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CLINICAL STUDY

Peritoneal dialysis requirements following open-heart surgery in children with congenital heart disease

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ABSTRACT

This article reviews our experience with 111 pediatric patients following open-heart surgery over 1-year period. Peritoneal dialysis was required in 34 of 111 children (30.6%). We randomly selected 33 patients who did not require peritoneal dialysis as control group. The indications of dialysis were oligoanuria and/or elevated serum creatinine level (19/34, 55.8%), fluid overload and/or hemodynamic alterations (10/34, 29.5%), and hyperkalemia and/or acidosis (5/34, 14.7%). Among the 34 dialyzed patients, 19 (55.6%) had acute renal failure (ARF). Cyanotic congenital heart disease was significantly higher in patients who required dialysis than the patients who did not require dialysis (67.6% and 22.6%, respectively, $p < 0.001$). Cardiopulmonary bypass time was significantly longer in patients with ARF than those without ARF ($p < 0.05$). Overall mortality rate was significantly higher in patients who required dialysis than control group (42.1% and 18.2%, respectively, $p < 0.05$). However, in the dialyzed group the mortality for patients who developed ARF was 68.4% and 6.7% for those who did not develop ARF [odds ratio (OR): 30.3, confidence interval (CI) 95%: 3.2–28.7, $p < 0.001$]. In conclusion in children high mortality rate following open-heart surgery was associated with ARF. Patients with cyanotic congenital heart disease and prolonged cardiopulmonary bypass time are at risk for ARF. The presence of these factors can be predicted in the early institution of peritoneal dialysis after cardiac surgery.

Keywords: peritoneal dialysis; cardiac surgery; acute renal failure; children

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INTRODUCTION

Acute renal failure (ARF) resulting from low cardiac output is a well-known and severe complication after congenital open-heart surgery.[1,2] Most studies did not classify the etiology and/or pathogenesis of this kind of ARF. Possible etiologies that have been suggested for the development of acute renal insufficiency in the immediate postoperative cardiac patient are preoperative cyanosis, preoperative renal insufficiency, preoperative congestive heart failure, polycythemia, history of diabetes mellitus, cardiopulmonary bypass time more than 140 minutes, postoperative hypotension, and low cardiac output.[3–6] Peritoneal dialysis is frequently used for ARF following open-heart surgery in children. Peritoneal dialysis is a safe and effective therapeutic measure for children after cardiac bypass surgery.[7] The role of peritoneal dialysis and the criteria of indications in postoperative therapy, technical details of applying it such as optimal timing of peritoneal dialysis, contents of dialysate solution, and indwelling volume and its complications are currently under discussion.[8,9] This report reviews our experience in pediatric patients requiring peritoneal dialysis following open-heart surgery over 1-year period.

PATIENTS AND METHODS

One hundred and eleven pediatric patients who underwent open-heart procedures from January to December 1999 were analyzed retrospectively. Peritoneal dialysis was required in 34 of 111 children. We randomly selected 33 patients who did not require peritoneal dialysis as control group. The study was approved by the Local Ethics Committee and an informed consent was obtained from the parents of all the participants.

Serum albumin, blood urea nitrogen (BUN), creatinine, hematocrit, and platelet levels of all patients were measured in preoperative and postoperative periods. All patients had normal serum creatinine and BUN levels before operation.

The indications for peritoneal dialysis were (1) oligoanuria (<0.5 mL/kg/h for more than 4 hours), resistant to controlled volume expansion, inotropes, vasodilators, and diuretics; (2) fluid overload; (3) electrolyte disturbances; and (4) serum creatinine level greater than 1.2 mg/dL. Fluid overload was defined as edema, increase of body weight in serial measurements, and difference between fluid uptake and urine output.

Peritoneal dialysis catheters were inserted at the end of cardiac surgery in all patients as a routine procedure. Tenckhoff pediatric catheters were placed in a midline subumbilical incision. Standard dialysis solutions with lactate as buffer were used. Exchange volume was usually 10 mL/kg of body weight. Duration of each exchange was 1–2 hours with 15 minutes indwelling time and 20–40 minutes drainage time. Frequency of peritoneal exchanges and dextrose concentration varied according to the patient need.

Statistics

The χ^2 test and Student's *t*-test were used for statistical analysis. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. *p*-Values < 0.05 were considered to indicate statistical significance. Statistical analysis was performed with SPSS for Windows version 11.0 (SPSS, Chicago, IL, USA).

RESULTS

Peritoneal dialysis was required in 34 of 111 children (30.6%). The median ages were 3 months (range 0–30 months) in dialyzed patients and 4 months (range 0–26 months) in control group ($p > 0.05$). The mean weights were 5.2 ± 2.5 kg (range 2.2–12.5 kg) in patients requiring dialysis and 5.69 ± 3.0 kg (range 2.2–15 kg) in control group ($p > 0.05$). The indications of dialysis were oligoanuria and/or elevated serum creatinine level (19/34, 55.8%), fluid overload and/or hemodynamic alterations (10/34, 29.5%), and hyperkalemia and/or acidosis (5/34, 14.7%). There was no significant difference in sepsis, hypotension, fluid therapy, postoperative central venous pressure, and cardiopulmonary bypass time between the dialyzed patients and the control group. Thirty of 67 patients suffered from cyanotic congenital heart disease and peritoneal dialysis was applied to 23 of them. Cyanotic congenital heart disease was significantly higher in patients who required dialysis than in patients who did not require (67.6% and 22.6%, respectively, $p < 0.001$) (Table 1). Among the 34 dialyzed patients, 19 (55.6%) had ARF. Hypotension was observed in patients with ARF and non-ARF group as 68.4% (13/19) and 33.3% (5/15), respectively ($p < 0.001$). Cardiopulmonary bypass time was significantly longer in patients with ARF than those without ARF (165.52 ± 76.3 and 121.67 ± 56.9 minutes, respectively, $p < 0.05$).

Overall mortality rate was significantly higher in patients who required dialysis than in control group (42.1% and 18.2%, respectively, $p < 0.05$). However, the mortality rate was 68.4% for patients who developed ARF and 6.7% for patients who did not develop ARF (OR: 30.3, CI 95%: 3.2–28.7, $p < 0.001$) (Table 2).

TABLE 1. Patient characteristics and clinical data.

	Patients with PD ($n = 34$)	Patients without PD ($n = 33$)	*p*-Value
Median age	3.0 months (0–30 months)	4.0 months (0–26 months)	>0.05
Mean weight	5.2 ± 2.5 kg	5.69 ± 3.0 kg	>0.05
Cyanotic/acyanotic	23/11	7/26	<0.001
Hypotension	52.9%	30%	<0.001
Sepsis	14.7%	12.1%	>0.05
Renal failure	55.6%	None	<0.05
Mortality	42.1%	18.2%	<0.05

DISCUSSION

Adequate kidney function after cardiopulmonary bypass is important with respect to care with fluid overload and hemodilution during cardiopulmonary bypass, leaky capillary syndrome and volume requirements

TABLE 2. Characteristics and clinical data of dialysis group.

	Patients with ARF ($n = 19$)	Patients without ARF ($n = 15$)	*p*-Value
Hypotension	68.4% (13/19)	33.3% (5/15)	<0.001
Mortality	68.4% (13/19)	6.7% (1/15)	<0.001
Mean cardiopulmonary bypass time	165.52 ± 76.3 minutes	121.67 ± 56.9 minutes	<0.05

after cardiopulmonary bypass, and the excretion of proinflammatory cytokines after cardiopulmonary bypass.[10,11] Renal replacement therapy is delivered in up to 10% of children undergoing cardiac surgery for correction of congenital heart disease and is associated with an increased mortality rate.[12,13] Acute peritoneal dialysis in postoperative open-heart surgery patients is being performed with greater frequency. Treatment alternatives of peritoneal dialysis are hemofiltration or severe fluid restriction and drug-induced diuresis. Fluid restriction is more conservative and less invasive. However, absolute requirements for electrolyte and drug infusions frequently lead to fluid accumulation despite aggressive diuretic therapy. This may further compromise depressed cardiorespiratory function. Compared to peritoneal dialysis especially in newborns and infants, hemofiltration has disadvantages because it requires systemic anticoagulation and vascular access.[5]

Indications for the institution of acute peritoneal dialysis include uremia, fluid overload, hyperkalemia, oliguria, and anuria. In addition, the myocardium in the postoperative patient is exquisitely sensitive to additional stress such as electrolyte imbalance, fluid overload, or acid–base derangement, and may necessitate dialysis without ARF.[4,14] Hemodynamic alterations are important in these patients after surgery. Peritoneal dialysis represents a simple and safe system for fluid removal.[15] It has been reported that children undergoing peritoneal dialysis had a continuous improvement in hemodynamics, as evidenced by rising mean arterial blood pressure, decreasing central venous pressure, and decreasing requirement for inotropic support.[8,9] It has been demonstrated that the use of the low-volume peritoneal dialysis technique (10 mL/kg cycled each hour) and a short indwelling time may have attributed to a low peritoneal irritation and caused less acute hemodynamic disturbances.[8,15,16] In their study, Morris et al. found that cardiac index was significantly higher with 10 mL/kg than when the abdomen was empty or contained a larger volume.[17] We also used similar peritoneal dialysis schedule.

We conducted a retrospective study of children after cardiac operation who were treated with peritoneal dialysis and compared with control group. Cyanotic congenital heart disease was significantly more frequent in the dialyzed patients. Overall mortality rate was higher in patients who required dialysis; moreover, we observed that the dialyzed patients who developed ARF had significantly higher risk for mortality than those who did not develop ARF. There was no significant difference in sepsis, postoperative hypotension, fluid therapy, and central venous pressure between the groups. The duration of severe renal ischemia is an important factor in the development of postoperative ARF. In this study, cardiopulmonary bypass time was longer in patients with ARF than those without ARF. It has been noted that cardiopulmonary bypass time and circulatory arrest time were recognized risk factors for postcardiopulmonary bypass surgery-related ARF.[1,2,9] Some authors even suggested that peritoneal catheter should be placed in the operating room if cardiopulmonary bypass time exceeds 90 minutes and circulatory arrest time exceeds 60 minutes.[8]

In conclusion, high mortality rate was associated with ARF following open-heart surgery in children. Patients with cyanotic congenital heart disease and prolonged cardiopulmonary bypass time are at risk for ARF. The presence of these factors can be a predictor of acute renal injury, so that early institution of peritoneal dialysis after cardiac surgery is necessary.

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

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