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Departments Visited	**Date**
Cardiology	22/01/2025
Nephrology	24/01/2025

I have attached photos of our visit, which were clicked after permission from the guiding doctor, assistant & patient. The images will only be used for educational Purposes.

Cardiology Department

Pacemaker Monitoring Room

During our visit, we were first taken to the Pacemaker Monitoring facility *Figure 1*. There were master devices from different companies. Companies like Medtronic, Boston Scientific, St. Jude, Biotronic are the leaders in pacemaker space. There were no Indian company which are making it in India. Patient with the pacemaker must visit the facility every year for monitoring. The master device is used to monitor a wide range of pacemakers of the same company. The device has a screen for interaction, a handhold probe to communicate with the pacemaker using NFC (Near Field Communication). The device can give information about the battery life, unwanted cardiac activity, and other cardiac events which are captured and stored in the pacemaker's memory. The pacemaker stores the data for the period between to sessions of monitoring. The master device can also be used to program the pacemaker for custom mode of operation depending upon the patient's requirement.

Figure 1: Pacemaker Monitoring Facility

Apart from pacemaker the master device can also be used to monitor ICD (Implantable Cardioverter Defibrillator) This connection is established through Bluetooth communication. This also are monitored for battery life and unusual cardiac events like arrythmias. Once the device is monitored the vital data are manually filled into a report for Doctor's intervention and checkup.

We saw few sterilized pacemakers which were used by foreign clients which were imported to India for poor patients. These pacemakers were donated by patients who were expired or got a new pacemaker. The were properly sterilized and new leads will be used before implanting.

Holter Monitor Room

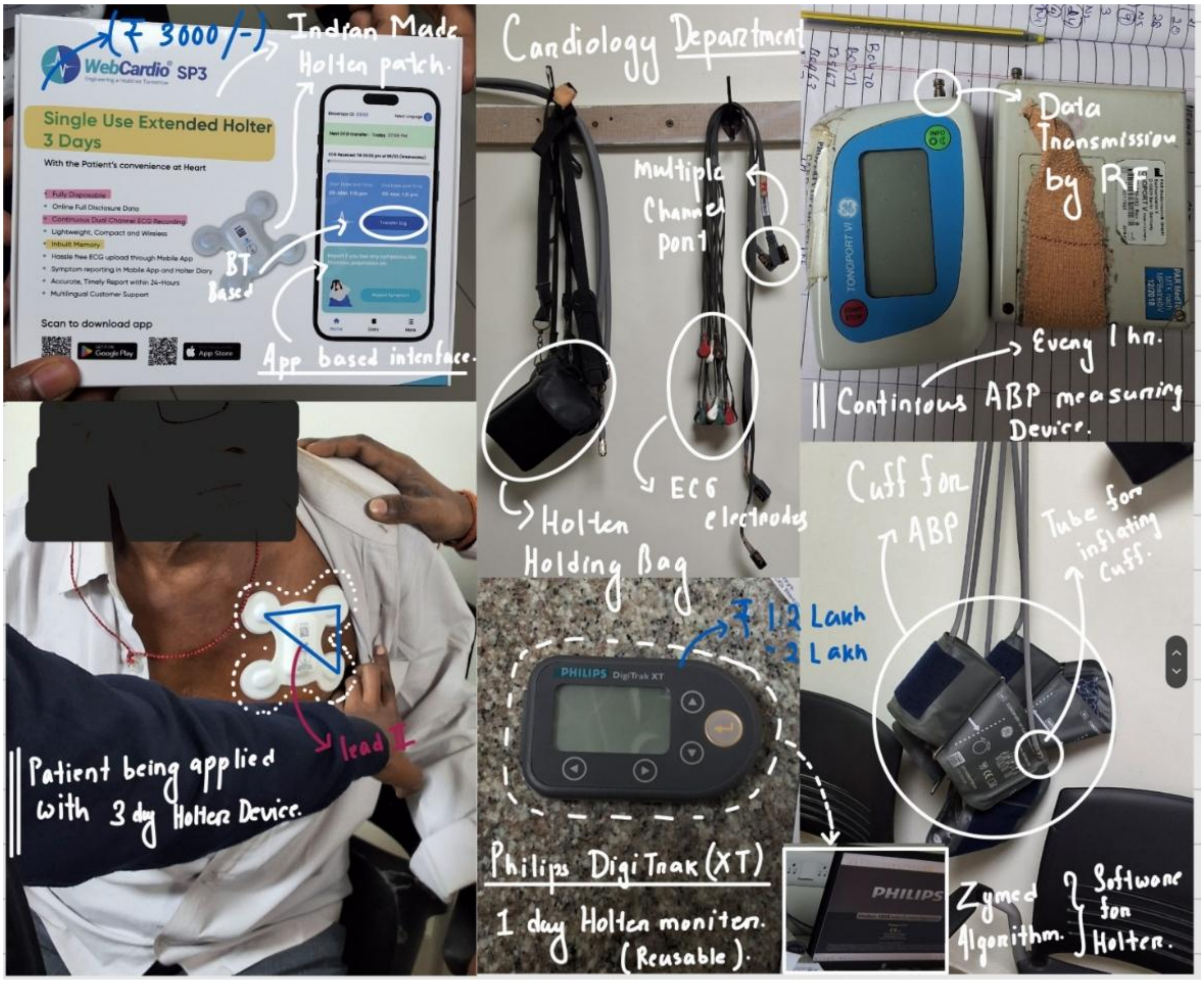

Figure 2 Holter Room with Holter monitors and ABPM.

In the Holter Monitor Room *Figure 2* we saw different types of Holter monitor. They were of 1,3,7 days type. 1 day type was from Philips and was reusable with a software to save data call Zymed Algorithm. 3 day and 7 day one was of WebCardio which is an Indian company and were non reusable. It is a telemedicine-based device whose data were ported to the cloud for Ai to work on the data. The data can be visualized via an application. These devices have their own memory for recording and saving data for limited period. We also saw an elderly patient using the 3-day device patch and a child of around 5 years was applied with 1-day Holter device.

We were introduced to a term called CATH lab which means catheterization lab. This is the lab/room where catheterization for the placements of the electrode leads and other catheter placement process is done.

There were devices for recording ABP (Ambulatory Blood Pressure) which records BP for 24 hours in every 1 hour or ½ hours by automatically inflating the cuffs. Then the data were transmitted to computer using RF antenna. This device was reusable and costed around 2-3 Lakhs INR. And single time monitoring costed around Rs 3000/- per patient.

There were not many patients in the OPD so we could not observe any more things. Based on the pacemakers and its most use we will consider arrythmia for our Pathophysiology.

Pathophysiology of Arrythmia

Arrhythmias occur due to disruptions in the heart’s normal electrical conduction system, affecting impulse generation or conduction. The heart's rhythm is normally controlled by the sinoatrial (SA) node, which generates impulses that travel through the atria, AV node, and ventricles. Arrhythmias can arise from abnormal impulse formation, such as enhanced or abnormal automaticity and triggered activity caused by early or delayed afterdepolarizations. Conduction abnormalities like reentry, conduction blocks, and accessory pathways also contribute.

Common causes include structural heart issues (e.g., fibrosis, infarction), electrolyte imbalances (e.g., potassium, calcium), autonomic dysfunction, ischemia, hypoxia, genetic mutations, or drug effects. Arrhythmias are classified as tachyarrhythmias (fast rhythm), bradyarrhythmias (slow rhythm), or premature contractions.

On a cellular level, disrupted sodium, potassium, or calcium ion flow alters action potential phases, leading to irregular rhythms. Clinically, they may cause palpitations, syncope, reduced cardiac output, stroke, or sudden death.

Technology Used

Here the listed technologies were used for diagnostic purpose in the clinics.

1. ***ECG (Electrocardiogram)***
2. ***Pacemaker***
3. ***ICD (Implantable Cardioverter Device)***
4. ***Holter Monitor***
    a. ***1-day***
    b. ***3-days***
    c. ***7-days***
5. ***ABPM (Ambulatory Blood Pressure Measurement)***

These were the main technologies used for diagnostic purposes in the cardiology department.

Limitations/Problems and their Solution.

Problem: The 3-days Holter by web cardio was inexpensive but of single time use only *Figure 3*. Once being used, they had to be disposed of. (***Company knowingly makes it single time use for profits***)

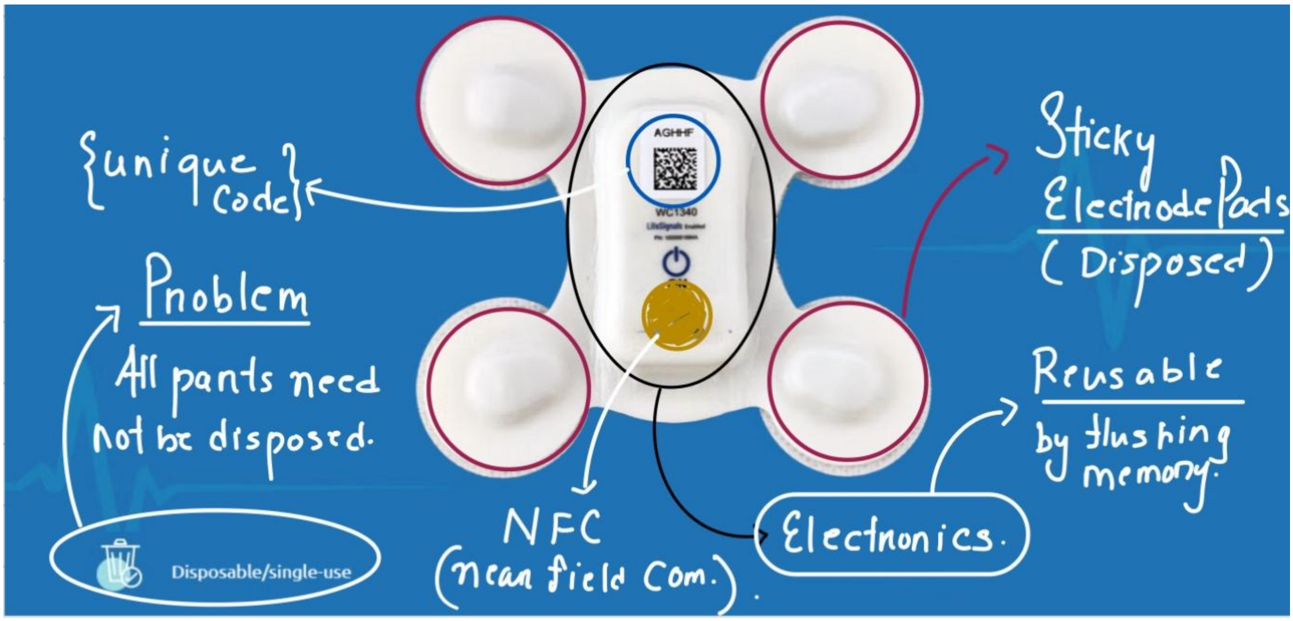

Figure 3 Problem with the Disposable Holter

Solution: *It has surface electrodes which needs to be disposed of. But the electronics can be used. Each device is identified by the unique code on the compartment and once used by a patient in the app cannot be used by other patients. To tackle this problem, we can remove the electronics and understand the communication protocol and the encoding of the data uses. Once we understand this, we can build our own software and transfer protocol to get the data from the device. Once this protocol and software is built, we can flush the memory in it electronically before using it again. Apart from it we need to make a physical compartment around it which can be attached to disposable part (sticky electrodes). After use for a particular patient, we can again use it by flushing memory and removing it from the electrodes. The solution as a schematic is given below.*

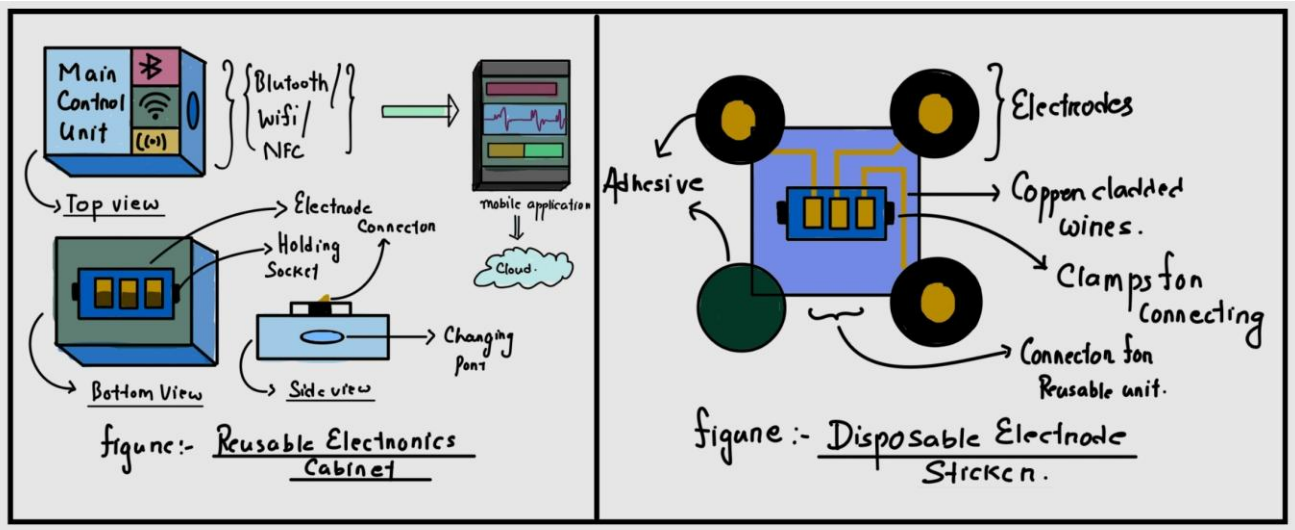

Figure 4 Concept Design of the reusable electronics cabinet with disposable Electrode sticker

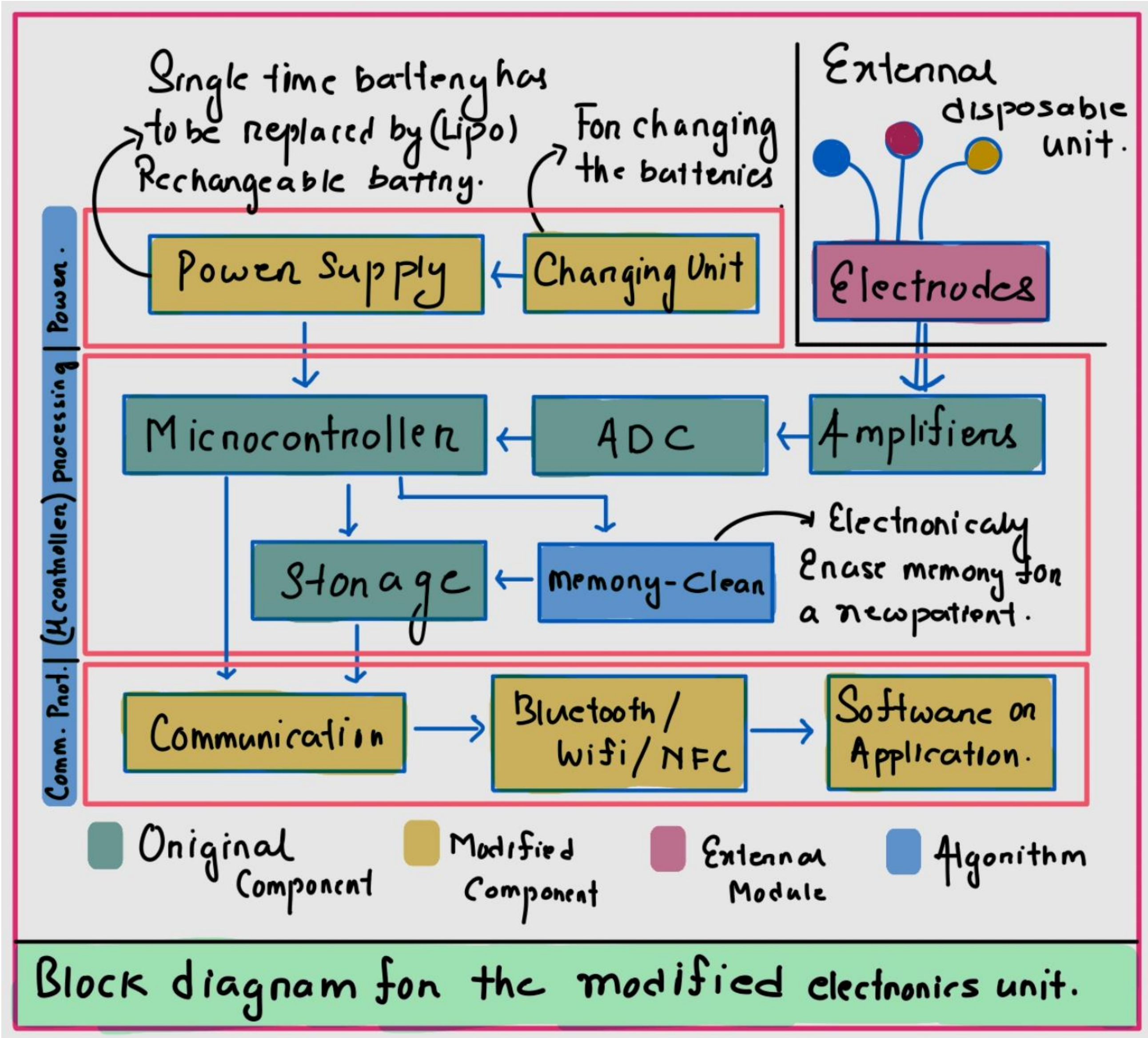

Figure 5 Block Diagram of the Device with all the features and parts

Problem: The pacemaker and ICD saved data and were communicated via com. modes, but it was done annually while monitoring is done. We can sometime miss the warnings of the body or the ICD itself due to the timeline of maintenance.

Solution: We can build application based on the communication protocols and transfer the data from the device to the app and then it can be ported into the web for remote patient monitoring. This would be easy on patient side and can be monitored regularly instead of annually. The idea is described as flowchart below.

Nephrology Department

Dialysis Room

During our visit, we were first taken to the dialysis room Figure 6. There were many patients in the room all were getting dialyzed. We observed a patient of around 50+ years of age. He had Chronic kidney failure the only treatment for it is (dialysis or transplantation). He was undergoing hemodialysis. It was meant to remove extra water un the body.

The process is done 2-3 times a week or else the fluids will start accumulating in the body. Patient must maintain the standard dry weight. The entire process of dialysis would take around 4 hours. The patient must lay down the entire time. For single time the cost is around Rs 3000/-. The main cost is of the dialysis cartridge, which is made of fibers and the blood has to pass through the fibers to get purified. Other components like bicarbonate water and RO water were produced inhouse so was of minimal cost.

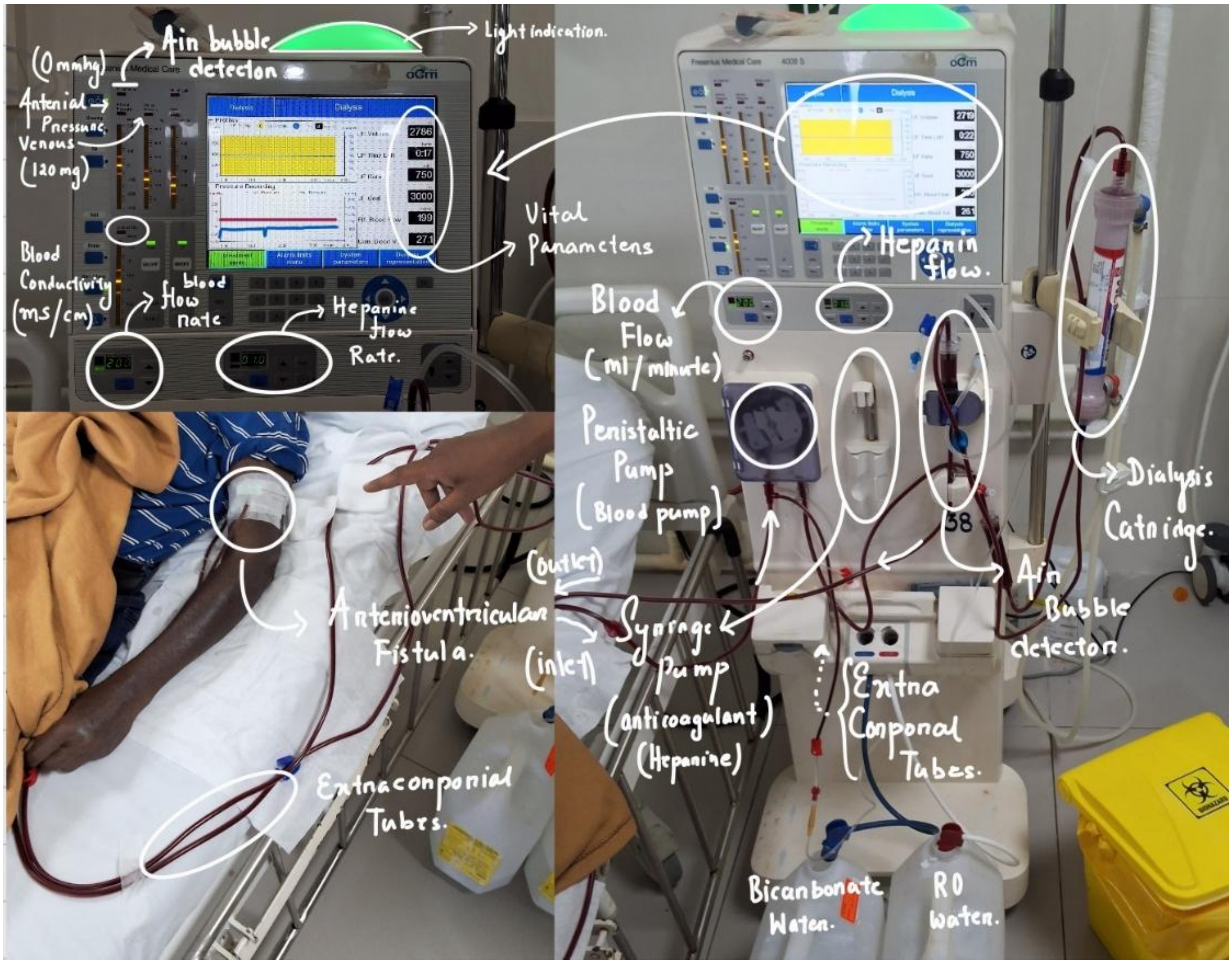

Figure 6 A elderly patient getting dialysis, parts of the machine and the vitals being monitored.

The blood was drawn from the AV Fistula of the left arm. Then the blood was pumped out of veins with 120mmHg pressure at the rate of 200ml/min using a peristaltic pump. Then the blood was checked for heparin concentration and was injected with 7000 units per 4 hours of heparin. Then the blood goes into the device and the ion, waste exchange happens and then the blood passes through the cartridge fiber and gets out of the device to a bubble chamber where the air bubble if present would be removed and then pumped back to the arteries with 0mmHg pressure. Patient with Hypertension and Diabetes must monitor.

After each use of the device the device is rinsed with RO water and again used. Every day each device is used for around 3-4 times of 4 hour each. There are bigger and powerful devices which were capable of dialysis when operation is being done. They can run for days at a stretch.

Apart from Hemodialysis there was peritoneal dialysis which is to flush out the peritoneal fluid and fill it with new fluid made artificially. This can be done at home and are little expensive than the trivial one.

Pathophysiology of Chronic Kidney Disease (CKD)

Chronic Kidney Disease (CKD) is a progressive condition characterized by the gradual loss of kidney function over time, resulting in the inability of the kidneys to adequately filter waste, regulate fluid and electrolyte balance, and maintain acid-base homeostasis. Dialysis is typically required in advanced stages (stage 5 CKD, also called End-Stage Renal Disease - ESRD) when the glomerular filtration rate (GFR) drops below 15 $mL/min/1.73m^2$ and conservative management fails.

1. Initial Insult and Progression of Kidney Damage:

- **Primary Causes**: Diabetes mellitus (diabetic nephropathy), hypertension (hypertensive nephrosclerosis), glomerulonephritis, polycystic kidney disease, and chronic infections.
- **Mechanism**:
  - Persistent damage leads to nephron loss.
  - Compensatory hyperfiltration occurs in remaining nephrons, increasing glomerular capillary pressure.
  - Chronic hyperfiltration causes glomerular sclerosis, fibrosis, and eventual nephron death.

Role of Dialysis in CKD:

Dialysis compensates for lost kidney function by performing the following:

- **Waste Removal:** Clears uremic toxins (e.g., urea, creatinine).
- **Electrolyte Regulation:** Corrects imbalances like hyperkalemia.
- **Fluid Management:** Prevents fluid overload and associated complications.
- **Acid-Base Balance:** Corrects metabolic acidosis.

Dialysis is life-sustaining for patients with ESRD, but it does not halt the progression of CKD or its complications.

Technology Used

Here the listed technologies were used for diagnostic purpose in the clinics.

1. ***Dialysis Machine***

   a. ***Peristaltic Pump***
   b. ***Syringe Pump***
   c. ***Bubble Chamber***
   d. ***Reverse Osmosis***
   e. ***Extracorporeal Circuit***
   f. ***Bicarbonate Cartridge***
2. ***AV Fistula making.***

These were the main technologies used for diagnostic purposes in the Nephrology department.

Limitations/Problems and their Solution.

Problem: The patient cannot move around while he\she is getting dialyzed.

Solution: No Solution for this as of now.

Problem: Dialyser cartridge was costly element of the entire dialysis process. How to reduce the price.

Solution: We can use 3D printer with resolutions around 100-200 micron to print these fibres which can reduce the cost by 10^{th}. The fibres are around 20-30 microns so its little difficult as of now but as we advance in the 3D printer technology, we can achieve this. Once the fibres are made using 3D printing technology, we can also reuse the material by melting it and then making it.