

Peritoneal dialysis for extremely low birth weight infants

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Objective: We determined the mortality ratio and risk factors of peritoneal dialysis (PD) in the treatment of acute kidney injury (AKI) in extremely low birth weight (ELBW) infants.

Methods: PD was performed in 14 ELBW infants (9 males and 5 females) from 1997 to 2010, out of more than 151 total ELBW infants seen during that period. Treatment with PD fluid was started at 10 ml/kg and gradually increased to 40 ml/kg checking for leakage and hyperglycemia, with a storage time of 60-90 min/cycle continuing for 24 hours.

Results: Fourteen ELBW infants were treated, 9 of whom were successfully weaned (6 infants died within several weeks after discontinuation and 3 survived). The mortality rate of patients treated with PD (9.2% of all ELBWI infants) was 79%. Patients that had complications involving fewer organs survived. All patients who received PD and suffered from intracranial hemorrhage, necrotizing enterocolitis, or disseminated intravascular coagulation died. Among the 7 patients with patent ductus arteriosus for whom PD was performed, 6 died. Among the 3 patients with pulmonary hemorrhage for whom PD was performed, 2 died. Patients who survived were weaned off PD within 6 days. The side effects of treatment included hyperglycemia, peritonitis, leakage of the PD fluid, and catheter obstruction.

Conclusions: Mortality of ELBW infants with AKI is quite high because patients' organs are immature and, therefore, often have other organ failures; however, PD itself can be performed safely. Starting PD treatment before the onset of anuria may improve the survival rate of ELBW infants with AKI.

Key words: acute kidney injury, extremely low birth weight infants, peritoneal dialysis, ductus arteriosus, intracranial hemorrhage

Introduction

Peritoneal dialysis (PD) for acute kidney injury (AKI) of newborns has been performed safely and we created the a standard protocol for initiating this dialysis. However, the prognosis is still poor for extremely low birth weight (ELBW) infants with AKI. PD is still the main method for treating children with AKI, especially neonates, because of their low body weight and the poor access to blood vessels. Several patients with contraindications for PD received hemodialysis in our hospital. We discuss the prognoses of these ELBW infants who received PD treatment for AKI.

Materials and Methods

Patients

From 1997 to 2010, we had 151 ELBW infant patients and performed PD in 14 of those (9 males and 5 females).

All of the patients were Japanese. The mean gestational age was 25 weeks and 3 days \pm 14 days, and the mean birth weight was 701 g \pm 118 g.

Statistical Analysis

The average of ratios in each group was compared using Fisher's PLSD (protected least significant difference) followed by ANOVA (analysis of variance). Results are presented as means \pm standard error (SE). P values of <0.05 were considered statistically significant.

Indications

Our criteria to start dialysis were treatment-resistant hyperkalemia, anuria or oliguria lasting more than 48 hours, treatment-resistant metabolic acidosis, and BUN (blood urea nitrogen) over 100 mg/dl. We also took into account the patients' general conditions and the prognoses of the original diseases. The main reasons for starting PD in this study were hyperkalemia and oliguria.

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Catheters

There are two ways to perform PD, using either using a double or a single route. We used a 10 French (J-VAC) drain or a single cuff Tenckhoff catheter (Covidien; Mansfield, MA, USA) or Tenckhoff peritoneal dialysis catheter (Cook Inc.; Bloomington, IN, USA).

Dialysis fluid

Dialysis fluid (1.5% PD-4, Baxter International; Deerfield, IL, USA), was started at 10 ml/kg and gradually increased to 40 ml/kg while checking for leaks and hyperglycemia. Storage time was 60-90 min/cycle and PD was continued for 24 hours.

Operations

After local anesthesia, a 23-gauge needle was inserted at the left side of the umbilicus under echographic guidance in order to inject 5 ml of sterile saline. The catheter was placed in the peritoneal cavity using a guidewire fixed to the skin with sterilized strip tape and covered by sterilized clear coating film (Figure 1).

Results

There were no statistical differences between patients

who survived those who deceased in the gestational age (26 weeks + 6 days \pm 9 days vs. 25 weeks + 5 days \pm 1 day), birth weight (743 g \pm 148 g vs. 690 g \pm 114 g), starting date of PD after birth (9.7 days \pm 9.9 days vs. 5.3 days \pm 3.3 days), and a duration of PD (4.7 days \pm 1.5 days vs. 7.7 days \pm 7.7 days) ($P > 0.1$) (Table 1). PD was performed on 14 of the 151 ELBW infants, 9 of whom were successfully weaned from PD (64%). Six of these 9 patients died within several weeks after stopping PD treatment due to other causes, and 3 patients survived. The mortality rate of all the ELBW infants at our hospital with AKI was 79%. The mortality rate of ELBW infants receiving PD and those without were 79% and 27%, respectively (Figure 2). The lower limits of weight and age for survivors were 614 g and 26 weeks 2 days, respectively, while those for the patients who died after weaning from PD were 546 g and 24 weeks 4 days, respectively.

The patients who survived showed less organ dysfunction compared with those who did not. The infants younger than 25 gestational weeks of age had trouble surviving in either the presence or absence of organ failure (Figure 3). Sepsis and disseminated intravascular coagulation (DIC) were not included as organ failure in this study. Four patients with patent ductus arteriosus

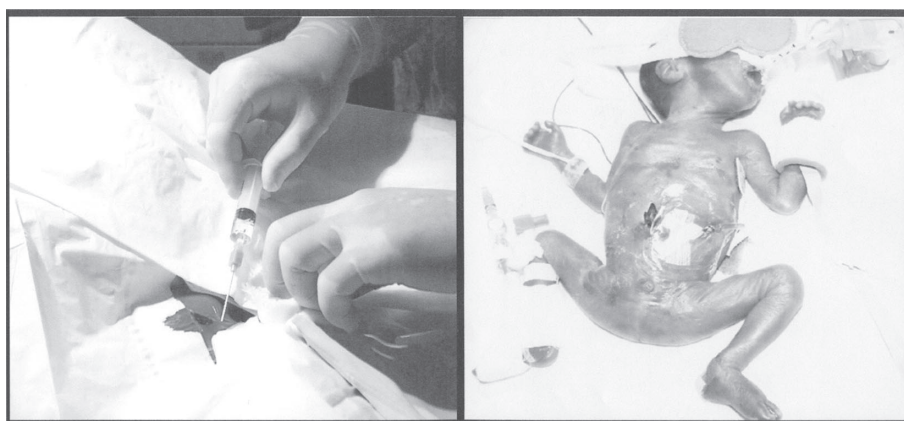


Figure 1. Insertion of peritoneal dialysis (PD) catheter in an extremely low birth weight (ELBW) infant*

Table 1. Patients' characteristics

	GA	BBW	Starting Date	Duration
Mean (14)	25 w + 6 d \pm 14 d	701 g \pm 118 g	6.2 d \pm 5.2 d	7.1 d \pm 6.9 d
Survival (3)	26 w + 6 d \pm 9 d	743 g \pm 148 g	9.7 d \pm 9.9 d	4.7 d \pm 1.5 d
Deceased (11)	25 w + 5 d \pm 1 d	690 g \pm 114 g	5.3 d \pm 3.3 d	7.7 d \pm 7.7 d

There were no statistical differences between survival and deceased in GA, BBW, starting data, and duration of PD ($P > 0.05$).

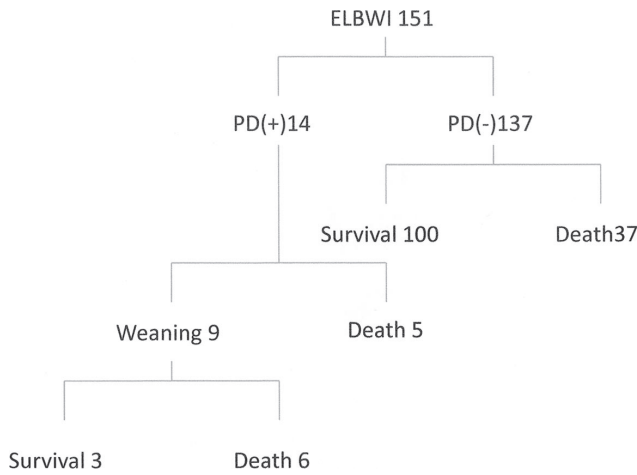


Figure 2. Prognosis of 151 extremely low birth weight (ELBW) infants

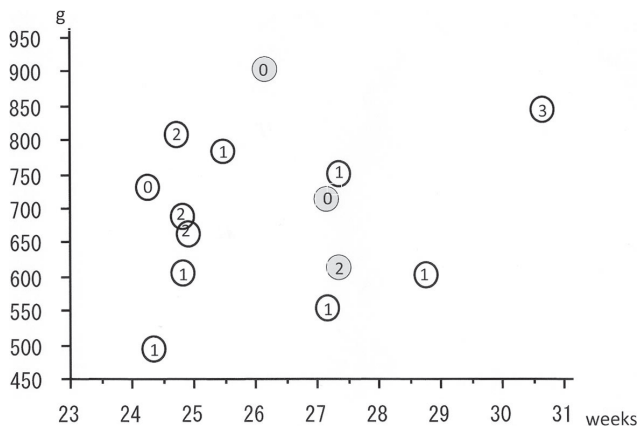


Figure 3. Influences of multiple organ failure in PD patients
Open circles indicate deceased. Yellow circles indicate survival. Number in circle indicates the number of other organ failures

Table 2. Complications of PD patients

	PDA	DIC	NEC	ICH	Sepsis	PH
Total	7	5	4	3	3	3
Survival	1	0	0	0	0	1
Deceased	3	3	2	1	1	1

PDA, patent ductus arteriosus; DIC, disseminated intravascular coagulation; NEC, necrotizing enterocolitis; ICH, intracranial hemorrhage; PH, pulmonary hemorrhage

were weaned off PD. All 3 patients with intracranial hemorrhage (ICH) died. All patients who suffered from DIC and sepsis and necrotizing enterocolitis died. Seven patients suffered complications due to patent ductus arteriosus of whom 6 died and 1 survived. Among the 3 patients with pulmonary hemorrhage for whom PD was performed, 2 died and 1 survived. Patients who survived were weaned off PD within 6 days (Table 2).

The side effects of the PD treatment were hyperglycemia, peritonitis, leakage of PD fluid, and catheter obstruction. These were all effectively managed and were not life threatening. PD itself can be performed safely; however, the mortality of ELBW infants with AKI is quite high because of the immaturity of the organs and organ failure. The patients who were weaned off PD died within a few weeks due to the deterioration of ICH, new ICH, or DIC.

Discussion

The survival rate of very low birth weight (VLBW) infants has steadily increased through the decades in Korea; 33.8% in the 1960s, 43.2% in the 1970s, 49.2% in the 1980s, and 67.1% in the 1990s.¹ This survival trend has continued throughout the 2000s 77.5% in 2002, 84.7% in 2007, and 85.7% in 2009.¹ ELBW infants are newborns weighting less than 1,000 g at birth. Their survival rates of ELBWIs showed a more marked increase during the same time in Korea; 8% in the 1960s, 37.4% in the 1990s, 56.1% in 2002, 67.7% in 2007, and 71.8% in 2009.²

In Japan, the survival rate of ELBW infants has also increased. It was 82.3% and 87.0% in 2000 and 2005 respectively.³ They have significantly lower survival rates compared with VLBW infants (1,000 g-1,500 g) but the gap is narrowing. In approximately 60% of ELBW infants death occurs within 1 week of life, the causes of which are mostly related to prematurity.⁴ Perinatal asphyxia is the major cause of death in infants in the first week of life, whereas sepsis is the primary cause after 4 weeks. Sepsis is also the primary cause of death in premature and low birth weight infants, and perinatal asphyxia is the main cause of death in full-term or normal weight infants.⁵

AKI occurs frequently during which time ICH and sepsis are the main causes of death followed by fetal distress and pulmonary hemorrhage. AKI without multiorgan failure itself is not a frequent cause of death, but the combination of AKI and multiorgan failure is a significant risk factor for mortality in preterm infants.⁶

Infants under 25 weeks of gestational age have difficulty surviving even without the presence of organ

failure, due to the immaturity of their organs. However, organ failure occurs more frequently and causes death. The main cause of the patients' death is a complication of the main cause of death.

There is no guideline-based evidence concerning indications for renal replacement therapy for ELBW infants. Treatment largely depends on the capabilities of any given medical facility. The indications for starting dialysis vary at different institutes. These differences may affect the survival rate in ELBW infants.

Yu et al. reported that the recovery rate from AKI of ELBW infants was 54%.⁷ Their recovery rate is similar to that in the present study of 64%. Their indications to perform PD were the same as those in our hospital.

All of the patients in present study suffered failure of at least 2 organs. The survival rate may increase with early PD treatment. We need to consider the indications of PD for ELBW infants.

Recently, hemodialysis (HD) to treat ELBW infants has increased, but there remain serious side effects with this treatment, including low blood pressure, risk of bleeding, respiratory distress, coagulation problems, long-term vessel stenoses, and arteriovenous fistulas. More evidence is needed to evaluate HD treatment for ELBW infants.

One reason we choose to use PD to treat in ELBW infants was that the priming volume is smaller than that for HD, which is too large; and, therefore, it is difficult to maintain the circulatory dynamics of the patient. In our hospital, the smallest priming volume for HD is 35 ml for infants larger than 5 kg. HD may be performed for infants weighing 2.5 kg if we determine that the risk is low. For infants weighting less than 2.5 kg, we must remove the chambers that increase the risk. In which case, we must pay extra careful attention to the patients' blood pressure, because hypertension may cause ICH, and hypotension may cause periventricular leukomalacia.

Another reason we chose PD to treat these patients is that in such small infants blood access is difficult, and blood flow is not sufficient. We sometimes encounter patients with complete obstruction of their femoral veins after HD. Yet another reason is that the dialysis circuit easily coagulates because of high hemoglobin concentration and it is difficult to control anticoagulation. It is noteworthy that the risk of the late-phase complications, such as blood vessel stenosis, remain unknown. Because of these reasons, we decided to perform PD because PD is safer in these extremely small

infants, especially in neonates.

Indications for HD treatment in ELBW infants at our hospital are: to remove substances of large molecular sizes including toxins, and cytokines, if PD is likely to cause severe respiratory disorder and presence of large lesions occupying excessive space in the peritoneal cavity, for severe water and electrolyte imbalances, and for high peritoneal permeability.

Complications limit the use of a catheter beyond 7-10 days due to the risk of leakage from the point of insertion. These complications were easily resolved by inserting the catheter into the contralateral side of the patients' body. There were no peritoneal infections in any of the patients in the present study.

We prefer to use the intermittent method. The continuous method may be safe because there is no tension to the abdominal cavity; however, it increases the risk of a puncture injury. Further studies with larger populations are warranted to elucidate these issues and to provide clearer guidelines for PD and HD treatments in ELBW infants to help improve their rate of survival.

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