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Peritoneal dialysis-associated peritonitis: clinical features and predictors of outcome

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ABSTRACT

Objectives: The objective of this study was to identify the epidemiological, clinical, and microbiological factors affecting the outcome of peritoneal dialysis (PD)-associated peritonitis.
Methods: All patients with PD-associated peritonitis, cared for at the University Hospital of Heraklion from 1990 to 2007, were retrospectively studied.
Results: A total of 247 episodes of PD-associated peritonitis occurring in 82 patients were evaluated. The median age of patients was 68 years (range 10–92 years); 51 (62%) were males. There were 104 episodes (42%) of Gram-positive peritonitis, 46 (19%) of Gram-negative peritonitis, 13 (5%) of polymicrobial peritonitis, and 11 (4%) of fungal peritonitis. There were 64 (26%) complicated episodes. The latter included 22 (8.9%) relapses, 13 (5.3%) repeated episodes, 18 (7.3%) catheter removals, and 11 (4.5%) deaths. In multivariate analysis, the presence of a purulent exit-site infection ($p < 0.001$), peritoneal dialysis effluent cell count $>100 \times 10^6$/l for more than 5 days ($p < 0.001$), use of antimicrobials during the preceding 3 months ($p < 0.05$), and low serum total protein level on admission ($p < 0.05$) were independent predictors of a complicated course.
Conclusions: Exit-site infection, more than 5 days with a peritoneal dialysis effluent cell count $>100 \times 10^6$/l, prior use of antimicrobials, and low serum total protein level are potential predictors of complicated PD-associated peritonitis and may distinguish high-risk cases.

1. Introduction

Peritoneal dialysis (PD) is an important form of renal replacement therapy for patients with end-stage renal disease (ESRD). The percentage of ESRD patients maintained on chronic PD is declining, due to the high incidence of peritonitis, which represents a frequent complication and the main cause of peritoneal catheter loss and termination of continuous ambulatory peritoneal dialysis (CAPD).[1] Usually after such an infection patients are managed by hemodialysis.[2–4]

The identification of risk factors, publication of guidelines, development of new techniques, and the implementation of more effective therapies have led to a reduction in the PD-associated peritonitis incidence.[5–7] However, this infection remains a significant cause of morbidity and mortality in patients undergoing PD.[8,9] There have been few studies investigating risk factors that could predict the outcome of this infection once it develops.[10]

The aim of this study was to identify epidemiological, clinical, and microbiological factors affecting the severity and outcome of PD-associated peritonitis.

2. Methods

This study was performed at the 650-bed University Hospital of Heraklion, Crete, Greece. The records of all patients hospitalized with PD-associated peritonitis between January 1990 and June 2007 were retrospectively reviewed.

The diagnosis was based on established criteria.[8] Peritonitis was defined by the presence of cloudy PD effluent with more than 100×10^6 white blood cells (WBC)/l and a WBC differential of more than 50% polymorphonuclear cells.[5] Because the definition of PD-associated peritonitis varied slightly during the long period of our study, we considered eligible only patients who fulfilled the above definition, irrespective of the time of diagnosis.

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The data extracted from the medical records included: demographic characteristics such as age at time of peritonitis, age at start of PD, sex, and cause of ESRD; underlying medical conditions; type of PD (CAPD/ambulatory peritoneal dialysis (APD)) and duration of PD therapy; data for each PD-associated peritonitis episode, including symptom duration, number of episodes, use of antimicrobials during the three preceding months (we were able to retrieve this information since all patients suffered from a chronic condition and were under continual and intensive observation), time interval between two episodes, presence of exit-site infection (erythema or drainage from the exit-site or both), causative organisms, type and duration of treatment, and length of hospital stay; laboratory examinations for each episode on admission, including WBC count, C-reactive protein (CRP), serum erythrocyte sedimentation rate (ESR), serum albumin and total serum protein levels, and WBC count in peritoneal dialysate; and outcome.

Regarding the peritonitis course, patients were divided into two groups: those with curable and those with complicated episodes. An episode was considered curable if resolution occurred with antimicrobial therapy, without catheter removal. An episode was considered complicated if there was relapse or the episode was repeated, if removal of the catheter took place and/or there was need for temporary or permanent hemodialysis, and, of course, if the outcome was fatal. Death was considered peritonitis-associated if due to sepsis, if it occurred at the time of a positive peritoneal dialysis fluid culture, or if it occurred during the hospitalization period for any patient admitted with peritonitis or happened within one month following the onset of the infection.[5] Episodes due to the same organism with the same sensitivity pattern occurring during the 4-week period after completion of antimicrobial therapy were defined as relapses.[5] An episode was considered repeated if due to the same organism with the same sensitivity pattern, but occurred after the 4-week period following the completion of therapy.[5]

Peritonitis was treated intraperitoneally. Initial empiric treatment consisted of vancomycin with an aminoglycoside or, alternatively, ceftazidime. The dosages used were as per standard guidelines.[8] Subsequent therapy depended on cultures and sensitivities.

2.1. Statistical analysis

Univariate analyses were first conducted to identify potential risk factors for complicated episodes. The association between two categorical variables was evaluated by Chi-square test or Fisher's exact test as appropriate. For continuous variables, the Student's *t*-test (for normally distributed variables) or the non-parametric Mann–Whitney test was used to compare the difference in mean values in the two groups. Variables showing a statistically significant association with complicated course, with a *p*-value of <0.05, were considered candidate variables for inclusion in the multivariate model in order to determine which variables were independent predictors of a complicated outcome. Stepwise multivariate logistic regression was performed including the potential candidate variables.

All analyses were conducted using SPSS version 13.0 (SPSS Inc., Chicago, IL, USA). All statistical tests performed were two-tailed; $p < 0.05$ was considered as statistically significant.

3. Results

During the 17.5-year study period, 247 episodes of PD-associated peritonitis were identified in 82 patients. The overall peritonitis rate was one episode per 14 patient-months or 0.89 episodes per patient-year.

The median age of patients was 68 years (range 10–92 years). There were 51 males (62%) and 31 females (38%). Seventy-four (90%) had an underlying disease, with the most frequent being diabetic nephropathy (23 patients; 28%). Fifty-one patients (62%) were on APD, while 31 (38%) were on CAPD. The median duration of peritoneal dialysis for all patients was 14 months (range 1–217 months). Demographics are shown in Table 1.

Gram-positive organisms were responsible for 104 episodes (42%), Gram-negative for 46 (19%), and fungi for 11 (4%). In 13 episodes (5%), peritonitis was polymicrobial, while in 73 (30%) cultures were negative. The causative organisms are listed in Table 2.

Staphylococcus epidermidis and *Staphylococcus aureus* were the most common Gram-positive organisms, isolated in 48 (46%) and 20 (19%) cases, respectively, while *Escherichia coli* was the most common Gram-negative organism and was identified in eight cases (17%).

One hundred eighty-three episodes (74%) were cured with the initial antimicrobial regimen. Sixty-four episodes (26%) were considered complicated and included 22 (8.9%) relapses, 13 (5.3%) repeated episodes, 18 (7.3%) catheter removals with temporary or permanent transfer to hemodialysis, and 11 (4.5%) deaths. The types of episode and the outcome of all cases are summarized in Table 3, while the characteristics of the 11 patients with a fatal outcome are shown in Table 4.

In the univariate analysis, episodes in which antimicrobial treatment was received at some point in time during the three preceding months were significantly associated with a complicated course, as compared to episodes without prior treatment (45% vs. 24%; $p = 0.001$). Furthermore, episodes where there was an exit-site infection were significantly associated with a complicated course when compared to episodes without this type of infection

Table 1
Patient demographic and clinical data

Characteristics	
Sex: male/female, *n*	51/31
Community: urban/rural, *n*	39/43
Age (years), mean ± SD	64.1 ± 16.2
Duration on dialysis (months), mean ± SD	21.5 ± 23.6
Co-morbidities, *n* (%)	
Hypertension	48 (59)
Cardiovascular disease	45 (55)
Diabetes mellitus	26 (32)
Secondary hyperparathyroidism	16 (20)
Obstructive pulmonary disease	7 (9)
Autoimmune disease	6 (7)
Cancer	2 (2)
Causes of ESRD, *n* (%)	
Diabetic nephropathy	23 (28)
Hypertensive nephrosclerosis	13 (16)
Glomerulonephritis	8 (10)
Polycystic kidney disease	7 (9)
Chronic pyelonephritis	5 (6)
Obstructive uropathy	5 (6)
Unknown	18 (22)
Other	3 (4)
Type of peritoneal dialysis, *n* (%)	
Continuous ambulatory	31 (38)
Ambulatory	51 (62)
No of peritonitis episodes, *n* (%)	
1	30 (37)
2	18 (22)
3–4	16 (19)
>5	18 (22)
Previous history of peritonitis, *n* (%)	
Yes	31 (38)
No	51 (62)

ESRD, end-stage renal disease.

Table 2
Microbiology of peritoneal fluid

Causative organism	Number of episodes (%)
Gram-positive organisms ($n = 104$)	
Staphylococcus epidermis	48 (46)
Staphylococcus aureus	20 (19)
Corynebacterium spp	8 (8)
Enterococcus spp	6 (6)
Streptococcus mitis	6 (6)
Staphylococcus hominis	5 (5)
Other[a]	11 (10)
Gram-negative organisms ($n = 46$)	
Escherichia coli	8 (17)
Pseudomonas aeruginosa	7 (15)
Enterobacter spp	7 (15)
Klebsiella spp	7 (15)
Acinetobacter spp	4 (9)
Other[b]	13 (28)
Fungi ($n = 11$)	
Candida albicans	5 (46)
Candida tropicalis	3 (27)
Candida inconspicua	2 (18)
Paecilomyces spp	1 (9)
Polymicrobial[c]	13 (5)
Culture-negative	73 (30)

[a] *Staphylococcus haemolyticus* (2), *Staphylococcus simulans* (1), *Staphylococcus warneri* (1), *Streptococcus bovis* (1), *Streptococcus sanguinis* (2), *Streptococcus agalactiae* (1), *Streptococcus salivarius* (1), *Streptococcus intermedius* (1), *Propionibacterium acnes* (1).

[b] *Pseudomonas stutzeri* (3), *Neisseria cinerea* (1), *Neisseria mucosa* (1), *Serratia marcescens* (3), *Proteus mirabilis* (3), *Haemophilus aphrophilus* (2).

[c] Corynebacterium group I–*Candida parapsilosis*; *Acinetobacter lwoffi–Pseudomonas aeruginosa*; *Enterococcus faecalis–Candida albicans*; *Streptococcus intermedius–Bacteroides spp*; *Escherichia coli–Enterococcus faecalis*; *Streptococcus mitis–Enterococcus spp*; *Staphylococcus warneri–Escherichia coli*; *Escherichia coli–Proteus mirabilis*; *Enterococcus faecalis–Enterococcus faecium*; *Serratia marcescens–Escherichia coli*; *Serratia marcescens–Staphylococcus epidermidis*; *Escherichia coli–Escherichia fergusonii*; *Klebsiella pneumoniae–Streptococcus salivarius*.

(28% vs. 4%; $p < 0.001$). Episodes where there was a history of previous peritonitis were also associated with a complicated course when compared to episodes without a history of peritonitis (61.5% vs. 16.7%; $p < 0.001$) (Table 5).

Univariate analysis also identified WBC count, low serum albumin and total protein on admission, and more than 5 days with a PD effluent cell count $>100 \times 10^6$/l, as significantly associated with a complicated course. Furthermore, patients with a complicated course were hospitalized longer compared to those with an uncomplicated course (6.7 vs. 3.9, $p < 0.001$) (Table 5).

There were no statistical differences in the type of peritonitis course caused by Gram-positive organisms when compared to those caused by Gram-negative organisms, as well as to those due to polymicrobial infections. Overall, when fungal peritonitis was compared to all other types, a significant increase in the incidence of a complicated course was noted (81.8% vs. 23.3%, $p < 0.001$).

Table 3
Type of peritonitis episode and outcome

	Number of episodes (%)
Curable episode	183 (74)
Complicated episode	64 (26)
Relapse	22 (8.9)
Catheter removal/transfer to HD	18 (7.3)
Repeated peritonitis	13 (5.3)
Death due to peritonitis	11 (4.5)
Total	247 (100)

HD, hemodialysis.

Logistic regression analysis revealed that the presence of a purulent exit-site infection (OR 11.321, 95% CI 3.561–35.988; $p < 0.001$), peritoneal dialysis effluent cell count $>100 \times 10^6$/l for more than 5 days (OR 1.588, 95% CI 1.311–1.923; $p < 0.001$), prior antibiotic use in the 3 months before the episode (OR 3.322, 95% CI 1.389–7.942; $p < 0.05$), and low serum total protein level on admission (OR 0.386, 95% CI 0.156–0.957; $p < .05$) were independent predictors of a complicated course (Table 6).

4. Discussion

The results of the present study confirm that peritonitis remains a serious cause of morbidity, mortality, and/or technical failures for patients maintained on PD therapy, as has been noted in other studies.[2–4]

The study also shows that patients treated with antimicrobials at some point in time during the 3-month period preceding the peritonitis episode, those with an exit-site infection, those with a peritoneal dialysis effluent cell count $>100 \times 10^6$/l for more than 5 days, and those with a low serum total protein level on admission, are at high-risk for a complicated course of PD-associated peritonitis.

Other researchers have previously found that both the duration of PD and the number of days that the peritoneal effluent cell count remains $>100 \times 10^6$/l are independent predictors of outcome in PD-associated peritonitis.[10] Our study confirms that a peritoneal effluent cell count $>100 \times 10^6$/l for more than 5 days represents a bad prognostic factor.

Other studies have reported that recent antimicrobial therapy is an important risk factor associated with fungal peritonitis[11] and peritonitis due to *Pseudomonas* species.[12] However, our study suggests that prior antimicrobial therapy during the 3 months preceding the episode is an independent predictor of a complicated course. A possible explanation for this result is that the use of antibiotics alters the body flora and provokes the development of resistant bacterial strains.[13]

Table 4
Characteristics of patients with a fatal outcome

Case	Age at episode, years	Sex	Peritoneal dialysis duration, months	Initial dialysate cell count, $\times 10^6$/l	Days of cells $>100 \times 10^6$/l	WBC on admission, $\times 10^9$/l	Organism
1	88	M	18	1230	3	15.4	*Candida albicans*
2	83	M	41	9800	10	16.7	*Klebsiella oxytoca*
3	63	M	19	3450	7	17.0	Negative
4	70	M	0.5	6770	6	16.7	Negative
5	89	F	0.5	412	10	15.6	Polymicrobial
6	42	F	13	8000	12	22.0	Polymicrobial
7	70	F	40	4400	12	21.0	Polymicrobial
8	78	M	14	3990	6	17.0	*Candida albicans*
9	76	M	107	1210	8	11.5	*Staphylococcus aureus*
10	73	F	70	9800	10	17.9	Polymicrobial
11	87	F	0.5	334	8	16.6	Negative
Mean (± SD)	74.5 (13.3)		29.4 (10.1)	4491 (3613)	8.3 (2.8)	17.036 (27.73)	

WBC, white blood cell count; M, male; F, female; SD, standard deviation.

Table 5
Factors associated with a complicated course (univariate analysis)

Factor	% Complicated episodes if factor present	% Complicated episodes if factor absent	*p*-Value
Male gender	43.1	51.6	NS
Urban community	46.15	47.6	NS
Co-morbidity			
Diabetes mellitus	38.5	50.0	NS
Hypertension	39.6	55.9	NS
Hyperparathyroidism	37.5	48.5	NS
Diabetic nephropathy	39.1	52.5	NS
History of peritonitis	61.5	16.7	<0.001
Continuous ambulatory peritoneal dialysis	35.5	49	NS
Clinical findings			
Fever	28.7	22.9	NS
Exit-site infection	72.0	20.7	<0.001
Prior antimicrobial use	40.3	20.0	0.001
	Curable episodes	Complicated episodes	
Age at the onset of peritonitis, mean ± SD	64.14 ± 15.44	64.09 ± 18.24	NS
Laboratory findings, mean ± SD			
WBC on admission, $\times 10^9$/l	10.427 ± 3.438	12.338 ± 3.949	0.001
Albumin on admission g/dl	3.66 ± 0.54	3.35 ± 0.54	<0.001
Total protein on admission g/dl	6.06 ± 0.66	5.47 ± 0.61	<0.001
Effluent cells on admission $\times 10^6$/l	2129 ± 2598	3198 ± 3212	0.003
Days for effluent cells $<100 \times 10^6$/l	3.68	6.38	<0.001
Days to normalization of WBC	2.11	3.11	0.001
Days of hospitalization	3.9	6.7	<0.001
Duration of peritoneal dialysis therapy (months)	20.25	25.03	NS
Interval between two episodes (months)	8.75	7.91	NS
Number of previous episodes	1.94	2.47	NS

NS, not significant; WBC, white blood cell count.

It is also known from earlier studies that peritonitis associated with an exit-site infection is less likely to respond to antimicrobial treatment when compared with peritonitis not related to such an infection.[14] Additionally, episodes of peritonitis associated with an exit-site infection often result in catheter loss and increased morbidity.[8,15] The present study strongly confirms these observations, since the presence of an exit-site infection was independently associated with a complicated course.

Low serum albumin has also been reported to be an adverse prognostic factor in adults with ESRD on continuous PD, predisposing to peritonitis.[16] In addition, low serum albumin predicts both mortality and prolonged hospital stay in patients with PD-associated peritonitis.[17] However, in our study, even though low serum albumin was associated more frequently with a complicated course on univariate analysis, it was not independently associated with a complicated course on multivariate analysis, as has been reported by others.[10]

Since long-term chronic PD therapy has been associated with alterations in peritoneal membrane structure and peritoneal macrophage function, it was thought that the duration of PD treatment might be a predictor of a complicated course, although data are inconclusive. Troidle et al.[18] revealed that the mortality rate was equal among patients with different PD therapy durations. On the other hand, Krishnan et al.[10] found that the duration of PD independently and adversely affected the outcome of peritonitis. We failed to find any relationship between PD duration and outcome.

Table 6
Predictors of a complicated course (multivariate analysis)

Variable	OR	95% CI	*p*-Value
Prior antimicrobial use (<3 months)	3.322	1.389–7.942	0.007
Presence of exit-site infection	11.321	3.561–35.988	<0.001
Total protein count on admission	0.386	0.156–0.957	0.04
Peritoneal dialysis effluent cell count $>100 \times 10^6$/l for >5 days	1.588	1.311–1.923	<0.001

OR, odds ratio; CI, confidence interval.

It has been hypothesized that the peritoneal dialysate WBC count may be an index of peritonitis severity and also predictive of the response to antimicrobials.[19] Indeed, there is a strong correlation between the number of days with a PD effluent cell count $>100 \times 10^6$/l and a complicated course of peritonitis. In our study, patients with a PD effluent cell count $>100 \times 10^6$/l for more than 5 days were at increased risk for a complicated course. The cut-off point of 5 days appears critical, since Krishnan et al.[10] also reported the same period as a predictor of complicated course.

Co-morbid diseases are common in this patient population and have been shown to predict mortality.[20,21] Furthermore, patients with diabetes mellitus are at high risk for peritonitis.[22] However, our study did not confirm that diabetes mellitus, cardiovascular disease, heart failure, or secondary hyperparathyroidism could affect the course of peritonitis. It should be noted that in the present study the number of patients with malignancies was small, hence immunodeficiency due to disease and/or chemotherapy could not be associated either with the course or with the outcome of the infection.

In the present study the outcome of peritonitis in patients on APD was not different when compared to patients on CAPD. This lack of difference has been shown by other investigators in the past.[23,24] Sex and age also did not influence the course and outcome of peritonitis, although some groups have suggested that age may be important. Choi et al.[25] observed that PD catheter removal because of peritonitis was more common in elderly patients, while Perez Fontan et al.[9] found that older age is a significant correlate of peritonitis-related mortality.

PD-associated peritonitis is most often due to contamination with skin flora, with *S. epidermidis* and *S. aureus* accounting for the majority of cases, as was found in the present study.[26] However, in the present patient population, in contrast to earlier observations, the type of infective organism did not influence peritonitis course.[8,27] Only cases caused by fungi had a significantly more complicated course, as has been described in previous studies.[11] Of

note, however, is the high incidence of culture-negative cases (30%) in the present study as compared to other series (20%).[5]

The fatality rate in the present series was 4.8%, falling within the range reported by others (1–6%).[9]

Our study has the inherent limitations of all retrospective studies. We were unable to discern the effects of patient education, socioeconomic status, nasal carriage of *S. aureus*, and nutritional status on peritonitis course and outcome.

In conclusion, patients with PD-associated peritonitis with an exit-site infection, a peritoneal dialysis effluent cell count $>100 \times 10^6$/l for more than 5 days, antimicrobial therapy during the three preceding months, and a low serum total protein level on admission are at high risk for a complicated course. These data suggest that simple clinical and laboratory findings remain useful tools, indicating in a timely manner the severity of the disease. Further study is needed to determine whether aggressive management of these cases improves outcome.

Conflict of interest: No conflict of interest to declare.

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