Twenty-five Years of Infant Dialysis: A Single Center Experience

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Objective To perform a retrospective analysis of the long-term outcome of infants with end-stage kidney disease (ESKD) treated at our center during the past 25 years.

Study design The total cohort (n = 52) was divided into era 1 (1983-1995; n = 23) and era 2 (1996-2008; n = 29). Dialysis morbidity, transplantation, and long-term survival rates were assessed and compared between the 2 eras.

Results Average age at initiation of dialysis was 4.4 ± 5.3 months (range, 0.5-18 months), with 96% begun on peritoneal dialysis. The predominant diagnoses were dysplasia/obstructive uropathy and autosomal recessive polycystic kidney disease. The overall survival rate is 46%, with current age of survivors ranging from 1.5 to 25 years. Mortality rates in the 2 eras were not significantly different. The predominant mortality occurred within the first year. Twenty-four patients received an initial renal transplant at 2.6 ± 1.7 years of age. Six patients (25%) required a second renal allograft. Increased risk for mortality included African-American ethnicity, oligoanuria, autosomal recessive polycystic kidney disease, and co-morbid diagnoses.

Conclusions Long-term survival is possible in infants with ESKD, although mortality and morbidity remain high. Technical innovations are needed to accommodate smaller infants undergoing dialysis. Early initiation of dialysis treatment is preferable because prognostic indicators remain poorly defined. *(J Pediatr 2009;155:111-7)*.

There is now experience spanning 4 decades of treatment of pediatric patients with end-stage kidney disease (ESKD) from throughout the world.[1-7] Infants and children <5 years old comprise only a small portion of the expanding pediatric ESKD population, but consume proportionately more resources with the least prospect for survival.[8-10] Data from voluntary registries are limited by selection bias and inconsistent reporting.[11] Single-center experiences offer important information on patient demographics and the application of consistent treatment protocols, but are limited by short follow-up periods and too few patients <5 years old at initiation of dialysis.[3-5,11] Thus, long-term outcomes of infants requiring dialysis during the first years of life remain unclear, especially in the United States.[1,12-15] The risk of mortality in younger patients is estimated to be 4 times greater than that of older children, regardless of dialysis modality,[2-11] and 10 times that of transplant recipients.[16] Renal replacement therapy (RRT) initiated during early life is a commitment to lifelong treatment, often requiring transitioning from dialysis to transplantation and back to dialysis.[8,16-19] Pediatric nephrologists worldwide continue to struggle with the ethical dilemma of whether to commit to a treatment that is burdensome financially and emotionally and may not offer substantial longevity or quality of life.[16-19] This report examines the long-term outcomes of a large group of infants treated with RRT during the past 25 years at our center through each stage of treatment, including dialysis and transplantation.

Methods

A retrospective analysis was performed on 52 infants treated at the University of Miami/Holtz Children's Hospital between January 1983 and January 2008 with ESKD, as defined by a congenital diagnosis of autosomal recessive polycystic kidney disease (ARPKD), obstructive uropathy with renal dysplasia, congenital nephrotic syndrome, or any chronic kidney injury requiring maintenance dialysis for survival. Patients who had acute and transient ischemic nephropathy or patients who died without elective dialysis during the first month of life were excluded. The study was approved by the institutional review board with waiver of consent authorization, and all subjects were assured anonymity in

ARPKD	Autosomal recessive polycystic kidney disease
CCPD	Continuous cycling peritoneal dialysis
CKD	Chronic kidney disease
DD	Deceased donor
ESKD	End-stage kidney disease
G -Tube	Gastrostomy tube
HD	Hemodialysis
iPTH	Intact parathyroid hormone
LRD	Living related donor
NAPRTCS	North American Pediatric Renal Trials and Collaborative Studies
PD	Peritoneal dialysis
rhGH	Recombinant human growth hormone

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compliance with the Health Insurance Portability and Accountability Act.

The medical records were reviewed for demographic characteristics, renal diagnoses, co-morbidities, oligoanuria, age at initiation of dialysis, complications of treatments, time and course of transplantation, and long-term survival and growth. The 25 years were arbitrarily divided into 2 eras to examine the impact of improvements in technology and experience at a single center. Era 1 included infants born from 1983 to 1995, and era 2 spanned 1996 to 2008.

Dialysis

Criteria for starting dialysis in an infant <18 months of age included oligoanuria associated with life-threatening electrolyte imbalance, critical fluid overload, serum creatinine level ≥3.5 mg/dL (≥300 μM/L), and/or failure to thrive with conservative management. Manual peritoneal dialysis (PD) was the preferred modality and was instituted by surgical placement of a single cuffed Tenckhoff or Cook catheter. Accurate infusion volumes were maintained by using volumetric drip chambers with manual exchanges every 1 to 2 hours. The PD infusion volume was increased gradually from 20 to 50 mL/kg (400-1000 mL/m^2 of body surface area). When the patient was tolerating a fill volume of 120 to 150 mL, the transition was made to an automatic cycling machine (American Medical Products cycler, Northbrook, Illinois; HomeChoice, Baxter Health Care, Deerfield, Illinois; or the Fresenius Freedom Cycler, Waltham, Massachusetts) for nightly continuous cycling peritoneal dialysis (CCPD).

When the patient was deemed unsuitable for PD or when the peritoneum was no longer functional, hemodialysis (HD) was initiated. HD was performed with either the Gambro HG100 or Fresenius F3 dialyzer with pediatric lines requiring a priming volume of approximately 100 mL. When the patient weighed <8 kg, the extracorporeal circuit was primed with whole blood or packed red cells plus 5% albumin. All infants required at least 4 hemodialysis sessions per week of 2 to 3 hours per session.

During the first decades of infant PD, dialysis sufficiency was based on maintaining adequate metabolic and fluid balance.[20] After Kidney Disease Outcomes Quality Initiative recommendations became available in the late 1990s, the dialysis prescription for nightly CCPD targeted a urea clearance per volume of distribution (Kt/V) of >2.0 per week, and HD prescriptions targeted a single-pool Kt/V >1.2 per session for optimal dialysis efficiency.[21,22]

Diet and Medications

Each patient had a diet designed to provide adequate calories for growth of 100% to 120% of recommended dietary allowance for weight and age and protein of 2 to 3 g/kg/day.[3,8] This was usually in the form of a low solute formula of high biological value protein (Similac PM 60/40, Columbus, Ohio; or Lactofree, Leeds, United Kingdom) that could be concentrated to a calorie density as high as 30 kcal/ounce. High biological value protein supplements were given up to an additional 1 to 2 g/kg/day for patients undergoing PD to compensate for the large amount of protein losses through the peritoneum. The goal was to maintain the blood urea nitrogen level at 50 mg/dL < (BUN) <80 mg/dL and serum albumin level at 3.0 g/dL ≤ [Alb] ≤4.5 g/dL. Sodium chloride supplements were also required for infants undergoing PD, ranging from 2 to 4 mEq/kg/day to maintain a serum sodium level of 135 mEq/L ≤ [Na] ≤145 mEq/L.

All patients received standard medications for ESKD to maintain control of bone and mineral metabolism and reference range hemoglobin values. This included calcium carbonate, sevelamer, or both as phosphate binders and calcitriol or paricalcitol as vitamin D analogues to maintain intact parathyroid hormone (iPTH) levels between 150 and 300 pg/mL.[23] Patients received subcutaneous erythropoietin and oral or intravenous iron supplements to maintain adequate hemoglobin levels >10<11 g/dL. Multivitamin supplements, pyridoxine, folic acid, and carnitine were also supplemented. Most infants required polystyrene resin (Kayexalate) to control serum potassium. Growth hormone was administered in doses of 0.05 mg/kg/day or 0.35 mg/kg/week after 1 year of age when available and at the discretion of the attending physician.[24]

Growth and Development

In infants surviving >18 months, growth was assessed by calculating the final height SD score at the last recorded encounter.[25] Neuropsychological development was determined from notations in the medical record about functionality, including neurological and psychological examinations when available. Functionality was divided in 3 major categories: 1) normal: minimal to no deficits; 2) pervasive developmental delay: requiring special education classes, occupational and speech therapies, or both; and 3) severely handicapped: severely impaired requiring custodial care.

Peritonitis

Episodes of peritonitis were defined as an effluent cell count >100 cells/mL^3, positive effluent culture results, or both. Recurrence of peritonitis and colonization of the peritoneal catheter were defined when signs and symptoms recurred within 1 week of discontinuing the antibiotic protocol. The treatment of peritonitis was carried out according to recommendations of the first reports in infant peritoneal dialysis and from the *Pediatric Handbook for Peritoneal Dialysis*.[20,21,26]

Statistical Methods

All datasets were analyzed for Gaussian distribution with the D'Agostino-Pearson omnibus test for normality. Continuous variables were expressed as means with SD, and categorical variables were expressed as proportions. Differences between variables were determined with the student *t* test for parametric data or the Mann-Whitney *U* test for nonparametric data. Intergroup comparisons were analyzed with the χ^2 test or Fisher exact test as appropriate, with calculation of odds ratios for estimation of risk occurrence. Patient survival was analyzed by Kaplan-Meier with