Original Article

Predictive factors for postoperative renal function after off-clamp, non-renorrhaphy partial nephrectomy

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Background: There is limited information on perioperative renal function during off-clamp, non-renorrhaphy open partial nephrectomy. Therefore, this retrospective study aimed to identify predictive factors of perioperative decline in renal function after off-clamp, non-renorrhaphy open partial nephrectomy.

Methods: Clinical records of 138 patients with renal tumors who underwent off-clamp, non-renorrhaphy open partial nephrectomy at our institution were reviewed. Off-clamp, non-renorrhaphy partial nephrectomy was performed using a soft coagulation system. Perioperative estimated glomerular filtration rate (eGFR) preservation was calculated, and predictors were identified using multivariate regression analysis at 5 days, 1 month, and 3 months after surgery.

Results: The median operation time was 122 minutes, and the median volume of estimated blood loss was 155 mL. The mean eGFR preservation at 5 days, 1 month, and 3 months after surgery was 95.3%, 91.0%, and 90.7%, respectively. Estimated blood loss was an independent predictor of perioperative decline in eGFR 5 days after surgery [odds ratio (OR): 0.97; 95% confidence interval (CI): 0.96, 0.98; P<0.001]. Preoperative eGFR and estimated blood loss were independent predictors of perioperative decline in eGFR 1 month after surgery (OR: 0.86; 95% CI: 0.77, 0.95; P=0.007 and OR: 0.98; 95% CI: 0.97, 0.99; P<0.001, respectively). Age, preoperative eGFR, and estimated blood loss were independent predictors of perioperative decline in eGFR 3 months after surgery (OR: 0.64; 95% CI: 0.54, 0.81; P<0.001, OR: 0.72; 95% CI: 0.61, 0.85; P<0.001; and OR: 0.98; 95% CI: 0.97, 0.99; P=0.004, respectively).

Conclusions: Estimated blood loss during surgery was a predictor of perioperative decline in eGFR within 3 months after off-clamp, non-renorrhaphy open partial nephrectomy. Age was a predictor of perioperative decline in eGFR 3 months after surgery.

Keywords: Estimated glomerular filtration rate (eGFR); kidney failure; nephrectomy; suture technique; warm ischemia

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Introduction

Partial nephrectomy has become the standard procedure for removing renal tumors. Robot-assisted partial nephrectomy (RAPN) has been established as a safe and minimally invasive procedure for tumors measuring <40 mm (1-3). Renal pedicle clamping and renorrhaphy are included in laparoscopic partial nephrectomy in most institutes. However, these operative procedures cause postoperative complications, such as renal function impairment or pseudoaneurysm, at a certain rate (4).

Preservation of estimated glomerular filtration rate (eGFR) and no chronic kidney disease (CKD) upgrading are important outcomes after RAPN (1,3,5,6). Although studies have reported eGFR preservation after on-clamp partial nephrectomy with renorrhaphy (open or laparoscopic), limited studies have reported that after off-clamp open partial nephrectomy without renorrhaphy. In particular, assessment of renal function impairment within 3 months after surgery is deficient.

We retrospectively analyzed the perioperative data of 138 patients who underwent off-clamp open partial nephrectomy without renorrhaphy. The association between perioperative renal function preservation and tumor characteristics and patient characteristics was analyzed. We present the following article in accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-22-321/rc).

Methods

Patients

Among 220 patients with renal tumors who underwent off-clamp, non-renorrhaphy open partial nephrectomy at our institute between 2013 and 2020, those with postoperative complications of urinoma or incomplete data were excluded. Therefore, clinical records of 138 patients were retrospectively analyzed. Our primary endpoint was to detect predictors of perioperative decline in eGFR within 3 months after off-clamp, non-renorrhaphy open partial nephrectomy. This study was conducted in accordance with the Declaration of Helsinki (revised in 2013). The study was approved by the institutional ethics board of NTT Medical Center Tokyo (No. 20-198) and individual consent for this retrospective analysis was waived.

Surgical techniques

The complexity of renal tumors was analyzed according to RENAL nephrometry scoring system (7). Briefly, (R)adius (tumor size as maximal diameter), (E)xophytic and endophytic properties, (N)earness of the tumor to the collecting system or sinus, and (L)ocation relative to the upper and lower polar lines were scored on a 1, 2 or 3-point scale. The RENAL score represents the sum of R, E, N, and L scores. All patients underwent open partial nephrectomy retroperitoneally. The renal pedicle was not secured, and renal pedicle clamping and cortical renorrhaphy were omitted. We used monopolar SOFT COAG (VIO300D, ERBE, Germany) with a normal saline drip for hemostasis. Surgical techniques have been described previously (8). In partial nephrectomy, the renal parenchyma was repeatedly separated bluntly using a spatula-shaped tip of a monopolar device, followed by soft coagulation of the separated renal parenchyma and bleeding blood vessels. To minimize blood loss, tumor resection was advanced by a millimeter unit. Resection beds were sutured with 4-0 VICRYL® when the collecting system was opened. Urine leakage was ruled out by intravenous injection of indigo carmine solution. TachoSil® was placed on the resection surface to ensure hemostasis.

Assessment of renal function and perioperative reduction in renal function

The eGFR was calculated using the equation $186 \times (\text{Creatinine}/88.4)^{-1.154} \times (\text{Age})^{-0.203} \times (0.742 \text{ if female})$. Perioperative eGFR preservation at 5 days, 1 month, and 3 months after surgery was calculated as postoperative eGFR/preoperative eGFR × 100 (%).

Statistical analysis

The Student's *t*-test was used to analyze continuous variables. Univariate and multivariate regression analyses were performed to identify predictors of postoperative eGFR preservation. Statistical significance was set at $P<0.05$. All statistical analyses were performed using the SPSS version 24. Factors that were statistically significant ($P<0.05$) in the univariate analysis were included in the multivariate analysis.

Results

Patient characteristics are described in *Table 1*. There were 92 (66.7%) male patients and 46 (33.3%) female patients. The median age and tumor size were 63 years [interquartile

Table 1 Patient and tumor characteristics

Variables	Data (n=138)
Sex (%)	
Male	92 (66.7)
Female	46 (33.3)
Median age, years (IQR)	63 (14.5)
Median BMI (IQR)	23.4 (5.12)
No. tumor laterality (%)	
Right	69 (50.0)
Left	69 (50.0)
Median tumor size, mm (IQR)	28 (21.5)
Median RENAL nephrometry score (IQR)	7 (2.0)
Exophytic/Endophytic properties (%)	
≥50% exophytic	41 (29.7)
<50% exophytic	62 (44.9)
Entirely endophytic	35 (25.4)
Location relative to the polar lines (%)	
Entirely above the upper or below the lower polar line	46 (33.3)
Lesion crosses polar line	64 (46.4)
>50% of mass is across polar line or mass crosses the axial renal midline or mass is entirely between the polar lines	28 (20.3)
Comorbidity, n (%)	
Hypertension	54 (39.1)
Diabetes mellitus	22 (15.9)
Dyslipidemia	17 (12.3)

BMI, body mass index; The RENAL nephrometry score was the sum of the sectional scores (R, E, N, and L); IQR, interquartile range.

Table 2 Surgical results and complications

Variables	Data
Median operative time, min (IQR)	122.5 (44.5)
Median volume of estimated blood loss, mL (IQR)	155 (247.5)
No. additional resections	0
No. conversion to nephrectomy	0
Intraoperative blood transfusion	0
Postoperative blood transfusion	0
Pathology, n (%)	
Clear cell RCC	92 (66.7)
Papillary RCC	13 (9.4)
Chromophobe RCC	10 (7.2)
Angiomyolipoma	17 (12.3)
Oncocytoma	2 (1.4)
Others	4 (2.9)
Mean eGFR preservation, % (SD)	
Five days after surgery	95.3 (14.9)
One month after surgery	91.0 (11.5)
Three months after surgery	90.7 (16.3)

eGFR, estimated glomerular filtration ratio; RCC, renal cell carcinoma; IQR, interquartile range.

range (IQR), 14.5 years] and 28 mm (IQR, 21.5 mm), respectively. Among the tumors, 41 (29.7%) were ≥50% exophytic, 62 (44.9%) were <50% exophytic, and 35 (25.4%) were entirely endophytic. The median nephrometry score was 7 (IQR, 2).

The surgical results are described in *Table 2*. The median operation time was 122.5 min (IQR, 44.5 min). The median estimated blood loss was 155 mL (IQR, 247.5 mL). There were no cases of conversion to nephrectomy or consequential renal hilum clamping. The mean eGFR preservation at 5 days, 1 month, and 3 months after surgery was 95.3%, 91.0%, and 90.7%, respectively. The relationship between age and perioperative eGFR decline is shown in *Figure 1*. Statistically significant reduction in eGFR was detected only in patients over 80 years old (*Figure 1*).

Tumor size, R, N, RENAL score, and estimated blood loss were predictors of perioperative decline in eGFR 5 days after surgery. Multivariate analysis revealed that estimated blood loss was an independent predictor of perioperative decline in eGFR 5 days after surgery [odds ratio (OR): 0.97; 95% confidence interval (CI): 0.96, 0.98; P<0.001] (*Table 3*).

Tumor size, R, RENAL score, estimated blood loss, and preoperative eGFR were predictors of perioperative decline in eGFR 1 month after surgery. Multivariate analysis revealed that preoperative eGFR and estimated blood loss were independent predictors of perioperative decline in eGFR 1 month after surgery (OR: 0.86; 95% CI: 0.77, 0.95; P=0.007; and OR: 0.98; 95% CI: 0.97, 0.99; P<0.001, respectively) (*Table 4*).

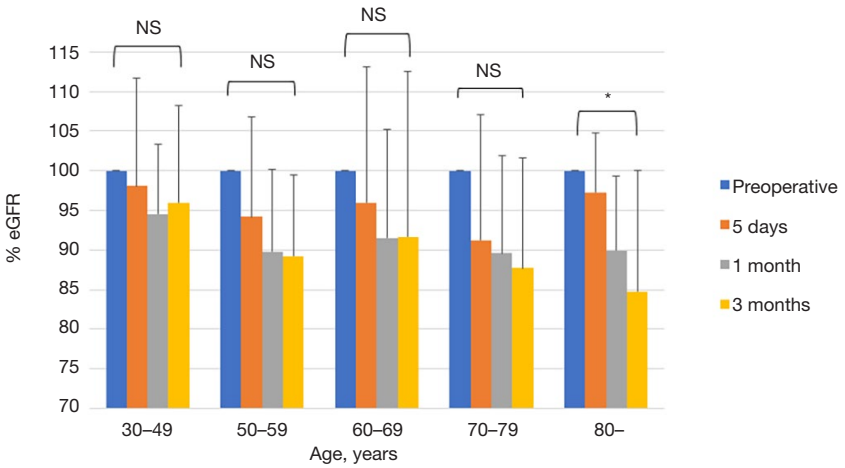

Figure 1 The relationship between age and changes is shown. *, P<0.05. eGFR, estimated glomerular filtration ratio; NS, not significant.

Table 3 Predictors of perioperative decline in eGFR 5 days after surgery: univariate and multivariate analysis

Variables	Univariate analysis			Multivariate analysis		
	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value
Age	−0.128 (−0.332, 0.077)	−0.105	0.219			
BMI	−0.470 (−1.054, 0.114)	−0.136	0.114			
Tumour size	−0.218 (−0.356, −0.081)	−0.261	0.02*			
Preoperative eGFR	−0.127 (−0.273, 0.018)	−0.147	0.073			
R	−6.417 (−11.209, −1.625)	−0.221	0.009*			
E	−0.926 (−2.487, 4.339)	−0.046	0.592			
N†	−3.752 (−6.615, −0.89)	−0.217	0.011			
L	−2.435 (−5.923, 1.054)	−0.118	0.17			
RENAL score†	−1.819 (−3.276, −0.362)	−0.207	0.015*	−1.151 (−2.557, 0.254)	−0.131	0.108
Operative time	−0.055 (−0.132, 0.023)	−0.118	0.168			
eBlood loss†	−0.024 (−0.033, −0.014)	−0.377	<0.001*	−0.022 (−0.032, −0.012)	−0.348	0.000*
HTN	−3.198 (−8.356, 1.96)	−0.105	0.222			
DM	−4.427 (−11.301, 2.446)	−0.109	0.205			
DL	−1.052 (−8.751, 6.647)	−0.023	0.787			

†, these factors were put into the multivariate regression analysis; *, P value <0.05 was considered statistically significant. eGFR, estimated glomerular filtration rate; BMI, body mass index; eBlood loss, estimated blood loss; R, radius; E, exophytic and endophytic properties; N, nearness of the tumor to the collecting system or sinus; L, location relative to the upper and lower polar lines; (R, E, N, and L were scored according to RENAL nephrometry scoring system); HTN, hypertension; DM, diabetes mellitus; DL, dyslipidemia; CI, confidence interval.

Table 4 Predictors of perioperative decline in eGFR 1 month after surgery. Results of univariate and multivariate analysis

Variables	Univariate analysis			Multivariate analysis		
	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value
Age	−0.118 (−0.275, 0.039)	−0.127	0.140			
Sex	1.08 (−3.08, 5.239)	0.044	0.608			
BMI	−0.167 (−0.618, 0.285)	−0.063	0.467			
Tumour size	−0.182 (−0.287, −0.077)	−0.283	0.001*			
Preoperative eGFR†	−0.137 (−0.248, −0.027)	−0.056	0.015	−0.149 (−0.257, −0.042)	−0.225	0.007*
R	−5.612 (−9.276, −1.948)	−0.252	0.003			
E†	0.441 (−2.204, 3.085)	0.028	0.742			
N	−2.187 (−4.425, 0.052)	−0.164	0.055			
L	−1.597 (−4.302, 1.107)	−0.1	0.245			
RENAL score†	−1.277 (−2.404, −0.15)	−0.189	0.027*	−0.57 (−1.679, 0.539)	−0.085	0.311
Operative time	−0.045 (−0.105, 0.015)	−0.126	0.144			
eBlood loss†	−0.015 (−0.023, −0.007)	−0.306	0.000	−0.015 (−0.023, −0.007)	−0.311	0.000*
HTN	−2.576 (−6.567, 1.415)	−0.109	0.204			
DM	−1.976 (−7.393, 3.442)	−0.062	0.472			
DL	−2.421 (−8.496, 3.653)	−0.068	0.432			

†, these factors were put into the multivariate regression analysis; *, P value <0.05 was considered statistically significant. eGFR, estimated glomerular filtration rate; BMI, body mass index; eBlood loss, estimated blood loss; R, radius; E, exophytic and endophytic properties; N, nearness of the tumor to the collecting system or sinus; L, location relative to the upper and lower polar lines; (R, E, N, and L were scored according to RENAL nephrometry scoring system); HTN, hypertension; DM, diabetes mellitus; DL, dyslipidemia; CI, confidence interval.

Age, tumor size, R, N, estimated blood loss, and preoperative eGFR were predictors of perioperative decline in eGFR 3 months after surgery. Multivariate analysis revealed that age, preoperative eGFR, and estimated blood loss were independent predictors of perioperative decline in eGFR 3 months after surgery (OR: 0.64; 95% CI: 0.54, 0.81; P<0.001, OR: 0.72; 95% CI: 0.61, 0.85; P<0.001; and OR: 0.98; 95% CI: 0.97, 0.99; P=0.007, respectively) (*Table 5*).

Discussion

We reported a perioperative decline in renal function during off-clamp, non-renorrhaphy open partial nephrectomy within 3 months after surgery.

The advantage of the off-clamp technique in perioperative renal function preservation is controversial. Deng *et al.* have reported less decrease in renal function in off-clamp surgery compared to that in on-clamp surgery (weighted mean difference: 4.81 mL/min/1.73 m^2; 95% CI: 3.53–6.08; P<0.00001) (9). Meanwhile, several studies have failed to show the advantages of off-clamp surgery in eGFR preservation over clamping surgery in pneumoperitoneum settings (10-13).

As for the advantage of renorrhaphy, the non-renorrhaphy technique failed to benefit the preservation of perioperative renal function for ≥T1b renal tumors in open partial nephrectomy compared with the cold ischemia technique (14). In this study, the renal function was analyzed at 4 and 6 months after surgery. However, studies comparing single-layered and double-layered renorrhaphy have shown the benefits of single-layered renorrhaphy in eGFR preservation (4,15,16). In these analyses, eGFR was assessed between the date of discharge and 1 month postoperatively. Considering these findings, it is possible that omission of renorrhaphy preserves renal function during the early postoperative period.

Table 5 Predictors of perioperative decline in eGFR 3 months after surgery. Results of the univariate and multivariate analysis

Variables	Univariate analysis			Multivariate analysis		
	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value	Unstandardized regression coefficient B (95% CI)	Standardized regression coefficient β	P value
Age†	−0.228 (−0.449, 0.008)	−0.173	0.043*	−0.435 (−0.661, −0.21)	−0.329	0.000*
Sex	−1.981 (−7.853, 3.89)	−0.057	0.506			
BMI	−0.073 (−0.727, 0.580)	−0.019	0.824			
Tumour size	−0.182 (−0.334, −0.03)	−0.199	0.019*			
Preoperative eGFR†	−0.185 (−0.342, −0.028)	−0.196	0.021	−0.319 (−0.482, −0.156)	−0.338	0.000*
R	−6.019 (−11.274, −0.764)	−0.191	0.025*			
E	0.706 (−3.014, 4.426)	0.032	0.708			
N	−3.058 (−6.21, 0.094)	−0.162	0.057			
L	−1.474 (−5.292, 2.344)	−0.065	0.446			
RENAL score†	−1.472 (−3.075, −0.13)	−0.154	0.071	−0.957 (−2.511, 0.597)	−0.100	0.225
Operative time	0.01 (−0.075, 0.095)	0.02	0.817			
eBlood loss†	−0.014 (−0.025, −0.003)	−0.206	0.015*	−0.015 (−0.026, 0.004)	−0.223	0.007*
HTN	−3.94 (−9.549, 1.67)	−0.118	0.167			
DM	−4.882 (−12.368, 2.604)	−0.11	0.199			
DL	−1.584 (−9.969, 6.8)	−0.032	0.709			

†, these factors were put into the multivariate regression analysis; *, P value <0.05 was considered statistically significant. eGFR, estimated glomerular filtration rate; BMI, body mass index; eBlood loss, estimated blood loss; R, radius; E, exophytic and endophytic properties; N, nearness of the tumor to the collecting system or sinus; L, location relative to the upper and lower polar lines; (R, E, N, and L were scored according to RENAL nephrometry scoring system); HTN, hypertension; DM, diabetes mellitus; DL, dyslipidemia; CI, confidence interval.

The RENAL score correlates with perioperative reduction in renal function during on-clamp partial nephrectomy (17). In this study, split renal function was measured using diethylene triamine penta-acetic acid scintigraphy, which showed a significant decrease in ipsilateral renal function 6 months after surgery, with no significant change thereafter (17).

There are limited data on perioperative renal function during combined off-clamp and non-renorrhaphy partial nephrectomy. We have recently reported the surgical results of off-clamp, non-renorrhaphy open partial nephrectomy for ≥T1b renal tumors (8). The perioperative eGFR preservation at 1 month and 3 months after surgery was 88.9% and 87.3%, respectively (8). In laparoscopic or robotic surgeries, perioperative eGFR preservation was 96.9–100% for highly selected patients (18-20). In our study, the eGFR preservation at 5 days, 1 month, and 3 months after surgery was 95.3%, 91.0%, and 90.7%, respectively. We believe our report will add some knowledge on the chronological recovery of renal function after off-clamp, non-renorrhaphy partial nephrectomy.

Importantly, preoperative eGFR did not negatively affect the decline in eGFR during off-clamp, non-renorrhaphy open partial nephrectomy. Our results suggest that this surgical technique can be safely adopted for patients with impaired renal function. Estimated blood loss was a predictor of perioperative decline in eGFR during the 3-month period following surgery. We assumed that damage to the renal parenchyma by soft coagulation directly contributed to the decline in postoperative eGFR. Impairment of the potential for renal function recovery by age may also affect eGFR recovery within 3 months after surgery (21).

This study had some limitations. First, it was a

retrospective study. Second, the postoperative eGFR was analyzed within 3 months following surgery.

Conclusions

We analyzed perioperative changes in renal function after off-clamp, non-renorrhaphy open partial nephrectomy until 3 months after surgery. Perioperative eGFR preservation rates at 5 days, 1 month, and 3 months after surgery were 95.3%, 91.0%, and 90.7%, respectively. Age was a predictor of decline in eGFR at 3 months after off-clamp, non-renorrhaphy open partial nephrectomy, while estimated blood loss during surgery remained a predictor of decline in eGFR throughout the 3 months after surgery. Our results suggest that off-clamp, non-renorrhaphy open partial nephrectomy can be safely adopted in patients with impaired renal function.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-22-321/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-22-321/coif). MK serves as an unpaid editorial board member of *Translational Andrology and Urology* from May 2022 to April 2024. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (revised in 2013). The study was approved by the institutional ethics board of NTT Medical Center Tokyo (No. 20-198) and individual consent for this retrospective analysis was waived.

References

1. Sri D, Thakkar R, Patel HRH, et al. Robotic-assisted partial nephrectomy (RAPN) and standardization of outcome reporting: a prospective, observational study on reaching the "Trifecta and Pentafecta". J Robot Surg 2021;15:571-7.
2. Grivas N, Kalampokis N, Larcher A, et al. Robot-assisted versus open partial nephrectomy: comparison of outcomes. A systematic review. Minerva Urol Nefrol 2019;71:113-20.
3. Furukawa J, Kanayama H, Azuma H, et al. 'Trifecta' outcomes of robot-assisted partial nephrectomy: a large Japanese multicenter study. Int J Clin Oncol 2020;25:347-53.
4. Bertolo R, Campi R, Mir MC, et al. Systematic Review and Pooled Analysis of the Impact of Renorrhaphy Techniques on Renal Functional Outcome After Partial Nephrectomy. Eur Urol Oncol 2019;2:572-5.
5. Bravi CA, Larcher A, Capitanio U, et al. Perioperative Outcomes of Open, Laparoscopic, and Robotic Partial Nephrectomy: A Prospective Multicenter Observational Study (The RECORd 2 Project). Eur Urol Focus 2021;7:390-6.
6. Minervini A, Campi R, Lane BR, et al. Impact of Resection Technique on Perioperative Outcomes and Surgical Margins after Partial Nephrectomy for Localized Renal Masses: A Prospective Multicenter Study. J Urol 2020;203:496-504.
7. Kutikov A, Uzzo RG. The R.E.N.A.L. nephrometry score: a comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 2009;182:844-53.
8. Nakamura M, Ambe Y, Teshima T, et al. Assessment of surgical outcomes of off-clamp open partial nephrectomy without renorrhaphy for ≥T1b renal tumours. Int J Clin Oncol 2021;26:1955-60.

9. Deng W, Liu X, Hu J, et al. Off-clamp partial nephrectomy has a positive impact on short- and long-term renal function: a systematic review and meta-analysis. BMC Nephrol 2018;19:188.
10. Antonelli A, Veccia A, Francavilla S, et al. On-clamp versus off-clamp robotic partial nephrectomy: A systematic review and meta-analysis. Urologia 2019;86:52-62.
11. Anderson BG, Potretzke AM, Du K, et al. Comparing Off-clamp and On-clamp Robot-assisted Partial Nephrectomy: A Prospective Randomized Trial. Urology 2019;126:102-9.
12. Kreshover JE, Kavoussi LR, Richstone L. Hilar clamping versus off-clamp laparoscopic partial nephrectomy for T1b tumors. Curr Opin Urol 2013;23:399-402.
13. Anderson BG, Potretzke AM, Du K, et al. Off-clamp robot-assisted partial nephrectomy does not benefit short-term renal function: a matched cohort analysis. J Robot Surg 2018;12:401-7.
14. Takagi T, Kondo T, Omae K, et al. Assessment of Surgical Outcomes of the Non-renorrhaphy Technique in Open Partial Nephrectomy for ≥T1b Renal Tumors. Urology 2015;86:529-33.
15. Bahler CD, Cary KC, Garg S, et al. Differentiating reconstructive techniques in partial nephrectomy: a propensity score analysis. Can J Urol 2015;22:7788-96.
16. Bahler CD, Dube HT, Flynn KJ, et al. Feasibility of omitting cortical renorrhaphy during robot-assisted partial nephrectomy: a matched analysis. J Endourol 2015;29:548-55.
17. Kwon T, Jeong IG, Ryu J, et al. Renal Function is Associated with Nephrometry Score After Partial Nephrectomy: A Study Using Diethylene Triamine Penta-Acetic Acid (DTPA) Renal Scanning. Ann Surg Oncol 2015;22 Suppl 3:S1594-600.
18. Tohi Y, Makita N, Suzuki I, et al. Off-Clamp, Non-Renorrhaphy Robot-Assisted Partial Nephrectomy : An Initial Experience in a Single Institution. Hinyokika Kiyo 2018;64:323-7.
19. Kim TS, Oh JH, Rhew HY. "Off-clamp, non-renorrhaphy" laparoscopic partial nephrectomy with perirenal fat and Gerota's fascia reapproximation: initial experience and perioperative outcomes. J Laparoendosc Adv Surg Tech A 2014;24:339-44.
20. Simone G, Papalia R, Guaglianone S, et al. 'Zero ischaemia', sutureless laparoscopic partial nephrectomy for renal tumours with a low nephrometry score. BJU Int 2012;110:124-30.
21. Denic A, Glassock RJ, Rule AD. Structural and Functional Changes With the Aging Kidney. Adv Chronic Kidney Dis 2016;23:19-28.

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