Original article

Renal hilum approach based on R.E.N.A.L Nephrometry Score in laparoscopic partial nephrectomy. Effects on surgical time, intraoperative bleeding and surgical complications. A single-center experience

Abordaje del hilio renal para la nefrectomía parcial laparoscópica basado en el puntaje del RENAL Score. Efectos sobre el tiempo quirúrgico, el sangrado intraoperatorio y las complicaciones quirúrgicas. Experiencia de un centro único

Juan J. Camean,[1*] Joaquin Chemi,[1] Fernando A. Diaz-Couselo,[1] Roberto F. Villalba Bachur,[1] Jorge H. Jaunarena,[1] Gustavo M. Villoldo.[1]

Abstract

Introduction: nephron-sparing surgery (NSS) has emerged as the preferred treatment for renal tumors, aiming to balance oncological outcomes and renal function preservation. Partial nephrectomy (PN) has shown comparable cancer-specific survival rates to radical nephrectomy (RN). Notably, postoperative renal damage is associated with both ischemia time and parenchymal loss, emphasizing the importance of preserving renal function during tumor resection. The R.E.N.A.L. Nephrometry Score (RNS), has enhanced the quantification of renal tumor characteristics and improved standardization, guiding surgical decisions. This study aims to describe different hilum approaches based on RNS during laparoscopic PN and analyze their impact on surgical time, intraoperative bleeding, and functional outcomes.

Methods: a retrospective analysis of 90 laparoscopic partial nephrectomy cases was conducted. Surgical time, estimated blood loss (EBL), renal hilum approach (including hilum dissection with renal artery clamping [HD&RAC], hilum dissection without renal artery clamping [HD&noRAC], and no hilum dissection with no renal artery clamping [noHD&noRAC), complication rates and RNS-guided complexity (low: RNS < 7, intermediate: RNS 7-9, high: RNS > 9) were assessed. The choice of hilum approach and abdominal access was determined by the physician based on tumor complexity assessed using RNS.

Results: surgical time varied significantly between hilum approaches, with HD&RAC being the longest (196min), followed by HD&noRAC (147min) and noHD&noRAC (130min). The mean surgical time was statistically significantly different between HD&RAC and HD&noRAC (p-value = 0.0005) and between HD&RAC and noHD&noRAC (p-value = 0.0001). Intraoperative bleeding was higher in the HD&RAC approach than the noHD&noRAC approach (p-value = 0.039). Pre- and post-surgery glomerular filtration rates did not significantly differ by hilum approach (p= 0.7255) or complexity of the renal mass (p= 0.5633). No intraoperative complications were reported. However, three patients with high RNS experienced postoperative urinary fistulas.

Conclusion: the choice of renal hilum approach significantly impacts surgical time and intraoperative bleeding during laparoscopic partial nephrectomy. Using RNS to guide the approach selection allows for optimal surgical outcomes without compromising glomerular filtration rate (GFR). Further research is needed to validate these findings in larger, multicenter studies and assess long-term outcomes associated with different hilum approaches in laparoscopic PN

Keywords:
partial nephrectomy, sschemia, RENAL score, hilum approach

***Corresponding author:**
Juan Jorge Camean. Addess Chile 2309, Don Torcuato, Provincia de Buenos Aires, Argentina. CP 1611. Email: juanjcamean@gmail.com

Citation: Camean J. J., Chemi J., Diaz-Couselo F. A., Villalba Bachur R. F., Jaunarena J. H., Villoldo G. M. *Renal hilum approach based on R.E.N.A.L Nephrometry Score in laparoscopic partial nephrectomy. Effects on surgical time, intraoperative bleeding and surgical complications. A single-center experience. Rev Mex Urol. 2024;85(6):* 1-11.

[1.] Instituto Alexander Fleming, Buenos Aires, Argentina.

Received: May 16, 2025.
Accepted: November 16, 2025.

Resumen

Introducción: la cirugía conservadora de nefronas (CNE) se ha consolidado como el tratamiento de elección para los tumores renales, buscando equilibrar los resultados oncológicos y la preservación de la función renal. La nefrectomía parcial (NP) ha mostrado tasas de supervivencia cáncer-específica comparables a las de la nefrectomía radical (NR). Cabe destacar que el daño renal postoperatorio se asocia tanto al tiempo de isquemia como a la pérdida parenquimatosa, lo que resalta la importancia de preservar la función renal durante la resección tumoral. La Escala de Nefrometría R.E.N.A.L. (RNS) ha mejorado la cuantificación de las características de los tumores renales y la estandarización, guiando las decisiones quirúrgicas. Este estudio busca describir diferentes abordajes hiliares basados en la RNS durante la NP laparoscópica y analizar su impacto en el tiempo quirúrgico, el sangrado intraoperatorio y los resultados funcionales.

Métodos: se realizó un análisis retrospectivo de 90 casos de nefrectomía parcial laparoscópica. Se evaluaron el tiempo quirúrgico, la pérdida sanguínea estimada (EBL), el abordaje del hilio renal (incluyendo disección del hilio con pinzamiento de la arteria renal [HD&RAC], disección del hilio sin pinzamiento de la arteria renal [HD&noRAC] y ninguna disección del hilio sin pinzamiento de la arteria renal [noHD&noRAC]), las tasas de complicaciones y la complejidad guiada por RNS (baja: RNS < 7, intermedia: RNS 7-9, alta: RNS > 9). La elección del abordaje del hilio y del acceso abdominal fue determinada por el médico en función de la complejidad del tumor evaluada mediante RNS.

Resultados: el tiempo quirúrgico varió significativamente entre los abordajes del hilio, siendo HD&RAC el más largo (196 min), seguido de HD&noRAC (147 min) y noHD&noRAC (130 min). El tiempo quirúrgico medio fue estadísticamente significativamente diferente entre HD&RAC y HD&noRAC (valor p = 0,0005) y entre HD&RAC y noHD&noRAC (valor p = 0,0001). El sangrado intraoperatorio fue mayor con el abordaje HD&RAC que con el abordaje noHD&noRAC (valor p = 0,039). Las tasas de filtración glomerular pre y posoperatoria no difirieron significativamente según el abordaje hiliar (p = 0,7255) ni la complejidad de la masa renal (p = 0,5633). No se reportaron complicaciones intraoperatorias. Sin embargo, tres pacientes con RNS alto experimentaron fístulas urinarias posoperatorias.

Conclusión: la elección del abordaje hiliar renal impacta significativamente el tiempo quirúrgico y el sangrado intraoperatorio durante la nefrectomía parcial laparoscópica. El uso de RNS para guiar la selección del abordaje permite obtener resultados quirúrgicos óptimos sin comprometer la tasa de filtración glomerular (TFG). Se necesita más investigación para validar estos hallazgos en estudios multicéntricos más amplios y evaluar los resultados a largo plazo asociados con diferentes abordajes hiliares en la NP laparoscópica.

Palabras clave:
nefrectomía parcial, esquemia, puntuación RENAL, abordaje hiliar

Introduction

Renal cell carcinoma (RCC) represents around 3 % of all cancers, with the highest incidence in Western countries.(1) Mortality rates are stable in most countries but have decreased 1-3 % in Western and Northern Europe, United States, and Australia due to decreased smoking rates, improved therapies, and access to medical care.[2,3]

Nephron-sparing surgery (NSS) has become the treatment of choice for tumors ≤7 cm and for patients at risk of significant loss of renal function.[4,5] In terms of oncological outcomes, there was no difference in cancer specific survival between partial nephrectomy (PN) and radical nephrectomy (RN).[6,7] Furthermore, NSS is associated with a significantly lower risk of chronic kidney disease.[8] Laparoscopic and robotic approaches compared with open PN had demonstrated no difference in progression free survival and overall survival in different studies.[9,10] The advantages of minimally invasive techniques are well documented with shorter hospital stay, lower blood loss and less analgesic requirement.[11]

Both ischemia time and parenchyma loss were associated with postoperative renal damage.[12] Along with complete tumor resection without complications, the primary goal for an ideal PN is the maximal preservation of renal function.[13] Considering this, efforts should be done in both reducing or eliminating ischemia time and preserving healthy renal parenchyma during tumor enucleation.

In 2009, Kutikov and Uzzo developed the R.E.N.A.L. Nephrometry Score (RNS) to quantify the anatomical characteristics of renal tumors and improved standardization. It is useful for characterizing tumors, and, as a predictive tool for complications, ischemia time, blood loss, and outcomes after partial nephrectomy.[14] The integration of modern imaging methods combined with this novel tool allowed urologists to perform safe and feasible surgeries with low complication rates.[15]

The aim of this study was to describe the different hilum approaches according to the RNS during laparoscopic PN and analyze its impact on surgical time, complications rates (intraoperative bleeding) and functional outcomes.

Material and methods

A retrospective cohort analysis was performed, including all patients who underwent laparoscopic PN for renal masses at the Instituto Alexander Fleming (IAF) between January 2012 and April 2020. IAF is a tertiary hospital affiliated to the University of Buenos Aires specialized in the care of cancer patients. Demographic variables, RNS, estimated blood loss (EBL), surgery time, renal hilum approach [hilum dissection and renal artery clamping (HD&RAC)], hilum dissection without renal artery clamping (HD&noRAC), no hilum dissection and no clamping (noHD&noRAC)] and complications (categorized as Clavien-Dindo > III) rates were recorded. Before surgery all patients underwent computed tomography to assess the RNS and renal vascularization. For study purposes, the patients were categorized according to the complexity of the renal mass in low (RNS < 7), intermediate (RNS: 7-9) and high (RNS > 9) risk. The hilum approach and the abdominal access performed (transperitoneal or retroperitoneal) were according to

physician discretion considering tumor complexity by RNS.

Three different strategies were employed for managing the renal hilum. In the clamp-less technique (HD&noRAC - noHD&noRAC), the distinction lies in the dissection of the renal hilum and renal artery. Specifically, when opting for the noHD&noRAC approach, neither the renal hilum nor the renal artery was individually dissected. Conversely, in cases employing the HD&RAC or HD&noRAC approach, meticulous dissection was executed up to the initial arterial branches. Arterial clamping and the associated ischemia time were integrated into the HD&RAC technique.

When choosing among the different types of renal hilar approaches (HD&RAC, HD&noRAC, and noHD&noRAC), tumor complexity emerged as a critical factor. In this context, various elements were evaluated, including the tumor's location, size, and its proximity to the renal sinus. Furthermore, considerations such as the patient's surgical history and the preferences of the surgeon were also included into the decision-making process.

Statistical analysis

The results of the categorical variables are reported as frequencies and percentages. The results of the quantitative variables are expressed as mean (and standard deviation) for normally distributed variables or median (and interquartile range –IQR-) for non-normally distributed variables.

Categorical variables were compared with the Chi-square test or the Fisher exact test. Bonferroni correction for multiple comparisons was performed.

An unbalanced two-way factorial ANOVA was performed to compare the effects of the renal hilum approach (HD&RAC, HD&noRAC, and noHD&noRAC) and the grade of complexity (low, intermediate, and high) on surgical outcomes. The model included an interaction term to assess whether the effect of the surgical approach depended on the level of complexity.

For normally distributed data, such as surgical time and the change in glomerular filtration rate (GFR), a standard factorial ANOVA was used. The normality of residuals was confirmed using the Shapiro-Wilk test, and homoscedasticity was assessed with the Breusch-Pagan test. When a factor showed a significant main effect, post-hoc pairwise comparisons were performed using the Tukey's Honestly-Significant-Difference (HSD) method to identify specific group differences.

For data with a non-normal distribution, such as intraoperative bleeding, a rank-based two-way ANOVA was performed. Similar to the other models, post-hoc pairwise comparisons were conducted to evaluate specific group differences, with p-values adjusted for multiple comparisons.

A two-tailed p-value less than 0.05 was considered to be statistically significant.

Statistical analysis was performed with R using the Integrated Development Environment RStudio.

The study was approved by the committee on research ethics at the institution in which the research was conducted and any informed consent from human subjects was obtained as required.

Results

Ninety patients were included for the study. Median age was 57 years (IQR: 51-67). Thirty-two (35.6 %) patients were female. The hilum approach was HD&RAC, HD&noRAC and noHD&noRAC in 62 (68.9 %), 16 (17.8 %) and 12 (13.3 %) patients, respectively.

The RNS was lower than 7 in 39 (43.3 %) patients, between 7 and 9 in 41 (45.6 %) patients and higher than 9 in10 (11.1 %) patients. Patient's demographic characteristics according to the renal hilum approach are in Table 1.

Table 1. Demographic characteristics according to the renal hilum approach

	HD&RAC (n = 62)	HD&noRAC (n = 16)	noHD&noRAC (n = 12)	p-value
Age in years – median (IQR)	57 (50-66)	58 (51.8-64.3)	60 (55.8-67.3)	0.673a
Female – n (%)	22 (68.8)	7 (21.9)	3 (9.4)	0.6293b
RNS – n (%)				0.049a
Low (≤ 6)	22 (56.4)	7 (18.0)	10 (25.6)	c
Intermediate (7-9)	31 (75.6)	8 (19.5)	2 (4.9)	c
High (≥ 10)	9 (90.0)	1 (10.0)	0 (0.0)	c
Tumor size in cm– median (IQR)	4 (3.1-5.4)e	3 (2.2-3.3)e	2.25 (1.9-3.0)e	<0.0001d

Abbreviations. HD&RAC: hilum dissection and renal artery clamping; HD&noRAC: hilum dissection without renal artery clamping; noHD&noRAC: no hilum dissection and unclamping; IQR: interquartile range; RNS: RENAL nephrometric score. a. Kruskal-Wallis rank sum test; b. Fisher exact test; c. no statistically significant p-values after adjusting for multiple comparisons with the Bonferroni's method; d. Wilcoxon rank sum test; e. multiple comparisons adjusted by the Bonferroni's method, HD&RAC vs HD&noRAC: p-value: 0.03, HD&RAC vs noHD&noRAC: p-value < 0.0001; HD&noRAC vs noHD&noRAC: p-value = 0.279.

Mean (SD) surgical time was 196 (46) min for the HD&RAC approach, 147 (46) min for the HD&noRAC approach, and 130 (44) min for the noHD&noRAC approach (Table 2).

Table 2. Surgical time, intraoperative bleeding and variation in renal function according to the renal hilum approach

Outcome variable	HD&RAC[a] (n = 62)	HD&noRAC[a] (n = 16)	noHD&noRAC[a] (n = 12)
Surgical time in minutes – mean (SD)	196 (46)	147 (46)	130 (44)
Low (RNS ≤ 6)	191 (40)	145 (21)	132 (41)
Intermediate (RNS: 7-9)	205 (49)	153 (63)	118 (74)
High (RNS ≥ 10)	175 (48)	120d	-e
Intraoperative bleeding in ml – median (IQR)	400 (205-600)	250 (188-425)	200 (138-262)
Low (RNS ≤ 6)	350 (213-575)	300 (150-375)	200 (163-288)

Continúa...

Intermediate (RNS: 7-9)	400 (210-700)	200 (188-418)	150 (125-175)
High (RNS ≥ 10)	400 (250-600)	700d	-e
Δ GFRb,c in ml/min/1.73m2 –mean (SD)	1.84 (14.93)	-0.92 (17.99)	3.87 (11.77)
Low (RNS ≤ 6)	-1.98 (12.61)	-1.01 (16.38)	3.45 (10.99)
Intermediate (RNS: 7-9)	3.12 (12.43)	-0.64 (14.12)	3.8 (4.38)
High (RNS ≥ 10)	5.78 (19.42)	6.1d	-e

Abbreviations. HD&RAC: hilum dissection and renal artery clamping; HD&noRAC: hilum dissection without renal artery clamping; noHD&noRAC: no hilum dissection and unclamping; GFR: glomerular filtration rate calculated by the MDRD formula; SD: standard deviation; IQR: interquartile range; RNS: R.E.N.A.L. Nephrometry Score. Footnotes: a. See Table 3 for ANOVA and pairwise comparisons results; b. Δ GFR = $GRF_{(pre\text{-}surgery)} - GFR_{(post\text{-}surgery)}$; c. n= 54, n= 14 and n= 11 in the HD&RAC, HD&noRAC and noHD&noRAC groups, respectively; d. one patient in the HD&noRAC and high complexity group; e. no patients in the noHD&noRAC and high complexity group.

A two-way factorial ANOVA revealed a statistically significant main effect of the renal hilum approach on mean surgical time ($p < 0.0001$). Post-hoc pairwise comparisons, adjusted for multiple comparisons, showed that the mean surgical time was significantly longer for the HD&RAC approach compared to both the HD&noRAC ($p = 0.0005$) and noHD&noRAC ($p = 0.0001$) approaches. There was no statistically significant difference in surgical time between the HD&noRAC and noHD&noRAC approaches ($p = 0.6731$) (Table 3).

Table 3. ANOVA results and pairwise comparisons. ANOVA with surgical outcomes as the dependent variable and renal hilum approach (HD&RAC, HD&noRAC, and noHD&noRAC) and the grade of complexity (low, intermediate, and high) as independent variables

Outcome variablea	Main effect of renal hilum approach	Main effect of surgical complexity	Interaction effect	Pairwise comparisons (Renal hilum approach)
Surgical time	$p < 0.001$	$p = 0.173$	$p = 0.895$	HD&RAC vs HD&noRAC: $p = 0.0005$ HD&RAC vs noHD&noRAC: $p = 0.0001$ HD&noRAC vs noHD&noRAC: $p = 0.673$
Intraoperative bleeding	$p = 0.054$	$p = 0.877$	$p = 0.361$	HD&RAC vs HD&noRAC: $p = 0.320$ HD&RAC vs noHD&noRAC: $p = 0.072$ HD&noRAC vs noHD&noRAC: $p = 0.671$
Δ GFRb	$p = 0.5773$	$p = 0.3202$	$p = 0.929$	N/A (No statistically significant effect of renal hilum approach nor surgical complexity)

Abbreviations. HD&RAC: hilum dissection and renal artery clamping; HD&noRAC: hilum dissection without renal artery clamping; noHD&noRAC: no hilum dissection and unclamping; GFR: glomerular filtration rate calculated by the MDRD formula.
a. unbalanced two-way factorial ANOVA; standard factorial ANOVA for surgical time and Δ GFR and rank-based ANOVA for intraoperative bleeding; b. Δ GFR = $GRF_{(pre\text{-}surgery)} - GFR_{(post\text{-}surgery)}$.

There was no statistically significant difference in mean surgical time according to the complexity of the renal mass (p-value = 0.1733). There was no statistically significant interaction between renal hilum approach and the complexity of the renal mass (p-value = 0.8953).

Median (IQR) intraoperative bleeding was 400 mL (205–600 mL), 250 mL (188–425 mL), and 200 mL (138–263 mL) for the HD&RAC, HD&noRAC, and noHD&noRAC approaches, respectively

A rank-based two-way ANOVA revealed that the main effect of the renal hilum approach on blood loss was not statistically significant (p = 0.0545). No statistically significant differences were found in pairwise comparisons among the three approaches after adjusting for multiple comparisons. Specifically, the difference between HD&RAC and noHD&noRAC showed a trend toward significance (p = 0.0722), while no significant differences were found between HD&RAC and HD&noRAC (p = 0.3204) or between HD&noRAC and noHD&noRAC (p = 0.6705)

The main effect of surgical complexity on blood loss was not significant (p = 0.8768), and there was no significant interaction between the renal hilum approach and surgical complexity (p = 0.3608).

All interventions were successfully completed, with no report of intraoperative complication. There were 3 patients in the group of high RNS who developed a urinary fistula after surgery and required a double J stent in 2 patients and percutaneous drainage in one patient for complete resolution (Clavien-Dindo III).

Data on the pre- and post-surgery GFR, estimated by the Modification of Diet in Renal Disease (MDRD) formula, were available for 79 patients. The distribution was as follows: 54 patients in the HD&RAC group, 14 in the HD&noRAC group, and 11 in the noHD&noRAC group.

A two-way factorial ANOVA revealed no statistically significant effects on the change in GFR after surgery. Neither the renal hilum approach (p = 0.5773), the complexity of the renal mass (p = 0.3202), nor their interaction (p = 0.9293) had a significant effect on the change in GFR. These results indicate that the change in renal function was similar across all surgical approaches and complexity levels.

Discussion

NSS is considered the treatment of choice for clinical T1a and an alternative for clinical T1b renal masses. This procedure has equivalent oncological outcomes and better postoperative renal function compared with radical nephrectomy.[16,17]

Further renal function outcomes depend on important non-modifiable factors such as previous chronic kidney diseases and tumor characteristics. Nevertheless, renal ischemia during partial nephrectomy continues to be the foremost modifiable risk factor contributing to impaired renal function subsequent to renal surgery.[18] Therefore, two different approaches without vascular clamping (HD&noRAC and noHD&noRAC) are used when it is feasible.

Vascular control is a critical aspect of performing a PN. The choice of vascular control technique depends on various factors, including the size and location of the tumor, surgeon's experience, patient's overall health and the need to preserve renal function, espe-

cially in solitary kidneys. Other main objectives include ensuring complete tumor removal, securing oncological margins, achieving careful hemostasis, and ensuring correct visualization of the renal defect for optimal closure of the urinary system and parenchymal tissue.

Our analysis showed a tendency for greater bleeding in the HD&RAC group compared to the noHD&noRAC group (p = 0.072), although this difference was not statistically significant after adjusting for multiple comparisons. This finding could be explained by the fact that, in the group of patients with HD&RAC, tumor complexity was moderate or high (RNS >7) on 54.5 % patients. In addition, for optimal vascular control complete dissection of the renal hilum should be done. Vascular injury during renal hilum dissection is a troublesome complication and may lead to intraoperative hemorrhage.[19] Even at high volume centers, the incidence of significant intraoperative bleeding can be as high as 3.5 % and may require open conversion in 1 % of the cases.[19] Avoiding unnecessary hilum dissection (noHD&noRAC), based on a validated nephrometry score, like RNS, could be a useful tool during a surgeon's decision approach. In our study, no intraoperative complications were reported regarding hilum dissection.

Our study did not find a statistically significant association between the complexity of the renal mass, based on RNS, and surgical time (p = 0.182). This suggests that more factors other than tumor complexity, such as the chosen hilum approach, may have an impact on surgical time. The HD&RAC approach had the longest mean surgical time, followed by HD&noRAC and noHD&noRAC approaches. This finding suggests that performing hilum dissection and renal artery clamping increases the overall surgical time. On the other hand, the noHD&noRAC approach had the shortest surgical time. This approach may be suitable for less complex cases where clamping is not required, leading to shorter surgical durations.

Despite standardization, reproducibility, and external validation demonstrating the reliability of the RNS, certain limitations have been observed.[14] Although nephrometry sums may be similar, the RNS reveals significant distinctions due to different anatomical features. These considerations can influence the decision-making process regarding the hilum approach. In our study, 56.4 % of patients with high complexity (HD&RAC) exhibited low complexity (nephrometry sum 4 to 6). This underscores the crucial role of surgeons' experience in determining the appropriate hilum approach.

The absence of intraoperative complications in our study population is encouraging and may reflect the safety and feasibility of different types of hilum approach. Low complications rates of Clavien-Dindo III were described. However, it is worth noting that three patients, with high RNS, developed urinary fistulas postoperatively, requiring additional interventions for resolution.

However, several limitations should be acknowledged. First, it is a single institution study, which may limit the generalizability of the results to other centers. Second, the retrospective nature of the study introduces the potential for selection bias and confounding factors. Prospective studies with larger sample sizes and multicenter collaborations would be valuable in confirming and expanding the findings of this study.

In conclusion, the choice of the hilum approach significantly influenced surgical

time and, although not statistically significant, showed a trend toward affecting intraoperative bleeding. The surgical approach choice based on the complexity of the renal mass, as assessed by RNS, can help to optimize surgical outcomes without compromising the GFR. Further research is needed to explore the generalizability of these findings and to assess long-term outcomes associated with different hilum approaches in laparoscopic PN.

CRediT Taxonomy

1. Juan J. Camean: Conceptualization, methodology, project management, supervision, visualization, drafting and editing.
2. Joaquin Chemi: Conceptualization, methodology, project management, supervision, visualization, drafting and editing.
3. Fernando A. Diaz-Couselo: Curation, formal data analysis, research, drafting, revision, and editing.
4. Roberto F. Villalba Bachur: Methodology, curation, formal data analysis, research, drafting.
5. Jorge H. Jaunarena: Curation, formal data analysis, research, drafting, revision, and editing.
6. Gustavo M. Villoldo: Conceptualization, methodology, project management, supervision, visualization, drafting and editing.

Conflict of interest

None

Financial support

None

References

1. **Ferlay J, Colombet M, Soerjomataram I, Dyba T, Randi G, Bettio M, et al.** Cancer incidence and mortality patterns in Europe: Estimates for 40 countries and 25 major cancers in 2018. *European Journal of Cancer (Oxford, England: 1990)*. 2018;103: 356–387. https://doi.org/10.1016/j.ejca.2018.07.005.
2. **Hollingsworth JM, Miller DC, Daignault S, Hollenbeck BK.** Rising incidence of small renal masses: a need to reassess treatment effect. *Journal of the National Cancer Institute*. 2006;98(18): 1331–1334. https://doi.org/10.1093/jnci/djj362.
3. **Levi F, Ferlay J, Galeone C, Lucchini F, Negri E, Boyle P, et al.** The changing pattern of kidney cancer incidence and mortality in Europe. *BJU international*. 2008;101(8): 949–958. https://doi.org/10.1111/j.1464-410X.2008.07451.x.
4. **Mir MC, Derweesh IH, Autorino R.** Reply to Jae Heon Kim and Benjamin I. Chung's Letter to the Editor re: Maria Carmen Mir, Ithaar Derweesh, Francesco Porpiglia, Homayoun Zargar, Alexandre Mottrie, Riccardo Autorino. Partial Nephrectomy Versus Radical Nephrectomy for Clinical T1b and T2 Renal Tumors: A Systematic Review and Meta-analysis of Comparative Studies. Eur Urol 2017;71:606-17. *European Urology*. 2017;72(5): e129–e130. https://doi.org/10.1016/j.eururo.2017.05.010.
5. **Marchioni M, Preisser F, Bandini M, Nazzani S, Tian Z, Kapoor A, et al.** Comparison of Partial Versus Radical Nephrectomy Effect

on Other-cause Mortality, Cancer-specific Mortality, and 30-day Mortality in Patients Older Than 75 Years. *European Urology Focus*. 2019;5(3): 467–473. https://doi.org/10.1016/j.euf.2018.01.007.

6. **MacLennan S, Imamura M, Lapitan MC, Omar MI, Lam TBL, Hilvano-Cabungcal AM, et al.** Systematic review of perioperative and quality-of-life outcomes following surgical management of localised renal cancer. *European Urology*. 2012;62(6): 1097–1117. https://doi.org/10.1016/j.eururo.2012.07.028.
7. **Kunath F, Schmidt S, Krabbe LM, Miernik A, Dahm P, Cleves A, et al.** Partial nephrectomy versus radical nephrectomy for clinical localised renal masses. *The Cochrane Database of Systematic Reviews*. 2017;5(5): CD012045. https://doi.org/10.1002/14651858.CD012045.pub2.
8. **Huang WC, Levey AS, Serio AM, Snyder M, Vickers AJ, Raj GV, et al.** Chronic kidney disease after nephrectomy in patients with renal cortical tumours: a retrospective cohort study. *The Lancet. Oncology*. 2006;7(9): 735–740. https://doi.org/10.1016/S1470-2045(06)70803-8.
9. **Kutikov, A, Smaldone, Marc C.** *Small Renal Mass, An Issue of Urologic Clinics*.. 1st edn 2017. https://shop.elsevier.com/books/small-renal-mass-an-issue-of-urologic-clinics/kutikov/978-0-323-52864-1 [Accessed 16th January 2026].
10. **Daneshmand S, Chan KG.** *Genitourinary Cancers*. Springer; 2018.
11. **Lee RA, Strauss D, Kutikov A.** Role of minimally invasive partial nephrectomy in the management of renal mass. *Translational Andrology and Urology*. 2020;9(6): 3140–3148. https://doi.org/10.21037/tau.2019.12.24.
12. **Volpe A, Blute ML, Ficarra V, Gill IS, Kutikov A, Porpiglia F, et al.** Renal Ischemia and Function After Partial Nephrectomy: A Collaborative Review of the Literature. *European Urology*. 2015;68(1): 61–74. https://doi.org/10.1016/j.eururo.2015.01.025.
13. **Hung AJ, Cai J, Simmons MN, Gill IS.** "Trifecta" in Partial Nephrectomy. *The Journal of Urology*. 2013; https://doi.org/10.1016/j.juro.2012.09.042.
14. **Kutikov A, Uzzo RG.** The R.E.N.A.L. nephrometry score: a comprehensive standardized system for quantitating renal tumor size, location and depth. *The Journal of Urology*. 2009;182(3): 844–853. https://doi.org/10.1016/j.juro.2009.05.035.
15. **Roussel E, Capitanio U, Kutikov A, Oosterwijk E, Pedrosa I, Rowe SP, et al.** Novel Imaging Methods for Renal Mass Characterization: A Collaborative Review. *European Urology*. 2022;81(5): 476–488. https://doi.org/10.1016/j.eururo.2022.01.040.
16. **Thompson RH, Boorjian SA, Lohse CM, Leibovich BC, Kwon ED, Cheville JC, et al.** Radical nephrectomy for pT1a renal masses may be associated with decreased overall survival compared with partial nephrectomy. *The Journal of Urology*. 2008;179(2): 468–471; discussion 472-473. https://doi.org/10.1016/j.juro.2007.09.077.
17. **Malcolm JB, Bagrodia A, Derweesh IH, Mehrazin R, Diblasio CJ, Wake RW, et al.** Comparison of rates and risk factors for developing chronic renal insufficiency, proteinuria and metabolic acidosis after radical or partial nephrectomy. *BJU international*. 2009;104(4): 476–481. https://doi.org/10.1111/j.1464-410X.2009.08376.x.
18. **Kopp RP, Mehrazin R, Palazzi K, Bazzi WM, Patterson AL, Derweesh IH.** Factors affecting renal function after open partial nephrectomy-a comparison of clampless and clamped warm ischemic technique. *Urology*.

2012;80(4): 865–870. https://doi.org/10.1016/j.urology.2012.04.079.

19. **Ramani AP, Desai MM, Steinberg AP, Ng CS, Abreu SC, Kaouk JH, et al.** Complications of laparoscopic partial nephrectomy in 200 cases. *The Journal of Urology*. 2005;173(1): 42–47. https://doi.org/10.1097/01.ju.0000147177.20458.73.