The Effectiveness of Partial Versus Radical Nephrectomy for pT3aN0M0 Renal Cell Carcinoma: A Propensity Score Analysis

Zheuyu Yang
Sun Yat-sen University Cancer Center https://orcid.org/0000-0001-7699-5743
Jibin Li
Sun Yat-sen University Cancer Center
Zefu Liu
Sun Yat-sen University Cancer Center
Peng Chen
Xinjiang Medical University Affiliated Tumor Hospital
Xing Bi
Xinjiang Medical University Affiliated Tumor Hospital
Zhiyong Li
Sun Yat-sen University Cancer Center
Pei Dong
Sun Yat-sen University Cancer Center
Hui Han
Sun Yat-sen University Cancer Center
Xiaobo He
Sun Yat-sen University Cancer Center
Xiaopeng Mao
Sun Yat-sen University First Affiliated Hospital
Shengjie Guo (guoshj@sysucc.org.cn)
Sun Yat-sen University https://orcid.org/0000-0001-7953-8775

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Abstract

Background

The survival benefit of partial nephrectomy (PN) in pT3a RCC patients is controversial. Here we aimed to determine the benefit of PN for T3aN0M0 renal cell carcinoma (RCC).

Methods

Data of patients with pT3aN0M0 RCC who were diagnosed between 2010–2012 in the National Cancer Institute Surveillance, Epidemiology, and End Results (SEER) database were retrospectively collected. We compared overall survival (OS) and cancer specific survival (CSS) using a Cox proportional hazards model between PN and radical nephrectomy (RN) in pT3aN0M0 RCC. Propensity score (–adjusted, –stratified, –weighted, and –matched) analyses were performed to control for imbalances in individual risk factors.

Results

A total of 1277 patients with pT3aN0M0 RCC were identified, of whom 200 patients were treated with PN and 1077 patients were RN. Patients who received PN were more likely to have small tumor size, well/moderately differentiation, peritumoral fat invasion, and less likely to have multiple site invasion and clear cell adenocarcinoma type ($p < 0.05$). PN showed favorable OS and CSS in 0-4cm pT3aN0M0 RCC ($p < 0.05$), and similar OS and CSS in 4-7cm pT3aN0M0 RCC, compared with RN using un-adjusted analyses. The Propensity score analyses further demonstrated the survival benefit of PN compared with the RN in 0-4cm pT3aN0M0 RCC ($p < 0.05$).

Conclusions

In this observational study, PN was associated with improved survival compared with RN in 0-4cm pT3aN0M0 RCC. Moreover, survival was comparable between PN and RN in 4-7cm pT3aN0M0 RCC. These data provided evidence that PN is an alternative choice for T3aN0M0 RCC less than 7 cm. Patients with 0-4cm pT3aN0M0 RCC may benefit from PN.

Background

Renal cell carcinoma (RCC) represents 2.2% estimated new cases and 1.8% estimated deaths of all cancers worldwide [1]. Surgery is the most important curative intention in patients with localized RCC, including partial nephrectomy (PN) and radical nephrectomy (RN). Though PN has comparable overall survival (OS) with RN in clinical T1 stage RCC, PN demonstrated better preserved kidney function, thereby potentially lowering the risk of development of cardiovascular disorders. According to the European Association of Urology Guidelines, PN is strongly recommended for patients with cT1 RCC (< 7 cm) [2].

Majority of cT1 RCC has consistent pathological T1 stage after surgery, while there is a rate of 3.2%-31% cT1 RCC upstaged to pT3a in the PN treatment [3]. Moreover, pT3a RCC upstaged from cT1 RCC was significantly associated with poor recurrence-free survival, overall survival, and cancer-specific survival [3]. According to the Eighth Edition of the Tumor-Node-Metastasis Staging Classification System, pT3a is defined based on anatomical tumor expansion including either vein, Renal pelvis or fatty infiltration, regardless of tumor size [4]. Several studies highlighted the importance of upstaging and underlying tumor characteristics such as tumor grade, size and complexity, and invasion site as predictors of recurrence and survival for pT3aRCC, while the surgery type is controversial [5–7].

This study aimed to investigate the survival benefit of PN compared with RN in pT3aN0M0 RCC.

Materials And Methods

Patients and Study Design

The data of patients with RCC from the Surveillance, Epidemiology and End Results (SEER) database were obtained through SEER*Stat 8.3.6 software (National Cancer Institute, Bethesda, MD, USA) (Accession number: 14558-Nov2018). A total of 1277 RCC patients who underwent partial or radical nephrectomy from 2010 to 2012 were enrolled by meeting the following including criteria: (Ⅰ) histologically confirmed renal cell carcinoma; (Ⅱ) pT3a stage; (Ⅲ) absence of lymph node and distant metastasis; (IV) age ≥ 18; (V) treated with PN or RN; (Ⅵ) single primary RCC.

The renal cancer coded as Primary Site (C64.9) and ICCC site recode ICD-O-3 (VI (b) Renal carcinomas). Partial surgery coded as surgery of primary site (30) and Radical surgery coded as surgery of primary site (50). The invasion site of perirenal fat invasion (PFI) coded as CS site-specific factor 1 (10) with CS extension (450 or 460), sinus fat invasion (SFI) coded as CS site-specific factor 1 (20) with CS extension (450 or 460), PFI and SFI coded as CS site-specific factor 1 (30) with CS extension (450 or 460), PFI and renal vein invasion (RVI) coded as CS site-specific factor 1 (10) with CS extension (601 or 605), SFI and RVI coded as CS site-specific factor 1 (20) with CS extension (601 or 605), and all the three factors coded as CS site-specific factor 1 (30) with CS extension (601 or 605). For each patient, collected data includes demographic (age, gender. race, year of diagnosis) and clinicopathologic information (tumor size, grade, laterality, pathology, invasion site for T3a, the 7th TNM classification, the surgical type, follow-up data and so on). The clinical data collected from the SEER database, which is a public research resource that does not require patient consent and ethical consent.

Outcomes

In this study, the outcomes included: OS and cancer-specific survival (CSS). They were coded by SEER.

Statistical Analysis

Categorical variables were presented as frequency and percentage, which were compared by Chi-squared test. Univariable logistic regression models were used to estimate crude odds ratios and 95% CIs to evaluate the association between each variable and surgical type (partial or radical nephrectomy). A Cox proportional

hazards model was used to compare OS and CSS of patients treated with PR and NR for all patients, patients with tumor size ≤ 4 cm, and patients with tumor size 4-7cm, respectively. The hazard ratios (HR) were calculated using four methods: stratifying on the propensity score in which patients were classified into quintiles by their propensity scores, 1: 1 ratio matching patients in the PR and NR groups by propensity score with a caliper of 0.1, using inverse probability weighting by the inverse of the propensity score of the treatment received, and adjusting for the propensity score by including it as a continuous covariate in the Cox model. We assessed heterogeneity of treatment effects with tests of interaction and subgroup analyses of age, gender, invasion site, tumor size, grade, laterality pathology. Propensity scores were estimated with a multivariable logistic regression model in which treatment assignment was regressed on age, gender, invasion site, tumor size, grade, and laterality pathology for all patients, patients with tumor size ≤ 4 cm, and patients with tumor size 4-7cm, respectively. All hypothesis tests were two-tailed with a significance level of 0.05. Statistical analyses were conducted using R version 3.0.2 and SPSS software version 24.0 (IBM, Armonk, NY, USA).

Results

Factors associated with the PN and RN

From an initial cohort of 244,943 patients with renal cell carcinoma in the SEER data set, 8713 patients were identified who were older than 18 years and had pT3aN0M0 disease. 7576 of whom had undergone PN and RN. 3741 of whom had a complete information. Furthermore, in order to ensure adequate 5-year follow-up time, 1277 patients with single primary kidney tumor met the study inclusion criteria from 2010 through 2012, and 200 of them (15.66%) received PN, 1077 received RN (84.34%).

Baseline patient characteristics are listed in Table 1. Patients who received PN were more likely to have small tumor size, well/moderately differentiation and PFI invasion, and less likely to have poor differentiation, more than one site invasion and clear cell adenocarcinoma type ($P < 0.05$ for all comparisons).

Table 1
Baseline characteristics of 1277 patients from SEER database

Characteristics	Partial nephrectomy (N = 200)	Radical nephrectomy (N = 1077)	Crude OR (95% CI)	P values
Age at diagnosis	61.86 ± 11.46	63.28 ± 11.81	1.01 (0.99–1.02)	0.117
Mean ± SD	62	63		
Median	34–87	24–95		
Range				
Year of diagnosis	71 (35.50%)	381 (35.38%)	1 (ref.)	0.012
2010	45 (22.50%)	343 (31.85%)	1.42 (0.95–2.12)	
2011	84 (42.00%)	353 (32.78%)		
2012			0.78 (0.55–1.10)	
Race	163 (81.50%)	934 (86.72%)	1.00 (ref.)	0.128
White	25 (12.50%)	80 (7.43%)	0.55 (0.34–0.90)	
Black	11 (5.50%)	58 (5.39%)	0.92 (0.47–1.79)	
Other (American Indian/AK Native, Asian/Pacific Islander)	1 (0.50%)	5 (0.46%)	0.87 (0.10–7.51)	
Unknown				
Tumor diameter	134 (67.00%)	114 (10.58%)	1 (ref.)	< 0.001
0 < diameter ≤ 4 cm	49 (24.50%)	400 (37.20%)	9.59 (6.51–14.14)	
4 < diameter ≤ 7 cm	14 (7.00%)	308 (28.57%)	25.86 (14.32–46.69)	
7 < diameter ≤ 10 cm	3 (1.50%)	255 (23.65%)	99.91 (31.15–320.40)	
Diameter＞10 cm				
Gender	143 (71.50%)	751 (69.73%)	1 (ref.)	0.616
male	57 (28.50%)	326 (30.27%)	1.08 (0.78–1.52)	
female				

PFI: perirenal fat invasion; SFI: sinus fat invasion; RVI: renal vein invasion

Characteristics	Partial nephrectomy (N = 200)	Radical nephrectomy (N = 1077)	Crude OR (95% CI)	P values
Grade	15 (7.50%)	43 (3.99%)	1 (ref.)	< 0.001
Well differentiated; Grade I	102 (51.00%)	390 (36.21%)	1.33 (0.71–2.49)	
Moderately differentiated; Grade II	74 (37.00%)	461 (42.80%)	2.17 (1.14–4.10)	
Poorly differentiated; Grade III	9 (4.50%)	183 (16.99%)	7.09 (2.91–17.28)	
Undifferentiated; anaplastic; Grade IV				
Laterality	100 (50.00%)	572 (53.11%)	1 (ref.)	0.419
Left - origin of primary	100 (50.00%)	505 (46.89%)	0.88 (0.65–1.19)	
Right - origin of primary				
Pathology	119 (59.50%)	794 (73.72%)	1 (ref.)	< 0.001
Clear cell adenocarcinoma	42 (21.00%)	71 (6.59%)	0.25 (0.16–0.38)	
Papillary adenocarcinoma	14 (7.00%)	54 (5.01%)	0.57 (0.31–1.07)	
Renal cell carcinoma, chromophobe type	23 (11.50%)	138 (12.81%)	0.89 (0.55–1.45)	
Others	2 (1.00%)	20 (1.86%)	1.49 (0.34–6.49)	
Renal cell carcinoma, sarcomatoid				
Invasion site	149 (74.50%)	468 (43.45%)	1 (ref)	< 0.001
PFI	22 (11.00%)	197 (18.29%)	2.78 (1.72–4.49)	
SFI	13 (6.50%)	51 (4.74%)	1.32 (0.68–2.55)	
PFI + SFI	5 (2.50%)	143 (13.28%)	6.71 (3.07–14.65)	
PFI + RVI	9 (4.50%)	151 (14.02%)	5.46 (2.72–10.98)	
SFI + RVI	2 (1.00%)	67 (6.22%)	7.19 (2.23–23.21)	
PFI + SFI + RVI				

PFI: perirenal fat invasion; SFI: sinus fat invasion; RVI: renal vein invasion

Un-adjusted Survival analysis

The median follow-up were 60 months and 65 months for patients in the PN therapy group and RN group, respectively. The 5-year OS was 85.87% (95% CI, 81.04–90.98%) and 67.81% (95% CI, 64.96–70.80%) in the

PN group and RN group, respectively ($p < 0.001$). PN group and RN group patients had 5-year CSS of 92.61% (95% CI, 88.95–96.42%) and 75.78% (95% CI, 73.09–78.56%), respectively ($p < 0.001$).

Based on tumor size, pT3aN0M0 RCC were divided into four subgroups: 0-4cm, 4-7cm, 7-10cm and > 10 cm. OS and CSS comparing PN and RN in all subgroups were further analyzed. The CSS and OS of PN are better than RN in 0-4cm subgroup, and they are similar with RN in the 4-7cm, 7-10cm and > 10 cm pT3aN0M0 RCC subgroups. (Fig. 1).

Propensity score survival analysis

The subgroup of 0-7cm pT3aN0M0 RCC was further analyzed (Table 2). PR group tended to have less multiple invasion sites, smaller tumor size, better differentiation, and less clear cell carcinoma, compared to RN group.

Table 2
Characteristics of pT3aN0M0 patients with tumor diameter 0-7cm

Characteristics	Partial nephrectomy (N = 183)	Radical nephrectomy (N = 514)	p values
Age at diagnosis	61.6 ± 11.7	64.3 ± 12.0	0.007
Mean ± SD	34–87	24–95	0.014
Range	135 (73.8)	328 (63.8)	
< 70	48 (26.2)	186 (36.2)	
≥ 70			
Gender	128 (70.0)	350 (68.1)	0.643
Male	55 (30.0)	164 (31.2)	
Female			
Invasion site	159 (86.9)	352 (68.5)	< 0.001
Single (PFI/SFI)	24 (13.1)	162 (31.5)	
Multiple			
Tumor diameter	134 (73.2)	114 (22.2)	< 0.001
0–4 cm	49 (26.8)	400 (77.8)	
> 4 cm			
Grade	113 (61.8)	256 (49.8)	0.005
I - II	70 (38.3)	258 (50.2)	
III - IV			
Laterality	91 (49.7)	267 (52.0)	0.606
Left	92 (50.3)	247 (48.0)	
Right			
Pathology	106 (57.9)	376 (73.2)	< 0.001
Clear cell adenocarcinoma	77 (42.1)	138 (26.9)	
Others			
PFI: perirenal fat invasion; SFI: sinus fat invasion			

Analyses inverse-probability-weighted by propensity score quintile also showed that PN was associated with improved OS (HR 0.34, 95% CI, 0.16 to 0.74) and CSS (HR, 0.1; 95% CI, 0.02 to 0.68) in the 0-4cm T3aN0M0 RCC group ($p < 0.05$). Propensity score -adjusted, -stratified and -matched analyses yielded similar results ($p <$

0.05) (Table 3). There is no evidence of heterogeneity in HR in subgroups defined by age, gender, grade, invasion site and pathology type (Table 4).

Table 3
Propensity score survival analyses of pT3aN0M0 patients with tumor diameter 0-7cm

	Cases (RN vs. PN)	Overall survival				Cancer specific survival			
		Events in RN (%)	Events in PN (%)	HR (95% CI)	P value	Events in RN (%)	Events in PN (%)	HR (95% CI)	P value
Diameter 0–4 cm									
Unadjusted	114 vs. 134	23 (20.2)	8 (6.0)	0.29 (0.13–0.65)	0.003	10 (8.8)	1 (0.8)	0.09 (0.01–0.68)	0.020
Propensity score-based models	114 vs. 134	23 (20.2)	8 (6.0)	0.33 (0.14–0.75)	0.008	10 (8.8)	1 (0.8)	0.09 (0.01–0.71)	0.022
Adjusted	114 vs. 134	23 (20.2)	8 (6.0)	0.34 (0.15–0.80)	0.013	10 (8.8)	1 (0.8)	0.08 (0.01–0.66)	0.019
Stratified	114 vs. 134	23 (20.2)	8 (7.3)	0.34 (0.16–0.74)	0.007	10 (8.8)	1 (0.8)	0.10 (0.02–0.68)	0.018
IPW	114 vs. 134	22 (20.2)		0.34 (0.16–0.74)	0.032	9 (8.3)	1 (0.9)	0.10 (0.02–0.68)	0.040
1:1 matched†	109 vs. 109			0.39 (0.16–0.92)				0.12 (0.02–0.91)	
Diameter 4–7 cm									
Unadjusted	400 vs. 49	114 (28.5)	13 (26.5)	0.94 (0.53–1.67)	0.835	74 (18.5)	8 (16.3)	0.89 (0.43–1.84)	0.743

Note: The propensity score of radical nephrectomy was estimated using a multivariable logistic regression model that included age, invasion site, gender, grade, laterality pathology, tumor diameter.

PN: partial nephrectomy; RN: radical nephrectomy; IPW: Inverse-probability-weighted

† with a caliper of 0.10

	Cases (RN vs. PN)	Overall survival				Cancer specific survival			
		Events in RN (%)	Events in PN (%)	HR (95% CI)	P value	Events in RN (%)	Events in PN (%)	HR (95% CI)	P value
Propensity score-based models	400 vs. 49	114 (28.5)	13 (26.5)	0.97 (0.55–1.73)	0.929	74 (18.5)	8 (16.3)	0.91 (0.0.44–1.89)	0.800
Adjusted	400 vs. 49	114 (28.5)	13 (26.5)	0.97 (0.54–1.73)	0.834	74 (18.5)	8 (16.3)	0.90 (0.43–1.88)	0732
Stratified	400 vs. 49	114 (28.5)	13 (26.5)	0.84 (0.46–1.53)	0.569	74 (18.5)	8 (16.3)	0.90 (0.44–1.83)	0.760
IPW	49 vs. 49	16 (32.7)	13 (26.5)	1.22 (0.55–2.73)	0.624	10 (20.4)	8 (16.3)	1.17 (0.42–3.22)	0.766
1:1 matched†									
Note: The propensity score of radical nephrectomy was estimated using a multivariable logistic regression model that included age, invasion site, gender, grade, laterality pathology, tumor diameter.									
PN: partial nephrectomy; RN: radical nephrectomy; IPW: Inverse-probability-weighted									
† with a caliper of 0.10									

Table 4
Subgroup analysis of factors associated with survival

Characteristics	Overall survival		Cancer specific survival	
	HR (95% CI)	P values	HR (95% CI)	P values
Age	0.15 (0.25–0.82)	0.829	0.20 (0.07–0.56)	0.21
< 70	0.41 (0.20–0.85)		0.48 (0.19–1.23)	
≥ 70				
Gender	0.40 (0.23–0.68)	0.811	0.25 (0.11–0.57)	0.478
Male	0.46 (0.19–1.08)		0.42 (0.13–1.41)	
Female				
Invasion site	0.41 (0.24–0.70)	0.508	0.31 (0.14–0.68)	0.876
Single (PFI-SFI)	0.57 (0.23–1.44)		0.34 (0.08–1.43)	
Multiple				
Tumor diameter	0.29 (0.13–0.65)	0.018	0.09 (0.01–0.68)	0.033
0–4 cm	0.94 (0.53–1.67)		0.89 (0.43–1.84)	
> 4 cm				
Grade	0.65 (0.36–1.19)	0.066	0.52 (0.20–1.38)	0.216
I-II	0.27 (0.12–0.57)		0.22 (0.08–0.59)	
III-IV				
Laterality	0.31 (0.15–0.65)	0.296	0.14 (0.03–0.59)	0.2
Left	0.52 (0.29–0.94)		0.41 (0.18–0.91)	
Right				
Pathology	0.31 (0.16–0.59)	0.095	0.27 (0.11–0.67)	0.784
Clear cell adenocarcinoma	0.67 (0.34–1.34)		0.32 (0.11–0.92)	
Others				
PFI: perirenal fat invasion; SFI: sinus fat invasion				

While for the 4-7cm pT3aN0M0 RCC group, the analyses adjusted, stratified, inverse-probability-weighted and -matched by propensity score quintile showed that PN has no benefit in OS and CSS, compared with RN (Table 3).

Discussion:

The role of PN in the treatment of cT1 RCC has been well studied. While Chen et al. showed that the rate of cT1 upstaged to pT3a ranged from 3.2–31%, median 5.5% [3]. Moreover, upstaged cT1/pT3a RCC was associated with poor recurrence-free survival, overall survival, and cancer-specific survival in the most of the reports [3]. It has been showed that several factors would affect the prognostic of pT3a RCC, such as tumor size, invasion site, tumor grade and pathology type. Tumor size over 7 cm is an important poor factor for predicting the outcome of patients with pT3a RCC with fat invasion [8, 9]. Furthermore, there is a trend of worse outcomes with tumor size increases from 0-4cm to 4-7cm and over 7 cm in pT3a RCC [10]. We previously showed that the PFI and SFI has similar prognosis, and single fat invasion site invasion has better survival than multiple sites invasion in pT3aN0M0 RCC [11]. There are also some studies showed that tumor grade and pathology type could affect the survival of pT3a RCC [12, 13]. These studies suggested tumor size, invasion site, tumor grade and pathology type were the prognostic factors of pT3a RCC.

The survival benefit of surgical type (PN/RN) in pT3a RCC patients is controversial. Great majority of studies showed that PN has similar survival outcomes with RN in pT3a RCC. There is very limited evidence regarding whether RN or PN is better in pT3a RCC [14]. Oh et.al. reported that PN provides similar recurrence-free survival outcomes compared with RN in patients with 0-4cm pT3a RCC [15]. Lee et al. showed no significant difference in survival of the PN group when compared to the RN group in tumor size < 7 cm pT3aRCC [16]. However, Ziegelmueller et al. showed that PN in pT3a RCC leads to better survival outcomes compared to RN in tumor size < 7 cm [17]. While Shah et al. reported PN was associated with shorter recurrent-free survival compared to RN in cT1/pT3a upstaged patients (49 PN vs 91 RN), in which the positive margin rate was approximately 15% (7/49), and more than half (4/7) of positive margin patients recurred in PN [18]. Although the survival benefit is inconsistent, most of the studies showed that PN patients had a higher postoperative eGFR than RN patients [19]. Actually, there are some shortcomings in previous studies, such as small sample size, short follow-up time, lacking invasion site and tumor size information, and including Nx/N1 patients. Moreover, single or inadequate analysis model is also an important factor.

To our knowledge, this observational study contains the largest cohort of pT3aN0M0 RCC to analyze the survival of PN (200 cases) and RN (1077 cases). And factors including age, gender, tumor size invasion site, grade, and pathology type, which may affect survival, were all analyzed. As it is rare to perform PN in pT3a RCC over 7 cm, thus we focus on pT3aN0M0 RCC less than 7 cm, comparing the survival differences between PN and RN. Unadjusted data showed that the characteristics of pT3aN0M0 patients are significantly different in tumor size, invasion site, tumor grade, pathology type and surgery type, therefore it is necessary to balance the bias by using analytic models. Previous studies did not balance the bias or just used the match model, which might result in unreliable conclusions. Propensity score analyses were more reliable to control imbalances in individual risk factors [20].

There are inconsistent conclusions of PN and RN for T3a RCC from previous studies, and majority of these studies showed similar survival outcomes between PN and RN in T3aN0M0 RCC. Our data showed that PN is associated with better survival compared to RN in 0-4cm pT3aN0M0 RCC. It is clear that the OS/CSS of PN is comparable to RN in cT1 RCC from the prospective and retrospective clinical studies, and PN decreases chronic kidney disease [21–23]. The survival benefit of PN in 0-4cm pT3aN0M0 RCC may be explained by Hamilton, Z.A., which showed that most recurrences were distant with a recurrence rate of 92.5% (99/107),

and loco-regional recurrence was only 11.2% (12/107) in upstaged pT3a RCC, which was even lower than loco-regional recurrence of 17.8% (30/169) in non-upstaged cT1-2 RCC [10]. Furthermore, Patel et al. reported that in pathologically upstaged pT3a RCC, PN did not adversely affect risk of recurrence and provided functional benefit [24].Although, Shah et al. reported that cT1/pT3a upstaged patients (49 PN/91 RN), the positive margin rate was approximately 15% (7/49) in PN, and more than half (4/7) of positive margin patients recurred [18]. The positive margin of PN significantly increased in cT1/pT3a RCC, compared with cT1/pT1 [25]. While, positive margin was not associated with local recurrence of pT3a RCC [10]. As distant recurrence is the major risk of locally advanced T3a RCC patients, therefore, local positive margin may not be a key prognostic factor in this cohort patients. Single, rather than multiple sites invasion, is the major invasion characteristic of 0-4cm pT3aN0M0 RCC, which is possible to be completely removed by PN surgery. Thus, the effect of the local disease control may be similar in 0-4cm pT3aN0M0 RCC patients between PN and RN. In this study, the results have further been confirmed by propensity score (–adjusted, –stratified, –weighted, and –matched) analyses, which may attenuate the possibility of bias. The cohort of 4-7cm pT3aN0M0 RCC, PN has similar survival outcomes compared with RN, which indicated that tumor size is still the key prognostic factor for pT3aN0M0 RCC.

PN is a technically demanding surgery, especially for patients with tumors > 7 cm, Fuhrman grade III-IV, and pT3a. RN is the first choice for T3a RCC. While PN can preserve additional renal function and lead less cardiovascular disorders, which may let pT3aN0M0 RCC patients have better tolerance to adjuvant therapy with targeted drug, and it is benefic for longer disease-free survival of advanced RCC patients [26]. Therefore, PN is not a contraindication for T3a RCC patients. Especially for T3a RCC patients with smaller size 0-4cm, whom even can benefit from PN.

Although this is the largest cohort used to assess the survival benefit of PN in pT3aN0M0 RCC, it has several limitations. Limitations of the present study include the retrospective nature of the analysis. Selection bias is another important limitation which is intrinsic to the retrospective design of the study. Though we analyzed several prognostic factors of pT3aN0M0 RCC including tumor size, grade, pathology type, and invasion site for the first time, some prognostic factors including positive margin, perioperative complication, renal function, metastasis and adjuvant therapy were not analyzed here. Propensity score-based approaches are sufficient for minimizing the impact of observed confounders, such methodology does not address unobserved confounders (ie, unmeasured patient selection factors for PN/RN that are also associated with survival such as hypertension and diabetes). Furthermore, there is no central pathology review to reconfirm pathological characteristics, as this was a national data set study, Lastly, follow-up was relatively short and endpoint events only occurred in a small part of patients.

Conclusion

The present study is the largest evaluation of PN in pT3aN0M0 RCC. Our data indicate that PN is associated with favorable survival in 0-4cm pT3aN0M0 RCC subgroup, even when controlling for known prognostic imbalances between PN and RN. And the survival is similar between PN and RN in 4-7cm pT3aN0M0 RCC subgroup. Given the fact that PN is the preferred choice for cT1 RCC, while PN to RN still showed comparable

prognosis of cT1/pT3a RCC, therefore it is not a contraindication to perform PN in selective cT3a RCC patients with tumors less than 7 cm.

Abbreviations

PN
partial nephrectomy
RCC
renal cell carcinoma
SEER
National Cancer Institute Surveillance, Epidemiology, and End Results
OS
overall survival
CSS
cancer specific survival
RN
radical nephrectomy
PFI
perirenal fat invasion
SFI
sinus fat invasion
RVI
renal vein invasion
HR
hazard ratios
IPW
Inverse-probability-weighted

Declarations

Ethics approval and consent

Data from SEER does not require patient consent and ethical consent. Data from our own hospital was approved by the Ethics Committee of our hospital.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article. More details are available from the corresponding author upon request.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

ZY, **JL**, **ZFL**, **PC**, **XH, XM** and **SG** performed the analysis. **ZY**, **JL**, **ZFL**, **XB**, **ZYL**, **PD**, **HH** analyzed the results. **ZY**, **JL**, **ZFL**, **XM** and **SG** prepared the tables and figures. **XH**, **XM** and **SG** designed the research. **SG** and all the coauthors wrote and approved the article.

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Figures

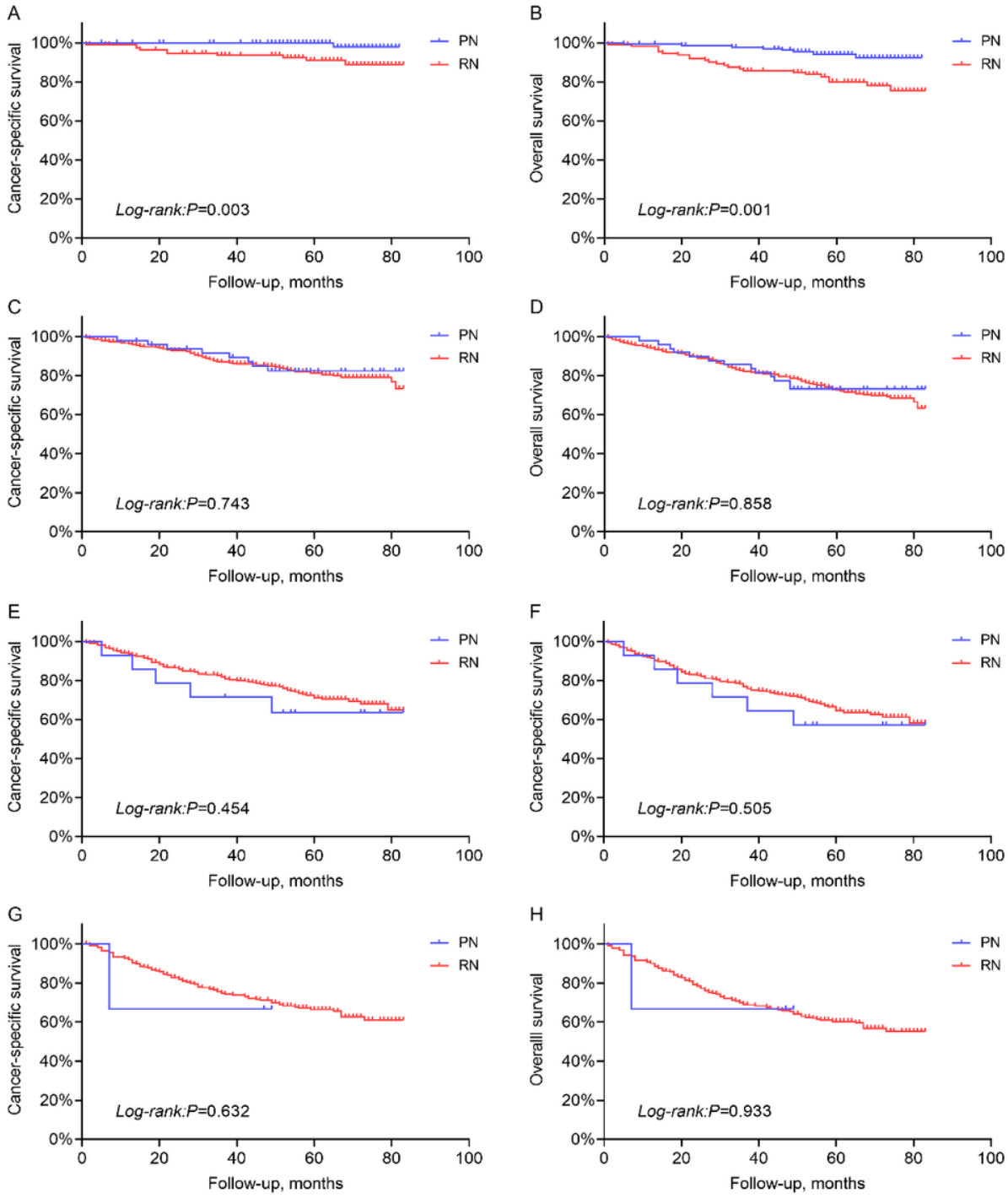

Figure 1

Cancer-specific survival and overall survival of pT3aN0M0RCC based on tumor size. (A) CSS of 0-4cm. (B) OS of 0-4cm. (C) CSS of 4-7cm. (D) OS of 4-7cm. (E) CSS of 7-10cm. (F) OS of 7-10cm. (G) CSS of ≥10cm. H) OS of ≥10cm. CSS: cancer-specific survival; OS: overall survival