Principles of Haemodialysis

Haemodialysis depends upon the basic scientific principles of diffusion, osmosis, ultrafiltration and convection. It is important that you familiarise yourself with these terms and understand how these principles apply to dialysis.

**Diffusion:**

Diffusion is the movement of solutes (dissolved particles) across a semi permeable membrane from regions of high solute concentration to regions of low solute concentration (see figure below). In haemodialysis the semi permeable membrane is an artificial (synthetic) membrane located within the dialyser. Smaller molecules that pass freely through this semi-permeable membrane (eg. urea, creatinine and potassium) are removed from the blood via diffusion. This occurs because the concentration of these solutes is higher in the blood than it is in the dialysate (Of course, waste products are not present in the dialysate at all!). The concentration gradient is maintained throughout the entire length of the dialyzer by employing a counter current system in which blood flows through the dialyser in one direction and dialysate in the opposite direction.

Diffusion is largely driven by the concentration gradient, however, other factors that may impact on the rate of diffusion are:

- Molecular size of solutes (smaller molecules will diffuse more easily than larger ones)
- Blood flow rate and the temperature and flow rate of the dialysate fluid
- Membrane characteristics within the dialyser ie. Surface area, pore size, shape, thickness, charge and number

![Diffusion Diagram](image-url)
Osmosis

Osmosis is the movement of water from an area of low solute concentration to an area of high solute concentration, or alternatively from an area of high water concentration to an area of low water concentration. This process occurs across a semi-permeable membrane. Eventually water will reach equilibrium on either side of this membrane. The rate at which osmosis takes place depends on many factors. These include:

– The patient- e.g; fluid status pre dialysis, co morbidities, blood pressure, blood flow rate
– the concentration gradient e.g. dialysate, fluid profiling
– The permeability of the membrane e.g. hi/low flux, size of dialyser.

An osmotic gradient exists when the osmolality of the solution on one side of the membrane differs from the osmolality of the solution on the other side of the membrane. During the dialysis treatment the osmotic gradient is manipulated in order to remove the set amount of plasma water. This is also how the removal of fluid is achieved during the treatment process of peritoneal dialysis. This is another form of treatment for ESKD.

Ultrafiltration

Fluid retained by patients undergoing renal replacement therapy must be removed to prevent serious complications such as pulmonary oedema. A process known as ultrafiltration removes this fluid. Ultrafiltration occurs when fluid moves across a semipermeable membrane as a result of a pressure gradient being applied across the membrane. The fluid will move from an area of higher pressure to an area of lower pressure (See Figure below).
In haemodialysis this pressure gradient is termed the Transmembrane Pressure (TMP). It is the result of positive pressure (the pressure created by forcing plasma into the dialysate) being exerted on the blood side of the dialysis membrane and negative pressure (the pressure created through the pulling of plasma into the dialysate) on the dialysate side of the membrane. In this manner fluid retained by the patient may be removed during haemodialysis.

**Convection:**

The process of solute drag or solute movement of middle molecules within a solvent from the blood compartment to that of the dialysate compartment is known as convection. Unlike diffusion, convection is dependent on the ease at which middle molecules are able to move within the solution across the semi permeable membrane. This is further dependant on the size of the molecules, the sieving co-efficient of the membrane, and the presence of hydrostatic pressure. This pressure is defined as the force required for plasma to move from the blood compartment into the dialysate compartment.

Convection has only been possible since the development of Hi-flux dialysers. These dialysers allow the combination of convection and diffusion. They have larger pores which allow for filtration of solutes with a molecular size up to 50,000 Daltons.