Peritonitis during continuous ambulatory peritoneal dialysis in children

Alan R. Watson, MB, ChB, MRCP
Annette Vigneux, RN
Robert M. Bannatyne, MB, ChB, Dip Bact, FRCPC
J. Williamson Balfe, MD, FRCPC

The use of continuous ambulatory peritoneal dialysis (CAPD) in children has proved beneficial. However, peritonitis remains the major complication. A review of the incidence of peritonitis in 55 children (mean age 9.6 years) who underwent CAPD between 1978 and 1984 showed that there were 67 episodes of peritonitis (1 per 9.4 patient-months) in 33 of the 55. Three patients accounted for 22 of the episodes. In all cases, treatment with antibiotics, given intraperitoneally, was successful. Cephalothin was routinely given for infections due to gram-positive organisms, tobramycin for infections due to gram-negative organisms. Peritonitis recurred in seven patients, of whom five had to have their catheters replaced because of associated chronic infections of the deep peritoneal cuff, the exit site or the catheter tunnel. Although peritonitis was a common complication of CAPD in this population, it did not affect the success of the technique.

La dialyse péritonéale continue ambulatoire (DPCA) a fait ses preuves chez l'enfant. La péritonite en reste la principale complication. Parmi 55 enfants (âge moyen: 9,6 ans) sous DPCA de 1978 à 1984, il est survenu chez 33 d'entre eux 67 épisodes de péritonite, soit 1 par 9,4 mois-malades. À eux seuls, trois enfants en présentent 22. L'antibiothérapie intra-péritonéale est efficace dans tous ces cas: céfalotine contre les germes Gram-positif, tobramycine contre les germes Gram-négatif. On observe la rechute de sept malades; chez cinq d'entre eux, une infection chronique du manchon péritonéal profond, du tunnel ou de la plaie externe impose le remplacement de la sonde. Malgré la fréquence de péritonite dans notre réunion de cas, cette complication n'affecte pas l'efficacité de la DPCA.

From the departments of Paediatrics and Bacteriology, Hospital for Sick Children, Toronto

Reprint requests to: Dr. Alan R. Watson, Department of Paediatrics, City Hospital, Hucknall Rd., Nottingham NG5 1PB, England

Continuous ambulatory peritoneal dialysis (CAPD) was introduced in 1978 into the management of children with end-stage renal disease. Since then it has been increasingly used in many pediatric centres[1-3] to enable children to lead relatively normal lives, with greater freedom, while awaiting transplantation. Compared with hemodialysis, CAPD allows improved school attendance, fewer fluid and dietary restrictions and steady-state biochemical control. However, CAPD involves a substantial risk of peritonitis. When renal transplantation is excluded, peritonitis is the most common reason for stopping CAPD in adults and has contributed to 2% of patient deaths during treatments.[4,5]

Early reports suggested that the incidence of peritonitis in children was one episode per 4 to 12.5 patient-months.[6-8] Our initial experience during 183 patient-months was one episode per 13.1 months.[1] In this report we describe our further experience with 55 pediatric patients over a 6-year period and examine the impact of peritonitis on CAPD as a therapy for children with chronic renal failure.

Patients and methods

From May 1978 to April 1984, 55 patients (30 boys and 25 girls) with a mean age of 9.6 years (extremes 0.2 and 19.1 years) underwent CAPD for an average of 11.5 months (extremes 1 and 59 months) at the Hospital for Sick Children, Toronto. A specialist nurse trained the patients or their parents in CAPD techniques during a 10- to 14-day inpatient period. One or both parents were taught to change their child's bag, and most

← For prescribing information see page 1080

patients over 12 years of age were also taught to change their own. Community and local hospital nurses were instructed in basic CAPD techniques so that dialysis could be performed at school or during hospital admissions for parent relief.[9] Three or four exchanges of 300-ml to 2000-ml volumes (30 to 50 ml/kg per exchange) were performed daily with a "spike" apparatus (System I, Baxter-Travenol Laboratories Inc., Malton, Ont.). Connecting-tube changes were performed monthly at the outpatient clinic.

A 20-ml sample of the initial peritoneal effluent was taken and a differential leukocyte count performed with a Fuchs–Rosenthal counting chamber (C.A. Hausser & Son, Philadelphia). The fluid was spun at 500 × *g* for 20 minutes, and Gram staining was performed on the pellet, which was then resuspended in 2 ml of sterile water to lyse the leukocytes and release viable intracellular bacteria. The supernatant and lysed pellet were cultured separately on blood agar and in thioglycollate broth. Cultures were examined daily for growth for 7 days.

Peritonitis was diagnosed when the peritoneal effluent was cloudy (leukocyte count greater than 100×10^6/L) or when organisms were detected in the effluent by either Gram staining or culture in patients with abdominal pain.[10]

Initial treatment included three flushings of the peritoneal cavity with the standard volume of 1.5% dialysis fluid (Dianeal, Baxter-Travenol). Unless the patient was asymptomatic and intraperitoneal bleeding rather than infection was suspected, therapy was started with cephalothin, 500 mg/L, and tobramycin, 1.7 mg/kg per bag, both given intraperitoneally. If gram-positive organisms were detected, cephalothin alone was continued, at a reduced dosage, 250 mg/L; if gram-negative organisms were identified, tobramycin alone (10 mg/L) was used. Patients experiencing their first episode of peritonitis were admitted to hospital whenever possible, but subsequent episodes were treated at home if the symptoms were mild. Leukocyte counts and cultures of the peritoneal effluent were examined daily in hospital only if the fluid was persistently cloudy after 48 hours. Tobramycin was given for 7 days and cephalothin for 2 weeks; therapy was continued until no organisms could be cultured. Oral or intravenous antibiotic therapy was used only if septicemia was suspected or if there was infection at the exit site or in the catheter tunnel. Heparin, 500 to 1000 IU/L, was added to all dialysis bags until the effluent was clear. The use of other "second-line" antibiotics depended on the susceptibility of the clinical isolate and the response to cephalothin or tobramycin.[11]

Relapse of peritonitis was defined as infection apparently with the same organism occurring less than 2 weeks after treatment was stopped.[10]

Statistical significance was assessed with an unpaired Student's *t*-test; a probability of 5% or less was taken as the level of significance.

Results

There were 67 episodes of peritonitis in 33 (60%) of the 55 patients during the 632 patient-months studied; the incidence was 1 episode per 9.4 patient-months. All of the patients with peritonitis responded to appropriate antibiotic therapy. No patient required removal of the indwelling peritoneal catheter when peritonitis first developed. However, seven patients had relapsing epi-

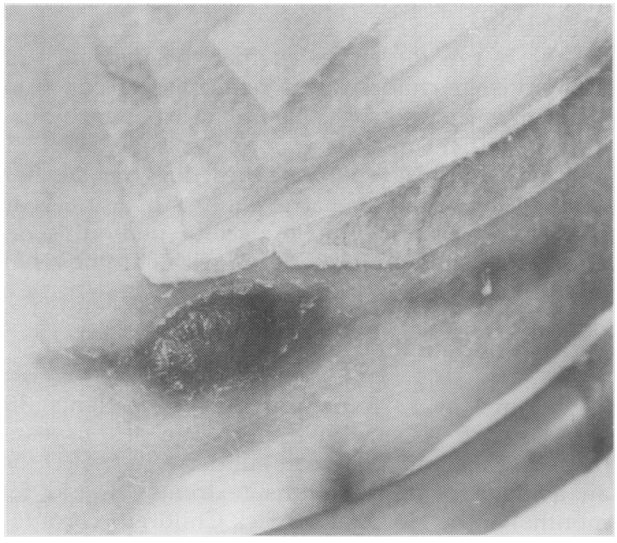

Fig. 1 — Chronically infected granuloma in abdominal wall over deep peritoneal Dacron cuff in 2½-year-old patient. Gastrostomy tube visible in lower right corner.

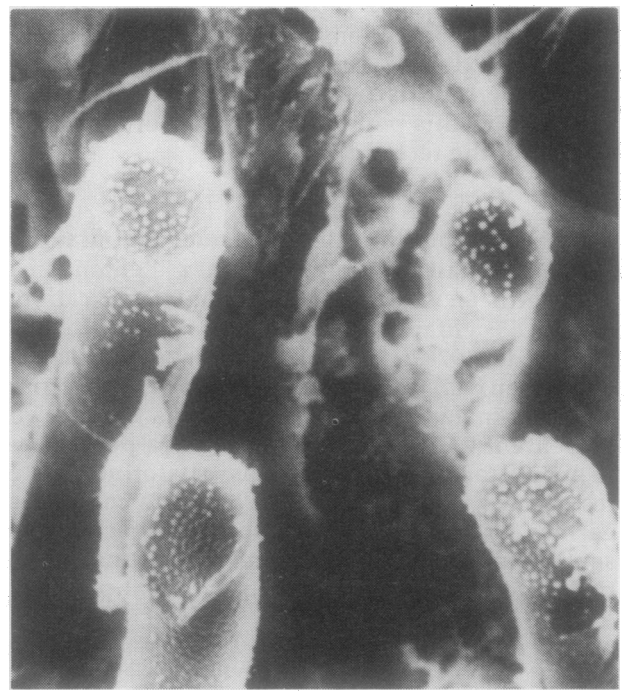

Fig. 2 — Scanning electron micrograph, showing fibres of peritoneal cuff infected with *Staphylococcus epidermidis* (×960, reduced approximately 15%).

sodes, and the catheter was replaced in five of them. Four patients had associated chronic infections of the exit site or the catheter tunnel, or both. The fifth had a superficial granuloma in the abdominal wall at the midline over the site of the deep peritoneal (Dacron) cuff (Fig. 1). Peritonitis due to *Staphylococcus epidermidis* recurred, and chronic infection of the cuff with the organism was demonstrated by scanning electron microscopy (Fig. 2). *S. epidermidis* was also cultured from the peritoneal catheter tube, which was removed in the patient who had recurrent peritonitis but no exit-site or catheter-tunnel infection.

The duration of CAPD was significantly shorter in the patients who did not have peritonitis (mean 7.6 ± 6.0 months, extremes 1 and 19 months) than in those who had at least one episode (mean 14.5 ± 12.1 months, extremes 3 and 59 months) ($p < 0.05$). There was no significant difference in the length of time before the first episode of peritonitis between 13 patients who performed their own dialysis (mean 5.7 ± 6.2 months, extremes 0.5 and 17 months) and 20 patients whose bags were changed by their parents (mean 4.6 ± 5.4 months, extremes 0.5 and 22 months). The mean length of time before the first episode of peritonitis in the first 3 years of the study was 3.6 ± 4.6 months (extremes 0.5 and 17 months), compared with 6.1 ± 6.0 months (extremes 0.5 and 22 months) in the last 3 years; the difference was not significant.

The organisms responsible for the episodes of peritonitis are shown in Table I. Gram-positive organisms accounted for 67% of the episodes, with an almost equal number caused by *S. aureus* and *S. epidermidis*. Three infections due to *Streptococcus viridans* were reportedly related to dental procedures. One infection caused by *Escherichia coli* occurred in an 18-month-old infant who had been undergoing CAPD for 12 months and had had a temporary colostomy for Hirschsprung's disease. None of the infections due to miscellaneous gram-negative organisms were associated with recognized intra-abdominal events. Peritoneal eosinophilia persisted in one infant for a month before spontaneously subsiding.

Three patients accounted for 22 of the 67 episodes of peritonitis. Two were noncompliant adolescent girls who had been transferred to CAPD because they lacked vascular access sites; a return to hemodialysis was not feasible. The third was a 3-year-old child who lived in a foster home and had poor nutritional status. When the episodes in these three patients were excluded from analysis, the incidence of peritonitis was one episode per 15.4 patient-months.

In patients whose serum levels were monitored, tobramycin concentrations reached 1.6 to 6.1 μg/L 3 hours after an intraperitoneal loading dose and 2.8 to 6.8 μg/L 24 hours later in steady state after six hourly exchanges containing tobramycin, 10 mg/L. No ototoxic effects were noted. In 1983, 7 of 26 patients undergoing CAPD spent an average of 8 days each (extremes 2 and 19 days) in hospital for peritonitis-related events.

Discussion

Although peritonitis remains a leading cause of illness and anxiety in our pediatric CAPD program, no patient has died from this complication, and in no case has treatment failure necessitated a permanent transfer to hemodialysis. This experience is in contrast to that in adults, of whom up to 40% have to be transferred to hemodialysis because of recurrent or refractory peritonitis; in addition, one death from peritonitis has been reported to occur every 480 patient-months in adults.[4,5] Although there are problems involving catheter tunnels and poor technique in all age groups, children generally are not exposed to contamination of the peritoneum due to a ruptured viscus or diverticular disease.

We have been fortunate in having a specialist CAPD nursing team from the outset. The benefits of improved teaching techniques and experience are suggested by the increasing interval between the start of CAPD and the first episode of peritonitis.

Although the current rate of peritonitis at our centre, one episode per 9.4 patient-months, is higher than that in 1981[1] (one episode per 13.1 patient-months), it still compares favourably with

Table I—Organisms that caused peritonitis in 33 children undergoing continuous ambulatory peritoneal dialysis

Organism	No. (and %) of episodes of peritonitis (n = 67)	No. of patients with relapsing episodes
Staphylococcus aureus	17 (25)	2
S. epidermidis	16 (24)	3
Streptococcus viridans	12 (18)	
Escherichia coli	3 (4)	1
Miscellaneous gram-negative organisms*	7 (10)	1
β-hemolytic *Streptococcus*	1 (2)	
No organism cultured†	11 (16)	

**Enterobacter, Acinetobacter, Citrobacter* and *Flavobacterium.*
†Includes one episode of peritoneal eosinophilia.

that in other pediatric and adult centres.[12,13] The higher rate reflects a larger population of patients who are undergoing CAPD for longer periods. Poor compliance and poor nutritional status in the three patients who accounted for 22 of the episodes would have resulted in early transfer to hemodialysis had these patients not had problems with vascular access sites. Another factor that is becoming increasingly important is the incidence of exit-site and catheter-tunnel infections, with which some episodes of peritonitis are undoubtedly associated.[14] The case in our patient with a chronically infected granuloma in the abdominal wall over the deep peritoneal cuff was extreme, but if peritonitis recurs following chronic exit-site or catheter-tunnel infection, early catheter change should be considered. Prophylactic therapy with penicillin during dental procedures may help to reduce the incidence of infections caused by *S. viridans*.

We had expected that children still in diapers would have a disproportionately higher incidence of infections with gram-negative organisms because of the greater possibility of fecal contamination. However, the incidence rate of such infections in our patients (14%) was lower than that found at other pediatric centres (20% to 33%).[13,15] Furthermore, our experience with one infant who had a colostomy and another patient who had undergone bilateral ureterostomy suggests that these high-risk procedures do not contraindicate CAPD if parents are well trained in CAPD techniques.

In 11 of the episodes of peritonitis (16%) the effluent yielded no organisms when cultured. This may have been due to varying procedures at the laboratories where culture was done in the case of children who lived at some distance from our centre.

The regimen of intraperitoneal cephalothin or tobramycin, or both, appears to have been effective in most instances. Although the low incidence of infections due to gram-negative organisms in our series suggests that cephalothin alone could be used initially, the synergistic action of cephalothin and tobramycin in rapidly killing organisms, reported from in-vitro studies,[16] has been a persuasive factor in our choice of initial therapy. The high serum levels in steady state in some of our patients have prompted a reduction in the recommended treatment dosage from 10 to 8 mg/L. The pharmacokinetics in children as distinct from adults also needs more careful definition.[17]

The fear of peritonitis was raised as one possible objection to the use of CAPD in children awaiting renal transplantation. This has proved to be unfounded. Apart from one episode of monilial infection, no post-transplantation episodes of peritonitis have occurred in our program to date.[18] If peritonitis develops in patients undergoing CAPD while awaiting transplantation, they are "put on hold" for 2 weeks while being treated. Those with infection of the exit site may undergo transplantation, at which time the catheter is removed.

Peritonitis is still the main complication of CAPD, but with early appropriate therapy, illness can be reduced. The incidence of peritonitis should also decrease as our knowledge of peritoneal defence mechanisms grows[19] and as the problems associated with the currently available catheters are overcome.[14]

We thank Dr. Paul Thorner, for the scanning electron micrographs, and the Medical Publications Department, Hospital for Sick Children, Toronto, for editorial assistance.

References

1. Balfe JW, Vigneux A, Willumsen J et al: The use of CAPD in the treatment of children with end stage renal disease. *Perit Dial Bull* 1981; 1: 35-38
2. Alexander SR: Pediatric CAPD update — 1983. *Perit Dial Bull* 1983; 3 (suppl): S15-S22
3. Salusky IB, Lucullo L, Nelson P et al: Continuous ambulatory peritoneal dialysis in children. *Pediatr Clin North Am* 1982; 29: 1005-1012
4. Fenton SSA: Peritonitis-related deaths among CAPD patients. *Perit Dial Bull* 1983; 3 (suppl): S9-S11
5. Nolph KD, Boen FST, Farrell PC et al: Continuous ambulatory peritoneal dialysis in Australia, Europe, and the United States: 1981. *Kidney Int* 1983; 23: 3-8
6. Fennell RS, Orak JK, Garin EH et al: Continuous ambulatory peritoneal dialysis in a pediatric population. *Am J Dis Child* 1983; 137: 388-392
7. Baum M, Powell D, Calvin S et al: Continuous ambulatory peritoneal dialysis in children — comparison with hemodialysis. *N Engl J Med* 1982; 307: 1537-1542
8. Fine RN, Salusky IB, Hall T et al: Peritonitis in children undergoing continuous ambulatory peritoneal dialysis. *Pediatrics* 1983; 71: 806-809
9. Vigneux A, Hall Y, Willumsen J et al: Pediatric C.A.P.D. — these families need help! [abstr]. *Perit Dial Bull* 1984; 4 (suppl): S69
10. Pierratos A: Peritoneal dialysis glossary. *Perit Dial Bull* 1984; 4: 2-3
11. Balfe JW, Stefanidis CJ, Steele BT et al: Continuous ambulatory peritoneal dialysis: clinical aspects. In Fine RN, Gruskin AB (eds): *End Stage Renal Disease in Children*, Saunders, Philadelphia, 1984: 135-148
12. Gokal R, Ramos JM, Francis DMA et al: Peritonitis in continuous ambulatory peritoneal dialysis. *Lancet* 1982; 2: 1388-1391
13. Salusky IB, Davidson D, Wilson M et al: CAPD/CCPD in children: update 1984. *Perit Dial Bull* 1984; 4 (suppl): S152-S155
14. Watson AR, Vigneux A, Hardy BF et al: Six years experience with CAPD catheters in children. *Perit Dial Bull* 1985; 5: 119-122
15. Muley-Alonso R, Opas LM, Lieberman E: Peritonitis during pediatric continuous ambulatory peritoneal dialysis [abstr]. *Eur J Pediatr* 1983; 140: 149
16. Loeppky C, Tarka E, Everett ED: Compatibility of cephalosporins and aminoglycosides in peritoneal dialysis fluid. *Perit Dial Bull* 1983; 3: 128-129
17. Paton TW, Manuel MA, Walker SE: Tobramycin disposition in patients on continuous ambulatory peritoneal dialysis. *Perit Dial Bull* 1982; 2: 179-181
18. Watson AR, Vigneux A, Balfe JW: Renal transplantation in children on CAPD and post-transplant ascites [C]. *Perit Dial Bull* 1984; 4: 189
19. Keane WF, Peterson PK: Host defence mechanisms of the peritoneal cavity and continuous ambulatory peritoneal dialysis. Ibid: 122-127

For prescribing information see page 1081 →