



quality of life, increased survival rate, and greater chance for rehabilitation. Kidney transplants may be obtained from deceased or living donors. In the United States in 2011, new kidney transplantations were performed in 15,652 people, although most of these patients (83%) received dialysis before transplantation.

There are two types of dialysis, hemodialysis and peritoneal dialysis. In the United States in 2011, 103,744 patients began hemodialysis, whereas only 7438 (7%) elected peritoneal dialysis. The distribution of patients receiving various modalities differs in other countries. Chronic dialysis is initiated when the patient displays signs of uremia, usually when eGFR is 10 mL/minute or less and there are no apparent reversible causes of kidney failure. However, chronic dialysis may be started at any time when complications of ESRD (e.g., fluid balance, potassium levels) cannot be controlled medically.

Hemodialysis

As illustrated in [Figure 32-4](#), blood is pumped from a vascular access into tubing that leads to a large number of capillary fibers bundled together in a dialyzer ([E-Fig. 32-6](#)). These capillaries are made up of semisynthetic materials that are semipermeable and therefore capable of allowing exchange of small molecules between blood and a dialysate solution, permitting countercurrent exchange. The solution contains sodium chloride, bicarbonate, and varying concentrations of potassium. Diffusion through the membrane allows low-molecular-weight substances such as urea and organic acids to move across according to the concentration gradient. Fluid is removed by *ultrafiltration*, which is achieved by applying transmembrane hydrostatic pressure across the dialyzer.

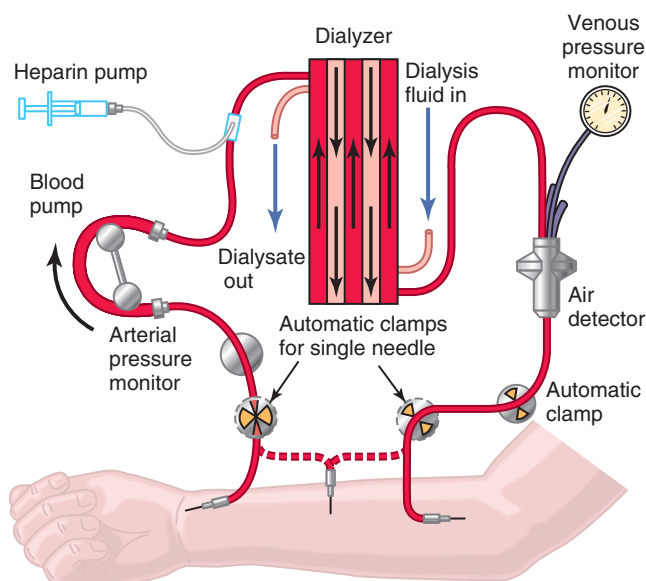


FIGURE 32-4 Essential components of a dialysis delivery system that, together with the dialyzer, make up an *artificial kidney*. In isolated ultrafiltration, no dialysis fluid is used (bypass mode). Also shown is the apparatus for using a single needle for inflow and outflow of blood from the patient. (From Keshaviah PR: Hemodialysis monitors and monitoring. In Maher JF, editor: Replacement of renal Function by dialysis, ed 3, Boston, 1989, Kluwer Academic Publishers.)

In the setting of ESRD, an average patient undergoing *intermittent* chronic hemodialysis requires 4 hours of dialysis three times a week. Common complications include hypotension and muscle cramping. Avoiding excessive fluid weight gain can minimize these complications.

An arteriovenous fistula (AVF) or arteriovenous graft (AVG) is recommended for permanent vascular access for hemodialysis, rather than an indwelling catheter. Although the goal is for more than 74% of prevalent hemodialysis patients to use an AVF or AVG for dialysis access (<http://www.healthypeople.gov/2020/>), many patients continue to use catheters, especially at the time of initiation of chronic hemodialysis. Temporary catheters are placed into the internal jugular, subclavian, or femoral vein, similar to other central venous lines. Permanent catheters have a cuff around the outer wall of the tubing and tunnel under the chest wall skin for some distance before entering the internal jugular vein. Catheters have a higher rate of infection and a higher risk for mortality compared with AVF or AVG.

Peritoneal Dialysis

In peritoneal dialysis, the peritoneal capillaries act as a semipermeable membrane similar to a hemodialysis dialyzer. This technique has several advantages over hemodialysis: it allows independence from the long time spent in dialysis units; it may not require as stringent dietary restrictions compared with hemodialysis; and it allows more patients to return to full-time employment. In *continuous ambulatory peritoneal dialysis*, dialysate of 2- to 3-L volumes is instilled through a peritoneal catheter ([E-Fig. 32-7](#)) into the peritoneal cavity for varying amounts of time and exchanged four to six times daily. In *continuous cyclic peritoneal dialysis*, the patient is connected to a machine, referred to as a *cycler*, that allows inflow of smaller volumes of dialysate with shorter dwell time overnight while the patient sleeps. Modifications to this regimen can be made to fit a patient's lifestyle and still achieve adequate clearance of toxins and removal of fluid. Ultrafiltration is achieved through increasing the dextrose concentration in the dialysate.

Two major drawbacks of peritoneal dialysis are peritonitis and difficulty in achieving adequate clearances in patients with excess body mass. Peritonitis can be treated with intraperitoneal antibiotics. Additionally, a slow deterioration occurs in the permeability of the peritoneal membrane, especially after one or more peritonitis episodes, leading to inadequate dialysis and, ultimately, the need to change the modality of RRT.

Kidney Transplantation

Kidney transplantation is the preferred modality of RRT. The variety of available immunosuppressive drugs, including rapamycin, mycophenolate mofetil, anti-interleukin-2 receptor antibodies, and novel agents such as belatacept have resulted in excellent graft survival.

Types of Kidney Transplants

Kidney transplant donors may be deceased or living and related or unrelated to the patient. The 1-year and 5-year graft survival rates are 91% and 71% with a deceased donor, and 97% and 85%, respectively, with a living donor.