Clinical Impact of a Protocolized Kidney Donor Follow-up System

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ABSTRACT

Background. Adequate kidney donor management after donation is increasingly emphasized due to concerns of renal function impairment after nephrectomy with increasing life expectancy. In this study, the clinical impact of a protocolized kidney donor follow-up system by nephrologists was evaluated.

Methods. A total of 427 living kidney donors underwent nephrectomy from January 2010 to December 2014 and were followed for at least 2 years at the Samsung Medical Center. Donors were followed-up by nephrologists after the establishment of a donor clinic with systemized protocols in January 2013. The primary outcomes were incidence of post-donation low estimated glomerular filtration rate (eGFR) and renal function adaptability. Secondary outcomes were changes in compliance and incidence of hyperuricemia and microalbuminuria.

Results. The patients were divided into 2 groups according to the time of nephrectomy: the pre-donor clinic period (n = 182) and the donor clinic period (n = 172). Preoperative eGFR in patients in the pre-donor clinic period was higher than that in patients in the donor clinic period. After donation, poor renal adaptation was less frequent in the donor clinic period compared to the pre-donor clinic period. Low eGFR tended to be less common during the donor clinic period. Shorter mean outpatient clinic visit intervals with more visits within 6 months after donation and earlier detection of de novo hyperuricemia were found during the donor clinic period.

Conclusion. A protocolized donor clinic run by nephrologists may improve post-nephrectomy renal outcomes and compliance and facilitate better management of potential risk factors of chronic kidney disease in donors.

LIVING donor kidney transplantation (LDKT) has been steadily increasing [1] because of a shortage of deceased donor organs [2] and the better outcome of renal allografts from living donors [3]. LDKT reduces not only the waiting period for KT in end-stage renal disease (ESRD) patients but also perioperative morbidity through elective surgery in a more controlled environment [4]. Despite the numerous benefits of LDKT in recipients, perioperative discomfort is inevitable, and there can be problems associated with unilateral nephrectomy in kidney donors despite their good health status. Previous studies reported that survival and quality of life in living kidney donors appear to be similar to those of the general population [5–7]. However, strictly speaking, the general population is not an adequate comparison target of living donors because donors are extremely healthy with normal renal function and are selected for donation only after undergoing a thorough examination. According to recent studies with a long observation period, with all other measures being equal, kidney

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donors showed an increased risk of proteinuria, hypertension, and ESRD [8,9]. However, the long waiting time for KT has led to the recent introduction of extended criteria living donors (ECLDs) [10,11]. The active application of ECLD may lead to an increase in the number of marginal donors with relatively vulnerable renal function or increased risk of chronic kidney disease (CKD) after donation [11].

Despite the importance of living donor follow-up, there are rarely special protocols or programs regarding donor management after kidney donation. In our institution, a nephrologist-run donor clinic was established in January 2013. Before establishing the donor clinic, there was an inconsistent follow-up schedule for donors by urologists, transplantation surgeons, or nephrologists after donation, and some donors visited outpatient clinics only once for a check-up of the wound. Moreover, there were no systematic programs to monitor donors' general health, including renal function. The clinical impact of the protocolized kidney donor follow-up system by nephrologists at the donor clinic was evaluated by focusing on renal function adaptation and de novo morbidities after nephrectomy.

MATERIALS AND METHODS

Study Cohort and Data Collection

This retrospective cohort study included 427 kidney donors who underwent unilateral nephrectomy for transplantation at the Samsung Medical Center between January 2010 and December 2014 and were followed for at least 2 years. A multidisciplinary team including transplant surgeons, transplant nephrologists, psychiatrists, and transplant coordinators strictly assessed all living donors preoperatively. A donor clinic operated by a nephrologist was established in January 2013. For the purposes of this study, the study period was divided into the pre-donor clinic period (from January 2010 to June 2012) and the donor clinic period (from January 2013 to December 2014). The 6-month period prior to the establishment of the donor clinic (July 2012 to December 2012) was excluded because it was an overlap period that could be simultaneously affected by the 2 different follow-up systems (Fig 1).

Laboratory results, including serum creatinine and uric acid, as well as urinalysis were serially collected from a preoperative baseline assessment with preoperative 24-hour urine creatinine clearance (CCr). The estimated glomerular filtration rate (eGFR) was calculated using the modified Modification of Diet in Renal Disease (MDRD) formula [12]. Renal function adaptability was assessed 3–6 months after donor nephrectomy. Seventy-three donors were excluded because they were in the overlap period or had insufficient follow-up data.

Ethics, Consent, and Permissions

The study was reviewed and approved by the Samsung Medical Center Institutional Review Board (No. 2015-10-109). Informed consent was waived by the Institutional Review Board because the data were obtained retrospectively from electronic medical records and did not contain sensitive information.

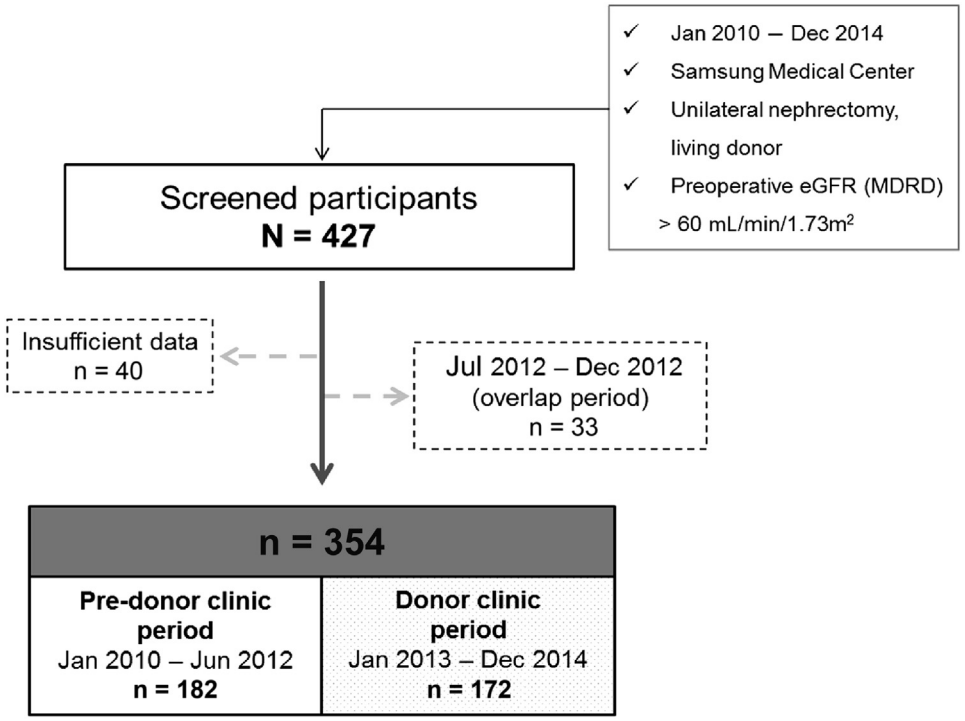

Fig 1. Study population. A total of 182 and 172 kidney donors were enrolled during the pre-donor clinic period and the donor clinic period, respectively. Donors receiving unilateral nephrectomy during the overlap period were excluded. Data were collected until 2 years after donor nephrectomy.

Kidney Donor Clinic and Systemized Follow-up Protocol

Headed by nephrologists, the donor clinic was established in close cooperation with urologists and transplantation surgeons. A thorough evaluation for potential risk factors of CKD and an individualized education program were included as cornerstones of the protocol of kidney donor clinic (Table 1). All kidney donors routinely consulted with the nephrologists before donation and underwent intensive monitoring and evaluation of their medical status, such as vital signs, urine output, and laboratory results, during the perioperative period. Nephrologists visited all donors in person to provide comprehensive counseling for better renal adaptation after donor nephrectomy and to educate them on the precautions they should take after discharge: avoidance of dehydration, high-protein or high-purine diet, herbal medication, prolonged use of non-steroidal anti-inflammatory drugs or cyclo-oxygenase-2 inhibitors, and smoking. Donors with alleged hyperuricemia were thoroughly educated about a low-purine diet. Education programs also included general lifestyle modification for preventing potential CKD risk factors, such as diabetes mellitus, hypertension, dyslipidemia, and atherosclerosis. Moreover, the importance of regular follow-up through a donor clinic for adequate renal adaptation was emphasized, especially within 6 months of donor nephrectomy.

At each visit to the donor clinic, a detailed medical examination by interview, physical examination including body mass index (BMI), and laboratory tests were performed for all donors. Laboratory tests included basic renal function parameters, serum uric acid, calcium, phosphate, electrolytes with total carbon dioxide, lipid profile, and liver enzymes. Urinalyses including urine microscopy and spot urine albumin-to-creatinine ratio were also monitored. The 24-hour urine sodium, calcium, uric acid, protein with albumin, and CCr were assessed when post-donation renal function was stabilized (usually within 6 months of the nephrectomy) for a thorough evaluation of diet and renal function. Ultrasound examination of the abdomen and remaining kidney and a chest x-ray were performed every 1 or 2 years depending on the donor's age and preexisting comorbidities such as fatty liver.

Definitions

The degree of renal adaptation after donor nephrectomy was assessed using two criteria: low eGFR and impaired renal adaptation. The low eGFR group was defined as those patients with an eGFR less than 60 mL/min/1.73 m^2 3–6 months postoperatively. Change in eGFR (ΔeGFR) was calculated as the absolute value of eGFR difference between each postoperative time point and preoperative baseline. Furthermore, the degree of renal adaptation was assessed as the percentage of post-operative MDRD eGFR vs. preoperative eGFR (%MDRD). The impaired renal adaptation was defined as %MDRD less than 60% 3–6 months postoperatively.

The diagnostic cutoff of hyperuricemia was based on sex: serum uric acid >7.0 mg/dL in males, > 6.0 mg/dL in females. Microalbuminuria was defined as spot urine albumin-to-creatinine ratio higher than 30 μg/mg creatinine.

Outcomes

Primary outcomes were renal function adaptability at six months after donation and donor clinic follow-up (changes in compliance). As described above, renal function adaptability was assessed with the development of low eGFR or impaired renal adaptation. Donor clinic follow-up was evaluated with total number and interval of clinic visits in the study period. We also analyzed the number of visits within 6 months of the nephrectomy. Secondary outcomes were incidence and detection times of de novo comorbidities, including hyperuricemia and microalbuminuria.

Statistical Analysis

Categorical variables and continuous variables were presented as frequency/percentage and mean ± standard deviation, respectively. Demographic and clinical characteristics of the entire cohort were compared between groups using the χ^2 test. Univariable and multivariable linear regression analyses were used to determine risk factors of the post-donation low eGFR group and impaired renal adaptation. Statistically significant differences between groups were defined by a P value < .05. These analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, United States).

Table 1. Systemized Protocols for Kidney Donors Were Applied Considering Individual Differences in the Donor Clinic Period

	Protocol Items
Pre-donation	• Thorough check-up: potential CKD risk factors including diabetes mellitus, hypertension, dyslipidemia, smoking, metabolic syndrome, other past medical history
	• Lifestyle and drug/herbal medicine history
	• Dietary habits (especially salt and fat intake)
	• Basic education for post-donation precautions
During admission	• Routine perioperative nephrology consultation
	• Tailored postoperative fluid therapy based on donors' vital signs, volume status, and laboratory results
	• Comprehensive counseling and detailed education for better renal adaptation
	• Individualized diet education
	• Brochure summarizing the precautions
Until post-donation 6 months	• Degree of renal adaptation and metabolic risk factors focusing on serum glucose, lipids, uric acid, and urinary albumin excretion
	• 24-hour urine chemistry to assess compliance to diet education between 3 and 6 months after donation
	• Individualized follow-up with counseling or education
After post-donation 6 months	• Regular follow-up with checking changes in renal function and potential risk factors of CKD depending on individual status
	• Kidney ultrasonography between 12 and 18 months after donation
	• Prescribe medications to preserve renal function if indicated

Abbreviation: CKD, chronic kidney disease.

Table 2. Baseline Characteristics of 354 Living Kidney Donors in 2 Different Periods

	Pre-donor Clinic Period	Donor Clinic Period	*P* Value
n	182	172	NA
Age (y)	40.7 ± 11.3	42.1 ± 11.5	.4
Male, n (%)	99 (54.4)	89 (51.7)	.7
Diabetes mellitus, n (%)	4 (2.2)	3 (1.7)	NA
Hypertension, n (%)	6 (3.3)	15 (8.7)	.04
eGFR (MDRD) (mL/min/1.73 m^2)	95.0 ± 16.2	89.4 ± 13.9	.003
eGFR ≥ 90 mL/min/1.73 m^2, n (%)	107 (58.8)	78 (45.3)	.01
CCr (mL/min)	118.2 ± 28.9	116.6 ± 27.3	.5
Serum uric acid (mg/dL)	5.2 ± 1.4	5.2 ± 1.5	.8
Hyperuricemia, n (%)*	21 (11.6)	24 (14.0)	.5
ACR (μg/mg Cr)	4.9 ± 3.6	8.4 ± 12.4	.04
Microalbuminuria, n (%)†	0	6 (3.55)	NA
Number of ECLD‡	40 (22.0)	60 (34.9)	.007

Continuous variables are expressed as mean value ± standard deviation and categorical variables are expressed as number (percentage).
Abbreviations: ACR, spot urine albumin-to-creatinine ratio; BMI, body mass index; CCr, creatinine clearance; Cr, creatinine; ECLD, extended criteria living donor; eGFR, estimated glomerular filtration rate; MDRD, Modification of Diet in Renal Disease; NA, not applicable.
*Hyperuricemia: serum uric acid > 7.0 mg/dL in men, > 6.0 mg/dL in women.
†Microalbuminuria: ACR > 30 μg/mg creatinine.
‡ECLD: at least 1 of the following criteria: Age > 60 years, BMI > 30 kg/m^2, hypertension, baseline eGFR < 80 mL/min/1.73 m^2, proteinuria, or microscopic hematuria.

RESULTS

Baseline Characteristics of Donors

There were 182 and 172 kidney donors in the pre-donor clinic period and donor clinic period, respectively (Fig 1). Preoperative baseline characteristics of the participants in the 2 periods are summarized in Table 2. In the donor clinic period, the donors' mean age was 42.1 years, 51.7% were men, and 1.7% had alleged diabetes mellitus. The proportion of donors with alleged hypertension was significantly higher in the donor clinic period than the pre-donor clinic period. There were no differences in the prevalence of hyperuricemia and microalbuminuria before donation between the 2 periods. Donors in the pre-donor clinic had significantly higher preoperative eGFR compared to those in the donor clinic period ($P < .001$). The proportion of donors who satisfied the criteria for ECLD (age > 60 years, BMI > 30 kg/m^2, alleged hypertension, pre-donation eGFR < 80 mL/min/1.73 m^2, and proteinuria or microscopic hematuria) [10,11] was significantly higher in the donor clinic period ($P = .007$).

Renal Function Adaptability (Impaired Renal Adaptation and Low eGFR Group)

To assess post-donation renal function adaptability, both absolute and relative changes in eGFR value were analyzed in the 3–6 month postoperative period (Table 3) because there was no difference in eGFR between 3–6 months and 2 years after donor nephrectomy. The incidence of low eGFR (eGFR <60 mL/min/1.73 m^2) after donation was 52.2% in the pre-donor clinic period and 55.2% in the donor clinic period ($P = .6$). The degree of renal adaptation (%MDRD) was also similar: 64.7% and 64.6%, respectively ($P = .2$). Although occurrence of low eGFR and the degree of renal adaptation did not significantly differ between the 2 periods, the proportion of donors with impaired renal adaptation (% MDRD <60%) was 29.1% in the pre-donor clinic period and 19.2% in the donor clinic period ($P = .03$). Figure 2A shows the incidence of low eGFR and impaired renal adaptation of the 2 different periods. Longitudinal post-donation renal adaptability for ECLDs is plotted in Fig 2B. Over 34% of donors were ECLD in the donor clinic period compared to only 22% in the pre-donor clinic period ($P = .007$). Nevertheless, the proportion of low eGFR and impaired renal adaptation in the donor clinic period was comparable with that in the pre-donor clinic period ($P = .8$ and .7, respectively).

Changes in Compliance (Outpatient Department Follow-up)

The mean visit interval between follow-up appointments in the outpatient department significantly differed between the 2 periods (Table 4). Donors in the donor clinic period had

Table 3. Renal Adaptability After Donor Nephrectomy in Each Period

	Pre-donor Clinic Period	Donor Clinic Period	*P* Value
Low eGFR group, n (%)*	95/182 (52.2)	95/172 (55.2)	.6
Renal adaptation (%MDRD)†	64.7 ± 8.4	64.6 ± 8.8	.2
Impaired renal adaptation, n (%)‡	53/182 (29.1)	33/172 (19.2)	.03

Continuous variables are expressed as mean value ± standard deviation and categorical variables are expressed as number (percentage).
Abbreviations: eGFR, estimated glomerular filtration rate; MDRD, Modification of Diet in Renal Disease.
*Low eGFR group: post-donation eGFR <60 mL/min/1.73 m^2 at 3–6 months postoperatively.
†Renal adaptation (%MDRD): [post-donation eGFR/preoperative eGFR] × 100.
‡Impaired renal adaptation: %MDRD <60% at 3–6 months postoperatively.

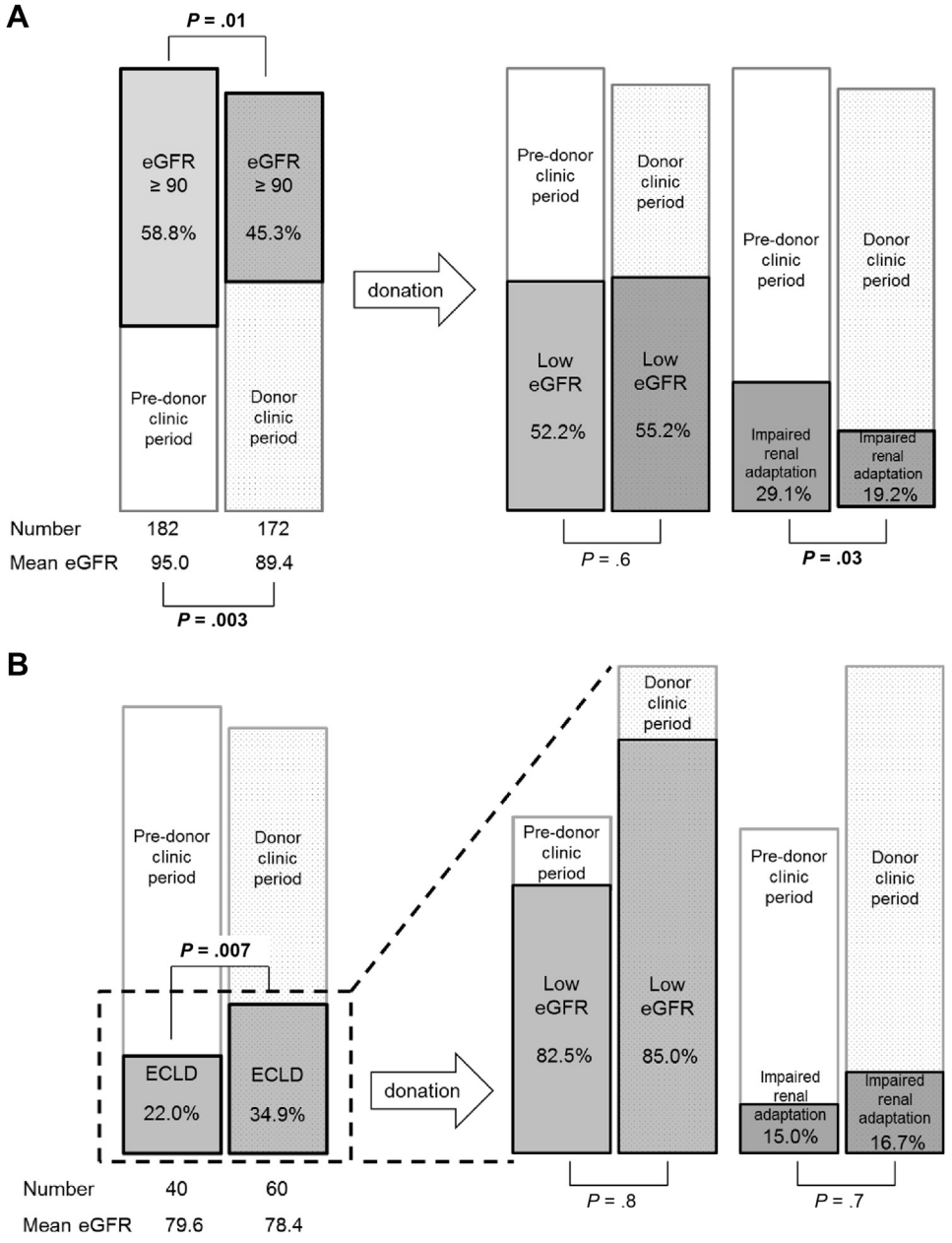

Fig 2. Comparison of post-donation renal outcomes in the pre-donor clinic and the donor clinic period. (**A**) The proportion of donors with good baseline eGFR (higher than 90 mL/min/1.73 m^2) was significantly higher in the pre-donor clinic period compared to the donor clinic period ($P = .004$). However, the development of low eGFR was comparable between the periods. Furthermore, the proportion of donors with impaired renal adaptation was lower in the donor clinic period compared to the pre-donor clinic period ($P = .003$). (**B**) Although the proportion of ECLDs was higher in the donor clinic period compared to the pre-donor clinic period ($P = .007$), the incidence of low eGFR and impaired renal adaptation in ECLDs was comparable between the two periods. Abbreviations: ECLD, extended criteria living donor; eGFR, estimated glomerular filtration rate.

shorter outpatient visit intervals ($P < .001$) and a significantly greater number of visits within the first 6 months after donation ($P < .001$) than those in the pre-donor clinic period.

Post-donation De Novo Morbidities: Hyperuricemia and Microalbuminuria

Table 5 shows the incidence of de novo morbidities such as hyperuricemia and microalbuminuria. The prevalence of

Table 4. OPD Follow-up Compliance After Donor Nephrectomy in Each Period

	Pre-donor Clinic Period	Donor Clinic Period	*P* Value
Number	182	172	NA
Mean visit intervals (months)*	5.6 ± 2.4	3.8 ± 2.5	< .001
Number of OPD visits ≤6 months after donation	1.11 ± 0.8	1.47 ± 0.8	< .001

Abbreviations: NA, not applicable; OPD, outpatient department.
*Mean visit intervals: last follow-up months/total number of follow-ups.

alleged hyperuricemia before donation was similar in the 2 different periods. However, the number of donors with de novo hyperuricemia after donation was significantly less in the donor clinic period ($P = .01$). Moreover, among donors who developed hyperuricemia, the time to diagnosis of hyperuricemia after donation was significantly shorter in the donor clinic period compared to the pre-donor clinic period (9.3 months in the donor clinic period vs 15.5 months in the pre-donor clinic period, $P < .001$). Similarly, diagnosis of de novo microalbuminuria was earlier in the donor clinic period compared to the pre-donor clinic period (19.7 months in the pre-donor clinic period versus 8.6 months in the donor clinic period, $P < .001$), although the proportion of de novo microalbuminuria for 2 years post-donation did not significantly differ between the 2 periods ($P = .8$).

Impact of the Donor Clinic on Impaired Renal Adaptation and the Proportion of Low eGFR Groups: Regression Analyses

Univariable and multivariable regression analyses for all donors were performed to assess the impact of the donor clinic and donors' characteristics on the post-donation renal outcome (Table 6). Older age at donation was significantly associated with low eGFR (odds ratio [OR], 1.04; 95% confidence interval [95% CI, 1.02–1.07]; $P < .001$). Also, a pre-donation eGFR higher than 80 mL/min/1.73m^2 was significantly associated with a decreased likelihood of low eGFR after donation (OR, 0.10 [95% CI, 0.06–0.17]; $P < .001$, Table 6).

On univariable analysis regarding impaired renal adaptation (Table 7), the donor clinic reduced the risk of impaired renal adaptation (OR, 0.58 [95% CI, 0.35–0.95]; $P = .03$) and pre-donation eGFR was significantly associated with impaired renal adaptation (OR, 3.19 [95% CI, 1.46–6.94]; $P < .001$). Higher pre-donation eGFR was still associated with impaired renal adaptation in the multivariable regression analysis (OR, 1.05 [95% CI, 1.03–1.07]; $P < .001$).

DISCUSSION

This study revealed the benefit of a nephrologist-led clinic in kidney donor follow-up. In the donor clinic period, all kidney donors were thoroughly taught about several general precautions by nephrologists during their hospital stay. The necessity for follow-up visits for monitoring the adequacy of renal adaptation and the importance of early detection and management of potential risk factors of CKD were also emphasized. Individualized education programs were provided considering each donor's preexisting or potential risk factors such as dyslipidemia, obesity, smoking habits, hyperuricemia, impaired fasting glucose or impaired glucose tolerance, diabetes mellitus, and hypertension. After establishment of the kidney donor clinic, donors tended to show better renal adaptability despite a growing number of ECLD. Through intense follow-up, earlier diagnosis of hyperuricemia or microalbuminuria were also achieved.

Living kidney donors have risks associated with the operation in the short-term and have the potential encumbrance of a single kidney for the rest of their lives. According to recent studies, living kidney donors show an increased risk of ESRD compared with healthy non-donors [9,13–15]. The number of donors affected by CKD risk factors such as diabetes mellitus, hypertension, dyslipidemia, hyperuricemia, and microalbuminuria has been increasing, as has prolonged life expectancy. Despite these disadvantages, LDKT has steadily increased due to the long waiting list of ESRD patients and the limited number of deceased donor kidneys available.

Moreover, after introduction and encouragement of KT based on the ECLD to overcome the donor shortage, people with well-controlled mild hypertension, obesity, relatively reduced eGFR, or even mild proteinuria or hematuria could be considered as potential kidney donors [16–26]. Strictly speaking, they are at potential risk of CKD development, and it cannot be concluded that the long-term medical consequences of these marginal donors would be the same as those

Table 5. Hyperuricemia and Microalbuminuria Before and After Donor Nephrectomy in Each Period

	Pre-donor Clinic Period	Donor Clinic Period	*P* Value
Number	182	172	NA
Pre-donation hyperuricemia, n*	21	24	.5
De novo hyperuricemia, n (%)	45/161 (28.0)	24/148 (16.2)	.01
Detection time of hyperuricemia (mo)	15.5 ± 13.1	9.3 ± 6.9	< .001
Uric acid lowering agents, n	7	13	.7
Pre-donation microalbuminuria, n†	0	6	NA
De novo microalbuminuria, n (%)	11/182 (6.0)	11/166 (6.6)	.8
Detection time of microalbuminuria (mo)	19.7 ± 14.1	8.6 ± 6.5	< .001

Abbreviation: NA, not applicable.
*Hyperuricemia: serum uric acid >7.0 mg/dL in men, > 6.0 mg/dL in women.
†Microalbuminuria: spot urine albumin-to-creatinine ratio >30 μg/mg creatinine.

Table 6. Regression Analyses for Low eGFR (Post-donation eGFR <60 mL/min/1.73 m^2)

	Univariable		Multivariable	
	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Donor clinic	1.13 (0.74–1.72)	.5		
Sex, female	0.99 (0.66–1.53)	.9		
Age	1.06 (1.04–1.08)	< .001	1.04 (1.02–1.07)	< .001
Pre-donation eGFR ≥80	0.04 (0.01–0.12)	< .001	0.10 (0.06–0.17)	< .001
Pre-donation serum uric acid	1.11 (0.96–1.28)	.2		
Pre-donation CCr	0.99 (0.98–1.00)	.01	1.00 (0.99–1.01)	.7

Abbreviations: CCr, creatinine clearance (mL/min); CI, confidence interval; eGFR, estimated glomerular filtration rate (mL/min/1.73 m^2).

who meet the standard criteria for kidney donation. Noqueira et al. reported that 42.7% of obese living kidney donors had an MDRD eGFR lower than 60 mL/min/1.73 m^2 after donation. During the follow-up period of less than 2 years, 19.4% developed microalbuminuria and 41.6% developed hypertension [27]. Some hypertensive ECLDs required additional antihypertensive medication and faced increased risks to CKD after donation [28,29]. The aggressive application of ECLD in LDKT may lead to an increase in the number of patients at risk of CKD after donation.

However, sufficient ongoing medical attention has not been provided to living kidney donors after donation, even those approved based on the ECLD, because they are not considered "potential patients." Most medical centers still do not have special professionals, education programs, or organized follow-up systems focusing on living kidney donors. After discharge, many donors do not receive regular check-ups or sufficient medical advice due to short-term interest from the transplantation team and lack of understanding of the donor themselves about the importance of regular follow-up. These situations are similar in most European countries and the United States, not just in Korea. Although a post-donation follow-up system for kidney donors was reported to be set up in Poland in 2006 [30], this study included only 141 kidney donors (less than half of our study population) and did not focus on the importance of principal physicians in the long-term follow-up of donors. Our study notably investigated the medical efficacy of nephrologist-centered donor follow-up system and revealed that better renal adaptation and early diagnosis of de novo morbidities linked with CKD could be achieved through this system despite the increasing ECLDs.

Although adverse renal outcomes and de novo morbidities after donation are relatively rare, CKD risk factors, including hypertension, prediabetes, hyperuricemia, and microalbuminuria, still need to be prevented and properly managed in order to improve donors' long-term outcome. These problems can be potentially preventable and manageable through regular monitoring and timely treatment based on an organized donor follow-up system [31]. Microalbuminuria is a known risk factor of CKD progression [32], and emerging evidence supports a pathogenic role of hyperuricemia in CKD progression [33–37]. Early detection of these problems would allow timely interventions such as a low purine diet or urate-lowering agents for hyperuricemia and a low-salt diet or a low-dose angiotensin receptor blocker for microalbuminuria, consequently reducing the risk of CKD.

Our study supports the important role of nephrologists in the development of an effectively organized donor management program by showing that both a donor clinic and an education program operated by a nephrologist can improve renal adaptability and diagnosis of de novo morbidities earlier in kidney donors. This system offers the opportunity for closer collaboration among nephrologists, urologists, and transplant surgeons with regard to donor evaluation, education, and long-term follow-up. Initial screening for potential kidney donors with a thorough evaluation process and proper management of donors during the early postoperative period after donor nephrectomy are crucial to improve the long-term outcomes of donors because post-donation renal function is usually stabilized within 6 months post-donation [38–40]. During follow-up, not only renal function per se but also several laboratory

Table 7. Regression Analyses for Impaired Renal Adaptation (% MDRD <60%)

	Univariable		Multivariable	
	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Donor clinic	0.58 (0.35–0.95)	.03	0.73 (0.43–1.23)	.2
Sex, female	0.92 (0.57–1.50)	.7		
Age	1.01 (1.00–1.08)	.4		
Pre-donation eGFR ≥80	3.19 (1.46–6.94)	.004	1.05 (1.03–1.07)	<.001
Pre-donation serum uric acid	0.89 (0.75–1.05)	.2		
Pre-donation CCr	0.93 (0.90–1.07)	.9		

Abbreviations: CCr, creatinine clearance (mL/min); CI, confidence interval; eGFR, estimated glomerular filtration rate (mL/min/1.73 m^2); MDRD, Modification of Diet in Renal Disease.

and clinical parameters reflecting potential risk of CKD need to be monitored.

Some limitations deserve consideration in this study. First, there is a generalizability issue across ethnicity because our data only included living Korean kidney donors at a single institution. However, this can be a positive factor of our study, which sought to verify the clinical effectiveness of a new donor management system by avoiding confounding factors such as differences in ethnicity or laboratory facility. Second, the study was conducted retrospectively with a relatively short follow-up period. To overcome this limitation, donors who underwent nephrectomy during the overlap period were excluded. We also confirmed that there were no differences in renal function between 6 months and 2 years post-donation. Third, there were differences in baseline characteristics between the 2 periods. Although the donor clinic period had a greater number of donors with ECLD criteria, donors tended to show better renal outcomes, which further supports the clinical effectiveness of the system.

Our study strongly supports both the necessity and effectiveness of a systemized donor follow-up system. The kidney donor clinic with well-organized donor management programs operated by a nephrologist enabled better renal outcomes despite the increasing number of ECLDs, as well as early diagnosis and timely intervention of de novo morbidities associated with CKD progression. These results suggest that nephrologists need to participate enthusiastically in general management and follow-up of kidney donors because they are at risk of becoming potential CKD patients.

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