CHAPTER **51**

THE DIALYSIS PATIENT

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Chronic renal failure is defined as a persistent impairment of kidney function. It results from irreversible loss of large numbers of functioning nephrons. It is seen clinically as a progressive loss of kidney function, and may result in complete renal failure requiring renal replacement therapy. When renal replacement therapy is implemented, the condition is termed end-stage renal disease (ESRD).

ESRD occurs in more than 70,000 people per year in the United States. It is more common in males than females, and is seen more prevalently in African Americans than any other race. The most common cause is diabetes mellitus, and others include hpertension, glomerulonephritis, polyarteritis nodosa, lupus erythematosus, amyloidosis, renal vascular disorders, pyelonephritis, tuberculosis, urinary tract obstruction, and polycystic disease.

The ultimate goal in the treatment of chronic renal disease is interruption of the progressive loss of kidney function. Unfortunately this can't always be accomplished, so renal replacement must be implemented. The two main types of renal replacement therapy are hemodialysis and peritoneal dialysis. Although each of these types is a different approach, their end result is the same

Hemodialysis

Hemodialysis began in the 1960s with the development of the external arteriovenous shunt and the endogenous arteriovenous fistula. Although technically feasible, long-term dialysis at this time was extremely expensive and only available in a few hospital centers. It was not until 1973 when Medicare entitlement for the treatment of ESRD was enacted by Congress, and therefore the unrestricted treatment of renal failure with dialysis began in the United States.

The basic principle behind hemodialysis is the passage of blood through a dialyzer extracting unwanted substances away from the blood. Solutes are removed from the blood predominately by diffusion. Diffusion entails the movement of solutes, such as creatinine, urea, and potassium, from the blood to the dialysate across a semipermeable membrane. The dialysate fluid consists of a mixture of treated water, electrolyte, glucose, and bicarbonate solutions. This mixture provides the optimum physiological levels of electrolytes to be maintained in the patient's blood and for waste products to be removed. Fluid is removed from the blood by ultrafiltration. A hydrostatic pressure gradiant is present across the dialysis membrane, which allows fluid to move from high pressure to low pressure. Positive pressure is applied to the blood and negative pressure to the dialysate, resulting in movement of excess water from the blood to the dialysate.

Vascular access is essential for the process of hemodialysis. This vascular access is the sole way in which the blood exits and enters the body during the process of hemodialysis. The three main types of dialysis access are dual-lumen catheter, arterio-venous fistula, and synthetic grafts. The dual lumen catheter can be permanent or temporary. It is inserted into the internal jugular, subclavian, or femoral veins. These veins are used due to their size and accessibility. Arterio-venous fistula (AVF) is the long-term vascular access of choice. They are formed by surgical subcutaneous anatomosis of an artery to a vein. Common sites for AVFs are the wrist, utilizing the radial artery and cephalic vein, and the elbow, utilizing the brachial artery and any large vein in the area. Finally, synthetic grafts are used when an AVF cannot be created, such as in patients with comorbid vascular disease. Synthetic grafts are used to join an artery to a vein. Grafts have the disadvantage of being more prone to clotting and infection.

Modern dialysis machines consist of the dialyzer, a pump that regulates blood flow, and a dialysate solution delivery system. The dialyzer is the core of the hemodialysis process. The removal of water and waste products take place in the dialyzer. It consists of a blood component and a dialysate component separated by a semipermeable membrane. Dialyzers of different size and efficiency levels are selected to meet the needs of the individual patient. Standard dialysis membranes activate not only the complement cascade, but also activate the clotting cascade. This

activation of the clotting cascade necessitates the need for anticoagulation during the hemodialysis process. This anticoagulation can be done in the form of repeated boluses or constant infusion.

There are several complications that can arise during the process of hemodialysis, hypotension, fever, hemorrhage, hypokalemia, and anaphylaxis. It is extremely important that patients are closely managed during dialysis to avoid such complications. There are also complications that can occur from long term use of dialysis, such as anemia, amyloidosis, and aluminum toxicity. Although hemodialysis is an effective treatment of ESRD, the annual mortality rate among dialysis patients remains the highest mortality in developed nations. The major cause of death among hemodialysis patients is cardiovascular complications. Discontinuing hemodialysis also is becoming an increasing cause of death among dialysis patients. Although dialysis is prolonging life, the question arises about the quality of life that is being prolonged.

Peritoneal Dialysis

Peritoneal dialysis (PD) is a method in which the peritoneum is used as a membrane to filter accumulated fluid and waste products from the blood. PD was introduced in the 1970s as an alternative to hemodialysis and has become a practical and widespread treatment for kidney failure. It allows the patient more convenience and independence as they do not have to have sessions at a dialysis center and can instigate treatments on their own. The process of PD involves filling the abdomen with dialysis solution. The peritoneum then allows waste products and extra fluid to pass from the blood into the dialysis solution. The used solution is then drained from the peritoneum and thrown away. This process takes about 30-40 minutes and technically is called an exchange. The period in which the solution is in the abdomen is called dwell time.

There are two forms of PD, Continuous Ambulatory Peritoneal Dialysis (CAPD) and Automated Peritoneal Dialysis (APD). CAPD involves treatments being performed during the day. The patient will drain a bag of dialysis solution into their abdomen and allow a period of 4-6 hours for dwell time. The solution is then drained and the cycle repeated up to 4 times a day. APD consists of utilizing an automated cycler to perform 3-5 exchanges during the night while the patient sleeps. Their dwell time then lasts the entire day.

Access to the peritoneum is through a catheter, which is surgically placed into the abdomen. These catheters are made of flexible silicone rubber and generally contain a cuff (made of polyester fabric) that merges with the scar tissue to keep the catheter in place. The end of the tubing in the peritoneum is perforated with multiple small holes to allow the free flow of solution in and out of the catheter.

Dialysis fluid or solution is available in 1.5 or 3.0 liter bags. The fluid is a sterile solution that contains electrolytes, lactate, and glucose. The electrolytes are in similar concentration to normal serum and aid in diffusion. Lactate is commonly used in solutions and aids in combating metabolic acidosis, which is a common complication of renal failure. Glucose (available in three different strengths) acts an osmotic agent to extract the wastes and extra fluid from the blood.

Potential complications that can occur with PD are numerous. The most common complication is peritonitis, which is usually caused by normal skin and nasal flora. The importance of preventing infection is adhering to strict hygiene rules and knowing how to identify the early signs and symptoms of peritonitis. Other complications include cardiovascular complications, catheter problems, constipation, problems with nutritional status (40% are undernourished), psychosocial difficulties, and increased intra-abdominal pressure which can cause hernias, leaks from the peritoneum, hydrothorax, alterations in respiratory function, and back pain.

Podiatric Surgery in the Dialysis Patient

Deciding whether to perform surgery on the patient undergoing renal dialysis can be a difficult decision. It is always best to consult their nephrologist or primary care physician before making a final decision. However one must consider whether the risk outweighs the benefits. According to the literature, patients with end-stage renal failure are generally considered poor candidates for surgery because of high (>54%) perioperative complications rates. One must also consider these rates were based mostly on nonpodiatric elective and emergency procedures. Looking at a patient on dialysis and performing surgery, one must consider several factors. The first is the co-existing diseases that are

present and may complicate the situation. Of course most of our patients that are on dialysis have diabetes, but usually the patient on dialysis has several medical problems. These medical conditions may include cardiac disease, hypertension, gastrointestinal disorders, chronic lung disease (i.e. asthma or COPD) and neurologic problems. Preoperative laboratory evaluation is key as well. Important values to consider are blood urea nitrogen (BUN) and creatinine. However most importantly, potassium levels should not be overlooked because imbalances in potassium levels can cause grave peri and postoperative complications for your patient. Another lab value to consider is the serum albumin.

If a decision is made to perform surgery in the dialysis patient, some common guidelines can be used to prevent complications concerning the dialysis therapy. First is their actual dialysis schedule. It has been recommended that pre-operative dialysis be performed within 24 hours of the surgery and again within 24 hours after the surgery. Checking laboratory values after the pre-operative dialysis before surgery is essential to preventing intra and postoperative complications. Decision of type of anesthesia is critical and should always be discussed with the anesthesiologist. In our neuropathic diabetic patients a local anesthetic may be used for an elective procedure, and Montiored Anesthesia Care (MAC) may be utilitized as well for more simple elective type procedures. Spinal anesthesia may be used for more involved procedures such as amputations or reconstructive procedures. General anesthesia should generally be avoided if possible, but can be used depending on the factors discussed above.

Potential postoperative complications include hyperkalemia, infection, hypotension, hemorrhage, and hypoventilation. Hyperkalemia is the most frequent complication following surgery in dialysis patients, occurring in up to 38% of patients. Hyperkalemia is best prevented by pre-operative dialysis, use of pre and perioperative potassium-free IV fluids, and an IV infusion of glucose preoperatively. Potassium levels should also be monitored especially in the early postoperative period. Significant hypotension (intraoperative and postoperative) can lead to thrombosis of the hemodialysis access site and thus is important to monitor and regulate. Hemorrhage is another consideration in dialysis patients as they most likely have predisposed multifactorial coagulopathy. Prevention is enhanced by preoperative dialysis immediately before surgery to aid in hemostasis and maintaining hemoglobin levels above 10 g/dl.

Pharmacological Approach to Renal Disease

Normal renal function is very important in the metabolism and elimination of many pharmacologic agents. Many of these agents undergo renal excretion, and those that do not undergo renal excretion may cause other adverse effects in patients with renal failure. As a result, it is important for the physician to make dose adjustments and be knowledgeable about the effects that medications can have in the renal-compromised patient.

There are several altered pharmokinetic principles in a patient with renal failure. The first of these is bioavailability. Bioavailability is the percentage of a given dose that enters the system's circulation. The absorption of a drug dictates its bioavailability and it may be altered in patients with renal failure. Volume of distribution is the second principle that can be altered. Volume of distribution can be determined by dividing the total amount of drug in the body by its concentration in the blood. The portion of a given agent that is bound to protein is an additional principle, which can be altered by renal failure. Renal failure tends to decrease protein binding, causing larger amounts of a drug to circulate in its unbound, inactive form. The final principle is biotransformation. This is the biochemical conversion from one chemical form to another.

The best approach to determining dosage adjustments in patients with renal failure entails 5 steps. Step one is performing a complete history and physical exam, including determining the cause of renal function, where it is acute or chronic renal disease, determining the patient's ideal body weight, and determining if the patient has coexisting hepatic disease. Step two is assessing renal failure by determining creatine clearance (Table 1) and glomerular filtration rate. Step three is to determine the loading dose needed for pharmacological agents. In patients with renal dysfunction, an agents half-life may be greater prolonged. Step four is determining the maintenance dose and dosing interval. Step five is monitoring drug levels. This is done after the loading dose or 3-4 maintenance doses.

Table 1

DETERMINING DOSAGE ADJUSTMENTS IN PATIENTS WITH RENAL FAILURE

Creatine Clearance = [(140-age) x ideal body weight] / (72 x serum creatine)
Glomerular Filtration Rate = 170 x [serum creatine]-0.999 x [age]-0.176 x [0.762 if female] x [1.180 if African American] x [BUN]-0.170 x [albumin]-0.318
Loading Dose = volume of distrubution x ideal body weight x desired plasma concentration
Dosing Interval = [normal creatine clearance / patient's creatine clearance] x normal interval
Dose = [patient's creatine clearance / normal creatine clearance] x normal dose

Unfortunately, dosage adjustments for patients with renal failure can be time consuming and at times difficult. Approximately two-thirds of all medications used in clinical practice are excreted completely or partially by the kidney. Knowledge of correct renal dosing is important for optimal efficacy and patient safety. There are medications that do not require dosage adjustments in patients with renal failure (Table 2). Most medications do require dosage adjustments in patients with renal failure, some examples of commonly prescribed podiatric medications are listed in Table 3. There are many sources that aid in this dosage adjustment a few of which can be found in the bibliography section of this paper. These sources give dosage adjustments usually based on glomerular filtration rate or creatinine clearance.

SUMMARY

Treating the patient on renal dialysis can be an unfamiliar and challenging experience for most podiatric physicians. The information provided in this paper was intended to familiarize the podiatric physician with the basic principles of dialysis and how to manage the patient with renal failure. Although a general knowledge base has been provided in this paper, one should remember to consult the nephrologist or primary care physician as needed for patient care.

Table 2

MEDICATIONS THAT DO NOT REQUIRE DOSE ADJUSTMENTS IN PATIENTS WITH RENAL FAILURE

Antibiotics
- Isoniazid
- Ceftriaxone
- Cefoperazone
- Azithromycin
- Dicloxacillin
- Nafcillin
- Doxycycline
- Minocycline
- Clindamycin

Anti-fungals
- Ketoconazole
- Griseofulvin
- Itraconazole
- Miconazole

Corticosteroids
- Betamethasone
- Cortisone
- Dexamethasone
- Hydrocortisone
- Prednisone
- Triamcinolone

NSAIDs
- Ibuprofen
- Naproxen
- Indomethacin
- Diclofenac
- Diflunisal
- Etodolac
- Flurbiprofen
- Ketoprofen
- Ketorolac
- Mefenamic Acid
- Phenylbutazon
- Pirozicam
- Sulindac

Table 3

RENAL DOSING FOR COMMONLY PRESCRIBED MEDICATIONS

Drug	Dose for Normal Renal Function	Adjustment for Renal Failure, GFR of >50mL/min	10-50mL/min	<10mL/min	Supplement for Dialysis
Cephalexin (Keflex)	250-500mg q6h	q6h	q6h	q8-12h	Hemo: 250mg after dialysis
Cefadroxil (Duricef)	0.5-1.0g q12	q12h	q12-24h	q24-48h	Hemo: dose after dialysis
Levaquin	250-500mg qd	Unchanged	250mg q24-48h	250mg q48h	Unknown
Codeine	30-60mg q4-6h	Unchanged	75%	50%	Unknown
Propoxyphene (Darvon)	65mg tid-qid	Unchanged	Unchanged	Avoid	None
Acetaminophen	650mg q4h	Unchanged	qQ6h	q8h	Hemo: half dose

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