Comparison of Long-Term Results After Nephron-Sparing Surgery and Radical Nephrectomy in Treating 4- to 7-cm Renal Cell Carcinoma

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Key Words: *renal cell carcinoma; radical nephrectomy; nephron-sparing surgery; overall survival; cancer-specific survival.*

Summary. *Objective. The aim of our study was to compare long-term oncological outcomes following nephron-sparing surgery (NSS) and radical nephrectomy (RN) for renal cell carcinoma (RCC) 4 to 7 cm in diameter.*

Material and Methods. The study included patients who underwent RN or NSS for RCC 4 to 7 cm in diameter between 1998 and 2009. The studied groups were compared with respect to the patients' age, sex, physical status according to the American Society of Anesthesiologists Physical classification, histological type, stage, tumor size, grade, duration of the operation, and complications. Survival was established using the Kaplan-Meier method. The risk factors for survival were analyzed using a multivariate Cox regression model.

Results. During the study, 351 patients underwent surgery: 317 patients (90.3%) underwent RN, and 34 (9.7%), NSS. The compared groups differed with respect to tumor size (P=0.001) and stage (P=0.006). The overall estimated 12-year survival was 53.7% after RN and 55.2% after NSS (log-rank test P=0.437). The 12-year cancer-specific survival in the RN and NSS groups was 69.6% and 80.6%, respectively (log-rank test P=0.198). Pathological stage and patients' age were the major factors affecting both overall and cancer-specific survival. The type of surgery (NSS or RN) had no effect on survival.

Conclusions. Our study showed that nephron-sparing surgery is a safe technique compared with radical nephrectomy that ensures good oncological control in the treatment of renal cell carcinoma measuring 4 to 7 cm and may be proposed as the treatment of choice for renal tumors not only up to 4 cm, but also 4 to 7 cm in size.

Introduction

Renal cell carcinoma (RCC), also known as adenocarcinoma of renal cortical cells, hypernephroma, clear cell carcinoma, or Grawitz tumor, is the most common renal tumor comprising 85% of all malignant renal tumors and 2%–3% of all malignant neoplasms in adults (1, 2). The increased frequency of the diagnosis of this disease is associated with the increased use of ultrasound examination back in 1980. RCC is the most lethal neoplastic disease of the urinary system: the mortality of patients with renal cell carcinoma is 56% compared with the mortality of only 20% among patients with prostate or urinary bladder cancer (1). The incidence of this cancer in the general population increases by 2.5% each year (2).

The progress in the diagnostics and treatment of RCC during the last decades has improved survival in individual patient groups. Since 1969, when Robson et al. published the data of their retrospective study on 88 cases of RCC, radical nephrectomy (RN) has become the golden standard in the surgical treatment of this disease. Eventually, the increasing numbers of detected small-size, initial-stage, and better-differentiated renal carcinomas expanded the indications for the application of partial nephrectomy (renal resection or nephron-sparing surgery [NSS]). This was caused by several reasons, one of which being that tumors in 20%–30% of patients following RN were found to be benign. In addition, an increasing body of evidence has indicated no difference in survival, cancer-specific survival, cancer-free survival, or relapse between patients undergoing NSS and those undergoing RN.

Other reason was an increased risk of renal failure following nephrectomy, which may impair total survival due to comorbidities such as heart failure (3). Mild or moderate renal failure was documented

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in 65% and 36% of patients, respectively, following RN and 20% and 5% of patients, respectively, after NSS (4).

Initially, NSS for patients with RCC was applied only in the presence of absolute (imperative) indications: tumor located in one functional kidney (anatomically or functionally single kidney) or a multifocal or bilateral renal tumor. Later on, the indications for NSS were expanded, and the procedure was applied in the presence of relative indications as well. Recently, the significance of NSS has been increasing in treating renal tumors when the function of the contralateral kidney remains normal, i.e. in the presence of elective indications. NSS indicated for RCC measuring 4 to 7 cm (stage T1b) had equivalent oncological results to those in patients who underwent RN (5–9). However, the significance of NSS in the presence of RCC measuring 4 to 7 cm has insufficiently been studied compared with RCC less than 4 cm in diameter.

The aim of our study was to compare long-term oncological outcomes following NSS and RN for RCC 4 to 7 cm in diameter.

Material and Methods

After the approval of the Regional Ethical Committee, 351 patients who underwent NSS or RN between January 1998 and December 2009 were included into the study.

Patients were considered eligible for entry into the study if they had solitary RCC measuring 4 to 7 cm and underwent RN or NSS for relative or elective indications. All of the patients underwent surgery with an open method. Patients with multiple or bilateral tumors, distant metastases, benign tumors in pathology specimens and those who underwent laparoscopic surgery were excluded from further analysis. Patients who underwent NSS for absolute indications (functionally or anatomically single kidney tumor) were excluded from the study as well.

The studied groups were compared with respect to the patients' age, sex, status according to the American Society of Anesthesiologists (ASA) criteria, tumor size, the grade of differentiation (G), pathological stage (pT), histological type, time in surgery, the rate of complications, and the duration of in-hospital stay.

Information on the status of these patients (alive or deceased, and the cause and the date of death) was gathered from the National Cancer Control and Prevention Center. The last registered date of passive observation was March 31, 2012. Depending on the cause of death, OS and CSS were evaluated.

Statistical data analysis was performed by using the SPSS 17.0 software. Categorical data were tested by using the chi-square test or the Fisher exact test as appropriate, and continuous data were tested using the Student *t* test. The Mann-Whitney test was used when data were not normally distributed. Overall survival (OS) and cancer-specific survival (CSS) were established using the Kaplan-Meier method, and curves were tested with the log-rank test. The effect of potential risk factors on survival was evaluated using a multivariate Cox regression model. The level of statistical significance was set $P<0.05$.

Results

During the study, 351 patients underwent surgery for RCC measuring 4 to 7 cm: 317 patients (90.3%) underwent RN, and 34 patients (9.7%), NSS. The characteristics of the studied population and patients divided into the RN and NSS groups are presented in Table 1.

The mean follow-up was 6.44 years: 6.46 years in the RN group, and 6.23 years, in the NSS group ($P=0.744$). In total, 133 patients (37.9%) died during the study: 123 patients (38.8%) died in the RN group, and 10 patients (29.4%), in the NSS group ($P=0.283$).

The analysis of the causes of death in 133 patients showed that 76 (57.2%) died from renal carcinoma, and in 51 patients (38.3%), the cause of death was other disease. In 6 cases (4.5%), the cause of death was unknown; therefore, these subjects were excluded from the specific mortality analysis.

The 5-, 7-, 12-, 14-year OS and CSS in all patients was 72.4%, 63.3%, 53.9%, and 45.5%, respectively, and 82.3%, 76.9%, 70.4%, and 70.4%, respectively (Fig. 1).

The 5, 7, and 12-year OS in patients who underwent NSS was 83.1%, 64.4%, and 55.2%, respectively, and in the RN group, 71.2%, 63.1%, and 53.7%, respectively (log-rank test $P=0.437$) (Fig. 2).

In the RN group, the 5-year CSS was 80.9%; 7-year CSS, 76.4%; and 12-year CSS, 69.6%. In the NSS group, the 5-year CSS was 97.1%, and the 7- and 12-year CSS, 80.6%. Even though CSS was better in the NSS group, the difference was not significant (log-rank test $P=0.198$) (Fig. 3).

The factors that significantly affected OS were the subjects' age, pT, G, and preoperative ASA class. Each year of age increased the risk of death by 1.033-fold. The increase of the ASA class or G by one point increased the risk of death by 1.7- and 1.6-fold, respectively. The increase of the pT (pT1 vs. pT2 vs. $\geqslant$pT3) by one unit increased the risk of death by 1.4-fold. OS was not affected by the surgical technique or tumor size (Table 2).

CSS was significantly affected by the subjects' age, pT, and ASA functional class. The most significant factor that increased the risk of death by 2.28-fold was tumor G. CSS was not affected by the surgical technique or tumor size (Table 2).

Table 1. Clinical and Pathological Characteristics of the Nephron-Sparing Surgery and Radical Nephrectomy Groups

Characteristic	NSS Group n=34	RN Group n=317	*P*	Total n=351
Age at surgery, years	62.2 (10.3)	63.4 (10.6)	0.512	63.3 (10.6)
Gender, %				
Male	55.9	51.7	0.645	52.1
Female	44.1	48.3		47.9
Postoperative complications, %	8.8	6.6	0.629	6.8
Tumor size, cm	4.67 (0.72)	5.25 (0.95)	0.001	5.19 (0.95)
Time in surgery, min	124.7 (46.6)	125.8 (48.2)	0.894	125.7 (48.0)
Postoperative duration, days	9.03 (4.44)	8.02 (5.16)	0.274	8.12 (5.09)
Patients' status according to the ASA, %				
ASA I	0	0.9	0.974	0.9
ASA II	38.2	39.1		39.0
ASA III	50.0	46.4		46.7
ASA IV	5.9	6.6		6.6
No data available	5.9	6.9		6.8
Histological type, %				
Clear cell	85.3	86.8	0.117	86.6
Papillary (chromophilic)	11.8	4.7		5.4
Chromophobic	2.9	1.3		1.4
Other histological forms	0	7.3		6.6
pT stage, %				
pT1	85.3	57.1	0.006	59.8
pT2	2.9	8.5		8.0
⩾pT3	11.8	34.4		32.2
Tumor differentiation grade (G), %				
G1	35.3	22.4	0.436	23.6
G2	50.0	53.0		52.7
G3	11.8	16.4		16.0
G4	0	0.9		0.9
No data available	2.9	7.3		6.8

Values are mean (standard deviation) unless otherwise indicated.
NSS, nephron-sparing surgery; RN, radical nephrectomy; ASA, American Society of Anesthesiologists.

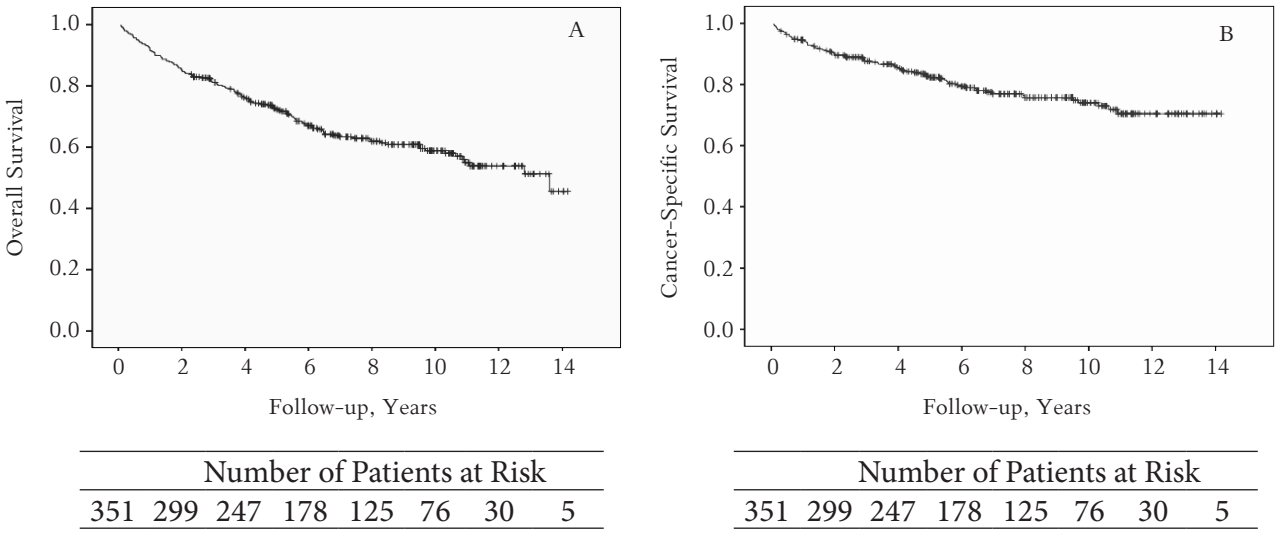
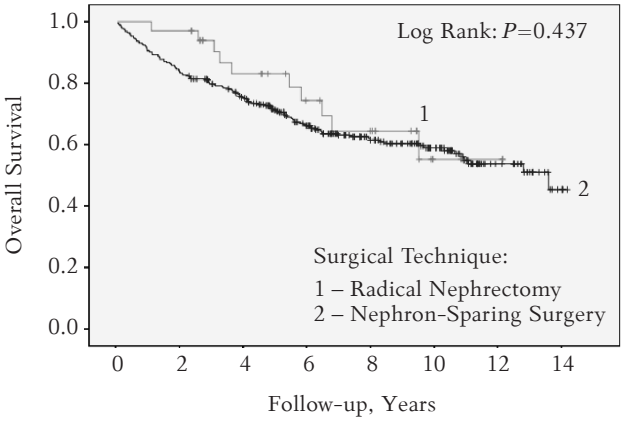


Fig. 1. Overall survival (A) and cancer-specific survival (B) in the studied population

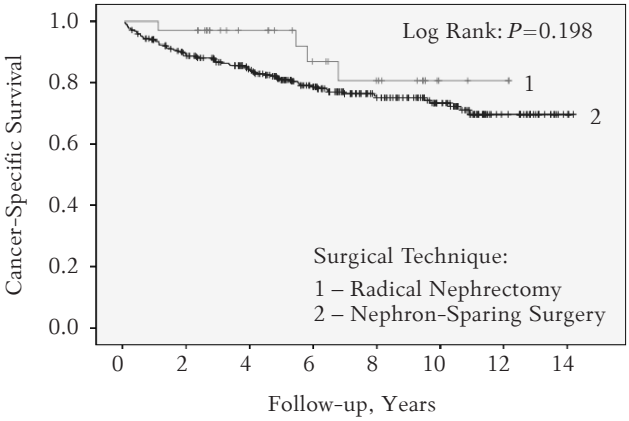
Discussion

Since 1969, when Robson et al. (10) published the results of their study, RN has been the golden standard in the treatment of RCC. Eventually, the improvement of diagnostics and the surgical treatment technique, and the increasing numbers of accidentally detected small-size renal tumors led to continuous improvement in the oncological and functional outcomes of NSS in the presence of absolute indications. This allowed for applying this technique in patients with elective indications, i.e. with the normal function of the contralateral kidney.



	Number of Patients at Risk							
1	317	266	224	162	113	73	28	5
2	34	33	23	16	12	3	2	

Fig. 2. Overall survival according the surgical technique in the studied population



	Number of Patients at Risk							
1	317	266	224	162	113	73	28	5
2	34	33	23	16	12	3	2	

Fig. 3. Cancer-specific survival according the surgical technique in the studied population

Table 2. Multivariate Cox Regression Models of Preoperative and Pathological Predictors of Survival

Prognostic factor	OS		CSS	
	Hazard Ratio (95% CI)	*P*	Hazard Ratio (95% CI)	*P*
Age	1.033 (1.014–1.053)	0.001	1.030 (1.005–1.056)	0.018
Tumor size	1.111 (0.926–1.333)	0.258	1.221 (0.964–1.546)	0.097
pT stage	1.405 (1.165–1.694)	0.0001	1.601 (1.247–2.056)	0.0001
ASA*	1.700 (1.232–2.346)	0.01	1.617 (1.042–2.511)	0.032
Tumor differentiation grade (G)*	1.639 (1.228–2.187)	0.01	2.283 (1.564–3.334)	0.0001
Surgical technique (NSS or RN)	0.961 (0.496–1.863)	0.907	1.248 (0.447–3.485)	0.673

*In 12.3% of cases, the preoperative American Society of Anesthesiologists class or the postoperative tumor differentiation grade (G) was not known.
NSS, nephron-sparing surgery; RN, radical nephrectomy; OS, overall survival; CSS, cancer-specific survival.

As a result of two studies conducted at the end of the last decade of the 20th century, 4 cm was "accidentally" selected as the greatest tumor size allowing for NSS. One of these studies, carried out by Hafez et al. (11), reported that 5-year survival was significantly better in the groups with renal tumors measuring <4 cm compared with the group of patients where the tumor size was >4 cm (96% vs. 86%). However, it is noteworthy that in the group of larger tumors, NSS was performed in the presence of absolute indications in 91% of the cases, 30% of the tumors were >7 cm in size, and no control group of patients undergoing RN was used. These data were used as the basis for selecting the margin of 4 cm when defining indications for elective NSS, and T1 tumors in the TNM classification were divided into the T1a (<4 cm) and T1b (4 to 7 cm) categories.

It has been proven that NSS performed in patients with renal cell carcinoma and a solitary tumor of ⩽4 cm (T1a) provides relapse-free long-term survival similar to RN (5–8). During the recent years, the significance of NSS in treating tumors exceeding 4 cm has been attracting increasing attention.

In one of the most recent and largest studies conducted by Crepel et al. (9), the 5-year cancer-specific survival in the presence of T1b RCC in the NSS group reached 91.4% compared with 95.3% in the RN group. Slightly different results were reported in a study by Patard et al. (8), where cancer-specific survival in the presence of RCC measuring >4 cm was better, but not significantly, in the NSS group (93.8%) than the RN group (91.0%). Better disease-specific survival in the NSS group was also observed in a study by Dash et al. (12) (83% vs. 73%), although the difference was not significant again.

In our study, the 5-year OS in the RN group was 71.2% compared with 83.1% in the NSS group; the 7-year OS was 63.1% and 64.4%, respectively, and the 12-year OS was 53.7% and 55.2%, respectively. CSS at 5 years was 80.9% and 97.1% in the RN and NSS groups, respectively; at 7 years, 76.4% and 80.6%; and at 12 years, 69.6% and 80.6%. The obtained findings are not exceptional compared with the findings on 5-year survival from the aforemen-

tioned studies, but our study is specific because it reported the data on 12-year survival.

When analyzing the outcomes of surgical treatment for RCC, several aspects have to be taken into consideration. Survival in the presence of RCC is known to be affected by patients' age, functional status, tumor size, histological type, G, and pT (7, 8, 13–18). Our Cox regression analysis also confirmed that in the presence of RCC measuring 4 to 7 cm, the aforementioned factors significantly influenced both OS and CSS independently of the type of surgery applied. While patients' age and concomitant diseases are known before surgery, and their effect on survival can be predicted, histological examination is possible only after surgery, and its effect on survival and the selection of the type of surgery is disputable.

RCC 4 to 7 cm in size is attributed to clinical stage T1b, yet stage pT is frequently greater. Leibovich et al. (18) reported in their study that 20% of the patients in the RN group had stage pT3a and pT3b tumors, while tumors of this stage in the NSS group were detected in only 1% of cases. According to the researchers, this undoubtedly resulted in significantly poorer CSS following RN than NSS (85.9% and 98.3%, respectively). Mitchell et al. (19) indicated even a greater percentage of cases with stage ⩾pT3 tumors in the presence of RCC measuring >4 cm (36.4% in the NSS group and 54.5% in the RN group). According to the authors, the estimated 5-year CSS was 96.2% in the NSS group and 97.8% in the RN group, while the type of surgery did not affect survival.

In our study, >pT1b tumors were detected in 40.2% of the subjects: in 14.7% of the subjects in the NSS group and in 42.3% of the patients in the RN group. In order to evaluate the effect of the surgical technique (NSS or RN) on survival, the subjects were divided into the groups pT1b, pT2, and ⩾pT3 by the tumor stage. No significant differences in survival following the surgery of different types in the presence of RCC of different pathological stages were detected. We agree with other authors stating that NSS as a surgical technique ensures good long-term surgical results in the presence of RCC of various stages, when the tumor size is 4 to 7 cm.

Preoperative radiology does not always allow a precise evaluation of the malignancy of the renal tumor (20, 21). Smaller tumors are more likely to be benign. The study by Frank et al. reported that the percentage of benign tumors decreased from 46.3% when the tumor size was <1 cm to 6.3% when the tumor size was 7 cm or more (22). Lesions measuring <4 cm are also more likely to be benign. Weight et al. (23) indicated that among renal tumors measuring 4 to 7 cm, 20% of tumors following NSS and 10% of tumors following RN were found to be benign with the mean tumor size being 4.1 cm and 5.0 cm in the NSS and RN groups, respectively. During the studied period, the percentage of benign tumors measuring 4 to 7 cm removed by applying the aforementioned surgical techniques in our institution was 5.6%.

When evaluating the significance of NSS in treating tumors >4 cm in size, the risk of relapse and multiple tumors should be taken into consideration. NSS is usually associated with a higher risk of relapse when compared with RN, but literature data are controversial. Patard et al. (8) in their study emphasized that RN was associated with a lower rate of local and systemic relapse if compared with NSS (0.6% and 2.3%). However, Mitchell et al. (19) reported that the surgical technique had no effect on relapse when treating RCC >4 cm in diameter. In the NSS and RN groups, 5-year survival was 93.5% and 83.3%, respectively. Antonelli et al. (24) in their study observed an unusually low rate of relapse in the NSS group (only 1.7%) when treating RCC measuring >4 cm (the mean postoperative follow-up was 72 months). We did not provide data on the time and the rate of relapse in our study, but we believe that the estimated 12-year CSS sufficiently reflects the risks of disease relapse and/or progression, which was lower in the NSS than in the RN group (80.6% vs. 69.6%).

The last but not least aspect in favor of NSS is preservation of the renal function. The rate of renal failure following NSS is lower than that observed after RN (25). Studies have demonstrated that glomerular filtration rate (GFR) is significantly better after NSS than RN. Mild (GFR <60 mL/min) or moderate (GFR <45 mL/min) renal failure was observed in 65% and 36% of the patients, respectively, who underwent RN compared with 20% and 5% of the patients, respectively, who underwent NSS (4). Preserved renal function is directly associated with better patients' quality of life and lower mortality associated with concomitant diseases. Weight et al. (26) demonstrated that in the presence of renal tumors measuring 4 to 7 cm, renal failure developed after RN was associated with a 25% increased risk of cardiovascular mortality and a 17% increased risk of mortality related to other concomitant diseases as compared with NSS. Thompson et al. (27) reported that NSS reduced the risk of chronic renal failure, cardiovascular mortality, and the development of certain complications (hip fractures) compared with RN. Such postoperative results suggest that NSS could be used as the treatment of choice for RCC measuring 4 to 7 cm.

It is widely accepted that NSS is technically more complicated than RN. According to literature, the rate of complications following NSS is up to 33%, while the respective rate after RN is up to 10% (9, 25). Our study showed that the rate of complications after NSS vs. RN was not different (8.8% vs. 6.6%, P=0.629), which suggests that this type of surgery is safe even in the presence of RCC measuring 4 to 7 cm.

Among the limitations of our study that might have influenced the results, one should mention the fact that the study was of a retrospective character, and the sample size of patients who underwent NSS was small. Besides, we did not evaluate either the time to relapse and its rate or the postoperative renal function. However, despite this, the evaluation of the short-term postoperative outcomes, when the mean follow-up is about 7 years and the overall 12-year and cancer-specific survival is estimated, allow us to present certain generalized conclusions.

Conclusions

Our study showed that nephron-sparing surgery is a safe technique compared with radical nephrectomy that ensures good oncological control in the treatment of renal cell carcinoma measuring 4 to 7 cm and may be proposed as the treatment of choice for renal tumors not only up to 4 cm, but also 4 to 7 cm in size.

Statement of Conflict of Interest

The authors state no conflict of interest.

References

1. Ljungberg B, Cowan N, Hanbury DC, Hora M, Kuczyk M, Merseburger AS, et al. Guidelines on renal cell carcinoma. European Association of Urology. The Netherlands; 2012. p. 25-7.
2. Reynard J, Brewster S, Biers S. Oxford handbook of urology. 2nd ed. Oxford: Oxford University Press; 2009. p. 232-41.
3. 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. J Urol 2008;179: 468-72.
4. Huang WC, Levey AS, Serio AM, Snyder M, Vickers AJ, Raj GV, et al. Chronic kidney disease after nephrectomy in patients with renal cortical tumors: a retrospective cohort study. Lancet Oncol 2006;7:735-40.
5. Uzzo RG, Novick AC. Nephron sparing surgery for renal tumors: indications, techniques and outcomes. J Urol 2001;166:6-18.
6. Lee CT, Katz J, Shi W, Thaler HT, Reuter VE, Russo P. Surgical management of renal tumors 4 cm or less in a contemporary cohort. J Urol 2000;163:730-6.
7. Delakas D, Karyotis I, Daskalopoulos G, Terhorst B, Lymberopoulos S, Cranidis A. Nephron-sparing surgery for localized renal cell carcinoma with a normal contralateral kidney: European three-center experience. Urology 2002;60:998-1002.
8. Patard JJ, Shvarts O, Lam JS, Pantuck AJ, Kim HL, Ficarra V, et al. Safety and efficacy of partial nephrectomy for all T1 tumors based on an international multicenter experience. J Urol 2004;171:2181-5.
9. Crepel M, Jeldres C, Perrotte P, Capitanio U, Isbarn H, Shariat SF, et al. Nephron-sparing surgery is equally effective to radical nephrectomy for T1BN0M0 renal cell carcinoma: a population-based assessment. Urology 2010;75:271-5.
10. Robson CJ, Churchill BM, Anderson W. The results of radical nephrectomy for renal cell carcinoma. J Urol 1969;101: 297-301.
11. Hafez KS, Fergany AF, Novick AC. Nephron sparing surgery for localized renal cell carcinoma: impact of tumor size on patient survival, tumor recurrence and TNM staging. J Urol 1999;162:1930-3.
12. Dash A, Vickers AJ, Schachter LR, Bach AM, Snyder ME, Russo P. Comparison of outcomes in elective partial vs radical nephrectomy for clear cell renal cell carcinoma of 4-7 cm. BJU Int 2006;97:939-45.
13. Raz O, Mendlovic S, Shilo Y, Leibovici D, Sandbank J, Linder A, et al. Positive surgical margins with renal cell carcinoma have a limited influence on long-term oncological outcomes of nephron sparing surgery. Urology 2010;75: 277-80.
14. Peycelon M, Hupertan V, Comperat E, Renard-Penna R, Vaessen C, Conort P, et al. Long-term outcomes after nephron sparing surgery for renal cell carcinoma larger than 4 cm. J Urol 2009;181:35-41.
15. Becker F, Siemer S, Humke U, Hack M, Ziegler M, Stöckle M. Elective nephron-sparing surgery should become standard treatment for small unilateral renal cell carcinoma: long-term survival data of 216 patients. Eur Urol 2006;49:308-13.
16. Margulis V, Tamboli P, Jacobsohn KM, Swanson DA, Wood CG. Oncological efficacy and safety of nephron-sparing surgery for selected patients with locally advanced renal cell carcinoma. BJU Int 2007;100:1235-9.
17. Thompson RH, Siddiqui S, Lohse CM, Leibovich BC, Russo P, Blute ML. Partial versus radical nephrectomy for 4 to 7 cm renal cortical tumors. J Urol 2009;182:2601-6.
18. Leibovich BC, Blute ML, Cheville JC, Lohse CM, Weaver AL, Zincke H. Nephron sparing surgery for appropriately selected renal cell carcinoma between 4 and 7 cm results in outcome similar to radical nephrectomy. J Urol 2004;171: 1066-70.
19. Mitchell RE, Gilbert SM, Murphy AM, Olsson CA, Benson MC, McKiernan JM. Partial nephrectomy and radical nephrectomy offer similar cancer outcomes in renal cortical tumors 4 cm or larger. Urology 2006;67:260-4.
20. Fan L, Lianfang D, Jinfang X, Yijin S, Ying W. Diagnostic efficacy of contrast-enhanced ultrasonography in solid renal parenchymal lesions with maximum diameters of 5 cm. J Ultrasound Med 2008;27:875-85.
21. Correas JM, Tranquart F, Claudon M. [Guidelines for contrast enhanced ultrasound (CEUS)-update 2008.] J Radiol 2009;90:123-38.
22. Frank I, Blute ML, Cheville JC, Lohse CM, Weaver AL, Zincke H. Solid renal tumors: an analysis of pathological features related to tumor size. J Urol 2003;170:2217-20.
23. Weight CJ, Larson BT, Gao T, Campbell SC, Lane BR, Kaouk JH, et al. Elective partial nephrectomy in patients with clinical T1b renal tumors is associated with improved overall survival. Urology 2010;76:631-7.
24. Antonelli A, Cozzoli A, Nicolai M, Zani D, Zanotelli T, Perucchini L, et al. Nephron-sparing surgery versus radical nephrectomy in the treatment of intracapsular renal cell carcinoma up to 7 cm. Eur Urol 2008;53:803-9.
25. Patard JJ, Pantuck AJ, Crepel M, Lam JS, Bellec L, Albouy B, et al. Morbidity and clinical outcome of nephron-sparing surgery in relation to tumor size and indication. Eur Urol 2007;52:148-54.
26. Weight CJ, Larson BT, Fergany AF, Gao T, Lane BR, Campbell SC, et al. Nephrectomy induced chronic renal insufficiency is associated with increased risk of cardiovascular death and death from any cause in patients with localized cT1b renal masses. J Urol 2010;183:1317-23.
27. 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. J Urol 2008;179: 468-72.

Received 5 May 2013, accepted 30 May 2013