UNIT-V

MATERIALS USED IN MEDICINE

5.5 ARTIFICIAL ORGANS: DIALYSIS & HEMOFILTRATION

Artificial kidney technologies like **hemodialysis (HD) and hemofiltration (HF)** are used to **remove waste, excess fluids, and toxins from the blood** in patients with kidney failure. These technologies function as **artificial kidneys** by replacing the filtration function of damaged or non-functional kidneys.

1. Types of Blood Filtration Technologies

Method	Principle	Best For
Hemodialysis (HD)	Uses a dialysis membrane to remove waste via **diffusion** and **ultrafiltration**.	Chronic kidney disease (CKD), end-stage renal disease (ESRD).
Hemofiltration (HF)	Uses high-permeability membranes to remove waste via **convection**.	Acute kidney injury (AKI), intensive care unit (ICU) patients.
Continuous Renal Replacement Therapy (CRRT)	Slow, continuous filtration (HD or HF) over 24 hours.	Critical patients in ICU with fluid overload.
Peritoneal Dialysis (PD)	Uses the **patient's peritoneal membrane** as a natural filter.	Home dialysis, mild CKD.

2. Key Materials Used in Dialysis & Hemofiltration

A. Dialysis Membrane (Artificial Kidney Filter)

The membrane plays a critical role in filtering waste while retaining essential blood components.

🔻 **Common Materials:**

- **Cellulose-Based Membranes** (Cuprophan, Cellulose Acetate) – Older, but risk of allergic reactions.
- **Synthetic Membranes** (Polysulfone, Polyethersulfone, Polyacrylonitrile) – Higher permeability, better biocompatibility.
- **High-Flux Membranes** – Allow for rapid removal of larger toxins.

🔻 **Example:**

- **Fresenius FX Dialyzers** – Use **polysulfone membranes** for high efficiency and low thrombogenicity.

B. Dialyzer Housing & Tubing

The blood and dialysate pathways must be **biocompatible, durable, and non-reactive**.

🔹 **Common Materials:**

- **Medical-Grade Polycarbonate (PC)** – Transparent, impact-resistant.
- **Polypropylene (PP) & Polyvinyl Chloride (PVC)** – Used for tubing.
- **Silicone Elastomers** – Used in flexible connectors and seals.

🔹 **Example:**

- **Baxter Prismaflex CRRT System** – Uses **polycarbonate housing** for durability.

C. Anticoagulant Coatings

To **prevent clotting**, blood-contacting surfaces in dialysis circuits may be coated with anticoagulant materials.

🔹 **Common Materials:**

- **Heparin Coatings** – Reduce thrombosis risk.
- **Polyethylene Glycol (PEG) Coatings** – Improve blood compatibility.
- **Albumin & Phosphorylcholine Coatings** – Mimic natural blood vessel surfaces.

🔹 **Example:**

- **Gambro Prismaflex Dialyzer** – Uses **heparin-coated membranes**.

3. Comparison of Dialysis & Hemofiltration Technologies

Feature	**Hemodialysis (HD)**	**Hemofiltration (HF)**	**Peritoneal Dialysis (PD)**
Filtration Method	Diffusion & ultrafiltration	Convection	Osmosis through peritoneum
Best For	Chronic kidney disease (CKD)	Acute kidney injury (AKI)	Home dialysis
Membrane Type	Synthetic (Polysulfone, PES)	High-permeability (PAN, AN69)	Peritoneal membrane

Feature	Hemodialysis (HD)	Hemofiltration (HF)	Peritoneal Dialysis (PD)
Duration	3-4 hours, 3x/week	Continuous (24-hour ICU setting)	4-6 exchanges per day
Risk of Clotting	High (requires heparin)	Lower	Low

4. Future Innovations in Artificial Kidney Technology

- **Wearable Dialysis Devices** – Miniaturized, battery-powered dialysis for mobility.
- **Bioartificial Kidneys** – Combining synthetic membranes with live kidney cells for real-time filtration.
- **Nanomaterial-Based Membranes** – Enhancing filtration efficiency while reducing clot risk.
- **Artificial Intelligence (AI) Integration** – Optimizing dialysis parameters based on patient data.