CLINICAL RESEARCH STUDY

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Multidisciplinary Care Program for Advanced Chronic Kidney Disease: Reduces Renal Replacement and Medical Costs☆

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ABSTRACT

BACKGROUND: Multidisciplinary care is advocated as an effective chronic kidney disease treatment program in a few, but not all, studies. Our study aimed to evaluate the effect of multidisciplinary care on renal outcome and patient survival using a larger cohort.

METHOD: A total 1382 chronic kidney disease patients, ages 18-80 years, with chronic kidney disease stage 3B-5, in nephrology outpatient clinics were enrolled. Using age, sex, chronic kidney disease stage, and diabetes mellitus as variables, 592 multidisciplinary care program participants were matched with 614 nonmultidisciplinary care patients. The primary outcomes were long-term renal replacement therapy and mortality. Secondary outcomes included changes of biochemical markers and blood pressure, infection hospitalization, cardiovascular events, and emergent start of long-term dialysis. Annual medical costs were compared.

RESULTS: There were no between-group differences regarding mortality. In the multivariate competing-risk regression model, the multidisciplinary care group had a better renal survival (hazard ratio 0.640; 95% confidence interval, 0.484-0.847; $P = .002$). This effect was most prominent in stage 4 (hazard ratio 0.375; 95% confidence interval, 0.219-0.640; $P < .001$), but not in stage 3B and 5 patients. The multidisciplinary care group showed a slower estimated glomerular filtration rate decline (-2.57 vs -3.74 mL/min/1.73 m^2, $P = .021$), and a smaller increase in phosphate ($+0.03$ vs $+0.33$ mg/dL, $P = .013$). Cardiovascular and infection events were both decreased in the multidisciplinary care group ($P < .001$). There was also less requirement of emergent start dialysis (39.6% vs 54.5%, $P = .001$). The annual cost for the multidisciplinary care group was lower than the nonmultidisciplinary care group (US $2372 vs $3794, $P < .001$). In addition, considering the reduction of patients requiring renal replacement therapy, the multidisciplinary care program saved a total US $1931 per patient annually.

CONCLUSIONS: Our analysis demonstrated that the multidisciplinary care program provided better health care and reduced renal replacement therapy in patients with advanced chronic kidney disease. By decreasing hospitalizations, emergent start, and the need for renal replacement therapy, the multidisciplinary care program was cost-effective.

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The incidence of end-stage renal disease in most countries is increasing. Chronic kidney disease, the major cause of end-stage renal disease, is associated with increased risk of comorbidities and mortality. Finding an effective treatment to prevent the progression is an important issue.

Multidisciplinary care is an integrative medical care system that includes doctors, nurses, and dietitians to participate in the medical treatment, patient education, diet consultation, behavior adjustment, and close monitoring system. Earlier studies demonstrated that multidisciplinary care participants were better prepared for dialysis.[1] There were also beneficial effects on patient overall survival, laboratory parameters,[2,3] less unplanned dialysis, and lower incidence of cardiovascular events.[4] However, there was a report revealing no beneficial effect on renal function progression.[5] The initial report of the Multifactorial Approach and Superior Treatment Efficacy in Renal Patients with the aid of Nurse practitioners (MASTERPLAN) study did not reveal improvement on cardiovascular outcomes, all-cause mortality and end-stage renal disease.[6] However, the extended follow-up showed a better composite outcome of end-stage renal disease, death, or 50% increase of creatinine.[7]

CLINICAL SIGNIFICANCE

- This study demonstrated the beneficial effect of a multidisciplinary care program in chronic kidney disease patients.
- Patients in a multidisciplinary care program had a benefit of risk reduction of 33.6% renal replacement therapy compared with patients not receiving this program.
- Patients receiving a multidisciplinary care program had less chance of admission or emergent dialysis.
- A multidisciplinary care program is cost-effective.

Taiwan initiated a nationwide multidisciplinary care program for stage 3B-5 chronic kidney disease patients in November 2006, after that a slower renal function deterioration was found.[8,9] A survey revealed a progressive decrease of end-stage renal disease incidence since 2007.[10] However, several studies in Taiwan showed a contradictory effect. One observation showed that multidisciplinary care was associated with a slower decline rate of estimated glomerular filtration rate (eGFR) and less initiation of dialysis.[11] In central Taiwan, multidisciplinary care participants had paradoxically more long-term dialysis.[12]

To provide evidenced-based data for the exact benefit of a multidisciplinary care program, we conducted a retrospective study to evaluate the effect of this program on dialysis incidence, eGFR decline, patient survival, change of biochemical markers, and medical costs.

METHODS

Participants

We performed a retrospective single-center analysis in National Taiwan University Hospital. Patients ages 18-80 years who were diagnosed with chronic kidney disease stage 3B-5 for at least 3 months and joined the pre-end-stage renal disease multidisciplinary care program between 2007 and 2009 were included. These patients were defined as a multidisciplinary care group. We excluded patients who have had a kidney transplant, had acute kidney injury, ever received renal replacement therapy, had Child Pugh class B-C liver cirrhosis, and had terminal malignancies. We used a 4-variable equation from the Modification of Diet in Renal Disease-4 equation ($186 \times Scr^{-1.154} \times Age^{-0.203} \times 0.742$ (if female) $\times$ 1.212) to estimate eGFR.

For the comparison group (nonmultidisciplinary care group), we choose patients not entering the multidisciplinary care program during the same period and treated at our nephrology outpatient clinic with the diagnosis of International Classification of Disease, 9th Revision codes 585 and 582. The inclusion and exclusion criteria were the same as the multidisciplinary care program recipients. We further matched those comparison group patients with multidisciplinary care group patients by chronic kidney disease stage, age, sex, and diabetes. All patients in the multidisciplinary care and nonmultidisciplinary care group were treated according to the Kidney Disease Outcomes Quality Initiative guidelines.[13] This study was approved by the National Taiwan University Hospital Research Ethics Committee.

Multidisciplinary Care Program

The multidisciplinary care program integrated the care of nephrologists, nurses, dieticians, and pharmacists. On visiting our nephrology clinic, those with eGFR $\leq$45 mL/min per 1.73 m^2 were all requested by the physician to join the program. The nursing staff conducted a detailed interview with the patients, consisting of basic knowledge of chronic kidney disease, lifestyle modification, clarifying risk factors, and condition of end-stage renal disease. Dietician consultation was conducted at the same time. The participants return to the clinic every 1-3 months, according to the judgments of primary care nephrologists. The educational programs conducted by the nursing staff and routine laboratory tests are required at least every 3 months. The registration fee was US $40 and annual fee was US $150 (stage 3B-4) or US $180 (stage 5). Once the patients entered chronic kidney disease stage 5, they were invited to visit our dialysis center to receive dialysis education regarding the modality of renal replacement therapy. Preparation of the hemodialysis vascular access or peritoneal dialysis catheter was encouraged when suitable.

Data Collections

Data of age, sex, underlying diseases, and comorbidity were recorded. The definition of cardiovascular disease

comprised congestive heart failure, coronary artery disease, cerebral vascular disease, and peripheral vascular disease. Medical records were reviewed to document the use of angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs), the hospitalizations due to cardiovascular events or infection. The blood pressure (BP) and biochemical data, including creatinine, hemoglobin, calcium, phosphorus, albumin level, and urine protein-to-creatinine ratio were recorded at baseline and then annually. For those who initiated long-term renal replacement therapy, the modality and the use of a temporary catheter were recorded. Our Medical Affairs Office provided the data on medical costs. Costs were calculated through December 31, 2012. For those who started hemodialysis or peritoneal dialysis, all costs from enrollment until the establishment of long-term dialysis catheter were calculated. For those who received preemptive renal transplantation, medical costs were recorded until just before the transplantation operation.

Outcomes

The primary outcomes of the study were all-cause mortality and initiation of long-term renal replacement therapy, including hemodialysis, peritoneal dialysis, or renal transplantation. For all those who started renal replacement therapy, we further analyzed whether they received emergent start of dialysis. Emergent start was defined as unplanned long-term dialysis with temporary catheter. Temporary dialysis due to acute kidney injury was not included. For those who received long-term hemodialysis, the initial vascular access was documented. Secondary outcomes included annual change of biochemical markers and BP, cardiovascular and infection hospitalization, and the need of emergent start of dialysis. For those who start renal replacement therapy within 1 year, the eGFR upon dialysis initiation was used to calculate the eGFR decline rate. Medical costs were also compared between groups. Patients were followed-up until reaching primary endpoints or until December 31, 2012.

Statistical Analysis

Baseline characteristics were described as mean ± SD for continuous variables, and frequency for categorical variables. The differences were analyzed using *t*-test and chi-squared test. Skewed variables, such as urine protein-creatinine ratio and the eGFR on dialysis initiation, were compared by Mann-Whitney *U* test. Event rates were compared by Poisson test.

Considering the potential of the competing risk of end-stage renal disease and death before end-stage renal disease, a competing risks model was used and cumulative incidence functions of end-stage renal disease were calculated, treating death as a competing event. Fine and Gray proportional hazards regression models were used to estimate the effect of multidisciplinary care program on the risks of end-stage renal disease and mortality. The subdistribution hazards ratios (HRs) from the model were determined to account for competing risk. Covariates adjusted in the regression model included: age, sex, diabetes mellitus, cardiovascular disease, systolic BP, eGFR, albumin, calcium and phosphate product, and log urine protein-creatinine ratio. In full model, the use of ACEIs/ARBs was included. HRs and 95% confidence intervals (CIs) were calculated for the association between multidisciplinary care and outcome.

The medical costs were estimated by multiplying the survival probability with the corresponding medical costs after adjusting an annual 3% discount rate. Per patient-year costs were further calculated by dividing the mean survival. The differences of medical costs were compared by *Z*-test.

All statistical tests were 2-tailed, and a *P*-value of $< .05$ was considered significant. The statistical analyses were performed with the use of SPSS version 19 (IBM, Armonk, NY) and STATA version 12 (StataCorp LP, College Station, TX). The medical costs were analyzed by ISQoL (http://www.stat.sinica.edu.tw/isqol/).

RESULTS

Baseline Characteristics

A total 1382 patients were enrolled, including 721 multidisciplinary care group and 661 nonmultidisciplinary care group patients. Using age, sex, chronic kidney disease stage, and diabetes mellitus status as variables, 592 multidisciplinary care recipients were matched to 614 nonmultidisciplinary care patients (**Figure 1**). The median follow-up time was 2.43 years. Most patients lived in metropolitan Taipei, and there were no differences between groups (87.2% vs 87.3%, $P = .944$). There were no differences regarding age, sex, body mass index, eGFR, and all major comorbidities (**Table 1**). The nonmultidisciplinary care group had higher BP, phosphate, and urine protein creatinine ratio. Baseline albumin and calcium were higher in the multidisciplinary care group, and there were no differences regarding hemoglobin level, uric acid, and the prescription of ACEI/ARB.

Survival Analysis

During the follow-up period, the mortality rates were 7.6% and 5.9% in multidisciplinary and nonmultidisciplinary groups, respectively ($P = .329$), which was not significantly different. Divided by chronic kidney disease stages, there were also no differences in stage 3B (9.6% vs 10.0%, $P = .892$), stage 4 (9.2% vs 5.9%, $P = .195$), and stage 5 (4.1% vs 2.7%, $P = .435$). Long-term renal replacement therapy was initiated in 230 patients (38.9%) in the multidisciplinary care group, and 319 patients (52.0%) in the nonmultidisciplinary care group. All patients started renal replacement therapy with an eGFR <15 mL/min/1.73m^2, and there was no difference in eGFR upon initiating renal replacement therapy (4.47 vs 4.40 mL/min/1.73m^2,

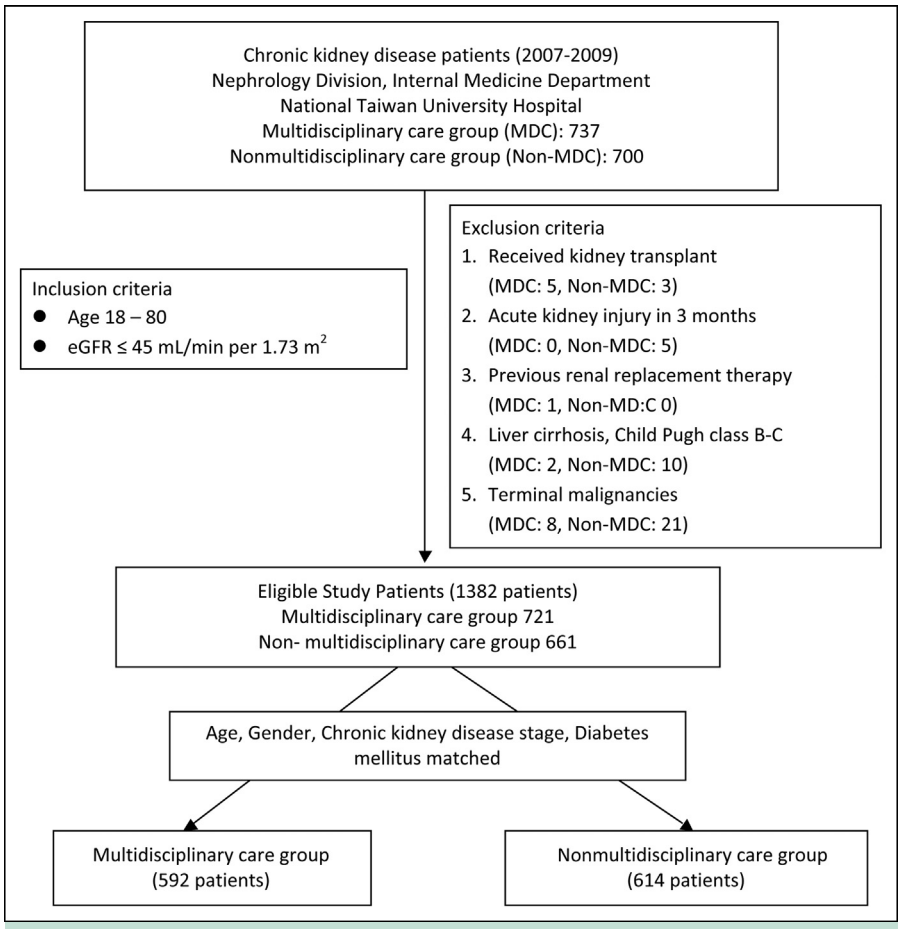

Figure 1 Study design, inclusion and exclusion criteria, and allocation of patients.

$P = .209$). Using death as a competing risk, the cumulative incidence of renal replacement therapy was lower in the multidisciplinary care group ($P < .001$, Figure 2A). In the subgroup analysis, renal outcome was better in chronic kidney disease stage 4 ($P < .001$) and stage 5 ($P = .01$) patients (Figure 2C, D), but not in stage 3 patients ($P = .44$) (Figure 2B).

In the Fine and Gray competing regression model, the multidisciplinary care program had a renoprotective effect, with crude HR 0.675 (95% CI, 0.570-0.800; $P < .001$). After adjusting demographic data, comorbidities, and biochemical data (Model 1), the multidisciplinary care program was a strong factor to reduce the risk of renal replacement therapy (HR 0.641; 95% CI, 0.483-0.851; $P = .002$). Considering the possible effect of ACEI/ARB in Model 2, multidisciplinary care program was associated with a 36.0% risk reduction (95% CI, 0.484-0.847; $P = .002$) (Table 2). Dividing the patients according to different chronic kidney disease stages, a lower rate of renal replacement was observed in stage 4 multidisciplinary care program participants (HR 0.375; 95% CI, 0.219-0.640; $P < .001$ in model 2). Stage 3B multidisciplinary care program participants had a 47.8% risk reduction, though it was not statistically significant ($P = .195$). The stage 5 participants had a better outcome with crude HR (0.757, $P = .011$), but this effect was not significant on multivariable adjustment ($P = .194$) (Table 2).

Secondary Outcomes

The multidisciplinary care group had a significantly slower annual eGFR decline rate (−2.57 vs −3.74 mL/min/1.73 m^2, $P = .021$). In a different stage, the multidisciplinary care group had lower but insignificant eGFR decline rates. Better phosphate control was noted in the multidisciplinary care group (+0.03 vs +0.33 mg/dL, $P = .013$). The multidisciplinary care group also showed some favorable annual biochemical change, such as hemoglobin (−0.11 vs −0.24 g/dL, $P = .269$) and urine protein-creatinine ratio (+0.379 vs +0.557 g/g, $P = .474$), although they were not statistically significant. There was no difference regarding BP control and change of albumin level between groups (Table 3).

During the follow-up period, the multidisciplinary care group had fewer adverse cardiovascular (0.04 vs 0.10 times per person-year, $P < .001$) and infection events (0.07 vs 0.12 times per person-year, $P < .001$). Hospitalization days due to the above reasons were also significantly shorter

Table 1 Baseline Characteristics Between Multidisciplinary Care and Nonmultidisciplinary Care Groups

	Multidisciplinary Care Group n = 592	Nonmultidisciplinary Care Group n = 614	*P*-Value
Age	62.16 ± 13.16	61.93 ± 13.68	.764
Sex (male)	57.9%	53.6%	.128
Body mass index (Kg/m^2)	24.79 ± 4.42	24.47 ± 4.27	.214
eGFR (mL/min/1.73m^2)	22.41 ± 11.64	22.05 ± 12.14	.601
Chronic kidney disease stage			.276
Stage 3B	31.8%	27.7%	
Stage 4	35.0%	36.0%	
Stage 5	33.3%	36.3%	
Diabetes mellitus	44.3%	45.0%	.808
Hypertension	95.8%	95.3%	.675
Cardiovascular disease	32.3%	34.0%	.513
Liver disease	9.5%	11.9%	.172
Cancer	13.0%	12.9%	.942
Systolic blood pressure (mm Hg)	133.08 ± 18.11	136.26 ± 18.16	.003
Diastolic blood pressure (mm Hg)	75.75 ± 11.15	78.76 ± 12.16	<.001
Hemoglobin (g/dL)	10.88 ± 2.05	10.67 ± 2.23	.102
Albumin (g/dL)	4.34 ± 0.43	4.06 ± 0.61	<.001
Calcium (mmol/L)	2.26 ± 0.17	2.15 ± 0.22	<.001
Phosphate (mg/dL)	4.11 ± 1.00	4.62 ± 1.36	<.001
Uric acid (mg/dL)	8.26 ± 1.96	8.27 ± 2.10	.939
Urine protein creatinine ratio (g/g)	1.230 (0.499-2.748)	2.078 (0.851-4.294)	<.001
ACEI/ARB	57.9%	56.0%	.502

Continuous variables were compared using *t*-test and categorical variables were compared using chi-squared test.
Urine protein creatinine ratio was expressed as median (25th and 75th quartile) and compared by Mann-Whitney *U* test.
ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; eGFR = estimated glomerular filtration rate.

(Table 3). The nonmultidisciplinary care group had significantly more emergency department visits ($P < .001$). On the other hand, the outpatient visits between groups showed no difference. The multidisciplinary care group was better prepared, with fewer patients requiring emergent start of dialysis (39.6% vs 54.5%, $P = .001$). For those receiving long-term hemodialysis, the multidisciplinary care group was better prepared with arteriovenous fistula or graft (46.6% vs 28.2%) There was no significant difference between groups in long-term renal replacement modalities ($P = .060$) (Table 3).

Medical Costs

The multidisciplinary care group had a significantly lower annual cost per patient year (US $2372 vs $3794, $P < .001$) and had less spent on emergency department (US $104 vs $189, $P < .001$) and inpatient treatment (US $829 vs $2128, $P < .001$). The cost of outpatient care was not significantly different (US $1439 vs $1477) (Table 4). Using our endemic data as reference, the estimated average annual cost for a patient requiring renal replacement therapy was US $20,054.[14,15] The annual risk for progression to renal replacement therapy was 8.7% in the nonmultidisciplinary care group. With a 36.0% risk reduction and a difference of US $16,260 between chronic kidney disease and end-stage renal disease, the annual cost savings attributed to less renal replacement therapy was US $509. Therefore, we concluded that the net savings per multidisciplinary care patient was US $1931 annually (Table 4).

DISCUSSION

Our analysis demonstrated better renal care for advanced chronic kidney disease patients receiving multidisciplinary care, with the risk reduction of 36.0% for renal replacement therapy. This effect might be one of the important reasons for the reduction of end-stage renal disease incidence in Taiwan since 2007.[10] The risk-reduction ratio in this study is greater compared with the 15% decrease in end-stage renal disease incidence in Taiwan. The main reason is that only 47% of stage 3B-5 chronic kidney disease patients were enrolled in this nationwide program until December 2013. If all patients are enrolled in the program, the decrease of end-stage renal disease incidence in Taiwan might be higher.

In our study, the effect of the multidisciplinary care program was most prominent in stage 4 patients. For stage 5 patients, the effect was not significant due to rapid entering into end stage. For stage 3B patients, it may take longer to reach the endpoint. It was difficult to see a difference with short-term follow-up and limited patient numbers. This phenomenon could also explain that the benefit of a multidisciplinary care program cannot be easily observed in early chronic kidney disease patients.[5,6]

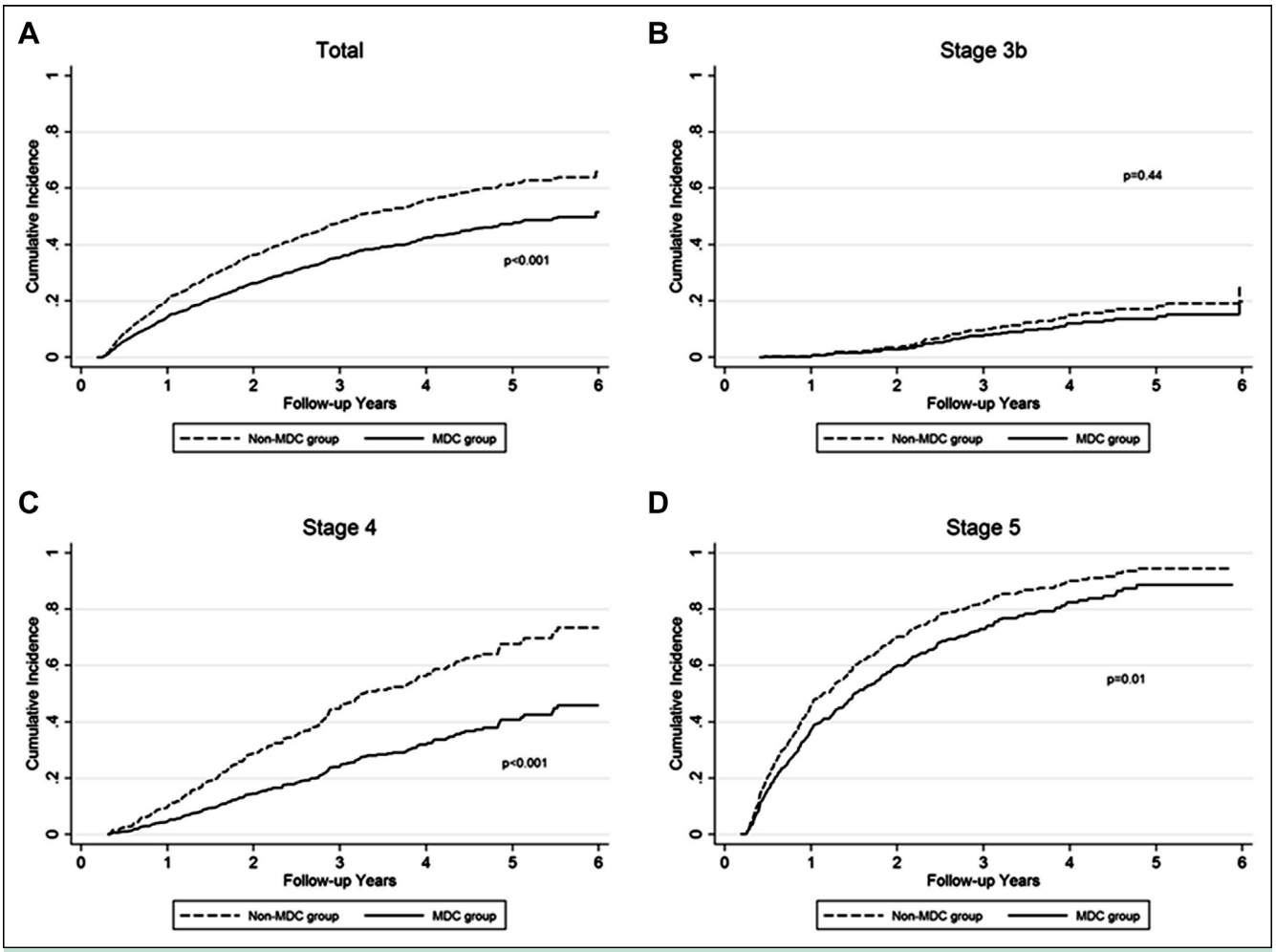

Figure 2 Cumulative incidence of renal replacement therapy using Fine and Gray model accounting death as a competing risk. Multidisciplinary care group had a better renal outcome. (**A**) In all patients. (**B**) Chronic kidney disease stage 3B patients. (**C**) Chronic kidney disease stage 4 patients. (**D**) Chronic kidney disease stage 5 patients. eGFR = estimated glomerular filtration rate; MDC = multidisciplinary care.

The guidelines of chronic kidney disease care consist of many aspects[13,16] and are quite complicated for patients and health care staffs. This complexity may reduce the motivation of patients to follow the guidelines. Therefore, sufficient supervision is necessary to reach the goal. Our study proved that multidisciplinary care program participants have significantly better phosphate control. Phosphate control is one of the indexes of medical compliance and

Table 2 Crude and Multivariate Adjusted Hazard Ratio of Renal Replacement Therapy for Multidisciplinary Care in All Patients and in Individual Stages

	All	*P*-Value	Stage 3B	*P*-Value	Stage 4	*P*-Value	Stage 5	*P*-Value
Univariate analysis	0.675 (0.570-0.800)	<.001	0.779 (0.413-1.471)	.442	0.465 (0.340-0.636)	<.001	0.757 (0.610-0.939)	.011
Multivariate analysis								
Model 1	0.641 (0.483-0.851)	.002	0.531 (0.187-1.511)	.236	0.361 (0.213-0.612)	<.001	0.810 (0.578-1.135)	.221
Model 2	0.640 (0.484-0.847)	.002	0.522 (0.195-1.395)	.195	0.375 (0.219-0.640)	<.001	0.802 (0.576-1.118)	.194

Fine and Gray regression model was used, accounting death as a competing risk factor.

Model 1: Adjust age, sex, diabetes mellitus, cardiovascular disease, systolic blood pressure, estimated glomerular filtration rate (eGFR), albumin, calcium X phosphate, Log urine protein creatinine ratio.

Model 2: Adjust age, sex, diabetes mellitus, cardiovascular disease, systolic blood pressure, eGFR, albumin, calcium X phosphate, Log urine protein creatinine ratio, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker.

Table 3 Secondary Outcomes and Medical Resource Use of Multidisciplinary Care and Nonmultidisciplinary Care Groups

	Multidisciplinary Care Group	Nonmultidisciplinary Care Group	
	Mean ± SD	Mean ± SD	*P*-Value
ΔeGFR (mL/min/1.73m^2)	−2.57 ± 6.64	−3.74 ± 10.40	.021
ΔeGFR (Stage 3B)	−1.02 ± 7.69	−2.06 ± 9.88	.286
ΔeGFR (Stage 4)	−2.84 ± 7.01	−4.47 ± 13.47	.118
ΔeGFR (Stage 5)	−3.76 ± 4.62	−4.30 ± 6.71	.333
ΔSystolic blood pressure (mmHg)	+0.80 ± 19.28	+0.70 ± 20.32	.935
ΔHemoglobin (g/dL)	−0.11 ± 1.50	−0.24 ± 1.70	.269
ΔAlbumin (g/dL)	−0.06 ± 0.42	+0.00 ± 0.55	.121
ΔPhosphate (mg/dL)	+0.03 ± 0.88	+0.33 ± 1.47	.013
ΔUrine protein creatinine ratio (g/g)	+0.379 ± 2.590	+0.557 ± 2.233	.474
	Multidisciplinary Care Group (Per Patient Year)	Nonmultidisciplinary Care Group (Per Patient Year)	
Cardiovascular admissions	0.04	0.10	<.001
Days	0.66	1.47	<.001
Infection admissions	0.07	0.12	<.001
Days	1.00	2.78	<.001
Emergent department visits	0.47	0.77	<.001
Outpatient visits	13.12	12.95	.910
	n (%)	n (%)	
Emergent start of renal replacement therapy	91/230 (39.6%)	174/319 (54.5%)	.001
Renal replacement therapy modality			.060
Hemodialysis	148/230 (64.3%)	216/319 (67.7%)	
Peritoneal dialysis	73/230 (31.7%)	100/319 (31.3%)	
Transplantation	9/230 (3.9%)	3/319 (0.9%)	
Start of hemodialysis			.001
Temporary catheter	72/148 (48.6%)	143/216 (66.2%)	
Tunneled catheter	7/148 (4.7%)	12/216 (5.6%)	
AVF/AVG	69/148 (46.6%)	61/216 (28.2%)	

Continuous variables were compared using *t*-test and categorical variables were compared using chi-squared test.
Event rates were compared by Poisson test.
Outpatient visits refer to visiting all specialties in our hospital, not just nephrology clinic.
AVF = arteriovenous fistula; AVG = arteriovenous graft; ΔeGFR = annual change of estimated glomerular filtration rate.

improves the renal outcomes in chronic kidney disease patients.[17] Dietician consultation and nurse's supervision both contributed to good phosphate control by emphasizing a low protein/phosphate diet[18,19] and drug compliance for phosphate binders.[20] Both contributed to a lesser increase of proteinuria[21] and brought better outcomes in the multidisciplinary care group.

The multidisciplinary care program also provided better health care. In our study, we noticed a marked decrease in infection and cardiovascular event compared with another cohort.[12] The need of unplanned dialysis was also lower, as in other studies.[11,12,22] It was noteworthy that the rate of emergent start was high in our study and another cohort in Taiwan[12] despite emphasis on patient education. This might be related to elder age in these cohorts, and reluctance of our people to accept access preparation without overt uremic symptoms. The frequency of outpatient visits between groups was nearly the same. We could conclude that the better outcome was not attributed to more intensive visits. A higher percentage of patients in the multidisciplinary care group choose renal transplantation for long-term renal replacement therapy. This difference illustrated another aspect of improving patient care by better education in renal replacement therapy modality selection.

Multidisciplinary care program is cost-effective in our analysis. Compared with other cohorts,[7,22] the outpatient medical cost per person-year was not higher in the multidisciplinary care group. We assumed that it was attributed to better disease control that could decrease cost. In addition, the medical costs on emergency department and inpatient treatment decreased significantly in the multidisciplinary care group. This phenomenon correlated with fewer cardiovascular events, infection events, and less need of unplanned dialysis.

There were several limitations in our study. First, this was a retrospective observational cohort without randomization. Physicians' preference and patients' issue could affect the result. However, there are ethical concerns about performing a randomized control trial in Taiwan, because it is probably beneficial, and promoting the multidisciplinary

Table 4 Medical Costs of Multidisciplinary Care and Nonmultidisciplinary Care Group

	Multidisciplinary Care Group (Per Patient Year)	Nonmultidisciplinary Care Group (Per Patient Year)	*P*-Value
Total medical costs	2372 ± 138 (2116～2522)	3794 ± 259 (3234～3994)	<.001
Emergent department	104 ± 7 (99～121)	189 ± 13 (174～212)	<.001
Inpatient	829 ± 57 (745～912)	2128 ± 137 (1921～2379)	<.001
Outpatient	1439 ± 113 (1297～1629)	1477 ± 61 (1362～1544)	.767
Estimated savings by less renal replacement therapy		509	
Net savings		1931	

Medical costs were calculated with per person-year and expressed as mean ± standard error (95% confidence interval).
Outpatient visits refer to visiting all specialties in our hospital, not just nephrology clinic.

care program is our national policy. Therefore, we used matching analysis in this study to adjust confounders to minimize bias. Because of the easy access to medical care in Taiwan and the high proportions of Taipei metropolitan residents, the disparity of social background may be limited between groups. All patients received standard nephrology care with similar ACEI/ARB use rate. Second, this study was performed in a single center. The result may not apply to all patients. Comparing our results with the data from the Taiwan Renal Registry Data System,[10] the number of patients enrolled in the multidisciplinary care program, and the renal replacement therapy incidence as mentioned above, all the data are similar. Therefore, we considered our result cohort cogent and representative of the multidisciplinary care programs in Taiwan. Third, only the medical costs in our hospital were included. However, as a tertiary medical center, most of our chronic kidney disease patients had all their diseases treated in our hospital. Therefore, we hypothesized that the medical costs outside of the hospital were few and equally distributed between groups.

Despite the limitations, the current study proved that the multidisciplinary care program provided better health care and reduced the incidence of long-term renal replacement therapy in advanced chronic kidney disease patients. With more patients enrolled in this nationwide program, we did observe a concomitant decrease in end-stage renal disease incidence in Taiwan. It was also cost-effective. We believe that this program should be applied to all advanced chronic kidney disease patients around the world.

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