CT SCAN MACHINE(COMPUTED TOMOGRAPHY)

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1 INTRODUCTION ABOUT CT SCAN

A **computerized tomography (CT)** scan combines a series of X-ray images taken from different angles around your body and uses computer processing to create cross-sectional images (slices) of the bones, blood vessels and soft tissues inside your body. CT scan images provide more-detailed information than plain X-rays do.

1.1 What is Tomography?

Tomography is imaging by sections or sectioning through the use of any kind of penetrating wave. The method is used in radiology, archaeology, biology, atmospheric science, geophysics, oceanography, plasma physics, materials science, astrophysics, quantum information, and other areas of science. The basic meaning of tomography is **producing images by passing any ray or wave.**

2 WORKING OF A CT SCAN MACHINE

The main concept behind working of a CT machine is same as the other imaging devices, which uses X-ray beams for the scan. But Unlike x-ray machine which uses a fixed x-ray tube, the CT scan machine uses a **motorized x-ray tube** that rotates around the circular opening of a donut-shaped structure called a gantry. During a CT scan, the patient lies on a bed that slowly moves through the gantry while the **x-ray tube rotates around the patient, shooting narrow beams of x-rays through the body.** One more difference from x-ray machines is that instead of films, CT scanners use special digital **x-ray detectors**, which are located directly opposite the x-ray source. As the x-rays leave the patient, they are picked up by the detectors and transmitted to a computer. Each time the x-ray source completes one full rotation, the CT computer uses sophisticated mathematical techniques to construct a **2D image slice** of the patient. The thickness of the tissue represented in each image slice can vary depending on the CT machine used Image slices can either be displayed individually or stacked together by the computer to generate a 3D image of the patient that shows the skeleton, organs, and tissues as well as any abnormalities the physician is trying to identify.

3 COMPONENTS OF A CT SCANNER

3.1 GANTRY

The gantry is the donut like or ring shaped part of the CT scanner. It houses many of the components necessary to produce and detect X-rays. These components are mounted on a rotating scan frame.

3.2 Slip Rings

Newer CT systems electromechanical devices called slip rings . Slip rings use a brush like apparatus to provide continuous electrical power and electronic communication across a rotating surface.

3.3 Generator

High frequency generator is currently used in CT scanners. The generator are designed to be small enough so that it can be located within the gantry. Generators produce high voltage and transmit it to the xray tube. The power capacity of the generator is listed in kilowatts (kW).

3.4 Cooling Systems

Cooling mechanisms are included in the gantry. Cooling mechanisms are important because many components can be affected by temperature fluctuations

3.5 X-ray Source – CT X-ray tube

X-ray tubes produce the xray photons that create the CT image. It is the main component of ct scanner as it works on the principle of x-ray and has a motorized x-ray tube.

3.6 Filtration

Compensating filters are used to shape the X-ray beam. They reduce the radiation dose to the patient and help to minimize image artifact. As we know that X- rays maybe harmful for the body, Filters are necessary to minimize the harmful effects.

3.7 Collimation

Collimation restrict the X-ray beam to a specific area, as a result it helps reduce scatter radiation. This scatter radiation reduces image quality and increase the radiation dose to the patient.

3.8 SOFTWARES USED IN CT SCAN-

The main software used in CT scan machines are called medical imaging softwares. These imaging softwares process the x-ray data collected by detector from ct machine and converts them to digital images. Some medical imaging softwares are Planmed, mediCAD,inSimo, etc.

SCOPE OF INNOVATIONS IN CT SCAN-

Innovations in the field of medical imaging devices can be made as to reduce the harmful effects of rays emitting, improving the quality of image producing, using advanced detectors to easily detect the rays, a compact CT scan can be made using the technology of **cloud computing and wireless technologies.**

CARDIOPULMONARY BYPASS MACHINE(CPB) (HEART-LUNG MACHINE)

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1 INTRODUCTION:

The cardiopulmonary bypass machine is also called a heart-lung machine. It takes over for the heart by replacing the heart's pumping action and by adding oxygen to the blood. **It is a device that does the work of providing blood (and oxygen) to the body when the heart is stopped for a surgical procedure.** Trained technicians called **perfusion technologists** (blood flow specialists, also called the "pump team") operate the heart-lung machine.

2 USE OF CARDIOPULMONARY BYPASS MACHINE:

The heart-lung machine is used during heart and lung surgeries, so as to keep them **working and perform the functions of heart and lungs**. To stop the heart without harming the patient, oxygenated blood must continue to circulate through the body during surgery without stopping. The cardiopulmonary bypass pump does the work of the heart, **pumping blood through the body**, and making sure that the tissues of the body get the oxygen they need. The machine also **adds oxygen to the blood** while taking over the pumping action of the heart, replacing the function of the lungs.

3 WORKING PRINCIPLE OF CPB MACHINE:

In basics, the cardiopulmonary bypass machine and circuitry are blood reservoirs, blood pumps, and gas exchangers, safety measures along with different ports for gas and drug delivery and exhaust etc. Gas exchange obeys the law of diffusion which states that, **'the amount of gas diffused across a membrane is proportional to the difference of the partial pressure across the membrane,** The blood pumps works on the basis of Hagen Poiseuille law of flow rate which states that **Flow is inversely proportional to the viscosity of the fluid.**

4 COMPONENTS OF CPB MACHINE:

4.1 PUMP:

There are two types of pumps that can be used in CPB machine-

- Roller pump- Roller pump includes two rollers positioned on a rotating arm, which compress a length of tubing to produce forward flow. This action gently propels the blood through the tubing.
- Centrigugal Pump- Centrifugal pump consists of impellers/stacked cones within housing. When rotated rapidly, negative pressure is created at one inlet, and positive pressure at the other, thus propelling the blood forward. By altering the speed of revolution (RPM) of the pump head, blood flow is produced by centrifugal force.

4.2 CANNULAE :

Cannulae connect the patient to the circuit and hence to the CPB machine. They are made of polyvinylchloride (PVC) and are wire reinforced to prevent obstruction. There are two types of cannula used in the heart during CPB-

- Single-stage cannulae - used during most open-heart surgeries, where two cannulae are inserted into the superior and inferior vena cava and joined by a Y-piece.
- Dual-stage cannulae - used for most closed-heart procedures, where a single cannula is inserted into the right atrium. Drainage occurs through gravity.

Venous cannulation- Intravenous (IV) cannulation is a technique in which a cannula is placed inside a vein to provide venous access

4.3 OXYGENATOR:

The oxygenator is designed to transfer oxygen to **infused blood and remove carbon dioxide** from the venous blood.Earlier, Bubble oxygenators were used, but now **Membrane oxygenators** are used. Membrane oxygenators consist of hollow microporous polypropylene fibres. Blood flows outside the fibre while gases pass inside the fibre, thus separating the blood and gas phases.

4.4 Heat Exchanger:

A heat exchange system used in **extracorporeal circulation** to warm or cool the blood or perfusion fluid flowing through the device

Extraporeal Circulation-- A procedure in which blood is taken from a patient's circulation to have a process applied to it before it is returned to the circulation.

4.5 TUBING:

These are generally made of PVC, due to PVC's durability and acceptable **haemolysis rate (loss of blood rate)**.

4.6 RESERVOIR:

They collect the blood drained from the heart. **Open reservoirs** are more commonly used. They allow passive removal of entrained venous air along with the option of applying vacuum to assist drainage. When they are used, a safe level of blood in the reservoir is maintained to avoid air entry into the arterial circuit. **Closed reservoirs** have a limited volume capacity, but offer a smaller area of blood contact with artificial surfaces.

4.7 GAS LINE AND BLENDER :

Delivers fresh gas to the oxygenator in a controlled mixture.

4.8 CARDIOPLOEGIA SOLUTION AND CANNULA:

The blood after being processed from oxygenator is then returned to the patient via an arterial cannula positioned in the ascending aorta or other major artery. Additional CPB circuit pumps or other components deliver cardioplegia solution to produce **cardiac electromechanical silence(i.e. to stop the heart from beating)**, which reduces the oxygen consumption, decompress the heart via a vent, and remove fluid (ultrafiltration).

4.9 ACT MACHINES:

Automated machines used to measure the **Activated clotting time**, which is the effectiveness of heparin, to prevent the clotting of blood.

5 WORKING OF A CPB MACHINE:

A special tubing is attached to a large blood vessel **that allows oxygen-depleted blood to leave the body** and travel to the bypass machine. There, the machine oxygenates the blood and returns it to the body through the second set of tubing, also attached to the body. The constant pumping of the machine pushes the oxygenated blood through the body, much like the heart does. The tubes must be placed in a blood vessel large enough to accommodate the tubing and the pressure of the pump. The two tubes ensure that blood leaves the body before reaching the heart and returns to the body after the heart, giving the surgeon a still and mostly bloodless area to work.

6 COMPLICATIONS OF CPB MACHINE:

Complications include oxygenator failure, pump malfunction, clotting in the circuit, tubing rupture, gas supply failure and electrical failure CPB causes decrease in Platelets. Clotting of blood due to mismanagement of ACT and Heparin may lead to serious complications.

7 SCOPE OF FUTURE INNOVATIONS IN CPB:

The CPB machines may be further improved by using technology such as **nanotechnology to developed semipermeable membranes** for better filtration of blood. ACT machines may be further developed using **Artificial Intelligence To expect accurate clotting time**. **Machine Learning** Can be used to monitor and alert about the vital parameters or the effectiveness of Heparin.

ELECTROCARDIOGRAM(ECG)

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1 Introduction To ECG:

Electrocardiogram or ECG is a process of recording of the heart's electrical activity. It is an electrogram of the heart which is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin. An electrocardiogram (ECG) is a simple test that can be used to check your **heart's rhythm and electrical activity**. Sensors attached to the skin are used to detect the electrical signals produced by your heart each time it beats. It's a common and painless test used to quickly detect heart problems and monitor your heart's health. The device used is known as ECG Machine.

2 Diagnosis By ECG:

ECG machine is helpful in diagnosing-

- Abnormal heart rhythm (arrhythmias)
- Blockage in any part of the heart.
- Heart attack.

3 WORKING PRINCIPLE OF AN ECG MACHINE:

The basic principle of the ECG is that **stimulation of a muscle alters the electrical potential of the muscle fibres**. Cardiac cells, unlike other cells, have a property known as **automaticity**, which is the capacity

to spontaneously initiate impulses. In simple words, we can say that an ECG works on the **responsiveness of the muscles after passing an electrical signal.**

4 COMPONENTS OF ECG MACHINE:

4.1 Electrodes:

Electrodes consist of two types, **the bipolar and unipolar**. The bipolar electrodes can be placed on both the wrists and the legs to measure the voltage differential between the two. Unipolar electrodes, measure the voltage difference or the electrical signal between a special reference electrode and actual body surface while being placed on both arms and legs.The ECG comprises 12 leads.

4.2 Amplifiers:

The amplifier reads the electrical signal in the body and prepares it for the output device. When the electrode's signal reaches the amplifier it is first sent to the buffer, the first section of the amplifier. When it reaches the buffer, the signal is stabilized and then translated.

4.3 Connecting Wires:

The connecting wires transmit the signal read from the electrodes and send it to the amplifier. These wires connect directly to the electrodes; the signal is sent through them and connected to the amplifier.

4.4 Output:

The output is a device on the ECG where the electrical activity of the body is processed and then recorded onto graph paper.

5 WORKING OF ECG:

- For an electrocardiogram, a person is made to lie in the resting position and electrodes are placed on arms, legs and at six places on the chest over the area of the heart. The electrodes are attached to the person's skin with the help of a special jelly. A total of 10 electrodes (points of contact with the body) are used to perform an ECG.
- The electrode picks up the current and transmit them to an amplifier inside the electrocardiograph. Then electrocardiograph amplifies the current and records them on a paper as a wavy line.
- In an electrocardiograph, a sensitive lever traces the changes in current on a moving sheet of paper.
- Modern ECGs may also be connected to a screen which displays the current and the waves.
- A normal ECG makes a specific pattern of three recognizable waves in a cardiac cycle. These wave are- **P wave, QRS wave and T-wave, P-R interval, S-T segment.**

6 LIMITATIONS OF ECG:

The ECG reveals the heart rate and rhythm only during the few seconds it takes to record the tracing. Sometimes the electrodes placed in the body may hurt the skin. Sometimes, The ECG is often normal or nearly normal with many types of heart disease.

7 SCOPE OF FUTURE INNOVATIONS:

ECG machines may be further developed using a better electrode technology for faster and accurate diagnosis. generating a **3D structure or report of heart** using ECG may be helpful. ECG machines are now also being developed to check the harmful effects of drugs on heart. Using cloud computing and generating reports on

mobile phones may be developed, and usage of less number of electrodes in the body. A **non-touch method** of ECG may be developed to prevent skin problems and better report.

HAEMODIALYSIS MACHINE

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1 ABOUT DIALYSIS-

The kidneys have an important role in maintaining health. When the person is healthy, the kidneys maintain the body's internal equilibrium of water and minerals (sodium, potassium, chloride, calcium, phosphorus, magnesium, sulphate) **Dialysis is a procedure to remove waste products and excess fluid from the blood when the kidneys stop working properly. It often involves diverting blood to a machine to be cleaned.** Normally, the kidneys filter the blood, removing harmful waste products and excess fluid and turning these into urine to be passed out of the body.

2 TYPES OF DIALYSIS:

There are Two major types of dialysis-

- Haemodialysis- Haemodialysis is the most common type of dialysis and the one most people are aware of. **Blood passes along the tube and into an external machine known as Haemodialysis Machine that filters it, before it's passed back into the arm along another tube.**
- Peritoneal dialysis- In peritoneal dialysis, a sterile solution containing glucose **(called dialysate)** is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a partially permeable membrane. No complex machines or blood exchange is required, but it is less effective than Haemodialysis

3 WORKING PRINCIPLE OF HAEMODIALYSIS:

The basic principle of Haemodialysis is **DIFFUSION**.It involves diffusion of solutes across a semipermeable membrane. Hemodialysis utilizes counter current flow, where the dialysate is flowing in the opposite direction to blood flow in the extracorporeal circuit.

4 COMPONENTS OF HAEMODIALYSIS MACHINE:

4.1 DIALYSATE:

Dialysate, also called dialysis fluid, dialysis solution or bath, is a solution of pure water, electrolytes and salts, such as bicarbonate and sodium. The purpose of dialysate is to pull toxins from the blood into the dialysate

4.2 Dialysis Machine :

A blood pump simply pumps the blood from the body into the machine through specially made tubes.

4.3 Syringe:

syringe contains a drug called **Heparin** which prevents the blood from clotting in the tubes.

4.4 Dialyzer:

The dialyzer is a large canister containing thousands of small fibers through which patient blood is passed. **The dialyzer is the key part of a dialysis machine where the cleaning of the blood takes place.**

4.5 Alarms:

order to protect the patient from any errors in functioning. The things that are monitored with alarms include: **Blood pressure within the machine ,Blood pressure of the patient ,Blood flow ,Temperature ,Dialysate mixture.**

4.6 Air Leakage Detector:

The detector is settled in the venous blood line and detects as well as in the purpose of avoiding air embolus.

4.7 Valves:

Several valves with electronic actuation are needed in the machine to allow variable mixing ratios.

4.8 Sensors:

Dialysis machines require many different types of sensors to monitor various parameters like Blood pressure, O2 saturation, Diasylate mixture.

5 WORKING OF HAEMODIALYSIS:

- Two tubes are connected via your hemodialysis access. Blood flows from your body into the machine through one of the tubes.
- A pressure monitor and pump work together to keep the flow at the right rate.
- Your blood enters the **dialyzer**, where it is filtered.
- **Dialysate solution** enters the dialyzer. It draws the waste out of your blood.
- Used dialysate solution is pumped out of the machine and discarded.
- Your blood goes through another pressure monitor and an air trap to make sure it's safe to go back into your body.
- Your cleaned blood returns to your body through the **second tube** attached to your access site.

6 HAEMODIALYSIS ACCESS:

Hemodialysis requires a surgical procedure, to create a connection between your blood vessels. This site is where the blood can flow in and out of your body during the dialysis treatments. This is called the dialysis access.
Three types of accesses:

- **Arteriovenous Fistula (AVF):** A surgically created connection between an artery and a vein, usually in your non dominant arm. This is the preferred type of access because of effectiveness and safety.
- **Arteriovenous Graft (AVG):** If your blood vessels are too small or not available, then the surgeon may use a synthetic material, a graft, to connect your artery to vein.
- **Central Venous Catheter (CVC):** This is usually used if you need emergency hemodialysis. It is also used as a temporary access when AVF or AVG is not yet available

7 SIDE EFFECTS OF HAEMODIALYSIS:

The most common side effects of hemodialysis include **low blood pressure, access site infection, muscle cramps, itchy skin, and blood clots.**

8 SCOPE OF FUTURE INNOVATIONS:

The development in haemodialysis can be made as by introducing a **wearable dialysis** which does not require an on-site visit for dialysis. **Cloud computing** may be used so as to preserve and store the patients's data. The dialysis membranes can be improved by **nanotechnology** so dialysis will be required less frequently.

PATIENT MONITOR(MULTIPARA MONITOR)

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1 ABOUT PATIENT MONITOR:

A Patient Monitor (also known as Multi-Para Monitors) are a medical monitor, is an electronic medical device that measures a **patient's vital signs and displays the data** so obtained, which may or may not be transmitted on a monitoring network. Physiological data are displayed continuously on a CRT or LCD screen as data channels along the time axis,

2 WHEN IT IS USED?:

Patient monitors are used when-

- Patients with unstable physiological regulatory systems, Or under drug overdose.

- Patients with a suspected life-threatening condition.
- Patients at high risk of developing a life-threatening condition
- Patients under ICU and Surgeries.

3 VITAL PARAMETERS MEASURED BY MULTIPARA-:

- Electrocardiogram(ECG)- Working Of the Heart
- Blood Pressure
- Blood Oxygen(SPO2)
- Heart Rate/ Pulse Rate
- Neurological monitoring, such as Intracranial pressure(ICP)
- Blood Glucose
- Body Temperature

4 COMPONENTS AND WORKING:

4.1 Sensors:

Sensors of medical monitors include biosensors and mechanical sensors. It requires different sensors for measuring different vital parameters. **Eg: Pressure sensors, flow sensors, temperature sensors, etc.**

4.2 Transducers:

Various transducers are used for measuring blood pressure and body temperature.

4.3 Display Monitor:

Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis.

4.4 The Capital Equipment :

As the patient monitoring device itself collects vital patient data, that data is then sent to the capital equipment where it is processed, stored, and displayed The Capital Equipment uses a complex interconnected system of circuits and **Printed Circuit Board(PCB's)** To process and display the data.

4.5 Translating component :

The translating component of medical monitors is responsible for **converting the signals from the sensors to a format that can be shown on the display device** or transferred to an external display.

4.6 Softwares:

Softwares used for processing data and displaying to the screen.

All the sensors and transducers are connected to the body, **The pulse clip for SPO2 and Heart rate, Transducer for temperature, Leads for ECG,** are connected at their respective positions. The data collected by them is then processed in the **Capital Equipment** and Translated into digital compatible signals by **Translating component**, and then processed by softwares. Then the processed data is sent to the **Display Monitor** where different paramters are displayed.

Communication Networking: A further development has been made in the field by introducing networking to

Patient monitoring systems. The system is connected to Hospital's Private Network, and the data collected by it can be seen At the Nursing stations or directly to the Doctors.

5 SCOPE OF FUTURE INNOVATIONS:

Many developments can be made in the field of multipara monitors. Patients's t real time data can be monitored by doctors **wirelessly using cloud computing. Advanced alarms and sensors** can be used to inform doctors if there is a change in parameters. Many developments can be made to measure **hormones level** in the body. **Real time drug management system** can be further developed in Monitoring system. **Advanced AI and ML** can be used to suggest the methods of solution for sudden change in parameters.