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CLINICAL STUDY

Peritoneal cells at admission: do they have prognostic significance in peritonitis?

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ABSTRACT

Peritonitis accounts for considerable morbidity and hospitalization in peritoneal dialysis (PD) patients. We investigated the factors related with time of hospital stay, especially focusing on the peritoneal cell profiles at the time of hospital admission in PD-related peritonitis. Eighty peritonitis attacks were evaluated. Data were collected at the time of hospital admission, clinical and biochemical parameters, including initial systemic and dialysate white cell counts (including percentage and differential count of neutrophils and lymphocytes) and length of hospital stay. Peritoneal leukocyte ($r = +0.289$, $p = 0.009$) and neutrophil counts ($r = +0.403$, $p < 0.0001$), peritoneal neutrophil percentage ($r = +0.492$, $p < 0.0001$), time of hospital admission ($r = +0.498$, $p < 0.0001$), and C-reactive protein (CRP) ($r = +0.231$, $p = 0.042$) were positively correlated; lymphomononuclear cell percentage ($r = -0.650$, $p < 0.0001$) was negatively correlated with hospitalization length. Hospital admission ≥ 24 hours of symptom onset was associated with higher CRP, dialysate leukocyte and neutrophil counts, longer hospitalization, and with lower dialysate lymphomononuclear cell percentage compared to admission < 24 hours ($p = 0.04$, $p = 0.04$, $p = 0.005$, $p < 0.0001$, and $p = 0.04$, respectively). In multiple linear regression, the time of hospital admission ($p = 0.002$), initial peritoneal neutrophil count ($p = 0.011$), and lymphomononuclear cell percentage ($p < 0.0001$) were independently associated with hospitalization length. Hospital admission within first 24 hours of peritonitis symptoms onset is of vital importance; delayed admission is associated with higher peritoneal leukocyte and neutrophil counts, and increased length of hospital stay.

Keywords: hospital admission; lymphomononuclear cell; neutrophil; peritoneal dialysis; peritonitis

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INTRODUCTION

The technique for peritoneal dialysis (PD) was first described by Popovich et al. in 1976. Since then, its use has increased rapidly, and, worldwide, the annual estimated growth of continuous ambulatory peritoneal dialysis (CAPD) is 12%.¹ The most common complication of PD therapy is peritonitis. Although there have been improvements in CAPD techniques (including the Y-set and twin-bag systems) and patient education, recurrent peritonitis still remains the most common complication of CAPD therapy.^{1,2–4} Peritonitis is an important clinical problem in automated peritoneal dialysis (APD) patients as well.⁵

The inflammatory response occurring during infection (peritonitis) is a multifaceted sequence of controlled events. During episodes of acute bacterial peritonitis, a characteristic profile of leukocyte trafficking is normally observed, with massive elevation in the number of neutrophils in the first 24 hours of infection,

which then decreases over time; the subsequent “switch” to lymphomononuclear cell influx is in evidence between days 4 and 5 of infection.⁶ Thus, there is a bimodal recruitment pattern during acute peritoneal infection/inflammation involving a switch from neutrophils to lymphomononuclear cells.⁷ Any interruption or breakdown in this precise and highly regulated network may result in a loss of control of the peritoneal innate immune response, which might potentially result in retention of the acute inflammatory infiltrate and/or in the maintenance of more chronic inflammatory exudates (mononuclear cell and lymphocyte) within the peritoneal cavity.⁶

The outcome of peritonitis can potentially be influenced by several factors, including microbial etiology, host factors, and interventional factors.⁸ Microbial etiology and antibiotic regimens have been extensively studied in the literature.^{8,9} Unfortunately, host factors have received inadequate attention.⁸ The primary aim of this study was to investigate the factors related to

the time of hospital stay, especially focusing on the peritoneal cell profiles at the time of hospital admission in patients with PD-related peritonitis.

MATERIALS AND METHODS

End-stage renal disease patients who were on PD therapy in Baskent University Hospital's Peritoneal Dialysis Unit and who suffered from peritonitis were included. The research was conducted in accordance with the principles set forth in the Helsinki Declaration (<http://www.wma.net/e/policy/b3.htm>) and was approved by the institutional ethical committee.

All patients on CAPD therapy used a double-bag system with a titanium connector (Baxter, Dianeal 137) and all patients on APD used a HomeChoice cyclor device (Baxter Healthcare Corporation, Deerfield, Illinois, USA). In our center, the initial and follow-up protocol of PD therapy includes the patients' and the family members' standard training in the first 3 weeks of the therapy by our staff.

PD patients, either on CAPD or on APD therapy, who had suffered from peritonitis, were included in the study. Exclusion criteria were peritonitis caused by fungi (because of a general high nonresolution rate and an indication for catheter removal) or *Mycobacterium tuberculosis*, presence of catheter exit site and/or tunnel infection (ruled out by radiological evaluation), steroid use (for any indication) during the peritonitis attack, history of renal transplantation, and presence of malignancy.

The time elapsed between the onset of symptoms of peritonitis and hospital admission was determined for each patient. The data including age, gender, weight (with an empty abdomen), height, PD vintage, PD modality, and the etiology for end-stage renal disease were noted. Body mass index was calculated according to the following formula:

$$\text{Body mass index} = \frac{\text{weight (kg)}}{[\text{height (m)}]^2}$$

Peritonitis was diagnosed according to the criteria defined by the Ad Hoc Advisory Committee on Peritonitis Management. Two of the three following criteria had to be fulfilled: (i) 100 or more white blood cells (WBC)/mm³ of dialysate; (ii) clinical manifestations of peritonitis (a cloudy dialysate or abdominal pain or fever); and (iii) positive dialysate culture.¹⁰ Episodes of recurrent/relapsing, repeat, or polymicrobial peritonitis were determined.¹¹

In all patients who had been admitted with signs and symptoms of peritonitis, the abdomen was

drained and the effluent was carefully inspected and sent for cell count (with differential), Gram stain, and culture. Patients on APD with a day dwell who presented during the day had cell counts similar to those on CAPD. In APD patients without a day dwell who presented with abdominal pain, 1 L of dialysate was infused and permitted to dwell a minimum of 1–2 hours, and then drained and examined for turbidity and sent for cell count (with differential), Gram stain, and culture. In equivocal cases, or in patients with systemic or abdominal symptoms in whom the effluent appears clear, a second exchange is performed with a dwell time of at least 2 hours.¹² For bacterial culture of PD effluent, freshly drained effluent was analyzed. Isolation and identification were performed using standard techniques.

For each episode of peritonitis, data were collected on the condition of the exit site, blood urea nitrogen, serum creatinine, total protein, albumin, electrolyte concentrations, C-reactive protein (CRP), hemoglobin, hematocrit, systemic WBC count (including percentage and differential count of neutrophils and lymphocytes), initial PD effluent white cell count (including percentage and differential count of neutrophils and lymphocytes), causative microorganism, presence of recurrent/relapsing or repeat peritonitis, and length of hospital stay due to peritonitis.

Following the diagnosis of peritonitis, all patients were hospitalized and were switched to standard (manual) CAPD procedure with a 4–6 hours dwell time. According to our protocol, all patients with peritonitis have been treated initially with empirical ampicillin–sulbactam and ciprofloxacin; thereafter antibiotic therapy was tailored to the results of bacteriological sensitivities.

Serum albumin level was measured by means of the bromocresol green method. A colorimetric method was used to measure serum calcium and phosphorus (Beckmann C × -7 autoanalyzer; Beckman Instruments Inc., Diagnostic Systems Group, Brea, California, USA). The turbidimetric latex agglutination method (Biosystems S.A., Barcelona, Spain) was used to determine CRP level. Other biochemical parameters were measured by means of standard laboratory methods.

Statistical analysis

Statistical analysis was performed using SPSS 11.5 for Windows (SPSS Inc., Evanston, Illinois, USA). The normality of the data was evaluated by the Kolmogorov–Smirnov test (Lilliefors modification). Data are shown as mean ± SD (normally distributed continuous variables), as median–range (nonnormally distributed continuous variables), and as a percentage (%). Pearson's and Spearman's correlation coefficients *r* were used for the analysis of continuous variables. Comparisons of the two groups were assessed by means of the *T*-test for

normally distributed continuous variables and by the Mann–Whitney *U*-test for nonnormally distributed continuous variables. Multiple linear regression analysis was performed to detect the potential predictors of hospitalization duration following a peritonitis attack. Results were considered statistically significant if the two-tailed *p*-value was <0.05.

RESULTS

Totally, 80 peritonitis attacks of 55 patients included in the study (mean age, 44.5 ± 16.1 years; male/female ratio = 23/32) were investigated. Mean PD vintage and mean body mass index were 48.3 ± 23.8 months and 24.4 ± 4.9 kg/m², respectively. Among 55 patients, 8 (14.5%) were on APD and 47 (85.5%) were on CAPD. Patients on APD were younger than patients on CAPD (*p* = 0.003) (data not shown).

The etiology for end-stage renal failure was unknown in 17 (30.9%) patients. Etiology was glomerulonephritis in 11 (20.0%), hypertension in 9 (16.4%), pyelonephritis in 5 (9.1%), polycystic kidney disease in 5 (9.1%), diabetes mellitus in 4 (7.3%), amyloidosis in 1 (1.8%), focal segmental glomerulosclerosis in 1 (1.8%), and miscellaneous in 2 (3.6%) patients.

During follow-up, 37 patients suffered from one attack, 13 patients suffered from two attacks, 4 patients suffered from three attacks, and 1 patient suffered from five attacks of peritonitis. The mean-time elapsed from the onset of clinical symptoms of peritonitis and hospital admission was 35.7 hours (median, 24 hours; minimum–maximum, 0–168 hours). Table 1 summarizes the laboratory parameters in peripheral blood and in PD effluent at the time of hospital admission.

The most common agents for peritonitis were Gram-positive microorganisms, which were isolated in 44 (55.0%) attacks. The most common causative Gram-positive agent was *Staphylococcus epidermidis* isolated in 28 (35.0%) attacks, followed by α -hemolytic streptococci isolated in eight (10.0%) attacks, and *Staphylococcus aureus* isolated in seven (8.7%) attacks. Peritoneal dialysate culture was negative in 23 (28.7%) attacks. Gram-negative agents were isolated in nine (11.3%) attacks, *Escherichia coli* in seven (8.7%) attacks, *Pseudomonas aeruginosa* in one (1.3%) attack, and *Morganella morganii* in one (1.3%) attack. The prevalence of polymicrobial peritonitis was 5.0% (4 attacks).

Recurrent/relapsing peritonitis was encountered in one patient and repeat peritonitis was encountered in five patients. In one patient with recurrent/relapsing peritonitis, the etiologic agent was *S. aureus*. In five

TABLE 1. Laboratory parameters of 80 peritonitis attacks of 55 patients at the time of hospital admission.

Parameter	<i>n</i> = 80
Blood urea nitrogen (mmol/L)	18.8 $\pm$ 4.9
Creatinine (μ mol/L)	901.7 $\pm$ 212.1
Total protein (g/L)	63.8 $\pm$ 7.5
Albumin (g/L)	34.8 $\pm$ 4.8
Calcium (mmol/L)	2.17 $\pm$ 0.24
Phosphorus (mmol/L)	1.43 $\pm$ 0.42
C-reactive protein (mg/L)	86.9 (1.0–523.0)
Hemoglobin (g/L)	109.3 $\pm$ 19.9
Hematocrit	0.32 $\pm$ 0.06
Peripheral blood leukocyte count ($\times 10^3/\mu$ L)	10.52 $\pm$ 4.19
Peripheral blood neutrophil %	77.4 $\pm$ 12.5
Peripheral blood neutrophil count ($\times 10^3/\mu$ L)	8.39 $\pm$ 4.23
Peripheral blood lymphocyte %	15.6 $\pm$ 14.0
Peripheral blood lymphocyte count ($\times 10^3/\mu$ L)	1.75 $\pm$ 1.83
PDE leukocyte count (/mm ³)	1020 (100–33,900)
PDE neutrophil %	88 (65–100)
PDE neutrophil count ($\times 10^3/\mu$ L)	1092 (78–32,205)
PDE lymphomononuclear cell %	8 (0–31)
PDE lymphomononuclear cell count (/mm ³)	80 (0–3580)

Note: PDE, peritoneal dialysis effluent.

patients with relapsing peritonitis, the etiologic agents were *S. aureus* in two patients, α -hemolytic streptococci in one patient, *S. epidermidis* in one patient, and *E. coli* in one patient.

The PD effluent leukocyte count at the time of hospital admission was positively correlated with the length of hospital stay (*r* = +0.289, *p* = 0.009) (Figure 1). The neutrophil count and percentage in the PD effluent at the time of admission were positively correlated with the length of hospital stay (*r* = +0.403, *p* < 0.0001 and *r* = +0.492, *p* < 0.0001, respectively). The lymphomononuclear cell percentage in the dialysis effluent (*r* = –0.650, *p* < 0.0001) was negatively correlated with the length of hospital stay. Table 2 demonstrates the correlations of neutrophil and lymphomononuclear cell percentages in the PD effluent at the time of hospital admission with clinical and laboratory parameters. The length of hospital stay was positively correlated with the time elapsed between the onset of symptoms of peritonitis and hospital admission (*r* = +0.498, *p* < 0.0001) and the serum CRP level at the time of admission (*r* = +0.231, *p* = 0.042).

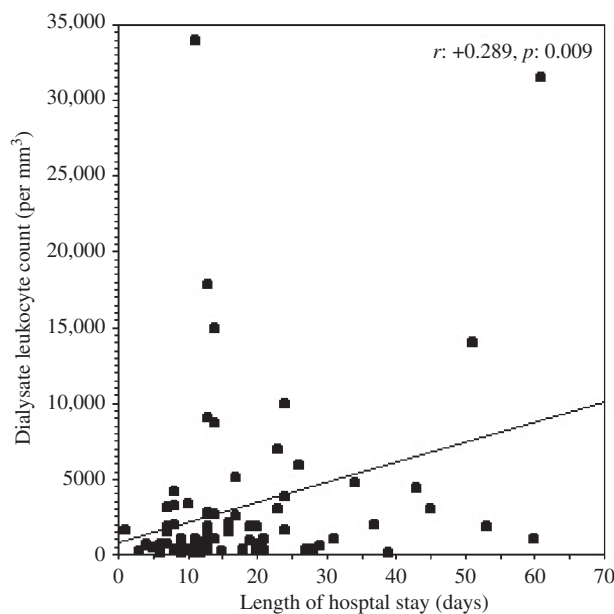


FIGURE 1. The regression graphic of peritoneal dialysis effluent leukocyte count at the time of hospital admission and the length of hospital stay.

Figures 2 and 3 demonstrate the regression graphics of these parameters.

In only 36 of 80 attacks (45.0%), patients were admitted to the hospital within the first 24 hours of the onset of peritonitis symptoms. The time elapsed

between the symptoms onset and the hospital admission was ≥ 24 hours in the remaining 44 attacks (55.0%). Table 3 demonstrates the comparative clinical and laboratory data of the patients who had been admitted to the hospital within or ≥ 24 hours of onset of peritonitis symptoms.

In PD patients who had been admitted to the hospital ≥ 24 hours after the onset of symptoms of peritonitis, serum CRP levels, PD effluent leukocyte, and neutrophil counts were higher, and PD effluent lymphomononuclear cell percentage was lower than those patients who were admitted within the first 24 hours ($p = 0.04$, $p = 0.04$, $p = 0.005$, and $p = 0.04$, respectively) (Table 3). The length of hospital stay because of peritonitis was higher in patients who had been admitted ≥ 24 hours after the onset of symptoms of peritonitis than those who had been admitted within the first 24 hours (Figure 4).

In the multiple linear regression analysis of factors present at the time of hospital admission (age, diabetes mellitus, dialysis vintage, time elapsed between the onset of peritonitis symptoms and hospital admission, albumin, CRP, PD effluent neutrophil count and lymphomononuclear cell percentage, and presence of polymicrobial peritonitis), time elapsed between onset of peritonitis symptoms and hospital admission (beta coefficient = 0.132, 95% confidence interval = 0.050–0.214, $p = 0.002$), PD effluent neutrophil count (beta coefficient = 0.001, 95% confidence interval = 0.000–0.001,

TABLE 2. The correlations of peritoneal dialysis effluent neutrophil and lymphomononuclear cell percentages at the time of hospital admission with clinical and laboratory parameters.

Correlation coefficient (<i>r</i>)	PDE neutrophil % (<i>r</i>)	<i>p</i>	PDE LMN % (<i>r</i>)	<i>p</i>
Age (years)	0.143	0.228	0.088	0.457
Body mass index (kg/m ²)	0.004	0.973	0.075	0.527
Length of hospital stay (days)	+0.492	<0.0001	−0.650	<0.0001
Blood urea nitrogen (mmol/L)	0.000	0.999	0.107	0.369
Creatinine (μmol/L)	0.042	0.723	0.009	0.939
Albumin (g/L)	0.038	0.750	0.033	0.783
Calcium (mmol/L)	0.083	0.486	0.066	0.580
Phosphorus (mmol/L)	0.032	0.790	0.008	0.949
C-reactive protein (mg/L)	0.169	0.156	0.205	0.084
Hematocrit	0.071	0.550	0.121	0.309
Peripheral blood leukocyte count ($\times 10^3/\mu\text{L}$)	0.228	0.052	0.112	0.345
Peripheral blood neutrophil %	0.016	0.890	0.049	0.678
Peripheral blood neutrophil count ($\times 10^3/\mu\text{L}$)	0.185	0.118	0.099	0.403
Peripheral blood lymphocyte %	0.192	0.369	0.077	0.722
Peripheral blood lymphocyte count ($\times 10^3/\mu\text{L}$)	0.319	0.129	0.164	0.444

Notes: PDE, peritoneal dialysis effluent; LMN, lymphomononuclear cell.

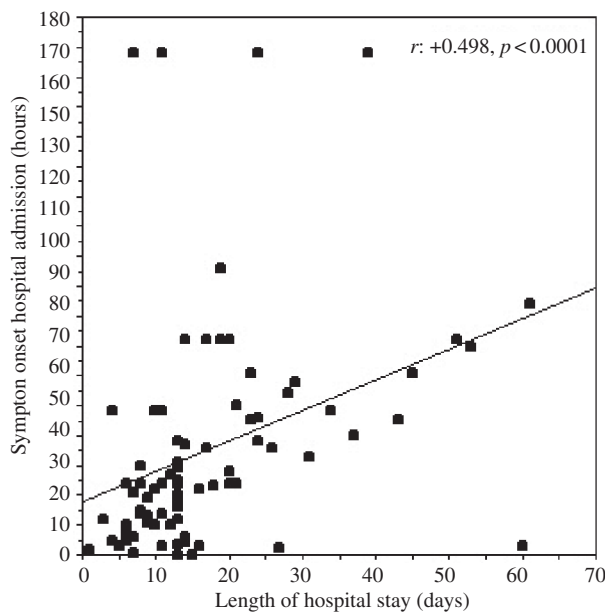


FIGURE 2. The regression graphic of the time elapsed between the onset of symptoms of peritonitis and hospital admission, and the length of hospital stay.

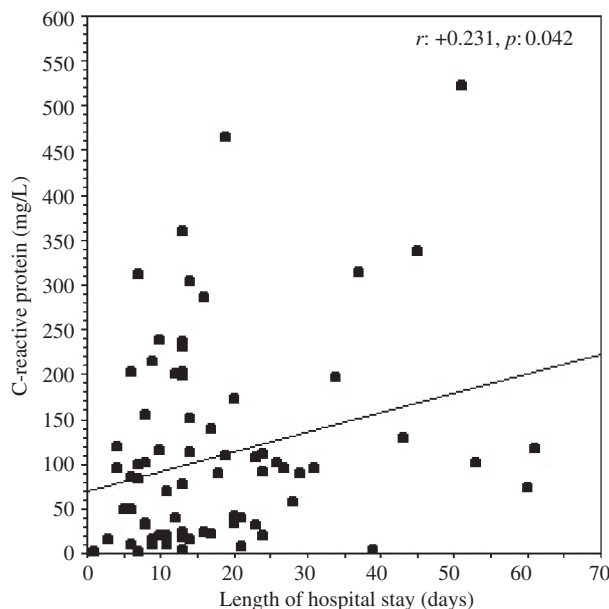


FIGURE 3. The regression graphic of serum C-reactive protein level at the time of hospital admission and the length of hospital stay.

$p = 0.011$), and PD effluent lymphomononuclear cell percentage (beta coefficient = -0.832 , 95% confidence interval = -1.191 – (-0.473) , $p < 0.0001$) were independently related with the length of hospital stay because of peritonitis in PD patients (Table 4).

DISCUSSION

Although the use of CAPD therapy has increased rapidly in the recent years, peritonitis, which is the most common complication encountered during the therapy, still accounts for considerable morbidity and mortality.^{1,2-4} In this study, we investigated the association of time of hospital admission, initial (present at the time of hospital admission) peritoneal neutrophil and lymphomononuclear cell profiles, clinical and laboratory parameters with the course of peritonitis, and the length of hospital stay because of peritonitis in PD patients.

The typical spectrum of isolates during peritonitis include Gram-positive organisms (67%), Gram-negative organisms (28%), and fungal (2.5%) or anaerobic organisms (2.5%).¹¹ The most common pathogen found in PD-related peritonitis is *S. epidermidis*, which is responsible for 30–45% of peritoneal infections.¹³ *Staphylococcus aureus* accounts for about 15% of the isolates.¹¹ In a study by Zelenitsky et al., 66.7% of peritonitis attacks were due to Gram-positive microorganism, whereas 28% of the attacks were due to Gram-negative microorganisms.¹⁴ Korbet et al. and Bernardini et al. have reported much higher incidences of Gram-positive peritonitis (79 and 74.2%, respectively) and a lower incidence of Gram-negative peritonitis (16 and 12%, respectively).^{15,16} In our study of 80 peritonitis attacks, the most common pathogens were Gram-positive microorganisms (55.0%), and *S. epidermidis* (35%) was the most commonly isolated Gram-positive microorganism. Gram-negative organisms were isolated in 11.3% of the attacks. The spectrum of pathogens isolated in our study was similar to those previously reported in the literature.^{11,13} Krishnan et al. observed polymicrobial peritonitis in 10% of infections.¹⁷ The incidence of polymicrobial peritonitis reported by Kim et al. and Bunke et al. was 16 and 14%, respectively.^{18,19} In our study, the incidence of polymicrobial peritonitis (5.0%) was relatively low compared to the reported incidence of 10% or higher in the literature.¹⁷⁻¹⁹ The incidence of culture-negative peritonitis, which may happen for a variety of technical or clinical reasons, in series ranges from 13.7 to 21%.^{4,17} The incidence of culture-negative peritonitis is high in peritonitis attacks because of low virulence microorganisms or coagulase-negative staphylococci and may rise up to 20% in some series.^{1,11} In our study, the incidence of culture-negative peritonitis was 28.7%, which was relatively higher than reported in the literature.

In a study by Krishnan et al., the patients who had a successful outcome following bacterial peritonitis had been on CAPD for a significantly shorter period of time than those patients who had nonresolution. The

TABLE 3. The comparative clinical and laboratory data of the patients who had been admitted to the hospital within or ≥ 24 hours of onset of peritonitis symptoms.

Parameter	<24 hours (<i>n</i> = 36)	≥ 24 hours (<i>n</i> = 44)	<i>p</i>
Age (years)	46.9 $\pm$ 17.4	42.4 $\pm$ 14.8	0.214
Dialysis vintage (months)	55.7 $\pm$ 25.2	48.7 $\pm$ 22.1	0.185
Blood urea nitrogen (mmol/L)	18.7 $\pm$ 5.1	18.9 $\pm$ 4.7	0.899
Creatinine (μ mol/L)	910.5 $\pm$ 221.0	892.8 $\pm$ 203.3	0.628
Total protein (g/L)	64.9 $\pm$ 6.9	62.9 $\pm$ 7.78	0.241
Albumin (g/L)	35.2 $\pm$ 4.5	34.5 $\pm$ 5.0	0.539
Calcium (mmol/L)	2.14 $\pm$ 0.29	2.19 $\pm$ 0.19	0.377
Phosphorus (mmol/L)	1.42 $\pm$ 0.42	1.45 $\pm$ 0.42	0.848
C-reactive protein (mg/L)	50 (1.0–311.7)	94 (3.8–523.0)	0.04
Hemoglobin (g/L)	112.2 $\pm$ 20.9	106.8 $\pm$ 19.0	0.234
Hematocrit	0.33 $\pm$ 0.06	0.31 $\pm$ 0.05	0.192
Peripheral blood leukocyte count ($\times 10^3/\mu$ L)	10.63 $\pm$ 4.41	10.41 $\pm$ 4.05	0.823
Peripheral blood neutrophil %	74.6 $\pm$ 14.4	79.8 $\pm$ 10.3	0.670
Peripheral blood neutrophil count ($\times 10^3/\mu$ L)	8.17 $\pm$ 4.41	8.58 $\pm$ 4.11	0.064
Peripheral blood lymphocyte %	17.3 $\pm$ 18.2	14.3 $\pm$ 9.9	0.586
Peripheral blood lymphocyte count ($\times 10^3/\mu$ L)	2.07 $\pm$ 2.47	1.48 $\pm$ 1.03	0.396
PDE leukocyte count (/mm ³)	855 (100–33,900)	1800 (100–31,500)	0.04
PDE neutrophil %	85 (65–100)	88.5 (70–95)	0.518
PDE neutrophil count ($\times 10^3/\mu$ L)	820 (78–32,205)	1745 (160–29,295)	0.005
PDE LMN %	9 (0–31)	5 (2–30)	0.04
PDE LMN count (/mm ³)	60 (0–3580)	89 (6–1740)	0.114

Notes: PDE, peritoneal dialysis effluent; LMN, lymphomononuclear cell.

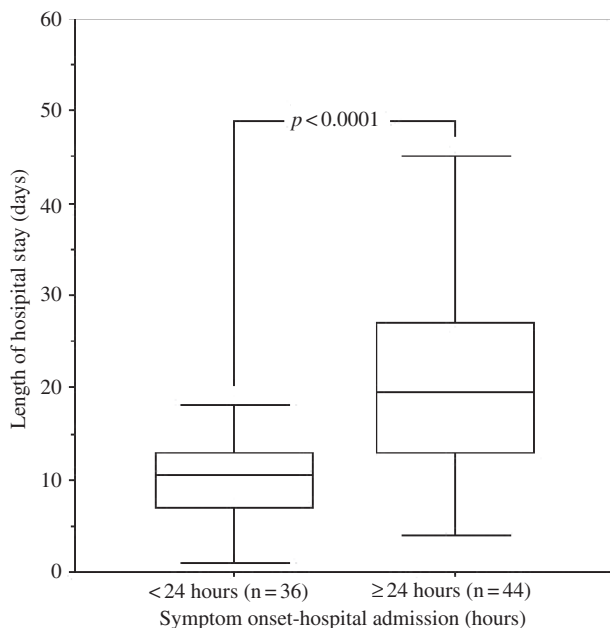


FIGURE 4. The comparisons of the lengths of hospital stay of patients who had been admitted to hospital within and ≥ 24 hours of the onset of peritonitis symptoms.

TABLE 4. Multiple linear regression analyses of potential predictors of the length of hospital stay because of a peritonitis attack.

Parameter	Standard beta coefficient	95% Confidence interval	<i>p</i>
Model constant	20.259	0.871–39.647	0.041
Age	0.132	–0.027–0.290	0.102
Diabetes mellitus	–7.727	–18.007–2.553	0.138
Dialysis vintage	0.081	–0.027–0.189	0.137
Time of hospital admission	0.132	0.050–0.214	0.002
Albumin	–3.526	–8.390–1.338	0.152
C-reactive protein	0.008	–0.014–0.030	0.469
PDE neutrophil count	0.001	0.000–0.001	0.011
PDE LMN %	–0.832	–1.191–(–0.473)	<0.0001
Polymicrobial peritonitis	4.007	–6.839–14.854	0.463

Notes: PDE, peritoneal dialysis effluent; LMN, lymphomononuclear cell.

nonresolution rate for those patients who had been on PD for more than 2.4 years was 24.4%, compared to 16.5% for those who had been on PD for less than 2.4 years.¹⁷ In our study, the time on PD was not related with the length of hospital stay because of PD-related peritonitis. However, the time elapsed between the onset of symptoms and hospital admission ($p = 0.002$), PD effluent neutrophil count ($p = 0.011$), and lymphomononuclear cell percentage ($p < 0.0001$) at the time of hospital admission were independently related with the length of hospital stay.

The severity of the attack is an important predictor of morbidity following peritonitis and to prevent delay in treatment, antibiotic therapy should be initiated as soon as the cloudy effluent is seen, even without waiting for confirmation of the cell count from the laboratory.^{6,12} In our study, we demonstrated that more than one half (55.0%) of the PD patients were not able to admit to the hospital within the first 24 hours of symptom onset, which represents the time of transition from innate to acquired immunity, the pivotal element in the resolution of peritoneal inflammation. They were admitted to hospital in an average of 35.7 hours after the onset of symptoms and were able to receive treatment thereafter. As the time elapsed between the onset of symptoms and the hospital admission increased, the length of hospital stay increased accordingly ($p < 0.0001$) and the length of hospital stay was significantly higher in patients who had been admitted ≥ 24 hours of symptom onset than those who had been admitted within first 24 hours ($p < 0.0001$).

CRP is a marker of inflammation. Troidle et al. noted that the CRP values rose from a baseline value of 15.01 ± 11.05 to 118.35 ± 96.86 mg/dL 48 hours after the onset of peritonitis.²⁰ In most patients, CRP levels return to normal within the 4-week period after the onset of treatment for peritonitis. However, 20% of the patients might have persistently elevated CRP values 4 weeks after the onset of peritonitis, and 33% of these patients have repeated episodes of peritonitis.²¹ In another study, Fontán et al. showed that the baseline risk of peritonitis-related mortality was significantly higher in patients with high baseline serum CRP levels.²² In our study, serum CRP levels of PD patients who had been admitted to the hospital ≥ 24 hours of symptom onset were higher than those who had been admitted within the first 24 hours ($p = 0.04$), and as the CRP level at the time of hospital admission increased, the length of hospital stay increased accordingly ($p = 0.042$).

In a retrospective analysis of 627 PD patients by Cueto-Manzano et al., it was demonstrated that peripheral blood lymphopenia was a predictor of mortality. Although the role of lymphopenia was not clear, it was suggested that it might be related to a worse nutritional

status or an altered immunological condition, which may decrease natural resistance to infection. They recommended that the total lymphocyte count be considered as an important predictive factor for CAPD outcome.²³ Additionally, it has been demonstrated that the longitudinal changes in peritoneal transport and ultrafiltration in CAPD patients correlated with cumulated WBC count during peritonitis, presumably as a result of unchecked mesothelial damage by neutrophils.²⁴ In PD-related peritonitis, the association of initial (present at the time of hospital admission) peritoneal neutrophil and lymphomononuclear cell profiles with the course of peritonitis and the length of hospital stay because of peritonitis is not exactly known. In our study, the initial PD effluent leukocyte count ($p = 0.009$), neutrophil count ($p < 0.0001$), and neutrophil percentage ($p < 0.0001$) were positively correlated with the length of hospital stay. The PD effluent lymphomononuclear cell percentage was negatively correlated with the length of hospital stay ($p < 0.0001$). Martikainen et al. studied 36 PD patients who had suffered from peritonitis and measured dialysate leukocyte count and serum CRP levels on days 1–4 of peritonitis. They showed that both leukocytes and CRP on day 4 were higher in patients with poor outcome (lack of disappearance of symptoms and signs of peritonitis during treatment with antibiotics). They reported that CRP > 100 mg/L and dialysate leukocyte count $> 350 \times 10^6$ /L on day 4 indicated poor outcome.²⁵ Fontán et al. found (although statistically not significant) a minor trend to higher peritoneal leukocyte counts in lethal peritonitis.²² In another study by Krishnan et al., for the peritonitis episodes in which the PD effluent cell count was > 100 μ L for more than 5 days, the nonresolution rate was 45.6%, compared to a 4.2% nonresolution rate when the cell count returned to < 100 μ L or less in < 5 days. They concluded that the number of days the PD effluent cell count remained > 100 μ L independently predicted the outcome of an episode of peritonitis. Additionally, they found that the number of peritonitis episodes before the episode in question, initial empiric treatment, serum albumin level, total lymphocyte count and initial dialysate WBC count, age, sex, diabetes, previous renal transplantation, and the use of steroids did not affect outcome of peritonitis.¹⁷ However, in their study, the data about the time elapsed between the onset of peritonitis symptoms and the time of PD effluent cell count was lacking. In our study, we demonstrated that in PD patients who had been admitted to the hospital ≥ 24 hours after the onset of symptoms of peritonitis, PD effluent leukocyte ($p = 0.04$) and neutrophil counts ($p = 0.005$) were higher and PD effluent lymphomononuclear cell percentage ($p = 0.04$) was lower than those patients who had been admitted within the first 24 hours.

We conclude that admitting to the hospital within the first 24 hours of peritonitis symptom onset is of vital importance as far as the course of peritonitis is concerned because delayed hospital admission for ≥ 24 hours is associated with higher PD effluent leukocyte and neutrophil counts, and increased length of hospital stay.

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