Turkish Journal of Medical Sciences

Volume 48 | Number 2 Article 5

1-1-2018

Peritoneal dialysis in neonates: six years of single center experience

FERDA ÖZLÜ

HACER YAPICIOĞLU YILDIZDAŞ

GÜL ŞEKER

HÜSEYİN ŞİMŞEK

AYSUN KARABAY BAYAZIT

See next page for additional authors

Peritoneal dialysis in neonates: six years of single center experience

Authors
FERDA ÖZLÜ, HACER YAPICIOĞLU YILDIZDAŞ, GÜL ŞEKER, HÜSEYİN ŞİMŞEK, AYSUN KARABAY BAYAZIT, and MEHMET SATAR

TÜBİTAK

Turkish Journal of Medical Sciences

http://journals.tubitak.gov.tr/medical/

Research Article

Turk J Med Sci
(2018) 48: 231-236
© TÜBİTAK
doi:10.3906/sag-1705-175

Peritoneal dialysis in neonates: six years of single center experience

Ferda ÖZLÜ[1,*], Hacer YAPICIOĞLU YILDIZDAŞ[1], Gül ŞEKER[2], Hüseyin ŞİMŞEK[1], Aysun KARABAY BAYAZIT[3], Mehmet SATAR[1]

[1]Department of Neonatology, Faculty of Medicine, Çukurova University, Adana, Turkey
[2]Department of Pediatrics, Faculty of Medicine, Çukurova University, Adana, Turkey
[3]Department of Pediatric Nephrology, Çukurova University, Adana, Turkey

Received: 31.05.2017 • **Accepted/Published Online:** 25.10.2017 • **Final Version:** 30.04.2018

Background/aim: Peritoneal dialysis (PD) is generally considered the practical dialysis modality for neonates in the treatment of acute kidney injury (AKI) and metabolic disturbances. The aim of this study was to evaluate the indications, complications, and outcomes of PD between January 2011 and December 2016.

Materials and methods: This study included all 56 neonates that underwent PD over six years in our neonatal intensive care unit (NICU). A retrospective chart review was performed for all patients in our institution.

Results: The incidence of PD was 1.32% (56/4230 patients) during this period. Mean birth weight of the patients was 2267.77 ± 1060.63 (540–5050) g. Thirty-four (60.7%) patients were premature. Fourteen patients (25%) were in the postoperative period of cardiac surgery due to congenital cardiac defects, fourteen patients (25%) were diagnosed with metabolic diseases, one patient had hypoxic ischemic encephalopathy, and another patient had severe pulmonary hypertension.

Conclusion: In the acute setting of a neonatal intensive care unit, PD performed in a neonate provides a technically simple method of steady fluid, solute removal, and correction of electrolyte abnormalities. A trocar catheter appears safe even in premature babies, and closed three-way stopcock system seems to be reliable at the bedside in NICUs.

Key words: Neonates, peritoneal dialysis, trocar catheter

1. Introduction

Peritoneal dialysis (PD) in neonates can be effective in treating acute kidney injury (AKI) and certain metabolic disturbances such as urea cycle defects with hyperammonemia and congenital lactic acidosis (1,2). PD can be required after cardiac surgery, because even in the absence of evident signs of renal dysfunction a clinical condition of fluid retention and generalized edema is common in neonates after major cardiosurgical interventions.

PD is generally considered the practical dialysis modality for neonates. This allows for the slow removal of fluid and solutes while avoiding hemodynamic instability (1). It is technically simple, and, when necessary, can be performed extensively in neonatal intensive care units. The advantages of PD are its requirement for less specialized expertise, fewer equipment resources, and lower costs. Percutaneously inserted PD catheters can be placed at the bedside. The National Kidney Foundation recommends PD over hemodialysis in children younger than 6 years due to problems with initiation and maintenance of venous access, which is necessary for hemodialysis and for preserving vessels for future transplant (3).

The complication rate with PD ranges from 4.8%, when only complications such as peritonitis, bowel perforation, and hemoperitoneum are considered, to 39%, when including even minor metabolic disturbances such as hyperglycemia and hypokalemia (4).

There is a paucity of data in the literature on the benefits and risks of neonatal PD. The aim of this study was to evaluate the indications, complications, and outcomes of PD between January 2011 and December 2016 in our unit.

2. Materials and methods

Following institutional review board approval, a retrospective chart review was performed for all patients in our institution between January 2011 and December 2016. This study included 56 neonates that underwent PD in our neonatal intensive care unit (NICU), Medical Faculty Hospital, Çukurova University. NICU is a tertiary

* Correspondence: ferdaozlu72@yahoo.com

unit with 40 beds, caring for neonates with both surgical and medical diseases. We usually perform PD if the patient has one of the following: physical evidence of total fluid overload and positive fluid balance, inadequate urine output (<1 mL/kg per hour) or anuria unresponsive to fluid challenge, intravenous furosemide for at least 4 h, acid-base or electrolyte disturbance unresponsive to medical treatment (pH < 7.10, serum K^+ > 8 mmol/L), progressive azotemia, hyperammonemia, and accumulation of neurotoxic metabolites (5,6).

In our unit, the procedure of PD in neonates is carried out as follows. The abdomen is filled with 5–10 mL/kg commercially available dialysis solution, and single-cuffed PD catheters with trocar are placed at 2/3 umbilicus–symphisis pubis length above the symphisis pubis percutaneously at the bedside by a neonatologist, under sterile conditions with local anesthesia (6,7). The part of the catheter with pores is long for neonates and so we cut off half of it and insert the other half. The intraperitoneal part is straight. To avoid peritoneal leakage, dialysis is started with small exchange volumes (10–20 mL/kg). All patients receive 500 IU heparin per liter, prophylactic cefazoline in the dialysate solutions (125 mg/L), and potassium, if the blood serum level is lower than 3.5 mmol/L during the period of dialysis. Volume is increased from 30 to 50 mL/kg when patients' respiratory and cardiac status permits. Peritoneal exchanges are performed hourly with 35- to 40-min dwelling time. Depending on the target fluid balance, dextrose concentration varies from 1.36% to 3.86%. Dialysis solution is connected with a three-way stopcock to both trocar catheter and waste bag in a closed manner under sterile conditions. Dialysis solution volume is arranged through an infusion pump in a controlled manner. The three-way stopcock is controlled manually.

The vital signs (temperature, pulse rate, and blood pressure) are evaluated regularly. Hourly fluid balance is calculated and dwell time adjusted to achieve the maximum negative fluid balance tolerated by the patient. Effectiveness of PD was measured with the improvement of hyperkalemia, uremia, metabolic acidosis, fluid overload, or hyperammonemia.

Indications for withdrawal of PD included resolution of clinical edema with urine output sufficient to maintain or negative fluid balance for at least 12 h, and correction of electrolyte imbalance.

AKI was diagnosed using the Acute Kidney Injury Network (AKIN) criteria (8), defined as a percentage increase in serum creatinine of 50% or more (1.5 times baseline) or a reduction in urine output of less than 0.5 mL/kg per hour for more than 6 h.

Peritonitis was suspected if patients had cloudy dialysate effluent or fever. The diagnosis of peritonitis was based on the presence of 1100 white blood cell/mL, with neutrophil count exceeding 50% of the total and a positive culture of the peritoneal fluid. An exit site leak was considered if there was dialysate moisture around the PD catheter.

Data of the demographic properties of patients, indications, duration, and complications (bleeding, peritonitis, bowel perforation, and extravasations) of PD were collected.

2.1. Statistical analysis

SPSS 19.0 was used for data analysis. Categorical variables were summarized using counts and percentages, whereas continuous variables were summarized in mean ± standard deviation, minimum, and maximum values.

3. Results

This study included all 56 neonates that underwent PD within six years in a tertiary NICU. The demographic characteristics and clinical data of the patients were recorded from their medical files. The incidence of PD among neonates was 1.32% (56/4230 patients) during this period. Indications of PD are given in Table 1. Mean birth weight of the patients was 2267.77 ± 1060.63 (540–5050) g. Thirty-four patients (60.7%) were premature. Fourteen patients (25%) were postoperated due to congenital cardiac defects, fourteen patients (25%) were diagnosed with metabolic diseases (urea cycle defects, organic acidemia), one patient had hypoxic ischemic encephalopathy (PD indication was anuria), and another patient had severe pulmonary hypertension (PD indication was severe metabolic acidosis) (Table 2).

Table 1. Indication for peritoneal dialysis.

Indication for PD	n	%
Anuria/oliguria	22	39.3
Increased creatinine level	10	17.9
Severe acidosis	14	25
Hyperammonemia	10	17.9
Total	56	

Table 2. Characteristics of the patients.

	Mean ± SD Min–max	
Birth weight of patients (g)	2267.77 ± 1060.63 (540–5050)	
Starting day of dialysis (day)	13.76 ± 15.54 (1–79)	
Duration of dialysis (day)	4.44 ± 3.04 (1–16)	
Premature 34 (60.7%)	Gestational age (week) Mean ± SD (min–max)	31.22 ± 4.03 (25–37)
	Birth weight (g) Mean ± SD (min–max)	1584.53 ± 827.50 (540–3600)
	After cardiac surgery	3
	Metabolic disease	5
	(Excluding these 8 preterm patients)	
	Starting day of dialysis (day) Mean ± SD (min–max)	14.37 ± 16.03 (1–79)
	Duration of dialysis (day) Mean ± SD (min–max)	4.37 ± 2.97 (1–16)
	Anuria/oliguria	10
	Increased creatinine level	10
	Metabolic acidosis	6
After cardiac surgery 14 (21.4%)	Starting day of dialysis (day) Mean ± SD (min–max)	6.91 ± 4.34 (1–13)
	Duration of dialysis (day) Mean ± SD (min–max)	3.27 ± 2.28 (1–8)
	Anuria/oliguria	10
	Increased creatinine level	2
	Metabolic acidosis	2
Metabolic disease 14 (25%)	Starting day of dialysis (day) Mean ± SD (min–max)	11.93 ± 12.51 (2–35)
	Duration of dialysis (day) Mean ± SD (min–max)	6.69 ± 4.09 (2–16)
	Metabolic acidosis	4
	Hyperammonemia	10

We did not observe any complication during the insertion of the trocar catheter. The dialysis catheter had to be changed in eleven (19.6%) patients due to malfunction in six patients, leakage in four patients, and bleeding in one patient. The peritoneal catheter was changed in five patients with metabolic disease.

During this study, 134 patients had cardiac surgery (shunt or switch operations) for congenital heart defects. Among them, fourteen (10.44%) patients needed PD after the operation. The peritoneal catheter was changed due to malfunction in five patients that underwent cardiac surgery.

Among the thirty-four preterm patients, five had PD for metabolic diseases and three had cardiac surgery. Five patients needed a catheter change. Ten preterm neonates weighed less than 1000 g at birth, and, to the best of our knowledge, three preterm babies among them were the smallest recorded in the literature (birth weight was 540, 690, and 695 g, respectively). None of these premature patients had electrolyte imbalance and fluid overload, due to dialysate fluid. The preterm baby with 540-g birth weight had PD at postnatal 4th day that lasted for six days. She was discharged on postnatal day 114.

Only one patient had peritonitis (1.78%). Dialysis ended due to recovery in sixteen patients (28.6%), whereas 40 (71.4%) patients (10 patients with cardiac surgery, 9 patients with metabolic disease, and one patient with hypoxic ischemic encephalopathy [HIE]) died during dialysis, due to primary diseases.

4. Discussion

This retrospective study evaluated six years of single institution experience in PD for neonatal patients. PD is frequently required in NICU and is a basic, rational, safe, and effective renal replacement treatment method in infants with AKI and metabolic disorders. It is preferred over hemodialysis and continuous renal replacement therapy in neonates due to the technical difficulties that require vascular access in small infants (1). The decision to initiate dialysis is necessitated by electrolyte abnormalities, worsening uremia, fluid overload, persistent acid-base abnormalities, and need for increased fluid intake to achieve nutrition in a patient with oliguria (1).

Advantages associated with PD include simplicity and lower cost of the procedure, absence of hemodynamic compromise, avoidance of the requirement of vascular access and anticoagulation, and efficacy in terms of fluid and solute management even in the youngest patients.

One of the most important indications for PD is AKI. Prerenal causes in neonates are common among AKI cases (9,10). Prerenal causes include hypovolemia from hemorrhage, dehydration, or third space losses. In this study, 57.2% (39.3% anuric and 17.9% with increased creatinine) of our patients had AKI prior to PD.

Urine output is the most common clinical measurement of renal function; however, most cases of reversible neonatal AKI develop long before the detection of oliguria or anuria (11,12). PD of twenty-two of our patients started due to anuria.

Acute renal injury is common in extremely low-birth weight infants with a frequency ranging from 8% to 24% (13). As reported in the literature, the main causes of renal failure in preterm infants are drug toxicity, hemodynamic disturbances, and sepsis (11,14). Thirty-two of our patients were premature and, among these, ten were extremely low-birth weight infants. Preterm patients may simultaneously have many indications of PD, and it is generally difficult to differentiate the main cause of renal failure. Additionally, term infants can be affected by AKI, in particular those with severe ischemia after hypovolemia, hypoxemia, and hypotension, with the leading causes being perinatal anoxia/ischemia, sepsis, and feeding problems. Twenty-four (42.8%) patients of this study were term babies.

Reported incidence rates of acute renal injury requiring replacement therapy after pediatric cardiac surgery have varied from 2.1% to 17% over the past decades (15,16). Several other authors have reported that renal replacement therapy is delivered in up to 10% of children undergoing cardiac surgery for congenital heart disease, and is associated with a high mortality rate (17,18). In our study, 8.20% of the patients that had had cardiac surgery in the previous six years needed PD. Although there is no evidence of renal dysfunction, a clinical condition of fluid retention and generalized edema is common in neonates after major cardiosurgical operations (18). Our postcardiac surgery patients needed PD mostly for oliguria/anuria.

Inborn errors of metabolism commonly manifest during the neonatal period due to accumulation of neurotoxins or irreversible neurologic damage. PD can effectively treat many neonatal metabolic disturbances, including urea cycle defects with hyperammonemia and congenital lactic acidosis. A total of 25% of our patients with PD had metabolic diseases. We preferred to use PD in newborn infants with metabolic disease due to its simplicity and easy application.

Moreover, HIE is an important risk factor for renal failure. In a study comparing asphyxiated neonates and healthy control subjects, only 21% of the babies had oliguric renal failure, whereas 78% were noted to have nonoliguric renal failure (19). In the same study, the mortality of infants with oliguric renal failure was 43%, whereas it was 8% in nonoliguric infants. In our study period, only one patient with HIE needed PD, during which he died.

PD complications are mainly caused by catheter-related problems or infection such as catheter malfunctioning, bowel perforation, and peritonitis. The most common complication is dysfunction of the catheter, which requires catheter replacement. Eleven (19.6%) patients in this study required catheter replacement and the most common reason was malfunction.

A life-threatening complication of the procedure is peritonitis, which was suffered by only one of our patients. Although the control of the three-way stopcock is manual, the overall system we use is a closed system. This closed system may be preferred in other hospitals when they do not have automatic machine control systems of PD.

Fluid leakage was the second common complication in our patients. In four patients, the leak resolved after

decreasing the exchange volume. Dialysis was still effective. Peritoneal fluid leakage around the PD catheter and the tunnel is a serious problem that can increase the risk of bacterial and fungal peritonitis.

To minimize the complications associated with PD access, a number of catheters have been tried in small infants, including a chest tube and vascular catheter (20,21). However, there is limited information on the outcome of PD in premature neonates. We had thirty-two premature patients who had dialysis, and we put a trocar catheter in all our patients. We did not experience any complications during the insertion of the catheter. Ten preterm babies were below 1000 g in birth weight. In our study, we report the smallest infants recorded in the literature, with 540-g birth weight.

These patients have high mortality rates due to the serious nature of the primary causes. Early recognition of the need for PD, and early application can contribute to reduction of mortality. When managed properly, dialysis is a lifesaving treatment in neonates with AKI. Many neonates that had PD for acute renal failure and died had complications unrelated to their dialysis or acute renal failure (1). Matthews et al. (22) reported a mortality rate as 61.3% in infants that underwent PD. In the study by Blowey et al. (23) in 23 newborn infants that underwent PD, the mortality rate was 35%. Maizlin et al. reported a mortality rate of 65.3% (24). The mortality rate of our patients who underwent PD was 71.4%, and all died due to causes other than dialysis. The higher mortality rate of our study may be due to our NICU being the only tertiary-level NICU in the southeastern part of the country, where all complicated cases with metabolic diseases, congenital heart defects, and high-risk pregnancies are admitted. Mortality in children suffering from multiorgan system failure was reported to have increased to 60%–70%, regardless of the type of renal replacement therapy performed (25). Therefore, the mortality rate of 71.4% found in our patients suffering from the above-mentioned diseases seems fairly acceptable.

There is no consensus on the type of specialist that inserts the PD catheter. Harshmann et al. reported a pediatric surgeon inserting the catheter, whereas Ustyol et al. reported a surgeon or neonatologist (6,7). In our unit, a neonatologist inserted the PD catheter.

Various commercial and improvised catheter types have been described for PD in neonates. Alpaslan et al. and Unal et al. reported two large series of PD in neonates, using rigid catheters in the infraumbilical position (26,27). Oyachi et al. describe the use of a flexible Blake silicone drain in a term infant requiring PD (28). Yu et al. detail the novel use of a vascular catheter placed in the upper right quadrant; however, high rates of catheter leak, poor drainage, and kinking were noted (29).

Macchini et al. compared different PD catheters and reported that dialysis was effective in all the children. They concluded that although leakage was observed in the 2 patients with Tenckhoff catheter, it did not significantly affect the efficacy of PD (13).

The retrospective nature of the study is its main limitation.

In conclusion, PD is a basic, rational, and feasible mode of dialysis for neonates. In the acute setting of a neonatal intensive care unit, PD performed in a neonate provides a technically simple method of adequate fluid and solute removal and correction of electrolyte disturbances. The trocar catheter appears to be safe even in premature babies, and the closed three-way stopcock system appears reliable at the bedside in NICUs.

References

1. Lee MM, Chua AN, Yorgin PD. Neonatal peritoneal dialysis. Neoreviews 2005; 8: 384-391.
2. Popovich RP, Moncrief JW, Nolph KD. Continuous ambulatory peritoneal dialysis. Artif Organs 1978;2: 84-86.
3. National Kidney Foundation. Guidelines for Peritoneal Dialysis. New York, NY, USA: National Kidney Foundation, 2000. Available at: www.kidney.org/proffesionals/KDOQ/guidelines_updates/doqiuppd_iii.html.
4. Sorof JM, Stromberg D, Brewer ED, Feltes TF, Fraser CD Jr. Early initiation of peritoneal dialysis after surgical repair of congenital heart disease. Pediatr Nephrol 1999; 13: 641-645.
5. Yu JE, Park MS, Pai KS. Acute peritoneal dialysis in very low birth weight neonates using a vascular catheter. Pediatr Nephrol 2010; 25: 367-371.
6. Ustyol L, Peker E, Demir N, Agengin K, Tuncer O. The use of acute peritoneal dialysis in critically ill newborns. Med Sci Monit 2016; 22: 1421-1426.
7. Harshman LA, Muff-Luett M, Neuberger ML, Dagle JM, Shilyansky J, Nester CM, Brophy PD, Jetton JG. Peritoneal dialysis in an extremely low-birth-weight infant with acute kidney injury. Clin Kidney J 2014; 7: 582-585.
8. Mehta RL, Kellum JA, Shah SV, Molitoris BA, Ronco C, Warnock DG, Levin A. Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. Crit Care 2007; 11: R31.
9. Agras PI, Tarcan A, Baskin E, Cengiz N, Gürakan B, Saatci U. Acute renal failure in the neonatal period. Ren Fail 2004; 26: 305-309.

10. Tóth-Heyn P, Drukker A, Guignard JP. The stressed neonatal kidney: from pathophysiology to clinical management of neonatal vasomotor nephropathy. Pediatr Nephrol 2000; 14: 227-239.

11. Andreoli SP. Acute renal failure in the newborn. Semin Perinatol 2004; 28: 112-123.

12. Haycock GB. Management of acute and chronic renal failure in the newborn. Semin Neonatol 2003; 8: 325-334.

13. Macchini F, De Carli A, Testa S, Arnoldi R, Ghirardello S, Ardissino G, Mosca F, Torricelli M, Leva E. Feasibility of peritoneal dialysis in extremely low birth weight infants. J Neonat Surg 2012; 1: 52.

14. Coulthard MG, Vernon B. Managing acute renal failure in very low birth weight infants. Arch Dis Child 1995; 73: 187-192.

15. Pedersen KR, Povlsen JV, Christensen S, Pedersen J, Hjortholm K, Larsen SH, Hjortdal VE. Risk factors for acute renal failure requiring dialysis after surgery for congenital heart disease in children. Acta Anaesthesiol Scand 2007; 51: 1344-1349.

16. Boigner H, Brannath W, Hermon M, Stoll E, Burda G, Trittenwein G, Golej J. Predictors of mortality at initiation of peritoneal dialysis in children after cardiac surgery. Ann Thorac Surg 2004; 77: 61-65.

17. Chan KL, Ip P, Chiu CSW, Cheung YF. Peritoneal dialysis after surgery for congenital heart disease in infants and young children. Ann Thorac Surg 2003; 76: 1443-1449.

18. Hassinger AB, Wald EL, Goodman DM. Early postoperative fluid overload precedes acute kidney injury and is associated with higher morbidity in pediatric cardiac surgery patients. Pediatr Crit Care Med 2014; 15: 131-138.

19. Gupta BD, Sharma P, Bagla J, Parakh M, Soni JP. Renal failure in asphyxiated neonates. Indian Pediatr 2005; 42: 928-934.

20. Kohli HS, Bhalla D, Sud K, Jha V, Gupta KL, Sakhuja V. Acute peritoneal dialysis in neonates: comparison of two types of peritoneal access. Pediatr Nephrol 1999; 13: 241-244.

21. Huber R, Fuchshuber A, Huber P. Acute peritoneal dialysis in preterm newborns and small infants: surgical management. J Pediatr Surg 1994; 29: 400-402.

22. Matthews DE, West KW, Rescorla FJ, Vane DW, Grosfeld JL, Wappner RS, Bergstein J, Andreoli S**.** Peritoneal dialysis in the first 60 days of life. J Pediatr Surg 1990; 25: 110-115.

23. Blowey DL, McFarland K, Alon U, McGraw-Houchens M, Hellerstein S, Warady BA. Peritoneal dialysis in the neonatal period: outcome data. J Perinatol 1993; 13: 59-66.

24. Maizlin II, Shroyer MC, Perger L, Chen MK, Beierle EA, Martin CA, Anderson SA, Mortellaro VE, Rogers DA, Russell RT. Outcome assessment of renal replacement therapy in neonates. J Surg Res 2016; 204: 34-38.

25. Golej J, Kitzmueller E, Hermon M, Boigner H, Burda G, Trittenwein G. Low-volume peritoneal dialysis in 116 neonatal and paediatric critical care patients. Eur J Pediatr 2002; 161: 385-389.

26. Alparslan C, Yavascan O, Bal A, Kanik A, Kose E, Demir BK, Aksu N. The performance of acute peritoneal dialysis treatment in neonatal period. Ren Fail 2012; 34: 1015-1020.

27. Unal S, Bilgin L, Gunduz M, Uncu N, Azili MN, Tiryaki T. The implementation of neonatal peritoneal dialysis in a clinical setting. J Matern-Fetal Neo M 2012; 25: 2111-2114.

28. Oyachi N, Obana K, Kimura S, Kubo M, Naito A, Nemoto A. Use of a flexible Blake® silicone drains for peritoneal dialysis in the neonatal intensive care unit. Pediatr Int 2011; 53: 417-418.

29. Yu JE, Park MS, Pai KS. Acute peritoneal dialysis in very low birth weight neonates using a vascular catheter. Pediatr Nephrol 2010; 25: 367-371.