DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CBM352 Human Assist Devices

UNIT-III ARTIFICIAL KIDNEY

3.2 Different types of hemodialyzer

The dialyzer is the part in the artificial kidney system in which the treatment actually takes place and where the blood is freed from the waste products.

i. It is the meeting point of two circuits, one in which the blood circulates and the other in which dialysis fluid flows.
ii. Dialyzers, in routine clinical use, may be classified according to three basic design considerations: coil, parallel plate and hollow fibre type. Each type of dialyzer has certain optimum operating requirements.
iii. The rate of clearance of substances such as urea, creatinine, etc. from the blood during passage through an artificial kidney is dependent upon the rate of the blood flow. As the flow rate falls, there is a disproportionate fall in clearance. At high flow rates, there is little advantage in further augmentation of the blood flow. The rate and pattern of the dialysate flow also influence overall performance in respect of clearance of waste products. Almost all commercial dialyzers use cellulosic type membranes, the most common being Cuprophan, a regenerated Cellulose, extremely thin, with high tenacity and puncture proof.
iv. The removal of waste products during dialysis is proportional to the concentration gradient across the membrane.
v. In order to effect the maximum gradient, the concentration of waste products in the dialysate should be maintained at zero. This is achieved in most currently employed machines by using the dialysate only once and then discarding it. In addition, counter-current flow through the artificial kidney is used so that the dialysate enters the kidney at the blood exit-end where blood concentration of waste products is at the lowest level.

vi. It is desirable for the resistance to blood flow in the dialyzer to be as low as possible, eliminating the need to employ a blood pump. In addition, the design of the blood compartment should be such that all the blood can be easily and completely returned to the patient at the end of dialysis.

vii. The design must effect an optimum, thin film of blood going through the dialyzer without streaming under perfused areas of membrane surface. Similarly, there must be optimum mixing in the dialysate compartment, effected via the membrane support structure.

viii. A typical dialyser consists of these parts
   i. Blood Compartment
   ii. Dialysate Compartment iii.
   iii. Semi permeable membrane. The membrane separates blood and dialysate .
   iv. Dialysate holding structure/frame

Types of Dialyzer:

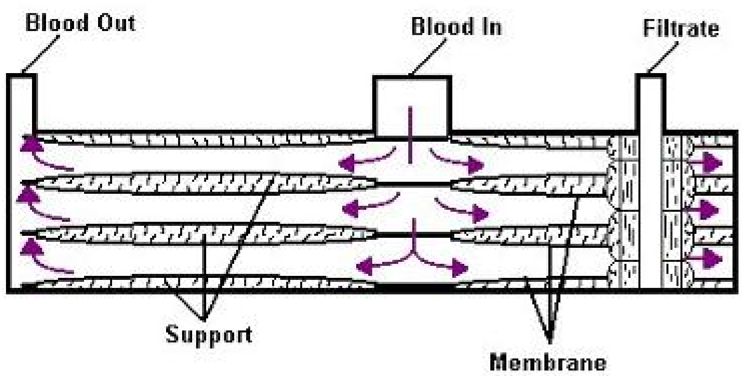
1. Parallel Plate Dialyser
2. Coil Kidneys
3. Hollow Fibre Dialyser:

3.2.2 Parallel Plate Dialyser

- This has parallel plates with ridges and grooves in them. The dialysate flows between the grooves or the ridges and a semi permeable membrane sits between the blood flow and grooves.
- The amount of blood in the dialyser is relatively small and hence at a given point of time the amount of blood outside the body is minimal. The surface area is of contact is large in parallel plate around 1 sq.mtr. and hence the resistance to flow is small, no blood pumps are needed. The arterial blood pressure will be sufficient. The Kiil dialyzer developed in Norway by Fred Kiil, has earlier been the most commonly used form of parallel flow dialyzer. It consists of three polypropylene boards with dialyzing membranes laid between them.
- The boards are held firmly with a frame on the top and bottom and are fastened by a series of bolts on the side. A rubber gasket runs along the periphery of the boards inner surface to prevent blood and dialysate leakage. The dialysate

enters through a stainless-steel port and flows along the grooves running across the board. The blood will flow through the membrane envelop, the membrane separates the dialysate flow and blood flow. Parallel plates can be visualised as flattened tubes inside the flattened space of the tube the blood flows and the entire membrane assembly on either side the dialysate will flow.

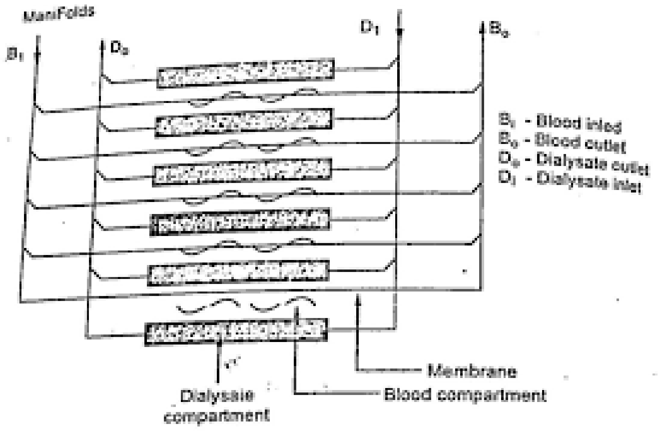
- The Kiil dialyzer is not disposable.
- It needs to be cleaned and re-built after each dialysis operation.
- With this type of dialyzer, a single-pass body temperature dialysate passes through the dialyzer once before going to the drain to obtain higher operational efficiency and to minimise bacterial infection.
- Several modifications have been introduced in the basic Kiil system. The parallel grooves have been replaced by pyramidal grooves which allow multiple point support for the membranes. This arrangement provides greater clearance of urea and creatinine under the same flow conditions because of increased surface area.



3.2.3 Coil Haemodialyser:

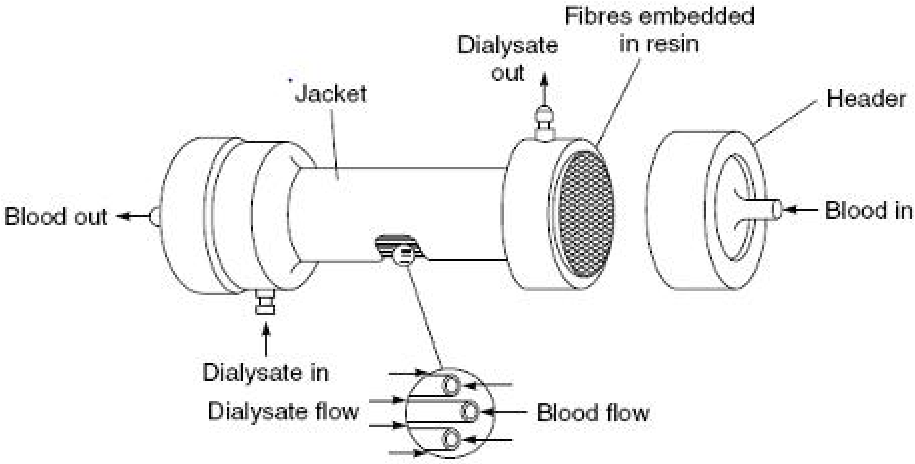
- This was the first commercial type kidney, it had a cellulose coil wired around a drum, this had unpredictable filtration rate.
- A coil hemodialyzer comprises a tubular membrane placed between flexible support wrapped around a rigid cylindrical core. The coil is immersed in a dialyzing bath. The tubular membrane can be of cellophane or cuprophane.
- The average wall thickness of cellophane membrane is 20–30 mm and that of cuprophane in the range of 18–75 mm.

- Coil dialyzers are available with several design variations, which include the type of membrane, the membrane support, the number of blood channels (1, 2 or 4), the width of the blood channels (38–100 mm) and surface area (0.7–1.9 m2). Coil dialyzers can be pre-fabricated because of their simple design.
- They are characterized by high dialysate flow rates and high resistance to blood.



3.2.4 **Hollow Fibre Artificial kidney**:

- This is the most commonly used modern haemodialyser.
- This makes use of counter current flow.
- Counter current flow is where the blood and the dialysate flows in the opposite direction.
- This is done to maximize the diffusive solute clearance as this maintains a constant pressure gradient along the length of the circuit. And the efficiency of counter current flow is almost 20% higher compared to the concurrent flow.
- This is gentle and hence used on the first time patient and pediatric patients. This has thousands of hollow tiny fibers held inside a cylindrical structure and blood flows in and out of the dialyser through manifold headers (multiple inlet and outlet). The fibres are jacketed in Plastic cylinder of 18 cm. In length and 7 cm. in diameter and the capillaries will have 200mm-300mm Internal diameter and a wall thickness of 25-30μm



➤ **Fig. 30.4** *Constructional details of hollow-fibre dialyser*

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