity group according to both PADUA and RENAL score was correlated to the incidence of any grade of postoperative complications (table 5c). The accuracy of each nephrometric score in the prediction of warm ischemia time > 20 minutes and high grade (Clavien 3-4) postoperative complications were evaluated by using Receiver Operating Characteristic (ROC) analyses (Figure 1). Both RENAL and PADUA scores demonstrated to be effective and comparable predictors of these perioperative outcomes, even though a slightly higher area under the curve (AUC) was reported for the latter in terms of WIT longer than 20 minutes (0,609 vs. 0,580) and high grade postoperative complications (0,638 vs. 0,620).

Discussion

In the present multi-institutional, international retrospective study, we demonstrated that the RENAL and PADUA nephrometric scores correlated with the perioperative outcomes after RAPN. In particular, WIT, console time and need for UCS closure as well as postoperative complications were significantly correlated to both scores in univariable and multivariable analysis. Furthermore, the logistic regression found that the calibration of the PADUA scoring is more accurate as the distribution of the cases in the three groups of low, intermediate and high-complexity is homogeneous and progressively correlated to the outcomes. Indeed, with regard to WIT, patients with intermediate to highly complex renal tumors according to the PADUA classification were found to have a 2.3- and 2.6-fold higher risk of WIT > 20 minutes ($p=0.011$ and $p=0.004$, respectively). Conversely, only those patients with high RENAL complexity experienced significantly longer WIT than the low complexity group. Similarly, intermediate to highly complex renal tumors according to the PADUA classification experienced a 2.3- and 2.7-fold higher incidence of grade 3-4 postoperative complications ($p=0.011$ and $p=0.004$, respectively), while only the high complexity group category according to RENAL score experienced a significantly higher risk of grade 3-4 complications than the low complexity group. Finally, intermediate and highly complex renal tumors according to the PADUA classification experienced a 2.3- and 3-fold higher incidence of UCS closure ($p=0.005$ and $p<0.001$, respectively), while the intermediate complexity according to RENAL score experienced a higher risk of UCS closure than high-complexity group (2.8- vs. 2.4-fold, $p=0.015$ and $p=0.043$, respectively).

To the best of our knowledge, this is the largest contemporary series comparing the accuracy of both PADUA and RENAL scores in a multi-institutional pure RAPN cohort. The present paper clearly showed that both RENAL and PADUA score were significantly correlated with perioperative results.

The correct characterization of renal tumors and vascular complexity by using a validated and reproducible nephrometry score may assist urologists in selecting the best surgical approach for each patient and potentially estimate the outcome [15-19]. Since partial nephrectomy is associated with a not negligible risk of perioperative complications, a careful evaluation of tumor's anatomy before surgery is crucial, allowing balancing the potential adverse outcomes of PN with its expected functional benefits [25,26].

Many nephrometry scores have been developed to estimate perioperative outcomes after partial nephrectomy [13-19]. The C-index is a morphometric descriptor of renal masses that incorporates tumor size and site and was associated to the postoperative nadir estimated glomerular filtration rate and the percent decrease in the estimated glomerular filtration rate after laparoscopic partial nephrectomy [15]. The score is widely investigated and externally validated but can be considered quite complex. Recently, Spaliviero et al [16] proposed the arterial-based complexity (ABC) score, to evaluate the size of the renal arterial branches needed to be dissected to achieve radical tumor excision, considering that the larger the arterial branch, the more complex the surgery will be. The score was significantly associated with WIT, postoperative complications and blood loss and it is quite simple. However, at the present time, the score has not been externally validated. Among the currently available scoring systems, PADUA and RENAL score are well-established systems and clearly demonstrated to be accurate tools associated with relevant perioperative and clinical aspects, such as WIT duration, rate of postoperative complications and residual glomerular filtration rate after nephron-sparing surgery for RCC [17-20]. In a retrospective analysis of 162 patients, Bylund et al. evaluated the correlations between nephrometric scores and surgical outcomes after PN [19]: PADUA score, RENAL score and C-index showed a statistically significant correlation with warm ischemia time ($p<0.001$). Notably, the total PADUA score performed slightly better than the other systems in terms of WIT and, unsurprisingly, correlated with the absolute change of estimated glomerular filtration rate after surgery. Desantis et al. recently reported data of 118 patients diagnosed with clinically localized renal tumors in a single Canadian Institution [27]: After adjusting for age and medical comorbidities, only the PADUA score was found to be significantly correlated with surgical (OR: 1.31, $p=0.02$) and overall (OR: 1.12, $p=0.04$) complications within 30 days after surgery. Conversely, the RENAL score and C-index failed to show such correlations. In a multi-institutional, international RAPN series by Ficarra et al, 347 patients have been retrospectively evaluated [20]. In multivariable analyses, PADUA stratification turned out to be independently correlated with WIT > 20 min, once adjusted for the effects of surgeon experience. The same group stratification demonstrated to beindependently associated with perioperative complications. Long and co-workers reported results of a single-institutional cohort of 177 PN patients [28]. Tumor's anatomical complexity was classified according to the RENAL nephrometry score. On multivariate analysis, RENAL categories only were independently

correlated with WIT (p=0.03), while no significant correlations between complexity groups and any grade or severe postoperative complications were found (p=0.51). In the same way, Ellison and colleagues, reporting data of 298 patients who underwent laparoscopic and robotic partial nephrectomy, found significant correlations between RENAL score and major postoperative complications (p<0.001) [29]. Borghesi et al., in 96 patients treated with open or laparoscopic partial nephrectomy, found that PADUA and RENAL scores were significantly associated with longer warm ischemia time and higher postoperative complications, especially in those patients with more challenging and complex renal tumors [30]. Others authors have published different results. Zhang et al [31] analyzed the correlations between the two scoring system and both WIT and perioperative complications and. In their series of 245 patients treated with laparoscopic PN, they found that only RENAL score was significantly correlated with warm ischemia time (P=0.03). No significant associations between PADUA Score and WIT (P=0.22) and between the PADUA and RENAL score and the occurrence of any grade of postoperative complications were observed (p=0.26 and p=0.44, respectively).

It is not surprising that with increasing of the complexity of renal tumors a longer hilar clamping time should be required in order to achieve safe excision and reconstruction. Consequently, nephrometry scores and, above all, the corresponding group categories could better correlate with perioperative outcomes than the tumor dimension alone. In the same way, the need of UCS closure and the postoperative complications may be directly correlated to the complexity of renal tumors, , as well shown by the present paper.

The present paper is not devoid of limitations. Firstly, pre-operative CT images have not been re-evaluated by a single physician, thus potentially biasing the assignment of nephrometric scores. Secondly, different surgeons, with different level of expertise in RAPN operated the patients and this could impact on many perioperative outcomes. However, those issues turn out to increase external validity and reproducibility of our results. Thirdly nephrometry scores do not take into account other patient factors such as BMI and perinephric fat adherence, which could affect surgical outcomes and may differ between centres and nephrometry categories. Finally, the study population might be relatively small, which could effect on the final results.

In this multi-institutional, international RAPN series, we showed the potential associations among RENAL and PADUA scoring systems and perioperative outcomes and postoperative complications. A slightly higher accuracy in the estimation of prolonged WIT and high-grade postoperative complications, although not statistically significant, was found for the PADUA score. Accordingly, an accurate stratification of patients should be always done, thus balancing the potential threats and benefits of a conservative surgery in each patient with renal tumor suitable for partial nephrectomy.

Acknowledgements

This research was partially supported by the grant of the project titled ""Presupposti e prospettive per lo sviluppo della chirurgia robot-assistita in Regione Emilia Romagna" (Cod. CUP E35J11000410002). We also acknowledge the Vattikuti Foundation.

References

1. Campbell SC, Novick AC, Belldegrun A et al. Guideline for management of the clinical T1 renal mass. J Urol 2009;182:1271-9.
2. MacLennan S, Imamura M, Lapitan MC et al. Systematic review of oncological outcomes following surgical management of localized renal cancer. Eur Urol 2012;61:972-993.
3. Van Poppel H, Da Pozzo L, Albrecht W et al. A prospective, randomised EORTC intergroup phase 3 study comparing the oncologic outcome of elective nephron-sparing surgery and radical nephrectomy for low-stage renal cell carcinoma. Eur Urol 2011;59:543-552.
4. Kim SP, Thompson H, Boorjan SA et al. Comparative effectiveness for survival and renal function of partial and radical nephrectomy for localized renal tumors: a systematic review and meta-analysis. J Urol 2012;188:51-57.
5. Scosyrev E, Messing EM, Sylvester R et al. Renal Function After Nephron-sparing Surgery Versus Radical

Nephrectomy: Results from EORTC Randomized Trial 30904. Eur Urol. 2013 Jul 2. pii: S0302-2838(13)00659-3. doi: 10.1016/j.eururo.2013.06.044.

6. Hadjipavlou M, Khan F, Fowler S et al. Partial vs radical nephrectomy for T1 renal tumours: an analysis from the British Association of Urological Surgeons Nephrectomy Audit. BJU Int. 2015 Mar 6. doi: 10.1111/bju.13114.
7. Borghesi M, Schiavina R, Gan M et al. Expanding utilization of robotic partial nephrectomy for clinical T1b and complex T1a renal masses. World J Urol. 2013 Jun;31(3):499-504
8. Shiroki R, Fukami N, Fukaya K, Kusaka M, Natsume T, Ichihara T, Toyama H.:Robot-assisted partial nephrectomy: Superiority over laparoscopic partial nephrectomy. Int J Urol. 2015 Nov 20. doi: 10.1111/iju.13001. [Epub ahead of print] Review.
9. Schiavina R, Mari A, Antonelli A et al. A snapshot of nephron-sparing surgery in Italy: a prospective, multicenter report on clinical and perioperative outcomes (the RECORd 1 project). Eur J Surg Oncol. 2015 Mar;41(3):346-52.
10. Mottrie A, Borghesi M, Ficarra V. Is traditional laparoscopy the real competitor of robot-assisted partial nephrectomy? Eur Urol. 2012 Dec;62(6):1034-6; discussion 1038-9.
11. Volpe A, Garrou D, Amparore D et al. Perioperative and renal functional outcomes of elective robot-assisted partial nephrectomy (RAPN) for renal tumours with high surgical complexity. BJU Int. 2014 Dec;114(6):903-9.
12. Volpe A, Blute ML, Ficarra V et al. Renal Ischemia and Function After Partial Nephrectomy: A Collaborative Review of the Literature. Eur Urol. 2015 Jul;68(1):61-74.
13. Kutikov A, Uzzo RG. The R.E.N.A.L. nephrometry score: a comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 2009; 182:844-853.
14. Ficarra V, Novara G, Secco S et al. Preoperative aspects and dimensions used for ana anatomical (PADUA) classification of renal tumors in patients who are candidates for nephron-sparing surgery. Eur Urol 2009; 56:786-793.
15. Samplaski MK1, Hernandez A, Gill IS, Simmons MN: C-index is associated with functional outcomes after laparoscopic partial nephrectomy. J Urol. 2010; 184(6):2259-63

16. M. Spaliviero, B.Y. Poon, C.A. Karlo, et al.: An arterial based complexity (ABC) scoring system to assess the morbidity profile of partial nephrectomy. Eur Urol, 69 (2016), pp. 72
17. Borghesi M. Della Mora L. Brunocilla E et al. Warm ischemia time and postoperative complications after partial nephrectomy for renal cell carcinoma. Actas Urol Esp. 2014 Jun;38(5):313-8.
18. Kwon T, Jeong IG, Ryu J et al. Renal Function is Associated with Nephrometry Score After Partial Nephrectomy: A Study Using Diethylene Triamine Penta-Acetic Acid (DTPA) Renal Scanning. Ann Surg Oncol. 2015 Mar 19. [Epub ahead of print].
19. Bylund JR, Gayheart D, Fleming T et al. Association of tumor size, location, R.E.N.A.L., PADUA and centrality index score with perioperative outcomes and postoperative renal function. J Urol. 2012 Nov;188(5):1684-9.
20. Ficarra V, Bhayani S, Porter J et al. Predictors of warm ischemia time and perioperative complications in a multicenter, international series of robot-assisted partial nephrectomy. Eur Urol. 2012 Feb;61(2):395-402.
21. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a color of 6336 patients and result of a survey. Ann Surg. 2004; 240: 205-213.
22. Edge SB, Byrd DR, Compton CC et al. AJCC Cancer Staging Manual. 7th ed. New York: Springer-Verlag; 2009.
23. Kovacs G, Akhtar M, Beckwith BJ et al. The Heidelberg classification of renal cell tumours. J Pathol. 1997 Oct;183(2):131-3.
24. Fuhrman SA, Lasky LC, Limas C et al. Prognostic significance of morphologic parameters in renal cell carcinoma. Am J Surg Pathol. 1982 Oct;6(7):655-63.
25. Hou W, Yan W, Ji Z. Anatomic features involved in technical complexity of partial nephrectomy. Urology. 2015 Jan;85(1):1-7.
26. Klatte T, Ficarra V, Gratzke C et al. A Literature Review of Renal Surgical Anatomy and Surgical Strategies for Partial Nephrectomy. Eur Urol. 2015 Apr 21. pii: S0302-2838(15)00312-7. doi: 10.1016/j.eururo.2015.04.010.
27. Desantis D, Lavallée LT, Witiuk K et al. The association between renal tumour scoring system components and complications of partial nephrectomy. Can Urol Assoc J. 2015 Jan-Feb;9(1-2):39-45.
28. Long JA, Arnoux V, Fiard G et al. External validation of the RENAL nephrometry score in renal tumours treated

by partial nephrectomy. BJU Int. 2013 Feb;111(2):233-9.

29. Ellison JS, Montgomery JS, Hafez KS et al. Association of RENAL nephrometry score with outcomes of minimally invasive partial nephrectomy. Int J Urol. 2013 Jun;20(6):564-70.

30. Borghesi M. Della Mora L. Brunocilla E et al. Warm ischemia time and postoperative complications after partial nephrectomy for renal cell carcinoma. Actas Urol Esp. 2014 Jun;38(5):313-8.

31. Zhang ZY, Tang Q, Li XS et al. Clinical analysis of the PADUA and the RENAL scoring systems for renal neoplasms: A retrospective study of 245 patients undergoing laparoscopic partial nephrectomy. Int J Urol. 2014 Jan;21(1):40-4.

Table 1: Clinical and pathological characteristics of the 277 patients.

Variable	
Median age (years) (IQR)	60 (49-68)
Gender (%)	
Male	183 (66.1)
Female	94 (33.9)
Charlson comorbidity index (%)	
≤2	181 (65.3)
>2	96 (34.7)
Indication for NSS (%)	
Elective*	243 (87.7)
Relative imperative#	15 (5.4)
Imperative§	19 (6.9)
Median clinical size (mm) (IQR)	33.0 (22.0-43.0)
Clinical tumor size (mm)	
≤4.0	181 (65.3)
4.1-7.0	93 (33.6)
≥7	3 (1.1)
Median PADUA score (IQR)	8 (7-10)
6-7	112 (40.4)
8-9	86 (31.0)
>9	79 (28.5)
Median RENAL score (IQR)	7 (5-8)
3-6	118 (42.6)
7-9	139 (50.2)
>9	20 (7.2)
Median WIT (min) (IQR)	17.0 (13.0-22.0)

Median console time (min) (IQR)	140 (119-187)
Median intraoperative estimated blood loss (ml) (IQR)	150 (80-250)
Packed red blood cells (%)	
1 unit	63 (22.7)
>1 unit	1 (0.4)
Urinary collecting system closure (%)	131 (47.3)
Median pathological size (mm)	30.0 (20.0-40.0)
Histological subtype (%)	
Benign	49 (17.6)
Clear cell	165 (59.6)
Papillary	41 (14.8)
Chromophobe	22 (7.9)
Pathological T stage in RCC (%)	
pT1a	166 (72.3)
pT1b	39 (17.1)
pT2a	3 (1.3)
pT3a	20 (8.8)
Positive surgical margins in RCC (%)	10 (4.4)

*RAPN performed in patients with contralateral healthy kidney

RAPN performed in patients in which the contralateral kidney has pre-existing renal disease, or its future function is threatened

§RAPN performed in patients with an anatomically or functionally solitary kidney.

Table 2: Distribution of the 277 patients in the three groups of PADUA and RENAL scoring systems

PADUA classification	**RENAL classification**		
	Low complexity (n=118; 42.6%)	**Intermediate complexity (n=139; 50.2%)**	**High complexity (n=20; 7.2%)**
Low complexity (n=112; 40.4%)	91 (32.8%)	20 (7.2%)	1 (0.3%)
Intermediate complexity (n=86; 31.0%)	25 (9%)	61 (22%)	0 (0%)
High complexity (n=79; 28.5%)	2 (0.7%)	58 (20.9%)	19 (6.9%)

Table 3 : Perioperative and postoperative outcomes according to the three groups of PADUA and RENAL scoring system.

Covariate	PADUA score			P value
	Low complexity	Intermediate complexity	High complexity	
Mean WIT, min (continuous)	14.9±8.0	18.6±6.4	20.3±9.3	<0.001
WIT >20 min (%)	21 (18.8)	30 (34.9)	30 (38.0)	0.003
Urinary calyceal system closure (%)	37 (33.0)	46 (53.5)	48 (60.8)	<0.001
Console time, min (continuous)	141.0±60.6	145.8±51.6	175±68.8	<0.001
Blood loss, ml (continuous)	193.6±222.7	191.1±183.4	239.5±249.3	0.275
Any grade postop. complications (%)	12 (10.7)	20 (23.3)	12 (15.2)	0.295
High grade postop. complications (%)	4 (3.6)	5 (5.8)	9 (11.4)	0.034
	RENAL score			P value
	Low complexity	Intermediate complexity	High complexity	
Mean WIT, min (continuous)	16.1±8.0	17.8±7.7	24.7±9.4	<0.001
WIT >20 min (%)	29 (24.6)	39 (28.1)	13 (65.0)	0.006
Urinary calyceal system closure (%)	30 (32.2)	80 (57.6)	13 (65.0)	<0.001
Console time, min (continuous)	134.0±59.2	165.5±61.4	169.3±57.2	<0.001
Blood loss, ml (continuous)	177.2±178.5	224.3±233.3	243.0±318.8	0.164
Any grade postop. complications (%)	13 (11.0)	25 (18.0)	6 (30.0)	0.021
High grade postop. complications (%)	5 (4.2)	9 (6.5)	4 (20.0)	0.032

Table 4: Intraoperative and postoperative complications in the 277 patients.

	Type of complication	**Treatment**	**Clavien grade**
Intraoperative (12, 4.0%)	6 Major bleeding from the tumor bed 1 Major bleeding from the tumor bed 1 Major bleeding from the tumor bed 3 Lesion of major vessels 1 splenic injury	Intraoperative repair Conversion to open Conversion to robotic RN Intraoperative repair Intraoperative repair	N/A
Postoperative (43, 15.5%)	2 cardiovascular 3 chylous leak 13 fever 7 hematoma	2 medical treatment 3 parenteral nutrition and diet 13 antibiotics 7 transfusions	Grade 2 (n=25)
	7 bleeding 6 urine leak 2 bowel occlusion	2 reintervention* 5 embolization 6 stent 2 reintervention#	Grade 3 (n=15)
	1 MI 2 pneumonia	1 intensive care unit 2 intensive care unit	Grade 4 (n=3)
	-	-	Grade 5 (n=0)

*laparoscopic surgical revision and suturing of the parenchymal defect

#cutting of small bowel adhesions by open surgical exploration

Table 5. Univariable and multivariable analysis evaluating of the correlations with long WIT (> 20 minutes) (a), need for UCS repair (b), any grade of postoperative complications (c) and grade 3-4 postoperative complications (d).

a.

WIT > 20 min	**Univariable analyses**		**Multivariable analysis with PADUA score**		**Multivariable analysis with RENAL score**	
	OR (95%CI)	**P value**	**OR (95%CI)**	**P value**	**OR (95%CI)**	**P value**
Age	0.983 (0.478-1.432)	0.091	-	-	-	-
Gender (female vs. male)	0.822 (0.964-1.004)	0.488	-	-	-	-
CCI (1-2 vs >2)	0.851 (0.491-1.475)	0.565	-	-	-	-
Clinical size	1.037 (1.018-1.057)	<0 001	-	-	-	-
PADUA score						-
6-7	1	ref	1	ref	-	
8-9	2.321 (1.213-4.444)	0.011	2.321 (1.213-4.444)	0.011		
10-14	2.653 (1.375-5.118)	0.004	2.653 (1.375-5.118)	0.004		
R.E.N.A.L. score			-	-		
3-6	1	ref			1	ref
7-9	1.197 (0.684-2.093)	0.529			1.197 (0.684-2 093)	0 529
10-12	5.700 (2.076 -15.647)	0.001			5.700 (2.076 -15.647)	0 001

b.

UCS repair	**Univariable analyses**		**Multivariable analysis with PADUA score**		**Multivariable analysis with RENALscore**	
	OR (95%CI)	**P value**	**OR (95%CI)**	**P value**	**OR (95%CI)**	**P value**
Age	0.991 (0.973-1.1.010)	0.374	-	-	-	-
Gender (female vs. male)	0.538 (0.323-0.894)	0.017	0 547 (0.324-0.924)	0.024	0.597 (0.342-0.982)	0.043
CCI (1-2 vs.>2)	1.041 (0.896-1.210)	0.597	-	-	-	-

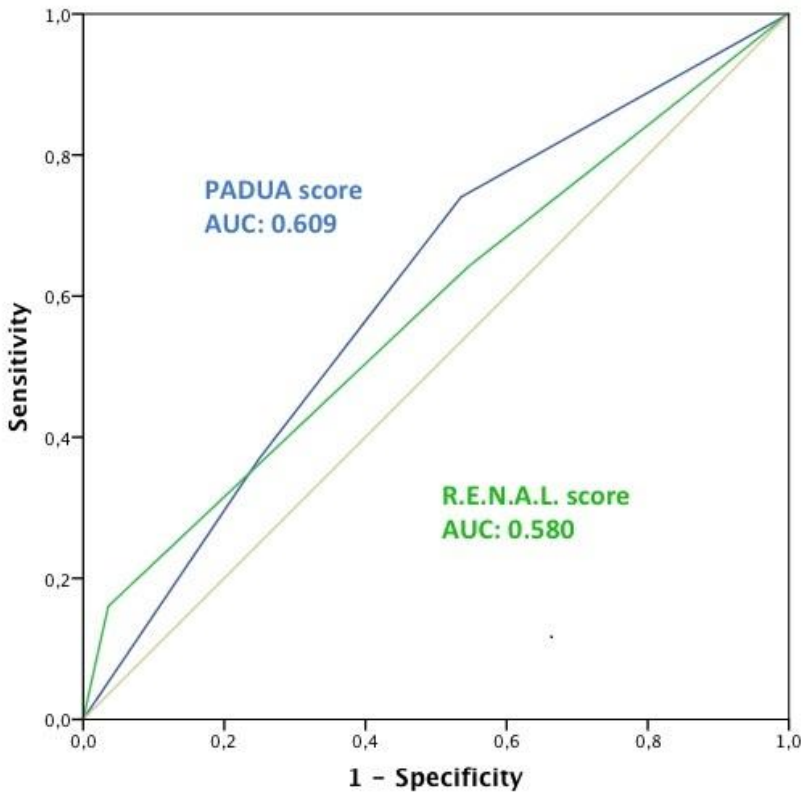
Clinical size	1.027 (1.009-1.045)	0.003	-	-	-	-
PADUA score 6-7 8-9 10-14	 1 2.331 (1.307-4.157) 3.139 (1.724-5.714)	 ref 0.004 <0 001	 1 2 329 (1.299-4.177) 3 090 (1.688-5.657)	 ref 0.005 <0.001	-	-
R.E.N.A.L. score 3-6 7-9 10-12	 1 2.855 (1.711-4.764) 3.910 (1.443 -10.593)	 ref <0 001 0.007	-	-	 1 2.801 (1.672-4.692) 2.491 (1.277 -9.548)	 ref 0.015 0.043

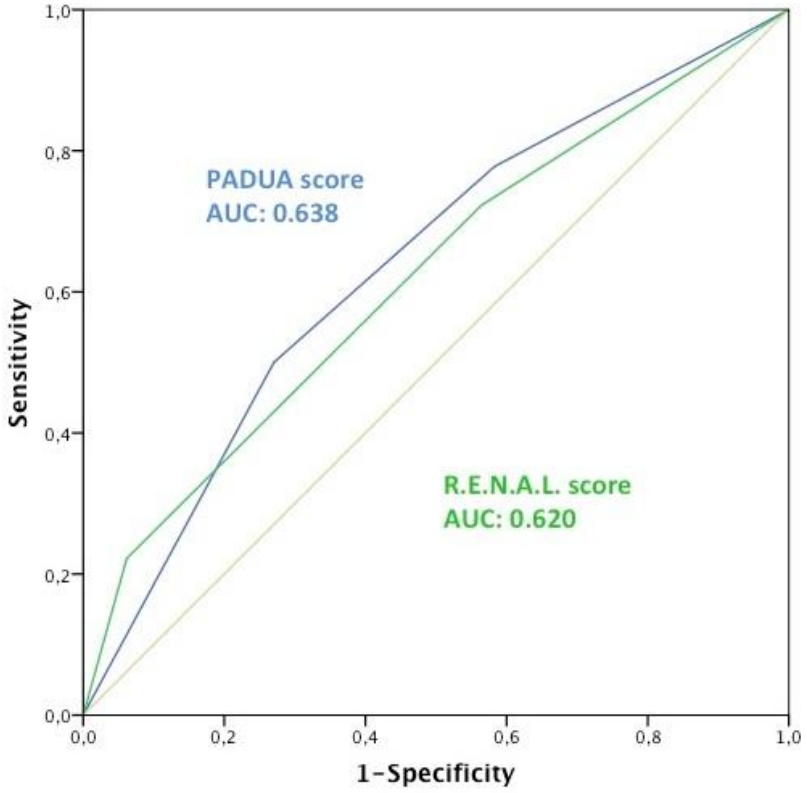
C.

Any grade postoperative ations	**Univariable analyses**		**Multivariable analysis with PADUA score**		**Multivariable analysis with RENAL score**	
	OR (95%CI)	**P value**	**OR (95%CI)**	**P value**	**OR (95%CI)**	**P value**
Age	1 022 (0.981-1.064)	0.298	-	-	-	-
Gender (female vs. male)	1258 (0471-3359)	0.647	-	-	-	-
CCI (1-2 vs.>2)	1 237(0.932-1641)	0.141	-	-	-	-
Clinical size	1 031 (0.968-1.061)	0.069	-	-	-	-
PADUA score 6-7 8-9 10-14	 1 1.667 (0.434-6.403) 3.471 (1.029-11.707)	 ref 0.457 0.045	 1 1.667 (0.434-6.403) 3.471 (1.029-11.707)	 ref 0.457 0.045	-	-
R.E.N A.L. score 3-6 7-9 10-12	 1 1 565 (0.510-4.884) 5.650 (1.372-23.262)	 ref 0.434 0.016	-	-	 1 1.565 (0.510-4.884) 5.650 (1.372-23.262)	 ref 0.434 0 016

d.

Grade 3-4 postoperative ations	**Univariable analyses**		**Multivariable analysis with PADUA score**		**Multivariable analysis with RENAL score**	
	OR (95%CI)	**P value**	**OR (95%CI)**	**P value**	**OR (95%CI)**	**P value**
Age	0 983 (0.478-1.432)	0.091	-	-	-	-
Gender (female vs. male)	0 822 (0.964-1.004)	0.488	-	-	-	-
CCI (1-2 vs.>2)	0 851 (0.491-1.475)	0.565	-	-	-	-
Clinical size	1 037 (1.018-1.057)	<0.001	-	-	-	-
PADUA score					-	-
6-7	1	ref	1	ref		
8-9	2 321 (1.213-4.444)	0.011	2 321 (1.213-4.444)	0.011		
10-14	2.653 (1.375-5.118)	0.004	2.653 (1.375-5.118)	0.004		
R.E.N A.L. score			-	-		
3-6	1	ref			1	ref
7-9	1.197 (0.684-2.093)	0.529			1.197 (0.684-2 093)	0.529
10-12	5.700 (2.076 -15.647)	0.001			5.700 (2.076 -15.647)	0.001


PADUA score
AUC: 0.609
R.E.N.A.L. score
AUC: 0.580
Sensitivity
1 - Specificity
0,0
0,2
0,4
0,6
0,8
1,0


PADUA score
AUC: 0.638
R.E.N.A.L. score
AUC: 0.620
Sensitivity
1-Specificity
0,0
0,2
0,4
0,6
0,8
1,0