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Feasibility of Resuming Peritoneal Dialysis after Severe Peritonitis and Tenckhoff Catheter Removal

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Abstract. Published guidelines suggest that after an episode of severe peritonitis that requires Tenckhoff catheter removal, peritoneal dialysis can be resumed after a minimum of 3 wk. However, the feasibility of resuming peritoneal dialysis after Tenckhoff catheter removal remains unknown. One hundred patients were identified with peritonitis that did not respond to standard antibiotic therapy in a specific center. Their clinical course was reviewed; in all of them, Tenckhoff catheters were removed and reinsertion was attempted at least 4 wk later. In 51 patients, the Tenckhoff catheter was successfully reinserted and peritoneal dialysis was resumed (success group). In the other 49 pateints, reinsertion failed and the patient was put on long-term hemodialysis (fail group). The patients were followed for 18.5 ± 16.8 mo. The overall technique survival was 30.8% at 24 mo. In the success group, 11 patients were changed to long-term hemodialysis within 8 mo after their return to continuous ambulatory peritoneal dialysis. In the fail group, 18 of the 20 deaths occurred within 12 mo after conversion to long-term hemodialysis. After resuming peritoneal dialysis, there was a significant decline in net ultrafiltration volume (0.38 ± 0.16 to 0.21 ± 0.19 L; $P = 0.03$) and a trend of rise in dialysate-to-plasma ratios of creatinine at 4 h (0.664 ± 0.095 to 0.725 ± 0.095; $P = 0.15$). Forty-five patients (88.2%) required additional dialysis exchanges or hypertonic dialysate to compensate for the loss of solute clearance or ultrafiltration, although there was no significant change in dialysis adequacy or nutritional status. It was concluded that after an episode of severe peritonitis that required Tenckhoff catheter removal, only a small group of patients could return to peritoneal dialysis. An early assessment of peritoneal function after Tenckhoff catheter reinsertion may be valuable.

Peritonitis is a common and serious complication of continuous ambulatory peritoneal dialysis (CAPD) (1,2). Although antibiotic therapy is generally effective, some patients fail to respond and Tenckhoff catheter removal is necessary. In this situation, the Ad Hoc Committee of the International Society of Peritoneal Dialysis suggests that peritoneal dialysis can be resumed after a minimum of 3 wk (3,4). However, this recommendation is made largely on the basis of expert opinion. In fact, CAPD patients in many countries are immediately switched to long-term hemodialysis after an episode of severe peritonitis that requires Tenckhoff catheter removal because it is believed that ultrafiltration failure is common after severe peritonitis (5,6).

In Hong Kong, CAPD is the first-line renal replacement therapy for all end-stage renal disease patients (7). When peritonitis develops, Tenckhoff catheter is removed and the patient is put on temporary hemodialysis only if the episode fails to resolve with antibiotics. Tenckhoff catheter reinsertion is attempted in all cases after a period of stabilization. As described in our previous studies (7–9), patients are only switched to long-term hemodialysis when Tenckhoff catheter reinsertion attempts fail because of peritoneal adhesion or when there is ultrafiltration failure due to peritoneal sclerosis. This policy provides an excellent opportunity for us to examine the prospect of peritoneal dialysis after severe peritonitis that requires Tenckhoff catheter removal in a large unselected group of CAPD patients. Here we demonstrate that peritoneal dialysis can be resumed successfully only in a small number of patients.

Materials and Methods

Patient Management

We reviewed all the episodes of CAPD peritonitis in our unit from January 1995 to December 2000. Data completeness was assured by our computerized Renal Registry, which was established by the end of 1994. We identified 1171 peritonitis episodes. The overall peritonitis rate was 18.7 patient-months per episode. The diagnosis of peritonitis was made on the basis of at least two of the following (10): (*1*) abdominal pain or cloudy peritoneal dialysis effluent (PDE); (*2*) leukocytosis in PDE (white blood cell count >100/ml); and (*3*) positive Gram-stain or culture from PDE. Episodes with peritoneal eosinophilia but negative bacterial culture were excluded. Bacterial culture of PDE was performed by BacTAlert bottles (Organon Teknika Corp., Durham, North Carolina). Isolation and identification

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were performed by standard technique. Antibiotic sensitivity was determined by comparative disc-diffusion method.

Peritonitis episodes were treated with standard antibiotic protocol of our center, which was changed systemically over time (9). Initial antibiotics for peritonitis were generally intraperitoneally administered third or fourth generation cephalosporin plus or minus vancomycin or cefazolin plus netilmicin. Antibiotic regimens for individual patients were modified when culture results of PDE were available. We followed standard guidelines for antibiotic dosages (3,4). In general, patients received antibiotics for at least 14 d (3,4). For peritonitis episodes caused by *Staphylococcus aureus* or *Pseudomonas* or *Xanthomonas* species, antibiotic therapy was continued for at least 21 d (3,4,9,11).

In general, if the PDE did not clear up on day 10 despite *in vitro* sensitivity of the bacterium, the Tenckhoff catheter would be removed. Nevertheless, the actual timing of Tenckhoff catheter removal varied for individual patient because of operating theater availability. After Tenckhoff catheters were removed, patients were put on temporary hemodialysis. The appropriate antibiotic therapy was continued for another 2 wk. Tenckhoff catheter reinsertion was attempted at least 4 wk after the old Tenckhoff catheter was removed. Tenckhoff catheter reinsertion was performed surgically under local anesthesia by paramedian subumbilical incision (12). As described previously (7,8), patients were only switched to long-term hemodialysis when attempts of Tenckhoff catheter reinsertion failed because of peritoneal adhesion or when there was ultrafiltration failure due to peritoneal sclerosis.

Case Selection

With the above definitions, PDE failed to clear up with antibiotic therapy in 162 episodes (13.8%) of peritonitis. Forty-three episodes were excluded from analysis because the patient died before the Tenckhoff catheter could be removed. Another 11 episodes were excluded because the patient died within 4 wk after Tenckhoff catheter removal and before the attempted Tenckhoff catheter reinsertion. We studied the demographic characteristics and clinical course of the remaining 108 episodes of peritonitis in 100 patients. In eight of the patients, there was more than one episode of peritonitis during the study period that required Tenckhoff catheter removal. For these patients, we only used the latter peritonitis episode for statistical analysis to avoid overlapping of data, because a history of severe peritonitis that required Tenckhoff catheter removal was counted as a risk factor of reinsertion failure during calculation (see below).

In 51 of the 100 patients, the reinsertion of Tenckhoff catheter was successful and peritoneal dialysis was resumed. They were designated as the success group. In the other 49 patients, Tenckhoff catheter reinsertion was attempted but failed, usually because of the intraoperative finding of significant peritoneal sclerosis and bowel adhesion. They were designated as the fail group and were put on long-term hemodialysis. During the review, previous severe peritonitis was defined as a peritonitis episode in the past that required Tenckhoff catheter removal. Relapse was defined as recurrence of peritonitis with the same organism within 28 d after the completion of antibiotic therapy.

Clinical Outcome

Actuarial patient survival and technique survival were studied. As described in our previous studies (8,13), transplantation and loss of follow-up were censored observations for actuarial patient survival. Patient deaths after conversion to hemodialysis were counted as events. Technique survival was defined as the patient remaining alive and on CAPD. All surviving patients were administratively censored on March 31, 2001, for survival analysis.

From July 1999, we performed standard peritoneal equilibration test (PET) (14) in 10 consecutive patients 4 wk after they returned to CAPD. The results were compared with that before the episode of peritonitis (usually 4 wk after the initiation of dialysis). The standard PET as described by Twardowski *et al.* (14) was used. Net ultrafiltration volume and dialysate-to-plasma ratios of creatinine (D/P) of creatinine at 4 h were taken as peritoneal transport parameters.

Statistical Analyses

Statistical analyses were performed by SYSTAT 7.0 for Windows software (SPSS Inc., Chicago, IL). All data are expressed as mean ± SD unless otherwise specified. Data were compared by χ^2 test, Fisher's exact test, *t* test, or Mann-Whitney *U* test as appropriate. Multivariate analysis by logistic regression with the nested model hypothesis and forward stepwise analysis was used to test for independent factors that predicted successful Tenckhoff catheter reinsertion. All baseline demographic and clinical variables were included in the model construction. The Kaplan-Meier analysis was used to express survival data. Actuarial patient survival was compared by the log rank test. Dialysis adequacy, nutritional indices, and peritoneal transport characteristics before and after peritonitis were compared by paired *t* test. $P < 0.05$ was considered significant. All probabilities were two-tailed.

Results

During the study period, PDE failed to clear up after 10 d of antibiotic therapy in 162 episodes of peritonitis, which accounted for 13.8% of all peritonitis episodes in our center during that period. We excluded 43 episodes from analysis because the patient died before Tenckhoff catheter could be removed. The causes of death were peritonitis (31 patients), cardiovascular disease (6 patients), systemic infection not related to peritonitis (4 patients), liver failure (1 patient), and malignancy (1 patient). Another 11 episodes were excluded because the patient died within 4 wk after Tenckhoff catheter removal and before the attempt of Tenckhoff catheter reinsertion. The causes of death were persistent peritonitis with intestinal obstruction (5 patients), cardiovascular disease (4 patients), and systemic infection not related to peritonitis (2 patients). The microbiologic causes of these peritonitis episodes were similar to those episodes of which the patients survived for 4 wk after Tenckhoff catheter removal.

This study focus on the remaining 100 patients, with 108 episodes of peritonitis, who survived 4 wk after Tenckhoff catheter removal. They were followed for 18.5 ± 16.8 mo. The baseline demography and clinical characteristics of the peritonitis episodes are summarized and compared in Tables 1 and 2, respectively. Attempt of Tenckhoff catheter reinsertion was generally a safe procedure. Nevertheless, one patient of the fail group was complicated by accidental small bowel perforation that required laparotomy repair.

Predicting Factors of Successful Tenckhoff Reinsertion

There was no significant difference in the baseline demographic characteristics, prevalences of underlying renal diagnosis, or diabetic status between the success group and the fail group. When compared with the success group, the fail group

Table 1. Baseline demographic and clinical data[a]

Parameter	Success Group	Fail Group
Number of patients	51	49
Gender (M:F)	31:20	24:25
Age (yr)	55.2 ± 12.8	50.8 ± 11.4
Duration on dialysis (mo)	29.7 ± 17.5	41.0 ± 29.2
Renal diagnosis		
glomerulonephritis	15	13
diabetic nephropathy	9	10
polycystic kidney	3	4
hypertensive nephrosclerosis	5	6
obstructive uropathy	7	8
others/unknown	12	18
Disconnect system, *n* (%)	36 (70.6%)	33 (67.8%)

[a] There was no significant difference between the two groups.

had marginally more peritonitis episodes in the past (median, 2 *versus* 1 episode; Mann-Whitney *U* test $P = 0.062$). The fail group was also more likely to have a history of severe peritonitis that required Tenckhoff catheter removal in the past (12 in 49 patients *versus* 3 in 51 patients; Fisher's exact test $P = 0.012$). There was no difference in the prevalence of exit site infection between the two groups. Relapse episode did not predict reinsertion failure (Table 2). Tenckhoff catheter reinsertion was attempted in the success group after a slightly longer period of peritoneal rest than in the fail group (Table 2), but the difference was not statistically significant.

The microbiologic causes of the peritonitis episodes are summarized in Table 3. Although Tenckhoff reinsertion failed in eight of the ten episodes of fungal peritonitis, the result was not statistically significant. Initial choice of antibiotic regimen did not predict failure of Tenckhoff reinsertion (details not shown). With multivariate analysis by logistic regression and forward stepwise analysis, only history of severe peritonitis was an independent predictor of Tenckhoff catheter reinsertion failure.

Patient and Technique Survival

The patients were followed for 18.5 ± 16.8 mo. During the follow-up, 16 patients of the success group died. The causes of death were cardiovascular disease (10 patients), another episode of peritonitis (3 patients), non-peritonitis infections (2 patients), and liver disease (1 patient). There were 15 patients changed to hemodialysis because of peritoneal sclerosis and ultrafiltration failure, two patients received transplants, and three patients were transferred to other dialysis centers.

On the other hand, 20 patients of the fail group died during the follow-up period. The causes of death were cardiovascular disease (11 patients), intestinal obstruction secondary to peri-

Table 3. Microbiologic causes of the peritonitis episodes

Parameter	Success Group (*n*)	Fail Group (*n*)
Number of patients	51	49
Organisms identified		
Staphylococcus aureus	2	3
coagulase-negative staphylococcal species	2	3
Pseudomonas species	16	18
other gram-negative bacilli	6	3
Mycobacterial species	3	1
fungal	2	8
mixed growth	11	9
no growth	9	4

Table 2. Clinical characteristics of the peritonitis episodes

Parameter	Success Group	Fail Group	*P*
Number of patients	51	49	
Previous peritonitis			
number of episodes, median (range)	1 (0 to 9)	2 (0 to 16)	0.062[c]
severe peritonitis[a] (*n*)	3	12	0.012[d]
Current episode is relapse[b] (*n*)	4	5	0.68[d]
Initial antibiotic regimen (*n*)			0.89[e]
vancomycin + cephalosporin	22	23	
cefazolin + netilmicin	18	15	
others	11	11	
Exit site infection (*n*)	13	14	0.73[e]
Number of days between Tenckhoff catheter removal and reinsertion, median (range)	40 (28 to 125)	32 (28 to 112)	0.3[c]

[a] Severe peritonitis is defined as peritonitis that required Tenckhoff catheter removal.
[b] Relapse is defined as recurrence of peritonitis with the same organism within 28 d after the completion of antibiotic therapy.
[c] Mann-Whitney *U* test.
[d] Fisher's exact test.
[e] χ^2 test.

toneal sclerosis (3 patients), non-peritonitis infections (3 patients), malignancy (2 patients), and unknown (1 patient). Eighteen of the 20 deaths occurred within 12 mo (12 within 6 mo) after conversion to long-term hemodialysis. Six patients received transplants, and three patients were transferred to other dialysis centers. The actuarial patient survival is summarized in Figure 1. The success group had a significantly better actuarial patient survival than the fail group did (survival at 24 mo was 80.3% and 56.2%, respectively; log rank test $P = 0.01$).

Only 13 of the 100 patients remained alive and on CAPD 24 mo after the attempt of Tenckhoff catheter reinsertion. The overall technique survival by Kaplan-Meier estimate was 30.8% at 24 mo. In fact, the technique survival of the 100 patients began at 51% because 49 of the patients belonged to the fail group. When the technique survival of the success group was further analyzed, 15 patients changed to hemodialysis because of peritoneal sclerosis and ultrafiltration failure (11 of them within 8 mo after their return to CAPD). The technique survival of the success group was 56.3% at 24 mo.

Peritoneal Permeability and Dialysis Adequacy

In the success group, the standard PET was performed in ten consecutive patients 1 mo after CAPD was resumed. The results were compared with the PET result of the same patient before the development of peritonitis. After resuming CAPD, there was a significant decline in the net ultrafiltration volume at 4 h (0.38 ± 0.16 to 0.21 ± 0.19 L; $P = 0.03$) (Figure 2) and a trend of rise in D/P creatinine at 4 h (0.664 ± 0.095 to 0.725 ± 0.095; $P = 0.15$), although the latter was not statistically significant. There was no significant change in peritoneal Kt/V or nutritional indices after resuming CAPD (details not shown). However, 14 patients required additional dialysis exchange (for example, from 4 to 5 exchanges/d) to maintain adequate clearance, and another 31 patients required hypertonic exchanges to maintain adequate ultrafiltration. Only six patients could continue with their original CAPD regimen (*i.e.*, the regimen before the onset of peritonitis).

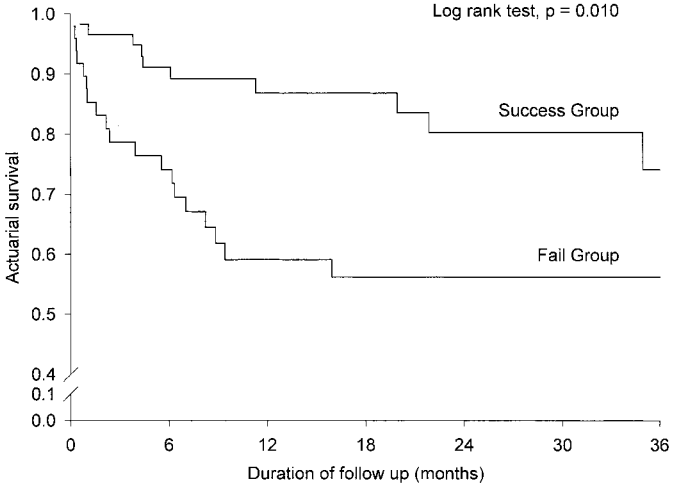

Figure 1. Comparison of actuarial patient survivals between the success group and the fail group.

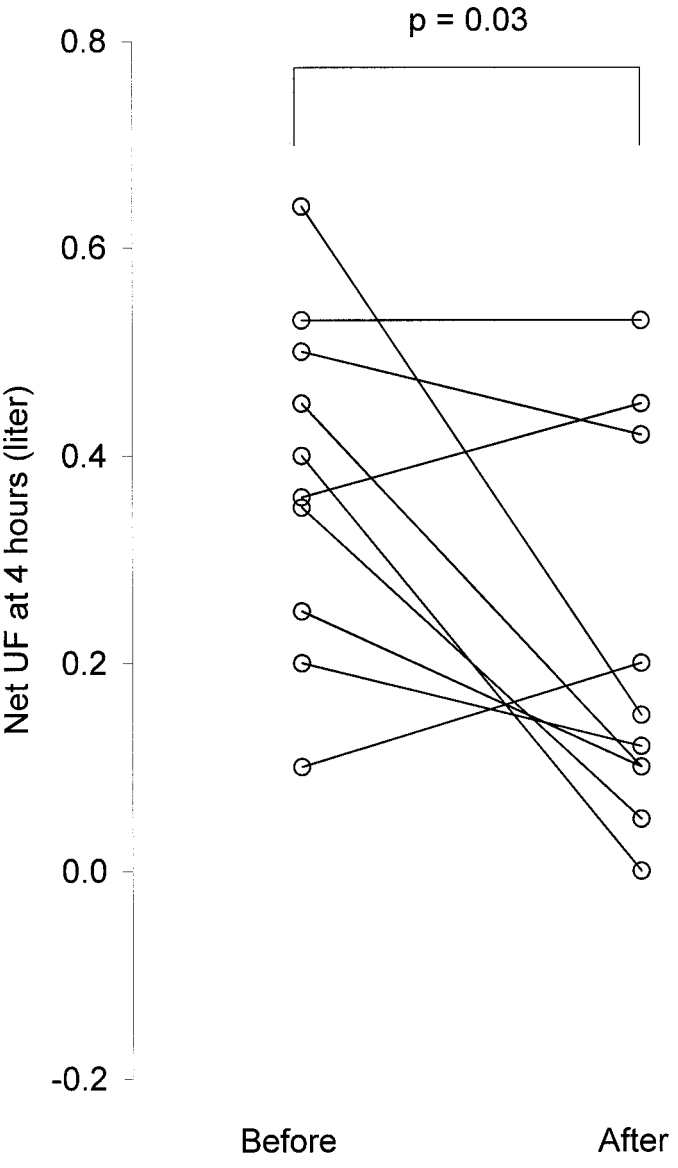

Figure 2. Net ultrafiltration (UF) volume at 4 h during peritoneal equilibration test (PET) before and after peritonitis.

Discussion

In this study of Chinese CAPD patients, we examined the outcome of peritoneal dialysis after an episode of severe peritonitis and Tenckhoff catheter removal. We found that peritoneal dialysis could be resumed successfully in only a small proportion of these patients. It is important to note that in Hong Kong, Tenckhoff catheter reinsertion is attempted in all CAPD patients after Tenckhoff catheter removal and a period of stabilization. As a result, we do not have data on the clinical course of patients who have severe peritonitis but do not attempt Tenckhoff catheter reinsertion.

We found that the success group had a significantly better actuarial patient survival than the fail group. Our observation

did not prove that peritoneal dialysis is a better option for long-term renal replacement therapy in this group of patients. It was most likely that the fail group had more severe peritonitis episodes, which would have contributed to peritoneal adhesion as well as high mortality. Nevertheless, our findings highlighted the fact that failure of Tenckhoff catheter reinsertion *per se* is a predictor of poor survival.

Besides a history of severe peritonitis that required temporary hemodialysis, we could not identify any other clinical factor that could predict failure of Tenckhoff catheter reinsertion. There are two implications. First, our finding provides clinical evidence to support the International Society of Peritoneal Dialysis recommendation (3,4): Tenckhoff catheter reinsertion could be attempted after a period of peritoneal rest (for 4 wk in our present series). Second, there exist important factors that govern the development of peritoneal adhesion in response to peritonitis not yet unidentified. Previous work from our group (15,16) and others (17–19) suggest that the individual variation of inflammatory cytokine responses might be important. The role of inflammatory cytokines and fibrosing factors in peritoneal adhesion requires further studies.

We found that most of the deaths in the fail group occurred within 6 to 12 mo after conversion to hemodialysis (Figure 1). Similar observations had been noted by Woodrow *et al.* (20). Our findings suggest that the excess death early after conversion to hemodialysis, although apparently unrelated, might be an indirect consequence of peritoneal dialysis (for example, inadequate dialysis or poor BP control). As Woodrow *et al.* (20) pointed out, during the statistical analyses of actuarial patient survival of peritoneal dialysis patients, deaths within 6 to 12 mo after conversion to long-term hemodialysis should be attributed to peritoneal dialysis and counted as events. This definition is different from that applied in most of the published studies on peritoneal dialysis survival (8,21,22). It remains unclear, however, whether a change in the definition of event would have an important effect on the survival analysis and interpretation of published literature.

The 2-yr actuarial patient survival rate of the success group was 80.3% in the present study. The result is similar to the overall peritoneal dialysis population of our center, which had a 2-yr survival rate of 83.0% (8). The 2-yr technique survival rate was 56.3% in the success group of the present series, compared with 72.8% of the overall dialysis population (8). However, direct comparison of technique survival to the general CAPD population may not be appropriate because of the difference in duration of dialysis.

We found that most of the technique failures occur within 6 to 8 mo after resumption of peritoneal dialysis, indicating the presence of severe residual damage after peritonitis. An early assessment of peritoneal function after Tenckhoff catheter reinsertion, for example, either by the standard PET (14) or by the modified PET with 4.25% dextrose solution recently proposed for investigation of ultrafiltration failure (23), may be a logical method to prevent the patient from having inefficient peritoneal dialysis as a result of peritoneal sclerosis.

The optimal timing of assessing peritoneal function in this situation remains undefined. We performed the standard PET 4 wk after the resumption of peritoneal dialysis in 10 consecutive patients since mid-1999. We found that peritoneal transport characteristics were substantially affected by peritonitis. Net ultrafiltration declined, and D/P of creatinine at 4 h possibly increased after an episode of peritonitis that required Tenckhoff catheter removal. It is important to note that the number of cases in this study was small, and we did not have sufficient statistical power to detect a small, though clinically important, change in D/P of creatinine at 4 h. The change of peritoneal transport characteristics in the present series was consistent with our previous study in which serial PET was performed (16).

Despite a change in peritoneal transport, dialysis adequacy and nutritional status could be maintained in most patients, and the change in peritoneal transport characteristics could be compensated by increasing dialysis exchange volume or using hypertonic dialysis solution. In addition, it could be argued that at least part of the reason for increasing dialysis exchange volume was attributed to the concomitant loss of residual renal function. However, it is important to appreciate that both the present study and our previous one (16) inevitably underestimated the impact of peritonitis on peritoneal transport because only those patients who could return to peritoneal dialysis and achieve an edema-free state could have PET performed. In fact, PET was not possible in seven patients of the success group after they returned to CAPD because of persistent fluid overload. They were diagnosed as peritoneal failure by clinical judgment.

In general, Asian dialysis patients enjoyed a better clinical outcome when compared with white patients (7,24). It could be argued on the basis of our findings that all CAPD patients (probably even more important for non-Asian patients) who have severe peritonitis and Tenckhoff catheter removal should be put on long-term hemodialysis without further attempt of Tenckhoff catheter reinsertion. However, the clinical benefit and cost effectiveness of this policy could only be proved by a randomized study.

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