Five-year kidney functional change from the new baseline kidney function after partial nephrectomy in patients with clinical T1 renal tumors

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Abstract

Background: To investigate subsequent renal function from the new baseline in patietns who underwent partial nephrectomy (PN) for renal tumors, and analyze factors associated with the renal functional change.

Methods: This study included 466 patients who underwent PN for stage 1 kidney tumors and were regularly followed up for at least 5 years. The new baseline kidney function was defined as eGFR at 6 months after surgery. Kidney function was evaluated at every year for five years after surgery, and kidney function change was calculated as eGFR at 6 months after surgery-eGFR at each year after surgery/eGFR at 6 months after surgery × 100 (%). Factors associated with kidney functional change were evaluated with multivariate cox regression analysis.

Results: The median age of patients was 60 years, and 76% of them were male. The median preoperative eGFR was 68 ml/min/1.73m^2, and 35% and 14% of the patients had hyptertension and diabetes mellitus (DM), respectively. The new baseline eGFR was 61 ml/min/1.73m^2. The mean kidney function change from the new baseline was -0.7% at one year, -1.1% at two years, -2.7% at three years, -3.8% at four years, and -5.4% at five years. Multivariate analysis showed that DM, preoperative lower eGFR and high complexity tumors were significantly associated with decreased kidney function from baseline to five years after surgery.

Conclusions: Kidney function sequentialy decreased from the new baseline after PN. DM, lower preoperative eGFR and high complexity tumor were independent predictors for deterioration of eGFR from the new baseline to 5 years postoperatively.

Introduction

Radical nephrectomy (RN) and partial nephrectomy (PN) are performed as curative surgeries for clinically localized renal cancer. The indication for each method is dependent on tumor size, tumor location or patient comorbidities. Several guidelines suggest the optimal therapeutic strategies for kidney tumors[1, 2].

Deteriorated kidney function associate with cardiovascular event, which result in decreased survival[3]. Based on the theory, to avoid development of chronic kidney disease, PN is recommended for patients with localized kidney tumors given that oncological warranted situation. The indication for PN is expanding for more large or complex tumors due to robotic surgery which can provide precise technique and clear vision.

Kidney function after PN could be predicted by preoperative factors such as patient's comorbidities, tumor factors including tumor size and location or preoperative kidney function. Several studies commented in this issue[4-7]. Bhindi et al. proposed a stratification system to predict renal function after PN and RN, and demonstrated that age, diabetes, preoperative eGFR, preoperative proteinuria, tumor size,

time from surgery, hypertension or a solitary kidney are predictors for postoperative eGFR in RN or PN[4]. In these studies, baseline eGFR to compare postoperative renal function was defined as preoperative kidney function. Postoperative sequential change in eGFR compared to the new baseline was not well-analyzed.

Theoretically, natural history of renal function after surgery is decreased by year due to nephron damage resulted from increasing age or comorbidities such as diabetes. On the other hand, in some cases, hyperfiltration in remaining nephron compensate renal function, which result in apparently increased kidney function. To know the postoperative sequential renal function change after surgery or predictors for sequential kidney functional deterioration may help physician care for patients after surgery to avoid developing chronic kidney disease. In the present study, we defined postoperative renal function at 6 months after surgery as new baseline renal function, and compared sequential kidney function for five years to the new baseline renal function.

Materials And Methods

Study design and patient population

This institutional review board-approved retrospective study screened consecutive 1894 patients with clinical T1 renal tumors who underwent RN and PN in a single institution between January 1990 and December 2014. Patients who were followed at least 5 years after PN were included. Patients with insufficient medical records or with renal replacement therapy at the time of surgery were excluded from the study. Finally, 466 patients were included in the analysis.

Declarations

The Internal Ethics Review Board of Tokyo Women's Medical University approved our retrospective study (Institutional Review Board approval no. 5587). It was carried out in accordance with the principles outlined in the Declaration of Helsinki. The requirement for written informed consent was waived due to the retrospective nature of the study(Tokyo Women's Medical University, Ethical Review Board, approval number 5587).

Data collection

The following patient information was included in the analysis: age, sex, body mass index (BMI), Charlson Comobidity Index (CCI), comorbidities such as diabetes (DM), protein urea, and hypertension (HTN), surgical approach (open, laparoscopic, or robot assisted PN), tumor size, tumor complexity stratified by RENAL NS[8], and pathological findings. Tumor stage was determined according to the 2009 TNM Classification of Malignant Tumors[9] and the pathological diagnosis was established according to the 2016 World Health Organization classification [10]. All patients underwent computed tomography (CT) (from the chest to the pelvic cavity), a blood test, and urine test every 6 months within 3 years after surgery, followed by annually thereafter.

Surgery

The indication of the surgical approach including open, laparoscopic, or robot-assisted PN was dependent on the treatment period and tumor factors. Open and laparoscopic PN had been applied until 2014. Since 2014, robot assisted PN has been performed for most patients.

Renal function evaluation

All serum creatinine measurements were performed at a single clinical reference laboratory, and eGFR values were estimated using the Modification of Diet in Renal Disease 2 equation modified for Japanese patients, as stipulated by the Japanese Society of Nephrology (eGFR = 194 × serum creatinine $(mg/dL)^{-1.094}$ × $age^{-0.287}$ × 0.739 [if female])[11]. Preoperative renal function was evaluated < 2 months before the surgery. New baseline renal function was defined as eGFR which was measured at 6 months after surgery. All patients examined renal function at least every 1 year within 5 years after surgery. Kidney function was evaluated at every year for five years after surgery, and kidney function change was calculated as eGFR at 6 months after surgery-eGFR at each year after surgery/eGFR at 6 months after surgery × 100 (%).

Outcome

The primary outcome of this study was sequential change of kidney function from the new baseline eGFR for 5 years after surgery. The supplementary outcome was to examine the predictive factors for kidney functional deterioration from the new baseline eGFR to eGFR at 5 years after surgery.

Statistical analysis

Continuous variables were analyzed with the Mann-Whitney U test, and categorical variables were analyzed with the χ^2 test. Multivariable cox regression analysis was used to determine the predictive factors for kidney functional deterioration. P-values <0.05 were considered statistically significant. All statistical analyses were performed with JMP version 11.2.0 (SAS Institute Inc., Cary, NC, USA).

Results

Patient characteristics are shown in Table 1. Of 466 patients, 352 (76%) were male. The median patient age was 60 years, and the median BMI was 24 kg/m^2. Median preoperative eGFR was 68 $ml/min/1.73m^2$. Sixteen percent of patients had medical history of DM, whereas 43% had HTN. The median tumor size was 29 mm. Open, laparoscopic, and robotic PN were performed in 68%, 21%, and 11% of the patients, respectively.

Figure 1 showed sequent change in eGFR for 5 years after PN in total cohort. The mean new baseline eGFR (6 months after surgery) was 61.4 $ml/min/1.73m^2$, and the sequential eGFR at 1-year, 2-year, 3-year, 4-year and 5-year were 61.4 $ml/min/1.73m^2$, 60.4 $ml/min/1.73m^2$, 59.4 $ml/min/1.73m^2$, 58.8

ml/min/1.73m^2 and 57.9 ml/min/1.73m^{2,} respectively, which was significantly decreased compared to new baseline eGFR. The mean kidney function change from the new baseline was -0.7% at one year, -1.1% at two years, -2.7% at three years, -3.8% at four years, and -5.4% at five years.

Table 2 showed eGFR change at 5 year after PN from the new baseline eGFR according to each factor. The presence of DM, HTN, proteinuria, lower preoperative eGFR, high CCI score, and high-complexity tumor were significantly associated with decreased eGFR. Other factors such as sex, age, BMI and surgical approach were not significantly associated with change in eGFR.

Table 3 showed multivariate analysis of factors associated with kidney functional change from new baseline to 5 years after surgery. The presence of DM (HR, 2.34; 95%CI, 1.14-4.82), preoperative progressed grade chronic kidney disease (HR, 3.00; 95%CI, 1.34-6.71), and high complexity tumor(HR, 2.72; 95%CI, 1.23-6.04) were significant predictive factors for development of decrease in eGFR > 15%.

Discussion

We investigated sequential kidney function for 5 years in 466 patients with clinical stage 1 renal tumors who PN and compared eGFR in each year to the new baseline eGFR which was defined as eGFR at 6 months after surgery. In total cohort, eGFR was significantly decreased year by year (-5.4% decrease at five year). In addition, the presence of DM, preoperative progressed grade CKD, and high complexity tumor were significant predictive factors for > 15% decline in eGFR from the new baseline to 5-year eGFR by multivariate analysis.

In the present study, eGFR decreased from the new baseline (61.4 ml/min/1.73m^2) to 5 year after surgery (57.9 ml/min/1.73m^2), meaning an average decrease of 0.70 ml/min/1.73m^2 per year. Our study included patients who could completely review renal function in 5 years after surgery, which was rare study as to patients who underwent PN for kidney tumors. On the other hand, natural history of kidney functional decline in general population was previously reported. According to one of the first published study, clearance rate decreased by 1ml/min per year of age between age 40 and 80[12, 13]. According to the Baltimore Longitudinal Study of Aging, creatinine clearance declined by a mean of -0.75 ml/min/1.73m^2 per year in a cohort without renal disease, followed up to 23 years, although 35% of individuals in this study did not experience a decline in renal function[13-15] . As for eGFR, the change in eGFR over time was calculated using data on 4380 participants with the mean eGFR baseline 79ml/min/1.73m^2 and older adults (65 years) from the Cardiovascular Health Study, which showed that the mean change in eGFR was -0.4 ml/min/1.73m^2 per year of follow-up evaluation using the serum creatinin-based equation[13, 16]. Comparing to these previous studies, the results of our study indicating a mean decline in eGFR (0.44 ml/min/1.73m^2/year) may be acceptable despite different a study period and different patient backgrounds.

Our study provided that preoperative CKD stage associated with decline in eGFR from the new baseline renal function. Decline in eGFR for five years was 4.2%, 5.5% and 14% in patients with CKD stage 2 or

less, CKD stage 3a and CKD stage 3b or more, respectively. Several studies also reported the association between CKD stage and the decline in eGFR. Hemmelgran et al. investigated renal functional change in 10,184 people with 66 years of age or older and demonstrated that progressed CKD stage impacted on the significant decline in eGFR in each category such as sex and DM. For example, the percent decline in mean eGFR was 2.8%, 4.2%, and 15.5% in the subjects with eGFR 60-89, eGFR 30-59 and eGFR < 30, respectively in the cohort of males without DM[17]. Although there were some differences including patient's background or duration of the study, the trend of renal function deterioration of our data is compatible with the previous study.

DM was a significant factor for renal functional deterioration from the new baseline to 5 years in the present study. In fact, patients with DM had grater decline in eGFR with 10% over the 5-year period, compared to those without DM with 4.5%. According to the study among a community-based cohort of subjects 66 years of age and older, subjects with DM showed the percent decline in eGFR over 2-year period with 6.5% and 7.1% for female and male subjects, respectively. On the other hand, subjects without DM showed the percent decline in eGFR with 2.3% and 3.5% for female and male, respectively[17]. These correlation between subjects with DM and without DM was similar to our study, despite the difference of the study period.

In the present study, patients with a high-complexity tumor had a significant reduction in eGFR from the new baseline over 5 years after surgery compared to those with a low-complexity tumor in multivariate analysis. Although the etiology is uncertain, compensatory hypertrophy in the contralateral kidney might be associated with our result. Park et al. investigated the association between tumor size and contralateral kidney volume before radical nephrectomy, and demonstrated that patients with tumors sized >7 cm had a significantly larger contralateral kidney volume than those with tumors sized 4–7 cm or 4 cm. This indicates that compensatory hypertrophy in the contralateral kidney occurs before surgery in case of large kidney tumors[18]. Additionally, the same group reported that the median contralateral kidney volume change after radical nephrectomy was significantly larger in patients with tumors sized 4 cm or 4–7 cm compared to those with a tumor sized > 7 cm[19]. We can therefore conclude that compensatory hypertrophy in the contralateral kidney in patients with small renal tumors begins right after surgery[19]. Another possible reason may be the decreased ability for compensation. A contralateral kidney with a large tumor is overloaded before surgery compared to that with a small tumor, which results in decreased ability for compensation. In the present study, the tumor size tended to be larger in patients with a high-complexity tumor (40 mm) than in those with an intermediate-complexity tumor (32 mm) and a low-complexity tumor (25 mm). Therefore, less contralateral kidney compensation after surgery might occur in patients with high-complexity tumors than in those with low-complexity tumors, and might associate significantly with decreased eGFR from new baseline until 5 years after surgery. Further examination including volumetric studies of contralateral kidneys is warranted to explain the hypothesis.

The present study has several limitations. First, the study was retrospective, performed in a single institution, and included a population of tertiary care patients. Second, this study included patients who could be completely reviewed renal function for 5 years after surgery; therefore, those who died of any

reasons or with missing data were excluded from the study, which suggests that our study did not reflect renal functional change in all patients who underwent kidney tumor surgery. Third, the surgical approach including open, laparoscopic and robot assisted PN was mostly dependent on the study periods, which results in the difference of background. The strengths of this study were the large number of included patients and relatively long-term follow-up renal functional data. In addition, comparison between the new baseline renal function and subsequent postoperative renal function in five years was rare, with regard to patients who underwent PN for renal tumors.

In conclusion, our study showed sequential decline in eGFR from the new baseline for 5 years after surgery for clinical T1 renal tumor. The presence of DM, progressed CKD stage and high complexity tumor associated with decreased change in eGFR from the new baseline to 5-year eGFR. Careful monitoring will be required for patients with such risk to avoid further kidney functional deterioration.

Abbreviations

PN: partial nephrectomy, eGFR: estimated glomerular filtration rate, DM: diabetes mellitus, HTN: hypertension,

Declarations

Ethical approval

All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards
Institutional review board approval number: Tokyo Women's Medical University, Ethics Review Board, approval number 5587.

Informed Consent: Owing to the retrospective observational nature of this study, the need for informed consent was waived, which was approved by Tokyo Women's Medical University, Ethics Reviwe Board

Consent to publish

Not applicable

Consent to publication

Not applicable

Availability of data and materials

The datasets genrated during and/or analyzed the current study are available from the correspondance author on reasonable request.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authors' Contribution

TT: conception and design, acquisition of data, drafting of the manuscript, critical revision, statistical analysis, supervision

KY: acquisition of data, statistical analysis, supervision

TI: statistical analysis, supervision

HF: supervision

HI: supervision

HK: supervision

JI: supervision

KO: statistical analysis, supervision

KT: supervision

HI: supervision

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Tables

Table 1: Patients demographics and tumor characteristics

Number of patients		466
Sex, male, n		352 (76%)
Median age, years (IQR)		60 (50-67)
Median BMI , kg/m2(IQR)		24 (22-26)
CCI, n	0-1	396 (85%)
	≥ 2	70 (15%)
Median preoperative eGFR, ml/min/1.73m^2 (IQR)		68 (58-79)
Hypertension, n		199 (43%)
Diabetes, n		75 (16%)
Proteinuria, n		8 (2%)
Median tumor size, mm, (IQR)		29 (21-39)
Tumor complexity, n	Low	145 (31%)
	Intermediate	245 (53%)
	High	76 (16%)
Surgical approach, n	Open	319 (68%)
	Laparo	97 (21%)
	Robot	50 (11%)
Histopathology, n	Clear cell	409 (88%)
	Papillary	31 (7%)
	others	26 (5%)

IQR: interquartile range, BMI: body mass index, CCI: Charlson Comorbidity Index, eGFR: estimated glomerular filtration rate

Table 2: 5-year Change in eGFR from new baseline according to each parameter, %, mean (SD)

		Preope	New baseline	5 years	Change (%)	p
Sex	Male (n=352)	67 ±17	61 ± 17	58 ±18	- 5.6 ± 17	0.7170
	Female (n=114)	69 ±18	63 ±18	59±18	- 4.9 ± 15	
DM	Yes (n=75)	64 ± 20	59 ±20	52 ±20	- 10 ± 22	0.0064
	No (n=391)	69 ±17	62 ±20	57 ±17	- 4.5± 15	
HTN	Yes (n=199)	61 ±18	55 ±17	50 ±18	- 7.8 ± 20	0.0067
	No (n=267)	73 ±15	66 ± 16	63 ±15	- 3.6 ± 13	
Proteinuria	Yes (n=8)	57 ± 18	52 ± 23	53 ± 13	7.4 ± 19	0.0253
	No (n=458)	68 ± 18	62 ± 17	58 ± 18	- 5.6 ± 16	
Age	< 60 (n=245)	74 ± 16	67 ±17	63 ± 17	- 5.2 ± 16	0.7741
	>60 (n=221)	62 ± 18	55 ± 16	52 ± 17	- 5.6 ± 17	
BMI	< 24 (n=245)	69 ± 19	63 ± 19	59 ± 18	- 5.2 ± 15	0.8157
	>24 (n=221)	67 ± 16	60 ± 16	57 ± 17	- 5.6 ± 18	
Preope eGFR	< 45 (n=45)	36 ± 7.0	33 ± 8.6	28 ± 11	- 14 ± 27	0.0010
	45-60 (n=90)	54 ± 4.2	50 ± 8.4	47 ± 11	- 5.5 ± 18	
	>60 (n=331)	76 ± 13	68 ± 14	65 ± 14	- 4.2 ± 13	
CCI	0 (n=289)	72 ± 16	61 ± 16	61 ± 17	-4.4 ± 14	0.0056
	1 (n=107)	64 ± 19	55 ± 18	55 ± 18	-4.3 ± 18	
	≥ 2 (n=70)	60 ± 21	50 ± 22	50± 22	- 11 ± 22	
Tumor complexity	Low (n=145)	68 ± 16	62 ± 14	60 ± 18	- 2.6 ± 14	0.0100
	Intermediate (n=245)	68 ± 18	61 ± 19	57 ± 19	- 5.8 ± 17	

	High (n=76)	69 ± 19	62 ± 18	55 ± 18	- 9.6 ± 18	
Surgical approach	Open (n=319)	67 ± 19	60 ±19	57± 19	-5.1 ± 17	0.5767
	Laparo (n=97)	74 ± 15	66 ± 14	63 ± 15	-5.3 ± 12	
	Robot (n=50)	65 ± 13	62 ± 11	58 ± 14	-7.7 ± 17	

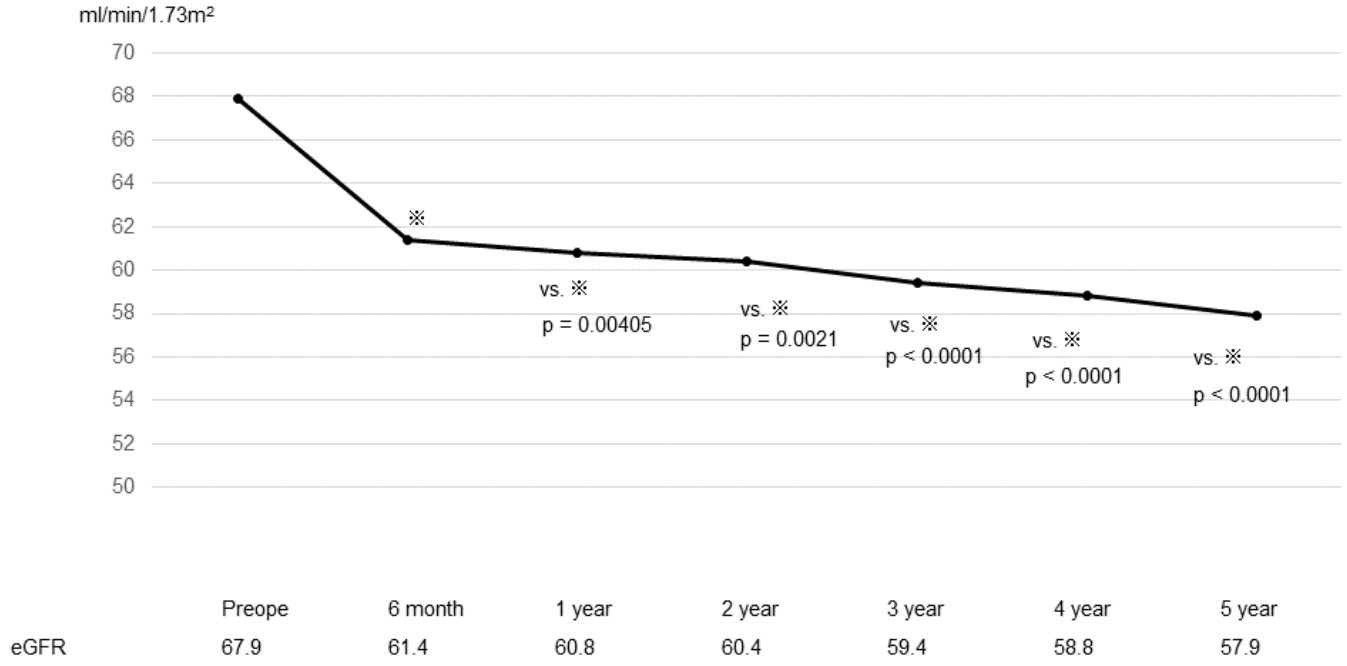
BMI: body mass index, DM: diabetes mellitus, HTN: hypertension, eGFR: estimate glomerular filtration rate, CCI: Charlson Comorbidity Index, preope: preoperative

Table3: Multivariate analysis of predictive factors for development of decrease in eGFR > 15%

Factors		HR (95%CI)	p
Sex	Female	reference	
	Male	0.77 (0.43-1.38)	0.3837
DM	No	reference	
	Yes	2.34 (1.14-4.82)	0.0212
HTN	No	reference	
	Yes	1.60 (0.94-2.74)	0.0843
Proteinuria	No	reference	
	Yes	1.60 (0.94-2.74)	0.0843
Age	< 60	reference	
	>60	0.81 (0.48-1.36)	0.4152
BMI	< 24	reference	
	>24	1.25 (0.75-2.09)	0.3964
Preope eGFR	>60	reference	
	45-60	1.09 (0.57-2.09)	0.7882
	< 45	3.00 (1.34-6.71)	0.0076
CCI	0	reference	
	1	1.22 (0.60-2.46)	0.5570
	≥ 2	1.89 (0.94-3.79)	0.0741
Tumor complexity	Low	reference	
	Intermediate	1.43 (0.78-2.62)	0.2439
	High	2.72 (1.23-6.04)	0.0137
Surgical approach	Open	reference	
	Laparo	1.73 (0.88-3.37)	0.1106
	Robot	1.64 (0.75-3.60)	0.2168

BMI: body mass index, DM: diabetes mellitus, HTN: hypertension, eGFR: estimate glomerular filtration rate, CCI: Charlson Comorbidity Index, preope: preoperative

Figures



	Preope	6 month	1 year	2 year	3 year	4 year	5 year
eGFR	67.9	61.4	60.8	60.4	59.4	58.8	57.9

Figure 1

Sequential change in eGFR for 5 years after surgery in total cohort. eGFR in each year was significantly decreased compared to new baseline eGFR.