Peritoneal dialysis is a technique whereby infusion of dialysis solution into the peritoneal cavity is followed by a variable dwell time and subsequent drainage. Continuous ambulatory peritoneal dialysis (CAPD) is a continuous treatment consisting of four to five 2-L dialysis exchanges per day (Fig. 4-1A). Diurnal exchanges last 4 to 6 hours, and the nocturnal exchange remains in the peritoneal cavity for 6 to 8 hours. Continuous cyclic peritoneal dialysis, in reality, is a continuous treatment carried out with an automated cycler machine (Fig. 4-1B). Multiple short-dwell exchanges are performed at night with the aid of an automated cycler machine. Other peritoneal dialysis treatments consist of intermittent regimens (Fig. 4-2A-C).

During peritoneal dialysis, solutes and fluids are exchanged between the capillary blood and the intraperitoneal fluid through a biologic membrane, the peritoneum. The three-layered peritoneal membrane consists of 1) the mesothelium, a continuous monolayer of flat cells, and their basement membranes; 2) a very compliant interstitium; and 3) the capillary wall, consisting of a continuous layer of mainly non-fenestrated endothelial cells, supported by a basement membrane. The mesothelial layer is considered to be less of a transport barrier to fluid and solutes, including macromolecules, than is the endothelial layer [1]. The capillary endothelial cell membrane is permeable to water through aquaporins (radius of approximately 0.2 to 0.4 nm) [2]. In addition, small solutes and water are transported through ubiquitous small pores (radius of approximately 0.4 to 0.55 nm). Sparsely populated large pores (radius of approximately 0.25 nm, perhaps mainly venular) transport macromolecules passively. Diffusion and convection move small molecules through the interstitium with its gel and sol phases, which are restrictive owing to the phenomenon of exclusion [3,4]. The splanchnic blood flow in the normal adult ranges from 1.0 to 2.4 L/min, arising from celiac and mesenteric arteries [5]. The lymphatic vessels located primarily in the subdiaphragmatic region drain fluid and solutes from the peritoneal cavity through bulk transport.
4.2 Dialysis as Treatment of End-Stage Renal Disease

The extent of lymph drainage from the peritoneal cavity is a subject of controversy owing to the lack of a direct method to measure lymph flow.

Dialysis solution contains electrolytes in physiologic concentrations to facilitate correction of acid-base and electrolyte abnormalities. High concentrations of glucose in the dialysis solution generate ultrafiltration in proportion to the overall osmotic gradient, the reflection coefficients of small solutes relative to the peritoneum, and the peritoneal membrane hydraulic permeability. Removal of solutes such as urea, creatinine, phosphate, and other metabolic end products from the body depends on the development of concentration gradients between blood and intraperitoneal fluid, and the transport is driven by the process of diffusion. The amount of solute removal is a function of the degree of its concentration gradient, the molecular size, membrane permeability and surface area, duration of dialysis, and charge. Ultrafiltration adds a convective component proportionately more important as the molecular size of the solute increases.

The peritoneal equilibration test is a clinical tool used to characterize the peritoneal membrane transport properties [6]. Solute transport rates are assessed by the rates of their equilibration between the peritoneal capillary blood and dialysate (see Fig. 4-8). The ratio of solute concentrations in dialysate and plasma at specific times during the dwell signifies the extent of solute transport. The fraction of glucose absorbed from the dialysate at specific times can be determined by the ratio of dialysate glucose concentrations at specific times to the initial level in the dialysis solution. Tests are standardized for the following: duration of the preceding exchange before the test; inflow volume; positions during inflow, drain, and dwell; durations of inflow and drain; sampling methods and processing; and laboratory assays [7].

Creatinine and urea clearance rates are the most commonly used indices of dialysis adequacy in clinical settings. Contributions of residual renal clearances are significant in determining the adequacy of dialysis. The mass-transfer area coefficient (M TAC) represents the clearance rate by diffusion in the absence of ultrafiltration and when the rate of solute accumulation in the dialysis solution is zero. Peritoneal clearance is influenced by both blood and dialysate flow rates and by the M TAC [8]. Therefore, the maximum clearance rate can never be higher than any of these parameters. At infinite blood and dialysate flow rates, the clearance rate is equal to the M TAC and is mass-transfer–limited. Large molecular weight solutes are mass-transfer–limited; therefore, their clearance rates do not increase significantly with high dialysate flow rates [9]. In CAPD, blood flow and M TAC rates are higher than is the maximum achievable urea clearance rate. However, the urea clearance rate approximately matches the dialysate flow rate, suggesting that the dialysate flow rate limits CAPD clearances.

**Peritoneal Dialysis Regimens**

**FIGURE 4-1** Continuous peritoneal dialysis regimens. A, Continuous ambulatory peritoneal dialysis (CAPD); B, continuous cyclic peritoneal dialysis (CCPD) is shown. Multiple sequential exchanges are performed during the day and night so that dialysis occurs 24 hours a day, 7 days a week.
4.3 Principles of Peritoneal Dialysis

**Figure 4-2**
Intermittent peritoneal dialysis regimens. Peritoneal dialysis is performed every day but only during certain hours. **A**, In daytime ambulatory peritoneal dialysis (DAPD), multiple manual exchanges are performed during the waking hours. **B**, Nightly peritoneal dialysis (NPD) is also performed while patients are asleep using an automated cycler machine. One or two additional daytime manual exchanges are added to enhance solute clearances.

**Figure 4-3**
Solute removal. Solute concentration gradients are at maximum at the beginning of dialysis and diminish gradually as dialysis progresses. As the gradients diminish, the solute removal rates decrease. Solute removal can be enhanced by increasing the dialysate flow rate by either increasing the intraperitoneal dialysate volume per exchange or increasing the frequency of exchange. By convection or enhanced diffusion, solutes are able to accompany the bulk flow of water. (From Nolph and coworkers [10]; with permission.)