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The Acute Temporary Peritoneal Dialysis in Neonates: A Five-Year Experience

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ABSTRACT

***Background*:** The aim of this prospective study was to evaluate the characteristics of patients, treated by acute peritoneal dialysis (PD). We also assessed the indications for PD, PD-associated complications and neonatal outcomes in our patients.

***Methods*:** During five years, 30 term newborns underwent temporary cycling PD. The procedure was performed by applying the manual technique. A straight and relatively rigid peritocat catheter (Germany) was percutaneously inserted in neonates. Statistical analysis was performed, using Chi-square and student's t-test.

***Results*:** All subjects were term newborns, including 16 females (52%) and 14 males (48%). In total, 16 cases (52%) were born via cesarean section. The average age and weight of neonates at catheter insertion were 15 days (range of 5-26 days) and 2800 g (range of 2300-4060 g), respectively. The mean PD duration was two days. There was no significant difference between gender, weight, mode of delivery and associated complications. In total, 74% of patients needed assisted ventilation. No case of death was reported due to catheter insertion; however, 12 patients (40%) died during PD. PD-related complications were reported in 70% of patients, and the most common complication was catheter outflow failure (14 cases, 46%). The underlying causes included inborn errors of metabolism (16 cases, 52%) and acute renal failure (14 cases, 48%). Urea cycle enzyme defect, along with hyperammonemia, was the most common etiologic disease (9 cases).

***Conclusion*:** PD is an effective treatment for seriously ill newborns with life-threatening conditions such as acute renal failure or certain inborn errors of metabolism. However, mortality rate remains high due to the severity of underlying diseases and comorbidities.

Keywords: Acute, Newborn, Peritoneal Dialysis, Temporary

Introduction

Peritoneal dialysis (PD) is generally regarded as the optimal dialysis modality for neonates. PD facilitates the slow removal of fluids and solutes, while preventing hemodynamic instability. PD is technically a simple treatment modality, which can be continuously performed in neonates, hospitalized at neonatal intensive care units (NICUs) (1).

The ability of peritoneum to act as a dialyzing membrane was first established by Putnam in 1922 and further elaborated by Ganter later that decade (2). Acute kidney failure (AKF) has been reported in 6-24% of critically ill neonates, treated at intensive care units (ICUs) (1, 3). Also, previous studies have reported a survival rate of 50% to 90% (1, 2).

For neonates with AKF, who typically require a relatively brief duration of dialysis, the decision to perform the procedure is largely dependent on the infants' size. Although effective and successful dialysis has been reported in infants weighing less than 1 kg, these cases are fraught with difficulty (1). In fact, PD is generally performed after a failed conservative treatment.

Indications for dialysis include decompensated metabolic acidosis, hyperkalemia and/or progressive azotemia, AKF, hyponatremia with symptomatic volume overload, hypocalcemia, hypophosphatemia and inability to provide adequate nutrition given the need for fluid restriction in face of oliguria, hyperammonemia and accumulation of neurotoxic metabolites (4, 5).

The common complications of PD include blood tinged dialysis solution return, bacterial, fungal and eosinophilic peritonitis, peritoneal fluid leakage around the PD catheter and diaphragmatic hernia.

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Moreover, serious associated complications include bowel perforation and bladder rupture (1, 6).

Dialysis has been applied for the treatment of neonatal renal failure for decades. However, in Iran, there is limited information regarding disorders, which cause renal failure and require PD for augmenting the removal of toxic chemicals and improving renal function, associated complications, morbidity and mortality during PD in newborns. Therefore, the aim of this prospective study was to evaluate the characteristics of neonates, treated by PD at the NICU and assess the underlying causes, PD-related complications and neonatal outcomes.

Method

This prospective, case series, descriptive, analytical study was conducted on newborns, requiring PD, who were admitted to the NICU of Sarvar-Sheikh Children Hospital during five years (2006-2011). Indications for PD based on diagnosis after conservative management included de-compensated metabolic acidosis, hyperkalemia and/or progressive azotemia, acute renal failure, hyponatremia with symptomatic volume overload, hypocalcemia, hyperphosphatemia and inability to provide adequate nutrition due to the need for fluid restriction in face of oliguria, hyperammonemia and accumulation of neurotoxic metabolites.

The exclusion criteria were as follows: 1) necrotizing enterocolitis; 2) recent abdominal surgery; 3) diaphragmatic or abdominal wall disruptions; 4) incomplete data; and 5) parents' refusal. For each subject, two informed consents were obtained (one for regular procedures and one for high-risk procedures).

Demographic data were recorded and catheterization for PD was performed at the NICU. For prepping and draping, a sterile mask, cap, gown and gloves were carefully used. Local anesthesia was induced in patients by xylocaine 1%. 16G, OD: 1.7mm, L: 45mm gauge angiocatheter was inserted in order to reach the peritoneal cavity and 30-50 ml/kg of dextrose 1.5% (dialysis solution) was infused in the abdomen to make it moderately tense.

A 1-2 cm skin incision was made over the desired location (at midline, 1-2 cm below the umbilicus). For this purpose, Tro-Venocath Novo (Peritocat 1.5X2.7X200 mm, Braun/ Melsungen, Germany) was used. The trocar catheter was pushed through the peritoneum and was directly advanced toward the small pelvis, without using a guide.

The length of the intra-abdominal catheter was determined as the distance between the umbilicus and symphysis pubis (plus one centimeter). Moreover, the length was adjusted to the size of peritoneal space; afterwards, the drainage of peritoneal fluid was started. The catheter was changed or removed if necessary and a new one was inserted; the new catheter was inserted at the same site.

Heparin, electrolytes and antibiotics were added to the PD fluid, as recommended, and the catheter was removed within three days of insertion or after the patient's condition was stabilized. We kept an accurate record of all fluid intake and output.

The complications were as follows: bright and grossly bloody effluent, cloudy dialysate drainage, bowel perforation, bladder rupture, puncture of large intra-abdominal blood vessels, catheter leakage, pericatheter leakage, outflow failure due to catheter obstruction, omental attachment, infections (positive PD outflow culture, peritonitis and exit-site infections), fluid, electrolyte and metabolic imbalance (i.e., hyperglycemia, hyper-natremia, hypoalbuminemia, hypophosphatemia, hypomagnesemia, hypotension and fluid overload) and cardio-respiratory embarrassment (respiratory rate > 60 bpm, heart rate > 160 bpm).

The position of the catheter tip was determined by abdominal radiography or portable abdominal ultrasonography. The characteristics of dialysate fluid were as follows: Mg 1.5 meq/L, Ca 3.5 meq/L, lactate 355 meq/L, Na 132 meq/L, Cl 102 meq/L, total osmolality 340 mosm/L and dextrose anhydrous BP .75.69 mmol or 13.636 g 1000 ml.

The exchange time for inflow, dwell and drain was one hour. 30-50 ml/kg inflow was by gravity, usually requiring about 10 minutes; warm dialysate solution (37° C) was used. The dwell time was 30 minutes for achieving an exchange. The outflow time was approximately 20 minutes, depending on the total volume to be drained. If the outflow was poor, obstruction was managed by changing the patient's position for optimal outflow and changing the catheter. Also, 15 ml of dialysis fluid from the catheter port was sent for cytological analysis, microbiological evaluation and culture every day.

Data were analyzed by SPSS version 13. Statistical analysis was performed, using Chi-square and student's t-test. P-value less than 0.05 was considered statistically significant.

Results

During five years, 30 newborn patients were on temporary cycling PD at Sarvar-Sheikh Children Hospital. The most common cause of

dialysis was inborn error of metabolism, reported in 16 patients (52%). Also, 14 cases with AKF (48%) underwent PD due to unresponsiveness to conservative medical management.

According to the findings, 16 patients were female (52%) and 14 cases (48%) were male. All patients were term infants (>37 weeks of gestation). Mode of delivery was cesarean section in 16 cases (52%) and vaginal delivery in 14 patients (48%). The average age at catheter insertion was 15 days (range of 5-26 days). The average birth weight of infants was 2800 g (range of 2300-4060 g). There was no significant difference between male and female subjects in terms of gender, weight, mode of delivery and rate of complications.

Overall, 12 patients (40%) died during PD; however, no mortality was directly related to catheter insertion. Also, one newborn needed PD twice within 15 days; the first PD insertion was done at 5 days of age and the second at 15 days of age.

In total, 22 patients (74%) needed assisted ventilation with an endotracheal tube. Before PD, 8 patients with hyperammonemia (26.7%), who had inborn errors of metabolism, underwent two blood transfusions. Also, PD catheters in four patients were changed because of obstruction (three cases in the omentum). Moreover, PD catheters were removed in three cases with bowel perforation, urinary injury and fungal peritonitis.

In five cases, the catheter had to be replaced due to leakage. Also, in patients with catheter malfunction or catheter outflow failure, the catheter had to be replaced. Omentectomy at the time of catheter placement was not performed in our patients. Also, no subjects required peritoneal catheters beyond the acute dialysis period.

The median duration of catheter use was two days (range of 1-3 days). PD-related complications were reported in 70% of patients (patients had more than one complication). The reported complications were as follows: catheter outflow failure or malfunction (14 cases), bloody peritoneal fluid (5 cases), pericatheter leakage (5 cases) catheter obstruction (4 cases), omental attachment around the catheter (3 cases), abdominal distention (3 cases), cardio-respiratory embarrassment (6 cases), fungal infection of peritoneal fluid (1 case), metabolic disorders (1 case), bowel injury (1 case) and bladder injury (1 case). Abdominal wall hernia was developed in no patients.

The indications for dialysis were as follows: AKF due to severe dehydration (2 cases), bilateral renal vein thrombosis (1 case), pseudomonas sepsis (1 case), cardiac failure & congenital cardiac defect (4 cases), congenital bilateral hydronephrosis (2 cases), asphyxia (1 case), hypernatremia (2 cases) and pseudohypoaldosteronism (1 case).

Additionally, congenital metabolic disorders included classic maple syrup urine disease (5 cases), methyl malonic acidemia (2 cases), urea cycle defect with hyperammonemia (9 cases) and argininosuccinase deficiency (1 case).

Discussion

According to the published literature, peritoneal dialysis is regarded as the first method of choice for renal failure treatment in neonates and is the most commonly used renal replacement modality (4, 5, 7). PD is an effective means for the management of metabolic disorders, as well as renal failure in neonates (8). Acute temporary PD is also considered as an appropriate mode of treatment for AKF in preterm newborns and infants up to one year of age.

The overall mortality rate was reported to be 59% in small preterm infants (9). A mortality rate of 45% due to renal failure has been reported in NICU admissions (2). In fact, renal failure accounts for 7% of all deaths in newborns admitted to ICUs (2, 5). In this study, the mortality rate was estimated at 40%, which was associated with the fatal condition of infants at the time of catheter insertion and the severity of complex underlying diseases.

Previous studies have also noted a high mortality rate. In fact, the mortality rate was the highest (100%) in infants with congenital heart disease and renal failure, following cardiopulmonary bypass. Interestingly, 100% mortality was reported in non-oliguric patients with congenital metabolic disorders (2).

Unal S et al. reported inborn error of metabolism as a common etiologic disorder in PD (10). Similarly, in the present study, the most common indication for PD was inborn error of metabolism (52%). On the contrary, in a study by Hakan, the most common underlying cause of PD was acute tubular necrosis (8).

In previously published research concerning chronic PD, infection was the most common complication (2). In our study, catheter outflow failure or malfunction (14 cases) was the most common complication, whereas fungal infection of peritoneal fluid was reported in only one case. Following catheter removal, systemic antifungal therapy (amphotericin B) was continued in the patient with infection. In fact, the low incidence of

infection may be simply due to the relatively short duration of PD.

In the present study, PD catheter obstruction was reported in 7 cases. In fact, in four patients, the PD catheter became occluded with fibrin or the adjacent bowel and in three patients; omental attachment around the catheter was reported. Several researchers have observed that peritoneal catheter obstruction due to omental adherence occurs frequently enough to recommend routine omentectomy at the onset of catheter placement. Therefore, routine omentectomy is not indicated when inserting acute PD catheters in newborns. However, partial omentectomy is reasonable when the omentum presents through the small peritoneal opening at laparotomy (2); however, we did not perform omentectomy in any of our cases.

Peritoneal fluid leakage around the PD catheter and along the tunnel is a serious problem that can increase the risk of bacterial and fungal peritonitis. PD can be confirmed as the source of leakage at PD catheter exit site when the dextrose-detecting strip, dipped in the liquid, indicates a high dextrose concentration. Management strategies include PD discontinuation in favor of hemodialysis, placement of a new PD catheter (rare), temporary discontinuation of PD for 2-7 days or a substantial decrease in PD fill volume (1).

In the present study, blood-tinged outflow was due to vascular injury in the abdominal wall or mesentery (5 cases), similar to a previous research (6). Dialysate leakage was reported in five cases due to the initiation of PD with larger volumes in a watertight peritoneal seal around the catheter.

The development of abdominal wall hernias (e.g., inguinal, umbilical and incisional) is not uncommon in patients with increased intra-abdominal pressure or fluid due to ascites, ventriculoperitoneal shunts or PD. However, no cases of hernia were reported in our study, which may be due to the short duration of PD. The development of abdominal distention alone in one case and its association with cardio-respiratory embarrassment in 6 cases were due to PD fill volume, which was recovered by decreasing the inflow solution.

In the present study, two cases showed serious intra-abdominal damages (1 case of bladder injury and 1 case of bowel injury); the most possible reason was the length of straight catheter, which eroded into the viscera. In these cases, the catheters were removed and the patients were managed via medical treatments.

Cases of intestinal perforation, associated with ventriculoperitoneal shunting, suggest that the catheter can be removed and the infant may be safely treated with antibiotics, gastric suction and bowel rest. In premature infants, the length of straight dialysis catheters may increase the risk of bowel perforation, particularly in the rectum. In fact, PD application is less effective and troublesome for low-birth-weight infants (11). Technical considerations may be of importance in decreasing the incidence of bowel perforation. Moreover, pigtail dialysis catheter is less likely to erode into the bowel (2).

Recent studies have reported that extracorporeal dialysis or continuous venovenous hemodialysis (CVVHD) is more effective than PD in improving the prognosis of newborns. However, CVVHD can be only performed at specialized centers. It was observed that CVVHD decreased the level of toxic metabolites much faster than PD, shortened the dialysis duration and positively affected the neurological outcomes (12).

Conclusion

All PD is an effective therapy for seriously ill newborns with life-threatening conditions such as AKF or certain inborn errors of metabolism. Mortality remains high due to the severity of underlying diseases and comorbidities. However, a promising survival rate can be achieved in 60% of cases who would have otherwise succumbed to the disease.

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