

Chapter 2

WHAT IS HEMODIALYSIS?

(Adapted from various sources)

It is the purpose of this discussion to bring to you, as a prospective user of an artificial kidney, some understanding of the working of this device, its usefulness, and its limitations. The application of an artificial kidney is sometimes referred to as *hemodialysis*, and the apparatus itself may be called an *extracorporeal hemodialyzer*. *Hemo* simply means blood. *Dialysis* is of Greek origin, meaning “to pass through”; the present use implying a filtering (or passing through) process. *Extracorporeal* means “outside the body”; hence an extracorporeal hemodialyzer filters the blood outside the body.

Hemodialysis has long ago gone from an experimental procedure and last ditch stand against end-stage renal disease to a well established and effective therapy for the rehabilitation of the patient with chronic kidney disease. Although the artificial kidney approximates only some of the human kidney’s many functions, the body nevertheless adjusts remarkably well to the state maintained by the machine. There are now many patients who continue to thrive and function as productive citizens after many years of hemodialysis (including the editor, now beyond twenty-five years on dialysis). Among these are people from all walks of life.

How does it work? Consider for a moment a container or tank divided by a vertical partition. We will make this partition a sheet of cellophane. One compartment of the cellophane-partitioned tank will be filled with blood. The other will be filled with a solution of certain minerals and water (the dialysate bath).

The cellophane partition forms what is known as a *semipermeable membrane*. By semipermeable, we mean that some substances will permeate, or pass through it, but others will not. The sheet of cellophane may be thought of as having microscopic holes or “pores” through which particles of small molecular size may pass.

Normal blood is 90% water. Molecules of water in our two compartment tanks will pass freely back and forth through the cellophane

membrane between the blood and the bath. However, blood also contains red and white cells, protein, fat, sugar, minerals (called *electrolytes*, such as sodium, potassium, calcium, magnesium, chloride, bicarbonate, and phosphate), and waste products (such as urea, creatinine, uric acid, and others). The red and white cells of the blood are much too large to pass through the cellophane, so they remain confined to the blood compartment. The same is true of the fat and protein molecules.

However, electrolytes, because of their small molecular size, pass freely (or “dialyze”) through the cellophane membrane in both directions. In this situation, the principle of diffusion applies. According to this principle, particles in a solution of high concentration pass through a semipermeable membrane into a solution of lower concentration until there is equal concentration of particles on both sides of the membrane.

The concentration of the various electrolytes in blood must be maintained within narrow limits if serious harm to the whole person is to be avoided. Therefore, in the bath compartment of our dialyzer, we adjust the concentration of sodium, potassium, chloride, and other electrolytes to approximate the levels in normal human blood serum. Thus, through the process of dialysis, the concentrations of these particles will become nearly equal on both sides of the cellophane membrane.

Metabolic waste products in the blood—urea, creatinine, and others—are some of the substances we wish to remove. These are larger molecules than the electrolytes, but they are still small enough to pass through the cellophane membrane (although more slowly). Therefore, again utilizing the principle of diffusion, if we have none of these substances in the bath solution, they will pass from the blood compartment to the bath side. We thus “dialyze out” the undesirable waste products in blood. After a while the concentration of urea and other wastes will build up on the bath side of the membrane and eventually reach the same concentration as in the blood. In actual hemodialysis, the bath solution is changed either periodically or continuously, so that a constant supply of fresh bath is provided to keep the bath waste level low, thus allowing more wastes to be removed from the blood.

The clinical use of hemodialysis to remove accumulated wastes from the body of the person whose diseased kidneys can no longer do so depends upon the process outlined above. Blood is taken from an artery through a system of tubes. It is then passed through the dialyzer unit of the artificial kidney so that the blood is separated from the bath fluid by a cellophane-like membrane. The exchange of water and electrolyte molecules and the transfer of waste particles from blood to bath occur as the blood courses along the membrane. Eventually, the blood is returned by a tube to the patient's vein. (Anticoagulant is added to the blood to prevent clotting in the dialyzer.)

There are several different kinds of hemodialyzers or artificial kidneys in use. The most common is the *hollow fiber* dialyzer. This is a plastic cylinder containing a bundle of thousands of tiny hollow cellophane-like fibers through which the patient's blood passes in one direction. Dialysate circulates around and between the fibers in the opposite direction.

In the layer or *parallel plate* type, two, four, or more sheets of cellophane are stacked in sandwich style between supporting boards. Gaskets around the edges prevent leakage. Blood flows between two sheets of cellophane, while dialysate fluid passes along the other side of each cellophane sheet.

All operate on the same basic principles. Typically, treatments are received two or three times weekly, the duration of treatment depending upon the type of equipment, the patient's medical requirements and other factors.

Another function of the artificial kidney is known as *ultrafiltration*, the removal of excess water from the patient. Inside the dialyzer, there is a certain resistance to the flow of blood. This resistance puts the blood in the dialyzer under a high pressure with respect to the surrounding dialysate bath. As a consequence, water is "squeezed" out of the blood. If the patient has gained more than the recommended amount of fluid weight since the previous dialysis, negative pressure (suction) can be applied to the dialysate (in the case of a hollow fiber dialyzer).

Dialysis is not painful, although most patients will from time to time experience some discomfort, such as headache, leg cramps, or nausea, particularly during the initial period of adjustment to the treatments. These temporary side effects may respond to the administration of saline solution (infused into the dialyzer's blood lines), or to being placed in a head-lower-than-feet position, or to other appropriate medical therapies.

In order to do well on dialysis, you will be required to limit your intake of fluids and certain foods, as described in Chapter 17. At this point, you may wonder why, if dialysis takes over the work of a patient's diseased kidneys, it is necessary to have these dietary restrictions. Normal kidneys do their work around the clock; the artificial kidney, only for several hours every two to four days. Moreover, the artificial kidney can perform only a few of the many complex functions performed by normal kidneys (see Chapter 1).

At present, artificial kidney machines are cumbersome and require considerable supervision. Their operation consumes time the patient would prefer to spend doing something else. Moreover, their operation is costly. Eventually, there may be simpler and more economical dialyzers that could be used perhaps one or two hours each day. Wearable and even implantable dialyzers are envisioned. Such devices would entail less interference with the patient's activities; he or she may feel better, and could have greater freedom in food and fluid intake. The future looks promising for the development of improved techniques and equipment.

It is possible for some patients, under highly controlled circumstances, to stay alive with a single hemodialysis (on today's equipment) every two or three weeks. But the patient would be pretty sick and feel poorly. One could have dialysis every day and feel better for it, but there would be little time left for anything else, and the cost would be prohibitive. Accordingly, the amount and frequency of dialysis prescribed for most patients is a compromise between what would theoretically be best for them, and what is most practical in terms of time and money.

In order for you to be dialyzed, it will be necessary for you to undergo a minor surgical procedure to create a means by which blood can easily be removed from and returned to your body during the dialysis treatments.

This may be the insertion of a plastic tube into an artery and a vein, the tube being connected to the artificial kidney during each treatment. This plastic tube is called a *shunt*. More commonly, a surgeon connects an artery directly to a vein under the skin; this results in a gradual enlargement of the vein with a high blood flow through it. This type of connection is called an *arterio-venous (A-V) fistula*. Needles can readily be inserted into the enlarged vein and connected to the machine. These and other types of “circulatory access” are described in Chapter 9.