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Predicting positive surgical margins in patients treated with robot-assisted partial nephrectomy: results from a prospectively maintained dataset of a single tertiary referral center

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Abstract

Aim: To identify the incidence and evaluate predictors of positive surgical margins (PSMs) after robot-assisted partial nephrectomy (RAPN) in patients with clinical T1 renal cell carcinoma (RCC).

Methods: After securing ethics committee approval, we analyzed our institution's prospectively maintained RCC database. Our cohort included 1611 patients who underwent RAPN between January 2017 and December 2022. Surgical specimens were evaluated using standard practices, and the International Society of Urological Pathology (ISUP) grading system was employed.

Results: The majority (69.5%) of the 1,611 patients were males. Median age and Body Mass Index were 62.6 years and 26.9 kg/m^2, respectively. Overall, 18.6% and 21.1% of the patients had an Eastern Cooperative Oncology Group

(ECOG) score ≥ 1 and American Society of Anesthesiologists physical status (ASA PS) score ≥ 3, respectively. Surgical indications were elective in 90.5% of cases. The preoperative aspects and dimensions used for an anatomical (PADUA) score median was 8.0 (interquartile range: 7.0-9.5). The predominant histotype was clear cell RCC, accounting for 70.4% of the cohort. PSMs were detected in 6.7% of the patients. Multivariable logistic regression showed surgical indications with an odds ratio (OR) of 6.06 ($P < 0.001$), surface, intermediate, base (SIB) score > 1 with an OR of 2.37 ($P = 0.001$), and PADUA score with an OR of 1.10 ($P = 0.006$) were significant predictors of PSMs.

Conclusion: Attaining negative margins remains the oncological cornerstone of partial nephrectomy. Our data underscore that tumor-specific (PADUA score) and surgical parameters (imperative indication, SIB score > 1, off-clamp approach) are the principal determinants for PSMs after RAPN.

Keywords: Partial nephrectomy, positive margin, predictors, renal cancer, robotics

INTRODUCTION

Partial nephrectomy (PN) has been widely accepted as the preferred treatment for patients with clinical T1 renal cell carcinoma (RCC)[1]. This method not only offers the advantage of preserving renal function but also has oncologic outcomes similar to radical nephrectomy[2,3]. However, one challenge in PN is the potential for positive surgical margins (PSMs). PSM rates after PN have been reported to range from 0% to 10%[4]. This risk appears to be higher in surgeries involving smaller, high-grade tumors or those considered imperative, regardless of the surgical approach used[5,6].

The implications of PSMs on cancer recurrence and patient survival are still debated among experts. While some studies suggest that local tumor recurrence is more common in cases with PSMs, especially for inherently aggressive tumors, others find minimal impact of PSMs on cancer-specific survival[7,8]. Given the lengthy progression of T1 RCC after surgery, the PSM could be used as a surrogate of oncologic outcome after surgery, and, as such, it is an essential measure for evaluating outcomes after PN. Evidence suggests that patients with PSMs might experience reduced overall survival; however, other factors related to patient characteristics, such as age and comorbidities, and tumor characteristics, such as tumor fat invasion and nucleolar grade, might play a role[9]. In the current literature, there is a noticeable gap in models designed to predict the likelihood of PSMs after PN.

The present study aims to fill this gap by identifying predictors of PSMs after PN based on data from a prospectively maintained database of a tertiary referral center.

METHODS

Population data

After obtaining approval from the ethics committee, we accessed and examined our continuously updated institutional RCC database, which was maintained prospectively. From this database, we specifically analyzed 1611 patients who underwent robot-assisted PN (RAPN) between January 2017 and December 2022. Patient characteristics, such as age, gender, Body Mass Index (BMI), and comorbidity status, were documented. This included the Charlson Comorbidity Index (CCI) assessment, among others.

The principles of SIB (Surface, Intermediate, Base) score assignment have been previously described[10,11]. In summary, post-operative examination allowed the medical practitioner to demarcate the Circumferential Surface, Intermediate, and Base meta-zones within the intrarenal section of the PN specimen. Subsequently, the domain with the most minimal boundary (named score-specific area) within each meta-zone was

discerned. Points, varying from zero to two, were allocated depending on the robustness of the healthy renal boundary extracted concomitant with the tumor (absence of visibly discernible healthy renal boundary versus a slim healthy renal boundary versus an abundant healthy renal boundary). Thereafter, the comprehensive resection technique (RT) was categorized into enucleation (SIB grade 0-2), enucleoresection (SIB grade 3-4), or resection (SIB grade 5). Surgical indications were characterized as elective (localized singular RCC with a normal opposite kidney), relative (localized singular RCC with concomitant conditions such as diabetes, hypertension, and lithiasis that might potentially influence renal functionality in subsequent periods), and imperative (bilateral synchronous tumors, multiple tumors, moderate to severe chronic kidney disease, or in scenarios of malignancy compromising an anatomically or functionally solitary kidney).

The Preoperative Aspects and Dimensions Used for an Anatomical (PADUA) Classification of Renal Tumors was used to evaluate the nephrometric complexity of each renal mass. All research activities in this study involving human participants adhered to the ethical standards of our institution and national research guidelines and were consistent with the 1964 Helsinki Declaration and subsequent amendments. Every participant in the study gave informed consent.

Pathological evaluation and outcome

Surgical specimens were processed based on the standard practices at our institution, evaluated by expert uropathologists. Each specimen underwent a detailed examination, including marking the surgical margins (SMs) with ink and assessing the tumor's size, color, and gross appearance. There was no centralized review of pathological slides.

The primary objective of this study was to determine the incidence and identify factors predicting PSMs after RAPN. In the assessment of SMs, specimens underwent preservation in 10% buffered fixative. These were then subjected to extended macroscopic examination. Parameters such as dimensions, chromatic features, and overall appearance (ranging from solidified to vesicular) were documented. The SM was delineated using a colorant solution. Following the meticulous segmentation of the tumor, sections were derived to secure tissue fragments from the tumor site, uninvolved tissue, and adjacent surgical boundaries. Additional fragments encompassing the tumor, organ protective layer, and surrounding adipose tissue were incorporated. A margin was designated as positive if tumor cells interacted with the colorant. Conversely, the margin was classified as non-affirmative when malignant renal structures were absent from the colorant-marked boundaries. The neoplasms underwent hierarchical categorization, in line with the criteria established by the American Joint Committee on Cancer tumor, node, metastases classification standards[12].

Statistical analysis

For statistical purposes, descriptive statistics were obtained, reporting medians [and interquartile ranges (IQR)] for continuous variables and frequencies and proportions for categorical variables, as appropriate. Multivariable logistic regression models considering factors significantly related to margins status at univariable analysis were applied to analyze predictors of PSMs. Statistical significance in this study was set as $P < 0.05$. All reported P values are 2-sided. Two different multivariable models were built, including various baseline clinical and intraoperative surgical features. Analyses were performed using Statistical Package for Social Sciences (SPSS) version 29.0.2.0 (SPSS Inc, Chicago, IL).

RESULTS

From the 1,611 patients analyzed, Table 1 presented the demographic and clinical characteristics, with 1,120 (69.5%) males and 491 (30.5%) females. The median age was 62.6 years, with an IQR of 54.7 to 72.0 years.

Table 1. Preoperative characteristics of 1,611 patients treated with partial nephrectomy for RCC

Preoperative characteristics (*n* = 1,611)			
Gender	• Male	1,120	69.5%
	• Female	491	30.5%
Age (years)		62.6	54.7-72.0
BMI (kg/m^2)		26.9	23.9-28.8
EcoG score	• ≥ 1	299	18,6%
ASA PS	• ≥ 3	340	21.1%
CCI PS score		1	0-2
AA-CCI PS score		3	2-5
Surgical indication	• Elective	1,458	90.5%
	• Relative	207	12.8%
	• Imperative	54	3.4%
Tumor side *n.* %	• Right	811	51.4%
	• Left	800	48.6%
Clinical T *n.* %	• T1a	1,485	71.5%
	• T1b	539	26.0%
	• T2	52	2.5%
Tumor growth pattern	• ≥ 50% exophytic	829	51.5%
	• < 50% exophytic	641	39.8%
	• Entirely endophytic	141	8.8%
Tumor location relative to the PL	• Entirely above PL	790	49.0%
	• ≤ 50% crosses PL	584	36.3%
	• > 50% crosses PL	237	14.7%
Nearingness to the collecting system	• ≥ 7 mm	875	54.3%
	• > 4 but < 7 mm	317	19.7%
	• ≤ 4 mm	419	26.0%
Hilar tumor, *n.* %		171	10.6%
PADUA score, median IQR		8.0	7.0-9.0
PADUA score complexity index	• 6-7	776	48.2%
	• 8-9	561	34.8%
	• ≥ 10	274	17%
Baseline hemoglobin (mg/dL), median (IQR)		14.3	13.3-15.2
Baseline creatinine (mg/dL), median (IQR)		0.9	0.8-1.1
Baseline eGFR (mL/min), median IQR		84.6	69.5-100.4

RCC: Renal cell carcinoma; BMI: Body Mass Index; EcoG: Eastern Cooperative Oncology Group; ASA PS: American Society of Anesthesiologists physical status; CCI PS: Charlson Comorbidity Index physical status; PL: polar line; PADUA: preoperative aspects and dimensions used for an anatomical; IQR: interquartile ranges; eGFR: estimated glomerular filtration rate.

The BMI had a median of 26.9 kg/m^2 (IQR: 23.9-28.8), and 299 (18.6%) patients had an Eastern Cooperative Oncology Group (ECOG) score ≥ 1. American Society of Anesthesiologists physical status (ASA PS) score ≥ 3 was noted in 340 (21.1%) of the patients. The median CCI was 1 (IQR: 0-2), while the median age-adjusted CCI performance status (AA-CCI PS) score was 3 (IQR: 2-5). Regarding surgical indication, 1,458 (90,5%) were elective, 207 (12.8%) were relative, and 54 (3.4%) were imperative. For the tumor side, 811 (51.4%) were on the right and 800 (48.6%) were on the left.

The PADUA score median was 8.0 (IQR: 7.0-9.5). Baseline hemoglobin, creatinine, and estimated glomerular filtration rate (eGFR) were 13.9 mg/dL (IQR: 13.3-15.2), 0.9 mg/dL (IQR: 0.8-1.1), and 84.6 mL/min (IQR: 69.5-100.4), respectively.

In Table 2, surgical details and histopathology were reported. Pedicle clamping showed 217 (13.5%) patients were off-clamp and 1,394 (86.5%) were on-clamp. The median warm ischemia time was 16 min (IQR: 10-21). A retroperitoneal access was employed in 138 (8.5%) patients. Clear cell RCC was the predominant histotype, seen in 1,134 (70.4%) patients. SIB score distribution revealed that 1,129 (70.1%) patients had a score of 0-2, 468 (29%) had a score of 3-4, and 14 (0.9%) had a score of 5. The PSM was observed in 109 (6.7%) patients.

Table 3 displayed two models of the multivariable logistic regression analysis.

In the initial model, imperative surgical indication exhibited an OR of 6.06 (95%CI: 2.58-14.22, $P < 0.001$). SIB > 1 had an OR of 2.37 (95%CI: 1.43-3.92, $P = 0.001$), and off-clamp tumor resection demonstrated an OR of 3.00 (95%CI: 1.41-6.39, $P = 0.004$). The PADUA score resulted in an OR of 1.10 (95%CI: 1.03-1.17, $P = 0.006$). Age and the American Society of Anesthesiologists (ASA) score did not show statistical significance at multivariable analysis. In the second model, the PADUA score was replaced by collecting system tumor compression as a significant predictor (OR 1.34, 95%CI 1.12-1.84, $P = 0.001$), while tumor diameter did not reach significance at multivariable analysis.

DISCUSSION

In oncology surgical practices, the comprehensive excision of tumors significantly influences the surgical efficacy. In PN, notwithstanding the absence of consistent consensus in clinical studies, a heightened likelihood of local recurrence appears to be associated with patients presenting PSMs[13]. It is pertinent to highlight that empirical evidence from various research studies indicates an elevated risk of recurrence for patients with PSMs, especially in the context of high-risk tumors characterized by determinants that intrinsically exhibit a pronounced relapse potential, such as escalated tumor dimensions, pT3a stage, and elevated grading[14,15]. Conversely, in primary tumors of a lower grade, PSMs are postulated to exhibit reduced malignant potential owing to a diminished rate of cancer progression[16]. Furthermore, the obliteration of malignant cells due to coagulation, mechanical perturbations, or induced ischemic damage during nephron-sparing surgery (NSS) might curtail the persistence and proliferation of neoplastic cells at the excision margin[17].

In our study involving 1,611 patients, demographic and clinical characteristics were extensively analyzed. Notably, 109 (6.7%) of them had PSMs. Within the realm of surgical oncology, understanding the influence of various factors on outcomes, especially when dealing with PSMs, is crucial. Our multivariable logistic regression analysis to detect clinical predictive factors associated with a higher rate of PSMs revealed several pivotal findings.

The SIB score is an evaluative measure derived post-surgery that standardizes the thickness of healthy renal margins assessment around the tumor. In simple terms, it categorizes specimens into enucleation, enucleoresection, or resection based on the aggregate score of three distinct macro-areas. Our analysis highlighted a notable odds ratio (OR) of 2.37 for SIB > 2 ($P = 0.001$), highlighting its consequential influence on PSMs. The reason for such a result warrants an in-depth analytical discussion: indeed, the uncomplicated enucleation of the tumor along the pseudocapsule, in contrast to a conventional excision of the adjacent healthy parenchyma, might allow for better respect of the natural cleavage plane. This approach reduces the risk of inadvertently penetrating the neoplasm, especially in instances of anomalous configurations, and inadvertently leaving remnants of the SM.

Table 2. Perioperative and pathologic characteristics of 1,611 patients treated with partial nephrectomy for RCC

Perioperative characteristics (*n* = 1,611)			
Pedicle clamping	• Off-clamp	217	13.5%
	• On-clamp	1,394	86,5%
	• Warm ischemia time, median IQR	16	10-21
Surgical access	• Retroperitoneal	138	8.5%
	• Transperitoneal	1,473	91.5%
SIB score	• 0-2	1,129	70.1%
	• 3-4	468	29.0%
	• 5	14	0.9%
Histotype	• Clear cell RCC	1,134	70.4%
	• Papillary RCC	314	19.5%
	• Chromophobe RCC	148	9,2%
	• Unclassified RCC	2	0.1%
	• Other renal tumors	175	10.9%
Pathological T stage	• pT1a	1,190	73.9%
	• pT1b	496	29.1%
	• pT2	31	1.9%
	• pT3a	117	7.3%
Nucleolar grading G1-G4		2	2-3
Positive surgical margins		109	6.7%

RCC: Renal cell carcinoma; IQR: interquartile ranges; SIB: surface, intermediate, base.

Table 3. Multivariable analysis to predict the risk of positive surgical margins in 1611 patients treated with partial nephrectomy for RCC

Variable	Model 1			Model 2		
	OR	95%CI	*P*	OR	95%CI	*P*
Imperative indication	6.06	2.58-14.22	< 0.001	6.81	2.32-17.69	< 0.001
SIB > 2	2.37	1.43-3.92	0.001	2.29	1.51-3.48	< 0.001
Off-clamp tumor resection	3.00	1.41-6.39	0.004	2.64	1.26-5.53	0.01
Age	1.01	0.99-1.02	0.14	1.01	0.98-1.02	0.28
ASA score (cont. variable)	1.11	0.82-1.50	0.47	1.64	0.78-1.62	0.54
PADUA score	1.10	1.03-1.17	0.006	-	-	-
Collecting system tumor compression	-	-	-	1.34	1.09-2.84	0.001
Tumor diameter (cont. variable)	-	-	-	1.09	0.84-1.49	0.36

RCC: Renal cell carcinoma; OR: odds ratio; SIB: surface, intermediate, base; ASA: American Society of Anesthesiologists; PADUA: preoperative aspects and dimensions used for an anatomical.

Surgical indications allow for the classification of cases based on the necessity and background of the surgical procedure. They range from elective, for standard cases of unilateral RCC, to imperative, in more pressing situations such as bilateral tumors or when dealing with a solitary kidney[18]. In the multivariable assessment, imperative surgical indications registered a substantial OR of 6.06 ($P < 0.001$), underscoring its indispensable role in shaping surgical outcomes.

The PADUA Classification, which offers a gradation system for nephrometric complexity of renal tumors, is an instrumental determinant for surgical planning[19]. PADUA score was significantly associated with PSMs. This aspect has already been underscored in other multicentric cohorts[20], highlighting the necessity for careful management due to the higher risk associated with complex masses. To better evaluate which

nephrometric aspects could be associated with a higher risk of PSMs, an additional multivariable analysis was conducted, excluding the PADUA score and including tumor dimension and collecting system compression, which showed significant associations with PSMs in univariate analysis. These factors were consequently included in our multivariable analysis model, and it showed collecting system tumor compression as a significant predictor (OR 1.34, 95%CI 1.12-1.84, $P = 0.001$).

Among intraoperative surgical factors, off-clamp tumor resection held notable significance with an OR of 3.00 in the PSM prediction, reinforcing its critical role in the outcome[21]. The choice to opt for off-clamp tumor resection in surgeries, while advantageous in some scenarios, presents its own set of challenges[22]. The off-clamp approach may compromise the surgeon's visual field, obscuring the clear delineation of structures and potentially decreasing the quality of the resection[23]. Some experts advocate for optimal hilar clamping specifically to circumvent this limitation. However, it is imperative to note that the literature offers varying perspectives on the matter: in fact, some systematic reviews examining the potential impact of renal pedicle management techniques on partial nephrectomies have found that the specific technique employed - whether clamping or not - does not necessarily influence surgical or oncological outcomes[24]. This suggests that while visualization and surgical field clarity are undoubtedly crucial, other factors, skills, and methodologies also play pivotal roles in determining the surgery's success[25].

In discussing these results, achieving tumor-free margins during PN is an essential oncological goal, with implications for surgical success. While literature suggests varying views, local recurrence appears more probable in patients with PSMs, particularly in the context of high-risk tumor characteristics[14]. In contrast, low-grade primary tumors exhibit less aggressive PSM potential due to their slower cancer progression rate[15]. Some believe the possibility of tumor cell destruction during NSS might mitigate malignant cell proliferation at resection sites[16].

Another aspect that warrants attention is the influence of surgeon expertise and, more in general, the surgical caseload of the center on PSMs. The RECORD 2 study, in fact, underscored the significant contribution of the annual PN volume in influencing PSM outcomes, stressing the importance of centralization of this surgery in high-volume centers for this treatment[26]. Notwithstanding our meticulous approach, inherent limitations such as potential biases due to the absence of information about surgeon expertise and variations in surgical techniques across surgeons must be acknowledged[27,28].

Our study has inherent limitations. Firstly, although data collection was maintained prospectively in our internet-based platform, the nature of our retrospective analysis could introduce biases. Secondly, certain parameters such as clinical tumor size and deployment of intraoperative tools (e.g., ultrasound, near-infrared fluorescence) were unavailable in this database. Therefore, their potential influence on PSMs remains unexplored in this analysis. Novel technological advancements in robotic surgery and 3D modeling might further enhance surgical precision[29,30]. Thirdly, the unicentric nature of this study could present potential variation in practices and techniques. Fourthly, our research did not involve a centralized pathological review, which could introduce variability in the reporting of PSMs based on individual practices within the institution. Fifthly, we did not detail the specific experience or learning curve of each surgeon involved in the procedures. Consequently, we did not consider the potential variance in outcomes due to surgical experience, relying instead on the overall center caseload as an approximate metric of experience.

It remains crucial for our model's predictions concerning PSMs to be tested on other cohorts to ensure their applicability and relevance to a broader population undergoing PN.

In conclusion, the primary aim of PN, from an oncological perspective, is to secure negative margins. Based on our prospectively maintained dataset, tumor's (higher PADUA score and, in particular, collecting system tumor compression) and surgical (imperative indication, SIB score > 2 and off-clamp approach) features represent the main drivers for PSMs. Further study remains necessary to assess the implication of PSMs on survival outcomes.

DECLARATIONS

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Authors' contributions

Conceptualized and designed the study, coordinated the project, led data analysis and interpretation: Mari A
Assisted in conceptualizing and designing the study, contributed to data analysis and involved in manuscript drafting: Grosso A
Worked on data collection and preliminary data analysis and involved in drafting the manuscript: Coco S
Contributed to data collection, specifically in terms of patient interviews and helped manage the dataset: Cadenar A
Managed and organized data, assisted in data acquisition and validation: Bacchiani M
Conducted statistical analyses, involved in manuscript revision for intellectual content: Lambertini L
Drafted and revised manuscript, contributed to study design and literature review: Massaro E
Assisted in recruiting patients, contributed to data collection, helped draft clinical parts of the manuscript: Cianchi G
Responsible for organizing the data and supporting its storage and retrieval, involved in manuscript revision: Conte FL
Took part in the design of the study, specifically in the ethical considerations and methodology, reviewed and edited the manuscript: Sandulli A
Contributed to data analysis and interpretation, provided critical feedback and revisions to the manuscript: Salamone V, Di Maida F, Olivera L, Oriti R, Scelzi S
Contributed to data analysis and interpretation, was responsible for data quality control: Giudici S
Assisted in data collection and entry, contributed to statistical analysis: Mariottini R
Assisted in data collection and patient interviews, contributed to study design: Olivera L
Involved in data verification and quality control, assisted in preparing data for analysis: Vittori G
Involved in manuscript editing and proofreading, contributed to ethical considerations: Masieri L
Supervised the project, contributed to study design, analysis, and manuscript editing, provided final approval of the version to be published: Minervini A

Availability of data and materials

The data that support the findings of this study are available from Careggi Hospital but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of AOU Careggi Hospital - Comitato Area Vasta Centro.

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None.

Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of AOU Careggi Hospital and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethics committee approval was obtained from AOU Careggi Hospital - Comitato Area Vasta Centro. The approval has been registered by Regional Ethics Committee for Clinical Trials of Tuscany under the code: 16210_OSS. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

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REFERENCES

1. EAU. Renal cell carcinoma. Available from: https://uroweb.org/guidelines/renal-cell-carcinoma. [Last accessed on 30 May 2024].
2. Mari A, Di Maida F, Tellini R, et al. Oncologic outcomes in patients treated with endoscopic robot assisted simple enucleation (ERASE) for renal cell carcinoma: results from a tertiary referral center. *Eur J Surg Oncol* 2019;45:1977-82. DOI PubMed
3. Pecoraro A, Roussel E, Amparore D, et al. New-onset chronic kidney disease after surgery for localised renal masses in patients with two kidneys and preserved renal function: a contemporary multicentre study. *Eur Urol Open Sci* 2023;52:100-8. DOI PubMed PMC
4. Di Maida F, Campi R, Lane BR, et al. Predictors of positive surgical margins after robot-assisted partial nephrectomy for localized renal tumors: insights from a large multicenter international prospective observational project (the surface-intermediate-base margin score consortium). *J Clin Med* 2022;11:1765. DOI PubMed PMC
5. Grosso AA, Marin DM, Di Maida F, et al. Robotic partial nephrectomy with en bloc removal of a renal vein thrombus for multiple cT3a renal cell carcinoma lesions. *Eur Urol Open Sci* 2022;44:33-6. DOI PubMed PMC
6. Mari A, Tellini R, Porpiglia F, et al. Perioperative and mid-term oncological and functional outcomes after partial nephrectomy for complex (PADUA score ≥10) renal tumors: a prospective multicenter observational study (the RECORD2 Project). *Eur Urol Focus* 2021;7:1371-9. DOI PubMed
7. Tellini R, Antonelli A, Tardanico R, et al. Positive surgical margins predict progression-free survival after nephron-sparing surgery for renal cell carcinoma: results from a single center cohort of 459 cases with a minimum follow-up of 5 years. *Clin Genitourin Cancer* 2019;17:e26-31. DOI PubMed
8. Carbonara U, Simone G, Capitanio U, et al. Robot-assisted partial nephrectomy: 7-year outcomes. *Minerva Urol Nephrol* 2021;73:540-3. DOI PubMed
9. Antonelli A, Minervini A, Mari A, et al; RECORd Project-LUNA Foundation. TriMatch comparison of the efficacy of FloSeal versus TachoSil versus no hemostatic agents for partial nephrectomy: results from a large multicenter dataset. *Int J Urol* 2015;22:47-52. DOI PubMed
10. Minervini A, Campi R, Kutikov A, et al. Histopathological validation of the surface-intermediate-base margin score for standardized reporting of resection technique during nephron sparing surgery. *J Urol* 2015;194:916-22. DOI
11. Minervini A, Carini M, Uzzo RG, Campi R, Smaldone MC, Kutikov A. Standardized reporting of resection technique during nephron-sparing surgery: the surface-intermediate-base margin score. *Eur Urol* 2014;66:803-5. DOI PubMed
12. Paner GP, Stadler WM, Hansel DE, Montironi R, Lin DW, Amin MB. Updates in the eighth edition of the tumor-node-metastasis staging classification for urologic cancers. *Eur Urol* 2018;73:560-9. DOI PubMed
13. Minervini A, Campi R, Sessa F, et al. Positive surgical margins and local recurrence after simple enucleation and standard partial nephrectomy for malignant renal tumors: systematic review of the literature and meta-analysis of prevalence. *Minerva Urol Nefrol* 2017;69:523-38. DOI PubMed
14. Maida F, Campi R, Grosso AA, et al; Collaborators. Prognostic features of upstaged pT3a renal tumors with fat invasion after robot-assisted partial nephrectomy: is it time for a new subclassification? *Eur J Surg Oncol* 2023;49:862-7. DOI PubMed
15. Campi R, Grosso AA, Lane BR, et al; SIB International Consortium. Impact of Trifecta definition on rates and predictors of "successful" robotic partial nephrectomy for localized renal masses: results from the Surface-Intermediate-Base Margin Score International Consortium. *Minerva Urol Nephrol* 2022;74:186-93. DOI PubMed
16. Minervini A, Campi R, Lane BR, et al. Impact of resection technique on perioperative outcomes and surgical margins after partial nephrectomy for localized renal masses: a prospective multicenter study. *J Urol* 2020;203:496-504. DOI PubMed

17. Porpiglia F, Bertolo R. Re: Positive surgical margins and local recurrence after simple enucleation and standard partial nephrectomy for malignant renal tumors: systematic review of the literature and meta-analysis of prevalence. *Eur Urol* 2018;73:480-1. DOI PubMed
18. Di Maida F, Grosso AA, Sforza S, et al. Surgical management of synchronous, bilateral renal masses: a 1-decade referral center experience. *Eur Urol Focus* 2022;8:1309-17. DOI PubMed
19. Grosso AA, Di Maida F, Tellini R, et al. Robot-assisted partial nephrectomy with 3D preoperative surgical planning: video presentation of the florentine experience. *Int Braz J Urol* 2021;47:1272-3. DOI PubMed PMC
20. Campi R, Di Maida F, Lane BR, et al; Members of the SIB International Consortium. Impact of surgical approach and resection technique on the risk of Trifecta Failure after partial nephrectomy for highly complex renal masses. *Eur J Surg Oncol* 2022;48:687-93. DOI PubMed
21. Tuderti G, Mastroianni R, Anceschi U, et al. Assessing the trade-off between the safety and effectiveness of off-clamp robotic partial nephrectomy for renal masses with a high RENAL score: a propensity score-matched comparison of perioperative and functional outcomes in a multicenter analysis. *Eur Urol Focus* 2023;9:1037-43. DOI PubMed
22. Bove P, Bertolo R, Sandri M, et al. Deviation from the protocol of a randomized clinical trial comparing on-clamp versus off-clamp laparoscopic partial nephrectomy (CLOCK II laparoscopic study): a real-life analysis. *J Urol* 2021;205:678-85. DOI PubMed
23. Antonelli A, Cindolo L, Sandri M, et al; AGILE Group (Italian Group for Advanced Laparo-Endoscopic Surgery). Is off-clamp robot-assisted partial nephrectomy beneficial for renal function? *BJU Int* 2022;129:217-24. DOI PubMed
24. Capitanio U, Larcher A, Cianflone F, et al. Hypertension and cardiovascular morbidity following surgery for kidney cancer. *Eur Urol Oncol* 2020;3:209-15. DOI PubMed
25. Anceschi U, Brassetti A, Tuderti G, et al. Risk factors for progression of chronic kidney disease after robotic partial nephrectomy in elderly patients: results from a multi-institutional collaborative series. *Minerva Urol Nephrol* 2022;74:452-60. DOI PubMed
26. Stencel MG, MacLeod L, Yabes JG, Yu M, Davies BJ, Jacobs BL. Partial nephrectomy drives the association between high-volume centers and decreased mortality: a surveillance, epidemiology, and end results-medicare analysis. *Urology* 2023;181:55-62. DOI PubMed
27. Minervini A, Tuccio A, Masieri L, et al. Endoscopic robot-assisted simple enucleation (ERASE) for clinical T1 renal masses: description of the technique and early postoperative results. *Surg Endosc* 2015;29:1241-9. DOI PubMed
28. Minervini A, Campi R, Di Maida F, et al. Tumor-parenchyma interface and long-term oncologic outcomes after robotic tumor enucleation for sporadic renal cell carcinoma. *Urol Oncol* 2018;36:527.e1-527.e11. DOI PubMed
29. Minervini A, Grosso AA, Di Maida F, et al. How far is too far? *Int Braz J Urol* 2020;46:871-2. DOI PubMed PMC
30. Grosso AA, Lambertini L, Di Maida F, Gallo ML, Mari A, Minervini A. Three-dimensional reconstruction and intraoperative ultrasonography: crucial tools to safely approach highly complex renal masses. *Int Braz J Urol* 2022;48:996-7. DOI PubMed PMC