Care of the Pediatric Patient on Chronic Dialysis

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Optimal care of the pediatric end-stage renal disease (ESRD) patient on chronic dialysis is complex and requires multidisciplinary care as well as patient/caregiver involvement. The dialysis team, along with the family and patient, should all play a role in choosing the dialysis modality which best meets the patient's needs, taking into account special considerations and management issues that may be particularly pertinent to children who receive peritoneal dialysis or hemodialysis. Meticulous attention to dialysis adequacy in terms of solute and fluid removal, as well as to a variety of clinical manifestations of ESRD, including anemia, growth and nutrition, chronic kidney disease–mineral bone disorder, cardiovascular health, and neurocognitive development, is essential. This review highlights current recommendations and advances in the care of children on dialysis with a particular focus on preventive measures to minimize ESRD-associated morbidity and mortality. Advances in dialysis care and prevention of complications related to ESRD and dialysis have led to better survival for pediatric patients on dialysis.

Key Words: End-stage renal disease, Dialysis, Infants, Children, Adolescents

Care of end-stage renal disease (ESRD) in infants, children, and adolescents involves significantly more than just achieving adequate dialysis in terms of solute and fluid removal. Optimal care includes determination of the appropriate time for dialysis initiation and the best modality for the patient and family, in addition to meticulous attention to a variety of clinical manifestations of ESRD including anemia, growth, and nutrition, chronic kidney disease–mineral bone disorder (CKD-MBD), cardiovascular health, and neurocognitive development.[1]

ETIOLOGY OF ESRD

The leading causes of pediatric ESRD include congenital anomalies of the kidney and urinary tract, accounting for 34% to 43% of ESRD, followed by glomerulonephritis at 15% to 29%.[2-5] The cause of ESRD also varies by age and race, whereas congenital anomalies of the kidney and urinary tract are more common in children aged <12 years and glomerular-based disease occurs more often in adolescents, with the most common disorder being focal segmental glomerulosclerosis.[2,3] The latter disorder is particularly common in black adolescents with ESRD, in part related to the influence of apolipoprotein L1.[4]

INITIATION OF DIALYSIS/CHOICE OF DIALYSIS MODALITY

The provision of renal replacement therapy should be considered when the patient's estimated glomerular filtration rate decreases to approximately 10 to 15 mL/min/1.73 m^2 based on recommendations from pediatric expert committees.[5-8] Most importantly, the decision to initiate dialysis should also take into consideration the presence of clinical and biochemical abnormalities that are not amenable to medical therapy. Uncontrolled metabolic acidosis, electrolyte abnormalities (particularly hyperkalemia), fluid overload and hypertension, and symptomatic uremia are objective indications for dialysis initiation. An inability to provide adequate nutrition due to fluid and dietary restrictions is an additional indication. Occasionally, subjective clinical symptoms such as fatigue and poor school performance may lead to the decision to initiate dialysis. In addition and unique to children, although dialysis itself may not directly improve growth in children with CKD, dialysis initiation may indirectly improve growth through better control of CKD-MBD and an increased capacity to meet nutritional needs.[9,10]

The choice of dialysis modality should be tailored to meet the needs of each patient and family. In addition to medical-related considerations, patient age, lifestyle choice, parental preference, as well as the home environment and the ability to adhere to home-based dialysis therapy must be considered.[1,11] When home-based dialysis is selected for the pediatric patient, the associated caregiver responsibilities can lead to an increased caregiver burden as most patients do not qualify for home health nursing. As such, this burden of care can have an adverse impact on marriage, care of siblings, work, and finances.[12,13]

PERITONEAL DIALYSIS—SPECIFIC CONSIDERATIONS/MANAGEMENT ISSUES

Peritoneal dialysis (PD) is the most common dialysis modality prescribed worldwide to infants and children with ESRD, particularly in children aged <5 years.[14-16] Advantages of PD over hemodialysis (HD) include better preservation of residual renal function (RRF), avoidance of the need for vascular access, less strict dietary and fluid restrictions, ability to provide dialysis at home, and less disruption to daily activities such as school.[17-20] As noted previously, disadvantages of PD include an increased "burden of care" to the family, as well as possible patient/caregiver nonadherence to prescribed therapy, and the risk of PD-associated infections.[21-24]

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Absolute contraindications to PD include conditions that are unique to children and that compromise the integrity of the abdominal cavity and peritoneum, such as omphalocele, gastroschisis, bladder exstrophy, and diaphragmatic hernia. Relative contraindications include impending abdominal surgery, scheduled living donor kidney transplantation in <3 months, and lack of appropriate caregiver or suitable home environment.[25]

In choosing a PD catheter, the use of a double-cuffed PD catheter with a downward- or lateral-facing exit site is recommended to decrease the risk of catheter-related infection. In addition, intraoperative prophylactic antibiotics should be provided within 60 minutes before the incision for PD catheter placement.[24,26] A gastrostomy tube/button, which is oftentimes necessary in infants for nutritional support, should preferentially be placed before or at the time of PD catheter placement to decrease the risk of infection, with the catheter exit site placed on the contralateral side of the abdomen.[26] Postoperatively, the PD catheter should be immobilized with only weekly dressing changes initially to allow for exit site healing.[26,27] Long-term exit-site care should include cleaning the exit site with a sterile antiseptic solution followed by application of a topical antibiotic.[26,28]

The PD prescription for the pediatric patient needs to take the variation in patient size into consideration. In turn, the fill volume should be based on body surface area rather than weight, given the age-independent relationship between peritoneal membrane surface area and body size. The recommended fill volume, based on prior data regarding recruitment of peritoneal surface area and intraperitoneal pressure, varies by age with values of 1000 to 1200 mL/m^2 for patients >2 years and 600 to 800 mL/m^2 for patients <2 years.[6,18,29,30] The transport capacity of a patient's peritoneal membrane is another important prescription factor because of its influence on fill volume and exchange frequency; therefore, assessment of solute transport rates across the peritoneum should be performed using the peritoneal equilibration test (PET).[31,32] It should be recognized that the functional membrane transport capacity may be enhanced in young infants as increased intraperitoneal pressure may preclude the use of an optimal body surface area–related fill volume before the PET.[18]

Automated PD is the most frequently used PD modality in pediatric patients when use of the cycler is not cost-prohibitive. The 3 automated PD modalities consist of the following: continuous cycling PD, nightly intermittent PD, and tidal PD. Continuous cycling PD is the preferred modality for anuric patients and is commonly used with a standard prescription of 5 to 10 cycles provided over 9 to 12 hours overnight, with an identical fill volume and duration for each cycle throughout the night. A last fill, which typically is 50% of the nocturnal fill volume and is retained throughout the day, can be provided with dialysate containing either glucose or icodextrin as the osmotic agent, the latter used to enhance ultrafiltration in patients with high peritoneal membrane transport capacity and suboptimal ultrafiltration. In nightly intermittent PD, often performed in pediatric patients with substantial RRF and automated nocturnal exchanges are provided with no dialysis during the day, an approach that may benefit daytime feeding tolerance. In tidal PD, commonly used for patients who have mechanical problems with drainage or pain during the drain phase of an exchange, an initial infusion of dialysis solution into the peritoneal cavity is followed by only partial drainage for the majority of exchanges. As a result, dialysate is retained at the end of each exchange, resulting in constant contact between dialysis solution and the peritoneal membrane and ideally, the prevention of pain. Adapted PD, a new approach to the automated PD prescription, which still requires study in children, is characterized by sequential short- and longer-dwell exchanges with small and large dwell volumes, to enhance volume and solute removal, respectively.[33]

CLINICAL SUMMARY

- Optimal care of the pediatric patient with ESRD on chronic dialysis requires a multidisciplinary approach to address and prevent potential complications related to ESRD.
- In addition to managing anemia, CKD–mineral bone disorder, and cardiovascular health, pediatric patients with ESRD on dialysis also require special attention to fluid and blood pressure management, growth, nutrition, and neurocognitive development.
- Cardiovascular events continue to be the leading cause of death, regardless of pediatric age group, highlighting the importance of attention to the management of cardiovascular health for all pediatric ESRD patients.
- Survival while on dialysis has improved over the past 2 decades; however, younger age, black race, and poor growth continue to be predictors of decreased survival.

Dialysis adequacy is typically measured as solute clearance (eg, urea removal) scaled for the urea volume of distribution, *Kt/V* urea, with a minimum target of a total (peritoneal and RRF) weekly *Kt/V* urea of ≥1.8, a value empirically slightly greater than what is recommended for adults. Clearance should be measured within the first month after initiating dialysis therapy. Clearance should be reassessed if there is a change in the clinical status that could impact solute removal such as decreased RRF, repeated peritonitis episodes, or if there is evidence of underdialysis such as increased fatigue, decreased appetite, worsening fluid retention, or more difficult to control/new onset hypertension.[6] In view of the frequent contribution of cardiovascular disease to pediatric patient morbidity and mortality, fluid removal and control of blood pressure are other important adequacy parameters (see cardiovascular health).

The most significant infectious complications that occur in patients on PD are catheter exit-site/tunnel infections and peritonitis. The frequency of peritonitis, which is a leading cause of hospitalization, death, and permanent