CLINICAL STUDY

Early Initiation of Peritoneal Dialysis after Arterial Switch Operations in Newborn Patients

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Abstract

Background and aim: We investigated the clinical outcome of early initiated peritoneal dialysis (PD) use in our newborn patients who underwent arterial switch operation (ASO) for transposition of the great arteries (TGA) and had routine intraoperative PD catheter implantation. We determined the risk factors for PD, factors associated with prolonged PD, morbidity, and mortality. The aim of the present study was to describe our experience of using PD in this patient cohort.

Materials and Methods: Eighty two patients who were diagnosed with TGA and TGA-ventricular septal defect (VSD) and who had undergone TGA correction operation at Başkent University, Istanbul Medical Research and Training Hospital between 2007 and 2012 were retrospectively investigated. All the patients were under 30 days old. PD catheters were routinely implanted intraoperatively at the end of the operation. PD was initiated in transient renal insufficiency. In the absence of oliguria and increased creatinine level, PD was established in the presence of one of the following: clinical signs of fluid overload, hyperkalemia (>5 mEq/L), persistent metabolic acidosis, lactate level above 8 mmol/L or low cardiac output syndrome. The patients were divided into two groups according to the need for postoperative PD (PD group and non-PD group). PD was initiated in 32 (39%) patients after the operation, whereas 50 (61%) patients did not need dialysis. The clinical outcomes and perioperative data of the two groups were compared.

Results: The demographics in the two groups were similar. Cardiopulmonary bypass time was longer in the PD group [non-PD group, 175.24 ± 32.39 min; PD group, 196.22 ± 44.04 min (p < 0.05)]. Coronary anomaly was found to be higher in the PD group [non-PD group, n = 2 patients (4.0%); PD group, n = 7 patients (21.9%); p < 0.05]. There was more need for PD in TGA + VSD patients [simple TGA patients, n = 14; TGA + VSD patients, n = 18 (p < 0.05)]. PD rate was higher in patients whose sterna were left open at the end of the operation (p < 0.05). The ventilator time [non-PD group, 4.04 ± 1.51 days; PD group, 8.12 ± 5.21 days (p < 0.01)], intensive care unit stay time [non-PD group, 7.98 ± 5.80 days; PD group, 15.93 ± 18.31 days (p < 0.01)], and hospital stay time were significantly longer in the PD group [non-PD group, 14.98 ± 10.14 days; PD group, 22.84 ± 20.87 days (p < 0.01)].

Conclusion: We advocate routine implantation of PD catheters to patients with TGA-VSD, coronary artery anomaly, and open sternum in which we have determined high rate of postoperative PD need.

Keywords: congenital, newborn, open heart surgery, peritoneal dialysis, renal failure

INTRODUCTION

Acute renal failure (ARF) is a common complication in children following extensive pediatric cardiac surgery due to low cardiac output, massive hemolysis, and high fluid overload. Despite ongoing efforts to decrease its occurrence, ARF remains a frequent complication of cardiac surgery. The reported ARF incidence ranges between 1% and 17%, depending largely on the criteria used to define the condition and the associated mortality is high (between 21% and 70%).

Postcardiomyotomy use of peritoneal dialysis (PD) in children became an accepted practice in the 1970s and it is usually the renal replacement therapy (RRT) of choice. It is preferred in clinical situations such as hypotension/hemodynamic instability (patients with closed or open sternum), disturbed coagulation, or difficult venous access, especially in very young children. Although the choice of RRT remains controversial, PD has been demonstrated to be useful in light of the ease of application, effectiveness in fluid removal and avoidance of the need for anticoagulation, and establishment of additional vascular access.
Some centers routinely implant PD catheter in patients who undergo correction operation for transposition of the great arteries (TGA), whereas others apply only in selected patients. In our practice, all children with ARF following cardiac surgery are routinely treated with PD, which is an effective and safe method that requires no advanced technology. We investigated the clinical outcome of PD use in our newborn patients who underwent arterial switch operation (ASO) for TGA and had routine intraoperative PD catheter implantation. We determined the risk factors for PD, factors associated with prolonged PD, morbidity, and mortality. The aim of the present study was to describe our experience of using PD in this patient cohort.

MATERIALS AND METHODS

The clinical reports of 82 newborn patients who were diagnosed with TGA, TGA-ventricular septal defect (VSD), and who had undergone ASO operation in Başkent University, Istanbul Research and Training Hospital, between 2007 and 2012 were reviewed. All the patients were under 30 days old. Demographic data, preoperative risk factors, intraoperative variables, and postoperative complications were compared between patients requiring PD and those who did not need PD (Table 1).

Surgical Technique

All patients underwent ASO. The coronary buttons were reimplanted to the neoaorta using Edward-Bowe technique. Under mild hypothermic perfusion, the nor-mothermic blood cardioplegia was administered with mini cardioplegia technique. Modified ultrafiltration was performed in all the cases. Phentolamine infusion was routinely used during cardiopulmonary bypass (CPB). PD catheters were routinely implanted perioperatively at the end of the operation. The patients were divided into two groups according to the need for postoperative PD (PD group and non-PD group). PD was initiated in 32 (39%) patients after the operation, whereas 50 (61%) patients did not need dialysis. The clinical outcomes and perioperative data of the two groups were compared.

Data were collected from patient files and intensive care unit (ICU) registries. Demographic and clinical data including weight and age at the time of surgery, type of cardiac disease, surgical procedure details, pre- and postoperative renal function data, time to diagnose ARF and PD initiation after surgery, cardiopulmonary and aorta cross-clamping time, and duration of inotropic support were obtained (Table 2).

For patients requiring PD, the following data were additionally collected: initiation time and duration of PD; serum urea and creatinine levels before and after operation, before the start of PD, during PD, and just before discharge; the absolute amount of fluid withdrawn per day; daily fluid balance; and PD-related complications. In patients who were on ventilator support, peak inspiratory pressures before and after institution of PD were noted (Table 3).

Peritoneal Dialysis

Indications for PD included oliguria (0.5 mL/kg/h) for more than 6 h despite aggressive diuretic therapy and optimization of inotropic support. In the absence of oliguria and increased creatinine level, PD was established in the presence of one of the following: clinical signs of fluid overload, hyperkalemia (>5.5 mEq/L), persistent metabolic acidosis, lactate level above 8 mmol/L, or low cardiac output syndrome.

Catheters were routinely inserted at the end of surgical procedure. The PD catheters were of the Tenckhoff type Kendall Quinton Curl Catheter (Tyco Healthcare Group LP, Mansfield, MA, USA) of 62 cm length. The PD catheter was connected to a closed system for peritoneal drainage.
Table 3. Table demonstrating the postoperative hemodynamic and blood gas variables.

<table>
<thead>
<tr>
<th></th>
<th>Non-PD group (n = 50)</th>
<th>PD group (n = 32)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA (mmHg)</td>
<td>9.21 ± 1.85</td>
<td>10.15 ± 2.03</td>
<td>0.033*</td>
</tr>
<tr>
<td>LA (mmHg)</td>
<td>9.66 ± 2.73</td>
<td>9.70 ± 2.45</td>
<td>0.942</td>
</tr>
<tr>
<td>Systolic blood tension (mmHg)</td>
<td>63.3 ± 8.94</td>
<td>57.18 ± 9.26</td>
<td>0.004*</td>
</tr>
<tr>
<td>Inotrope score</td>
<td>22.64 ± 7.64</td>
<td>30.06 ± 8.74</td>
<td>0.001*</td>
</tr>
<tr>
<td>pH</td>
<td>7.41 ± 0.30</td>
<td>7.42 ± 0.08</td>
<td>0.835</td>
</tr>
<tr>
<td>HCO₃⁻ (mmol/L)</td>
<td>27.83 ± 3.39</td>
<td>26.83 ± 3.75</td>
<td>0.219</td>
</tr>
<tr>
<td>BE (mmol/L)</td>
<td>4.30 ± 4.32</td>
<td>2.31 ± 4.34</td>
<td>0.046*</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>4.97 ± 1.62</td>
<td>6.50 ± 3.39</td>
<td>0.022*</td>
</tr>
</tbody>
</table>

Notes: LA, left atrium; PD, peritoneal dialysis; RA, right atrium. *Indicates the p values which are significantly significant.

RESULTS

A total of 82 patients were enrolled in the study. There were 29 females (35.4%) and 53 males (64.6%). The mean age of the patients was 13.17 ± 7.84 days. The PD and non-PD groups consisted of 32 and 50 patients, respectively. The two groups were similar with respect to age, weight, height, and body mass index (Table 3). There was no difference between the two groups in terms of preoperative blood urea nitrogen (BUN) and creatinine levels (p > 0.05).

The rate of preoperative ventilatory and inotropic support was higher in the PD group (37.5% vs. 24% and 15.6% vs. 6%, respectively). However, none of the differences were statistically significant. The rate of preoperative prostaglandin E1 (PGE1) treatment and atrial septectomy were similar in the two groups.

There is a statistically significant relationship between PD need and diagnosis. The rate of TGA-VSD patients was higher in the PD group than that in the non-PD group (p = 0.018). The rate of coronary anomaly was statistically higher in the PD group (n = 1 vs. n = 7; 4% vs. 21.9%; p = 0.012).

The CPB time in the PD group was statistically longer than that of patients in the non-PD group (p = 0.016). However, there was no difference with respect to cross clamp times (p = 0.556). The extubation, ICU, and in-hospital stay times were significantly longer in the PD group (p = 0.001). The mortality rates were 8% in the non-PD group (4/50) and 18.8% in the PD group (6/32). The difference was statistically insignificant (p = 0.147).

No major complication (peritonitis or hemodynamic instability) was observed related to the PD catheter (during the use or after the withdrawal). Minor complications were hyperglycemia and catheter site induration and/or leakage but no infectious pattern. Catheter-related complications also were not observed in the non-PD group.

The rate of postoperative infection was statistically higher in the PD group (p = 0.003). The rate of delayed sternal closure was significantly higher in the PD group.
Catheter malfunctioning was observed in 10 (30.3%) patients, whereas the catheters had to be reimplanted in six (18.2%) patients. The catheter infection was observed in only one (3.03%) patient.

Ten (31.3%) patients in the PD group were on ventilator support before operation. The difference between preoperative and postoperative peak airway pressures was statistically insignificant (25.11 ± 4.10 vs. 25.89 ± 11.63 cm H2O; p = 0.846).

PD was effective in achieving negative fluid balance when compared with the non-PD group. There was a statistically significant difference in daily fluid balance between the two groups except for the first postoperative day (p < 0.05; p < 0.01). On the other hand, the serum BUN and creatinine levels in the PD group were statistically higher than the non-PD group (p < 0.05; p < 0.01). There were no difference in the BUN and creatinine levels at the time of discharge (p > 0.05).

The mean PD duration was 5.12 ± 4.19 days (median 4 days). PD longer than 5 days was accepted as prolonged PD. Prolonged PD was not associated with preoperative BUN, creatinine levels, younger age, and preoperative body weight (p > 0.05). There was also no relationship between prolonged PD and history of preoperative PGE1 treatment, atrial septectomy, infection, inotropic support, and intubation (p > 0.05).

**DISCUSSION**

Today, surgical intervention in complex congenital cardiac cases is often performed in the neonatal period. At birth and for several months thereafter, the kidneys function with very limited reserve. The glomerular filtration rate is reduced in newborns compared with that of older infants. Renal vascular resistance is high with correspondingly elevated circulating renin levels. Hormonal responses to volume loading including atrial natriuretic factor may also be limited in the newborn. All of these conditions render the neonate more prone to complications of ischemia than the older infant or child. After complicated operations with long CPB times such as ASO, there is a high incidence of ARF. Clinically, CPB is associated with a capillary leak syndrome, resulting in hypovolemia, and renal hyperperfusion.

Many different therapy modalities have been developed to reverse tissue edema and maintain postoperative negative fluid balance. Conventional medical treatment has included fluid restriction and diuretic therapy as well as inotropic support and afterload manipulation. When clinical and drug management cannot reverse these manifestations, RRT is mandatory. In this situation, RRT in children with ARF is required until the abnormalities are corrected, the cardiac function improves, and the kidneys recover their normal function, which happens a few days later. Our main indications for starting RRT were oliguria, anuria, and metabolic acidosis, which are similar to those described in other reports. We mostly initiate PD in the first postoperative 24 h; in three patients the PD onset times were postoperative 1st, 2nd, and 4th days, respectively. Our median PD duration was 4 days and the PD was shown to provide negative fluid balance during the treatment.

The prevalence of ARF requiring RRT in children after open heart surgery has been reported to range from 1.6% to 9% depending on the complexity of procedure, preoperative status, and criteria for commencement of the dialysis treatment. The mortality rate in children with ARF following heart surgery has been reported ranging from 10–90%. Various authors have demonstrated that an earlier initiation of dialysis is associated with a lower mortality rate. Several studies have compared PD with other dialysis methods in open-heart surgery. PD and hemodialysis (HD) are the two most commonly used methods. Few studies have compared PD with other dialysis methods in ARF patients. PD is postulated to be a more physiological and less inflammatory mode of dialysis than HD. Most of the complications of PD are minor and easily manageable. The complications of PD detected in this study were similar to those seen in other reports, consisting primarily of infection and catheter malfunction. The reported complications in catheter functioning are around 30%, nearly 2% being major complications, of the catheters inserted in their pediatric patients which is nearly identical with our cohort.
(30.3%). The leakage of the peritoneal fluid from the catheter site and ineffective drainage of the peritoneal fluid through the peritoneal catheter were accepted as peritoneal catheter malfunctioning. This is usually related to the omentum that surrounds the catheter and occludes the holes on the catheter. When we detect catheter malfunctioning, we initially try to open these holes by injecting saline with pressure by 20 and 50 cc syringes into the catheter. This maneuver sometimes helps to overcome the problem and the catheter may work for some time. In patients whom we plan to end the PD soon, we chose this approach instead of replacing the catheter with a new one. In four patients, we managed to drain the peritoneal cavity with this approach. However, in the rest six patients, we replaced the catheters with new ones, which we implanted on different sites. The catheters had worked until the dialysis treatments were terminated. However, the catheter infection rate in our study (3.03%) is lower than the reported rates. 5,26–28 We speculate that this is related to the intraoperative catheter placement which may reduce the infection and complication rate associated with this treatment modality. Intraoperative PD catheter placement may enable heightened sterility and improved localization of the instrument through placement under direct vision.

There are also concerns that the presence of dialysate in the peritoneal cavity may cause diaphragmatic splitting and result in higher ventilatory pressures in mechanically ventilated patients. This is particularly detrimental to patients who require lung-protective ventilation strategies to minimize lung trauma. In our cohort, 31.3% of the PD patients were on ventilator support before initiation of PD and there was no change in the peak pressures after the commencement of PD (p > 0.05).

Several studies have attempted to identify risk factors of ARF requiring RRT in children undergoing surgery for congenital heart disease. 8,28,29 Thus, the important determinants of the outcome of patients requiring PD appear to be the preoperative and postoperative cardio-pulmonary status rather than the renal status or timing of initiation of PD. It has been documented that low cardiac output, young age, low body weight, associated systemic disorders, high fluid overload, preexisting renal insufficiency, or mechanical ventilation before surgery were additional risk factors. 14 The risk factors determined in this study for PD in TGA patients less than 1 month old are CPB duration and presence of coronary anomaly. Santos also found CPB time as predictive of a subsequent need for PD. 3 Studies have demonstrated that patients with CPB times more than 90 min showed more pronounced kidney damage than patients with CPB times less than 70 min. 15,30 We were unable to determine a cut-off value due to the wide range of clinical data. Contrast-induced nephropathy can occur after angiography, particularly in infants and neonates. 31 We observed no change in renal function parameters and urine output after cardiac catheterization including atrial septectomy in this particular group of patient.

CONCLUSION

We believe that early initiation of PD with prophylactic PD catheter placement is a safe procedure with acceptable infection and mortality rate in newborn TGA patients. ARF is usually related to the complexity of the cardiac pathology and the duration of CPB. Unlike literature, our study group is composed of a subgroup of TGA patients who were under 30 days old and who underwent ASO. We found out that coronary anomaly in these patients is a risk factor for ARF and PD is highly effective and easy to manipulate in the renal replacement treatment of this cohort.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

REFERENCES


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