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ORIGINAL ARTICLES

RISK FACTORS FOR ADVERSE OUTCOMES AFTER PERITONITIS-RELATED TECHNIQUE FAILURE

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♦♦***Background:*** **Peritonitis is the leading cause of technique failure in peritoneal dialysis (PD) patients. Some patients experience recurrent ascites, encapsulating peritoneal sclerosis (EPS), and even death after catheter removal. Little is known, however, about the risk factors for such complications.**

♦♦***Methods:*** **The study subjects were 117 patients that had their PD catheter removed due to peritonitis between January 2000 and June 2006. Biochemical and clinical data were reviewed retrospectively. Serum C-reactive protein (CRP) and blood and effluent white blood cell counts (WBC) were measured at baseline and at 72 hours of peritonitis. Based on adverse outcomes, patients were classified into 4 groups: non-complication (NC; $n = 73$), recurrent ascites (A; $n = 26$), EPS (E; $n = 10$), and death directly related to peritonitis (D; $n = 8$).**

♦♦***Results:*** **Age at PD catheter removal was significantly higher in D group compared to NC group (62.0 ± 10.6 vs 51.2 ± 11.5 years, $p < 0.05$). In addition, mean PD duration was significantly longer in E group compared to NC and A groups (130.5 ± 48.1 vs 58.8 ± 42.4 vs 74.8 ± 47.4 months, $p < 0.01$). Compared to baseline, effluent WBC was significantly decreased in NC group after 72 hours of peritonitis. In addition, serum CRP level was significantly decreased in NC and A groups, whereas it was significantly increased in D group. Multivariate analyses adjusted for age, PD duration, blood and effluent WBC, serum CRP, and micro-organisms revealed that serum CRP level at 72 hours predicted significantly the development of EPS [odds ratio (OR) 1.15, $p < 0.05$] and peritonitis-related death (OR 1.18, $p < 0.01$). In addition, PD duration (per 1 month increase: OR 1.03, $p < 0.05$) and age at PD catheter removal (per 1 year increase: OR 1.11, $p < 0.05$) were identified as significant determinants of EPS and peritonitis-related death respectively. Only effluent WBC at 72 hours was significantly associated with the development of ascites (OR 1.27, $p < 0.05$).**

♦♦***Conclusion:*** **Older patients with long PD duration and those with persistently elevated serum CRP levels were likely to develop complications after peritonitis-related technique failure. Our study suggests that serial measurement of CRP may be helpful in predicting the development of complications after PD catheter removal.**

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KEY WORDS: Peritonitis; C-reactive protein; complications.

Peritoneal dialysis (PD) is an established treatment modality in end-stage renal disease patients; approximately 150 000 patients are being maintained on continuous ambulatory PD worldwide (1). However, the USRDS and other groups reported significantly lower technique survival in PD patients compared to hemodialysis (HD) patients, whereas overall patient survival was reported as not different between the two treatment modalities (2–4). The main reason for the lower technique survival with PD is peritonitis, although the incidence of peritonitis has decreased significantly since the introduction of the Y-set system (5,6). For peritonitis refractory to adequate antibiotic treatment, the PD

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catheter should be removed. While many patients do well without complications, leading to uneventful transfer to HD after PD catheter removal, some patients suffer from complications such as recurrent ascites, encapsulating peritoneal sclerosis (EPS), and peritonitis-related death.

Therapeutic options for EPS are very limited. Intensive treatment with immunosuppression, tamoxifen, enterolysis, *etc*. with diverse outcomes has been reported (7). Although EPS confers poor prognosis, with a mortality rate as high as 40%, early diagnosis and treatment may improve survival. Patients diagnosed with EPS after cessation of PD therapy frequently present with recurrent ascites. Ascites due to acute inflammation can be resolved quickly, but not in cases of severe and chronic changes to the peritoneal membrane. Therefore, early identification of those patients that are likely to experience postoperative problems would be of significant clinical value. However, little is known about pertinent clinical and laboratory data that can predict adverse outcomes after PD catheter removal following refractory peritonitis. Therefore, we undertook this study to investigate risk factors for developing short-term complications following peritonitis-related technique failure.

PATIENTS AND METHODS

PATIENT SELECTION AND DATA COLLECTION

This was a single-center study with retrospective data collection. Study subjects were 117 PD patients that undertook PD catheter removal due to peritonitis that did not respond to standard antimicrobial treatment from January 2000 to June 2006. International Society for Peritoneal Dialysis (ISPD) committee guidelines for diagnostic criteria and management of PD peritonitis, including the criteria for catheter removal, were followed (8,9). The initial regimen was first-generation cephalosporin combined with aminoglycoside, which was then changed to other antibiotics according to the sensitivity test results. Culture-negative peritonitis not responding to the initial treatment was treated with vancomycin, third-generation cephalosporin, and an aminoglycoside. Fungal peritonitis was managed by immediate catheter removal followed by subsequent intravenous amphotericin-B therapy for 3 weeks. For peritonitis refractory to adequate antibiotic treatment, the PD catheter was removed and the patients switched to HD. Antibiotic treatment was provided for more than 2 weeks following PD catheter removal.

Patients with PD duration less than 3 months and age less than 18 years were excluded. Also, patients that had other reasons for PD catheter removal, such as ultrafiltration failure, abdominal surgery, kidney transplantation, and death not related to peritonitis, were excluded.

Demographic and clinical data were collected based on retrospective review of patients' records: gender, age, primary renal disease, duration of dialysis, age at the start of PD and at PD catheter removal, total peritonitis episodes, duration of hospitalization, time to catheter removal, and complications such as recurrent ascites, EPS, and death. The following laboratory data were obtained from tests done at the diagnosis of peritonitis (baseline) and at 72 hours after start of treatment: white blood cell counts (WBC), hematocrit, BUN, creatinine, albumin, cholesterol, calcium, phosphorus, ferritin, and C-reactive protein (CRP). Data for peritoneal equilibration test and Kt/V urea, which were measured within 3 months before the onset of peritonitis, were also collected. In addition, causative micro-organisms and effluent WBC at the onset and at 72 hours of peritonitis were examined. Adverse outcomes were defined as recurrent ascites, EPS, and peritonitis-related death that developed within 90 days after PD catheter removal. Recurrent ascites was defined if paracentesis was required more than three times to resolve ascites. Paracentesis was conducted when symptoms of bowel compression, such as abdominal discomfort or respiratory difficulty, were evident and were not relieved spontaneously. All these patients had no evidence of EPS on ultrasonography or abdominal computed tomographic (CT) scans. Diagnosis of EPS was made based on clinical symptoms, such as nausea, vomiting, and abdominal discomfort, and CT scan findings, such as peritoneal thickening, bowel dilation, air–fluid level, loculated ascites, and increased mesenteric fat density (10,11). Peritonitis-related death was defined as death caused by PD peritonitis-induced sepsis. There was no death caused by a secondary peritonitis such as bowel perforation. All peritonitis-related deaths occurred within 60 days of PD catheter removal (1.4 ± 0.6 months). Additionally, 5 deaths were noted among 10 patients that developed EPS within a median follow-up duration of 24 months. These patients were not included in the death group because all patients with EPS survived over 90 days.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS software, version 13.0 (SPSS Inc., Chicago, Illinois, USA) for Windows operating system (Microsoft Corp., Redmond, Washington, USA). All data are expressed as mean ± SD. To compare the differences between the complication groups and the non-complication group, ANOVA tests were used for continuous variables and chi-square tests

were used for categorical variables. Multivariate logistic regression analyses were performed to determine risk factors for each adverse outcome after PD catheter removal. Factors with p value less than 0.10 on univariate analyses were subjected to multivariate analyses. All probabilities were two-tailed and the level of significance was set at 0.05.

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF PATIENTS

Of the 117 patients, 65 were men and mean age at PD catheter removal was 53.0 ± 11.8 years. Mean PD duration was 71.6 ± 48.9 (range 3 – 185) months and mean follow-up duration after PD catheter removal was 28.6 ± 22.7 months. A total of 348 peritonitis episodes occurred and overall peritonitis rate of these 117 patients was 0.82 episodes/patient-year. The most common cause of end-stage renal disease was diabetes mellitus nephropathy (n = 30, 25.6%), followed by chronic glomerulonephritis (n = 29, 24.8%) and hypertension (n = 15, 12.8%).

Patients were classified into four groups according to adverse outcomes that developed following PD catheter removal: non-complication (NC; n = 73), recurrent ascites (A; n = 26), EPS (E; n = 10), and death directly related to PD peritonitis (D; n = 8).

COMPARISON OF CLINICAL CHARACTERISTICS AND BIOCHEMICAL DATA AMONG THE FOUR GROUPS

Table 1 presents the differences in clinical characteristics and biochemical data among the four groups. There were no differences in age at the start of PD, total peritonitis episodes, Kt/V urea, or dialysate-to-plasma creatinine ratio at 4 hours among the four groups. However, age at PD catheter removal was significantly higher in D group compared to NC group (62.0 ± 10.6 vs 51.2 ± 11.5 years, $p < 0.05$). In addition, mean PD duration was significantly longer in E group compared to NC and A groups (130.5 ± 48.1 vs 58.8 ± 42.4 vs 74.8 ± 47.4 months, $p < 0.01$). Time to PD catheter removal was not different among the four groups. Among biochemical data measured at 72 hours of peritonitis, serum cholesterol level was significantly higher in NC group compared to A and D groups (142.5 ± 38.2 vs 118.6 ± 34.1 vs 104.1 ± 27.2 mg/dL, $p < 0.05$). In addition, serum albumin level was lower in D group compared to NC group but did not reach statistical significance (Table 1).

Table 2 and Figures 1 and 2 show serial changes in blood and effluent WBC and serum CRP levels among the four groups. Baseline serum CRP level was significantly higher in E group compared to NC group. Subsequent follow-up of this parameter after 72 hours of peritonitis revealed that E and D groups had significantly higher CRP levels compared to NC and A groups. In addition, effluent WBC at 72 hours was significantly lower in NC group than in the other three groups, and blood WBC at 72 hours was significantly higher in E group compared to NC group (Table 2). Compared to baseline, effluent WBC was significantly decreased in NC group after 72 hours of peritonitis. However, it was not significantly decreased in A group and it showed an increasing trend in E and D groups without statistical significance (Table 2 and Figure 1). In addition, serum CRP level was significantly decreased in NC and A groups, whereas it remained persistently elevated in E group and was even more increased in D group (Table 2 and Figure 2). When serum CRP level was monitored beyond 72 hours, it continuously decreased to normal in NC group, whereas it decreased slowly over a longer period in A group (data not shown).

COMPARISON OF MICRO-ORGANISMS AMONG THE FOUR GROUPS

Causative micro-organisms are provided in Table 3. Culture-negative peritonitis rates were relatively higher (30.1%) in NC group compared to A, E, and D groups. Overall, micro-organisms were not significantly different among the four groups. However, NC group had a trend toward a lower rate of gram-negative bacteria or fungal peritonitis that did not reach statistical significance.

MULTIVARIATE ANALYSES OF RISK FACTORS FOR ADVERSE OUTCOMES

Multivariate logistic regression analyses were performed separately to assess the risk factors of each adverse outcome (*i.e.*, recurrent ascites, EPS, and death) after PD catheter removal (Table 4). Variables with p value less than 0.10 on univariate analyses were adjusted for multivariate analyses, and these included age at PD catheter removal, PD duration, effluent WBC at 72 hours, and serum CRP level at 72 hours. Blood WBC at 72 hours was considered only in the analysis for EPS, and micro-organisms (gram negative and fungus vs not) only for recurrent ascites and death. For EPS, serum CRP level at 72 hours [odds ratio (OR) 1.15, $p < 0.05$] and PD duration (per 1 month increase: OR 1.03, $p < 0.05$) were significant predictors for the development of EPS. In addition, serum CRP level at 72 hours (OR 1.18, $p < 0.01$) and age at PD catheter removal (per 1 year increase: OR 1.11, $p < 0.05$) were identified as significant determi-

TABLE 1
Comparison of Clinical Characteristics and Biochemical Data Among Four Groups of Peritoneal Dialysis (PD) Patients

	Non-complication	Recurrent ascites	EPS	Death
Patients (*n*)	73	26	10	8
Gender (male/female)	41/32	15/11	5/5	4/4
Age at PD start (years)	46.4±12.2	47.3±12.6	46.9±10.8	53.5±10.6
Age at PD removal (years)	51.2±11.5	54.6±11.8	55.2±12.6	62.0±10.6[b]
Duration of PD (months)	58.8±42.4 (55)	74.8±47.4 (66)	130.5±48.1[a,c] (133)	88.9±29.3 (75)
Diabetes mellitus	19 (26.0%)	6 (23.1%)	2 (20%)	3 (37.5%)
Cardiovascular comorbidity	13 (17.8%)	4 (15.4%)	1 (5%)	2 (25.0%)
Time to PD catheter removal (days)	5.0±1.1	4.9±0.9	4.7±1.0	4.5±0.8
Hospital days	21.8±17.2 (18)	41.4±20.9[a] (38)	45.5±24.0[a] (43)	45.6±26.2[a] (39)
Peritonitis (total *n* episodes)	2.88±2.20	2.77±1.68	2.50±1.65	2.81±1.87
Peritonitis rate (episodes/patient-year)	0.98±1.08	0.55±0.50	0.56±0.94	0.50±0.45
Kt/V urea	1.93±0.50	1.93±0.52	2.23±0.24	1.91±0.20
PET (D/P Cr at 4 hours)	0.73±0.27	0.68±0.12	0.75±0.15	0.69±0.19
Hematocrit (%)	30.5±3.7	28.6±5.0	27.6±3.9	28.1±2.0
Calcium (mg/dL)	8.8±0.9	8.6±0.8	8.4±1.2	8.8±0.6
Phosphorus (mg/dL)	4.4±1.3	3.9±1.4	4.0±1.2	3.5±1.9
BUN (mg/dL)	44.9±13.9	44.2±20.1	46.0±16.1	39.7±20.1
Creatinine (mg/dL)	10.0±3.6	9.7±3.6	9.9±2.5	8.2±2.9
Total cholesterol (mg/dL)	142.5±38.2	118.6±34.1[b]	119.6±37.0	104.1±27.2[b]
Serum albumin (g/dL)	2.6±0.5	2.4±0.4	2.6±0.6	2.2±0.3
Ferritin (mg/dL)	325.5±269.3	733.5±673.7[a]	951.5±529.3[a]	698.9±583.8

PET = peritoneal equilibration test; D/P Cr = dialysate-to-plasma ratio of creatinine; EPS = encapsulating peritoneal sclerosis.
[a] $p < 0.01$ versus non-complication group.
[b] $p < 0.05$ versus non-complication group.
[c] $p < 0.01$ versus ascites group.
All data are expressed as mean±SD. Median values are presented in parentheses for PD duration and hospital days. Laboratory data were measured at 72 hours of peritonitis.

nants of peritonitis-related death. On the other hand, only effluent WBC at 72 hours was significantly associated with development of ascites (OR 1.27, $p < 0.05$). None of the baseline parameters was an independent predictor of complications after PD catheter removal.

DISCUSSION

Although there have been studies aimed at identifying risk factors for PD peritonitis (12,13), as well as risk factors associated with catheter removal following acute peritonitis episodes (14), studies specifically aimed at evaluating pertinent clinical and laboratory data that can predict adverse outcomes after PD catheter removal following refractory peritonitis have not been reported yet. In the present study, 44 patients (representing 38% of 117 patients that required catheter removal) developed various complications postoperatively, which caused them considerable morbidity and mortality, whereas the remainder had an uneventful transition into HD. Early identification of patients likely to develop complications post-catheter removal would be of considerable clinical value.

The major finding of this study was that persistently elevated serum CRP level was a significant determinant of both EPS and peritonitis-related death after PD catheter removal. In addition, long-term PD duration and old age were independently associated with high risk of EPS and peritonitis-related death, respectively, following technique failure due to peritonitis. No baseline parameters were independent predictors of complications, although baseline CRP level was significantly higher in E group compared to NC group.

C-reactive protein is a marker of inflammation and an elevated serum level is associated with increased risk of mortality and morbidity in end-stage renal disease patients (15–17). A recent study by Zalunardo *et al.* showed that higher serum CRP at baseline and at the third week after diagnosis predicted short- and long-term adverse outcomes respectively in PD-associated peritonitis (18). Patients with higher CRP levels at diagnosis had greater odds of adverse short-term outcomes, such as switch to

TABLE 2
Serial Changes in Blood and Effluent White Blood Cell Counts (WBC) and Serum C-Reactive Protein (CRP) Levels Between Baseline and 72 Hours of Peritonitis

Group		Blood WBC (/mm^3)	Effluent WBC (/mm^3)	Serum CRP (mg/dL)
Non-complication	Baseline	9693±5111	2413±3513	12.2±11.5
	At 72 hr	9058±4220	1292±1662[b]	7.8±7.5[b]
Recurrent ascites	Baseline	10066±6791	3684±3192	16.3±8.2
	At 72 hr	9617±7498	2793±2139[a]	11.1±4.6[c]
EPS	Baseline	12 428±8606	3332±3335	23.4±11.3[a]
	At 72 hr	15 005±8156[a]	4107±3601[a]	23.9±11.5[a,d]
Death	Baseline	9606±4761	2525±2142	17.4±6.0
	At 72 hr	12 800±4326	3266±1655[a]	24.2±7.9[a,b,d]

EPS = encapsulating peritoneal sclerosis.
[a] $p < 0.01$ versus non-complication group.
[b] $p < 0.01$ versus baseline.
[c] $p < 0.05$ versus baseline.
[d] $p < 0.01$ versus ascites group.

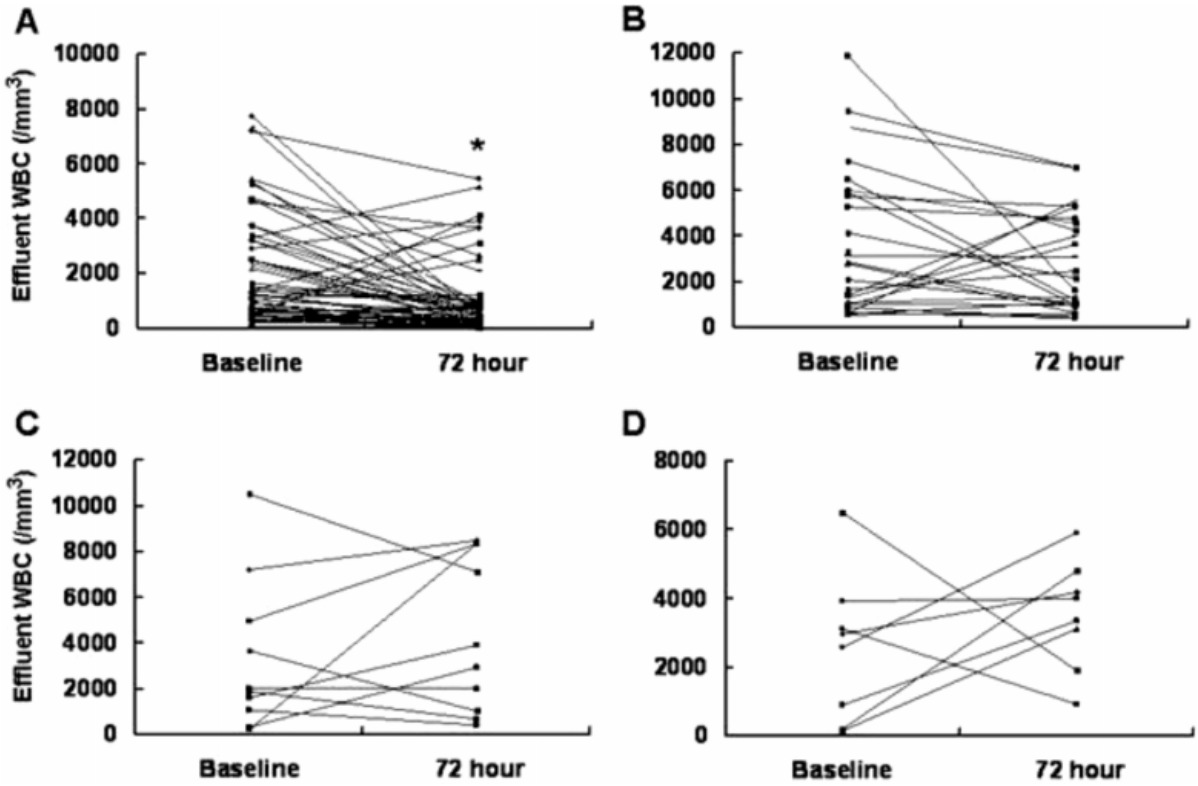

Figure 1 — Changes in effluent white blood cell count (WBC) between baseline and 72 hours of peritonitis. Effluent WBC at 72 hours was significantly decreased compared to baseline in the non-complication group. A = non-complication group; B = ascites group; C = encapsulating peritoneal sclerosis group; D = death group. *$p < 0.01$ versus baseline.

HD, death, persistent infection beyond planned therapy duration, and relapse. Highlighting the importance of serum CRP level, these results are in line with the present study, although we particularly focused on the outcomes of patients that underwent PD catheter removal due to peritonitis. Our data showed that elevated serum CRP level could be a useful marker for predicting EPS and mortality after PD catheter removal. To the best of our knowledge, there has been no report suggesting that elevated CRP level is a significant predictor of the development of EPS, although it is commonly increased in the acute stage of EPS (11). Of note, baseline CRP level was

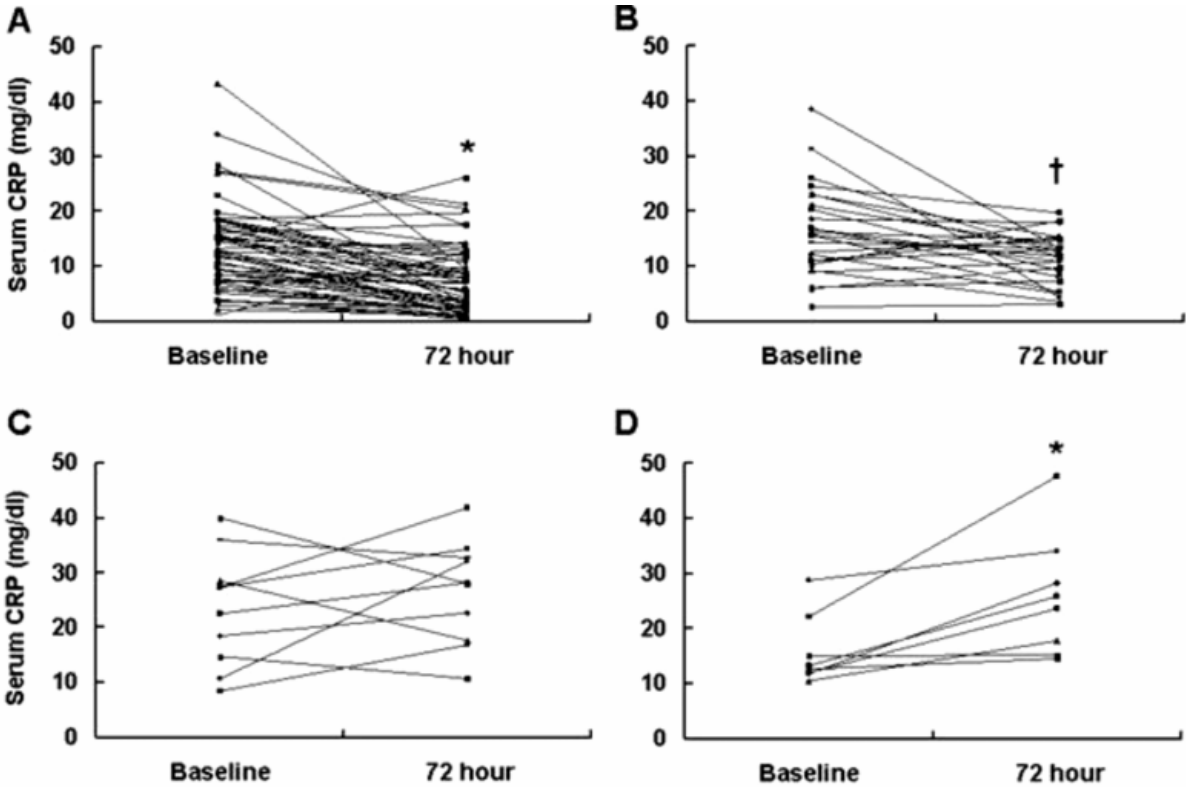

Figure 2 — Changes in serum C-reactive protein (CRP) levels between baseline and 72 hours of peritonitis. Serum CRP level was significantly decreased compared to baseline in the non-complication group and the ascites group, whereas it was significantly increased in the death group. A = non-complication group; B = ascites group; C = encapsulating peritoneal sclerosis group; D = death group. *$p < 0.01$ versus baseline; †$p < 0.05$ versus baseline.

TABLE 3
Comparison of Micro-Organisms Among Four Groups

	Non-complication	Recurrent ascites	EPS	Death
Gram positive	24 (32.9%)	9 (34.6%)	2 (20%)	2 (25%)
MSSA	11	6	2	2
MRSA	6	1	0	0
MRCoNS	4	0	0	0
Others	3	2	0	0
Gram negative	17 (23.3%)	10 (38.4%)	2 (20%)	4 (50%)
Pseudomonas species	7	5	0	1
Escherichia coli	3	4	1	1
Others	7	1	1	2
Fungus and tuberculosis	10 (13.7%)	4 (15.4%)	3 (30%)	2 (25%)
Candida species	7	3	2	2
Tuberculosis	3	1	1	0
No growth	22 (30.1%)	3 (11.5%)	3 (30%)	0 (0%)
Total	73 (100%)	26 (100%)	10 (100%)	8 (100%)

MSSA = methicillin-sensitive *Staphylococcus aureus*; MRSA = methicillin-resistant *Staphylococcus aureus*; MRCoNS = methicillin-resistant coagulase-negative staphylococcus; EPS = encapsulating peritoneal sclerosis.

not a significant determinant of adverse outcomes in the multivariate analyses (for EPS: OR 1.06, $p = 0.334$; for death: OR 0.92, $p = 0.162$). This finding suggests that serial measurement of this parameter rather than a single measurement might be a valuable tool for monitoring the efficacy of antibiotic treatment and for

TABLE 4
Multivariate Logistic Regression Analyses for Adverse Outcomes After Peritoneal Dialysis (PD) Peritonitis-Related Technique Failure

	Odds ratio (95% CI)	*p* Value
Recurrent ascites[a]		
PD duration (per 1 month increase)	1.00 (0.99–1.01)	0.696
Effluent WBC (per 1000/mm^3 increase)[b]	1.27 (1.02–1.60)	0.045
Serum CRP (per 1 mg/dL increase)[b]	0.94 (0.87–1.05)	0.361
Age at catheter removal (per 1 year increase)	1.01 (0.97–1.06)	0.624
Gram(–) or fungus (yes vs no)	2.90 (0.45–11.05)	0.245
Encapsulating peritoneal sclerosis[c]		
PD duration (per 1 month increase)	1.03 (1.01–1.06)	0.021
Blood WBC (per 1000/mm^3 increase)[b]	1.07 (0.90–1.26)	0.446
Effluent WBC (per 1000/mm^3 increase)[b]	1.10 (0.75–1.62)	0.633
Serum CRP (per 1 mg/dL increase)[b]	1.15 (1.02–1.28)	0.020
Age at catheter removal (per 1 year increase)	1.01 (0.92–1.10)	0.874
Peritonitis-related death[a]		
PD duration (per 1 month increase)	0.99 (0.97–1.01)	0.443
Effluent WBC (per 1000/mm^3 increase)[b]	1.16 (0.77–1.74)	0.470
Serum CRP (per 1 mg/dL increase)[b]	1.18 (1.06–1.32)	0.004
Age at catheter removal (per 1 year increase)	1.11 (1.01–1.22)	0.041
Gram(–) or fungus (yes vs no)	1.16 (0.16–8.19)	0.884

WBC = white blood cell count; CRP = C-reactive protein; CI = confidence interval.
[a] Adjusted for age, PD duration, effluent WBC, serum CRP level, and micro-organisms (gram negative or fungus vs not).
[b] These parameters were measured at 72 hours of peritonitis.
[c] Adjusted for age, PD duration, blood and effluent WBC, and serum CRP level.

predicting adverse outcomes. Relevant to our results are the earlier report by Hind *et al.* that the height of CRP response correlated well with the severity and extent of peritoneal damage (19). They found that patients that recovered uneventfully after antimicrobial treatment showed a prompt fall in CRP from its peak value within 48 hours of the start of antimicrobial treatment, whereas each patient in whom the serum CRP value remained raised after treatment had a complicated course.

Factors implicated in the etiology of EPS are long-term PD duration, recurrent peritonitis, bioincompatible PD solution, chlorhexidine, beta-blocker use, *etc.* (10). Our study also revealed that PD duration was a significant determinant of EPS developing after peritonitis-related catheter removal. Long-term exposure to glucose-based bioincompatible PD fluid may alter the normal immunologic reactions against bacteria (18,20,21). Fibrin deposits, collagen accumulation, and decreases in the viability and number of peritoneal macrophages may all contribute to decreased peritoneal host defense (21–23). Considering these deleterious effects, long-term PD patients are more likely to develop severe peritonitis, which often requires catheter removal, and are at increased risk of developing complications postoperatively, such as EPS and mortality. In this regard, EPS might be an ongoing complication of long-term PD (first hit), with the second hit being the peritonitis, resulting in fulminant EPS as suggested by Honda and Oda (24).

Earlier reports implicated PD duration as an important predictor of outcome following bacterial peritonitis, such as nonresolution [defined as death due to peritonitis, catheter removal, or transfer to HD (25)] and peritonitis-related mortality (26). In the present study, PD duration was not an independent risk factor for peritonitis-related death, although PD duration was longer in the D group compared to the NC group. This difference could be due to the relatively small number of patients in the D group ($n = 8$). A recent study also reported that PD duration was not predictive of outcome including mortality (18). In accordance with a recent report (26), increased age was also a significant risk factor for peritonitis-related death in this study. However, other reports found no significant association between age and peritonitis-associated outcomes (17,25).

In the present study, only effluent WBC at 72 hours was significantly associated with the development of ascites. Although serum CRP level was more elevated and gradually decreased over a longer period compared to

NC group, it was not a significant determinant of the development of ascites. This finding implies that severe peritoneal inflammation might contribute to this complication and that systemic inflammation was less severe in this population. Ascites after PD catheter removal could be induced by persistent peritonitis-related inflammation. Some mediators such as endothelial nitric oxide synthase and vascular endothelial growth factor might contribute to the development of ascites (27,28). Ascites developing after catheter removal could also be caused by inadequate volume and uremic control during HD treatment. However, this is very unlikely since these patients were carefully monitored for volume control with periodic chest x ray and more frequent HD. On the other hand, development of ascites could be a process of EPS (11). Twenty-six patients that presented recurrent ascites in our study did not show typical signs or symptoms and typical findings of EPS on ultrasonography or CT scan. Ascites spontaneously resolved in most patients during follow-up; however, careful attention should be paid to these patients and in monitoring the development of EPS.

There are several limitations in this study. This was a retrospective study with a small number of patients. The small numbers of patients in E and D groups might have led to inadequate statistical power. For example, neither gram-negative bacteria nor fungal peritonitis was a significant predictor of death, despite a higher rate of these micro-organisms in D group compared to NC group. An earlier report identified the etiologic agent as a definite marker of peritonitis-related mortality, with fungal and enteric peritonitis being associated with higher mortality (26). The relatively higher rate of culture-negative peritonitis (30.1% in NC group) is another weakness. This may have influenced the potential role of bacterial etiologic agents as a risk factor. It is possible that sterile peritonitis induced by icodextrin might be involved in the high rate of culture-negative peritonitis in NC group. However, this is very unlikely because most patients in this group responded well to antimicrobial treatment and only 4 patients used icodextrin. Malnourished PD patients are more likely to develop postoperative complications such as prolonged infection and peritonitis-related mortality (26,29). In our study, D group might have been more malnourished, as indicated by their lower cholesterol levels. Serum albumin level was lower in D group although this was not statistically significant. Serum cholesterol level was not an independent risk factor for death in this study (data not shown). Unfortunately, nutritional assessments utilizing Subjective Global Assessment or anthropometric measurements were not performed at baseline or during treatment.

In conclusion, the present study revealed that persistently elevated serum CRP level, older age, and long PD duration are significant predictors of adverse outcomes in PD patients after peritonitis-related catheter removal. Our study suggests that serial measurements of serum CRP during the course of peritonitis may be helpful in earlier identification of individuals at greater risk of developing complications following PD catheter removal.

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