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Original Article

Peritoneal Dialysis in Children: Infectious and Mechanical Complications: Experience of a Tertiary Hospital in Elazığ, Turkey

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ABSTRACT

Background: Peritoneal dialysis (PD) is frequently used in pediatric patients with renal failure. **Aim:** In the present study, we evaluated the indications and complications of PD and patients' outcomes in pediatric patients. **Patients and Methods:** Medical records of patients who underwent PD between 2012 and 2019 were analyzed retrospectively. The patients were divided into two groups as acute PD (APD) (Group 1) and chronic PD (CPD) (Group 2). If the patient was diagnosed with acute kidney injury (AKI), an APD catheter was inserted, while a CPD catheter was inserted for patients with stage 5 chronic renal failure or those in which AKI persisted for more than 6 weeks. **Results:** Group 1 and Group 2 consisted of 62 and 64 patients, respectively. The most common indications for PD were AKI (64.5%) in Group 1, and obstructive uropathy and reflux nephropathy (45.3%) in Group 2. The overall complication rate was 30%. These were leakage at the catheter insertion site (11.2%), catheter occlusion (4.8%), and peritonitis (4.8%) in Group 1; and peritonitis (14.1%), catheter occlusion (6.2%), and inguinal hernia (4.6%) in Group 2. The mortality rate was 72.5% and 23.4% in Group 1 and Group 2, respectively. The most common causes of mortality were multisystem organ failure (40%) and sepsis (33.5%) in both groups. A total of 83 patients (32 in Group 1 and 51 in Group 2) had omentectomy. Catheter revision and/or removal were performed in 11.9% of all patients. Omentectomy had no effect on the prevention of catheter occlusion ($p > 0.05$). **Conclusion:** The mortality rate is lower in CPD patients than in APD patients. Although PD in pediatric patients is associated with potential complications, its actual rate is relatively low. The primary catheter dysfunction rate is low, and omentectomy has no significant effect on preventing catheter occlusion.

Keywords: *Children, complications, peritoneal dialysis, renal failure*

Introduction

Supporting renal functions encompasses a wide variety of modalities and clinical situations, from the outpatient to the critically ill. Renal replacement therapy (RRT) replaces non-endocrine kidney functions that meet metabolic demands or provides adequate nutrition when supportive therapy is not enough. Other indications for RRT beyond renal failure include electrolyte or acid-base abnormalities, fluid overload, and intoxications. The primary indication for RRT is acute or chronic renal failure. It can be administered intermittently or continuously using extracorporeal (hemodialysis) or paracorporeal (peritoneal dialysis (PD)) methods.[1,2] The patient's age appears to be the most critical factor affecting the decision of which dialysis method to choose.[3]

Artificial support for the functions of inadequate organs has a long history since the beginning of the last century.

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PD is a type of dialysis that uses the peritoneum as a membrane through which fluid and dissolved substances are exchanged with the blood. In PD, a specific solution is introduced through a permanent tube in the lower abdomen and then removed. The solution is typically made of sodium chloride, hydrogen carbonate, and an osmotic agent such as glucose. PD started to be used as an alternative treatment to hemodialysis in pediatric patients with renal failure and/or congenital metabolic disorders in the 1960s.[4,5] Previously, complications such as infections, hernias, hyperglycemia, hemorrhage, and blockage of the catheter were common. However, techniques developed by Popovich and Tenckhoff in the 1960s–1970s reduced the complications that limited the use of this method. PD is preferred over hemodialysis since it is lower in cost and easier to apply, and also because it is difficult to provide vascular access in small children to supply adequate blood flow for hemodialysis. Thus, PD is used as the first choice in the treatment of pediatric patients with renal failure.[6,7]

Although solute clearances in PD are lower than in daily intermittent hemodialysis, PD can provide adequate ultrafiltration (UF) rates and control of biochemical derangements.[8,9] PD is frequently used in pediatric patients with renal failure. This study aimed to evaluate the indications and complications of PD and patients' outcomes in pediatric patients.

Subjects and Methods

This study included 126 patients who underwent PD in the pediatric and neonatal intensive care units of Firat University Hospital. These patients were referred from secondary healthcare institutions to our hospital, which is a tertiary reference hospital. The present study was approved by the Non-Invasive Research Ethics Committee of Firat University (approval date/no: 24.11.2015/20-11). Medical records of patients aged 0–16 years that underwent PD between 2012 and 2019 were retrospectively reviewed. The patients were divided into two groups according to the type of PD: Group 1 consisted of acute PD (APD) patients and Group 2 consisted of chronic PD (CPD) patients. Patients' gender, age, diagnosis, complications, laboratory results, and outcomes were evaluated.

The decision for performing PD was made by pediatric nephrologists. Indications for PD were renal failure presenting with medically intractable fluid-electrolyte imbalance, oliguria, acid-base imbalance along with uremia symptoms (convulsion, hypoactivity, lethargy, etc.), and/or inborn errors of metabolism (hyperammonemia, etc.).

An APD catheter was inserted under local anesthesia by opening a small incision in which the supra-umbilical catheter was passed under sterile conditions. A CPD catheter was placed under general anesthesia with a midline incision after omentectomy in all patients. Single-cuff straight catheters (Covidien, Argyle™, Mansfield, USA) were used for APD, while double-cuff straight catheters (Medionics, Anderson Avenue, Markham, Ont, Canada) were used for CPD. Single-cuff straight catheters (8.5 French) were used for extremely low birth weight babies. Omentectomy was performed in cases where omentum was visible from the incision line while inserting the APD catheter.

The dialysis prescription was adjusted according to the patients' needs. The basic principles include the use of frequent, continuous exchanges with low-volume dialysate. Dianeal PD2 (1.5%–2.5% dextrose) (Baxter Healthcare, Deerfield, USA) or Physioneal 40 (Baxter Healthcare, SA, Castlebar, Ireland) was used as the dialysis solution. While routinely APD was initiated immediately after the insertion of a catheter, CPD was started 10–14 days after the catheter placement to avoid fluid leakage. All patients were treated with prophylactic cefazolin before catheter insertion. PD was started with a 10–20 mL/kg solution, which was gradually increased to 30–40 mL/kg to prevent dialysate leakage and respiratory complications. Dwell time was usually kept between 40 and 60 min per cycle to ensure adequate UF rates. Infants less than 12 months were kept as short as 20 min of dwell time to maintain effective UF. Heparin was added at a dose of 250–500 U/L to prevent clot formation. To avoid fluid overload, PD was started at a concentration of 2.5 g/100 ml (2.5%) of glucose. After a few cycles, the dialysate concentration was switched to 4.25% if more efficient UF was required, or to 1.5% if the patient was euvolemic or hemodynamically unstable. If required, KCl was added to the dialysate solution at a concentration of 3–4 mEq/L to maintain normokalemia. In addition, patients were closely monitored for the development of hyperglycemia. Vital signs of the patients were checked before and after each PD cycle.

Definition of terms: If the patient was diagnosed with acute kidney injury (AKI), an APD catheter was inserted, while a CPD catheter was inserted in patients with stage 5 chronic renal failure or those that AKI persisted for more than 6 weeks during the first admission. Adequate dialysis was defined as improvement in the patient's hemodynamic status, resolution of edema, adequate UF rates, and improving metabolic parameters (serum electrolytes, serum creatinine, and blood urea nitrogen levels). A blood glucose level >125 mg/dL was considered as hyperglycemic. Cloudy peritoneal dialysate or fever was considered as having probable

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peritonitis. A definitive diagnosis of peritonitis was made by the presence of >100 cells/mL white blood cell count, >50% neutrophil, and positive culture in the peritoneal fluid. Wetness around the PD catheter exit site was considered as an indicator of catheter leakage. Isolation of a microorganism from the wound culture was considered as an indicator of wound infection. Multiple organ failure is defined as failure of at least two of the following organs: liver, lung, and kidney. The outcome of patients was "discharged alive" or "death." Living patients were followed up after discharge in terms of long-term prognosis and possible complications as long as they were treated with PD.

Data analysis/management: SPSS 20 package software was used for statistical analysis. The Chi-square test was used to identify factors affecting complications and mortality rate. A *P* value of <0.05 was considered significant.

Results

Out of a total of 138 patients, 12 cases whose data could not be obtained or who were missed from follow-up were excluded from the study; accordingly, the data of a total of 126 patients were analyzed. The age distribution of these patients was between 2 days and 16 years, with a mean of 3.57 ± 4.58 years. Group 1 consisted of 62 patients (62/126). Of them, 29 (46.7%) were males and 33 (53.3%) were females. The most common indications for APD were AKI (*n*: 40, 64.5%), inborn error of metabolism (*n*: 12, 19.3%), and obstructive uropathy and reflux nephropathy (*n*: 5, 8.1%) [Table 1]. Complications related to PD were seen in 18 patients (29%); these were catheter leakage (*n*: 7, 11.2%), catheter occlusion (*n*: 3, 4.8%), and peritonitis (*n*: 3, 4.8%). Microorganisms causing peritonitis in each of the patients with peritonitis were *Klebsiella pneumoniae* (*n*: 1), *Staphylococcus epidermidis* (*n*: 1), and *Acinetobacter baumannii* (*n*: 1). The distribution of complications related to APD is presented in Table 2. Mortality (*n*: 45, 72.5%) were mainly due to multisystem organ failure (*n*: 18, 40%), sepsis (*n*: 13, 28.8%), and inborn error of metabolism (*n*: 9, 20%). The causes of mortality in APD patients are presented in Table 3. Mortality rates were higher in neonates and APD patients. Furthermore, mortality was high in patients with multiorgan failure due to respiratory and circulatory failure and fluid-electrolyte disturbances. Recovery was observed in 59% (10/17) of surviving patients. However, proteinuria and hypertension developed in three patients and chronic kidney disease in four patients.

Group 2 consisted of 64 patients (64/126), 33 of whom (51.6%) were male. The most common indications for CPD were obstructive uropathy and

Table 1: Indications for acute peritoneal dialysis

Diagnosis	Number of patients (*n*)	%
Acute kidney injury	40	64.5
Inborn error of metabolism	12	19.3
Urea cycle defects (*n*: 3)		
Congenital lactic acidosis (*n*: 3)		
Methylmalonic acidemia (*n*: 2)		
Maple syrup urine disease (*n*: 1)		
Propionic acidemia (*n*: 1)		
Citrullinemia type I (*n*: 1)		
Non-ketotic hyperglycinemia (*n*: 1)		
Obstructive uropathy and reflux nephropathy	5	8.1
Congenital nephrotic syndrome	2	3.2
Autosomal recessive polycystic kidney disease	2	3.2
Bilateral renal agenesis	1	1.7
Total	62	100

Table 2: Complications related to peritoneal dialysis

Complication	Group 1 Number of patients *n* (%)	Group 2 Number of patients *n* (%)	Total Number of patients *n* (%)
Peritonitis	3 (4.8)	9 (14.1)	12 (9.5)
Catheter leakage	7 (11.2)	-	7 (5.5)
Catheter occlusion	3 (4.8)	4 (6.2)	7 (5.5)
Catheter exit place infection	2 (3.2)	2 (3.1)	4 (3.2)
Inguinal hernia	-	3 (4.6)	3 (2.4)
Bleeding from the catheter insertion site	2 (3.2)	-	2 (1.6)
Encapsulated peritoneal sclerosis	-	2 (3.1)	2 (1.6)
Bowel perforation	1 (1.6)	-	1 (0.8)
Total	18 (29)	20 (31.2)	38 (30.1)

Table 3: Causes of mortality in patients that underwent acute peritoneal dialysis

Causes of mortality	Number of patients (*n*)	%
Multisystem organ failure*	18	40
Sepsis	13	28.8
Inborn error of metabolism	9	20
Urea cycle defects (*n*: 3)		
Congenital lactic acidosis (*n*: 2)		
Methylmalonic acidemia (*n*: 1)		
Maple syrup urine disease (*n*: 1)		
Propionic acidemia (*n*: 1)		
Citrullinemia type I (*n*: 1)		
Heart failure	4	8.9
Hydrops fetalis	1	2.3
Total	45	100

* *P*<0.0029

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reflux nephropathy (*n*: 29, 45.3%), hemolytic uremic syndrome (*n*: 16, 25%), and autosomal recessive polycystic kidney disease (*n*: 9, 14%) [Table 4]. Complications related to CPD occurred in 20 patients (31.2%), which was mostly peritonitis (*n*: 9, 14.1%). Microorganisms causing peritonitis in each patient were *Escherichia coli* (*n*: 5), *Staphylococcus aureus* (*n*: 2), and *Candida albicans* (*n*: 2). Furthermore, catheter occlusion (*n*: 4, 4.6%), and inguinal hernia which appeared after PD (*n*: 3, 4.6%) were among other common complications. Catheter-related complications were higher in patients with CPD and long-term PD. The distribution of complications related to CPD is presented in Table 2. Mortality was seen in 15 (23.4%) patients mostly due to sepsis (*n*: 5, 33.5%). The causes of mortality in CPD patients are presented in Table 5. Follow-up of 13 surviving APD patients showed complete recovery and their catheters were removed, and the 36 surviving CPD patients are still undergoing dialysis without any problems.

The main laboratory abnormalities were high urea and creatinine levels (*n*: 119, 94.4%) and hyperammonemia (*n*: 4, 3.2%). Electrolyte disorders mainly were hypocalcemia (*n*: 52, 41.3%), hyponatremia (*n*: 5, 27.8%), hyperkalemia (*n*: 30, 23.8%), and hypernatremia (*n*: 13, 10.3%). A total of 83 patients underwent omentectomy (APD/CPD = 32/51).

The mean duration of PD was 12.8 days in Group 1 and 19.4 months in Group 2. Catheter revision and/or removal was applied in 15 (11.9%) patients with peritonitis (*n*: 2/3, Group 1/Group 2), 4 patients with catheter leakage (all in Group 1), 3 patients with catheter occlusion (*n*: 1/2, Group 1/Group 2), 2 patients with sclerosing peritonitis (all in Group 2), and one patient with intestinal perforation (Group 1). In addition, two patients with fungal peritonitis, aged 1 month and 1.5 years, who used a single-cuffed catheter, received antifungal therapy for 3 weeks after the catheter was removed. There was no significant difference between patients with and without omentectomy in terms of catheter occlusion ($p > 0.05$).

Table 4: Indications for chronic peritoneal dialysis

Diagnosis	Number of patients (*n*)	%
Obstructive uropathy and reflux nephropathy	29	45.3
Hemolytic uremic syndrome	16	25
Autosomal recessive polycystic kidney disease	9	14
Nephrotic syndrome	8	12.5
Tumor lysis syndrome	2	3.2
Total	64	100

Table 5: Causes of mortality in patients that underwent chronic peritoneal dialysis

Causes of mortality	Number of patients (*n*)	%
Sepsis*	5	33.5
Obstructive uropathy and reflux nephropathy	2	13.3
Acute lymphoblastic leukemia	2	13.3
Multiple anomalies (VACTERL syndrome)	2	13.3
Autosomal recessive polycystic kidney disease	2	13.3
Glomerulopathy	2	13.3
Total	15	100

* $P<0.003$, VACTERL: Vertebral, anal, cardiac, tracheo-esophagial, renal, limb

Discussion

There are many different indications for PD. Ladd *et al.*[10] have defined the most common indications for PD as a hemolytic uremic syndrome (32%), idiopathic acute kidney failure (15%), and congenital kidney failure (10%). Hakan *et al.*[11] reported that the most common indications for APD were AKI (68.8%) and inborn error of metabolism (23.4%), mainly congenital lactic acidosis (8/18, 44.4%) and hyperammonemia due to urea cycle defects (7/18, 38.9%). In the present study, the most common indications for PD were AKI (64.5%) in Group 1, while it was obstructive uropathy and reflux nephropathy (45.3%) in Group 2. Accordingly, our PD indications were similar to other studies.[11,12] When we looked at our PD indications, it was found that our CPD indications were comparable with the results of Ladd *et al.*,[10] while our APD indications were close to the results of Hakan *et al.*[11] We considered that these results might be related to the age groups of the patients.

Complications seen during PD applications can be classified as infectious/non-infectious causes. Peritonitis has been reported to be the most common reason for the catheter revision in the first year of treatment.[13] It has also been reported that peritonitis is seen more frequently in children aged 0–2 years compared to both older children and adults.[7,14] However, some studies reported that peritonitis is observed in adults and children at the same rate.[15,16] It is widely accepted that the use of double-cuff catheters or the use of swan neck catheters and thus the downward orientation of the catheter exit reduces peritonitis rates.[7] In addition, preoperative antibiotic prophylaxis reduces the risk of peritonitis.[17] In our study, peritonitis was observed in a total of 12 patients (9.5%).

Catheter occlusion is one of the common complications.[18,19] It is usually caused by wrapping the omentum in the tube. However, occlusion has also been reported in patients undergoing partial omentectomy. Routine omentectomy is a controversial issue during

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catheter insertion.[18] In pediatric surgery centers, omentectomy is routinely performed approximately in 53–59% of patients.[11,20] In the study of Cribbs *et al.*,[20] the rate of catheter-related dysfunction was lower in patients undergoing omentectomy. In the study of Conlin *et al.*[21] conducted on 92 children, catheter occlusion rate was 5% in patients undergoing omentectomy, and while it was 10% in patients without omentectomy. On the contrary, Stewart *et al.*[19] reported that omentectomy had no effect on this complication. The catheter may need to be revised sometimes.[7,13,18] It is accepted that catheter occlusion is affected by some factors such as the surgeon's experience, the child's weight, and catheter type.[18] Catheter occlusion was one of the most common (11%) non-infectious catheter complications in our study. The omental wrapping was the most common cause of catheter occlusion. However, in our study, there was no significant difference between patients who underwent omentectomy and those who did not. Catheter revision was required in three patients, while the catheter was reopened in four patients by position change and pressurized irrigation.

In our patients, the most common complication in Group 1 (11.2%) was catheter leakage, especially in newborns with low birth weight. Kara *et al.*[15] reported that dialysate leakage around the catheter was observed three times more frequently in patients less than 12 kg. The reason for this may be the thinness of the abdominal wall and the loosening of the sutures placed in the edematous tissues. Other studies reported that there was no significant leakage in patients who started PD early with small volumes.[11,14] In case of dialysate leakage, depending on the general condition of the patient, it is recommended to reduce the dialysis volume (10–20 mL/kg) or discontinue the PD. In cases where leakages are not resolved, catheter revision or hemodialysis should be considered instead of PD. Our results were comparable with the literature.[7,15,22] In our study, dialysate leakage was detected only in seven (5.5%) APD patients. The problem was resolved by reducing dialysis volume in three cases and catheter revision in four cases.

Swelling, redness, or purulent discharge in the tunnel area or catheter exit site is the clinical signs of infection, which could cause peritonitis. Treatment involves hospitalization of the patient and catheter revision, if necessary, and initiation of appropriate antibiotic therapy.[7,19] It has been reported that this complication is less common in patients undergoing preoperative prophylaxis.[20] Some authors have applied daily ciprofloxacin solutions or antibiotic creams to the catheter exit site to prevent catheter infections. However, these treatments controlled the infection by 50% to 60%. These treatments have proven to be inadequate, especially in infections caused by resistant microorganisms.[23] In resistant infections, the source of the infection is usually the cuff.[23] Dizdar *et al.*[23] recommends gentamicin injection around the cuff in catheter tunnel infections. It is reported that 85% of resistant infections can be controlled by this treatment, which is well tolerated by children. If there is no response to treatment, catheter revision may be required.[13] In our study, catheter exit site infection developed in four (3.2%) cases (2 in Group 1 and 2 in Group 2). They were treated with local dressing in addition to systemic and local antibiotics; catheter revision was not required in any case. Umbilical, inguinal, or incisional hernias, which are more common in young children, may occur in ≥50% of patients with CPD catheters.[19] Some surgeons recommend narrowing and repairing the inner ring to prevent the development of the inguinal hernia when the inner ring is opened during laparoscopic catheter placement.[24] In our study, three patients in Group 2 developed inguinal hernia which was bilateral in one patient that was repaired with non-absorbable sutures.

Although information about mortality is limited in patients undergoing PD, death is usually caused by infections. Matthews *et al.*[12] reported a 61.3% mortality rate in neonates who underwent PD, while Kendirli *et al.*[25] reported a 56.7% mortality rate in pediatric patients aged 3.9 to 5.6 years. In our study, mortality rates were 72.5% in Group 1 and 23.4% in Group 2. Overall 47.6% mortality rate of our series was comparable to the above-mentioned studies. In our series, multisystem organ failure ranks first among the causes of mortality in Group 1, while sepsis ranked first in Group 2.

PD still maintains its importance in the treatment of renal failure in pediatric patients. The limitations of our study were i) a limited number of cases due to its single-center design, ii) being retrospective, and iii) involving more than one practitioner.

In conclusion, PD, which is frequently used in pediatric patients with renal failure, is an effective and safe treatment method. Although PD in pediatric patients is associated with potential complications, its actual rate is relatively low. The primary catheter dysfunction rate is low, and omentectomy has no significant effect on preventing catheter occlusion. Mortality rates in pediatric patients treated with PD are still high due to underlying diseases. However, the mortality rate is lower in CPD patients than in APD patients.

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Authors' contribution

U.B. and M.A. designed the study, M.S., T.T., A.K., and M.K.G. collected and analyzed data, and U.B., M.A., and A.K. wrote the manuscript. All authors read and approved the final manuscript.

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Conflicts of interest

There are no conflicts of interest.

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