Long-term follow-up evaluation of renal function in patients treated with peritoneal dialysis after cardiac surgery for correction of congenital anomalies

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Background: Available data on the long-term renal outcome of patients who required renal replacement therapy after cardiac surgery for correction of congenital cardiac anomalies are scarce. The aim of the present study was to investigate the long-term renal prognosis of children treated with peritoneal dialysis after surgical correction of congenital heart anomalies.

Methods: The present single-center cohort study was based on clinical data from patients who underwent surgery for the correction of congenital heart disease between 1996 and 2004 at the Schneider's Children's Medical Center of Israel, and developed acute kidney injury (AKI) requiring peritoneal dialysis. Perioperative risk factors were analyzed. Survivors were followed up for 3.5 to 10.5 years after their surgery. Renal function was assessed in survivors by physical examination, including blood pressure, growth evaluation, urinalysis, glomerular filtration rate estimated from plasma creatinine using the Schwartz formula, and ultrasonographic examination of the kidneys.

Results: There were 2994 children who underwent surgery during the study period. Eighty-four children (2.84%) developed postoperative AKI that was managed with peritoneal dialysis. Seventy-six children were included in our study, 8 were excluded because of a lack of complete data. Of the 76 children included, 35 died during the immediate postoperative period, 15 died during the interim of nonrenal causes, and 26 were alive at the time of follow-up evaluation. Twenty-five patients with a complete evaluation had blood pressure measurements in the normal range. Plasma creatinine levels were normal for age. Only 1 child, who had a pre-existing congenital renal anomaly, had an abnormal glomerular filtration rate. None of the children had proteinuria. Three children were treated with angiotensin-converting enzyme inhibitors and 2 were treated with furosemide for congestive heart failure. We found no risk factors associated with immediate postoperative death.

Conclusions: Despite the development of AKI requiring dialysis after surgical correction of congenital cardiac anomalies, the long-term renal prognosis in survivors is good. (J Thorac Cardiovasc Surg 2014;147:451-5)

Acute kidney injury (AKI) is a frequent and serious complication of cardiac surgery. Reported rates of patients who require renal replacement therapy after open heart surgery range from 1.6% to 7.7%.[1-5] The mechanism of the renal injury involves both postischemic (preoperative, operative, and postoperative low cardiac output) and toxic (contrast media for diagnostic cardiac catheterization, nephrotoxic drugs, myoglobin, and so forth) factors. Peritoneal dialysis is the preferred treatment, and therefore several large cardiac centers routinely insert a Tenckhoff catheter at the conclusion of complicated cardiac procedures.[3-7] This is particularly important in young children in whom vascular access may become problematic and complicate the use of hemofiltration.[5,6]

Children who develop AKI for various reasons requiring renal replacement therapy are known to be at high risk for residual kidney damage.[8] Most of the rather large number of publications published to date have focused on the short-term outcome of children who required peritoneal dialysis after cardiac surgery.[3-7,9] The overall short-term mortality rates reported in these studies ranged from 50% to 60% in earlier studies[4] to only 20% in later studies.[8] To date, only 1 study attempted to discern the long-term renal outcome of those patients who required renal replacement therapy. The study conducted more than 20 years ago by Shaw et al[10] described the renal function 1 to 5 years after discharge of a total of 11 long-term survivors.

The aim of the present study was to investigate the long-term renal outcome of children treated with peritoneal dialysis after cardiac surgery for the correction of congenital anomalies.

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Abbreviations and Acronyms
AKI = acute kidney injury
GFR = glomerular filtration rate
pRIFLE = pediatric risk, injury, failure, loss, end-stage renal disease

MATERIALS AND METHODS

The medical files of all patients who underwent surgery for congenital heart disease from 1996 to 2004 at a tertiary pediatric medical center were reviewed. All patients who developed AKI requiring renal replacement therapy with peritoneal dialysis were included in our study.

After children undergo cardiac surgery at our center, dialysis is performed with a standard double-cuffed Tenckhoff catheter inserted during surgery or just before initiation of dialysis. Commercially available peritoneal dialysis fluids are infused via a simple closed system; the dialysate later is drained mechanically through the indwelling catheter into a collecting device. For the present study, we recorded the indications for, in addition to data on potential preoperative, intraoperative, and postoperative risk factors for, immediate and long-term mortality.

Preoperative Risk Factors

The preoperative risk factors evaluated were the type of cardiac malformation, preoperative cardiac catheterization, use of diuretics (specifically furosemide), use of prostaglandins, need for vasopressor treatment, and other medications. The preoperative glomerular filtration rate (GFR) was calculated using the Schwartz[11] formula. Other congenital malformations and syndromes were recorded as well.

Intraoperative Risk Factors

To define the complexity and risk of each procedure, we used the Risk Adjusted Classification for Congenital Heart Surgery, which has been proven valid and accurate.[12,13] Other intraoperative risk factors that were evaluated were length of time on cardiopulmonary bypass, aortic cross-clamp time, lowest body temperature during surgery, and open or closed sternal cavity at the end of surgery.

Postoperative Risk Factors

The postoperative risk factors evaluated were medical treatment (mainly inotropic medications and furosemide), cardiopulmonary resuscitation, extracorporeal membrane oxygenation, and significant arrhythmias, defined as any of the following: ventricular tachycardia, ventricular fibrillation, supraventricular tachycardia, junctional ectopic tachycardia, or use of an external pacemaker.

Dialysis Initiation

In our study we looked at reasons for dialysis initiation, the interval between the surgical procedure and dialysis initiation and the length of dialysis, to see if any of these factors affected survival. We also examined peek creatinine and urea levels. We used the modified pediatric risk, injury, failure, loss, end-stage renal disease (pRIFLE) criteria[14] to categorize and stratify the degree of renal injury at the time of dialysis initiation.

The patients were divided into 3 groups by outcome: those who died immediately after surgery, those who died after discharge, and those who were still alive during the present study. The parents of all survivors were contacted and invited to bring their child to the clinic for evaluation of renal function. Our study was approved by the hospital institutional review board and was performed in accordance with the Declaration of Helsinki. After written informed consent was obtained, physical examination, including measurement of blood pressure, growth evaluation, urinalysis, estimation of GFR from plasma creatinine level according to the Schwartz[11] formula, and renal ultrasound were performed.

Statistical Analysis

The data were analyzed using BMDP Software (Los Angeles, Calif).[15] Continuous variables were analyzed by outcome using 1-way analysis of variance, and discrete variables were analyzed using the Pearson chi-square test or the Kruskal-Wallis test, as appropriate. Kaplan-Meier survival estimates were calculated. A P value of .05 or less was considered significant.

RESULTS

Of the 2994 patients who underwent surgery at our center between 1996 and 2004 to correct a congenital cardiac anomaly, 84 (2.8%) had severe postoperative AKI and were treated with peritoneal dialysis. Eight patients were excluded from the study because of a lack of follow-up data. These included 2 patients who transferred to another hospital and 2 patients who left the country. The remaining 76 patients formed the study group. Thirty-five patients (46%) died immediately after surgery, 15 patients (20%) died after discharge, and 26 patients (34%) survived to the present study.

The cohort consisted of 40 boys (52%) and 36 girls (48%), with a median age of 45 days at surgery and a median weight of 3.47 kg (range, 1.6-71 kg). There was no statistically significant difference between the outcome groups in background characteristics or indications for dialysis (Table 1).

Preoperative Risk Factors

Forty-six patients (61.3%) had a cyanotic heart malformation, of whom 21 died in the immediate postoperative period, 8 died after discharge, and 17 survived ($P = .9$; 95% confidence interval $\pm$ 0.1). Twenty-three patients underwent cardiac catheterization before surgery, usually (20 patients) to perform a Rushkind procedure.

Fifteen of the 76 patients (19.7%) had a syndromic or chromosomal abnormality, namely trisomy 21 (8 patients), 22q11.2 deletion (DiGeorge/velocardiofacial syndrome, 4 patients), 4P deletion (Wolf Hirschhorn syndrome, 1 patient), Kabuki syndrome (1 patient), and VACTER (vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies) association (1 patient). Nine patients (11.8%) had pre-existing congenital renal malformations that were identified on the preoperative renal ultrasound examination: horseshoe kidney (4 patients), bilateral mild pyelectasis (2 patients), right dysplastic kidney (1 patient), pelvic kidney (1 patient), and left multicystic dysplastic kidney with right ectopic kidney (1 patient). The number of patients with renal malformations was too small to ascertain the effect of renal malformations on survival.

The most frequent preoperative medications used were furosemide (46% of patients), prostaglandins (36.8%; to maintain a patent ductus arteriosus), and vasopressors (26.3%). There was no significant difference among the 3 groups regarding the use of prostaglandins or vasopressors (Table 1). Other medications included amiodarone,