Journal of Pediatric Surgery 53 (2018) 640–643

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Obstruction of peritoneal dialysis catheter is associated with catheter type and independent of omentectomy: A comparative data analysis from a transplant surgical and a pediatric surgical department

Josephine Radtke [a,b,*], Raphael Schild [c], Marc Reismann [b], Robert-Richard Ridwelski [b], Caroline Kempf [d], Bjoern Nashan [a], Karin Rothe [b], Martina Koch [a]

[a] Department of Hepatobiliary and Transplant Surgery, University Medical Center Hamburg-Eppendorf UKE, University Transplantation Center UTC, Hamburg, Germany
[b] Department of Pediatric Surgery, Charité University Medicine Berlin, Berlin, Germany
[c] Department of Pediatric Nephrology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany
[d] Department of Pediatric Nephrology, Charité University Medicine Berlin, Berlin, Germany

ARTICLE INFO

Article history:
Received 19 February 2017
Received in revised form 29 June 2017
Accepted 30 June 2017

Key words:
Catheter
Kidney insufficiency
Obstruction
Peritoneal
Dialysis
Surgical complication

ABSTRACT

Background: Peritoneal dialysis (PD) catheter occlusion is a common complication with up to 36% of catheter obstructions described in the literature. We present a comparison of complications and outcome after implantation of PD catheters in a transplant surgical and a pediatric surgical department.
Methods: We retrospectively analyzed 154 PD catheters, which were implanted during 2009–2015 by transplant surgeons (TS, University Medical Center Hamburg-Eppendorf, Germany, n = 85 catheters) and pediatric surgeons (PS, Charité University Medicine Berlin, Germany, n = 69 catheters) in 122 children (median (range) age 3.0 (0.01–17.1) years) for acute (n = 65) or chronic (n = 89) renal failure. All catheters were one-cuffed or double-cuffed curled catheters, except that straight catheters were implanted into smaller children (n = 19) by TS in Hamburg.
Results: Patient characteristics and operation technique did not differ between the departments. Peritonitis was the most common complication (33 catheters, 21.4%). Leakage (n = 18 catheters, 11.7%) occurred more often in children weighing <10 kg (p < 0.001). The incidence of obstruction and dysfunction was significantly higher in catheters used in PS than catheters used in TS (30.4% vs. 11.8%, p = 0.004). Omentectomy did not reduce the incidence of catheter obstruction (p = 1.0). Perforation at the catheter tips was larger and appeared to be rougher in catheters used in PS than the catheters in TS.
Conclusions: The type of catheter and presumably the type of perforation at the catheter tip may influence the incidence of peritoneal dialysis catheter obstruction.

Acute renal failure (ARF) and chronic renal failure (CRF) are uncommon in children. The incidence of CRF is estimated to be 12.1 cases/million, but the incidence of ARF is difficult to define, as it is often managed conservatively by ICU staff [1,2]. Peritoneal dialysis (PD) is the preferred method when dialysis is necessary in children [2]. It enables dialysis in hemodynamically unstable patients and small children including neonates [3]. Furthermore, no vascular access and no anticoagulation are needed [2]. Despite PD implantation being considered a safe technique, surgical complications during the first 60 days after implantation are estimated to be as high as 40% [4–6]. Obstruction, infectious complications, leakage, and dislocation are the most common complications [4–8]. The incidence of complications is higher in children with a weight less than 10 kg [4,9]. There has been a debate in the literature about whether omentectomy reduces the rate of dialysis catheter obstruction and performance of omentectomy depends on surgeons' preference [2,4–6,8,10].

We previously reported the complication rate in pediatric patients at a department of hepatobiliary and transplant surgery [11]. Here we present the first comparison of complications and outcome after

* Corresponding author at: Department of Pediatric Surgery, Charité University Medicine Berlin, Augustenburger Platz 1, 13353 Berlin, Germany. Tel.: +49 30 450 666 747; fax: +(49) 30 450 566 905.
E-mail address: josephine.radtke@charite.de (J. Radtke).

http://dx.doi.org/10.1016/j.jpedsurg.2017.06.028
0022-3468/

implantation of peritoneal dialysis catheter by transplant surgeons vs. pediatric surgeons at two German hospitals. We posed the question, whether operation technique and type of catheter had an effect on the complication rates.

1. Methods

This is a two center retrospective study of all peritoneal dialysis catheters that were implanted in patients <18 years of age, from January 2009 until August 2015, at the Department of Hepatobiliary and Transplant Surgery at the University Hospital of Hamburg-Eppendorf, in Hamburg, Germany, and at the Department of Pediatric Surgery at the Charité University Medicine Berlin, in Berlin, Germany. A total of 154 PD catheters were included in the analysis.

At the University Hospital of Hamburg-Eppendorf, peritoneal dialysis catheters were one-cuffed or double-cuffed, either straight with a length of 31 cm (Covidien Neonatal; Covidien; Mansfield, MA, USA) or curled with a length of 39 cm (Argyle Curl Cath Peritoneal Catheter or Kendall Quinton Curl Catt; Covidien; Mansfield, MA, USA). The nephrologist and surgeon together estimated the catheter length by taking the distance between the umbilicus and symphysis into account. At the Charité University Medicine in Berlin peritoneal dialysis catheter were always curled and one-cuffed or double-cuffed Joline PD catheters with different lengths (Joline GmbH, Hechingen, Germany). The nephrologists chose the catheter length by measuring the distance between the umbilicus and symphysis and then subtracting 2 cm to obtain the curl-to-cuff distance.

Acute renal failure (ARF) was defined as the necessity of dialysis within the first three months, whereas chronic renal failure (CRF) was defined as need for renal replacement therapy any time thereafter.

Every PD catheter implantation was performed by a specialist of either general or pediatric surgery. At both centers, implantations of peritoneal dialysis catheters were performed through an open approach; a laparoscopic technique was not used. Omentectomy was performed as a partial omentectomy through the open incision by delivering the omentum until tension was achieved and coagulation or ligation of the visible part of the omentum. The catheter was implanted with a downward pointing direction so that the tip was oriented retrovesically. A purse-string suture often sutured the first Dacron cuff to the peritoneum. Every catheter was tunneled through the abdominal wall over a distance of several centimeters to a separate exit site. The second cuff was located in the tunnel. At the end of the operation, every catheter was tested for water-tightness with approximately 10 ml/kg body weight dialysis solution. At both centers, parents received catheter care education by a dialysis nurse during the hospital stay. The education was structured and documented on special forms. To prevent infections, parents were taught the handling of the catheter (e.g. the nontouch technique) and were educated about surroundings. Parents were trained to recognize catheter-associated infections by using a scoring system. In cases of complications, catheter care education was repeated to eliminate any misconduct. At both centers, dialysis nurses and pediatric nephrologists were available around the clock in case of problems.

Data about the surgeon, the operation technique, the duration of the operation, the type of catheter, and the performance of partial omentectomy were obtained from the surgery reports. Medical charts were analyzed for weight at operation, sex, diagnosis, date on which dialysis was started, date of catheter explantation, and complications during the first 6 months after implantation. Peritonitis was defined as a positive microbiological culture of dialysate or a high leucocyte count in the dialysate (>100/μl). Wound infection and leakage were detected by physician examination. Obstruction and dislocation were diagnosed either by the surgeon during revision or by clinical or radiological examination (x-ray). Revision was any reoperation performed under general anesthesia.

Magnification of peritoneal dialysis catheters was performed with a microscope (Ultra microscope II (Light Sheet Microscope), magnification 1.26).

1.1. Statistical analysis

Categorical variables were compared using a chi-square test and were presented as frequencies and percentages. Continuous variables were analyzed using an unpaired *t*-test and were reported as mean ± standard deviation (SD) values. Age was summarized as median and range. Data were statistically analyzed with SPSS version 22 (IBM; Armonk, NY, USA). A P value ≤0.05 was considered significant.

2. Results

2.1. Patient characteristics

In the study period, transplant surgeons implanted 87 peritoneal dialysis catheters in 74 children (37 boys, 37 girls) of which two catheters were never used and therefore excluded from further analysis. During the same period, pediatric surgeons implanted 69 catheters in 50 children (29 boys, 21 girls). At the department of transplant surgery, 9 specialists implanted a total of 85 catheters. Five surgeons implanted more than 10 PD catheters each, and 4 surgeons implanted less than 10 catheters each. At the department of pediatric surgery, 9 specialists implanted a total of 68 catheters. Four surgeons implanted more than 12 catheters each, and 5 surgeons implanted 1–6 PD catheters each. The patient characteristics and operation technique did not differ between the departments (Table 1). Sixty-five catheters were implanted owing to acute renal failure, and 89 catheters were implanted owing to chronic renal failure. The most common cause for ARF was hemolytic uremic syndrome (n = 53, 81.5%), followed by rare causes such as infectious diseases (n = 7), heart disease (n = 3) and metabolic disease (n = 2). Congenital anomalies of the kidney and urinary tract were the reason for CRF in most cases (n = 41, 46.1%), followed by polycystic kidneys (n = 16, 18.0%), chronic kidney damage after hemolytic uremic syndrome (n = 12, 13.5%) and focal segmental glomerulosclerosis (n = 12, 13.5%). The median (range) age at catheter implantation was 3.0 (0.01–17.1) years.

2.2. Peritoneal dialysis catheter complications

During the first 6 month after implantation peritonitis was the most common complication (21.4% of peritoneal dialysis catheter). The second most common complication was obstruction/dysfunction, which occurred in a total of 31 peritoneal dialysis catheters (20.1%). Obstruction/dysfunction occurred in 21 out of 69 PD catheters in pediatric surgery (PS; 30.4%) and in 10 out of 85 PD catheters in transplant surgery (TS; 11.8%; $p = 0.004$, Table 2). When analyzing the children's weight, there was no significant difference between the departments for obstruction in children weighing <10 kg ($p = 0.58$). In children weighing

Table 1
Patient characteristics in transplant surgery (TS) and in pediatric surgery (PS).

	TS (n = 85)	PS (n = 69)
Median age [years]	2.52 (range 0.00–15.5)	3.23 (range 0.03–17.1)
Male [n]	47 (55.3%)	45 (65.2%)
Female [n]	38 (44.7%)	24 (34.8%)
Children's weight [kg]	17.7 ± 16.2	18.5 ± 12.2
Acute renal failure [n]	39 (45.9%)	26 (37.7%)
Chronic renal failure [n]	46 (54.1%)	43 (62.3%)
Explantation of a catheter at the time of implantation [n]	17 (20.0%)	19 (27.5%)
Duration of operation [min]	49.7 ± 21.5	55.3 ± 21.0
Lifetime of catheter [days]	110.6 ± 215.0	84.8 ± 184.5

>10 kg obstruction occurred more often in catheters implanted in the department of pediatric surgery (31.6%) vs. catheters implanted in the department of transplant surgery (6.1%; $p = 0.001$). In most cases (n = 15), the catheter was occluded with parts of omentum (n = 9 in PS, n = 6 in TS). A specific reason for dysfunction could not be found in 12 cases (n = 9 in PS, n = 3 in TS). Rare causes of obstruction were blood clots (n = 1 in TS), gelatinous mass (n = 1 in PS), position in between intestine (n = 1 in PS), and obstruction with parts of fimbrian funnel (n = 1 in PS). Leakage occurred in 18 (11.7%) catheters and was more likely in children with a weighing <10 kg ($p < 0.001$, Table 3). Sixteen (10.4%) peritoneal dialysis catheters dislocated.

2.3. Omentectomy and catheter type and its influence on obstruction/dysfunction

Overall, partial omentectomy was performed during implantation of 33 out of 154 (21.4%) peritoneal dialysis catheters. Omentectomy was significantly more often performed in PS (n = 24) than in TS (n = 9; $p < 0.001$). In PS, omentectomy was mainly performed during implantation of the first catheter (n = 17); whereas in TS, omentectomy was rarely performed during implantation of the first catheter (n = 3) and mainly during implantation of the second catheter (n = 5). When analyzing all catheters with obstruction, the performance of (partial) omentectomy had no protective effect ($p > 0.9$). Partial omentectomy also did not have a positive effect when analyzing obstruction in TS ($p = 0.8$) or PS ($p = 0.7$) separately.

2.4. Skill of the surgeon

Complications, total complication rate, and amount of revisions did not significantly differ in surgeons who implanted more than 10 PD catheters vs. surgeons who implanted less than 10 PD catheters. In a second analysis, only surgeons who implanted more than 10 PD catheters were included. To evaluate the learning curve, complications of the first 5 PD catheters were compared to the subsequent PD catheters of the respective surgeon. There was no significant difference in peritonitis, dislocations, leakage and amount of revisions. When analyzing the obstruction rate, obstructions were significantly more frequent in the first 5 implantations vs. the subsequent PD catheter implantations (45% vs. 16.7%; $p = 0.022$) in the department of pediatric surgery. The rate of omentectomy did not differ for the first 5 implantations vs. the subsequent implantations ($p = 0.2$). There was no significant difference for obstruction when comparing the first 5 implantations vs. the subsequent implantations ($p = 0.2$) in the department of transplant surgery.

3. Discussion

This is a two-center retrospective analysis of complications during the first six months after implantation of peritoneal dialysis catheters in children. We posed the question whether operation technique, patient characteristics, and catheter type had an effect on the complication rate. In our study, only an open approach was performed. A laparoscopic procedure was not used, as several studies found not difference in catheter complications [4,12,13].

The high amount of hemolytic uremic syndrome as a reason for ARF was because of the hemolytic uremic syndrome epidemic in north Germany in 2011 [14]. Peritonitis was the most common complication overall during the first 6 month after implantation (21.4% of catheters), which is consistent with the literature reporting peritonitis at rates of 9.8% to 22.7% in the first 8 weeks after implantation [5,6]. Wound infection was rare in our analysis (n = 6 catheters, 3.9%). Stone et al. reported a wound infection rate of 3.0% [6]. We believe that the low amount of wound infections in our study could be because of the retrospective study design, whereby conservatively managed wound infections would sometimes be missed. The number of cuffs has been discussed as a protective mechanism against infectious complications. Lewis et al. demonstrated a higher incidence of peritonitis associated with *S. aureus* and consequent catheter loss in pediatric patients with single-cuffed vs. double-cuffed PD catheters [15]. Studies on adult patients have shown that the use of double-cuffed PD catheters had no significant benefit with respect to peritonitis and exit site infections [16,17]. In the present study, in both departments either one-cuffed or double-cuffed peritoneal dialysis catheters were used in line with recent recommendations [18]. Despite great effort, we were unable to acquire sufficient data on the number of cuffs to provide reliable evidence on their possible influence on infectious complications. Nessim et al. published a study in 2010 stating that double-cuffed PD catheters lowered the *S. aureus* peritonitis rate among patients initiating PD before 2001. They concluded that the loss of association between cuff number and peritonitis after 2000 may be because of better exit-site care [19]. Owing to the importance of exit-site care for the prevention of infectious complications parents at our centers receive catheter care education by a dialysis nurse during the hospital stay which is then repeated in case of infectious complications to eliminate any misconduct.

Obstruction and dysfunction of the catheter were the second most common complications (n = 31, 20.1% of catheters). The catheter was occluded with parts of omentum in 15 cases. As omentectomy has always been a partial omentectomy, an obstruction with omentum after catheter implantation is still possible. We found one catheter to be blocked with parts of the fimbrian funnel. This has been shown to be a possible cause of catheter obstruction for females and should be kept in mind as a possibility for obstruction in girls [20–22]. It has been shown that ultrasound is able to identify the catheter obstruction and recognize the etiology [23,24].

As the main result of our two-center study, we found that obstruction and dysfunction of the catheter occurred more often in patients in the pediatric surgery department in comparison to patients in the transplant surgery department, despite the same operation technique and similar patient characteristics. Nevertheless, it must be kept in mind that there might be differences in the surgical technique, the catheters, the patient populations, or the hospitals and their practices that were not captured by our analysis. As the benefit of (partial) omentectomy concerning obstruction rate has been a subject of debate [4–8], we analyzed this in detail. Partial omentectomy was performed more often in the department of pediatric surgery, where obstruction and dysfunction were more common. In the department of hepatobiliary and transplant surgery, omentectomy was rarely performed during

Table 2
Complications in transplant surgery (TS) and in pediatric surgery (PS).

Complication	TS (n = 85)	PS (n = 69)	*P*-value
Peritonitis [n]	20 (23.5%)	13 (18.8%)	0.481
Obstruction/Dysfunction [n]	10 (11.8%)	21 (30.4%)	**0.004**
Leakage [n]	9 (10.6%)	9 (13.0%)	0.637
Dislocation [n]	10 (11.8%)	6 (8.7%)	0.535
Wound infection [n]	5 (5.9%)	1 (1.4%)	0.157
Revision of PD catheter [n]	24 (28.2%)	29 (42.0%)	0.073

Table 3
Complications depending on children's weight.

Complication	Weight < 10 kg (n = 47)	Weight > 10 kg (n = 107)	*P*-value
Peritonitis [n]	17 (36.2%)	16 (15.0%)	0.481
Obstruction/Dysfunction [n]	10 (21.3%)	3 (6.1%, TS), 18 (31.6%, PS)[a]	0.814
Leakage [n]	12 (25.5%)	6 (5.6%)	<**0.001**
Dislocation [n]	8 (17.0%)	8 (7.5%)	0.074
Wound infection [n]	3 (6.4%)	3 (2.8%)	0.290
Revision of PD catheter [n]	24 (51.0%)	29 (27.1%)	**0.004**

[a] Obstruction rate significantly differed between the department of transplantation surgery (TS) vs. the department of pediatric surgery (PS); $p = 0.001$.

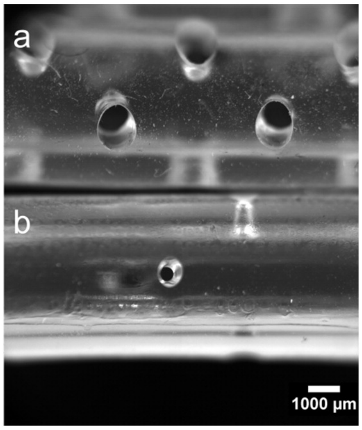

Fig. 1. Joline and Argyle peritoneal dialysis catheter in direct comparison.

insertion of the first catheter and was more common at implantation of a second catheter when the first catheter was affected by obstruction.

When analyzing the skill of the surgeon, we did not find a significant difference in complication rate in surgeons who implanted less vs. more than 10 PD catheters. However, when investigating only surgeons with more than 10 implantations we were able to demonstrate an elevated number of obstructions in the first 5 PD catheters of the respective surgeon in the department of pediatric surgery. This occurred despite a similar rate of partial omentectomies. We therefore conclude that the technique might have changed which we cannot tell by the surgery report.

Nephrologists have been debating whether different types of peritoneal dialysis catheter are associated with an increased risk for obstruction, so we magnified the catheter tips using a microscope (Fig. 1). The PD catheters used in PS had larger perforations in comparison to catheters used in TS. It is imaginable that omentum is more easily dragged into the larger perforations. Meanwhile Argyle peritoneal dialysis catheters are used in both departments. Further observations might show if this modification is associated with a reduction of obstruction and dysfunction rates at the department of pediatric surgery.

In conclusion, we were able to show that complication rates in the two centers did not differ except for obstruction/dysfunction of the catheters, which occurred more often in the pediatric surgery department in Berlin. Patient characteristics and operation technique did not differ between the departments. Obstruction was significantly more frequent in the department of pediatric surgery in Berlin vs. the department of transplant surgery in Hamburg only in children weighing >10 kg. We were able to show that surgeons who implanted more than 10 PD catheters had a learning curve with a decreasing rate of obstructions. Interestingly, we saw a difference in the perforation at the tip of the peritoneal dialysis catheters supporting the idea that obstruction rates may depend on catheter type. We therefore conclude that rate of obstruction results from multiple parameters including surgeon's experience, the child's weight, and catheter type.

Our study has the limitation of a retrospective study. Nevertheless, as follow-up care takes place at the respective center, it is unlikely that severe complications would have been missed. Furthermore there may be differences e.g. in the patient populations, the hospitals, the surgical technique, or the catheters that were not captured by our analysis.

Acknowledgments

The authors would like to thank Dr. Ewa Smajek and Dr. Markus Böttcher (LaVision BioTec, Bielefeld, Germany) for their tips on microscopy. We would also like to thank Michael Hanna, PhD, (Mercury Medical Research & Writing) for proof-reading the manuscript.

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