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EDITORIAL COMMENTARY

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New insights on preventing and managing peritonitis

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Abstract Methods to prevent peritonitis are an essential component of any successful peritoneal dialysis (PD) program. Careful attention to training of the parents and child on the proper technique of PD and avoidance of manual spiking by using an assist device for the cycler, or use of the double-bag system for continuous ambulatory PD, should decrease risk of peritonitis from touch contamination. Secondly, reduction of peritonitis can be achieved through reduction of exit site infections by use of mupirocin antibiotic cream at the exit site of the PD catheter as part of routine care. If an exit site infection develops and is refractory to therapy, then the PD catheter can be successfully replaced as a single procedure, to reduce the risk of peritonitis. The third step in reducing the risk of peritonitis is to avoid repetitive episodes with the same organism. This may again involve replacing the catheter; as long as the effluent can be cleared, this again can be performed as a single procedure, thus allowing the child to avoid the trauma of hemodialysis. The focus in pediatric PD programs must always be on preserving the peritoneal membrane, and not on preservation of the catheter. With careful attention, peritonitis can become an uncommon event.

Keywords *Staphylococcus* · Peritoneal dialysis catheter · Refractory peritonitis · Recurrent peritonitis · Peritoneal catheter exit site infection

Some children on peritoneal dialysis (PD) do not get peritonitis, while other children have multiple episodes, as shown in Fig. 1 [1]. In both children and adults, a minority of patients have the majority of episodes [1, 2]. Finkelstein et al. [2] found that one-third of adults on PD had 2 or more peritonitis episodes, and that in these patients the mean number of episodes per patient was 5, with an astonishing range of 2–17. Most had multiple episodes with the same organism, particularly *Staphylococcus* species. Such patients are at serious risk of not only peritoneal membrane damage, but even sclerosing peritonitis and death [3, 4].

A common approach to the management of frequent PD infections is to transfer the child to hemodialysis (HD)–peritoneal infections are a major cause of transfer [5]. This approach can lead to social and school problems in a child. Furthermore, HD also carries a considerable risk of infection, although the type of infection differs. HD patients (particularly those using a HD catheter) are at risk for bacteremia rather than peritonitis [6]. Therefore, a better approach than transfer to HD is one that decreases the risk of infection on PD.

The first step in preventing peritonitis is to have a proper training program of sufficient length by a skilled PD training nurse [7]. The leading cause of peritonitis continues to be contamination at the time of the PD exchange. Peritonitis due to skin organisms such as coagulase-negative *Staphylococcus*, *Corynebacterium*, and *Bacillus* species are generally accepted as caused by contamination. However, PD patients or the care-giver may also have on their (unwashed) fingers *Streptococcus viridans*, *Staphylococcus aureus*, *Micrococcus*, *Proteus* species, *Klebsiella pneumoniae*, *Enterobacter* species, *Escherichia coli*, and *Acinetobacter* species. Teaching the

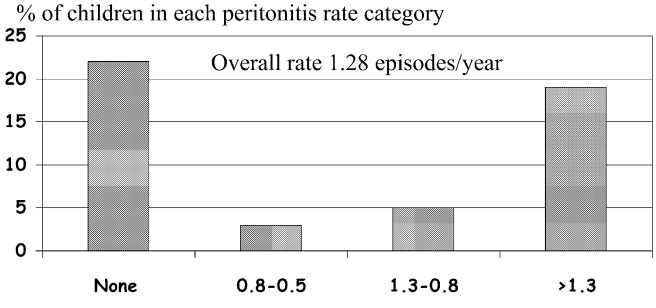

Fig. 1 Percentage of children within each range of peritonitis rates. Data from reference [1]

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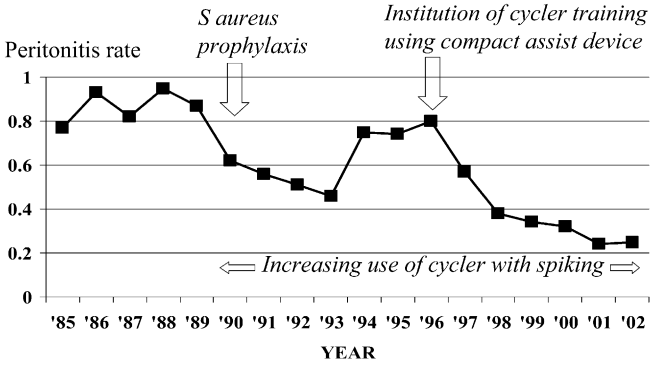

Fig. 2 Peritonitis rates over time in the peritoneal dialysis (PD) program at the University of Pittsburgh, showing interventions. Data from the University of Pittsburgh PD Registry

patient and family members a proper hand washing technique is critical in preventing peritonitis. Touching the connection after hand washing using chlorhexidine followed by thorough drying markedly reduces the numbers of bacteria reaching the peritoneal cavity [8]. Absence of hand washing results in considerably higher numbers of organisms on the connection with accidental touching, and wet hands are even worse, resulting in up to 4,500 organisms transferred to the connection port [8].

Holloway et al. [7], in a multi-center international survey of training procedures in children on PD, showed that the more time spent on theory and the practical aspects of training, the lower the subsequent peritonitis rates ($P<0.01$). Proper training of sufficient length of the patient and family in aseptic technique is obviously critical in reducing peritonitis from contamination. It is unfortunate that in some programs there is no nurse dedicated to the PD program, sometimes no nurse with special experience with children, and that other responsibilities of the nurse may limit her ability to perform training of appropriate length.

Contamination can also be reduced by avoidance of manual spiking by use of double-bag system for continuous ambulatory PD (CAPD) and use of a compact assist device for the spiking with a cycler that requires spiking. We found in our program that use of a cycler that involved spiking increased our peritonitis rate to one episode per year at risk (with most episodes due to coagulase-negative *Staphylococcus*). Our patients on the double-bag CAPD system had 0.2 episodes per year at risk. Since more of our patients were using the cycler, our peritonitis rates doubled overall (Fig. 2). This increased peritonitis risk was eliminated by institution of the use of a compact assist device in all cycler patients. Use of the device minimally increases the time of the procedure and is well accepted by the patients.

The second step to reduce peritonitis risk—after reducing the risk of contamination at the time of the PD connections—is to prevent catheter-related peritonitis. In a program without *S. aureus* prophylaxis, 15%–20% of peritonitis episodes are due to catheter infections, with *S. aureus* and *P. aeruginosa* accounting for the great majority of these infections [9]. Patients most at risk for *S. aureus* catheter-related peritonitis are those who are *S. aureus* carriers [10], but immunosuppressed patients are also at increased risk [11]**.** Often a care-giver (parent, etc.) is performing the PD for the child, and the care-giver may be a carrier. Therefore, the most-rationale approach to prevention is to provide prophylaxis to the exit site of all children on PD. This eliminates a need to culture the nares of the care-givers. Daily exit site mupirocin was highly effective in reducing *S. aureus* exit site infections and related peritonitis episodes in our program [12]. This protocol is well accepted by the patients, who use a cotton swab to place a thin smear of mupirocin cream around the catheter exit site after bathing. Although resistance to mupirocin is slowly emerging after a decade of use in some programs, the protocol still seems to be effective [13].

If despite all precautions, refractory exit or tunnel infection does occur, then the catheter should be replaced prior to the development of peritonitis, to prevent peritonitis. This can be done as a single operation [14]. In this way PD does not have to be interrupted.

The third step in reducing peritonitis is to properly manage repetitive episodes with the same organism—which means replacing the catheter. Once the patient has more than one episode of peritonitis with the same organism, even if separated in time, consideration should be given to replacing the catheter. Replacement of the catheter in the patient with frequent peritonitis appears to decrease the risk of repeat peritonitis with the same organism, even episodes separated by many months [2]. In some patients the slime layer around the intra-abdominal portion of the catheter becomes colonized with micro-organisms (and this occurs most often with *Staphylococcus*), which leads to recurrent episodes of peritonitis. This occurs most often with peritonitis due to coagulase-negative *Staphylococcus* (which is usually considered to be due to either contamination or recurrence from biofilm) and *S. aureus* (which is usually exit site related, but can also be due to biofilm). Catheter replacement in this setting can be easily accomplished (once the effluent has cleared) as a single, simultaneous removal and replacement of the catheter, with re-institution of PD using low volumes for 2 weeks, thus avoiding even a temporary transfer to HD [15, 16]. This approach has been well validated in children, and is likely to be better accepted by the child than transfer to HD, even temporarily.

Refractory peritonitis is defined as an episode in which cloudy fluid persists for 5 days after appropriate antibiotic therapy is initiated. Krishnan et al. [17] found that if the fluid was still cloudy after 5 days, the failure rate was 46%. The ISPD treatment guidelines for children suggest removal after 72–96 h, if the effluent fails to improve with appropriate antibiotic therapy [18]. Delaying catheter removal for refractory peritonitis has dismal results—with as many as 35% of the patients dying, and another 32% with subsequent peritoneal membrane failure [19]. Therefore, in cases of refractory peritonitis the catheter should be removed within 5 days (sooner if deemed necessary by virtue of the appearance of the child), and the patient transferred temporarily to HD. One of the most-common

errors in managing peritonitis is delay in removing the catheter in episodes that are not responding.

Fungal peritonitis accounts for about 3% of episodes in children [20]. Usually the child has severe abdominal pain, and the effluent white blood cell count is high. Gram stain is often helpful in establishing the diagnosis early. *Candida* is by far the most-common organism. Risk factors include frequent peritonitis, immunosuppression, and antibiotic therapy. Gastrostomy feedings do not pose a risk [20]. Of children with fungal peritonitis, 90% require catheter removal, so this process should not be unduly delayed. The catheter can be re-inserted, but a waiting period of 2–3 weeks is advisable [18]. Approximately 10% of patients will have peritoneal fibrosis, making PD no longer an option. Prophylaxis with nystatin, 10,000 units/kg per day given to the patient taking antibiotics, successfully reduces the risk of *Candida* peritonitis [21, 22]. This approach should be considered in children at high risk for fungal peritonitis, including those with frequent bacterial peritonitis, on prolonged courses of antibiotics, or with impaired immune systems.

Peritonitis remains one of the most-serious problems facing the child on PD. Each PD team should have a program of tracking all PD-related infections and implementing appropriate corrective approaches as needed. This process, as shown in Fig. 2, can result in very low infection rates in the PD program. Our rates (in adults) are currently at 0.24 per year or 1 episode per 50 patient-months. Low rates of peritonitis can be achieved by careful training by a skilled dedicated PD nurse, use of the best connection technology (in particular avoiding manual spiking), and use of exit site mupirocin to prevent *S. aureus* infections in all patients.

In patients with either recurrent or refractory peritonitis, the goal should always be that of preservation of the peritoneal membrane, not saving the PD catheter. With repeated peritonitis episodes with the same organism, the catheter should be replaced. This can be performed as a single procedure, with no interruption of PD. With refractory and fungal peritonitis, the catheter should be removed. This approach should help preserve the peritoneal membrane for future use, which is critically important in the child, who is facing many future years with kidney disease.

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