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Minerva Urology and Nephrology 2021 August;73(4):509-17
DOI: 10.23736/S2724-6051.21.04390-1

ORIGINAL ARTICLE

Comparison between minimally-invasive partial and radical nephrectomy for the treatment of clinical T2 renal masses: results of a 10-year study in a tertiary care center

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ABSTRACT

BACKGROUND: Even if partial nephrectomy (PN) is nowadays considered the standard for managing cT1 renal masses, its role in the management of cT2 kidney tumors is controversial. We aimed to compare oncologic and functional outcomes of minimally invasive radical nephrectomy (RN) and PN in cT2 renal masses.
METHODS: Patients with cT2 renal masses underwent minimally-invasive PN or RN performed by a highly experienced single surgeon from 2009 to 2019 were considered. Demographic, perioperative and functional variables were compared. Cumulative incidence plot and competing risks regression (CRR) models were used to test differences in 5-year cancer-specific mortality (CSM) and 5-year other-cause mortality (OCM) rates. Kaplan-Meier and Cox regression model was used to test differences in 5-year progression free survival (PFS) rates.
RESULTS: Overall, 52 PN *vs.* 64 RN patients were identified. Relative to RN, PN patients recorded higher rates of complications (25% *vs.* 7.8%, P=0.02) but lower upstaging rate (≥pT3a 64.1% *vs.* 19.2%, P<0.0001). Functional outcomes were in favor of PN (all P<0.001). No differences were recorded between 5-year CSM and OCM according to nephrectomy type. At CRR models, older age and upstaging were independent predictors of 5-year OCM and CSM, respectively (all P<0.01). Finally, only upstaging, high grade tumors and presence of positive surgical margins were identified as independent predictors of 5-year PFS (all P<0.01).
CONCLUSIONS: In experienced hands the treatment of cT2 renal neoplasms with minimally-invasive PN is feasible, providing perioperative and oncological safety profiles comparable to RN, with advantages in terms of functional outcomes.

(*Cite this article as:* Amparore D, Pecoraro A, Piramide F, Checcucci E, De Cillis S, Volpi G, *et al*. Comparison between minimally-invasive partial and radical nephrectomy for the treatment of clinical T2 renal masses: results of a 10-year study in a tertiary care center. Minerva Urol Nephrol 2021;73:509-17. DOI: 10.23736/S2724-6051.21.04390-1)

KEY WORDS: Kidney neoplasms; Nephrectomy; Minimally-invasive surgical procedures.

Historically, radical nephrectomy (RN) represented the elective surgical treatment for kidney cancer.[1] Over the last twenty years, partial nephrectomy (PN) gained an increasing role in the management of organ-confined renal tumors,[2] also thanks to the extension of indications given by the diffusion of minimally invasive approaches.[3, 4]

This change of course has been due to the evidence of similar oncological outcomes with better renal function recovery after PN in comparison with RN.[5]

Moreover, in subgroups of patients with preexisting chronic kidney disease (CKD), the nephron sparing approach, has become an imperative indication, if feasible, to reduce the evolution to end-stage kidney disease (ESKD).[6]

Nowadays, PN represents the gold standard for the elective surgical management of clinical T1 renal neoplasms, so in case of tumors up to 7 cm of diameter, whenever technically feasible.[2, 7] The surgeon's expertise plays a central role in conditioning this choice, that has to be balanced considering the radiological features of the renal mass (appearance and surgical complexity) and the characteristics of the patient (renal function status and comorbidities).[8, 9]

The currently unanswered question is if such conservative approach could be indicated also for organ- confined lesions larger in size, like cT2 tumors. Indeed, in these cases PN is technically more challenging and its role needs to be proved in terms of safety and long-term oncological efficacy.[2] Contemporary systematic reviews and meta-analyses demonstrate that PN is a safe and feasible approach also for the treatment of large tumors, optimizing renal function recovery and showing survival rates not inferior to RN.[10-12] Nevertheless, such studies are based on retrospective series with small sample sizes, including different surgical approaches, especially open surgery ones, or with limited follow-up.[13, 14] For the above-mentioned reasons, the role of PN for the surgical management of cT2 tumors is still under scrutiny.

In order to give a contribution in such field of research, our aim is to evaluate and compare retrospectively the perioperative, oncological and functional outcomes of the patients treated at our Institution with both minimally-invasive PN and RN for cT2 renal neoplasms across ten years.

Materials and methods

We retrospectively reviewed our institutional prospectively maintained database and extracted data about all patients with cT2 renal tumors treated with minimally invasive (robot-assisted or laparoscopic) PN or RN between January 2009 and January 2019.

All patients with significant deterioration of preoperative renal function (defined as kidney failure by CKD classification[15]), patients with single kidney or anatomical malformations such as horseshoe kidney, as well as patients treated with open approaches were excluded from the analysis. All procedures were performed by a single experienced surgeon (F.P.), with high expertise in minimally invasive surgery (MIS), after completion of his learning curve (more than 250 MIS before 2009). The choice of the approach (PN *vs.* RN) was assessed case by case by the surgeon considering the radiological features of potential aggressiveness of the neoplasm (not only the size but also the presence of polycyclic or inhomogeneous pseudocapsular margin or the evidence of intralesional necrosis)[16] and its surgical complexity, as well as the kidneys[17] and patients characteristics.[13, 14]

All specimens were analyzed by a dedicated pathologist experienced in uro-pathology (E.B.). Patients were followed up at three, six, twelve months and then annually up to 10 years with contrast enhanced CT scan.

Variables of interest

The following oncological variables were considered: local recurrence and time of recurrence, progression-free survival (PFS), site and time of progression, death and cause of death (cancer or other cause-related), expressed as cancer-specific mortality (CSM) and other-cause mortality (OCM). Considering functional variables, serum creatinine (sCr) and estimated glomerular filtration rate (eGFR) were assessed postoperatively (between third and fifth postoperative day) and one year after surgery. Baseline weighted differentials among pre-, postoperative and one-year values were calculated too.

Statistical analysis

Statistical analyses consisted of five analytical steps.

First, descriptive statistics included means and standard deviations, medians and interquartile ranges, as well as frequencies and proportions for continuous and categorical variables, respectively. The statistical significance of differences in means, medians and proportions was evaluated with Student's *t*-test, Kruskal-Wallis, and chi-square tests. Second, Box and whisker plots were used to depict functional outcomes distribution (eGFR) preoperatively, postoperatively and after one year from surgery according to type of nephrectomy.

Third, Kaplan-Meier methodology was used to estimate overall 5-year PFS rates according to type of nephrectomy (PN *vs*. RN).

Fourth, we relied on cumulative incidence plots and fitted multivariable competing-risks regression models (CRR), testing the effect of PN *vs*. RN on 5-year CSM and 5-year OCM.

Covariates consisted of age at procedure, preoperative eGFR, gender (male *vs*. female), type of nephrectomy (RN *vs*. PN), pathological T stage (<T3a, ≥T3a), histological subtype (benign histology *vs*. clear cell RCC *vs*. non-clear RCC).

Fifth, we relied on Cox multivariable model predicting PFS, adjusted for type of nephrectomy (RN *vs*. PN), pathological T stage (<T3a *vs*. >T3a), histological subtype (benign histology *vs*. clear cell RCC *vs*. non-clear RCC), tumor grade (LG *vs*. HG), presence of necrosis, presence of positive surgical margins.

For all statistical analyses, R software environment for statistical computing and graphics (version 3.4.3) was used. All tests were two sided with a level of significance set at P<0.05.

Results

Population characteristics

Overall, 116 cT2 kidney cancer patients were selected (Table I). Of those, 52 (44.8%) and 64 (55.1%) were treated with PN and RN, respectively.

Relative to RN (Table I, II), PN patients were more often males (76.9% *vs*. 53.1%, P=0.01), with higher preoperative hemoglobin levels (14.2 *vs*. 13.3 g/dL, P=0.001), treated more often with robot-assisted approach (42.3% *vs*. 3.1%, P<0.001) and with retroperitoneal access (42.3% *vs*. 21.9%, P=0.03). Postoperative complications rate resulted higher in PN group (25% *vs*. 7.8%, P=0.02), but with only one Clavien >2 compli-

Table I.—*Descriptive characteristics of cT2 patients (N.=116) diagnosed with renal masses and treated with partial (PN) or radical nephrectomy (RN), between 2008-2018.*

Variable		Overall (N.=116)	Partial nephrectomy (N.=52, 44.0%)	Radical nephrectomy (N.=64, 55.1%)	P value
Age, years	Mean (SE)	59.1 (1.28)	57.3 (1.841)	60.5 (1.765)	0.2
	Median (IQR)	58 (50-70)	56.5 (49.8-66.2)	60 (50-72)	
Gender	Female	42 (36.2%)	12 (23.1%)	30 (46.9%)	0.01
	Male	74 (63.8%)	40 (76.9%)	34 (53.1%)	
BMI	Mean (SE)	25.4 (0.287)	25.4 (0.643)	25.4 (0)	0.9
	Median (IQR)	25.4 (25.4-25.4)	25.4 (24.4-26.2)	25.4 (25.4-25.4)	
CCI	≤2	99 (85.3%)	47 (90.4%)	52 (81.2%)	0.2
	>2	17 (14.7%)	5 (9.6%)	12 (18.8%)	
PADUA score	Mean (SE)	10.3 (0.129)	10.1 (0.177)	10.5 (0.182)	0.09
	Median (IQR)	10 (9-11)	10 (9-11)	10 (9.8-12)	
Clinical tumor size, mm	Mean (SE)	88.9 (2.073)	84.4 (2.741)	92.5 (2.969)	0.08
	Median (IQR)	80 (75-100)	78 (74-87.8)	85 (75-105)	
Preoperative Hb, g/dL	Median (IQR)	13.7 (0.136)	14.2 (0.1)	13.3 (0.1)	0.001
	Median (IQR)	13.6 (13.3-14.5)	14.2 (13.6-14.8)	13.3 (13.3-14)	
Preoperative creatinine, mg/dL	Mean (SE)	1 (0.02)	1.1 (0.05)	1 (0.02)	0.1
	Median (IQR)	1 (0.9-1.1)	1 (0.9-1.2)	1 (0.9-1)	
Preoperative eGFR, mL/min	Median (IQR)	79.6 (2.079)	80 (3.453)	79.2 (2.54)	0.8
	Median (IQR)	79.2 (67.6-86.4)	80 (64-92.9)	79.2 (69.5-84.2)	
Hypertension	No	56 (48.3%)	27 (51.9%)	29 (45.3%)	0.6
	Yes	60 (51.7%)	25 (48.1%)	35 (54.7%)	
Side	Left	62 (53.4%)	25 (48.1%)	37 (57.8%)	0.3
	Right	54 (46.6%)	27 (51.9%)	27 (42.2%)	

SE: standard error; IQR: interquartile range.

Table II.—*Perioperative characteristics of cT2 patients (N.=116) diagnosed with renal masses and treated with partial (PN) or radical nephrectomy (RN), between 2008-2018.*

Variables		Overall (N.=116)	Partial nephrectomy (N.=52, 44.0%)	Radical nephrectomy (N.=64, 55.0%)	P value
Operative time, min	Mean (SE)	127.4 (-3.966)	134.5 (6.555)	121.6 (4.754)	0.1
	Median (IQR)	121 (100-150)	130.5 (98.2-165)	120 (103-135)	
Blood loss, mL	Mean (SE)	213.3 (-19.437)	207.1 (34.906)	218.3 (21.156)	0.7
	Median	180 (150-180)	100 (100-200)	180 (180-180)	
Ischemia time, min	Mean (SE)	–	23.4 (1.05)	–	–
	Median (IQR)	–	23 (20-26)	–	
Length of stay, days, days	Mean (SE)	7.2 (0.258)	7.4 (0.526)	7.1 (0.195)	0.5
	Median (IQR)	7 (6-7)	6.5 (5-9)	7 (7-7)	
Tumor size, mm	Mean (SE)	89.2 (2.246)	85.8 (3.321)	92.1 (3.027)	0.1
	Median	80 (75-100)	80 (71.8-90)	82.5 (75-102.8)	
Surgical approach	Laparosc	91 (78.4%)	29 (55.8%)	62 (96.9%)	
	Robot-assisted	25 (21.6%)	23 (44.2%)	2 (3.1%)	<0.001
Access type	Retro	36 (31%)	22 (42.3%)	14 (21.9%)	0.03
	Trans	80 (69%)	30 (57.7%)	50 (78.1%)	
Intraoperative transfusion	No	110 (94.8%)	49 (94.2%)	61 (95.3%)	
	Yes	6 (5.2%)	3 (5.8%)	3 (4.7%)	0.9
Postoperative	No	98 (84.5%)	39 (75%)	59 (92.2%)	0.02
Complications	Yes	18 (15.5%)	13 (25%)	5 (7.8%)	
Type of complications	No compl	98 (84.5%)	39 (75%)	59 (92.2%)	
	Fever	3 (2.6%)	3 (5.8%)	0 (0%)	
	Pneumonia	2 (1.7%)	2 (3.8%)	0 (0%)	0.07
	Postop bleeding	4 (3.4%)	3 (5.8%)	1 (1.6%)	
	Urine leakage	1 (0.9%)	1 (1.9%)	0 (0%)	
	Others	8 (6.9%)	4 (7.7%)	4 (6.2%)	
Clavien-Dindo classification	0	98 (84.5%)	39 (75%)	59 (92.2%)	0.07
	I	11 (9.5%)	8 (15.4%)	3 (4.7%)	
	II	6 (5.2%)	4 (7.7%)	2 (3.1%)	
	III	1 (0.9%)	1 (1.9%)	0 (0%)	
	Median (IQR)	13.5 (10-23.5)	27.5 (17.5-36.5)	12 (7-20.2)	0.3

SE: standard error; IQR: interquartile range.

cation (postoperative bleeding requiring angio-embolization, P=0.9).

Considering pathological variables (Table III), mean tumor size was 89.2±2.2 mm, with a significant higher rate of upstaging (>pT3a) for RN (64.1% *vs.* 19.2%, P<0.0001). PN patients harbored more often benign histology (26.9% *vs.* 9.4%, P<0.001).

No differences were recorded in postoperative sCr levels comparing PN and RN (Supplementary Digital Material 1: Supplementary Table I, Supplementary Figure 1). Conversely, relative to RN, PN patients showed higher eGFR values (70.8 *vs.* 53.3 mL/min/m^2, P<0.001). This difference was maintained also after 12 months (74.8 *vs.* 59.2 mL/min/m^2 for RN and PN, P<0.001). Focusing on baseline weighted differential values, significant differences in favor of PN were found between pre- and postoperative sCr and eGFR (P<0.0001, P=0.005), and between pre- and one-year eGFR (P=0.001).

Survival analyses

The median follow-up time was 46 months, without differences between groups. Cumulative incidence plots showed 5-year CSM rates of 7.7% *vs*. 16.7% (P=0.08) and 5-year OCM rates of 5.1% *vs*. 6.6% (P=0.9), for PN and RN respectively (Figure 1).

In multivariable Competing-risk regression models (Supplementary Digital Material 2: Supplementary Table II, Supplementary Table II), and after adjustment for OCM, pT>3a independently predicted higher 5-year CSM (HR=28.2, CI: 21.6-30.5, P=0.02). Conversely, type of nephrectomy was not statistically related to the above-mentioned outcome (HR for PN=0.9, CI: 0.1-1.6, P=0.9). Additionally, when considering

TABLE III.—*Pathological and oncological characteristics of cT2 patients (N.=116) diagnosed with renal masses and treated with partial (PN) or radical nephrectomy (RN), between 2008-2018.*

Variables		Overall (N.=116)	Partial nephrectomy (N.=52, 44.0%)	Radical nephrectomy (N.=64, 55.1%)	P value
pT stage	pT1a	1 (0.9%)	1 (1.9%)	0 (0%)	<0.001
	pT1b	6 (5.2%)	6 (11.5%)	0 (0%)	
	pT2	37 (31.9%)	20 (38.5%)	17 (26.6%)	
	pT3a	46 (39.7%)	9 (17.3%)	37 (57.8%)	
	pT3b	4 (3.4%)	1 (1.9%)	3 (4.7%)	
Malignant histology		96 (82.8)	38 (73.1%)	58 (90.6%)	<0.001
Upstaging	<pT3a	65 (56%)	42 (80.8%)	23 (35.9%)	<0.001
	≥pT3a	51 (44%)	10 (19.2%)	41 (64.1%)	
RCC histological subtype	Clear cell	61 (52.6%)	16 (30.8%)	45 (70.3%)	<0.001
	Papillary	15 (12.9%)	13 (25%)	2 (3.1%)	
	Chromophobe	15 (12.9%)	7 (13.5%)	8 (12.5%)	
	Others	25 (21.6%)	16 (30.8%)	9 (14.1%)	
RCC histological subtype	Clear cell	61 (52.6%)	16 (30.8%)	45 (70.3%)	1E-04
	Non-clear cell	30 (25.9%)	20 (38.5%)	10 (15.6%)	
ISUP grading	G1	5 (4.3%)	3 (5.8%)	2 (3.1%)	0.1
	G2	36 (31%)	19 (36.5%)	17 (26.6%)	
	G3	38 (32.8%)	13 (25%)	25 (39.1%)	
	G4	10 (8.6%)	2 (3.8%)	8 (12.5%)	
	Gx	27 (23.3%)	15 (28.8%)	12 (18.8%)	
Tumor grade	Low grade	68 (58.6%)	37 (71.2%)	31 (48.4%)	0.02
	High grade	48 (41.4%)	15 (28.8%)	33 (51.6%)	
Positive surgical margins	No	113 (97.4%)	51 (98.1%)	62 (96.9%)	0.5
	Yes	3 (2.6%)	1 (1.9%)	2 (3.1%)	
Presence of necrosis	No	35 (30.2%)	15 (28.8%)	20 (31.2%)	0.9
	Yes	81 (69.8%)	37 (71.2%)	44 (68.8%)	
Local recurrence	No	49 (42.2%)	49 (94.2%)	0 (0%)	<0.001
	Yes	3 (2.6%)	3 (5.8%)	0 (0%)	
	Others	64 (55.2%)	0 (0%)	64 (100%)	
Disease progression	No	96 (82.8%)	48 (92.3%)	48 (75%)	0.02
	Yes	20 (17.2%)	4 (7.7%)	16 (25%)	
Site of progression	Adrenal	1 (0.9%)	0 (0%)	1 (1.6%)	0.4
	Brain	1 (0.9%)	0 (0%)	1 (1.6%)	
	Contralateral kidney	2 (1.7%)	0 (0%)	2 (3.1%)	
	Liver	1 (0.9%)	0 (0%)	1 (1.6%)	
	Lung	2 (1.7%)	0 (0%)	2 (3.1%)	
	Multiple sites	6 (5.2%)	3 (5.8%)	3 (4.7%)	
	Nodes	1 (0.9%)	1 (1.9%)	0 (0%)	
	Others	102 (87.9%)	48 (92.3%)	54 (84.4%)	
Follow up, months	Mean (SE)	45.9 (2.827)	46.3 (4.158)	45.6 (3.881)	0.8
	Median (IQR)	41 (22.2-65.5)	43.5 (22.2-65.5)	40.5 (22.2-64.8)	
Time to progression, months	Mean (SE)	20 (4.776)	26.5 (7.053)	17.4 (6.072)	
	Median (IQR)	13.5 (10-23.5)	27.5 (17.5-36.5)	12 (7-20.2)	0.3

SE: standard error; IQR: interquartile range; pT: pathological stage; RCC: renal cell carcinoma.

OCM the endpoint of interest, age at procedure was the only predictive factor for higher 5-year OCM (HR=1.2, CI: 1.0-1.4, P=0.01).

Kaplan-Meier plots were generated and focused on PFS at five years of follow-up, according to type of nephrectomy (Figure 2). For PN *vs.* RN the 5-year PFS was 92.2% *vs.* 72.8% (P=0.02).

At Cox multivariable model focusing on the pathological variables potentially influencing PFS (Supplementary Table II, Supplementary Table III), pT>3a stage (HR=20.0, CI:19.0-23.8, P=0.01), high ISUP grade tumors (HR=4.1, CI: 1.1-6.6, P=0.02) and evidence of PSM (HR=36.1, CI: 25.5-45.4, P<0.001) resulted to be independent predictor of disease progression. Of note, the type of nephrectomy did not influence the PFS (HR for PN=0.7, CI: 0.1-3.5, P=0.7).

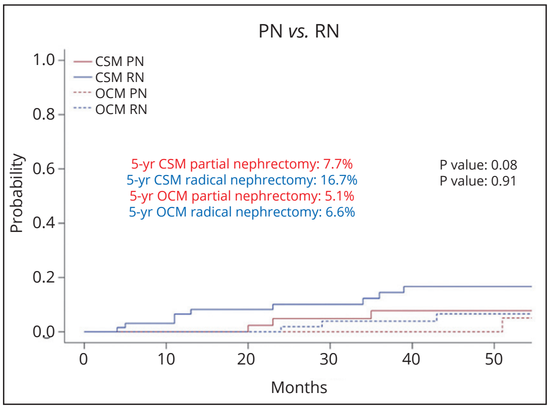

Figure 1.—Cumulative incidence plots representing 5-year cancer-specific mortality (CSM) and other cause mortality (OCM) for patients treated with PN and RN.

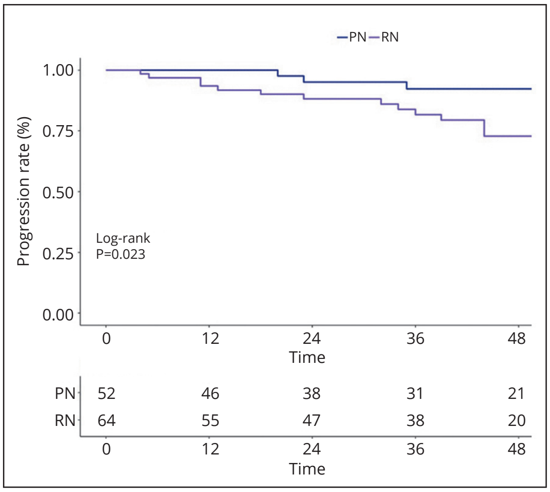

Figure 2.—Kaplan-Meier plots for prediction of 5-year progression-free survival in patients treated with PN and RN.

Discussion

In last years, the renal MIS scenario has been revolutionized by the spread diffusion of nephron sparing approaches,[18, 19] nowadays representing the gold standard treatment for clinical T1 renal tumors.[2]

The progressive extension of the indication to conservative surgery in even more complex cases has led to consider such approach also in case of large renal tumors.[20-22] Thus, the feasibility of minimally invasive PN is nowadays under scrutiny for cT2 lesions.[14] Literature on this topic is limited because of the surgical complexity of such procedures, the heterogeneity of case series and their limited follow-up.[13, 14]

To give a contribution in such field of research, we aimed to evaluate and compare perioperative, oncological and functional outcomes of our cT2 renal tumors cohort, underwent both minimally invasive PN and RN.

The results of the study highlight some interesting points of discussion.

First, after stratification per type of nephrectomy (PN *vs.* RN), the resulting groups of patients did not show significant preoperative differences (except for the gender and Hb levels, whatever without clinical relevance), even if those undergone RN were affected by larger lesions in comparison with those treated with PN (around 1 cm larger, difference not reaching statistical significance).

Indeed larger lesions, even if with the same cT stage of smaller ones, can result more difficult to manage with minimally invasive conservative approaches and more often be addressed to RN. Groups resulted comparable also in terms of intraoperative variables. This reads that minimally invasive PN was not burdened by higher OT, EBL or intraoperative complications offering similar intraoperative outcomes with respect to RN. However, the two more recent meta-analyses available by Mir *et al.*[11] and Li *et al.*,[12] show higher EBL rates in PN patients relative to RN. This could be explained considering that in our case series all procedures were performed by a single expert surgeon, able to manage and consequently minimize intraoperative bleedings. This is also the reason why we recorded a short warm ischemia time within PN patients (23.4 min) similar to other series of PN for the treatment of cT1 renal tumors[23] which did not significantly impair the renal function.

Conversely, PN patients showed a higher postoperative complications rate than RN (25% *vs.* 7.8%, P=0.02). This result is in line with other studies, confirming higher risks for conservative approaches.[11, 12, 24] However, focusing only on major complications, the two groups were comparable, with one single complication scored as Clavien 3a in PN group. Again, from these data it seems that PN is a safe approach also in case of large tumors, but the expertise of the surgeon is crucial to minimize perioperative risks. Indeed, data coming from multicenter case series in which many surgeons performed interventions, shows higher rates of major complications for patients treated with PN.[11, 12]

Additionally, analyzing pathological variables, significant differences in terms of upstaging between the groups were recorded; starting from the same clinical stage, a pathological finding of locally advanced/infiltrating tumor occurred more often in patients underwent RN than PN. This is in accordance with several other studies.[25-28] For example, in a retrospective analysis including 2573 patients with T1-T2 renal tumors, Hamilton *et al*. found a higher pT3a upstaging rate for RN group.[25] Similar results were also recorded by Reix *et al*. considering only cT2a lesions.[26] Moreover, in a multicenter study considering robot-assisted PN for cT2 renal tumors, the upstaging rate was 37%.[13] At last, Veccia *et al.* identified tumor size as an independent predictor of upstaging in T1 renal neoplasms.[28]

Finally, concerning functional variables, clear advantages were found for PN. Indeed, the differential values of early and one-year postoperative eGFR resulted significantly better in PN group (Supplementary Table I). These data are in accordance with the literature showing better one-year postoperative eGFR in cT2 kidney tumor patients treated with PN relative to RN.[11, 29]

Second, we focused on potential CSM disadvantages that might be associated with the use of PN, relative to RN. However, cumulative incidence plots showed no statistically significant difference between PN and RN patients (7.7 *vs*. 16.7%, P=0.08), also if a higher rate of upstaging in RN group was recorded. Similarly, other studies,[11, 12] confirm our results showing that PN, when feasible for organ-confined renal masses >7 cm, is oncologically safe in terms of CSM rates if compared with RN.

Moreover, also when we relied on CRR models after adjustment for the confounding effect of OCM, type of nephrectomy did not affect 5-year CSM rates. Conversely, the pathological stage was the only independent factor predicting higher CSM rates, in according with other studies.[13, 28]

Third, we also made important observations regarding risk of OCM. Our CRR models that focused on OCM according to PN *vs*. RN, did not identify a statistically significant difference in OCM rates between the two management strategies. These observations, even if different from previous literature findings,[11, 12] could be explained by the fact that comorbidities predisposing to OCM (85% of the patients having CCI ≤2) and subsequently OCM were equally distributed between PN and RN patients (5.1% *vs*. 6.6%, P=0.9). Moreover, these findings are supported by young population age (median 59 years) and an optimal preoperative renal function (mean 79.6 mL/min/m^2) recorded in both groups.

Finally, in the light of the important differences in terms of pathological tumor characteristics we focused on potential PFS disadvantages that might be associated with the use of PN, relative to RN. However, even if Kaplan-Meier plots showed higher progression rates in patients treated with RN, our Cox multivariable model failed to show statistically significant difference in 5-year PFS (HR for PN=0.7, CI: 0.1-3.5, P=0.7) between the two management strategies.

Taken together, results of our study suggest that minimally invasive PN is a feasible approach even in case of large renal masses, with a good profile in terms of perioperative and oncological safety and better functional outcomes if compared with RN. Nevertheless, surgeon's experience plays a key role in the choice of nephrectomy type balancing radiological and clinical features of the tumor, as well as patient health status.[12-14, 30] When facing with a clinically organ-confined large lesion with aggressive appearance or surgically complex, or when the surgeon's experience is limited, RN has to be considered as the safest option.[16]

Limitations of the study

The present study has some limitations. First, the small sample size of our cohort, as well as its retrospective nature are important biases. Second, even if the oncological follow-up is extended up to a median of 46 months, functional variables are available up to 12 months only. Third, the increase in PN over RN during the study period could be a potential confounder. This evidence is explained by the extension of indication to

PN due to the introduction of robotic surgery in the minimally- invasive surgery scenario. The choice between minimally invasive PN and RN were made by one high-volume surgeon, on the basis of surgical, radiological and clinical features of the tumor and of patient health status. The final choice was made case by case, when technically feasible, trying to favor the conservative approach. This could not be representative of the entire urological community, especially of less experienced urological surgeon.

Lastly, due to small sample size, in the multivariable competing risks regression models, was not possible to adjust for the effect of important variables, such as tumor grade, local recurrence or disease progression.

Conclusions

The results of this study confirm that PN, when performed by expert surgeons, is a safe and effective minimally-invasive option for cT2 renal masses. Its safety profile is not inferior to RN in terms of perioperative outcomes and does not expose patients to higher risks of CSM or tumor progression. Contrarily, functional outcomes are in favor of PN both right after surgery and in the long term.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—Daniele Amparore and Angela Pecorare contributed equally and share first authorship. Christian Fiori and Francesco Porpiglia contributed equally and share senior authorship. Study concepts: Daniele Amparore, Angela Pecoraro, Francesco Porpiglia. Study design: Daniele Amparore, Angela Pecoraro, Francesco Porpiglia. Data acquisition: Enrico Checcucci, Sabrina De Cillis, Federico Piramide, Gabriele Volpi, Alberto Piana, Paolo Verri, Stefano Granato, Michele Sica. Quality control of data and algorithms: Matteo Manfredi, Cristian Fiori, Francesco Porpiglia. Data analysis and interpretation: Daniele Amparore, Angela Pecoraro, Francesco Porpiglia. Statistical analysis: Angela Pecoraro, Daniele Amparore. Manuscript preparation: Daniele Amparore, Angela Pecoraro. Manuscript editing: Daniele Amparore, Angela Pecoraro. Manuscript review: Francesco Porpiglia, Cristian Fiori. All authors read and approved the final version of the manuscript.

History.—Article first published online: April 22, 2021. - Manuscript accepted: April 2, 2021. - Manuscript revised: March 19, 2021. - Manuscript received: February 4, 2021.

Supplementary data.—For supplementary materials, please see the HTML version of this article at www.minervamedica.it