

# Impact of dialysis modality on technique survival in end-stage renal disease patients

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Received: May 22, 2014

Revised: August 12, 2014

Accepted: August 19, 2014

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**Background/Aims:** This study analyzed the risk factors for technique survival in dialysis patients and compared technique survival rates between hemodialysis (HD) and peritoneal dialysis (PD) in a prospective cohort of Korean patients.

**Methods:** A total of 1,042 patients undergoing dialysis from September 2008 to June 2011 were analyzed. The dialysis modality was defined as that used 90 days after commencing dialysis. Technique survival was compared between the two dialysis modalities, and the predictive risk factors were evaluated.

**Results:** The dialysis modality was an independent risk factor predictive of technique survival. PD had a higher risk for technique failure than HD (hazard ratio [HR], 10.8; 95% confidence interval [CI], 1.9 to 62.0;  $p = 0.008$ ) during a median follow-up of 11.0 months. In the PD group, a high body mass index (BMI) was an independent risk factor for technique failure (HR, 1.3; 95% CI, 1.0 to 1.8;  $p = 0.036$ ). Peritonitis was the most common cause of PD technique failure. The difference in technique survival between PD and HD was more prominent in diabetic patients with a good nutritional status and in non-diabetic patients with a poor nutritional status.

**Conclusions:** In a prospective cohort of Korean patients with end-stage renal disease, PD was associated with a higher risk of technique failure than HD. Diabetic patients with a good nutritional status and non-diabetic patients with a poor nutritional status, as well as patients with a higher BMI, had an inferior technique survival rate with PD compared to HD.

**Keywords:** Survival; Hemodialysis; Peritoneal dialysis; Body mass index; Diabetes

## INTRODUCTION

The choice of dialysis modality is affected by both medical and non-medical factors, including patient preference and social and geographic factors. Although the long-term maintenance of dialysis modalities has been realized, evaluation of the risk factors associated with technique survival in dialysis is important when selecting a dialysis modality.

The long-term prognosis of end-stage renal disease (ESRD) patients according to dialysis modality remains controversial. Peritoneal dialysis (PD) is generally associated with a higher survival rate than hemodialysis (HD) in the early period after commencement of dialysis [1-3]. Moreover, PD is associated with greater preservation of residual renal function (RRF) than HD [1,4,5]. However, it also has a considerably higher technique failure rate than HD. The various causes of technique failure in the

early stage of PD (i.e., within the first year after its initiation) include infection, catheter dysfunction, peritoneal leaks, or psychosocial problems. Among these, peritonitis is the most common cause of technique failure in the early period of PD. In the later stage, the common causes of technique failure in PD include peritonitis, ultrafiltration (UF) failure, and catheter-related infection [5-7].

In Korea, several retrospective single-center studies of technique survival in PD have been reported [8-12]; however, no comparative reports on technique failure involving multicenter prospective cohorts have appeared. Therefore, to compare technique survival between dialysis modalities and to evaluate the associated factors, we analyzed technique survival in dialysis patients enrolled in the prospective observation cohort at the Clinical Research Center for End-Stage Renal Disease (CRC for ESRD) in Korea.

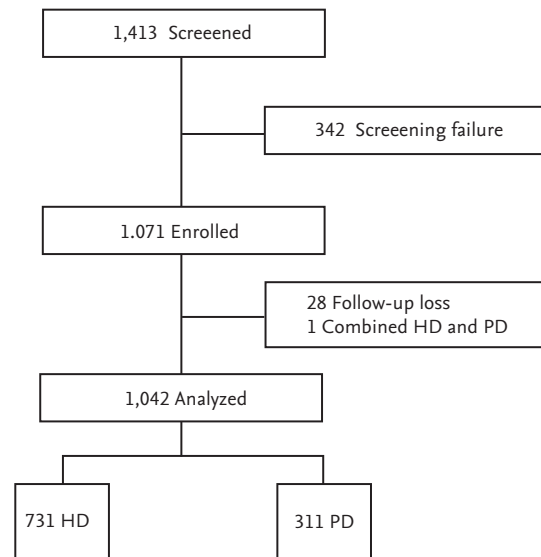
## METHODS

### Patients

A total of 32 hospitals—including 5 university-based tertiary hospitals and 26 general or provincial hospitals—participated in the study. From September 2008 to June 2011, a total of 1,413 incident patients were screened, of whom 342 did not meet the inclusion criteria. Thus, 1,071 incident patients were enrolled in the prospective study. After excluding 28 patients who were lost to follow-up and one patient who underwent HD and PD concordantly, a total of 1,042 incident patients were included in the study (Fig. 1). This study was performed according to the Helsinki Declaration, and the Institutional Review Board of each participating institute approved the study protocol. All of the patients provided informed consent to participate in the study.

### Data

Data were collected at the initiation of enrollment and included age, sex, dialysis duration, follow-up duration, etiology of ESRD (e.g., diabetes, hypertension, glomerulonephritis), comorbidities, and smoking status. Comorbidities included chronic lung disease, peripheral vascular disease, cerebrovascular disease, congestive heart failure, arrhythmia, connective tissue disease, pep-



**Figure 1.** Patient characteristics at the Korean Clinical Research Center for end-stage renal disease from September 2008 to June 2011. HD, hemodialysis; PD, peritoneal dialysis.

tic ulcer disease, and tumor.

Laboratory data included body mass index (BMI), hemoglobin, serum albumin, and RRF, which was calculated as the average of creatinine clearance and urea nitrogen clearance from 24 hours urine collection, and was normalized according to body surface area. The nutritional status was assessed by a subjective global assessment of nutrition (SGA). In this analysis, SGA-A represents a normal nutritional status (6 and 7 points), SGA-B represents a mild-to-moderate malnutrition status (3, 4, and 5 points), and SGA-C represents a severe malnutrition status (1 and 2 points) [13].

### Definition

The dialysis modality was defined as that in use 90 days after initiation of dialysis. Technique failure was defined as a change in dialysis modality that persisted for 60 days. Death and follow-up cessation (e.g., consent refusal, general condition exacerbation, kidney transplantation, transfer) were censored.

### Statistics

The results are presented as mean  $\pm$  standard deviation or percentages. The baseline characteristics of each modality were compared by Student *t* test for serial variation factors, and chi-square tests for independent fac-

tors. Technique survival was analyzed by Kaplan-Meier analysis, and the log-rank test was used to evaluate differences in technique survival rate according to various factors. The independent factors associated with technique survival were extracted by multivariate Cox proportional hazards regression analysis, which was adjusted for dialysis modality, sex, age, BMI, hemoglobin, albumin, RRF, SGA, chronic lung disease, cerebrovascular disease, diabetes, congestive heart failure, and tumor. The analysis was conducted using SPSS version 19.0 (IBM Co., Armonk, NY, USA). A *p* value less than 0.05 was considered statistically significant.

## RESULTS

### Baseline characteristics of the patients

Among the 1,042 incident patients, PD patients were significantly younger than HD patients ( $53.8 \pm 13.4$  years vs.  $60.0 \pm 14.1$  years;  $p < 0.001$ ). Sex distribution did not differ between patient groups (male, 60.0% vs. 60.0% in the HD and PD groups, respectively), and dialysis duration was also not different between the groups ( $12.8 \pm 6.9$  months vs.  $12.7 \pm 6.9$  months). The mean follow-up duration was  $10.9 \pm 7.4$  and  $11.1 \pm 7.1$  months in the HD and PD groups, respectively. Regarding the etiology of ESRD in HD and PD patients, diabetes was the most common cause (50.2% and 46.0%, respectively), followed by hypertension and glomerulonephritis. There was a significant difference in the distribution of the etiology between the groups ( $p < 0.001$ ).

The BMI in HD patients was significantly higher than that in PD patients ( $23.3 \pm 3.5$  vs.  $22.7 \pm 3.4$ , respectively;  $p = 0.020$ ). Hemoglobin and serum albumin levels were not significantly different between the groups. There were also no significant differences between groups in terms of SGA and RRF. Regarding the comorbidities, chronic lung disease was significantly more common in the HD group than in the PD group (12.1% vs. 5.3%,  $p < 0.001$ ). The tumor rate was higher in the HD group than in the PD group (8.6% vs. 2.6%,  $p < 0.001$ ). The rates of peripheral vascular disease, cerebrovascular disease, congestive heart failure, arrhythmia, connective tissue disease, and peptic ulcer disease were not significantly different between the groups. These data are summarized in Table 1.

### Risk factors for predicting technique survival in incident dialysis patients

In the Cox proportional hazard analysis, the dialysis modality (hazard ratio [HR] in the PD group vs. the HD group, 10.78; 95% confidence interval [CI], 1.87 to 62.00;  $p = 0.008$ ) was the only significant factor associated with technique survival. Other factors such as sex, age, BMI, hemoglobin, serum albumin, RRF, SGA, and comorbidities did not significantly affect technique survival (Table 2).

### Comparison of technical survival between modalities

The technique survival rate of HD was significantly higher than that of PD (Fig. 2), with 1- and 2-year technique survival rates of 99.8% and 99.0% in the HD group and 96.8% and 89.3% in the PD group, respectively. In the incident HD group, the total number of technique failures was 2. One patient requested a change to the dialysis modality from HD to PD 5 months after initiation of HD. Another patient changed to PD for control of ascites 20 months after commencement of HD. The most common cause of technique failure in PD was peritonitis (63.6%). Other causes included inadequate dialysis (9.1%), patient preference (9.1%), and surgery (9.1%) (Table 3). Among the PD patients with technique failure, 63.6% failed to maintain PD for the first year after initiating dialysis, with 71.4% of these patients failing to maintain PD for the first 6 months.

### Risk factors for technique failure in incident PD patients

We further analyzed the risk factors for PD technique failure. In incident PD patients, only a high BMI was a significant risk factor for technique failure (HR, 1.34; 95% CI, 1.02 to 1.77;  $p = 0.036$ ). Moreover, the risk for technique failure increased 1.3-fold with each 1 kg/m<sup>2</sup> increase in BMI (Table 4). Sex, age, hemoglobin, albumin, RRF, SGA, and presence of comorbidities were not significant factors for technique failure in PD patients. The total patient population was divided by the median BMI value (22.8 kg/m<sup>2</sup>). Although a significant difference in technique survival rate was found between HD and PD patients in the higher BMI group (Fig. 3A), there were no significant differences in technique survival rate in the lower BMI group (Fig. 3B).

**Table 1. Baseline characteristics of the incident dialysis patients**

Variable	Hemodialysis (n = 731)	Peritoneal dialysis (n = 311)	p value
Male sex	439 (60.0)	186 (60.0)	0.941
Age, yr	60.0 ± 14.1	53.8 ± 13.4	< 0.001
Dialysis duration, mon	12.8 ± 6.9	12.7 ± 6.9	0.869
Follow-up duration, mon	10.9 ± 7.4	11.1 ± 7.1	0.596
Etiology of ESRD			< 0.001
Diabetes	367 (50.2)	143 (46.0)	
Hypertension	115 (15.7)	59 (19.0)	
Glomerulonephritis	94 (12.9)	65 (20.0)	
Others	155 (21.2)	44 (14.2)	
Body mass index, kg/m <sup>2</sup>	23.3 ± 3.5	22.7 ± 3.4	0.020
Hemoglobin, g/dL	9.1 ± 5.1	9.1 ± 1.5	0.760
Serum albumin, g/dL	3.3 ± 0.6	3.4 ± 0.7	0.099
Smoking, %			0.195
Non-smoker	398 (57.2)	156 (51.7)	
Smoker	82 (11.8)	35 (11.6)	
Ex-smoker	216 (31.0)	111 (36.7)	
Subjective global assessment, %			0.372
A	422 (66.4)	196 (70.7)	
B	208 (32.8)	80 (28.9)	
C	5 (0.8)	1 (0.4)	
RRF, mL/min/1.73 m <sup>2</sup>	3.91 ± 3.80	4.29 ± 3.78	0.328
Comorbidities			
Chronic lung disease	85 (12.1)	16 (5.3)	< 0.001
Peripheral vascular disease	69 (9.8)	20 (6.6)	0.097
Cerebrovascular disease	88 (12.6)	30 (9.8)	0.216
Diabetes	419 (59.0)	159 (51.5)	0.025
Congestive heart failure	101 (14.4)	40 (13.1)	0.569
Arrhythmia	18 (2.6)	5 (1.6)	0.360
Connective tissue disease	69 (9.9)	31 (10.1)	0.899
Peptic ulcer disease	55 (7.9)	21 (6.9)	0.583
Tumor	60 (8.6)	8 (2.6)	< 0.001

Values are presented as number (%) or mean ± standard.  
ESRD, end-stage renal disease; RRF, residual renal function.

### Differences in technique survival rate between dialysis modalities according to the presence of diabetes and nutritional status

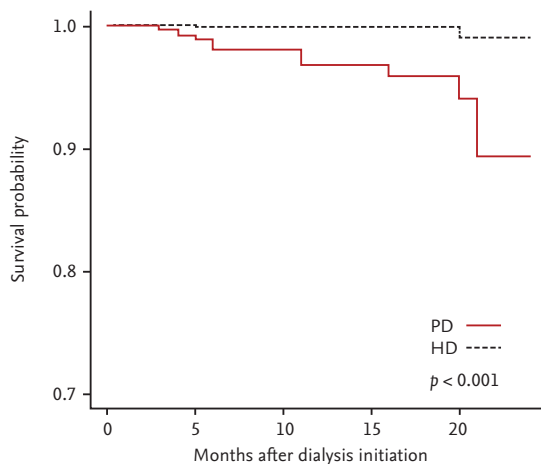
We further analyzed the technique survival of each modality according to the presence of diabetes and SGA category. A statistically significant difference in technique survival rate between dialysis modalities was found in

the SGA-A and diabetes groups, as well as the SGA-B, SGA-C, and non-diabetes groups (Fig. 4A and 4C). The SGA-A and non-diabetes groups did not show a significant difference in technique survival rate between modalities (Fig. 4B). The SGA-B, C, and diabetes groups could not be analyzed due to an insufficient number of patients in the PD group.

**Table 2. Risk of technique failure in incident dialysis patients based on the Cox model**

Variable	Reference	Hazard ratio (CI)	p value
Peritoneal dialysis	Hemodialysis	10.78 (1.87–62.00)	0.008
Male sex	Female	0.89 (0.21–3.88)	0.879
Age, yr	-	1.03 (0.97–1.09)	0.301
Body mass index, kg/m <sup>2</sup>	-	1.10 (0.89–1.37)	0.377
Hemoglobin, g/dL	-	0.98 (0.64–1.51)	0.941
Albumin, g/dL	-	0.72 (0.22–2.33)	0.581
RRF, mL/min/1.73 m <sup>2</sup>	-	1.03 (0.84–1.26)	0.798
SGA < 5	6, 7	4.93 (0.52–47.01)	0.165
Chronic lung disease	No	1.16 (0.11–12.91)	0.902
Cerebrovascular disease	No	1.36 (0.14–12.87)	0.787
Diabetes	No	1.90 (0.35–10.43)	0.461
Congestive heart failure	No	1.68 (0.30–9.53)	0.558
Tumor	No	3.68 (0.31–44.40)	0.306

CI, confidence interval; RRF, residual renal function SGA, subjective global assessment.



Number of patients at risk	
PD	311 251 176 103 54 18
HD	731 582 433 269 10 32

**Figure 2.** Technique survival rate according to dialysis modality. The technique survival rate of HD was higher than that of PD ( $p < 0.001$ ). HD, hemodialysis; PD, peritoneal dialysis.

## DISCUSSION

This study is the first prospective cohort study to compare technique survival according to dialysis modality in Korea. Only dialysis modality was independently associated with technique survival by multivariate analysis after adjusting for baseline characteristics. Moreover,

**Table 3. Causes of technique failure in peritoneal dialysis patients**

Cause of failure	Patient no. (%)
Peritonitis	7 (63.6)
Recurrent/persistent	4 (57.1)
Acute	3 (42.9)
Inadequate dialysis	1 (9.1)
Patient preference	1 (9.1)
Surgery	1 (9.1)
Other	1 (9.1)
Total	11 (100.0)

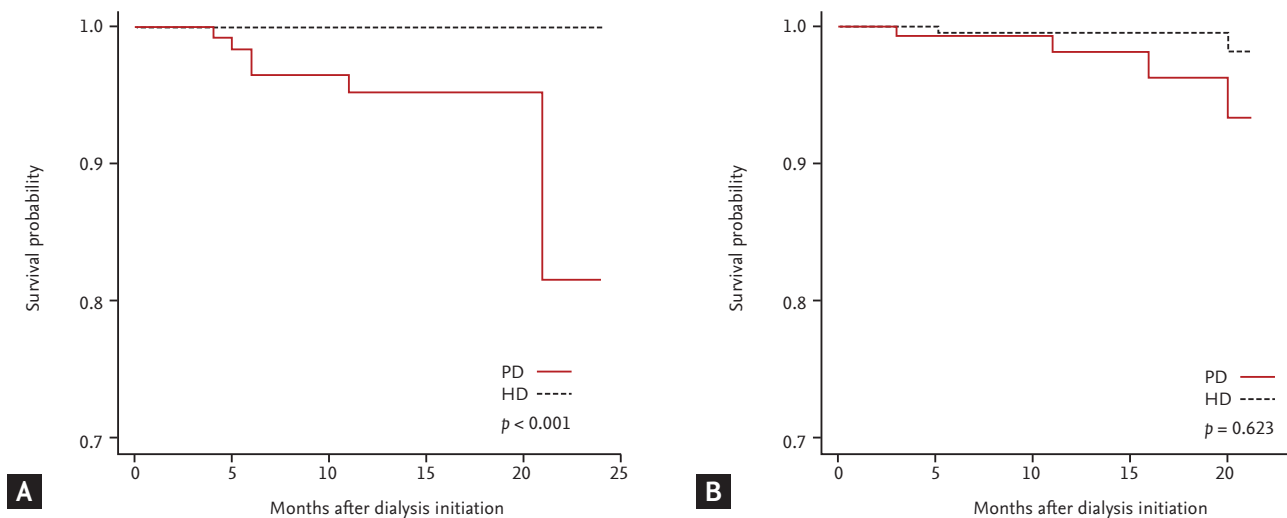
the risk of technique failure of PD was 10-fold higher than that of HD. Similarly, previous studies in other countries reported that HD has a higher technique survival rate. In 2001, NEetherlands COoperative Study on the Adequacy of Dialysis (NECOSAD) reported a higher technique survival rate for HD than PD, and the results were similar to those reported before 2000 [14]. In 2005, a cohort study from the United States reported that the rate of conversion of HD to PD was < 5%, whereas that of conversion of PD to HD was ~25% [15]. In Korea, patients with ESRD secondary to lupus nephritis showed similar results, with the technique survival rate of HD being higher than that of PD [16].

There are prominent characteristic differences be-

**Table 4. Risk of technique failure in incident peritoneal dialysis patients based on the Cox model**

Variable	Reference	Hazard ratio (CI)	<i>p</i> value
Male sex	Female	1.06 (0.15–7.37)	0.953
Age, yr	-	1.10 (0.99–1.21)	0.065
Body mass index, kg/m <sup>2</sup>	-	1.34 (1.02–1.77)	0.036
Hemoglobin, g/dL	-	1.25 (0.56–2.82)	0.589
Albumin, g/dL	-	0.67 (0.10–4.27)	0.667
RRF, mL/min/1.73 m <sup>2</sup>	-	0.84 (0.60–1.17)	0.306
SGA < 5	6, 7	8.67 (0.60–181.6)	0.164
<b>Comorbidities</b>			
Chronic lung disease	No	0.25 (0.00–88.85)	0.640
Cerebrovascular disease	No	3.33 (0.16–67.29)	0.434
Diabetes	No	4.17 (0.30–58.65)	0.289
Congestive heart failure	No	5.30 (0.70–40.26)	0.107

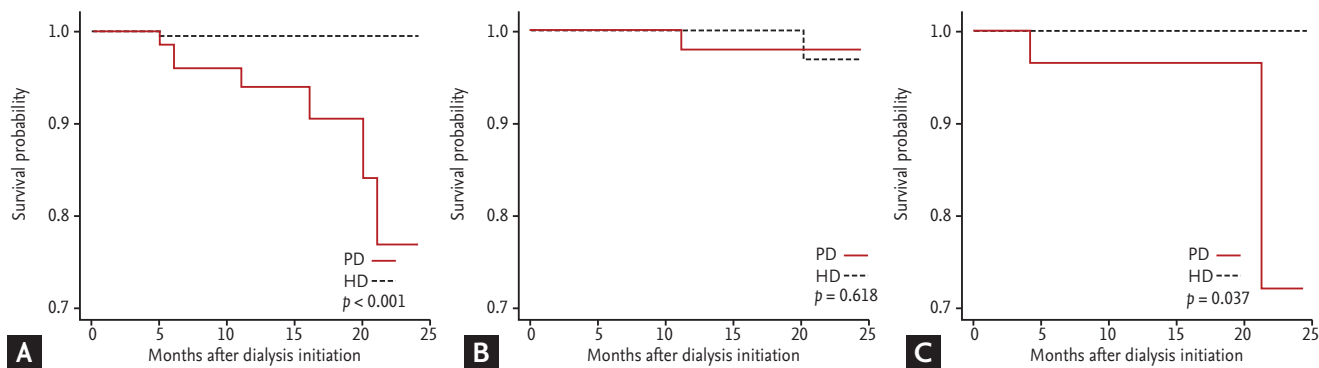
CI, confidence interval; RRF, residual renal function; SGA, subjective global assessment.



**Figure 3.** Technique survival rate in the higher (A) and lower (B) body mass index (BMI) groups. The higher BMI group showed a statistically significant difference in technique survival rate between dialysis modalities (A). However, the lower BMI group did not show a significant difference in technique survival rate (B). HD, hemodialysis; PD, peritoneal dialysis.

tween the two modalities, including in terms of modality access. PD catheters could be harmful in cases of severe peritonitis, so early removal may be needed depending on the presence of conditions such as fungal infection, refractory bacterial peritonitis, and encapsulating peritoneal sclerosis [17]. In contrast, vascular access for HD can be repaired repeatedly or recreated on the other side. However, HD patients who have inadequate conditions for maintaining HD such as central vein stenosis, recurrent thrombotic obstruction of vascular access, and severe congestive heart failure

might be recommended to switch from HD to PD. In addition, a PD catheter can be reinserted to resume PD after resolution of severe peritoneal infection. Cases in which PD was restarted within 60 days after PD catheter removal were not counted as technique failures in our study. Although the characteristics of technique survival differed between PD and HD, both modalities could be discontinued due to various clinical conditions. Studies have compared technique survival rates between the two modalities because analysis of associated risk factors is necessary to improve the technique survival rate in di-



**Figure 4.** Technique survival rate according to the presence of diabetes and malnutrition. SGA-A & DM (A), SGA-A & non-DM (B), SGA-B, C, & non-DM (C). The SGA-A and diabetes group, and SGA-B, C, and non-diabetes groups showed a statistically significant difference in technique survival rate between dialysis modalities (A, C). The SGA-A and non-diabetes groups did not show a significant difference in technique survival rate between modalities (B). SGA, subjective global assessment; DM, diabetes mellitus; HD, hemodialysis; PD, peritoneal dialysis.

alysis patients.

The causes of technique failure in PD include peritonitis, patient preference, inadequate dialysis, and surgery. Among these causes, peritonitis most commonly results in technique failure. In the present study, UF failure was not the main cause of technique failure, possibly because the study was conducted within 2 years of initiation of PD. In a previous study from the UK, the most common cause of technique failure in PD was reported to be peritonitis, followed by poor dialysis, failed peritoneal access, wish to transfer to HD, complications of high intra-peritoneal pressure, poor UF, and cessation of dialysis [7]. Thus, our study confirms the previously reported finding that peritonitis is a leading cause of technique failure in PD. In the United States, the Choices for Healthy Outcomes in Caring for ESRD (CHOICE) study reported infections as the leading reason for transferring from PD to HD, followed by cardiovascular factors (fluid overload) and abdominal surgery, pancreatitis/malnutrition, decreased mental capacity, and abdominal wall defect [18]. On the other hand, the Australia & New Zealand Dialysis & Transplantation (ANZDATA) registry reported social reasons as the most common primary cause of technique failure in PD, followed by infection, mechanical/technical complications, and dialysis failure [19]. In many Asian countries, peritonitis was the most common cause of technique failure in PD [11,20,21]. In Spain, peritonitis was the main reason for transfer to HD from PD, followed by UF problems, insufficient dialysis or problems related to the perito-

neal catheter [22]. Thus, peritonitis remains the most common cause of technique failure in PD in most developing countries and some developed countries; however, in other countries, it has been replaced by social reasons.

BMI was the only independent risk factor for technique failure in PD in the present 2-year follow-up study. We additionally analyzed the data regarding the number of peritonitis cases in two BMI groups, dichotomized by the median BMI value. In the high BMI group, four of seven cases (57.14%) of technique failure were attributed to peritonitis, compared to three of four patients (75.00%) in the low BMI group. The difference was not statistically significant because of the low number of events. Therefore, whether technique failure in the high BMI group could be attributed to the higher incidence of peritonitis remains unknown. In a combined cohort study involving Chinese and Canadian centers during a 5-year follow-up that commenced in 2000, BMI, albumin, and female gender in the Chinese centers were independent predictors of technique failure in PD [21]. In Pakistan, an 18-year follow-up study that commenced in 1995 reported that BMI was the only factor significantly associated with technique survival, on the basis of a univariate analysis. However, in India, a study of BMI and PD outcomes involving four BMI groups (obese, overweight, normal, and underweight) reported that all of the BMI categories showed a similar technique survival rate with PD, with obese patients having a greater risk of peritonitis [23]. On the basis of these results, we analyzed

the difference in technique survival rates between dialysis modalities according to BMI category. Patients with a higher BMI had higher technique survival when HD was used as the dialysis modality.

To determine the specific factors that resulted in the difference in technique survival between dialysis modalities, we divided the two groups according to the presence of diabetes and malnutrition. The difference in technique survival between dialysis modalities was more prominent in diabetic patients with a good nutritional status and non-diabetic patients with malnutrition. These findings suggest that the technique survival rate would be higher with HD rather than PD in diabetic or malnourished patients. In general, diabetic PD patients have a higher technique failure rate [24-26]. Previous studies have suggested that poor glycemic control is associated with a higher technique failure rate in PD patients [26,27]. The effect of glycemic control using non-glucose-based PD fluid on technique survival should be investigated in future studies. The use of icodextrin-containing solutions in diabetic PD patients enhances the technique survival rate. However, this beneficial effect was attributed to improved control of body fluid status rather than good glycemic control [28]. Therefore, use of PD in diabetics should be decided on an individual-patient basis. Several reports on the relationship between nutrition and technique failure in PD patients have been published [6,10,29,30]. Serum albumin, lean body mass, and SGA had positive relationships with technique survival rate. A Chinese study reported that an increase in lean body mass reduced the HR for technique failure in PD [29]. The Canada-USA (CANUSA) study reported that a decreased serum albumin concentration was associated with an increased risk of technique failure; however, other estimates of nutrition (normalized protein catabolic rate, SGA, lean body mass) were not associated with technique failure [30]. Kwon et al. [31] reported that serum albumin had a significant effect on the technique survival rate of Korean PD patients. In this study, the nutritional status was assessed by SGA, and the results confirmed that patients with a poor nutritional status have lower technique survival rates with PD than in HD.

The limitations of this study were the small number of patients with technique failure and the short follow-up period. In addition, we did not analyze the direct

association between BMI and peritonitis, or between diabetic control or nutritional status and technique failure. Thus, additional long-term follow-up studies of the technique survival rates of dialysis modalities that investigate the associations between technique failure and various risk factors are warranted.

In summary, dialysis modality was the only independent risk factor predictive of technique survival in incident dialysis patients. The findings of this multicenter, prospective cohort study conducted in Korea confirms that the technique failure rate of PD is higher than that of HD during the early period of dialysis treatment. In addition, BMI was the only independent risk factor for technique failure using the early period of PD. The difference in technique failure rate between the HD and PD groups was more prominent in patients with a higher BMI and diabetic patients with a good nutritional status, as well as in non-diabetic patients with a poor nutritional status.

## KEY MESSAGE

1. In a Korean prospective end-stage renal disease cohort, dialysis modality was an independent risk factor for technique failure in incident patients. The risk of technique failure was higher for peritoneal dialysis (PD) than hemodialysis (HD).
2. In subgroup analysis, the difference in technique survival rate between HD and PD was remarkable in patients with a higher body mass index, as well as in diabetic patients with a good nutritional status and in non-diabetic patients with a poor nutritional status.

## Conflict of interest

No potential conflict of interest relevant to this article was reported.

## Acknowledgments

This research was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health and Welfare, Republic of Korea (HI15C0001 and HI10C2020) and supported by a National Research Foundation of Korea (NRF) grant



funded by the Korean government (2014R1A5A2009242).

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