

Pediatric Hemodialysis Fact Sheet

Renal Failure (End Stage Kidney Disease)

Our kidneys are remarkable organs that maintain a constant balance between acid/base, electrolytes and mineral, blood pressure, fluids, red blood cell (RBC) production, and bone growth. Chronic kidney disease (CKD) is an abnormality of kidney structure or function for more than 3 months. CKD is further classified into five stages based on estimated glomerular filtration rate (eGFR), with stage 1 indicating normal GFR and stage 5 progressing to renal failure requiring dialysis (end stage kidney disease [ESKD]) (see Table 1). GFR is a determination of the kidney function. In patients 1-16 years of age, eGFR can be determined by using the following formula:

$$eGFR = k \times \text{height (cm)} / \text{serum creatinine (mg/dl)} \quad k = 0.413 \text{ (Pirojsakul et al., 2015)}$$

Table 1.
KDOQI Classification of the Stages of Chronic Kidney Disease

Stage	GFR (ml/min/1.73m ²)
1	≥90
2	60-89
3	30-59
4	15-29
5	<15

ESKD may occur in children as a result of many systemic disorders or congenital malformations. The cause of ESKD varies by age and race. Congenital abnormalities of the kidneys and urinary tract account for 34-43% of ESKD in children less than 12 years of age and glomerulonephritis accounts for 15-29% of ESKD in adolescents (Chua & Warady, 2017). In North America, the prevalence of CKD is two to three times higher in African-American children compared to Caucasian children (Becherucci et al., 2016). Children with ESKD experience symptoms relating to the failure of the kidneys to perform their essential functions such as:

- **Anemia** (reduced number of red blood cells [RBCs]) is primarily the result of the kidney's reduced production of erythropoietin. Erythropoietin is a hormone responsible for stimulating the

bone marrow to produce RBCs. Other factors such as iron and vitamin deficiency, inflammation, and other hormonal imbalances also contribute to anemia (Chua & Warady, 2017).

- **Nutritional imbalances** in ESKD lead to many complications resulting in poor growth and reduced neurocognitive function. Frequent nutritional assessments by renal dietitians and nephrologists are required to ensure optimal growth and neurocognitive function (Chua & Warady, 2017).
- **CKD mineral bone disorder (CKD-MBD)** is a complex disorder involving abnormalities in mineral metabolism, vascular (or other soft tissue calcifications), and bone disease (Ferris, Miles, & Seamon, 2016). Children who develop ESKD during the first 2 years of life experience the greatest amount of growth delay due to one-third of growth occurring during this time of life (Becherucci et al., 2016).
- **Cardiovascular mortality** in patients on dialysis is increased by 1,000 times when compared with their healthy peers. This increased risk is caused by hypertension and fluid overload from reduced urine output, leading to heart failure (Chua & Warady, 2017).
- **Reduced neurocognitive function** may occur in patients with ESKD. Infants with ESKD experience the highest risk of neurocognitive delay due to rapid brain growth occurring during the first year of life. Anemia, hypertension, poor nutrition, seizure disorders, and other exposures increase the risk of neurocognitive delays (Chua & Warady, 2017).

Treatment of children with ESKD can be complicated and involves close monitoring by the nephrology team, medication administration, renal specific diet, family support, and those in renal failure may require dialysis/transplantation teams. Renal transplantation should be the goal in managing these children.

Treatment Options

Currently, there are four treatment options for patients with ESKD: in-center hemodialysis, home hemodialysis, peritoneal dialysis, and transplantation. The decision not to treat is a fifth option in patients with terminal, complex medical conditions. As mentioned previously, the ultimate goal in patients with ESKD is renal transplantation.

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Hemodialysis

Hemodialysis is a treatment option that cleans the blood of excess waste products and removes excess fluid. The hemodialysis machine removes the child's blood by a central venous catheter (CVC) that is placed in a large blood vessel or a surgically created arteriovenous fistula (AVF) or arteriovenous graft (AVG). The blood passes through an artificial kidney or dialyzer where excess water and waste products are removed. In-center hemodialysis is performed 2-6 days a week in the dialysis facility. A trained care provider performs home hemodialysis nightly in the child's home.

Vascular Access

Central Venous Catheter

A CVC is a double lumen catheter that is tunneled under the skin and leads directly to the heart. On occasion, a temporary catheter may be placed in event that a patient starts dialysis emergently in an acute setting. Patients usually do not leave the hospital with a temporary catheter. A permanent catheter can be used for a longer period of time. Permanent catheters are tunneled under the skin. Cuffed catheters are typically used when an AVF or AVG is maturing, healing, unable to be placed, or if a renal transplant is imminent. The preferred location for a catheter is in the internal jugular vein.

Care for the CVC:

- Keep the dressing clean and dry.
- This dressing will be changed by the dialysis nurses at least weekly; however, parents are taught to change in the event it becomes loose, dirty, or wet.
- Signs and symptoms of infection should be reported immediately to the dialysis center; fever, redness, drainage, or pain at the catheter exit site.
- Report any bleeding at catheter exit site.
- Apply direct pressure and transport patient to emergency room if catheter becomes dislodged. Apply pressure to the insertion site of a cuffed catheter rather than the exit site. The insertion site is above the exit site and usually has a small scar.

Arteriovenous Fistula

An AVF is created when an artery is surgically connected to a vein, most commonly in an arm. The strong flow of the arterial blood through the vein increases the size of the vein and thickens the vein wall. Large needles can be placed into the AVF with every treatment providing the blood flow needed for hemodialysis. AVFs are the preferred hemodialysis access as it does not introduce foreign objects into the child and has fewer complications.

Arteriovenous Graft

If a child does not have large enough blood vessels to create a successful AVF, an AVG may be placed. A graft is synthetic tubular material used to attach the artery to the vein, which then provides an area of increased blood flow. Large needles are also placed into grafts to provide the required blood flow for hemodialysis.

Care for the AVF or AVG:

- Protect access extremity from trauma.
- No blood pressure or blood draws in access extremity.
- No tight clothing, backpacks, large purses, or constrictive jewelry on the access extremity.
- Patency is assessed by auscultation with a stethoscope for presence of a bruit and palpation for presence of a thrill.
- Constant assessment for signs and symptoms of infection such as pain, swelling, erythema, and fever.
- The chronic renal center must be notified immediately in the absence of a bruit or thrill, or if the child presents with symptoms of infection.
- Weightlifting restricted to 25 lbs in the access extremity.

Medications

Dialysis patients must comply with fluid restrictions, dietary restrictions, and a medication regimen in addition to their dialysis treatments in order to maintain optimal patient outcomes. These can be exceptionally challenging to the pediatric patient. Fluid restrictions are based on the size of the child and the amount of residual urine the child still produces. The diet restricts sodium, potassium, and phosphorus; found in most food children often like to eat. There are medications that must be taken at certain times of the day and medications that are given at dialysis. Some of the common ones being:

- Calcium carbonate (Phoslo®), sevelamer (Renvela®, Renagel®), lanthanum (Fosrenol®): These are phosphate binders, when taken with meals may decrease the rate of bone loss that is common in dialysis patients.
- Calcitriol (Rocaltrol®): The vitamin D analog for the management of hypocalcemia.
- Erythropoiesis-stimulating agent (Epogen®/Retacrit®/Aranesp®/Mircera®/Procrit®): These medications promote red blood cell production, decreasing or eliminating the need for blood transfusions. These medications may be given subcutaneously or intravenously.

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They are often given IV via the hemodialysis circuit at time of treatment.

- Venofer® (Iron Sucrose), INFed® (Iron Dextran), Ferrlecit®/Nulecit® (sodium ferric gluconate complex), Ferrous sulfate: Iron supplementation for the treatment of iron deficiency anemia and is often given IV during dialysis.
- Renal vitamin.
- Human growth hormone: Long term treatment for failure to grow.
- Paracalcitriol (Zemplar®): Used for the prevention and treatment of secondary hyperparathyroidism associated with renal failure.

Children must depend on their parents or guardians to assist them in maintaining compliance with diet, medication regimens, and fluid restrictions.

Challenges for Children on Hemodialysis

Because children should gain weight with normal growth, blood pressure, weight data, and the physical exam should be utilized to evaluate estimated dry weight frequently. Difficulty tolerating fluid removal during treatment, weights greater than estimated dry weight (EDW) after dialysis with normal or low blood pressures, and no appreciable edema likely indicates actual weight gain associated with growth.

One of the major challenges for children on hemodialysis is dietary and fluid restrictions. For infants, it is a challenge for the parents as most, if not all, of their nutrition is in liquid form. For the school age child, social issues become a factor. Other children don't understand why the child cannot have French fries and a soda with them. Peer pressure may make compliance much more difficult.

Fluid removal during dialysis can be difficult in children. To prevent low blood pressure during dialysis, ideally no more than 5% of the child's EDW should be removed in a session (Kaur & Davenport, 2014). Therefore, children on hemodialysis must dialyze anywhere from 3-6 days per week. This does interfere with time in school. School age children tend to miss several hours of school in a week. Dialysis centers try to supplement their learning with tutors and hospital-based schoolteachers.

Children who grow up with renal failure may very well look physically different than other children their age. They may be small in stature, their skin may be having a different hue, and they may have a very obvious graft of fistula in one of their extremities. Children with catheters cannot swim or get the CVC wet during bathing. Special waterproof dressings are provided to the family to place on the child during bathing. Children with grafts or fistulas, as well as catheters, are encouraged to participate in sports as long as they can protect their vascular access from harm. These factors can be limiting, and thus emotionally challenging.

What is the Goal?

The goal for children on hemodialysis is optimal patient outcomes in order to remain as healthy as possible for an eventual kidney transplant. Patient care is very individualized based on the child's health status, physical and emotional age, parental/guardian support and resources, as well as many other factors. Not all children will qualify for a kidney transplant; therefore, the goal would be to maintain optimal health until the patient is old enough to transition to adult care.

References

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