

# The additional benefit of weighted subjective global assessment (SGA) for the predictability of mortality in incident peritoneal dialysis patients

## A prospective study

Taeyoung Yun, MS<sup>a</sup>, Ye Eun Ko, MS<sup>a</sup>, Seung-Jung Kim, MD, PhD<sup>b</sup>, Duk-Hee Kang, MD, PhD<sup>b</sup>, Kyu Bok Choi, MD, PhD<sup>b</sup>, Hyung Jung Oh, MD, PhD<sup>c,d,\*</sup>, Dong-Ryeol Ryu, MD, PhD<sup>b,d,e,\*</sup>

### Abstract

Although subjective global assessment (SGA) is a widely used tool for nutritional investigation, the scores are dependent on the inspectors' subjective opinions, and there are only few studies that directly assessed the usefulness of SGA and modified SGA in incident peritoneal dialysis (PD) patients. A total of 365 incident PD patients between 2009 and 2015 were enrolled and measured with SGA and calculated using serum albumin and total iron binding capacity (TIBC) levels for weighted SGA. Cox analyses were performed to delineate the association between SGA or weighted SGA and all-cause mortality, and a receiver-operating characteristic was conducted to reveal the additional benefit of weighted SGA on predicting adverse clinical outcomes. The Kaplan–Meier curve showed that the cumulative survival rate in patients with “Good nutrition” (G1) was significantly higher compared to those with “Mild to severe malnutrition” (G2). G2 was significantly associated with an increase in the mortality even after adjusting for several covariates compared with G1. Moreover, a 1-unit increase in weighted SGA was also significantly correlated with mortality after adjustment of the same covariates, while G2 was not significantly associated with an increase in the mortality among young-aged (under 65 years) groups. Meanwhile, a 1-unit increase in weighted SGA was significantly related to an increase in mortality in all the subgroup analyses. Furthermore, the AUCs of weighted SGAs in all groups were significantly increased compared with those of SGA alone. In conclusions, the evaluation of nutritional status based on SGA in incident PD patients might be useful for predicting mortality. However, weighted SGA with serum albumin and TIBC can provide additional predictive power for mortality compared with SGA alone in incident PD patients.

**Abbreviations:** BMI = body mass index, BUN = blood urea nitrogen, CAD = coronary arterial disease, CAPD = continuous ambulatory peritoneal dialysis, CHF = congestive heart failure, CI = confidence interval, CLD = chronic lung disease, DM = diabetes mellitus, ESRD = end-stage renal disease, HD = hemodialysis, HR = hazard ratio, hs-CRP = high-sensitivity C-reactive protein, liver disease, PEW = protein energy wasting, SGA = subjective global assessment, TIBC = total iron binding capacity.

**Keywords:** albumin, incident peritoneal dialysis, subjective global assessment (SGA), TIBC, weighted SGA

## 1. Introduction

Nutritional status can affect mortality among chronic dialysis patients,<sup>[1–3]</sup> and various methods have been used in its evaluation.<sup>[4–8]</sup> Among these methods, the subjective global assessment (SGA) is a widely used representative tool for

nutritional investigation.<sup>[9,10]</sup> Although the SGA was initially developed to evaluate the nutritional status of cancer patients undergoing operation,<sup>[11,12]</sup> it is not only available for the nutritional assessment of dialysis patients, but also very practical and convenient to evaluate malnutrition in patients with end-

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<sup>a</sup> College of Medicine and Graduate School of Medicine, Ewha Womans University, <sup>b</sup> Department of Internal Medicine, College of Medicine, Ewha Womans University, <sup>c</sup> Ewha Institute of Convergence Medicine, <sup>d</sup> Research Institute for Human Health Information, Ewha Womans University Mokdong Hospital, <sup>e</sup> Tissue Injury Defense Research Center, Ewha Womans University, Seoul, Korea.

\* Correspondence: Hyung Jung Oh, Ewha Institute of Convergence Medicine, Ewha Womans University Mokdong Hospital, Seoul 07985, Korea (e-mail: ohjmd@naver.com); Dong-Ryeol Ryu, Department of Internal Medicine, School of Medicine, Ewha Womans University, Seoul 07985, Korea (e-mail: drryu@ewha.ac.kr).

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stage renal disease (ESRD).<sup>[1,9,12,13]</sup> However, SGA is limited in that the responses depend on the inspectors' subjective opinions.<sup>[10,13]</sup>

Albumin and total iron binding capacity (TIBC) are reliable objective indicators of nutritional assessment in dialysis patients.<sup>[4,10,14–18]</sup> Thus, several studies have suggested supplementing the SGA with these variables to better evaluate nutritional status in ESRD patients.<sup>[13,19]</sup> However, there has been few studies to directly investigate the usefulness of the modified SGA in ESRD patients, especially, incident continuous ambulatory peritoneal dialysis (CAPD) patients.<sup>[1]</sup>

Indeed, a decrease in albumin is seen in hemodialysis (HD) patients, and an even larger decrease tends to be observed in PD patients.<sup>[20–24]</sup> Thus, an SGA modified to include serum albumin and TIBC might be especially useful to predict the clinical outcomes of PD patients.<sup>[13,25]</sup> Moreover, diabetes mellitus (DM) and age are factors known to influence nutritional status.<sup>[26–29]</sup> Therefore, in this study, we investigated the additional effect of weighted SGA (SGA plus the assessment of serum albumin or TIBC) on all-cause mortality in incident CAPD patients and compared its usefulness in each group stratified by the presence of DM and age (patients older than 65 years vs younger).

## 2. Subjects and methods

### 2.1. Patients

All ESRD patients who started CAPD between May 2009 and December 2015 at one of the 36 Clinical Research Centers for ESRD in Korea were initially recruited for this prospective observational multicenter study. This study was part of a nationwide multicenter joint network prospective cohort study on ESRD patients in Korea, designed to improve survival rates and quality of life and to set up effective treatment guidelines (clinicaltrials.gov NCT00931970). We excluded patients who were younger than 18 years or were expected to survive <90 days. Patients who died within 90 days of CAPD initiation, failed to maintain CAPD for >90 days, or retained automatic PD (automatic peritoneal dialysis) for their dialysis therapy were also excluded. In contrast, we included patients with reliable laboratory results, a body mass index (BMI) below 40 kg/m<sup>2</sup>, a TIBC level between 10 and 700 μg/dL, and a high-sensitivity C-reactive protein (hs-CRP) level below 200 mg/L. Finally, a total of 365 incident PD patients were included in the final analysis.

The study protocol was approved by the Institutional Review Board of each participating center, and all patients provided written informed consent to participate in the study.

### 2.2. Data collection

Demographic and clinical data, such as age, gender, BMI, and comorbid diseases, were investigated at the time of enrollment. Cardiovascular disease was defined when the patients had a history of coronary, cerebrovascular, and/or peripheral vascular disease. We designated coronary arterial disease (CAD) when the patients had a history of angina, myocardial infarction, coronary angioplasty, or coronary arterial bypass grafts; cerebrovascular disease when they had undergone transient ischemic attack, stroke, or carotid endarterectomy; and peripheral arterial disease when there was a history of claudication, any peripheral revascularization procedure, or ischemic limb loss and/or ulceration. Chronic lung disease (CLD) included chronic obstructive pulmonary disease, sleep-disordered breathing, and

interstitial lung disease. Moderate-to-severe liver disease was defined as chronic hepatitis with elevated liver function test results, symptomatic chronic active hepatitis requiring medication, esophageal varices, ascites, liver cirrhosis, history of portocaval shunts, or previous surgical procedure for portal hypertension.

Laboratory data were measured from fasting blood samples, which were drawn 2 hours after the first PD exchange with 1.5% dextrose dialysate at the time of study enrollment. Blood was assessed for hemoglobin, albumin, blood urea nitrogen, creatinine, total cholesterol, triglycerides, TIBC, and hs-CRP. The preceding overnight dwell was regulated to 1.5% dextrose dialysate to make the glucose load same. Body weight was measured in the morning after the first dialysate was drained. Serum albumin was measured using the bromocresol green method,<sup>[30]</sup> and serum ferritin was measured using an immunoradiometric assay with polyclonal reagents. The measurements of transferrin correlated closely with indirect transferrin concentrations determined from measurements of TIBC with a correlation coefficient of 0.96.<sup>[31]</sup> Thus, TIBC levels could be reliably used to calculate transferrin concentrations, and we calculated serum transferrin on the basis of TIBC according to the following formula as described elsewhere<sup>[31]</sup>: serum transferrin (mg/dL) × 1.25 = TIBC (mg/dL).

### 2.3. Subjective global assessment

Nutritional status of patients was evaluated using the 7-point SGA scale, which contained medical history and physical examination. Medical history consisted of 4 categories: weight loss, gastrointestinal symptoms, functional capacity, and comorbidities.<sup>[9]</sup> Physical examination included loss of subcutaneous fat, muscle wasting, and edema.<sup>[2]</sup> Each component was rated from 1 to 7, and the overall SGA score was determined. Based on overall SGA score, patients were classified into 3 groups: A = SGA score 6 to 7 (well nourished), B = SGA score 3 to 5 (mildly to moderately malnourished), or C = SGA score 1 to 2 (severely malnourished). There were only 4 patients that fit the criteria for the C (severely malnourished) group, so they were combined with the B group. Finally, the 2 groups were designated "Good nutrition" (G1, SGA A) or "Mild to Severe malnutrition" (G2, SGA B + SGA C). Moreover, SGA was assessed and reported by an experienced dietician in each center. However, a trained physician assessed a subset of 10 to 15 patients in each center to evaluate the degree of interrater agreement.

### 2.4. Outcome measures

All patients were followed up prospectively after all baseline assessments. All mortality events were retrieved from the database and carefully reviewed. The primary endpoint was all-cause mortality. Loss to follow-up, renal transplantation, transfer to HD, and recovery of renal function after the first 3 months of PD commencement were censored at the end of the PD treatment.

### 2.5. Weighted SGA

Because the scoring system of SGA is mostly based on history and physical examination,<sup>[9,10]</sup> weighted SGA was defined by adding serum albumin or TIBC into conventional SGA. The score of the conventional SGA was designated "1" when the patient had "Good nutrition" status and "2" when the patient had "Mild to

**Table 1****Baseline characteristics at the enrollment among the groups of incident peritoneal dialysis patients.**

	Nutritional status			P
	Total N = 365 (100%)	Good nutrition N = 226 (62%)	Mild to severe malnutrition N = 139 (38%)	
Age, y	51.3 ± 13.4	50.3 ± 13.1	52.9 ± 13.8	.067
Male, n, %	220 (60.3)	88 (63.3)	132 (58.4)	.353
Body mass index, kg/m <sup>2</sup>	22.7 ± 3.4	22.6 ± 3.2	22.8 ± 3.7	.612
Comorbidity diseases, n, %				
Diabetes mellitus	172 (47.1)	102 (45.1)	70 (50.4)	.331
CAD	40 (11.0)	14 (6.2)	26 (18.7)	<.001
Peripheral vascular disease	26 (7.1)	14 (6.2)	12 (8.6)	.379
Congestive heart failure	46 (12.6)	21 (9.3)	25 (18.0)	.015
Cerebrovascular accident	8 (2.2)	3 (1.3)	5 (3.6)	.150
Chronic lung disease	11 (3.0)	9 (6.5)	2 (0.9)	.002
Liver disease (moderate to severe)	15 (4.1)	12 (5.3)	3 (2.2)	.141
Laboratory				
Hemoglobin, g/dL	9.2 ± 1.6	9.1 ± 1.7	9.2 ± 1.6	.447
Albumin, g/dL	3.4 ± 0.6	3.4 ± 0.6	3.4 ± 0.6	.282
Blood urea nitrogen, mg/dL	84.5 ± 36.6	85.3 ± 38.8	83.2 ± 32.6	.578
Creatinine, mg/dL	8.8 ± 4.0	8.9 ± 4.1	8.4 ± 3.8	.271
Total cholesterol, mg/dL	162.3 ± 48.3	166.1 ± 50.1	155.8 ± 44.5	.052
Triglyceride, mg/dL	130.4 ± 74.8	126.9 ± 66.3	136.2 ± 86.8	.259
TIBC, μg/dL	222.7 ± 47.5	226.6 ± 45.9	216.5 ± 49.4	.047
hs-CRP, mg/L	2.8 ± 12.8	2.9 ± 11.6	2.6 ± 14.6	.819

Data are presented as n (%) or mean ± SD. CAD = coronary arterial disease, hs-CRP = high-sensitivity C-reactive protein, SD = standard deviation, TIBC = total iron-binding capacity.

severe malnutrition.” In addition, based on the normal values of albumin and TIBC – 3.5 g/dL in albumin and 240 μg/dL in TIBC – these patients were scored as follows: “1” when serum albumin concentration was more than 3.5 g/dL or “2” when it was less than 3.5 g/dL, and “1” when the TIBC level was 240 μg/dL or more or “2” when the TIBC level was lower than 240 μg/dL. The sum of all components ranged from 3 to 6, and a higher score reflected a poorer nutritional status.

## 2.6. Subanalysis

All patients were also separated based on the presence of DM (non-DM vs DM) and age (younger patients [less than 65 years old] vs older patients [65 years old and older than 65 years old]). Additionally, we investigated the usefulness of SGA and weighted SGA for all-cause mortality in each group.

## 2.7. Statistical analysis

Statistical analyses were performed using SPSS for Windows, version 20 (SPSS Inc., Chicago, IL). Continuous variables were expressed as mean ± standard deviation and categorical variables as number (percentage). According to baseline SGA, the patients were stratified into 2 groups: the “well-nourished” group was called the “Good nutrition” group (G1; n = 226) and the “mild to moderate” and “severe malnutrition” groups were designated the “Mild to severe malnutrition” group (G2; n = 139). The baseline characteristics were compared between the 2 groups using Student *t* test for continuous variables and the  $\chi^2$  test for categorical variables. Cumulative survival curves were created by the Kaplan–Meier method, and the survival was compared using a log-rank test. Moreover, multivariate proportional regression analyses were conducted to assess the association between SGA and the mortality of incident PD patients including each subgroup. The variables that had statistical significance at

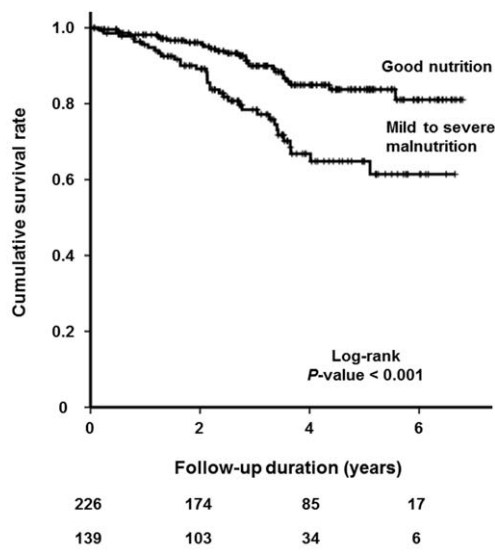
baseline, including age and gender, were used to perform univariate analysis. Moreover, the variables with a *P*-value < .05 in univariate analysis, age, and gender were also adjusted for in a multivariate analysis. Hazard ratios (HRs) and 95% confidence intervals (CIs) were used to provide the relative risk for death of the incident PD patients. Furthermore, a receiver-operating characteristic curve was performed to assess whether weighted SGA had additional benefits for predicting mortality than SGA alone in all patients and in each group. A *P* value less than .05 was considered statistically significant.

## 3. Results

### 3.1. Baseline characteristics

Among the total 365 incident PD patients, the mean age was 51.3 ± 13.4 years, 220 (60.3%) patients were male, and the mean BMI was 22.7 ± 3.4 kg/m<sup>2</sup>. In total, 172 (47.1%) patients had DM, 40 (11.0%) patients were suffering from CAD, and 26 (7.1%) patients were diagnosed with peripheral arterial disease. Moreover, patients were coping with other previous comorbidities as presented in Table 1. In regard to laboratory data, mean hemoglobin, albumin, blood urea nitrogen, creatinine, total cholesterol, triglyceride, TIBC, and hs-CRP concentrations were 9.2 g/dL, 3.4 g/dL, 84.5 mg/dL, 8.8 mg/dL, 162.3 mg/dL, 130.4 mg/dL, 222.7 μg/dL, and 2.8 mg/L, respectively.

In this study, a trained physician assessed a subset of 10 to 15 patients for interassessor agreement of SGA, and there was no significant interassessor’s discrepancy (data not shown). When we stratified the patients based on the results of baseline SGA, the G2 group had significantly more CAD, congestive heart failure (CHF), and CLD than the G1 group, but the TIBC level was significantly higher in G1 compared with G2. However, the other laboratory data including serum albumin were not significantly different between the 2 groups (Table 1).



**Figure 1.** Kaplan–Meier curve for all-cause mortality. During the follow-up period, the cumulative survival rate in the “Good nutrition” group was significantly higher than that in the “Mild to severe malnutrition” group ( $P < .001$ ).

### 3.2. The usefulness of SGA and weighted SGA for nutritional evaluation in Korean incident PD patients

During the follow-up period (median 3.2 years), 61 patients (16.7%) died. The Kaplan–Meier curve showed that the cumulative survival rate in G1 was significantly higher compared to that in G2 ( $P < .001$ ) (Fig. 1). Moreover, univariate Cox proportional regression analysis revealed that the HR of G2 was 2.54 (95% CI; 1.53–4.22,  $P < .001$ ) with G1 as a reference. In addition, the HRs of a 1-year increase in age and the presence of CAD, CHF, and CLD were 1.06 (95% CI; 1.04–1.08,  $P < .001$ ), 4.01 (95% CI; 2.31–6.97,  $P < .001$ ), 3.93 (95% CI; 1.97–5.83,  $P < .001$ ), and 4.50 (95% CI; 1.93–10.49,  $P < .001$ ), respectively, while the HR of a 1  $\mu\text{g/dL}$  increase in TIBC was 0.99 (95% CI; 0.98–1.00,  $P < .001$ ). Furthermore, G2 was still significantly associated with an increase in all-cause mortality even after adjusting for age, gender, the presence of CAD, CHF, CLD, and TIBC (HR; 1.78, 95% CI; 1.03–3.05,  $P = .038$ ) compared with G1.

Considering weighted SGA, the univariate Cox analysis revealed that the HR was 2.27 (95% CI; 1.66–3.10,  $P < .001$ )

with statistical significance according to a 1-unit increase in weighted SGA. Moreover, a 1-unit increase in weighted SGA was still significantly associated with the development of all-cause mortality even after adjusting for age, gender, CAD, CHF, CLD, and TIBC (HR; 1.65, 95% CI; 1.02–2.46,  $P = .013$ ; Table 2).

We then investigated the usefulness of baseline SGA after stratifying these patients based on the presence of DM or age of 65 years old or older, and the baseline characteristics are presented in the Supplementary Data, <http://links.lww.com/MD/B930>. Multivariate Cox proportional regression analyses showed that G2 was significantly associated with an increase in all-cause mortality in the non-DM group (HR; 2.86, 95% CI; 1.00–8.16,  $P = .049$ ) after adjusting for age and gender and in the DM group (HR; 2.04, 95% CI; 1.11–3.75,  $P = .021$ ) even after adjustment for age, gender, and CAD. G2 was also significantly associated with an increase of all-cause mortality in older patients (HR; 2.96, 95% CI; 1.14–7.69,  $P = .026$ ) after adjusting for age, gender, CAD, and CVA, whereas no significant association was observed in younger patients (HR; 1.86, 95% CI; 0.98–3.53,  $P = .058$ ). Meanwhile, a 1-unit increase in weighted SGA was revealed to be significantly related to an increase in all-cause mortality in all subgroup analyses (Table 3).

### 3.3. The additional benefits of weighted SGA on predicting all-cause mortality

Figure 2 reveals that the AUC of SGA and weighted SGA for all-cause mortality was 0.616 ( $P = .004$ ) and 0.708 ( $P < .001$ ), respectively. Moreover, receiver-operating characteristic curves were examined with non-DM, DM, older than 65 years of age, and younger than 65 years of age, and the AUCs of baseline SGA for the all-cause mortality were 0.608 (in DM group,  $P = .030$ ), 0.681 (in older age group,  $P = .015$ ), with statistical significance, but 0.631 (in non-DM group,  $P = .091$ ) and 0.578 (in younger age group,  $P = .120$ ) with no statistical significance. However, the AUCs of the weighted SGAs in all the groups were significantly increased compared with those of SGA alone, even though the magnitude of the increase was different in each group (Fig. 3).

## 4. Discussion

In the current study, SGA was significantly correlated with an increase of all-cause mortality in incident CAPD patients. However, in the subanalysis for younger PD patients, it was not significantly associated with an increase of all-cause mortality. In contrast, weighted SGA was found to reflect

**Table 2**  
Cox proportional regression analysis for all-cause mortality in the incident peritoneal dialysis patients.

	Univariate		Multivariate (A) <sup>*</sup>		Multivariate (B) <sup>†</sup>	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Good nutrition (vs mild to severe malnutrition)	2.54 (1.53–4.22)	<.001	1.78 (1.03–3.05)	.038	–	–
Weighted SGA (per 1 unit increase)	2.27 (1.66–3.10)	<.001	–	–	1.65 (1.11–2.46)	.013
Age (per 1 y increase)	1.06 (1.04–1.08)	<.001	1.04 (1.02–1.07)	<.001	1.04 (1.02–1.06)	<.001
Female (vs male)	0.70 (0.41–1.20)	.195	1.21 (0.68–2.16)	.526	1.15 (0.65–2.05)	.628
CAD (vs without CAD)	4.01 (2.31–6.97)	<.001	1.53 (0.78–3.02)	.218	1.51 (0.77–2.97)	.232
CHF (vs without CHF)	3.93 (1.97–5.84)	<.001	2.11 (1.12–3.98)	.021	1.87 (0.98–3.54)	.056
CLD (vs without CLD)	4.50 (1.93–10.49)	<.001	1.55 (0.61–3.94)	.356	1.42 (0.56–3.60)	.460
TIBC (per 1 $\mu\text{g/dL}$ increase)	0.99 (0.98–1.00)	<.001	0.99 (0.99–1.00)	.005	1.00 (0.99–1.00)	.319

CAD = coronary arterial disease, CHF = chronic heart failure, CI = confidence interval, CLD = chronic lung disease, HR = hazard ratio, SGA = subjective global assessment, TIBC = total iron-binding capacity.

<sup>\*</sup> (A) Multivariate analysis for all-cause mortality with SGA.

<sup>†</sup> (B) Multivariate analysis for all-cause mortality with weighted SGA.



**Table 3**  
**Multivariate Cox proportional regression analysis for all-cause mortality in each stratified group\*.**

	Non-DM group <sup>†</sup> N = 193 (53%)		DM group <sup>‡</sup> N = 172 (47%)		Older patients group <sup>§</sup> N = 68 (19%)		Younger patients group <sup>¶</sup> N = 297 (81%)	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
Good nutrition (vs mild to severe malnutrition)	2.86 (1.00–8.16)	.049	2.04 (1.11–3.75)	.021	2.96 (1.14–7.69)	0.026	1.86 (0.98–3.53)	.058
Weighted SGA (per 1 unit increase)	2.55 (1.29–5.01)	.007	1.73 (1.22–2.46)	.002	2.41 (1.32–4.42)	0.004	1.82 (1.25–2.66)	.002

CI=confidence interval, DM=diabetes mellitus, HR=hazard ratio, SGA=subjective global assessment.

\* Patients stratified based on the presence of DM or the age of 65 years old.

<sup>†</sup> Non-DM group: adjusted for age and gender.

<sup>‡</sup> DM group: adjusted for age, gender, and coronary arterial disease.

<sup>§</sup> Older patients group: adjusted for age, gender, coronary arterial disease, and cerebrovascular accidents.

<sup>¶</sup> Younger patients group: adjusted for age and gender.

predictability of all-cause mortality more than SGA alone, even in groups stratified by the presence of DM and age.

Generally, malnutrition refers to abnormalities induced by an inadequate diet<sup>[4]</sup> and has been well-known to be associated with aggravated clinical outcomes.<sup>[32,33]</sup> In PD patients, malnutrition is common, and its prevalent rate is higher than that in the healthy population. Moreover, malnutrition in PD patients results in protein energy wasting (PEW).<sup>[4,19,34]</sup> Previous studies have demonstrated that PEW is a significant risk factor for morbidity and mortality in dialysis patients.<sup>[4,34,35]</sup> Moreover, SGA can also be a reliable predictor for mortality in incident PD patients.<sup>[17,19,36,37]</sup> Leinig et al<sup>[37]</sup> showed that SGA was a significant prognostic indicator in incident PD patients (n=199), consistent with our results (n=365).

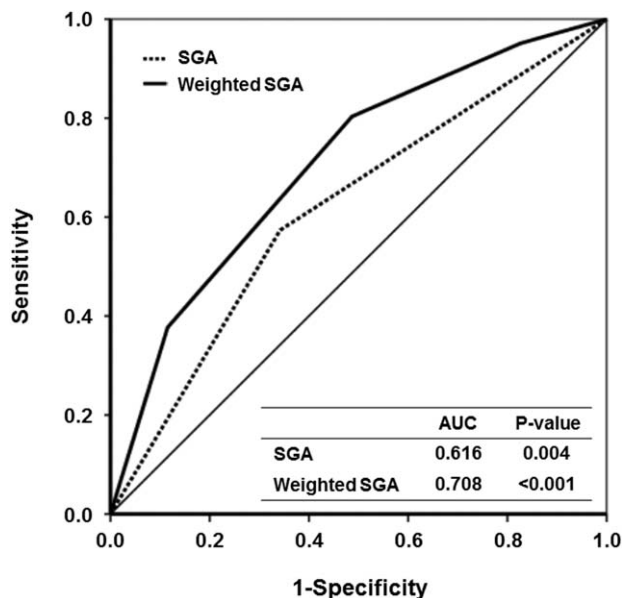
However, we did not observe a significant correlation between SGA and all-cause mortality in the subanalysis with younger PD patients. Indeed, the assessment of nutritional status remains challenging in older patients with incident PD.<sup>[26]</sup> Although measurements with SGA are common in both young and older patients on dialysis, age-related consequences should be consid-

ered in the interpretation of the results.<sup>[26]</sup> Rodrigues et al<sup>[26]</sup> indicated that, because SGA is highly reliant on the observer's skills, he/she should be aware that the elderly often show increased body fat in the trunk, whereas muscle mass is decreased. However, Santin et al<sup>[29]</sup> previously showed that SGA and malnutrition-inflammation score have good predictive validity in older HD patients, while it has not been validated in older PD patients.

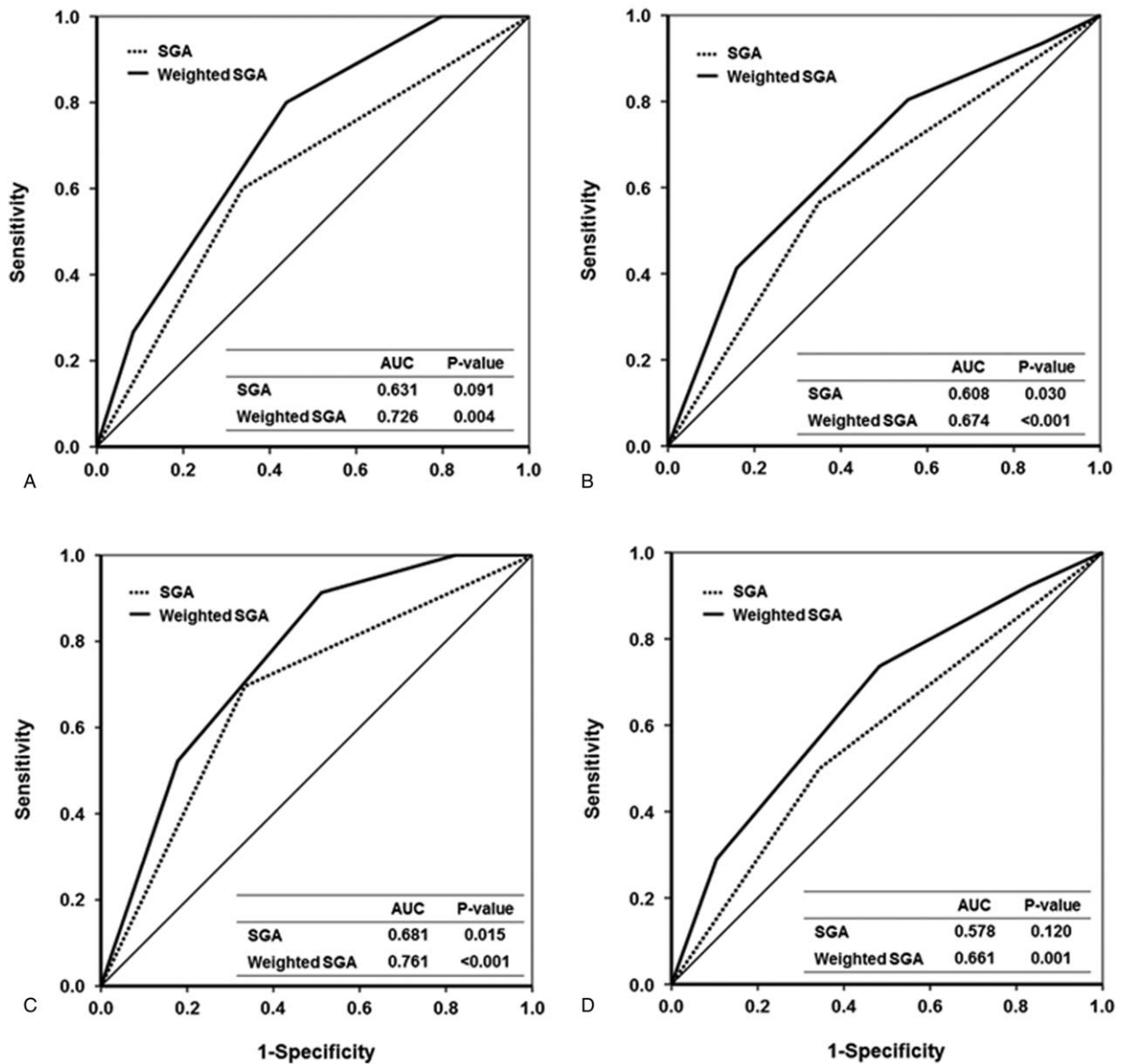
Older dialysis patients are prone to PEW,<sup>[38,39]</sup> and Qureshi et al<sup>[39]</sup> showed a significantly high prevalence of PEW in a group of patients aged 65 years and older compared with younger patients. However, there are various causes of PEW in patients with kidney disease, and SGA is a recommended tool for nutritional assessment but not a tool to identify PEW since SGA alone does not provide any insight into the different causes of PEW.<sup>[4,40]</sup> This disassociation might be found between younger and older patient groups.

Serum albumin generally has been considered a good laboratory parameter for nutritional status and one of the strongest predictors for all-cause mortality in dialysis patients.<sup>[14,15,18,41,42]</sup> In addition, serum transferrin level, represented by TIBC, has also been demonstrated to be strongly correlated with the nutritional status in dialysis patients.<sup>[16,43,44]</sup> As expected, weighted SGA had more power for predicting all-cause mortality compared with SGA alone in whole incident PD patients and even in the separate subanalysis in this study.<sup>[10,13,19,25]</sup> Taken together, these results indicate that weighted SGA provides an additional benefit for predicting all-cause mortality for nutritional evaluation in incident PD patients including younger patients compared with SGA alone.

There are several limitations in this study. First, the follow-up duration was relatively short compared with previous studies. Second, this study was limited to Korean incident PD patients, so one should be cautious when generalizing the results of this study to other ethnic groups. Third, SGA was examined and the laboratory data were measured only once at the time of enrollment. Therefore, it is difficult to clarify the association with SGA and mortality in detail. Fourth, we arbitrarily gathered "Mild to moderate malnutrition" and "Severe malnutrition" and took together into 1 group; "Mild to severe malnutrition," because there were only a few patients (n=4) in the "Severe malnutrition" group. However, the patients were not distributed evenly into groups. Fifth, we selected serum albumin and TIBC as nutritional indicators instead of other nutritional markers such as serum creatinine or normalized protein catabolic rate (nPCR). In addition, since half-life of albumin is 14 to 20 days and its pool is affected by a number of inflammatory conditions and drugs,



**Figure 2.** ROC curves using variables (SGA and weighted SGA) in all incident PD patients. The AUCs of SGA and weighted SGA for all-cause mortality were 0.616 (P=.004) and 0.708 (P<.001). AUC=area under the curve, ROC=receiver-operating characteristics, SGA=subjective global assessment.



**Figure 3.** ROC curves using variables (SGA and weighted SGA) in each group (DM vs non-DM or older vs younger patients). When the ROC curves were performed with non-DM (A), DM (B), age 65 years or older (C), and age less than 65 years (D), the AUCs of baseline SGA for all-cause mortality were 0.608 (in DM group,  $P = .030$ ) and 0.681 (in older age group,  $P = .015$ ) with statistical significance, but 0.631 (in non-DM group,  $P = .091$ ) and 0.578 (in younger age group,  $P = .120$ ) without statistical significance. However, the AUCs of weighted SGAs in all groups were significantly increased compared with those of SGA alone, even though the magnitude of the increase was different. AUC=area under the curve, DM=diabetes mellitus, ROC=receiver-operating characteristics, SGA=subjective global assessment.

especially those that affect liver function,<sup>[45]</sup> there might be limitation in using albumin and TIBC as nutritional indicators. However, in this study, we tried to find out the additional effect of serum albumin and TIBC on nutritional evaluation, and albumin is well-known to be a good laboratory parameter for nutrition. Moreover, TIBC was used as an additionally nutritional indicator by Kalantar-Zadeh et al,<sup>[10,13]</sup> since it is strongly correlated with the nutritional status in dialysis patients. In the future, the more study using other nutritional indicators will be required. Finally, scoring serum albumin and TIBC was determined arbitrarily based on the normal values. However, cut-off values for each laboratory metric are not clear-cut. Despite these limitations, the

present study was the first to investigate and compare the association between SGA and weighted SGA (including serum albumin and TIBC) in incident PD patients in a larger population. Moreover, this study showed the additional benefits of weighted SGA irrespective of the presence of DM and age (older vs younger).

In conclusion, the evaluation of nutritional status based on SGA in incident PD patients might be useful for predicting mortality. However, weighted SGA with objective parameters including serum albumin and TIBC can provide additional predictive power for all-cause mortality compared with SGA alone in incident PD patients.

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