Hemodialysis and Peritoneal Dialysis

The three primary treatment options for patients with end-stage renal disease (ESRD) or stage 5 chronic kidney disease (CKD) are:

1. Hemodialysis (HD)
2. Peritoneal dialysis (PD)
3. Kidney transplantation

Morbidity and mortality in dialysis patients

Nearly two thirds of all dialysis patients die within 5 years of initiation of dialysis treatment. Approximately 50% of deaths in dialysis patients are cardiovascular related. In fact, those with CKD are more likely to die from cardiovascular disease before they reach ESRD.

Infections, usually related to the dialysis access, are the second most common cause of death in dialysis patients. In addition, a dialysis patient's quality of life is generally poor.

Indications for dialysis

Recent guidelines recommends that planning for dialysis begin when patients reach CKD stage 4.

The primary criterion for initiation of dialysis is the patient's clinical status: the presence of persistent anorexia, nausea, and vomiting, especially if accompanied by weight loss, fatigue, declining serum albumin concentrations, uncontrolled hypertension or congestive heart failure, and neurologic deficits or pruritus. Some nephrologists use critical lab values of serum creatinine or blood urea nitrogen as indicators of when to initiate dialysis.

Urea reduction ratio (URR)

The delivered or desired dose of dialysis in terms of solute removal can be expressed as the URR or the Kt/V. The URR is a simple concept and is easily calculated as:

$$\text{URR} = \frac{\text{Predialysis BUN} - \text{Postdialysis BUN}}{\text{Predialysis BUN}} \times 100$$

Kt/V is a number used to quantify hemodialysis and peritoneal dialysis treatment adequacy. Kt/V is the fraction of the patient's total body water that is cleared of urea during a dialysis session.

- *K: dialyzer clearance of urea * t: dialysis time *V: volume of distribution of urea*

Hemodialysis

- Hemodialysis involves the perfusion of blood and dialysate on opposite sides of a semipermeable membrane. Solutes are removed from the blood by diffusion and convection. Excess plasma water is removed by ultrafiltration.
- Native arteriovenous (AV) fistulas are the preferred access for hemodialysis because of fewer complications and a longer survival rate. Venous catheters are plagued by complications such as infection and thrombosis and deliver low blood flow rates.
- During hemodialysis, patients commonly experience hypotension and cramps. Other more serious complications include infection and thrombosis of the vascular access.

Advantages of HD

1. Higher solute clearance allows intermittent treatment
2. Parameters of adequacy of dialysis are better defined and therefore underdialysis can be detected early
3. Technique failure rate is low
4. Even though intermittent heparinization is required, hemostasis parameters are better corrected with HD than PD
5. In-center HD enables closer monitoring of the patient.

Disadvantages of HD

1. Requires multiple visits each week to the HD center, which translates into loss of patient independence
2. Disequilibrium, dialysis-induced hypotension, and muscle cramps are common. May require months before the patient adjusts to HD
3. Infections in HD patients may be related to the choice of membranes, the complement-activating membranes being more deleterious
4. Vascular access is frequently associated with infection and thrombosis
5. Decline of risk reduction factor (RRF) is more rapid compared to PD

Complications

The most common complications that occur during the HD procedure include hypotension, cramps, nausea and vomiting, headache, chest pain, back pain, and fever or chills.

Intradialytic hypotension

Intradialytic hypotension (IDH) is primarily related to the rate and amount of fluid removed during typical treatments. Acute management of IDH includes placing the patient in the Trendelenburg position, decreasing the ultrafiltration rate, lowering the dialysate temperature, modifying dialysate electrolyte concentrations, and/or administering normal or hypertonic saline. Midodrine has been effective with managing IDH.

Muscle cramps

Skeletal muscle cramps complicate 5% to 20% of HD treatments. Nonpharmacologic interventions to reduce muscle cramps include adjusting the ultrafiltration rate to avoiding hypotension, volume contraction, or hypoosmolality. Other methods are compression devices, moist heat, massage, exercise, stretching or muscle flexing and should be considered first to minimize adverse consequences.

Acute treatment include administration of 100-200 mL bolus of IV normal saline or 10-20 mL of IV hypertonic saline (23.4%) over 3-5 minutes. 50 mL of 50% IV glucose is suggested for nondiabetic patients.

Both vitamin E and quinine significantly reduce the incidence of muscle cramps. The FDA has warned against the off-label use of quinine for muscle cramps because of potential serious side effects related to its use.

Vascular access complications

Thrombosis and infection are the most common vascular access complications. The use of oral anticoagulant or antiplatelet agents to maintain vascular access patency is controversial since the risk may be greater than the benefit.

Infection prophylaxis

HD patients who develop a fever during treatment should immediately be evaluated for infection; blood cultures should be collected prior to the administration of any prophylactic antibiotics. Treatment with systemic antibiotic plus an antimicrobial catheter lock solution may be needed. Preventative care includes minimizing the use and duration of catheters, proper disinfection and sterile technique, and the use of an antimicrobial ointment at the exit site (mupirocin, povidone-iodine).

Peritoneal dialysis

Peritoneal dialysis (PD) involves the instillation of dialysate into the peritoneal cavity via a permanent peritoneal catheter. The peritoneal membrane lines the highly vascularized abdominal viscera and acts as the semipermeable membrane. Solutes are removed from the blood across the peritoneum via diffusion and ultrafiltration. Excess plasma water is removed via ultrafiltration created by osmotic pressure generated by various dextrose or icodextrin concentrations. Patients on peritoneal dialysis are required to instill and drain, manually or via automated systems, several liters of fresh dialysate each day. The more exchanges completed each day results in greater solute removal.

Peritonitis is a common complication of peritoneal dialysis. Initial empiric therapy for peritonitis should include intraperitoneal (IP) antibiotics that are effective against both gram-positive and gram-negative organisms.

Peritoneal Dialysis Solutions

All forms of peritoneal dialysis use dialysate solutions, which are commercially available in volumes of 1 to 3L in flexible polyvinyl chloride plastic bags. The most commonly used solutions which are commercially available contain glucose or icodextrin with varying concentrations of electrolytes, such as sodium, chloride, calcium, magnesium, and lactate. Dialysate pH is maintained at 5.2. These solutions may contain dextrose or icodextrin (a glucose polymer).

Advantages of PD

1. Hemodynamic stability due to slow ultrafiltration rate.
2. Higher clearance of larger solutes, which may explain good clinical status in spite of lower urea clearance.
3. Better preservation of risk reduction factor.
4. Convenient IP route for administration of drugs such as antibiotics and insulin.
5. Suitable for elderly and very young patients who may not tolerate HD well.
6. Freedom from the "machine" gives the patient a sense of independence (for continuous ambulatory PD).
7. Less blood loss and iron deficiency, resulting in easier management of anemia or reduced requirements for erythropoietin and parenteral iron.
8. No systemic heparinization required.
9. Subcutaneous versus lV erythropoietin or darbepoetin may reduce overall doses and be more physiologic.

Disadvantages of PD

1. Protein and amino acid losses through peritoneum and reduced appetite from continuous glucose load and sense of abdominal fullness predispose patients to malnutrition.
2. Risk of peritonitis.
3. Catheter malfunction, exit site, and tunnel infection.
4. Inadequate ultrafiltration and solute clearance in patients with a large body size, unless large volumes and frequent exchanges are employed.
5. Patient burnout and high rate of technique failure.
6. Risk of obesity with excessive glucose absorption.
7. Mechanical problems such as hernias, dialysate leaks, hemorrhoids, or back pain are more common than HD.
8. Extensive abdominal surgery may preclude PD.
9. No convenient access for IV iron administration.

Peritonitis and catheter exit-site infections

Peritonitis is a major cause of catheter loss in PD patients. Also, PD patients experience an exit-site infection approximately once every 24 to 48 months. Patients with previous infections tend to have a higher subsequent incidence. The majority of exit-site infections are caused by S. aureus.

Initial empiric therapy for peritonitis should include agents effective against both gram-positive and gram-negative organisms. IP administration of antibiotics is the preferred delivery route over IV therapy.

Topical antibiotics and disinfectants appear to be effective agents for the prevention of exit-site infections.

Nasal carriage of *Staphylococcus aureus* is associated with an increased risk of catheter-related infections and peritonitis. Prophylaxis with intranasal mupirocin (or other effective topical antibiotics) at the exit site can effectively reduce *S. aureus* infections.

Fungal peritonitis is associated with a poor prognosis and high morbidity and mortality. If the Gram stain indicates the presence of yeast, treatment may be initiated with amphotericin B and oral flucytosine. Once culture and sensitivity results are available, fluconazole, caspofungin, or voriconazole may replace amphotericin B. Treatment with these agents should be continued orally for an additional 10 days after catheter removal.