Clinical Significance of Postoperative Nutritional Status as a Prognostic Factor in Kidney Transplant Recipients

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ABSTRACT

Background. Despite advancements in the management of kidney transplantation (KT), kidney transplant recipients (KTRs) have a higher risk of mortality than the age-matched general population. Improvement of long-term graft and patient survival is a significant issue. Therefore we investigated the effects of postoperative nutritional status on graft and patient survival and explored the predictive factors involved in nutritional status.

Methods. Our retrospective study included 118 KTRs who underwent KT at our hospital. Clinical and laboratory data were obtained from medical charts. The prognostic nutritional index (PNI) was used to assess nutritional status. Changes in nutritional status after KT were monitored and the effect of nutritional status on graft and patient survival was investigated. The variables involved in nutritional status were also explored.

Results. The KTRs in this cohort comprised 66 men and 52 women with a median age of 47 years at KT. There were 16, 32, and 22 cases of cadaveric, preemptive, and ABO-incompatible KTs, respectively. Postoperative PNI gradually improved and was stable from 6 months after KT. Although graft survival was regulated by ABO-compatibility, independent predictors for patient survival were history of dialysis, PNI, and serum-corrected calcium levels. Preemptive KT and inflammatory status contributed to PNI.

Conclusions. Nutritional status of KTRs improved over time after KT and could contribute to patient survival. Optimal nutritional educational programs and interventions can lead to better outcomes in KTRs. Further studies are needed to validate our results and develop appropriate nutritional educational programs, interventions, and exercise programs.

Kidney transplantation (KT) is a successful and cost-effective treatment option for patients with end-stage renal disease because it improves patients' survival and quality of life compared to maintenance hemodialysis or peritoneal dialysis [1,2]. The big discrepancy between organ demand and supply is a serious concern worldwide. In Japan, more than 90% of organs are obtained from live donors. Although preemptive kidney transplantation (PKT) has gradually increased, patients with a long-term history dialysis often undergo KT. Since the introduction of calcineurin inhibitors and mycophenolate mofetil, short-term graft survival has improved and patients with high immunologic risk can undergo KT safely and effectively [3]. Despite advancements in the management of KT, kidney transplant recipients (KTRs) have a higher risk of mortality than the age-matched general population [4]. To achieve more satisfactory long-term graft and patient survival, many challenging aspects of this field need to be resolved.

Most patients with chronic kidney disease (CKD) tend to have a poor nutritional status because of protein-energy wasting, and their degree of malnutrition increases as

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Table 1. Patients' Backgrounds

Variables	Number of Recipients (N = 118)	%
Age at operation (y)		
Median (IQR)	47 (35–57)	-
BMI at operation (kg/m^2)		
Median (IQR)	21.6 (19.2–24.4)	-
Follow-up period (mo)		
Median (IQR)	84 (55–124)	-
Sex		
Men	66	56
Women	52	44
Type of donation		
Cadaver	16	14
Live	102	86
PKT		
No	86	73
Yes	32	27
ABO-compatibility		
Compatible	96	81
Incompatible	22	19
Primary disease		
non-DM	97	82
DM	21	18
Cardiovascular disease		
No	112	95
Yes	6	5
Cerebrovascular disease		
No	111	94
Yes	7	6
Peripheral artery disease		
No	115	97
Yes	3	3
CCI		
0	79	67
≥1	39	33
CNI		
Tacrolimus	52	44
Cyclosporine	66	56

Abbreviations: BMI, body mass index; CCI, Charlson Comorbidity Index; CNI, calcineurin inhibitor; IQR, interquartile range; PKT, pre-emptive kidney transplantation.

CKD progresses [5,6]. Malnutrition is associated with the progression to dialysis in patients with stages 3–5 CKD and long-term dialysis can worsen nutritional status, together with chronic inflammation and arteriosclerosis [7]. Nutritional status in patients with CKD improves after KT, although some KTRs tend to be overweight or obese, resulting in poor prognoses due to the development of cardiovascular disease and other ailments [8]. Generally, nutritional status is better in KTRs than in those who undergo maintenance dialysis as renal replacement therapy [9].

The subjective global assessment (SGA) [10], malnutrition-inflammation score (MIS) [11], and geriatric nutrition risk index (GNRI) [12] are usually used as reliable assessments of the nutritional status of patients with CKD. In our previous study on live kidney donors, abdominal visceral adipose tissue and prognostic nutritional index (PNI) as a marker for nutritional status were independent prognostic markers for renal function after donor nephrectomy [13]. PNI was originally proposed for assessing perioperative nutritional status, postoperative complications, and survival of patients with colorectal cancer and was calculated using the following formula:

$10 \times$ serum albumin (g/dL) $+$ $.005 \times$ total lymphocyte count (/mm^3) [14,15].

In the present retrospective study we focused on the chronological change in nutritional status and used PNI (obtained from medical charts) as a nutritional status marker. The aim of this study was to evaluate nutritional status as a marker for graft and patient survival after KT and elucidate the association between nutritional status and inflammatory status.

MATERIAL AND METHODS

Patient Selection and Data Collection

In total, 139 consecutive KTRs between January 2002 and December 2015 at Nara Medical University Hospital were enrolled in this study. Of these, 21 KTRs (15.1%) were excluded from the analysis because their follow-up took place in other hospitals, a lack of data, and/or a follow-up period $<$ 36 months. Therefore, we retrospectively reviewed the medical charts of the remaining 118 KTRs and obtained the clinical and laboratory data. The KTRs were analyzed from the date of their first kidney transplantation until death, graft loss, or end of follow-up on September 30, 2018. Our study protocol was approved by the Institutional Review Board for Clinical Studies (Medical Ethics Committee ID: NMU-2014), which waived the requirement for informed patient consent because of the retrospective nature of the analysis.

Definition of Outcomes and Covariates

The outcome variables were death-censored graft survival and all-cause patient survival. Graft survival time was defined as the time from KT until permanent return to dialysis or the end of follow-up and was censored for death. Patient survival time was also defined as the time from KT until death or the end of follow-up.

Pretransplant dialysis duration was measured in days and defined as the time from the day of the first dialysis treatment until KT. In contrast, PKT was defined as KT without pretransplant dialysis. The schedule for protocol biopsy consisted of 1 month, 6 months, and 1 year after KT, and an episode biopsy was conducted when rejection was suspected. Biopsy-proven rejection (BPR) was defined according to the Banff 2013 classification [16]. The inflammatory markers neutrophil-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR) were calculated using the following formulas:

NLR = neutrophil count (/mm^3)/lymphocyte count (/mm^3)
PLR = platelet count (/mm^3)/lymphocyte count (/mm^3).

Chronological changes in nutritional status were investigated, as were whether nutritional status after KT affects graft and patient survival. Furthermore, variables that affect nutritional status were analyzed.

Statistical Analysis

Statistical analyses were performed and figures were plotted using the GraphPad Prism 7.0 (GraphPad Software, San Diego, Calif., United States). A survival curve was obtained using the Kaplan-Meier method and compared using the log-rank test for each

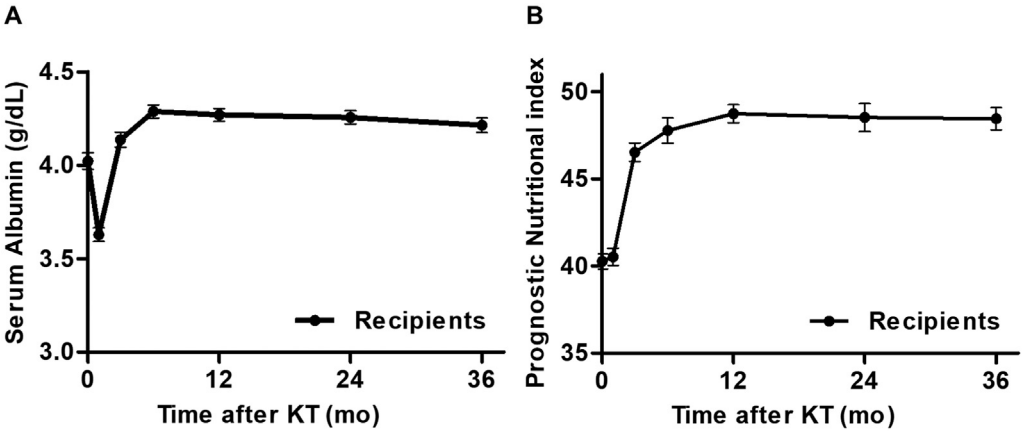

Fig 1. Chronological change in nutritional status after kidney transplantation. **(A, B)** Chronological change in serum albumin level and prognostic nutritional index after kidney transplantation. Both serum albumin level and prognostic nutritional index improved dramatically 3 months after kidney transplantation and were stable 6 months after kidney transplantation. KT, kidney transplantation.

prognostic variable. To identify independent prognostic factors for death-censored graft survival and patient survival after KT, multivariate analyses were performed using SPSS version 21.0 (IBM, Armonk, NY, United States). The cut-off value for each marker was determined using the receiver operating characteristic curve analysis. To identify prognostic factors for the level of PNI, univariate and multivariate analyses were performed via logistic regression analysis using SPSS version 21.0. Two-sided tests were used and $P<$ .05 was considered statistically significant in all analyses.

RESULTS

Patient Characteristics at Transplantation

Table 1 shows the baseline clinical characteristics of the cohort comprising 118 KTRs. The median age, body mass index, and follow-up period were 47 years, 21.6 kg/m^2, and 84 months, respectively (interquartile ranges were 35–57, 19.2–24.4, and 55–124, respectively). This cohort of KTRs comprised 66 men (56%) and 52 women (44%). Allografts were derived from 102 (86%) live donors and 16 (14%) cadaveric donors. ABO-incompatible KTs were performed in 22 KTRs (19%). Out of 118 KTRs, 21 (18%) had end-stage renal disease secondary to diabetic nephropathy. Preoperative history of cardiovascular disease, cerebrovascular disease, and peripheral artery disease were observed in 6, 7, and 3 KTRs, respectively. Thirty-nine (33%) KTRs presented with perioperative complications greater than grade 1 on the Clavien-Dindo system.

Chronological Change in Serum Albumin Level and PNI

To investigate chronological change in nutritional status, serum albumin levels and PNI were obtained from medical charts preoperatively and at 1, 3, 6, 12, 24, and 36 months after KT. Serum albumin levels decreased 1 month after KT and then gradually increased and improved compared to the preoperative level at 3 months after KT. After 6 months of KT, serum albumin levels were stable without significant change (Fig 1A). On the other hand, preoperative PNI and PNI a month after KT were almost at the same level and then PNI gradually increased. After 6 months of KT, PNI elapsed without a big change, just as serum albumin levels had (Fig 1B). Serum albumin levels and PNI had improved significantly at 3 months after KT.

Prognostic Role of Nutritional Status in KTRs

In the analysis of 118 KTRs, 19 (16%) had experienced graft loss and 16 (14%) had all-cause mortality after a median follow-up period of 84 months. The causes of death among KTRs were infection (4), chronic heart failure (6), cancer (2), colon perforation (1), cerebral hemorrhage (1), and unknown etiology (2). Univariate and multivariate analyses for graft and patient survival were performed to determine the prognostic value of postoperative nutritional status after KT. Although there was no significant difference in graft survival, KTRs with low PNI at 3 months after KT were at a higher risk of all-cause mortality than those with high PNI (Fig 2A; $P=.73$ and Fig 2B; $P=.0012$, respectively). The serum albumin level at 3 months after KT also showed that there was no significant difference in graft survival and a low level of serum albumin was a prognostic marker for a high risk of all-cause mortality (Fig 2C, $P=.89$, and Fig 2D, $P=.0012$, respectively). These trends were also observed in PNI and serum albumin levels at 6 months after KT (Fig 2E, $P=.17$, Fig 2F, $P=.0065$, Fig 2G, $P=.38$, and Fig 2H, $P=.024$, respectively).

PNI and serum albumin levels correlated with each other (Spearman's r = .84, $P<.0001$, data not shown). Therefore, we focused on PNI at 3 months after KT and performed univariate and multivariate analyses (Table 2). ABO-incompatible KT and history of BPR within 1 year after KT were associated with shorter graft survival in the univariate analysis, while incompatible KT was identified as an independent predictive marker for graft survival ($P=.024$, hazard ratio [HR] = 2.9, vs compatible KT). With regard to patient survival, older age, long-term dialysis history, low PNI, high levels of C-reactive protein (CRP), and low levels

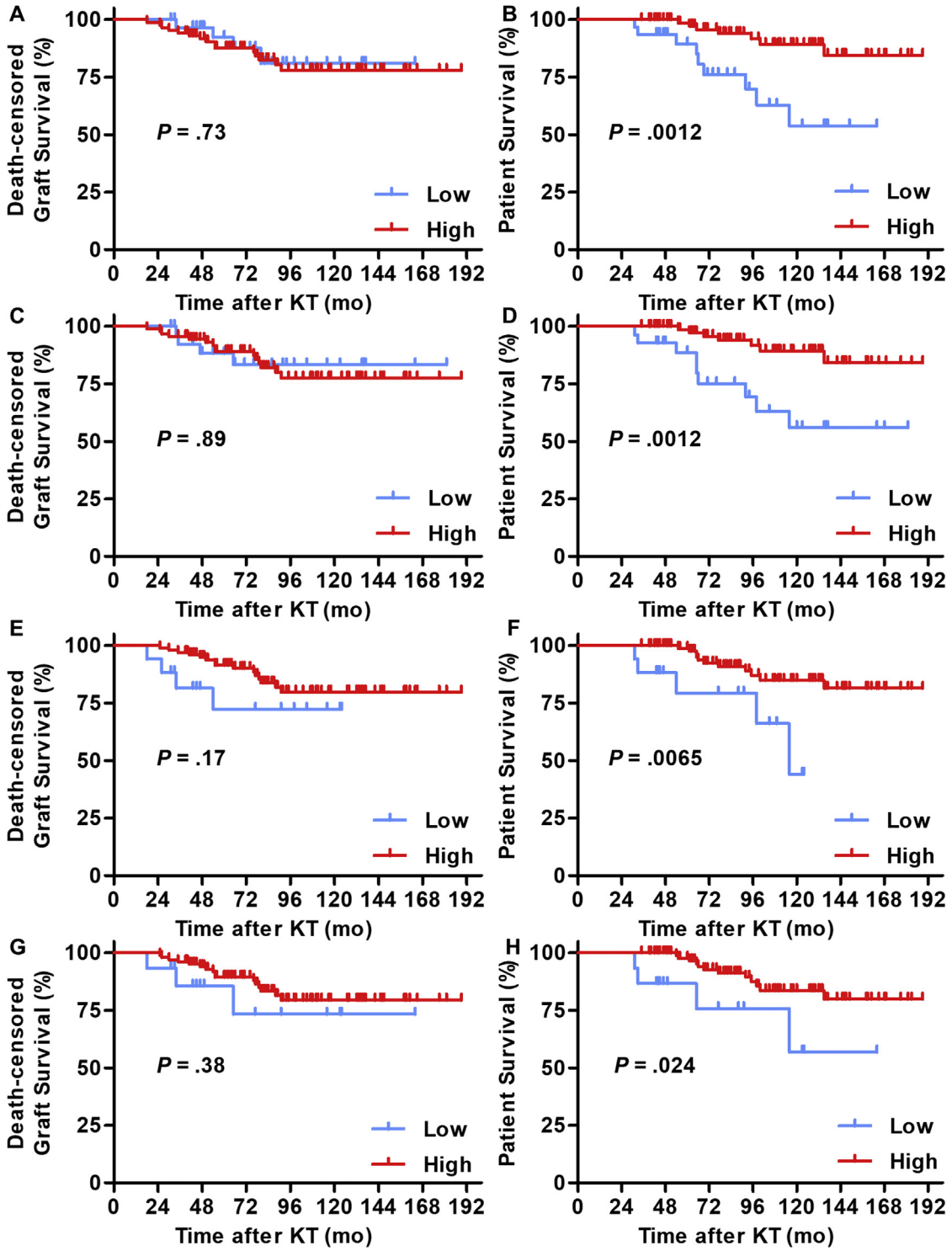

Fig 2. Kaplan-Meier plots for 118 kidney transplant recipients according to nutritional status. Death-censored graft survival and overall patient survival after kidney transplantation were plotted. **(A and B)** Survival curves according to prognostic nutritional index 3 months after kidney transplantation, high vs low. **(C and D)** Survival curves according to serum albumin level 3 months after kidney transplantation, high vs low. **(E and F)** Survival curves according to prognostic nutritional index 6 months after kidney transplantation, high vs low. **(G and H)** Survival curves according to serum albumin level 6 months after kidney transplantation, high vs low. **(A, C, E, F)** Death-censored graft survival was not significantly different between the 2 groups. **(B, D, F, H)** Kidney transplant recipients with high prognostic nutritional index or serum albumin levels had a lower risk of mortality than those with low prognostic nutritional index or serum albumin levels.

Table 2. Cox Regression Analysis of Prognostic Factor for Death-Censored Graft and Patient Survival

	Death-censored Graft Survival						Patient Survival					
	Univariate Analysis			Multivariate Analysis			Univariate Analysis			Multivariate Analysis		
Variables	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*
Age (y)												
<45	1						1			1		
>45	.6	.2–1.5	.29				3.3	1.2–8.7	.011	1.4	.3–6.1	.67
Sex												
Men	1						1					
Women	.9	.4–2.3	.89				1.2	.4–3.1	.76			
BMI												
<22	1						1					
≥22	.9	.4–2.2	.81				.5	.2–1.4	.21			
ABO-compatibility												
Compatible	1			1			1					
Incompatible	4.5	1.3–15.4	.015	2.9	1.1–7.5	.024	.7	.2–2.8	.66			
Type of donation												
Live	1						1					
Cadaver	.5	.1–1.6	.22				1.6	.4–5.9	.46			
Duration of dialysis												
<12	1						1			1		
>12	1.3	.5–3.2	.58				4.4	1.6–11.8	.0034	7.4	1.6–33.9	.01
PKT												
Yes	1						1					
No	2	.7–5.3	.17				2.1	.7–6.3	.2			
CNI												
Cyclosporine	1						1					
Tacrolimus	1	.4–2.4	.55				.8	.3–2.3	.32			
Primary disease												
non-DM	1						1					
DM	2.7	.8–8.7	.15				1.6	.5–6.0	.45			
BPR												
No	1			1			1					
Yes	4	.8–18.7	.053	2.5	.8–7.4	.11	1.5	.3–8.3	.21			
PNI												
>45	1						1			1		
<45	.8	.3–2.4	.73				7	2.2–22.7	.0012	2.8	1.0–7.6	.049
Total cholesterol												
>200	1						1					
<200	.9	.4–2.4	.91				.7	.3–1.9	.49			
Hemoglobin												
>11	1						1					
<11	1.5	.6–3.9	.38				1.6	.6–4.4	.38			
CRP												
<.2	1						1			1		
<.2	.6	.2–1.8	.41				3.2	1.0–10.3	.05	.8	.2–2.7	.68
NLR												
<5	1						1					
>5	.6	.2–1.4	.21				.9	.3–2.4	.83			
PLR												
<280	1						1					
>280	1.1	.4–2.8	.81				1	.4–2.7	.99			
Uric acid												
<7	1						1					
>7	1.7	.7–4.3	.23				1.9	.7–5.0	.22			
Serum sodium												
>140	1						1					
<140	.5	.2–1.2	.1				1.9	.7–5.1	.22			
Serum phosphorus												
>3.5	1						1					
<3.5	1.1	.4–3.2	.9				.8	.2–2.6	.69			

Table 2. (continued)

	Death-censored Graft Survival						Patient Survival					
	Univariate Analysis			Multivariate Analysis			Univariate Analysis			Multivariate Analysis		
Variables	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*
Correction calcium												
>9.5	1						1			1		
<9.5	.9	.4–2.3	.82				3.1	1.1–8.7	.029	3.9	1.4–11.0	.009

Abbreviations: BMI, body mass index; BPR, biopsy-proven rejection; CI, confidence interval; CNI, calcineurin inhibitor; CRP, C-reactive protein; DM, diabetes mellitus; HR, hazard ratio; NLR, neutrophil-lymphocyte ratio; PKT, pre-emptive kidney transplantation; PLR, platelet-lymphocyte ratio; PNI, prognostic nutritional index.

of serum-corrected calcium were associated with a high risk of all-cause mortality in the univariate analysis, while a history of long-term dialysis ($P = .01$, HR = 7.4, vs short-term), low PNI ($P = .049$, HR = 2.8, vs high PNI), and low levels of corrected calcium ($P = .009$, HR = 2.8, vs high levels) were identified as independent predictive markers for patient survival.

Association of PNI with Inflammatory Status

A logistic regression analysis was performed to investigate the predictive markers specifying PNI at 3 months after KT (Table 3). All laboratory data were used at 3 months after KT to avoid confusion. Older age, donation from cadaveric donor, a history of long-term dialysis, non-PKT, low level of hemoglobin, a high level of CRP, high NLR, and high PLR were associated with low PNI at 3 months after KT, while non-PKT ($P = .047$, odds ratio [OR] = 9.3, vs PKT), high levels of CRP ($P = .006$, OR = 5.2, vs low level), high NLR ($P = .022$, OR = 3.2, vs low NLR), and high PLR ($P = .038$, OR = 3.2, vs low PLR) were identified as predictive markers for low PNI, indicating that postoperative inflammatory status prevented the improvement of nutritional status.

DISCUSSION

The present study showed that nutritional status gradually improved after KT and was stable after 6 months of KT. Although ABO-compatibility was associated with graft survival, nutritional status was associated with patient survival but not graft survival. Postoperative improvement of nutritional status is thus essential for patient survival. A patient's dialysis history and inflammatory status are involved in the improvement of postoperative nutritional status. KTRs with short-term preoperative dialysis history or without inflammation are at a low risk of malnutrition after KT. In contrast, KTRs who have undergone PKT tend to have a good nutritional status. Figure 3 summarizes the present study. Although there was no significant difference in patient survival between ABO-compatible KT and ABO-incompatible KT in the era of advanced KT management, nutritional educational programs and interventions could lead to better prognoses and improved quality of life.

The breakthrough of immunosuppression regimens has improved short-term graft survival in KTRs [3]. Presently, overcoming chronic allograft rejection, which prevents long-term graft survival, is crucial. Chronic allograft rejection includes chronic allograft nephropathy, which comprises drug toxicity, arteriosclerosis, and other effects. The acquisition of immune tolerance could prevent acute and chronic allograft rejection, whereas the reduction of immunosuppressive agents could prevent or slow the development of drug-induced nephrotoxicity. The adequate management of hypertension, dyslipidemia, and other conditions could play important roles in inhibiting the development of chronic allograft nephropathy [17,18]. In the present study, postoperative nutritional status affected patient survival but not graft survival. To improve long-term graft survival, further development in the field of immunology is necessary. On the other hand, the improvement of postoperative nutritional status could be a way to prolong patient survival. Previous reports have suggested that transplanted kidney function was affected by various abnormalities in nutritional status and body composition and that the management of nutritional status was important for long-term graft survival. SGA scores are a subjective means of assessing nutritional status via a questionnaire; hence, objective assessment by bioelectrical impedance analysis is a more suitable method in KTRs [19,20].

This study indicates that PNI after KT could be a prognostic marker of nutritional status for patient survival and that early postoperative nutritional status could be involved in patient survival after KT. PNI calculated from laboratory data is also an objective assessment tool for nutritional status. In the present study, PNI was used as an independent prognostic factor for patient survival and in our previous report on bladder cancer, it was a prognostic factor for survival [21,22]. Several factors affect prognoses of graft and patient survival in KTRs, including the patient's immunologic profile, infection, primary disease, and complications. An understanding of the association between nutritional status and prognosis could help in long-term follow-up and also to achieve better management in KTRs, resulting in a good prognosis.

Inflammatory status is closely associated with prognosis in KTRs [23]. In the present study, inflammatory status was independently correlated with nutritional status. KTRs with elevated inflammation tended to have malnutrition compared to those with normal inflammation and malnutrition puts patients at a higher risk of mortality. Patients with CKD are often characterized by increased oxidative stress and persistent inflammation, which are correlated with each other, resulting in the progression of CKD [24].

Table 3. Logistic Regression Analysis of Prognostic Factor for Prognostic Nutritional Index 3 Months after Kidney Transplantation

	Univariate Analysis			Multivariate Analysis		
Variables	OR	95% CI	*P*	OR	95% CI	*P*
Age						
<45	1			1		
≥45	6.1	2.1–17.4	.0003	3.1	.9–10.9	.075
Sex						
Men	1					
Women	.9	.4–2.0	.84			
BMI						
<22	1					
≥22	1	.4–2.3	1			
ABO-compatibility						
Compatible	1					
Incompatible	.6	.2–1.8	.43			
Type of donation						
Live	1			1		
Cadaver	4.7	1.6–14.0	.0062	.8	.2–4.3	.83
Duration of dialysis						
<12	1			1		
≥12	3.5	1.4–8.4	.0063	.6	.1–2.4	.47
PKT						
Yes	1			1		
No	16.6	2.2–127.8	.0003	.3	1.0–83.4	.047
CNI						
Cyclosporine	1					
Tacrolimus	.7	.3–1.5	.4			
Primary disease						
non-DM	1					
DM	.9	.3–2.6	1			
BPR						
No	1					
Yes	.5	.1–2.3	.51			
Total cholesterol						
≥200	1					
<200	1	.4–2.4	1			
Hemoglobin						
≥11	1			1		
<11	4.2	1.5–12.0	.0048	2.5	.7–8.9	.15
CRP						
<.2	1			1		
≥.2	6.1	2.4–15.2	.0001	5.2	1.6–16.6	.006
NLR						
<.5	1			1		
≥.5	4.6	1.9–11.3	.0006	3.7	1.2–11.4	.022
PLR						
<280	1			1		
≥280	6.7	2.7–17.0	<.0001	3.2	1.1–9.8	.038
Uric acid						
<7	1					
≥7	1.2	.5–2.8	.67			
Serum sodium						
≥140	1					
<140	1.1	.5–2.5	.84			
Serum phosphorus						
≥3.5	1					
<3.5	1.6	.5–4.6	.61			
Correction calcium						
≥9.5	1					
<9.5	.9	.4–2.0	.83			

Abbreviations: BMI, body mass index; BPR, biopsy proven rejection; CI, confidence interval; CNI, calcineurin inhibitor; CRP, C-reactive protein; DM, diabetes mellitus; NLR, neutrophil-lymphocyte ratio; OR, odds ratio; PKT, pre-emptive kidney transplantation; PLR, platelet-lymphocyte ratio.

Anjos et al reported that a novel treatment involved in the inactivation of the oxidative stress-inflammation cycle was crucial to minimize mortality, especially deaths due to cardiovascular events. The nuclear factor erythroid 2-related factor-2, the master regulator of antioxidant genes regulating the expression of detoxifying enzymes of phase-II and antioxidant responses, could be a novel agent to reduce oxidative stress and inflammation in patients with CKD [25]. Malnutrition was also closely correlated with poor prognoses in patients with CKD and was strongly associated with inflammation [5,26,27], indicating that improving nutritional status and/or inflammatory status can lead to a good prognosis in CKD patients.

Overnutrition might lead to patients becoming overweight or obese. Despite a significantly improved prognosis compared to patients on dialysis, the survival duration of KTRs is reduced compared to that of the age-matched general population [4]. Sood et al reported that obese KTRs had a significantly higher risk of delayed graft function, BPR, death, and graft loss after KT [28]. Although excessive weight gain and obesity should be avoided for long-term health outcome, significant weight gain is common in KTRs. Weight gain is induced by various factors, including the relaxation of dietary restrictions, increased appetite, increased well-being, administration of immunosuppressive agents, and inadequate physical activity [29–31]. A randomized controlled trial performed by Henggeler et al showed that there was no significant difference in weight gain after KT between KTRs with intensive nutritional intervention care and those with normal nutritional care [32]. Importantly, weight gain was modest in both groups in that study [32]. Consciousness regarding nutrition might lead to the suppression of weight gain. Further studies are needed to develop an effective nutritional intervention, and the dissemination of knowledge regarding the importance of nutritional status is needed to improve prognoses in KTRs.

The present study has several limitations. The first is its retrospective nature from a single hospital with potential selection bias; for example, some patients were excluded because of lack of data. Second, this study included 118 patients, which is considered to be a relatively small sample size. Small sample sizes constitute a limitation of the work; to acknowledge this issue, further studies involving additional patients and longer follow-up periods are needed to verify our results. Third, nutritional status should be assessed not only by serum albumin level and PNI but also by SGA, MIS, and GNRI. SAG, MIS, and GNRI could not be investigated in this study because of a lack of data, so a

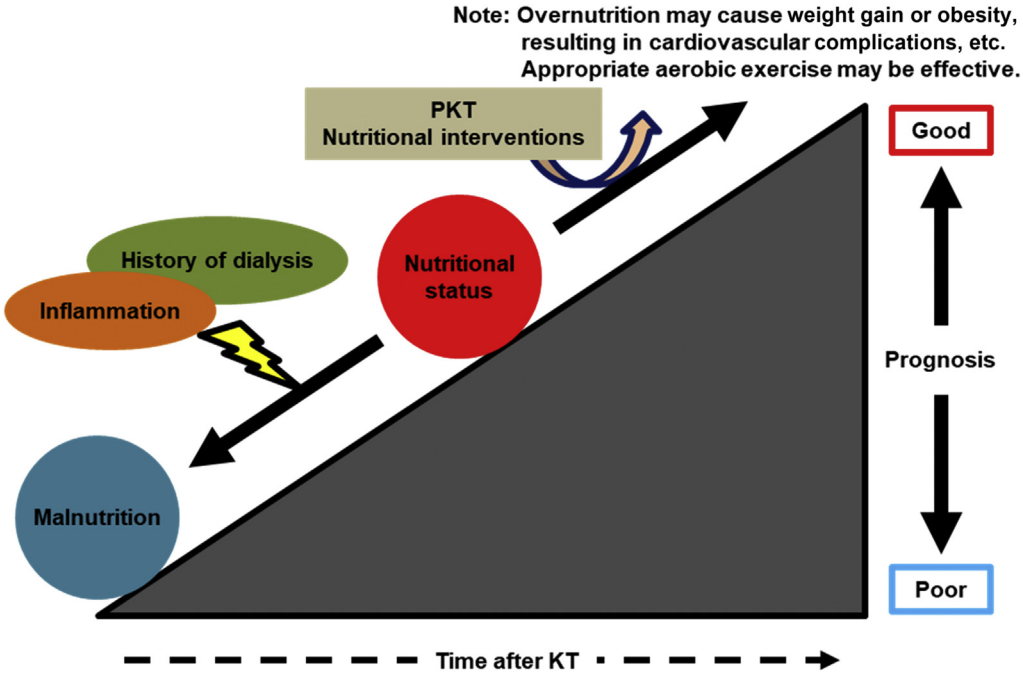

Fig 3. Schematic summary of this study. Nutritional status after kidney transplantation shows the clinical significance of prognosis in kidney transplant recipients, and prognostic nutritional index is useful as a nutrition-based marker. Inflammatory status and history of dialysis before kidney transplantation had a negative effect on the improvement of postoperative nutritional status. In contrast, recipients who underwent a preemptive kidney transplantation tended to have a good nutritional status after kidney transplantation. Long-term uremia may inhibit the improvement of nutritional status. Although the improvement of nutritional status led to a better outcome in kidney transplant recipients, we should consider the effects of overnutrition, leading to overweight or obese conditions, diabetes mellitus, cardiovascular disease, and other complications.

comparison of PNI with these factors must be done in the future. Fourth, the correlation of nutritional status with chronological changes in body weight could not be investigated. Further studies are necessary to validate and apply our results.

CONCLUSIONS

We explored the clinical significance of postoperative nutritional status in KTRs, demonstrating that postoperative nutritional status improved gradually, and that patient survival improved when postoperative nutritional status was adequate. We also suggest that inflammatory status plays a key role in inducing malnutrition and that long-term dialysis history might affect nutritional status. Therefore, we should consider postoperative nutritional status and educate patients on the importance of nutrition. Further studies are needed to develop appropriate educational programs, exercise programs, and nutritional interventions to improve prognoses in KTRs.

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