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Original Paper

Influence of Chronic Kidney Disease on Physical Function and Quality of Life in Patients after Coronary Artery Bypass Grafting

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Key Words

Chronic kidney disease · Coronary artery bypass grafting · Body composition · Physical function · Quality of life

Abstract

Aims: The purposes of this study were (1) to compare body composition, physical function, and quality of life (QOL) between patients after coronary artery bypass grafting (CABG) with and without chronic kidney disease (CKD) and (2) to analyze the factors associated with physical function and QOL domains in these patients. ***Methods:*** Thirty male post-CABG patients with CKD and 30 matched controls were recruited. All subjects underwent dual-energy X-ray absorptiometry for body composition evaluation. Physical function tests included the grip strength test, 30-second chair stand test (30CST), and 6-min walk test (6MWT). Physical activity and QOL were assessed using the long form of the International Physical Activity Questionnaire and the World Health Organization Quality of Life Instrument (WHOQOL)-BREF, respectively. ***Results:*** Post-CABG patients with CKD exhibited a lower arm lean mass and higher percent leg fat mass than those without CKD ($p < 0.05$). The patients with CKD also had lower 30CST scores, 6MWT distances, and QOL domain of social relationships scores than those without CKD after adjusting for covariates ($p < 0.05$). If NYHA class was considered in the model, NYHA class became the most important factor associated with 6MWT distances ($\beta = -0.647$, $p < 0.001$) and the QOL domains of psychological health ($\beta = -0.285$, $p = 0.027$) and environment ($\beta = -0.406$, $p = 0.001$). ***Conclusion:*** Post-CABG patients with CKD had worse body composition, physical function, and QOL than those without CKD, and this might be associated with a worse NYHA class.

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Introduction

Coronary artery disease (CAD) is the most prevalent fatal heart disease worldwide [1]. It has been reported that more than 500,000 coronary artery bypass grafting (CABG) surgeries are performed for CAD annually in the USA. Chronic kidney disease (CKD) is an important clinical comorbidity that increases the risk of death and myocardial infarction in patients with CAD [2]. It has been reported that CKD is present in 26% of patients undergoing CABG [3], and 31% of patients undergoing cardiac surgery have acute renal failure [4]. Preoperative and postoperative renal dysfunction has adverse effects on long-term mortality after CABG [5].

Although elective CABG surgery was reported to significantly improve patients' survival rates and quality of life (QOL), it is unknown whether CKD limits the beneficial effects of CABG procedures on patients' physical function and QOL. Many studies showed that patients undergoing dialysis and even mild-to-severe CKD experience decreases in physical function [6, 7]. The low levels of physical function and physical activity that characterize patients with CKD in all stages and treatments are associated with poor clinical outcomes [8]. However, little is known about the influence of CKD on the physical function and QOL of patients after CABG. In previous studies, only Parikh et al. [9] reported that patients with severe CKD who underwent CABG showed improvement in the mental health domain but no improvement in the physical functioning domain of QOL, and may have had worse physical function than those without severe CKD. However, they did not perform physical function tests in post-CABG patients with CKD. Outcomes that focus on physical functioning could help determine the impact of diseases on the overall functioning of the patients.

Patients undergoing CABG now have good long-term survival rates. A better understanding of the physical function and QOL of patients with CKD undergoing CABG will be an important health issue. The main purposes of our study were (1) to compare the body composition, physical function, and QOL between post-CABG patients with CKD and those without CKD and (2) to analyze the factors associated with physical function and QOL domains in these patients.

Subjects and Methods

Patients (aged 40–75 years) who had undergone CABG surgery in the Department of Cardiovascular Surgery at the Far Eastern Memorial Hospital in New Taipei City, Taiwan, ROC, were invited to participate in this study. The exclusion criteria were: (1) history of heart transplantation surgery or >2 CABG procedures; (2) history of cancer; (3) claudication; (4) amputation or being nonambulatory, with or without the use of a walker or a cane, or (5) visual or hearing impairment, because either would have prevented the patients from completing the questionnaires and study measurements. Thirty male post-CABG patients with CKD (stages III–V) and 30 without CKD were included in this study. This trial was approved by our institutional review board (NCT01932008). Written informed consent was obtained from each participant before the investigation.

Definition of CKD

CKD was defined as an estimated glomerular filtration rate (eGFR) of <60 ml · × min^{-1} · × 1.73 m^{-2} for ≥3 months. The eGFR was calculated using the Modification of Diet in Renal Disease Study formula: 186 × (serum creatinine)$^{-1.154}$ × (age)$^{-0.203}$ × 0.742 (if female) [10].

Outcome Measures

All subjects underwent dual-energy X-ray absorptiometry for body composition evaluation. Both lean body mass (LBM) and regional fat percentage were measured. Patients were asked to refrain from drinking more than 500 ml of fluid 1 h before their scans [11]. Physical function measurements included the grip strength test, 30-second chair stand test (30CST), and 6-min walk test (6MWT). The grip strength test and the 30CST measured the muscular strength of the upper and lower extremities, respectively. Participants

Table 1. Comparison of demographic characteristics between the two groups

	CKD	Matched	p value
Age, years	61.9±6.6	62.6±6.5	0.150
Postoperative time, months	46.6±24.4	43.0±25.1	0.478
Marital status			0.344
Single	1 (3.3)	2 (6.7)	
Married	25 (83.3)	27 (90.0)	
Widowed/divorced	4 (13.3)	1 (3.3)	
Educational level			0.446
Below high school	18 (60.0)	15 (50.0)	
High school	10 (33.3)	9 (30.0)	
College graduate	2 (6.7)	6 (20.0)	
Employment status			0.999
Nonworking	19 (63.3)	19 (65.5)	
Working	11 (36.7)	10 (34.5)	
Smoking			0.469
Never	8 (26.7)	11 (36.7)	
Quit	18 (60.0)	13 (43.3)	
Current	4 (13.3)	6 (20.0)	
Morbidity			
Hypertension	23 (76.7)	17 (56.7)	0.109
Diabetes	19 (63.3)	13 (43.3)	0.180
Hyperlipidemia	25 (83.3)	26 (86.7)	0.999
Cardiovascular accidents	2 (6.7)	0 (0)	0.500
Comorbidities			0.999
<3	19 (63.3)	20 (66.7)	
≥3	11 (36.7)	10 (33.3)	
NYHA class			<0.001
I/II	16 (53.3)	30 (100)	
III	14 (46.7)	0 (0)	
CKD stage			<0.001
III	22 (73.3)	–	
IV	4 (13.3)	–	
V	4 (13.3)	–	
Plasma profile			
Creatinine, mg/dl	2.84±2.57	0.98±0.13	<0.001
eGFR, ml/min/1.73 m^2	36.2±14.6	84.3±14.1	<0.001

Data are presented as mean ± standard deviation or n (%).

were asked to squeeze the Jamar Hand Dynamometer (Jamar, Jackson, Mich., USA) with maximum strength using the dominant hand with the elbow extended in the standing position. For the 30CST, the number of full stands completed within 30 s was recorded using a 17-inch chair with the patient's arms crossed upon the chest [12]. The self-paced 6MWT was used to evaluate each participant's functional capacity, according to the American Thoracic Society guidelines [13].

Physical activity levels were evaluated using the self-administered long form of the International Physical Activity Questionnaire (IPAQ). The patients were categorized into 3 levels of physical activity: low, moderate, and high physical activity [14]. The World Health Organization Quality of Life Instrument (WHOQOL)-BREF (the adapted version for Taiwan) was used for QOL assessment [15]. The WHOQOL-BREF consists of frequency, intensity, capability, and evaluation in a 5-point response format. Each domain score ranges from 4 to 20.

Statistical Analyses

The Statistical Package for the Social Sciences (SPSS) for Windows version 17.0 (SPSS Inc., Chicago, Ill., USA) was used for the analyses. Data are presented as mean ± standard deviation or percentage. Student's t test and the χ^2 test were used to examine the differences in baseline data and all measured variables between the two groups. Multiple linear regression analyses were used to evaluate the factors associated with physical

Table 2. Anthropometric data, body composition, physical activity, physical function, and QOL in the two groups

	CKD	Matched	p value
Anthropometrics			
Height, cm	164.57±5.09	164.36±5.09	0.757
Weight, kg	76.09±11.72	76.80±12.83	0.524
BMI	28.02±3.51	28.35±4.03	0.370
LBM, kg			
Arms	5.65±1.06	6.04±1.23	0.045
Legs	15.81±2.84	16.51±2.70	0.081
Trunk	23.49±3.18	23.49±3.15	0.995
Total body	48.55±6.86	49.78±6.96	0.171
Percentage of fat mass			
Android	44.88±7.07	43.78±6.05	0.514
Gynoid	32.63±4.89	31.04±4.38	0.165
Android/gynoid fat ratio	139±19	142±19	0.485
Arms	28.42±4.58	27.63±4.37	0.494
Legs	25.63±4.00	23.52±3.49	0.042
Trunk	38.49±5.68	37.24±5.47	0.357
Physical function			
Grip strength, kg	37.5±8.3	40.7±7.0	0.115
30CST score	15.6±4.8	20.0±5.6	0.004
6MWT distance, m	402.2±78.3	489.1±65.3	<0.001
Total body fat, %	32.38±4.43	30.82±4.09	0.145
Physical activity			0.446
Low	11 (36.7)	7 (23.3)	
Moderate	13 (43.3)	11 (36.7)	
High	6 (20.0)	12 (40.0)	
QOL domain			
Physical health	12.27±1.62	12.57±1.44	0.427
Psychological health	12.40±1.49	13.24±1.75	0.072
Social relations	12.53±2.28	14.17±2.04	0.005
Environment	13.85±1.77	14.99±1.64	0.011

Data are presented as mean ± standard deviation or n (%). BMI = Body mass index.

function measurements and QOL domains after controlling for the covariates. The candidate variables included physical activity, age, comorbidity, postoperative time, group, body composition, and NYHA class. A p value <0.05 was considered statistically significant.

Results

Clinical Characteristics

The mean age of our participants was 62.3 ± 6.5 years, and the mean postoperative duration was approximately 4 years (table 1). There was no significant difference in demographic data between the two groups, except for the CKD-related parameters. However, all participants in the CABG group without CKD were in NYHA class I/II (100%), a percentage significantly higher than among those with CKD (53.3%; $p < 0.001$).

Physical Function and QOL

Patients with CKD had a significantly lower arm lean mass and higher percentage of leg fat than the matched controls ($p < 0.05$) (table 2). All physical function test results, including 30CST scores and 6MWT distances, were significantly better in the matched group than in the

Table 3. Stepwise multiple regression analysis of the factors associated with physical function

Dependent variables	Adjusted R^2, %	Independent variables	Unstandardized coefficients		β	p value
			estimate (SE)	95% CI		
Model 1						
Grip strength	30.3	arm LBM	0.004 (0.001)	0.002 to 0.005	0.561	<0.001
30CST	31.3	group	3.959 (1.231)	1.494 to 6.425	0.356	0.002
		age	−0.304 (0.094)	−0.491 to −0.116	−0.351	0.002
		physical activity	2.021 (0.794)	0.431 to 3.612	0.282	0.014
6MWT	30.9	group	77.977 (18.578)	40.761 to 115.193	0.469	<0.001
		physical activity	26.392 (11.890)	2.574 to 50.210	0.248	0.031
Model 2						
Grip strength	40.1	arm LBM	0.004 (0.001)	0.002 to 0.005	0.540	<0.001
		NYHA class	−3.391 (1.044)	−5.481 to −1.300	−0.328	0.002
30CST	31.3	group	3.959 (1.231)	1.494 to 6.425	0.356	0.002
		age	−0.304 (0.094)	−0.491 to −0.116	−0.351	0.002
		physical activity	2.021 (0.794)	0.431 to 3.612	0.282	0.014
6MWT	50.5	NYHA class	−72.820 (10.531)	−93.925 to −51.714	−0.647	<0.001
		leg fat percentage	−5.702 (2.005)	−9.719 to −1.684	−0.264	0.006
		age	−3.292 (1.311)	−5.919 to −0.664	−0.234	0.015

Model 1: adjusted for physical activity, age, comorbidity, postoperative time, group, arm LBM, and leg fat percentage. Model 2: model 1 + NYHA class.

CKD group ($p < 0.05$). The percentage of high physical activity levels in the matched group was approximately twice that in the CKD group, but it did not reach statistical significance. Among the 4 QOL domains, the results were statistically significantly different in the social relationships domain ($p = 0.005$) and the environment domain ($p = 0.011$) between the two groups.

With regard to the factors related to physical function, grip strength was shown to be significantly associated with arm LBM ($\beta = 0.561$, $p < 0.001$) after controlling for covariates (table 3). Group was the most important factor associated with both 30CST ($\beta = 0.356$, $p = 0.002$) and 6MWT results ($\beta = 0.469$, $p < 0.001$) after controlling for covariates. If NYHA class was added to the model, this became the most important factor associated with 6MWT distances ($\beta = -0.647$, $p < 0.001$).

With regard to the factors related to QOL domains (table 4), the physical domain of QOL was significantly associated with physical activity ($\beta = 0.288$, $p = 0.016$), postoperative time ($\beta = 0.282$, $p = 0.018$), and android fat ($\beta = 0.272$, $p = 0.021$) after controlling for covariates. Group was the most important factor associated with the domains of psychological health ($\beta = 0.255$, $p = 0.049$), social relationships ($\beta = 0.359$, $p = 0.005$), and environment ($\beta = 0.311$, $p = 0.011$) after controlling for covariates. If NYHA class was added to the model, this became the most important factor associated with the domains of psychological health ($\beta = -0.285$, $p = 0.027$) and environment ($\beta = -0.406$, $p = 0.001$).

Discussion

Our results revealed that coexisting CKD was an important factor associated with shorter 6MWT distances and poor QOL in post-CABG patients. However, when NYHA class was considered in the regression, it became the most important factor associated with 6MWT distances and QOL domains. These findings indicate that post-CABG patients with CKD have

Table 4. Stepwise multiple regression analysis of the factors associated with QOL domains

Dependent variables	Adjusted R^2, %	Independent variables	Unstandardized coefficients		β	p value
			estimate (SE)	95% CI		
Model 1						
Physical health	22.8	physical activity	0.563 (0.227)	0.109 to 1.017	0.288	0.016
		postoperative time	0.017 (0.007)	0.003 to 0.032	0.282	0.018
		android fat	0.063 (0.027)	0.010 to 0.117	0.272	0.021
Psychological health	4.9	group	0.844 (0.420)	0.004 to 1.684	0.255	0.049
Social relations	11.4	group	1.633 (0.558)	0.517 to 2.750	0.359	0.005
Environment	16.5	group	1.104 (0.422)	0.258 to 1.949	0.311	0.011
		comorbidity	–1.114 (0.433)	–2.000 to –0.228	–0.300	0.015
Model 2						
Physical health	22.8	physical activity	0.563 (0.227)	0.109 to 1.017	0.288	0.016
		postoperative time	0.017 (0.007)	0.003 to 0.032	0.282	0.018
		android fat	0.063 (0.027)	0.01 to 0.117	0.272	0.021
Psychological health	6.5	NYHA class	–0.631 (0.279)	–1.189 to –0.073	–0.285	0.027
Social relations	11.4	group	1.633 (0.558)	0.517 to 2.75	0.359	0.005
Environment	26.3	NYHA class	–0.966 (0.268)	–1.502 to –0.43	–0.406	0.001
		comorbidity	–0.975 (0.418)	–1.812 to –0.138	–0.262	0.023
		postoperative time	0.017 (0.008)	0.001 to 0.033	0.233	0.042

Model 1: candidate variables: physical activity, age, comorbidity, postoperative time, group, and android fat. Model 2: model 1 + NYHA class.

worse physical function and QOL satisfaction, and this might be associated with a worse NYHA class.

Effect of CKD on Body Composition, Physical Function, and QOL

A previous study reported that patients with CKD would have lower LBM because of a CKD-associated higher rate of muscle protein degradation [16]. Conversely, excess body fat was reported to be associated with inflammation and oxidative stress in patients with stage III–IV CKD [17]. Several studies have reported changes in whole body LBM and fat mass in CKD populations, but few addressed the regional LBM and fat mass of the extremities in this population. Our post-CABG patients with CKD showed reduced limb LBM and significantly higher leg fat percentages than those without CKD. Since 47% of our CKD participants reported with NYHA class III congestive heart failure (although they were medically stable and without edema of the lower extremities), some cardiac disease-related factors might account for this difference from the controls. Therefore, we further analyzed the leg fat percentages of the CKD subpopulation with NYHA class I–II heart failure as compared with their BMI-matched controls, excluding the CKD subjects with NYHA class III heart failure, and a difference no longer existed ($p = 0.076$). This result is in agreement with that of a previous report by Foster et al. [18]. The authors compared whole body and regional LBM and fat mass in children and adolescents with CKD and those without. They found significantly lower adjusted dual-energy X-ray absorptiometry Z-scores of leg LBM, but not of leg fat mass, in CKD stage IV–V patients compared with controls. It seemed that CKD influenced LBM much more, and congestive heart failure severity might have more impact on fat mass. Future studies are needed to provide more information regarding regional body composition in patients with cardiorenal syndrome.

Specifically, we found that a higher leg fat percentage was significantly and negatively associated with 6MWT distances after controlling for covariates in our post-CABG patients with CKD. Oreopoulos et al. [19] reported that a higher percentage of body fat was associated with a worse NYHA class. Although we cannot explain the causal relationship between leg fat percentages and 6MWT distances based on our cross-sectional design, it reminded us of the importance of maintaining a proper body composition to improve physical function and prevent secondary complications in post-CABG patients with CKD.

Numerous studies have shown significantly deteriorated physical function in dialysis patients compared with population norms; it was impaired even in the early stages of CKD [20]. Several potential causes or mechanisms, including anemia, an increase in protein catabolism, an inflammatory state, and a decrease in protein synthesis, have been proposed to contribute to decreased physical function [21]. By contrast, relatively few studies have addressed physical function in the predialysis period among patients with CKD [22]. Walker et al. [23] recently reported that non-dialysis CKD is associated with a high risk of frailty or diminished physical function. In our study, we found that post-CABG patients with non-dialysis CKD had lower physical function performance test scores than those without CKD. Brodin et al. [24] reported that with every 1 ml × min^{-1} × 1.73 m^{-2} drop in eGFR, the odds of failing the 30CST were 1.5 times higher. Our results are in agreement with their findings. Increasing evidence suggests that a regular evaluation of physical functioning could help determine the impact of CKD on the overall functioning of a patient; however, encouragement to regularly participate in physical activities has not been incorporated into routine care [8].

CKD in the early stages is often asymptomatic, and awareness is low [21]. However, it has been reported that patients with CKD have impaired health-related QOL even in the early stages. In our study, post-CABG patients with CKD had lower social relationships and environment domain scores than those without CKD. The social relationships domain includes 4 factors: personal relationships, social support, sexual activity, and respect. Therefore, it is important to assess the health-related QOL of patients with CKD, especially in the early stages, to improve our understanding of the patients' perspective and increase awareness of a possibly growing decline in the social relationships domain of QOL.

Our results revealed that coexisting CKD is significantly associated with shorter 6MWT distances and poor QOL in post-CABG patients. However, this might be due to a worse NYHA class. Actually, a previous study reported that a significant negative correlation was observed between eGFR and NYHA class [25]. In our study, 73.3% of the post-CABG patients with CKD were stage III, that is, their renal dysfunction was relatively mild. Therefore, it is speculated that the influence of CKD on physical function and QOL in cardiorenal syndrome patients is dependent on the severity of CKD and CAD. Both CKD and CAD have a negative impact on physical function and QOL; however, cardiac dysfunction led to physical functional deterioration more directly and obviously. When coexisting CKD becomes progressive, it might amplify the negative influence on physical function and QOL. Future studies are needed to further clarify this issue.

Limitations of the Study

Several limitations of our study must be acknowledged. First, this was a cross-sectional study; therefore, the causal relationship of physical activity, body composition, and physical function to QOL cannot be established. Second, based on the results of multiple regression analyses, NYHA class contributed to the findings in the CKD population. However, our control group was not matched by NYHA class. Third, our study lacked proteinuria and albuminuria data, and the periods between the assessments of the study parameters after CABG showed a wide range chronologically, with a mean of about 4 years and a standard deviation of 2 years. Therefore, we could neither detect nor estimate whether CKD or CAD had progressed and what its influence might have been on the study parameters. Forth, only elective and stable patients were recruited, and this may have produced biased overestimates of physical activity and physical function in the study sample. Therefore, the generalizability of our findings is limited.

Conclusion

Post-CABG patients with CKD had worse body composition, physical function, and QOL than their non-CKD counterparts. Coexisting CKD was an important factor associated with shorter 6MWT distances and poor QOL in post-CABG patients. Our results suggest the need for clinical experts to ensure regular physical activity in post-CABG patients with CKD to maintain or improve their physical function and QOL.

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Disclosure Statement

The authors have no conflicts of interest to declare.

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