Risk factors for peritoneal dialysis catheter failure in children

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Background **Peritoneal dialysis catheter (PDC) failure still remains a common clinical problem in pediatric patients despite advancements in catheter placement and dialysis techniques. Our aim was to determine the risk factors that may lead to PDC failure, especially those factors that could be potentially modified to minimize PDC failures.**

Patients and methods **This study was designed as a retrospective chart review of 31 patients less than 12 years of age who had end-stage renal disease (ESRD) on whom a total of 54 operative PDC placements were carried out at the tertiary Children's Hospital, King Fahad Medical City, Riyadh, Saudi Arabia, from January 2007 to December 2010. The data included patient demographics and perioperative and operative variables.**

Results **Fifty-four PDCs were inserted in 31 pediatric patients with ESRD, of whom 17 (55%) were boys and 14 (45%) were girls. Young age showed a statistically significant effect on PDC failure [1.8 (±5) vs. 5 (±7.8), $P=0.007$], whereas weight did not ($P=0.085$). Five types of PDCs were used, which showed significant association with PDC failure ($P=0.009$). Supraumbilical paramedian abdominal entry incisions were used in 49 (90.7%) patients without peritoneal leakage in any case. Nonsimultaneous omentectomy and upward PDC exit site orientation showed significant association with PDC failure ($P \leq 0.001$). The causes of PDC failure included idiopathic peritonitis in 13 (56.5%), PDC occlusion by omentum in five (21.7%), PDC malposition in four (17.4%) patients, and PDC leakage in one (4.4%) patient. Peritonitis showed a high statistical significance in PDC failure with P value of less than 0.001. The serum albumin level at the time of PDC insertion was not statistically significant in terms of PDC failure ($P=0.40$) but had a high association with idiopathic peritonitis.**

Conclusion **Our study provides some recommendations to minimize PDC failures that include improvement of patients' nutritional status, use of a swan-neck double-cuffed catheter, paramedian abdominal entry incision, simultaneous omentectomy, downward orientation of exit site, and use of an up-to-date technique by a dedicated team for proper use of PDC. However, prospective studies possibly on a multicentric basis are necessary to standardize the best PDC insertion and maintenance techniques to minimize PDC failures and improve the quality of life for children with ESRD.** ***Ann Pediatr Surg*** **8:35–38 © 2012 Annals of Pediatric Surgery.**

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Background

According to the US Renal Data System and the North American Pediatric Renal Transplant Cooperative Study, ~5000 children younger than 20 years of age and approximately 200 children younger than 2 years of age are being treated annually for end-stage renal disease (ESRD) [1].

Peritoneal dialysis (PD) was first introduced in 1978 and has become the best renal replacement management modality in children with ESRD awaiting renal transplantation [2]. It is now a safe, effective, and well-tolerated form compared with hemodialysis, which requires child admission as an inpatient or clinic attendance as an outpatient for up to 4 h a day, 3 days every week. Nevertheless, PD can be performed at home by caregivers with minimum training [3].

Peritoneal dialysis catheter (PDC)-related complications and failure still remain a common clinical problem in pediatric patients and is as high as 70% in some series despite advancements in PDC placement and dialysis techniques [3]. There are multiple perioperative and patient-related factors affecting PDC survival, including operative technique, catheter selection, and patient variables that may influence catheter lifespan. There exists uncertainty regarding the optimal approach for surgical placement of PDC in children, and this is proven by the American Pediatric Surgical Association and the Canadian Association of Pediatric Surgeons [4].

Our aim in this study was to analyze the risk factors that may lead to PDC failure in children with ESRD, especially those factors that could be potentially modified to minimize PDC failures.

Patients and methods

A retrospective chart review was conducted on 31 patients of less than 12 years of age who had ESRD on whom a total of 54 operative PDC placements were carried out at the tertiary Children's Hospital, King Fahad Medical City, Riyadh, Saudi Arabia, from January 2007 to December 2010. Institutional Review Board approval was

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obtained. The data included patient demographics, serum albumin level, PDC details, types of surgery techniques, reasons for failure, and removal. These data identify perioperative and operative factors associated with failure and nonfailure groups. We did not consider a catheter as having failed if it was functioning when removed following successful renal transplantation or death.

The data were extracted from medical records according to a set proforma and entered into the Access database. Analysis was conducted using statistical software SPSS 18.0 (SPSS Inc., Chicago, Illinois, USA). Median [interquartile range (IQR)] was presented for age and weight, and categorical data were presented in the form of frequencies (percentages). Age and weight were compared between the two groups using the Mann–Whitney *U*-test, whereas categorical variables were compared using either the χ^2 or Fisher's exact test, as appropriate. *P* value less than or equal to 0.05 was considered statistically significant.

Results

Fifty-four PDCs were inserted in 31 pediatric patients with ESRD, of whom 17 (55%) were boys and 14 (45%) were girls; median (± IQR) age was 3.8 (± 6.5) years and weight was 15.5 (± 20) kg. Patients with median age 1.8 (± 5) showed significant PDC failure compared with patients with median age 5 (± 7.8), ($P = 0.007$), whereas weight did not show a significant effect on PDC failure ($P = 0.085$). Sixteen (52%) patients underwent a single PDC placement, 11 (35%) underwent two PDC placements, two (6.5%) underwent three PDC placements, one underwent four placements, and another one underwent six PDC placements. The causes of ESRD included six cases of renal dysplasia/hypoplasia (19.3%), five cases of congenital nephrotic syndrome (16.1%), five cases of reflux nephropathy (16.1%), three cases of obstructive uropathy (9.7%), and three cases each of focal glomerular sclerosis, glomerular nephropathy, hereditary nephropathy, and idiopathy (9.7%).

All PDCs were inserted by laparotomy and the patients were divided into two groups: the nonfailure group (NFG) comprising 31 (57.4%) patients and the failure group (FG) comprising 23 (42.5%) patients. The types of PDCs used are summarized in Table 1 and showed a highly significant PDC failure ($P = 0.009$). Supraumbilical paramedian abdominal entry incisions were used in 49 (90.7%) patients with no peritoneal leakage. Simultaneous omentectomy (SO) was performed in 34 (62.9%) patients and was associated with a lower PDC failure rate compared with when no simultaneous omentectomy was performed [20 (37%) patients; $P < 0.001$]. All PDC tips were placed in the pelvis and tunneled above the fascia before exiting at the skin site that was oriented downward in 32 (59%) patients and was associated with a lower PDC failure rate than when oriented upward in 22 (40.7%) patients, which showed a highly significant association with PDC failure ($P < 0.001$).

The causes of 23 PDC failures included 13 (56.5%) cases of idiopathic peritonitis, five (21.7%) cases of PDC occlusion by omentum, four (17.4%) cases of PDC malposition, and one (4.4%) case of PDC external tube leakage from a hole induced by the patient himself. Peritonitis was proven by peritoneal culture in 17 PDCs (31.4%), including three (17.6%) fungal, four (23.5%) *Staphylococcus aureus*, two (11.8%) *Staphylococcus epidermidis*, one (5.9%) *Pseudomonas aeruginosa*, and seven (41.2%) due to other bacteria. Peritonitis was significantly associated with PDC failure ($P < 0.001$). There was no significant difference in serum albumin levels between the two groups at the time of PDC insertion ($P = 0.400$).

Table 1 The risk factors at the time of peritoneal dialysis catheter insertions

PD-related variables	*N* (%)	NFG	FG	*P* values
Age (years)	3.8 (±6.5)	5 (±7.8)	1.8 (±5)	0.007
Weight (kg)	15.5 (±20) (mean = 15.7)	15.5 (±10) (17.4)	15.5 (±10) (13.3)	0.085
Type of catheter				0.009
Curled tip one cuffed	4 (7.4%)	3 (9.7%)	1 (4.4%)	
Curled tip two cuffed	25 (46.3%)	16 (51.6%)	9 (39.1%)	
Straight tip one cuffed	4 (7.4%)	0 (0.00)	4 (17.4%)	
Straight tip two cuffed	12 (22.2%)	4 (12.9%)	8 (34.8%)	
Swan-neck two cuffed	9 (16.7%)	8 (25.8%)	1 (4.4%)	
Omentectomy				< 0.001
Done	34 (63.0%)	29 (93.6%)	5 (21.7%)	
Not done	20 (37.0%)	2 (6.4%)	18 (78.3%)	
Exit site				< 0.001
Downward	32 (69.3)	26 (83.9%)	6 (26.1%)	
Upward	22 (40.7%)	5 (16.1%)	17 (73.9%)	
Serum albumin (g/dl)				0.400
10–20	5 (9.3%)	2 (6.5%)	3 (13.0%)	
21–30	38 (70.4%)	21 (67.7%)	17 (73.9%)	
> 30	11 (20.3%)	8 (25.8%)	3 (13.0%)	

Statistics presented are median (±IQR) and frequency (%).
FG, failure group; IQR, interquartile range; NFG, nonfailure group; PD, peritoneal dialysis.

Among the FG, 13 PDCs (56.5%) were removed and new PDCs were inserted at the same time; eight (34.8) cases were managed by antirenal failure medication until reinsertion and two (8.7%) PDCs were shifted temporarily to hemodialysis until infection could be controlled and a PDC could be reinserted. However, in NFG, 28 patients (90.3%) were on regular follow-up, two patients were transferred to another hospital for renal transplantation, and one patient died after 1 year from PDC insertion (not dialysis related). Salvage from failure was carried out for 10 PDCs. Five PDCs were salvaged from peritonitis failure by proper medical management: one in NFG and two in FG in whom the PDC was salvaged twice. The other five PDCs were salvaged by laparoscopy (three omentum occlusion and two due to malposition): one in NFG and two in FG in whom the PDC was salvaged twice.

Discussion

PD is used for renal replacement therapy in over 25 000 patients in the USA [5]. Placing PDC in children poses unique challenges, which are reflected in the high complication rates among children and are as high as 70% in some series [3].

Our study agrees with many recent studies [6,7] on the use of paramedian entry incision, SO, and downward exit site orientations in PDC. Chest wall location for the exit site is preferred in infants wearing diapers, in obese infants, and in those with ostomies [8]. Laparoscopy was used in adults and children to rescue the blocked PDC and later for initial placement [9,10]. In our study, laparoscopy was used primarily to rescue five blocked/misplaced PDCs. In accordance with the study by Cribbs *et al.* [3], PDC-related complications and failures were more during young age, especially in those less than 1 year and less than 10 kg.

Our findings corroborate those of previous studies claiming that use of the curled tip, swan-neck, and double-cuff PDC with downward exit delays the time to the first episode of peritonitis in children [11,12]. In contrast, Macchini *et al.* [7] had 89 PDCs implanted surgically with SO in 78 pediatric patients over a 16-year period. They found that a single-cuff catheter had a lower infection rate compared with a double-cuff catheter ($P = < 0.01$). However, Cribbs *et al.* [3] performed 121 PDCs in 81 patients and found that curled catheters offered no advantage against occlusion compared with straight catheters.

Despite the improvements observed in survival after catheter placement over the past several years, PDC infection and malfunction were confirmed to be the most common complications leading to PDC failure [6,7,13]. In our study, idiopathic peritonitis was the first cause of PDC failure ($P < 0.001$). Recurrent peritonitis may lead to irreversible change in peritoneal membrane function, resulting in permanent PD failure [14]; this may explain recurrent PDC peritonitis failures in two of our patients (four times and six times). Many recent studies recommend procedures that may reduce the rate of peritonitis, such as preoperative antibiotic prophylaxis, continuous medical education for the dialysis personnel and parents, intensive training flush before fill dialysis delivery systems, the double-bag connecting system, careful handwashing habits, treatment of nasal carriage of *S. aureus*, and early treatment of exit site infections [2].

In accordance with Rinaldi *et al.*'s [6] study, the second most common cause of PDC failure in our study was PDC obstruction (21.7%). In our study, PDC tip malposition occurred in 17.4% of patients and was one of the causes of PDC failure as a result of impaired dialysate outflow that needed replacement and insertion of new PDCs. Chen and Cheng [15] carried out a simple suture fixation technique of the catheter tip in 38 patients that successfully prevented catheter tip migration [15].

Serum albumin is a marker for malnutrition and also one of the factors predisposing to infection in uremic and dialysis patients. In our study there was no significant difference in serum albumin levels between the two groups at the time of PDC insertion ($P = 0.400$). However, in a study by Wong and colleagues among 1723 children, the researchers found that patients with hypoalbuminemia who were less than 18 years of age at the time of initiating dialysis are at a higher risk for death, and each reduction in serum albumin levels by 1 g/dl at the start of dialysis was associated with a 54% higher risk of death. This result was independent of other potential confounding variables. Hence, the prevention of malnutrition and associated hypoalbuminemia is critical for the improvement of long-term outcome and achievement of optimal growth in children on dialysis [16].

The methods for placement of PDC include the traditional open surgical technique, consisting commonly of a minilaparotomy, the percutaneous Seldinger technique, and recently laparoscopy [17–19]. Each of these techniques is associated with both potential advantages and disadvantages, and, when considering which insertion technique is best, cost-effectiveness, morbidity, and functional outcome should be considered [17]. In our study, we cannot give statistically comparative values because we used the open surgical technique in all PDC placements.

Conclusion

Our study provides some recommendations to minimize PDC failures, which include improvement of patients' nutritional status, use of a swan-neck double-cuffed catheter, paramedian abdominal entry incision, SO, downward orientation of the exit site, and use of an up-to-date technique by a dedicated team for proper use of PDC. However, prospective studies possibly on a multicentric basis are necessary to standardize the best PDC insertion and maintenance techniques to minimize PDC failures and improve quality of life for children with ESRD.

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Conflicts of interest

There are no conflicts of interest.

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