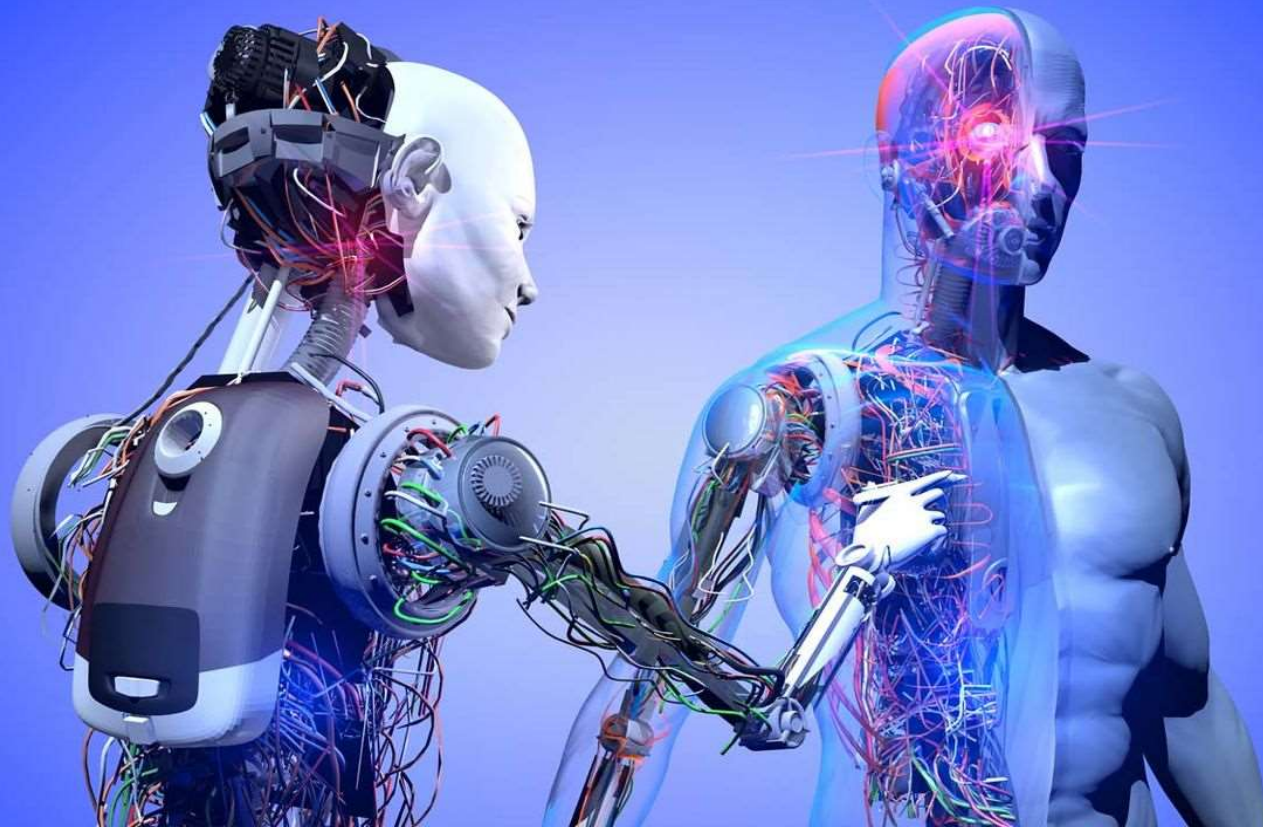


Introduction of BioMed

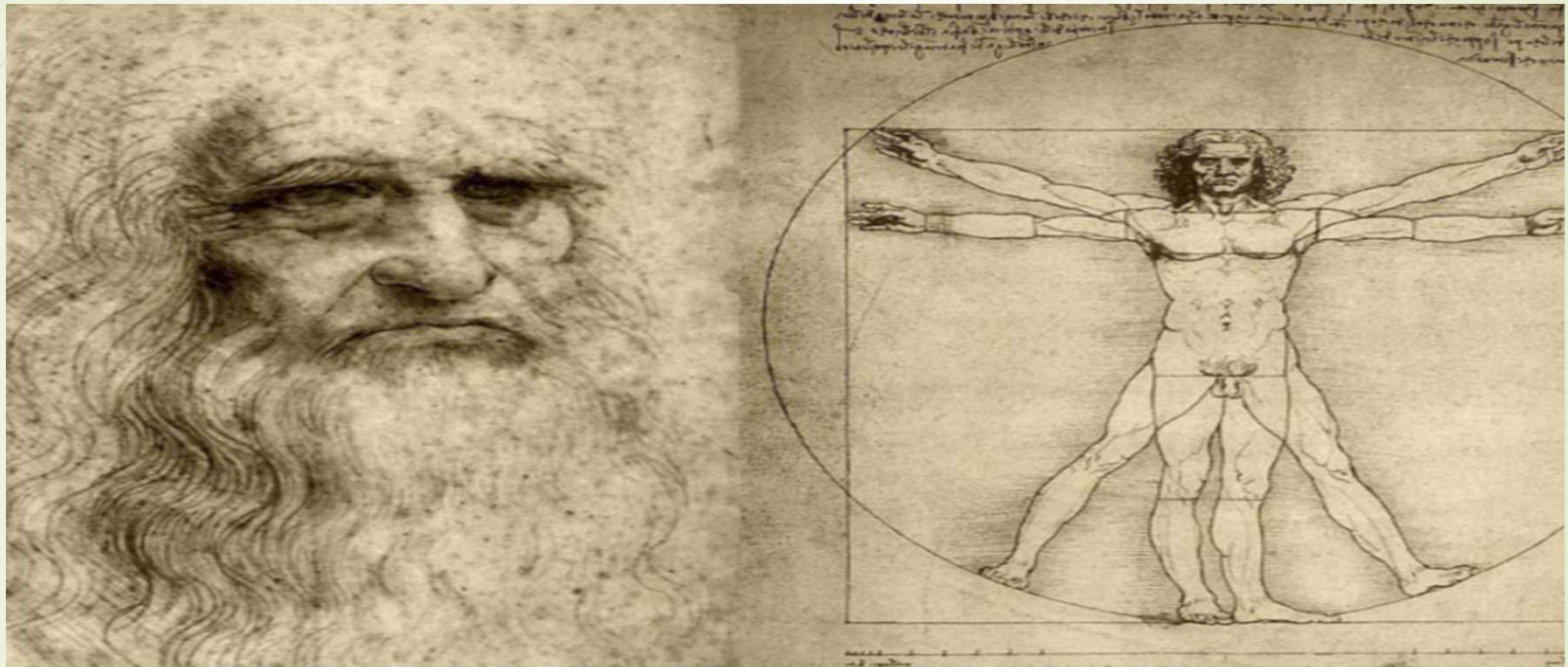




Presentation by
(1) Mr. MAU Kui-yuen
(AEnI/GES/HK2B/22)
Mobile: 62935484
(2) Mr. CHEUNG Man-ho
(EnI/AS3) Mobile: 908700
32

Break Time: 15:00 to
15:15
Q&A Time: 16:45
to 17:00

History of Bioengineering



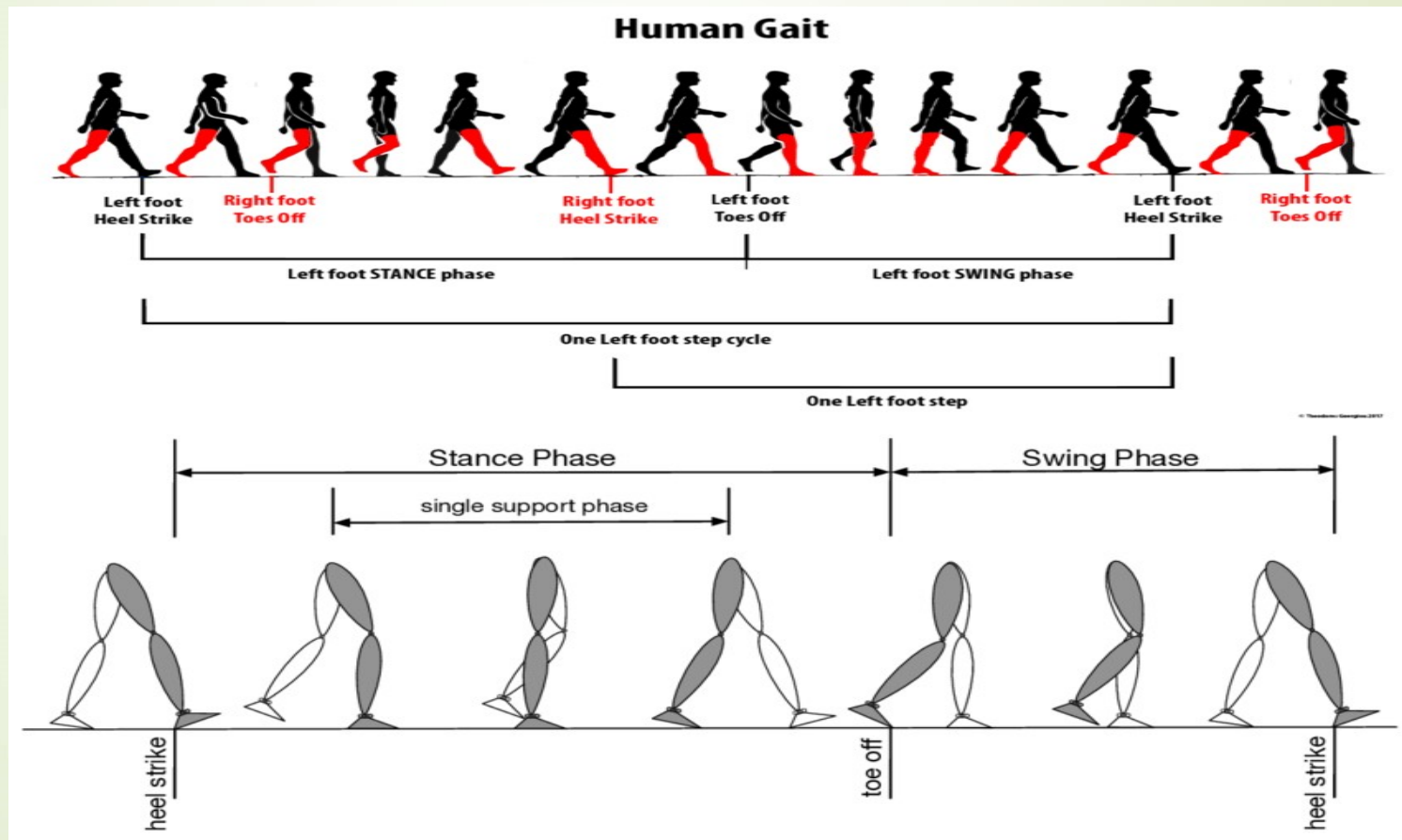
Leonardo da Vinci^[b] (15 April 1452 – 2 May 1519) was an Italian polymath of the High Renaissance who was active as a painter, draughtsman, engineer, scientist, theorist, sculptor and architect.^[3]



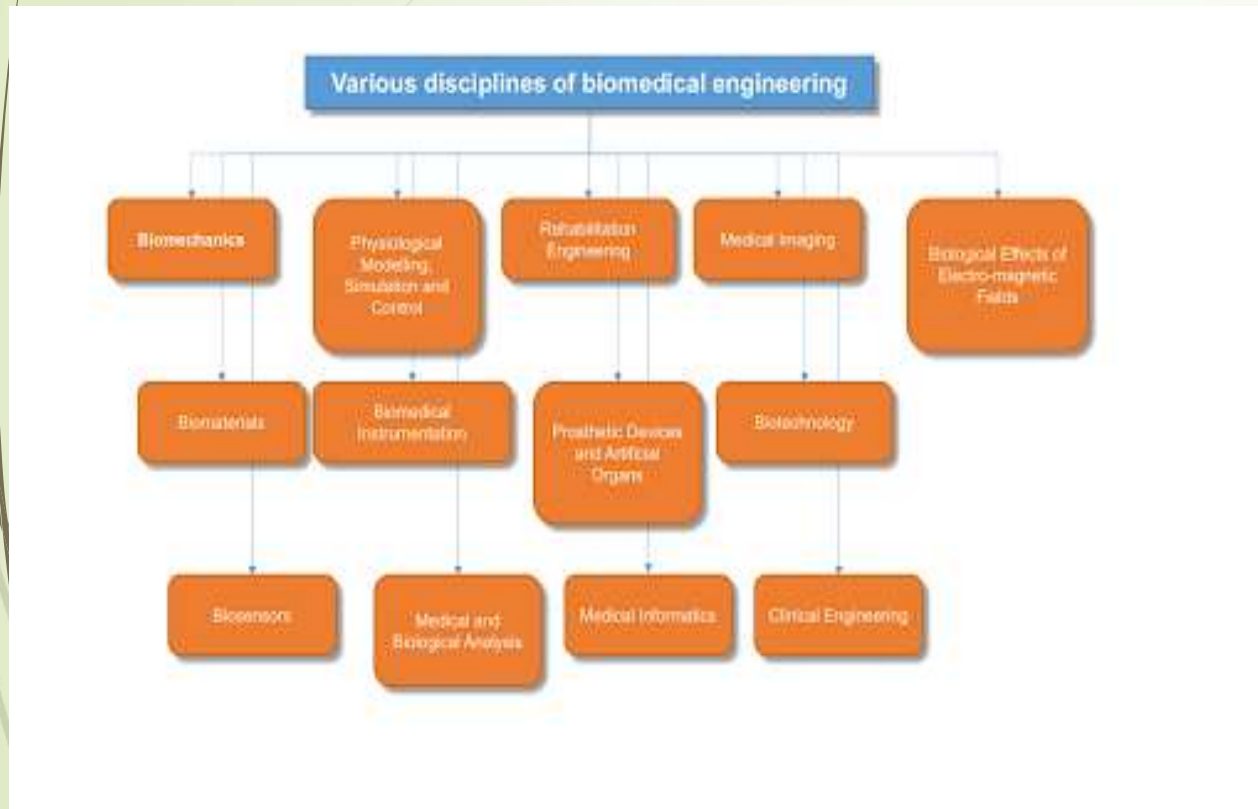
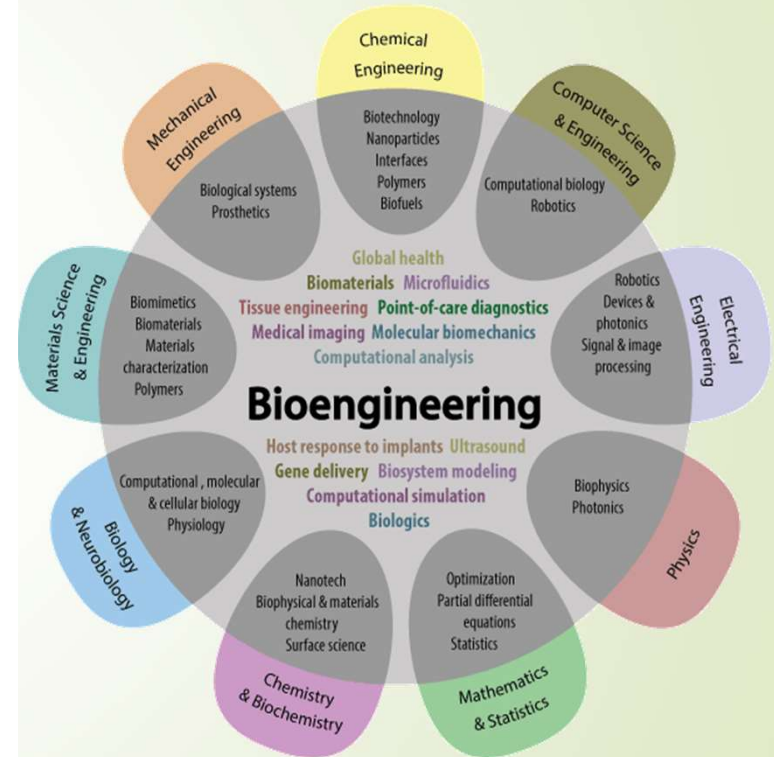
Biomedical Engineering(BME)

- Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through multidisciplinary activities that integrate engineering sciences with medical sciences and clinical practices.
- It is a discipline that applies principles and methods from engineering and physical sciences to the life sciences and medical sciences to understand, define , and solve problems in biology and medicine.

HUMAN LOCOMOTION



The Discipline of Biomedical Engineering





Biological Engineering and Medical Engineering

- Biological engineering is the biology-based engineering discipline that integrates life sciences with engineering in the advancement and application of fundamental concepts of biological systems from molecular to ecosystem levels.
- Medical engineering represents the application of all engineering and/or physical science fields to clinical medicine. It requires in-depth training in the physical sciences and engineering as well as some training in physiology and clinical medicine.



Areas for Rapid Development

- AI – assisted health technologies
- Robot-assisted surgery
- Molecular , cellular and tissue engineering
- Rehabilitation and orthopaedic engineering

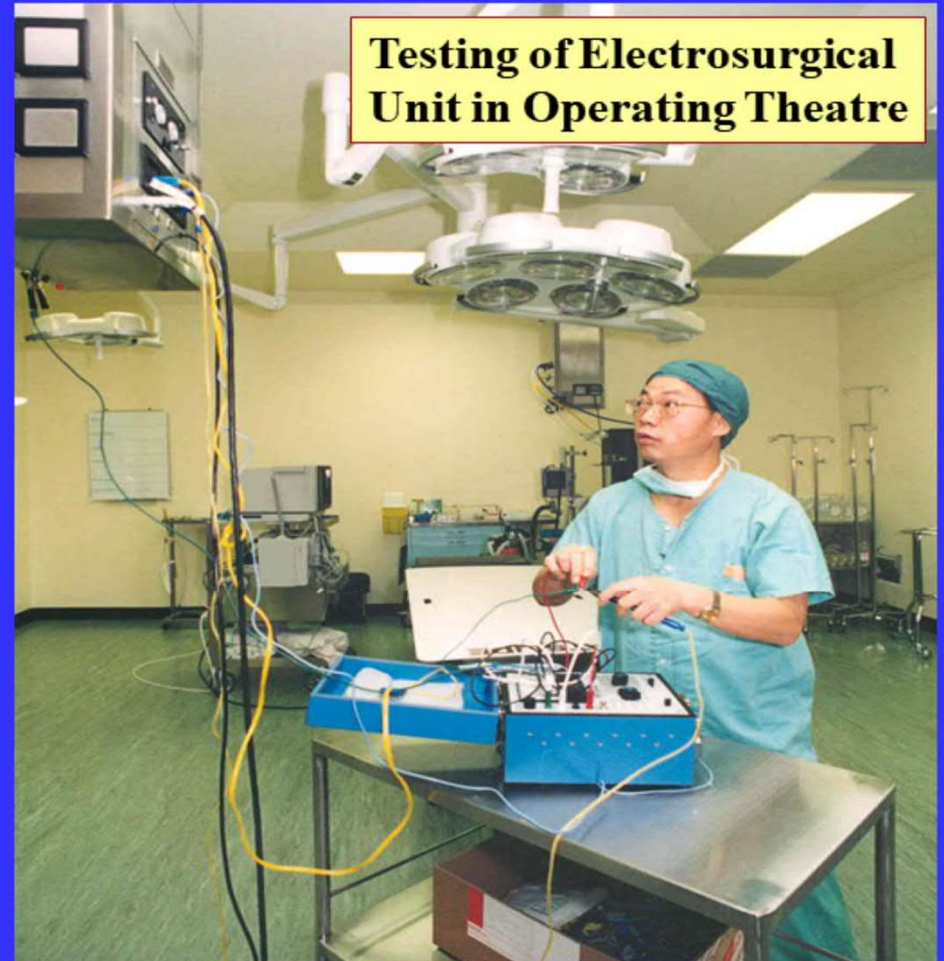
BME Services by EMSD

Frontline work

**Measurement of power output of
Laser equipment and Calibration**



**Testing of Electrosurgical
Unit in Operating Theatre**



What is the Electrical Safety Standard used in Hong Kong?

- For Medical Equipment

IEC 60601

- Laboratory Equipment

IEC 61010

- Laser Equipment

IEC 60825

IEC 60601-1-2	2007 (Edition 3)	2014 (Edition 4)
Radiated and Conducted Emissions	Follow CISPR 11	Follow CISPR 11 Home Healthcare specifically called out to be Class B. No ESD testing exemption via label on ports. Needs to be outlined in test plan if ports are excluded.
Harmonics and Flicker	Follow IEC 61000-3-2 and 61000-3-3	Follow IEC 61000-3-2 and 61000-3-3
Electrostatic Discharge (ESD)	+6kV contact discharge +2,4,8kV air discharge	+8kV contact discharge +2,4,8, 15kV air discharge
Radiated Immunity	<ul style="list-style-type: none"> 3 V/m, 80 MHz – 2.5 GHz 10V/m – Life support equipment 	<ul style="list-style-type: none"> 3 V/m, 80 – 2.7 GHz 10 V/m – Home Healthcare Proximity Fields from RF wireless communications equipment at select frequencies between 385 MHz – 5.785 GHz. Test level of 9 – 28 V/m depending on freq. Pulse modulation
Electrical Fast Transients (EFT)	<ul style="list-style-type: none"> 2 kV power lines 1 kV Interconnect lines 5 kHz and 100 kHz repetition rate 	<ul style="list-style-type: none"> 2 kV power lines 1 kV Interconnect lines 100 kHz repetition rate
Surge	Up to 2 kV power lines	Up to 2 kV power lines
Conducted Immunity	<ul style="list-style-type: none"> 3Vrms, 0.15 – 80 MHz Life support equipment, 10V in ISM freq. bands. 	<ul style="list-style-type: none"> 3V, 0.15-80 MHz 6V in the ISM bands in that range, plus for Home Healthcare in the Amateur bands in that range
Magnetic Field Immunity	3 A/m	30 A/m
Voltage Dips and Interruptions (VDI)	<ul style="list-style-type: none"> >95% reduction for 0.5 cycle, 60% reduction for 5 cycles, 30% reduction for 25 cycles at 0 crossing (0 and 180 degrees) >95% reduction for 5 seconds 	<ul style="list-style-type: none"> 100% reduction for 0.5 cycle at 0, 45, 90, 135, 180, 225, 270 and 315 degrees 100% reduction for 1 cycle, and 30% reduction for 25/30 cycles at single phase at 0 degrees 100% reduction for 250/300 cycles (5 sec.) and all devices remain safe
Electrical transient conduction along supply lines (conducted transients)	Not applicable	Home healthcare for devices powered by 12/24V from a vehicle. Testing as specified in ISO 7637-2.

What is the differences between Laboratory Equipment and Medical Equipment in IEC standard?

- No measurement in Patient Leakage Current, Patient Auxiliary Current and Mains on Applied parts in IEC61010 (Laboratory Equipment)
- Enclosure Leakage Current limit (normal condition) is less than 500uA in IEC61010 while it is less than 100uA in IEC60601.
- Enclosure Leakage Current limit (S.F. condition) is less than 3500uA in IEC61010 while it is less than 500uA in IEC60601.

States the Classes in the method of protection against electric shock? Explains each Class?

- Class I equipment – has a protective earth. Class I Medical electrical equipment should have fuses at the equipment end of the mains supply in both the live and neutral.
- Class II equipment – has double insulation or reinforced insulation, physical separation of live conductors, standards as being a single layer of insulation offering the same degree of protection against electric shock as double insulation.
- Class III equipment - defined in some equipment standards as that in which protection against electric shock relies on the fact that no voltages higher than safety extra low voltage (SELV) are present. SELV is defined in turn in the relevant standard as a voltage not exceeding 25V ac or 60V dc.

What are the meaning of below Symbols?

Medical Devices				
Class I	Class II	Type B Applied Part	Type BF Applied Part	Type CF Applied Part
				

The degree of protection for medical electrical equipment and is defined by the type designation (Type B, BF and CF)

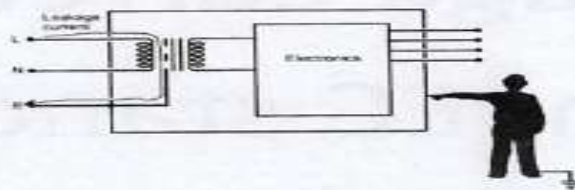
Type B – Equipment providing a particular degree of protection against electric shock, particularly regarding allowable leakage currents and reliability of the protective earth connection (if present).

Type BF – As type B but with isolated or floating (F-type) applied part or parts.

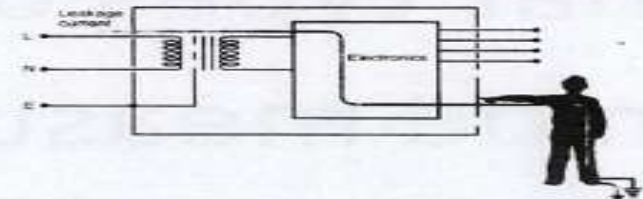
Type CF – Equipment providing a higher degree of protection against electric shock than type BF, particularly with regard to allowable leakage currents, and having floating applied parts.

What kinds of leakage current are measured in IEC standard for Medical Equipment?

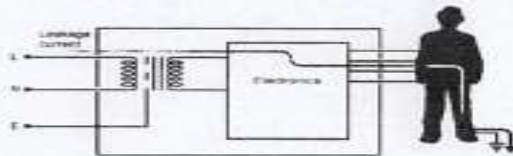
1. Earth leakage current



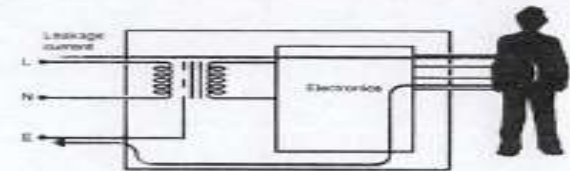
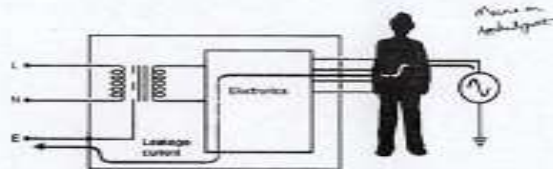
2. Enclosure leakage current



3. Patient leakage current

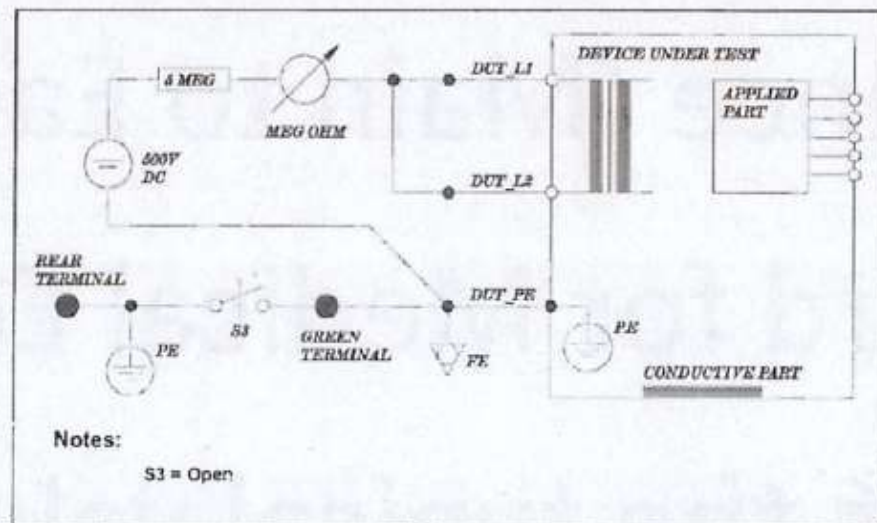


4. Patient auxiliary current



Draw a block diagram to illustrate how to measure the Insulation Resistance (Main to Earth) in IEC standard for Medical Equipment?
What is the typical value of this Insulation Resistance?

Test Principle: Mains Insulation Resistance

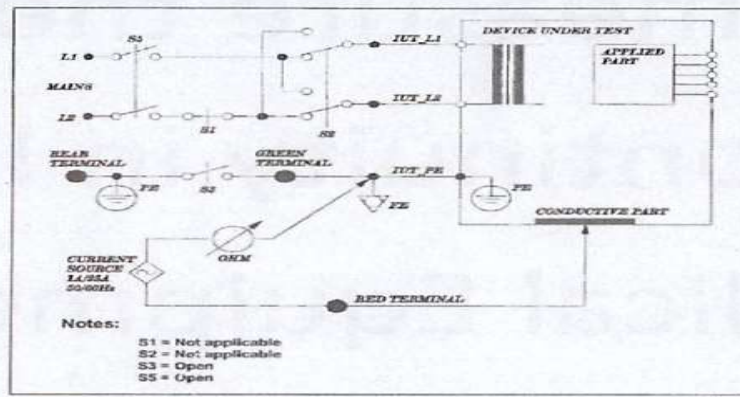


Function: Measures the insulation resistance (at 500 VDC) between L1 and L2 and DUT PE.
Applicable to: IEC 601-1, Class I
HEI 95, Class I
AS/NZS 3551, Class I

The main to earth insulation resistance should be $> 50\text{M ohm}$

Draw a block diagram to illustrate how to measure the Protective Earth Continuity in IEC standard for Medical Equipment?
What is the typical value of this Protective Earth Continuity?

Test Principle: Protective Earth Resistance



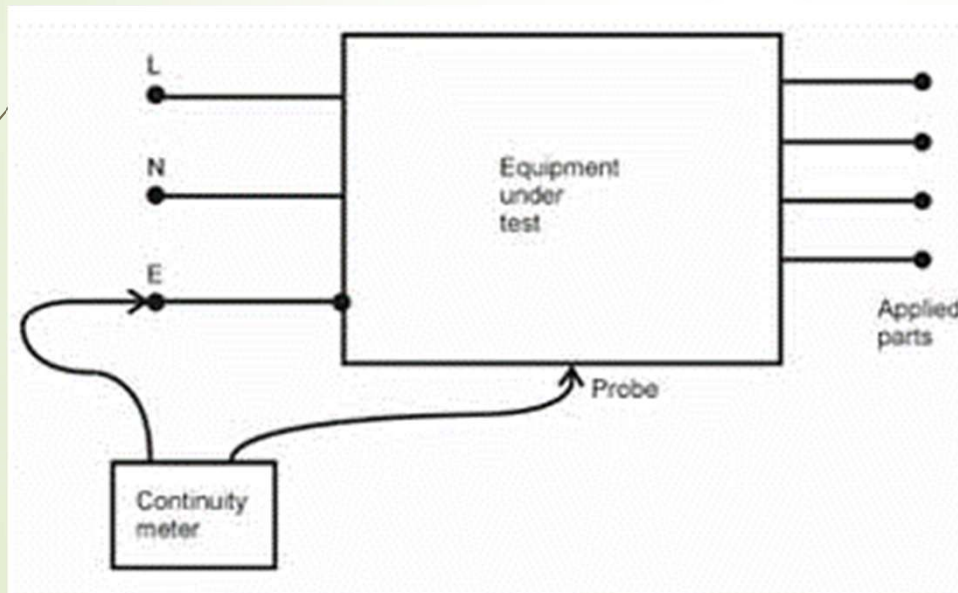
Function:	Measures the impedance between the 501PRO's outlet PE terminal and exposed conductive parts of the DUT that are connected to the DUT's protective earth. Test current is applied for approximately 5 seconds.															
Applicable to:	<table><tr><td>IEC 601-1, Class I:</td><td>Current source = 25 A $\pm$ 10%</td></tr><tr><td>VDE 751-1, Class I:</td><td>Current source = 5-25 A</td></tr><tr><td>HEI B5, Class I:</td><td>Current source = 1 A</td></tr><tr><td>VDE 701, Class I:</td><td>Current source = 1 A</td></tr><tr><td>IEC 1010, Class I:</td><td>Current source = 1 A</td></tr><tr><td>AAMI:</td><td>Current source = 1 A</td></tr><tr><td>AS/NZS 3551:</td><td>Current source = 1 A</td></tr></table>		IEC 601-1, Class I:	Current source = 25 A $\pm$ 10%	VDE 751-1, Class I:	Current source = 5-25 A	HEI B5, Class I:	Current source = 1 A	VDE 701, Class I:	Current source = 1 A	IEC 1010, Class I:	Current source = 1 A	AAMI:	Current source = 1 A	AS/NZS 3551:	Current source = 1 A
IEC 601-1, Class I:	Current source = 25 A $\pm$ 10%															
VDE 751-1, Class I:	Current source = 5-25 A															
HEI B5, Class I:	Current source = 1 A															
VDE 701, Class I:	Current source = 1 A															
IEC 1010, Class I:	Current source = 1 A															
AAMI:	Current source = 1 A															
AS/NZS 3551:	Current source = 1 A															

The Protective Earth Continuity should be ≤ 0.1 ohm (Earth Terminal), ≤ 0.2 ohm (Equipment Enclosure)

投影片 16

MMWP莫1 Mr MOK Wai Po 莫惠寶, 20/7/2020

In protective earth continuity test of IEC60601 (Class I, all types), states the current and interval used in the test.



➡ Between 10A to 25A for a period of at least 5 seconds.

When to perform the safety test?

- On newly acquired equipment prior to being accepted for use.
- During the routine planned preventive maintenance.
- After repairs have been carried out on equipment.

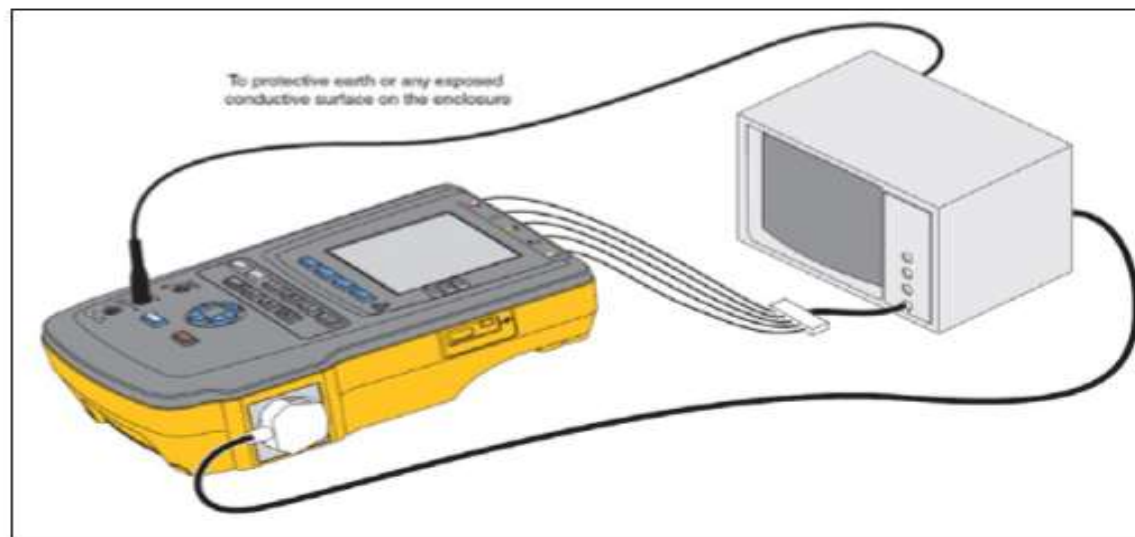


Figure 5. General connections to an electrical safety analyzer.

Pulse Oximeter

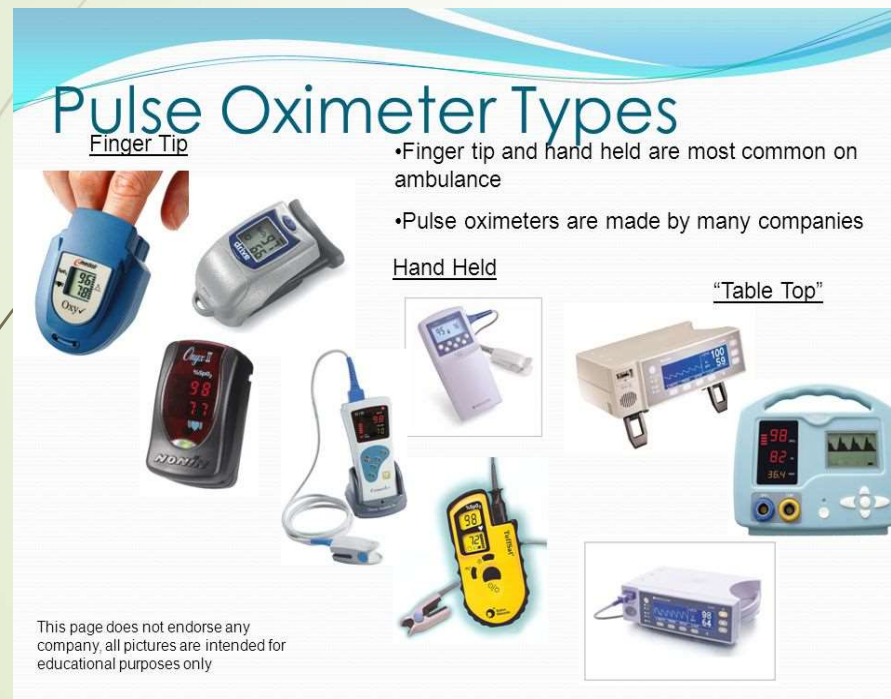
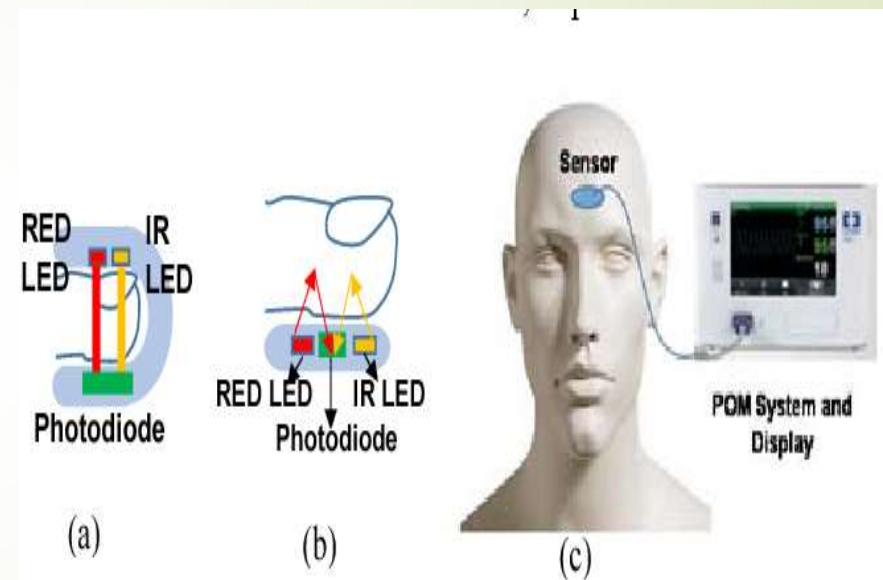
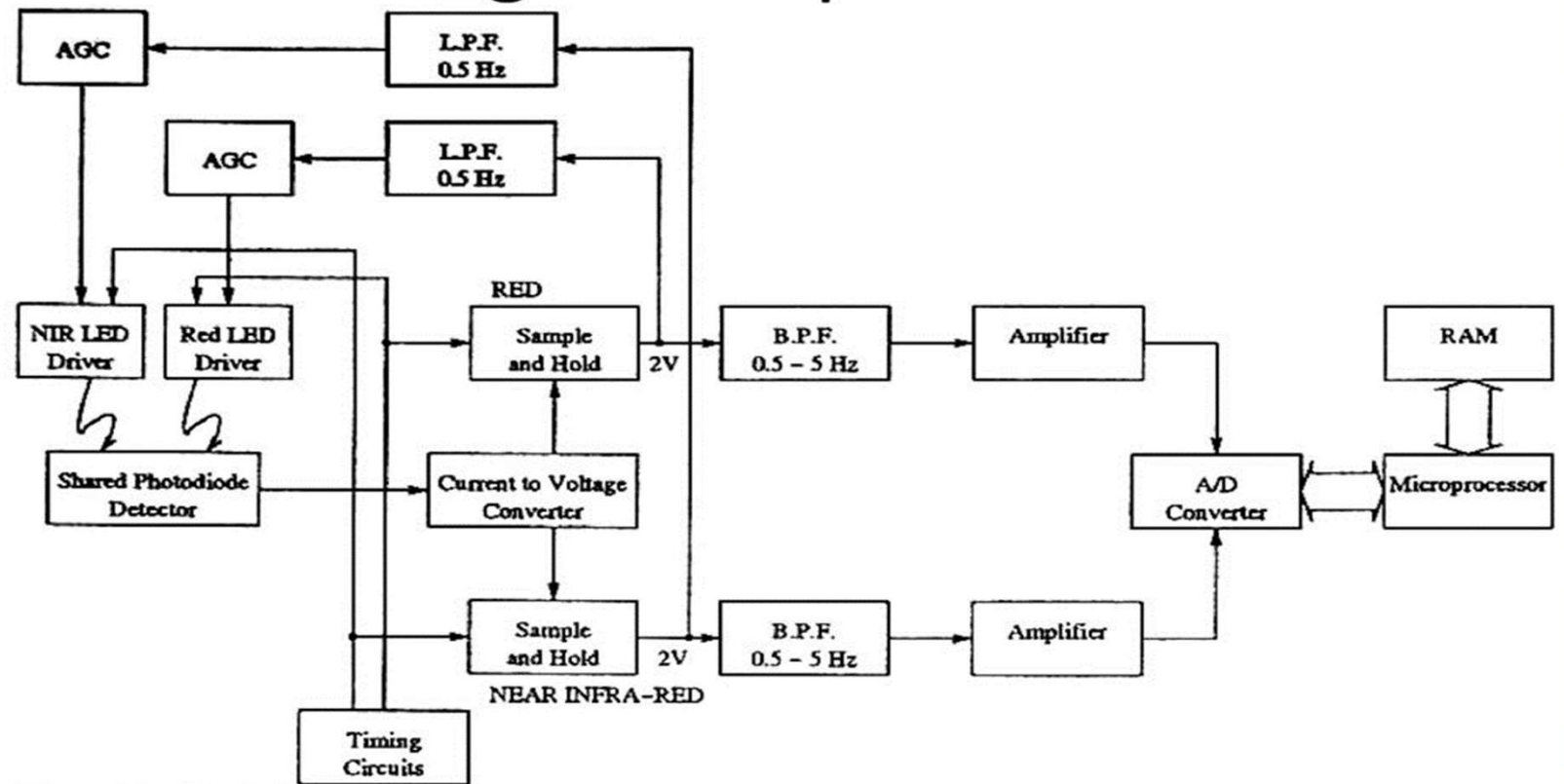


Fig. 1. Conventional pulse oximeters (POMs). (a) Finger transmission type. (b) Finger reflection type. (c) Forehead reflective type, sensor

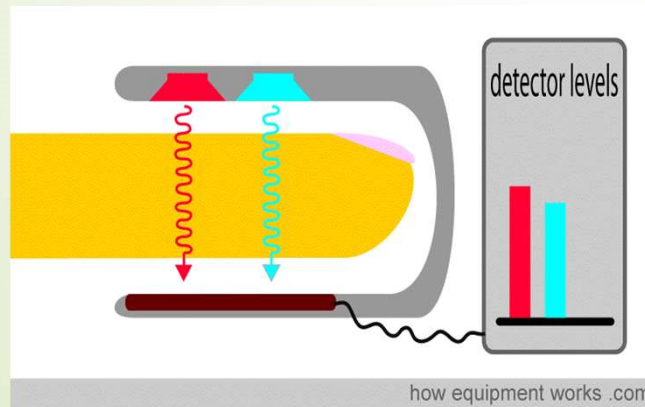
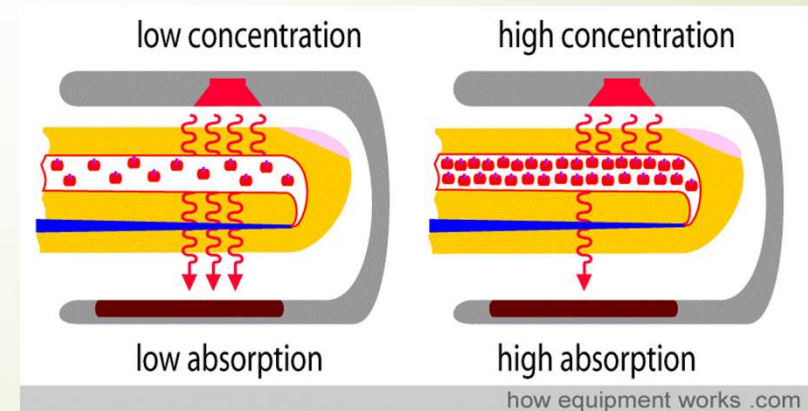
Block diagram of pulse oximeter



What are the components in Oximeter's sensor?

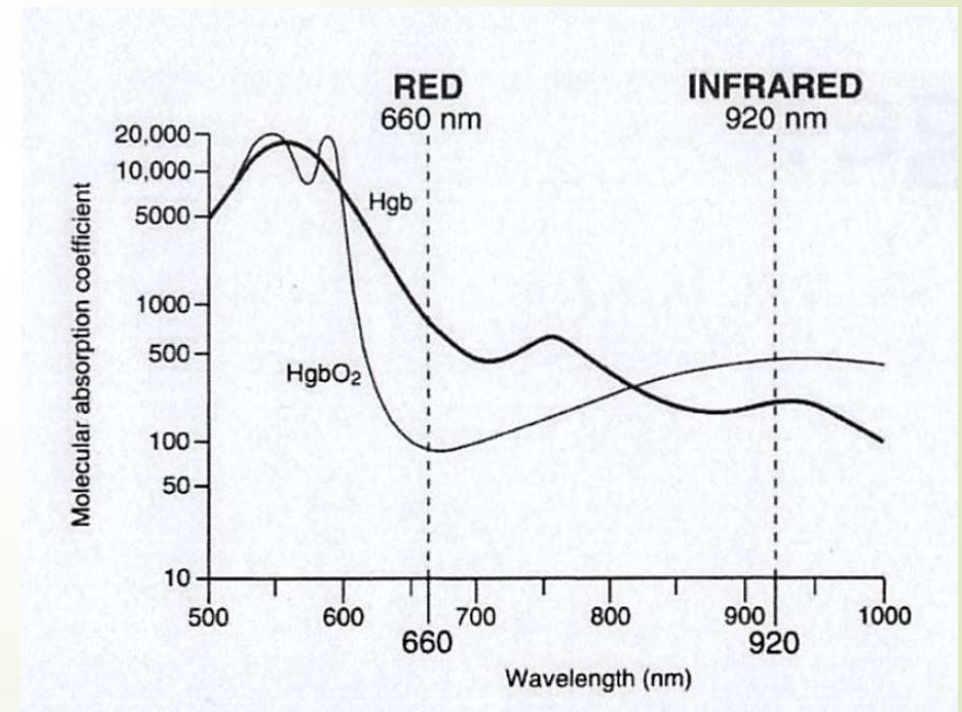
What are the typical values of these components?

- There are two small light-emitting diodes (LEDs) facing with two photodiodes. One is red, with wavelength of 660nm, and the other is infrared with a wavelength of 940nm.



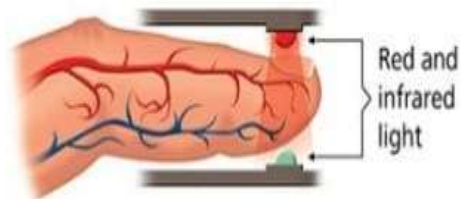
Why use two different LEDs and Photodiodes to measure the patient's SpO2? What is the advantage?

- To cancel the ambient light which will be affected the measuring reading.
- To obtain more accurate in SPO2 reading from the patient by comparing the absorption of HbO & HbCO2 with standing reading, it is a two point measurement method.

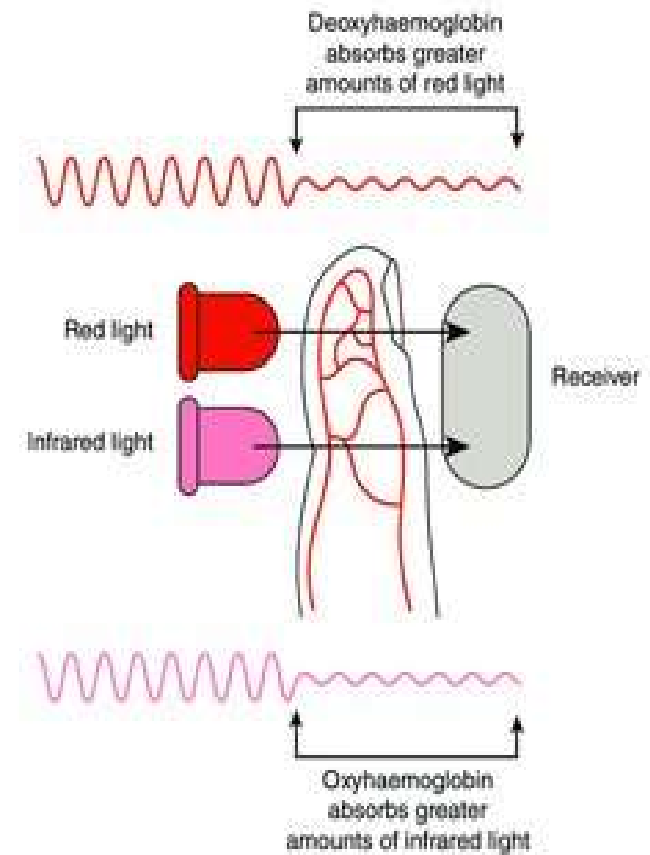


OPERATING PRINCIPLE

Pulse oximetry works on the principle of **spectral analysis** for measurement of oxygen saturation, i.e. the **detection and quantification** of components in solution by their unique light absorption characteristics.



Pulse oximeters combine the principle of **spectrophotometry and plethysmography** to noninvasively measure the oxygen saturation in arterial blood.



ECG Electrocardiogram

- **Electrocardiography** is the process of producing an **electrocardiogram** (ECG or EKG^[a]). It is a graph of voltage versus time of the electrical activity of the heart^[4] using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat). Changes in the normal ECG pattern occur in numerous cardiac abnormalities, including cardiac rhythm disturbances (such as atrial fibrillation and ventricular tachycardia), inadequate coronary artery blood flow (such as myocardial ischemia and myocardial infarction), and electrolyte disturbances (such as hypokalemia and hyperkalemia).

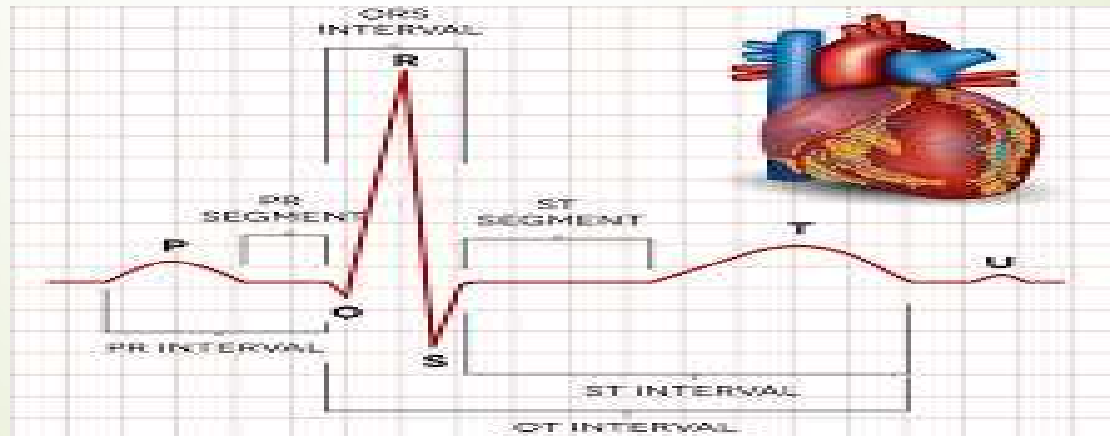


Figure 30.1 Lead ECG electrodes placement.
Source: Aaronson PJ, et al., 2013. Reproduced with permission of John Wiley & Sons.

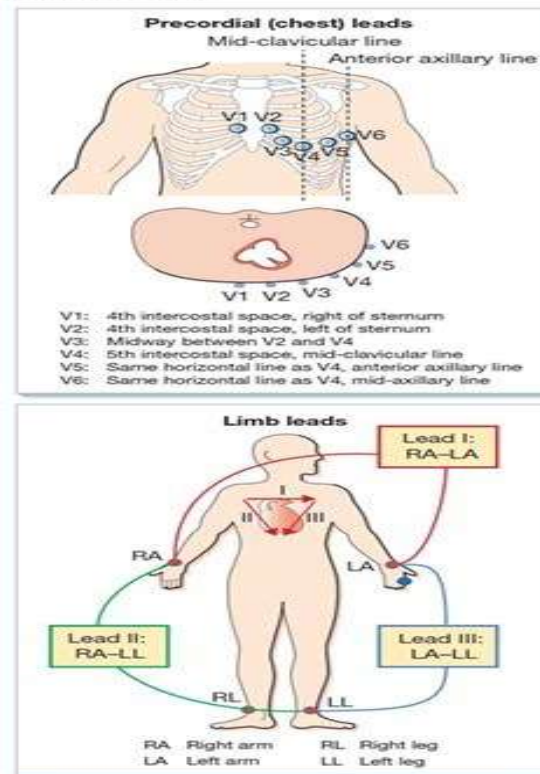


Figure 30.3 ECG waveform components.
Source: Aaronson PJ, et al., 2013. Reproduced with permission of John Wiley & Sons.

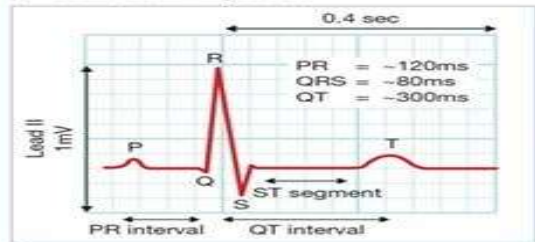


Figure 30.2 Origin of ECG waveform

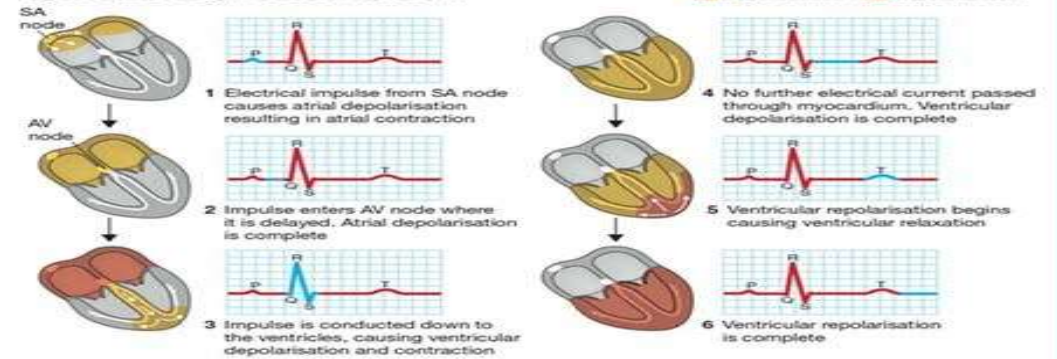


Figure 30.5 Normal 12-lead ECG with rhythm strip

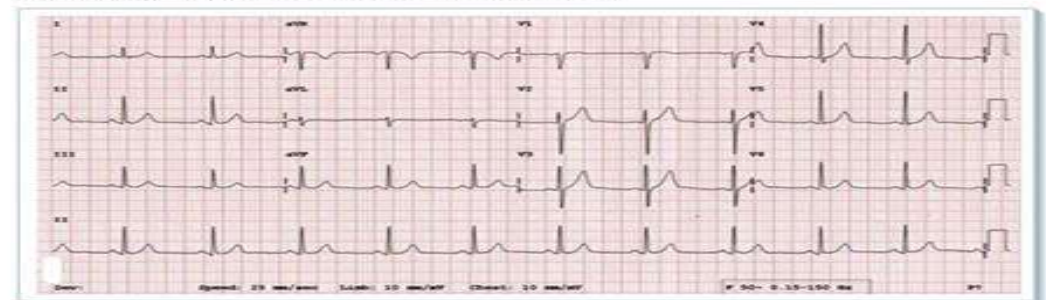
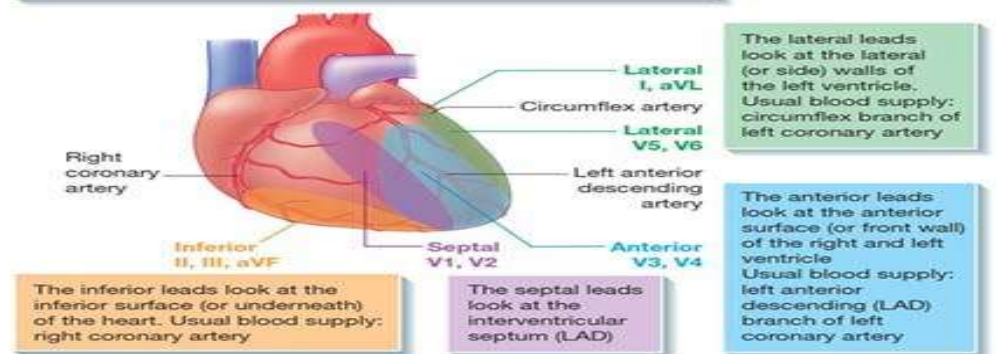
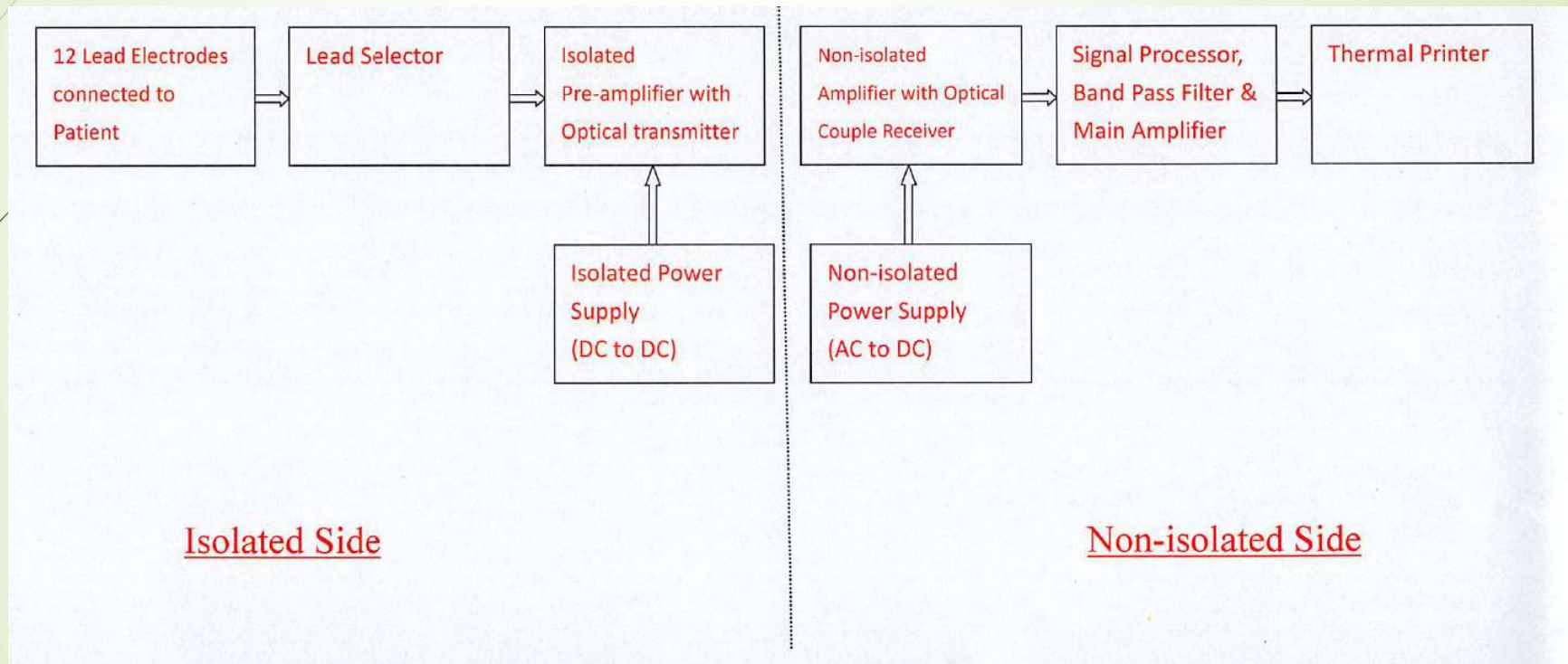


Figure 30.4 Contiguous ECG leads (looking at the same anatomical area)

Any precordial leads that are next to each other, e.g. V2 and V3



Block Diagram of a basic single channel ECG machine





The functions of each block in your diagram for this ECG Machine?

1. 12 lead Electrodes is to pick up an ECG signal to convert it to electrical signal (typical 0.5 mV ~ 2 mV)
2. A lead selector is to provide a desired ECG input connection for the pre-amplifier (e.g. Lead I, II, & III connections)
3. Isolated Pre-amplifier with optical transmitter is to amplify the isolated ECG signal & to transmit isolated ECG signal to non-isolated side
4. Isolated power supply is to provide the isolated power to the isolated side
5. Non-isolated power supply is to provide the power to non-isolated side and isolated side through DC to DC switching power supply circuit
6. Non-isolated Amplifier with Optical Couple Receiver is to receive and amplify an optical ECG signal from isolated side through Optical Coupling
7. Signal Processor, Band Pass Filter & Main Amplifier are conditioned the ECG signal
8. Thermal Printer is to print the ECG signal on the ECG paper.

The Common Mode Rejection Ratio (CMRR) in ECG Machine?

What is the typical value of CMRR for the standard ECG Machine?

The common-mode rejection ratio (CMRR) of a differential amplifier (or other device) is the measure of rejection by the device of unwanted input signals common to both input leads, relative to the wanted difference signal.

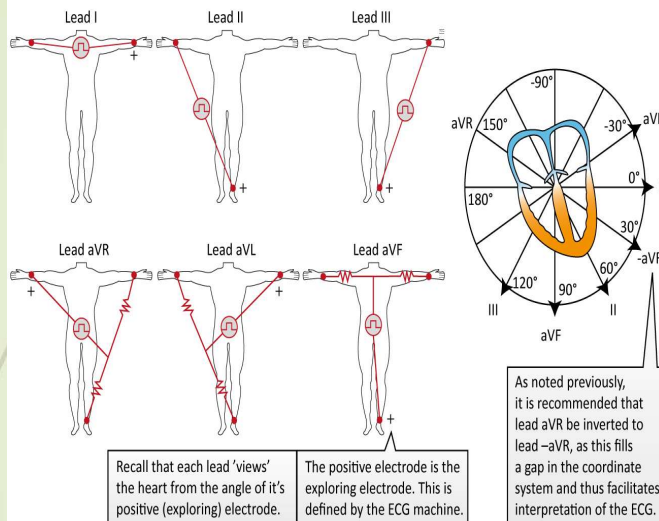
$$\text{CMRR} = \left(\frac{A_d}{|A_{cm}|} \right) = 10 \log_{10} \left(\frac{A_d}{A_{cm}} \right)^2 \text{ dB} = 20 \log_{10} \left(\frac{A_d}{|A_{cm}|} \right) \text{ dB}$$

Where A_d is the differential gain & A_{cm} is the common-mode gain

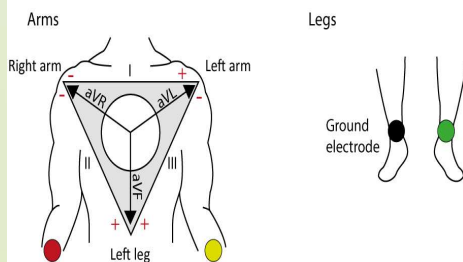
Typical value of CMRR for standard ECG Machine is 89 dB or greater in AAMI. (Association of the Advancement of Medical Instrument)

ECG Limb Lead

A) The limb leads and their view of the heart's electrical activity

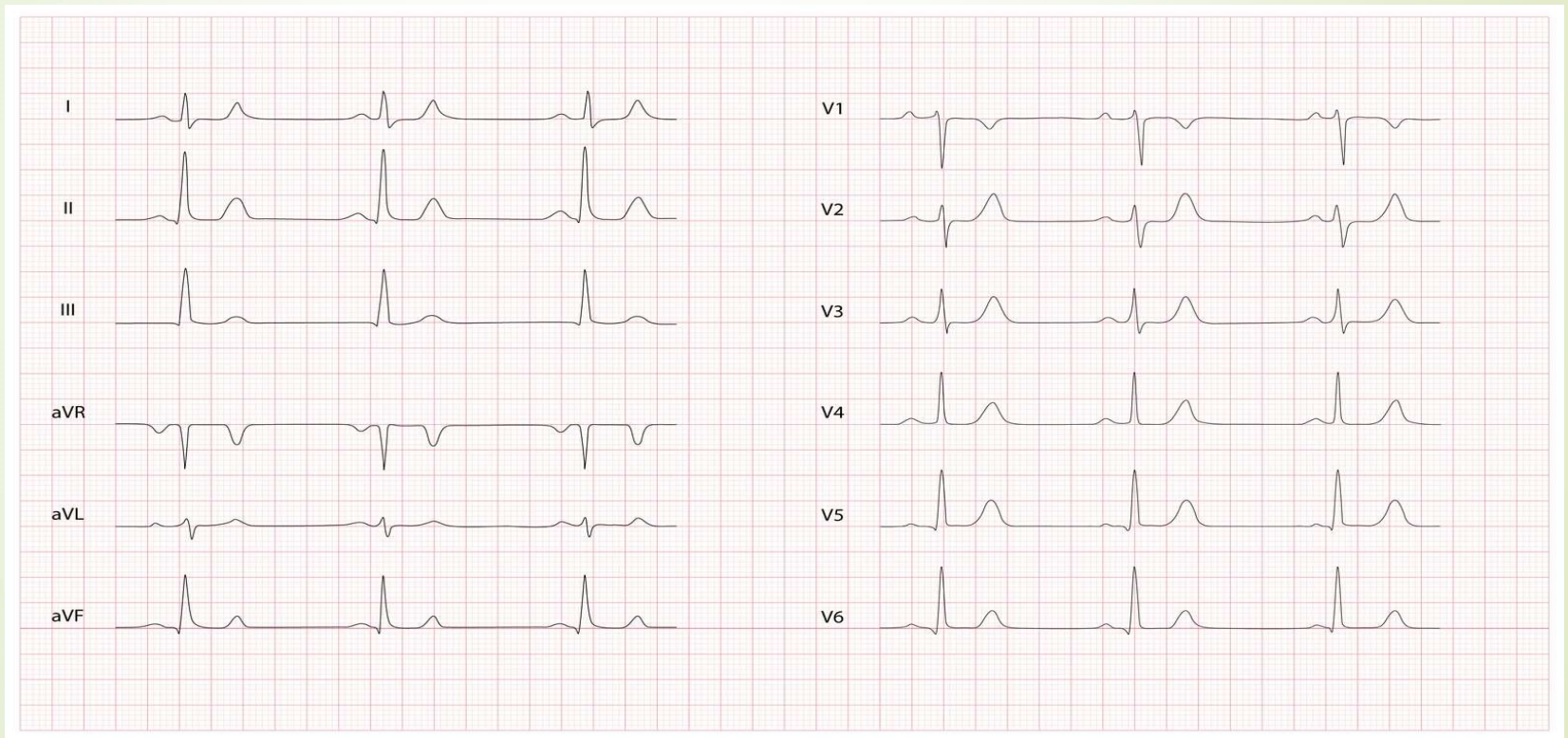


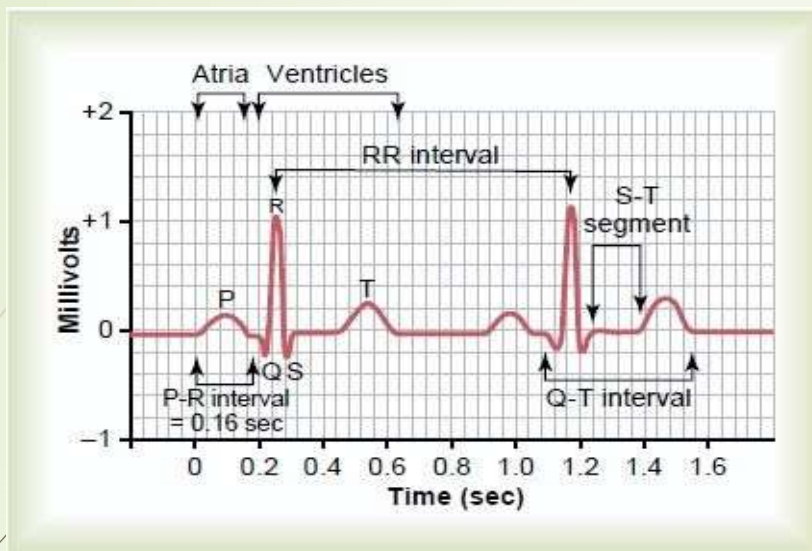
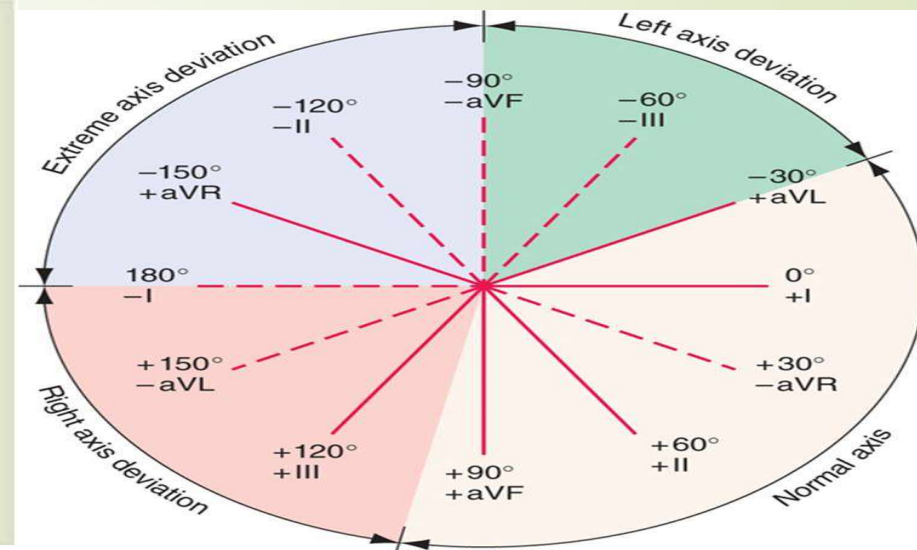
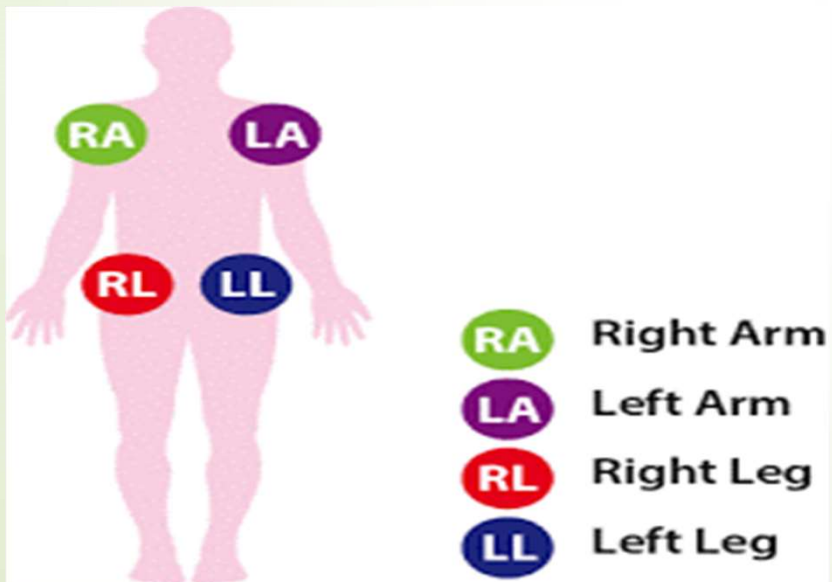
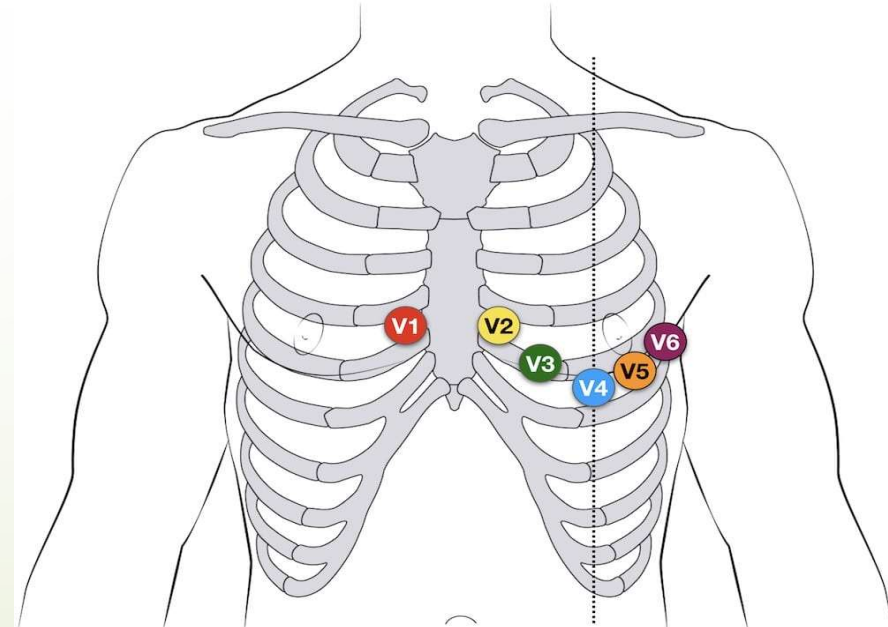
B) Einthoven's triangle



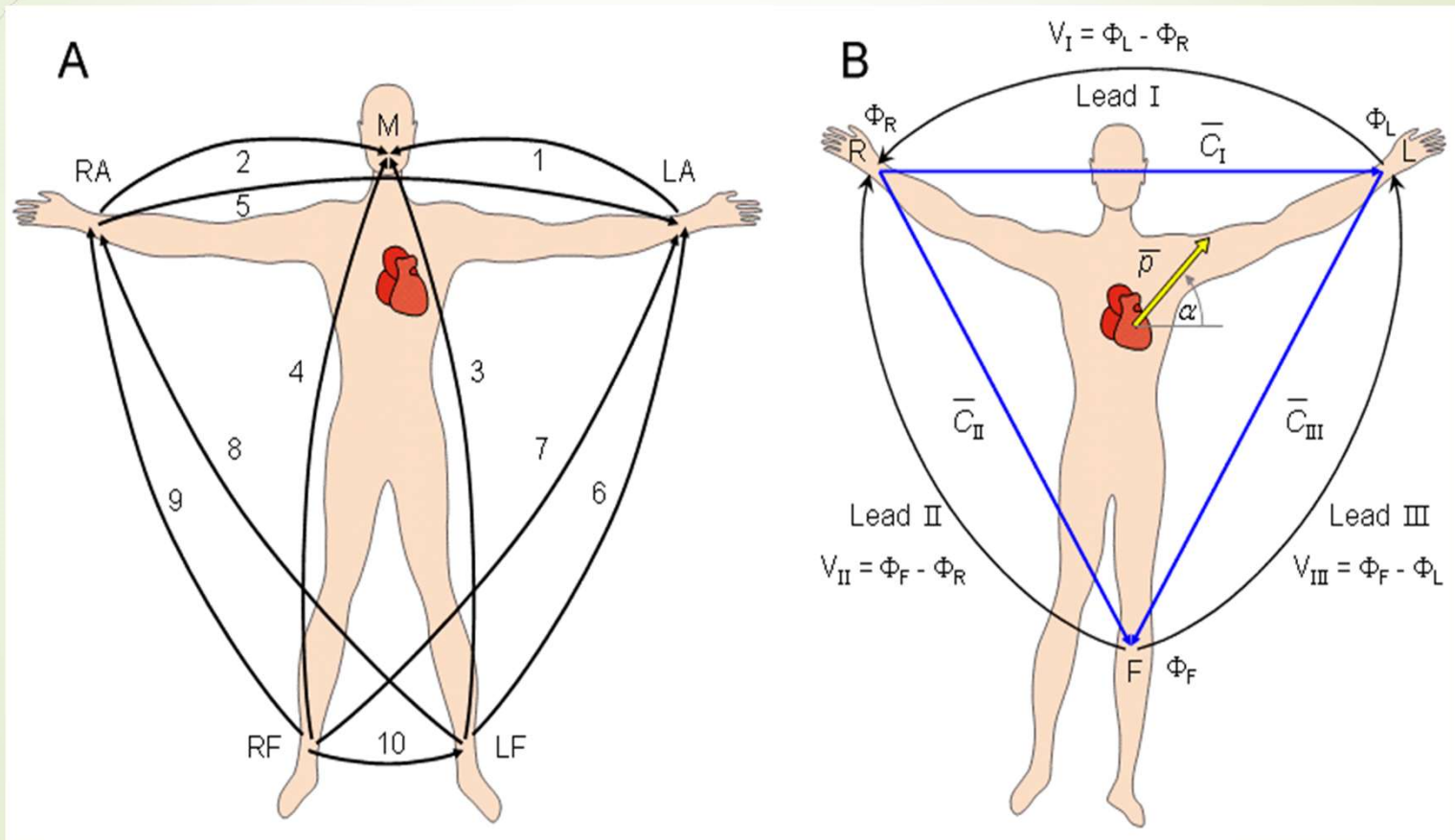
Derived Lead	Formula Used to Calculate
LEADIII	$LL - RA - LA = LEADII - LEADI$
aVR	$RA - (LA + LL)/2 = (LEADI + LEADII) 2$
aVL	$LA - (RA + LL)/2 = LEADI - LEADII/2$
aVF	$LL - (RA + LA)/2 = LEADII - LEADI/2$

12 Lead ECG reference Chart



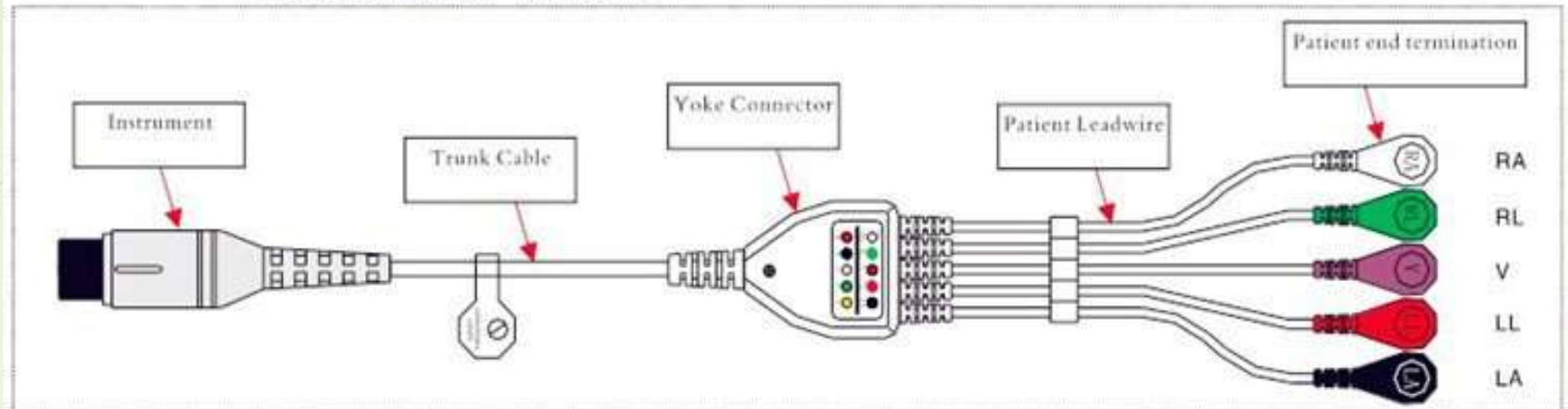


12 Lead ECG System

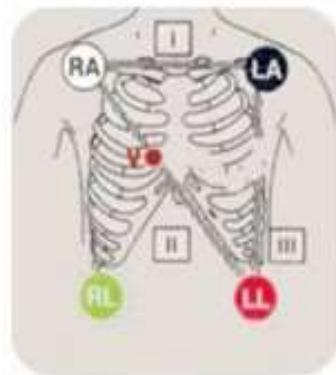


Location	AHA (American Heart Association)		IEC (International Electrotechnical Commission)	
	Inscription	Colour	Inscription	Colour
	RA	 White	R	 Red
	LA	 Black	L	 Yellow
	RL	 Green	N	 Black
	LL	 Red	F	 Green
	V1	  Brown/Red	C1	  White/Red
	V2	  Brown/Yellow	C2	  White/Yellow
	V3	  Brown/Green	C3	  White/Green
	V4	  Brown/Blue	C4	  White/Brown
	V5	  Brown/Orange	C5	  White/Black
	V6	  Brown/Purple	C6	  White/Purple

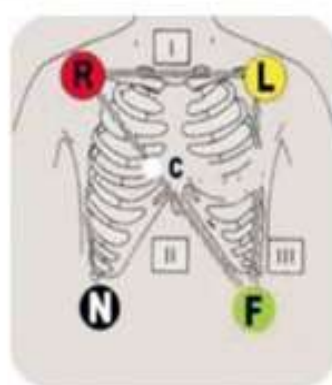
ECG CABLE PICTURE



Lead Position Marked



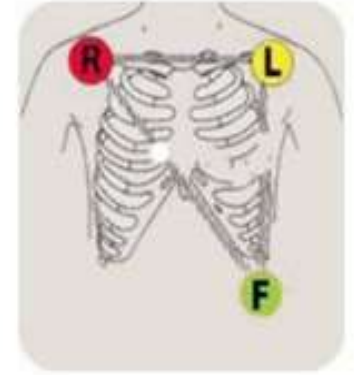
5-lead AHA



5-lead IEC

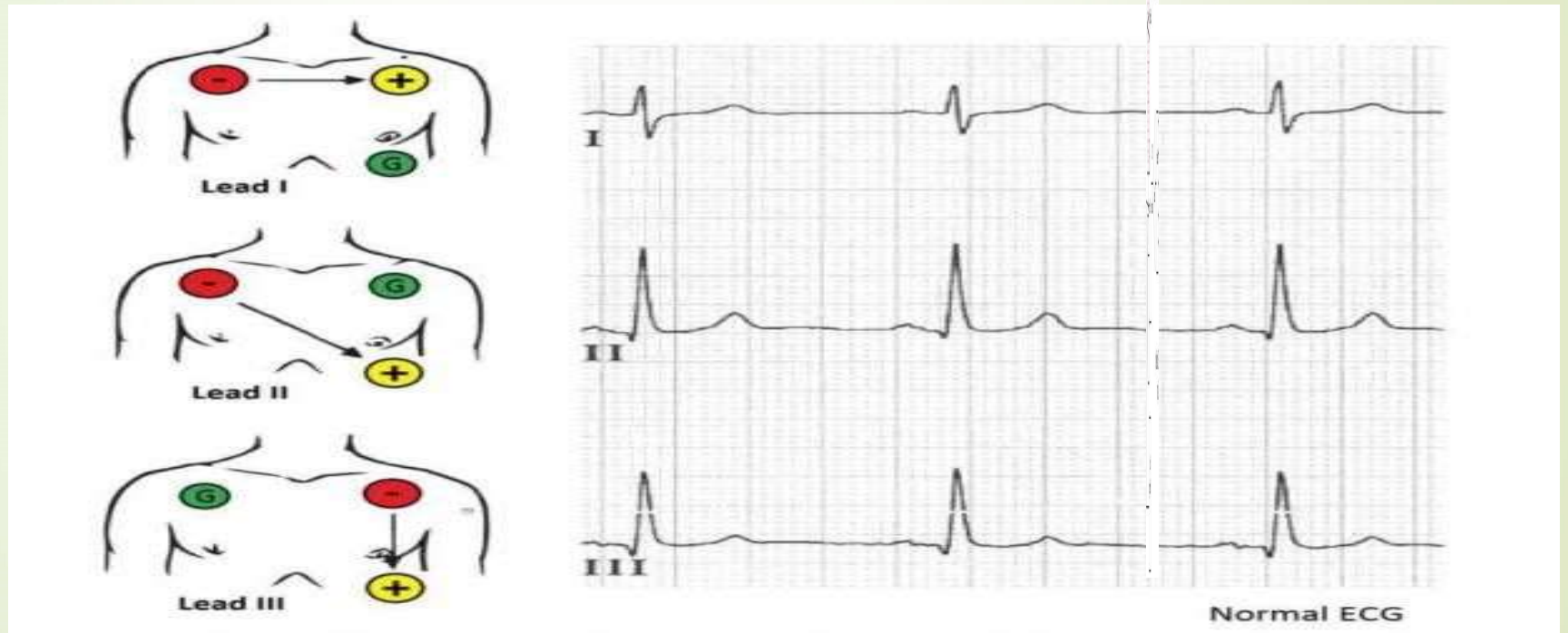


3-lead AHA

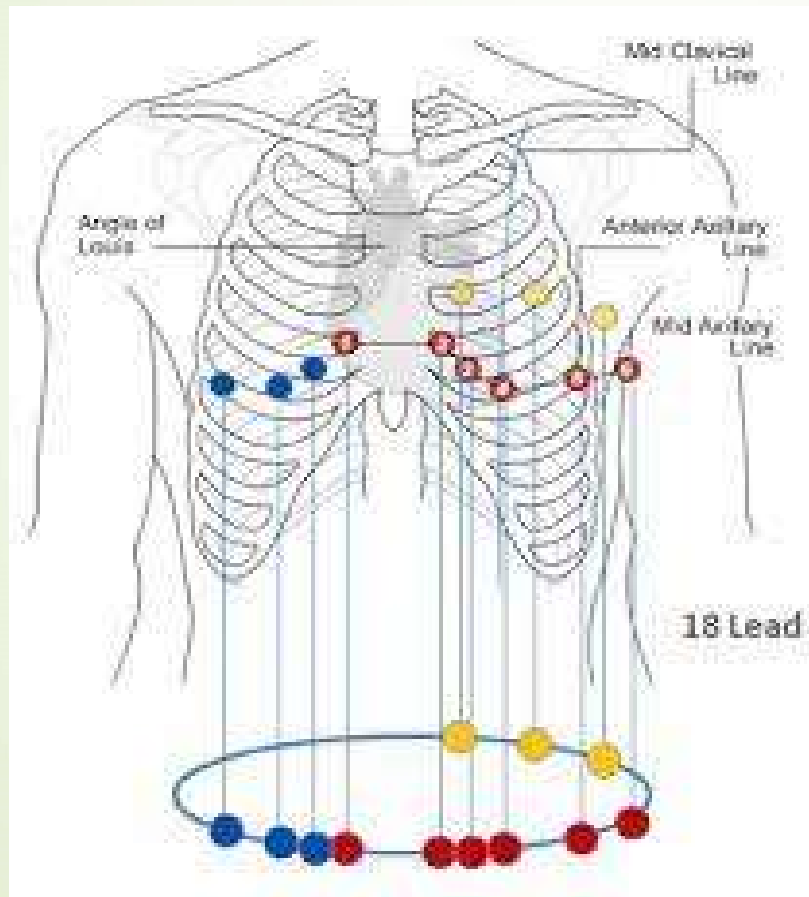
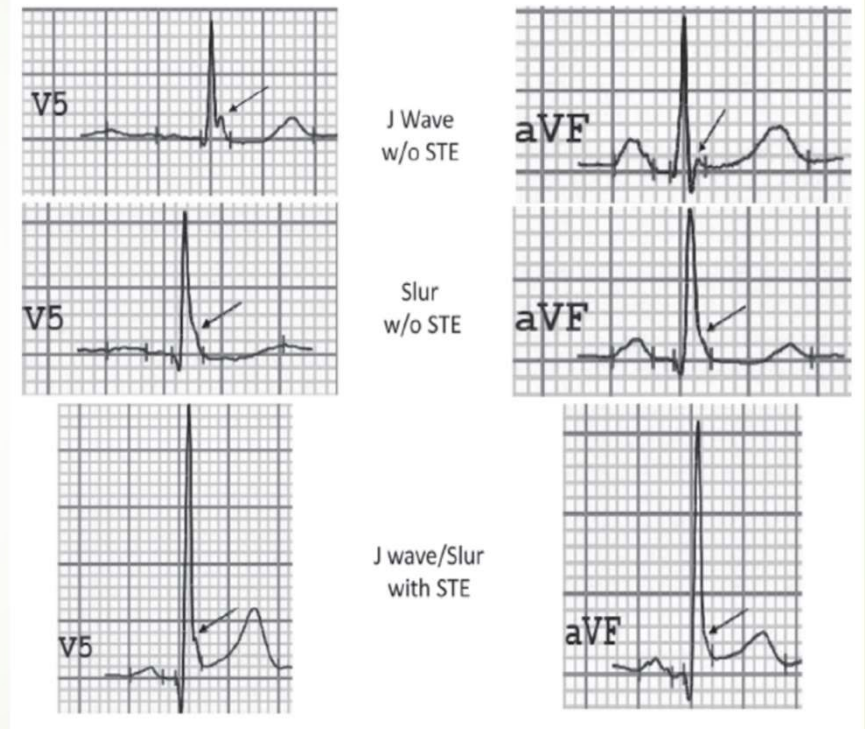


3-lead IEC

3 Lead ECG placement



Signal Averaged ECG



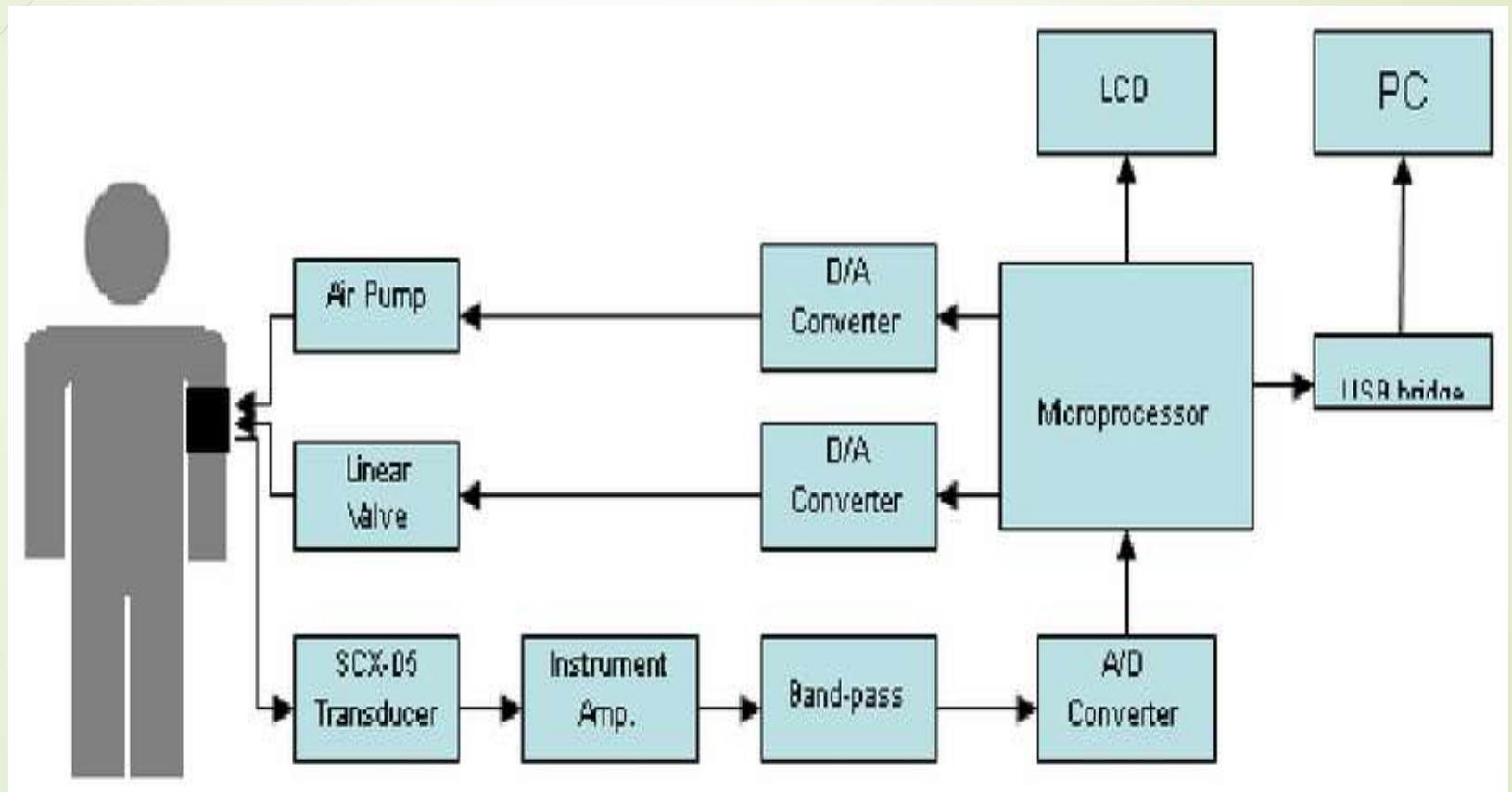
Signal averaged ECG in patients with early repolarization



What is the working principle of Non-invasive Blood Pressure Monitor?

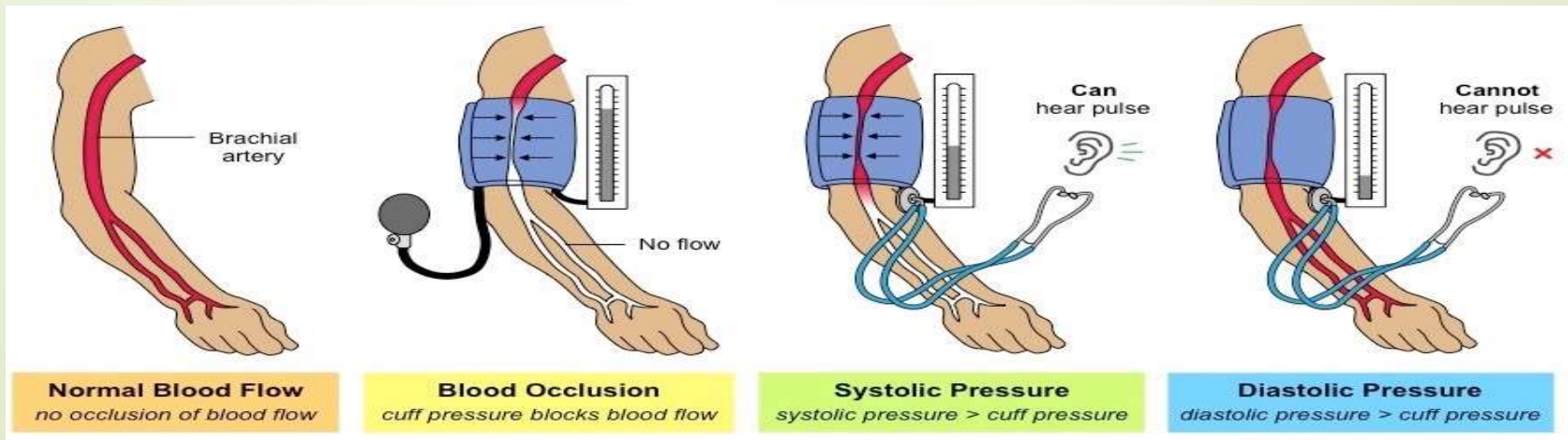
- By using Oscillometric measurement, the cuff is inflated to a pressure initially in excess of the systolic arterial pressure and then reduced to below diastolic pressure over a period of about 30 seconds. Over the deflation period, the recorded pressure waveform forms a signal known as the cuff deflation curve. A bandpass filter is utilized to extract the oscillometric pulses from the cuff deflation curve. The amplitude of oscillometric pulses increases to a maximum and then decreases with further deflation in order to estimate the systolic, diastolic and mean arterial pressure.

Block Diagram of Blood Pressure Monitor

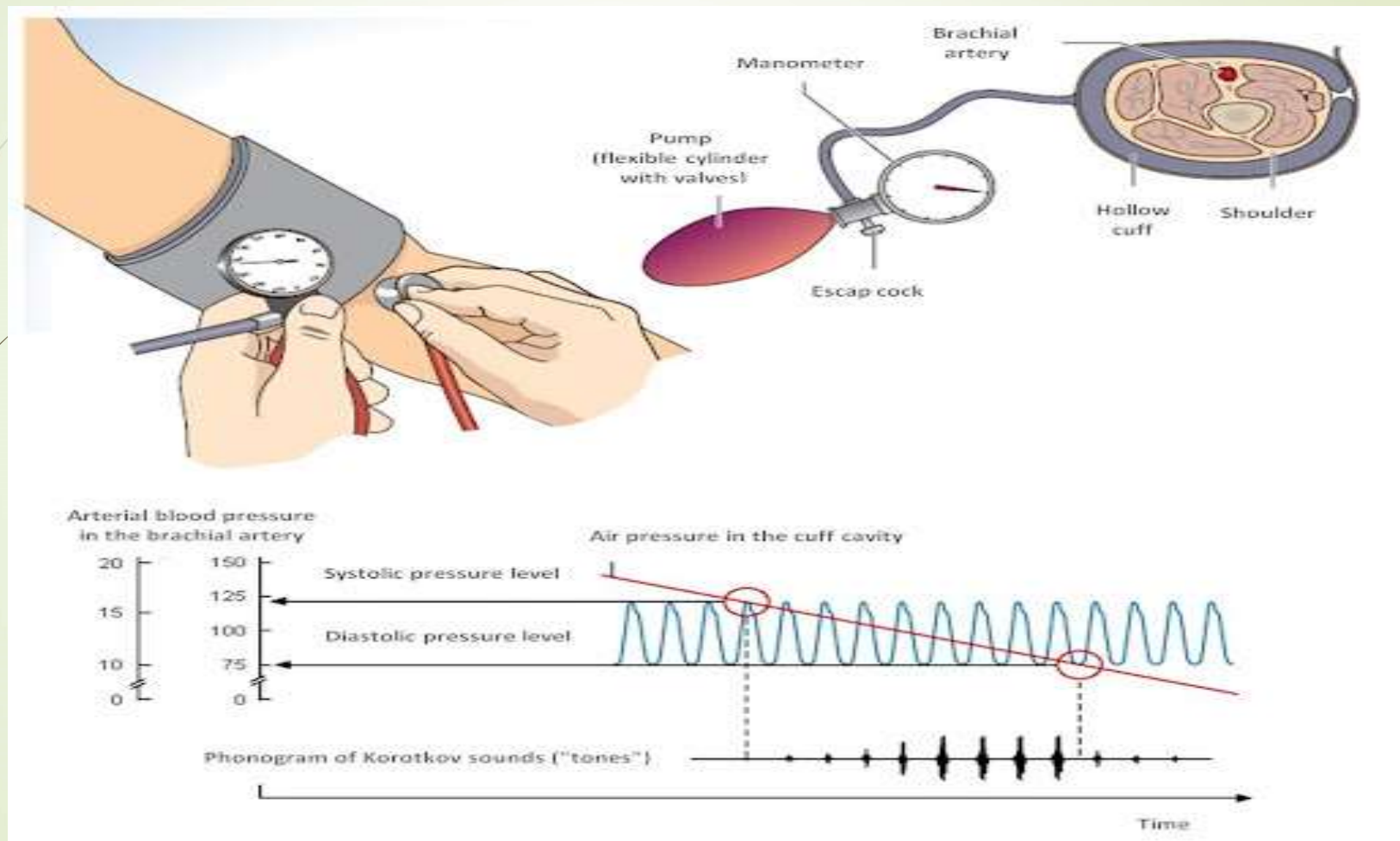


How to measure / determine the Systolic Pressure, Diastolic Pressure and Mean Pressure from the cuff deflation curve in NIBP?

- Firstly, here is no pulse amplitude in artery due to initial inflation pressure. After deflation cycle starting, the pressure is reduced gradually (typical 3-5mmHg per step) and there is a blood flow in the artery. Therefore, the first pulse amplitude (the highest pulse amplitude) is detected by microphone. It is known as Systolic Pressure of the artery. After that, the cuff pressure is decreased further that there are two cuff pressures with the same pulse amplitude; it is known as Mean Pressure of the artery. Then, the cuff pressure is decreased further and further until the first moment that the cuff pressure without pulse amplitude, it is known as Diastolic Pressure.



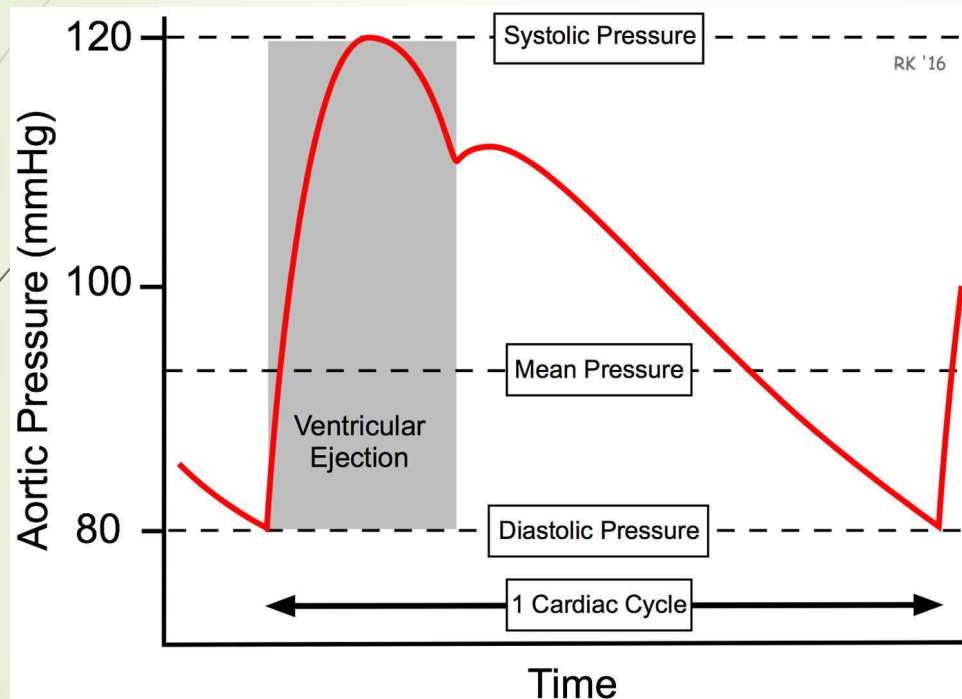
Arterial Blood Pressure



Understanding Blood pressure Readings

Blood pressure category	Systolic mmHg		Diastolic mmHg
Low blood pressure	less than 90	or	less than 60
Normal blood pressure	90 – 119	and	60 – 79
Prehypertension	120 – 139	or	80 – 89
Hypertension Stage 1	140 – 159	or	90 – 99
Hypertension Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Medical emergency!)	Higher than 180	or	Higher than 110

Mean Arterial Pressure



How to Calculate
the Mean Arterial
Pressure (MAP)

$$\text{MAP} = \frac{\text{SBP} + 2(\text{DBP})}{3}$$

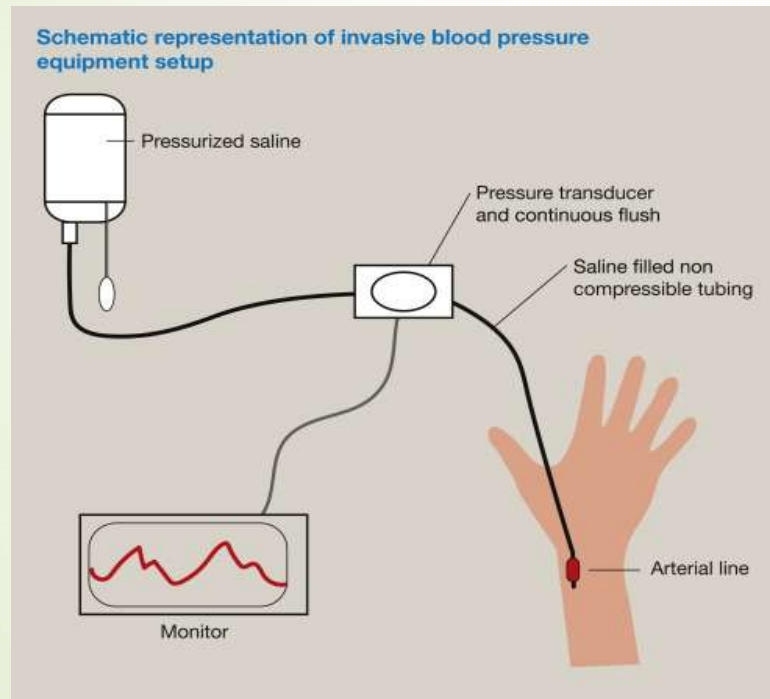
Lippincott
NursingCenter®

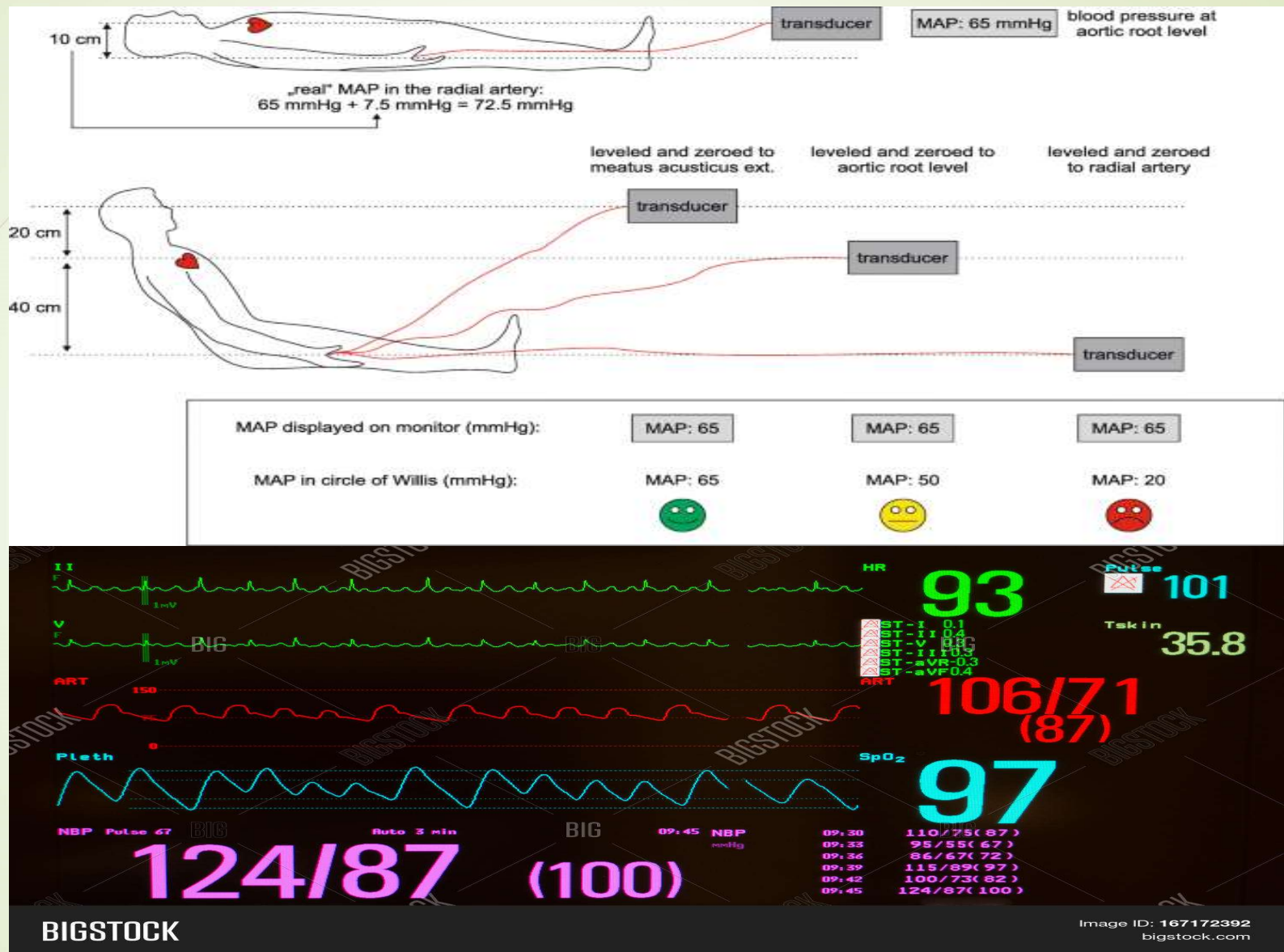


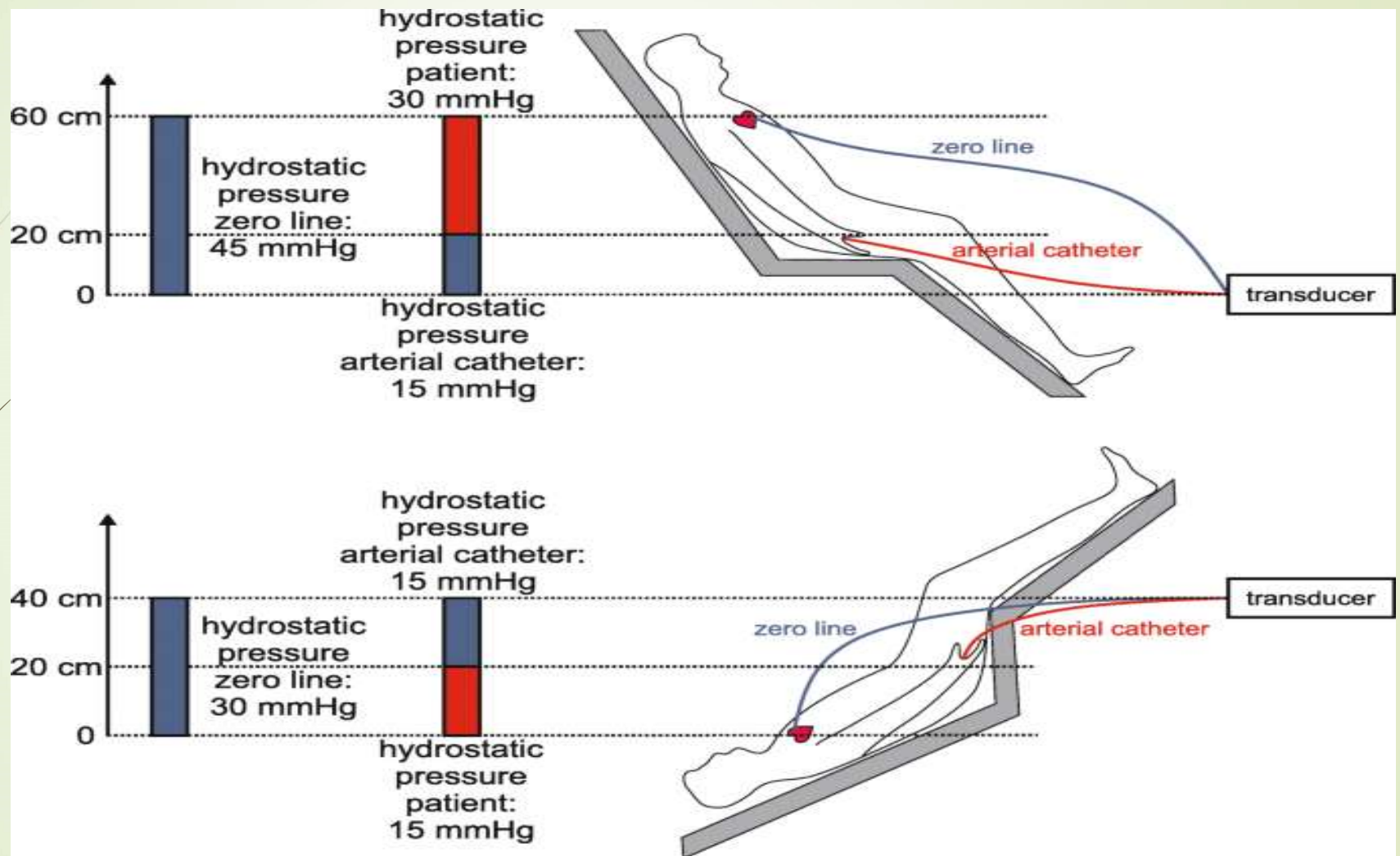
What are the results if the cuffs are undersize or oversize?

- It is essential that the cuff size is correct: undersized cuffs may yield too high a pressure; oversized cuffs yield too low a pressure.

Invasive Blood Pressure Monitoring







Block Diagram of Defibrillator Monitor

PRINCIPLE OF DEFIBRILLATION

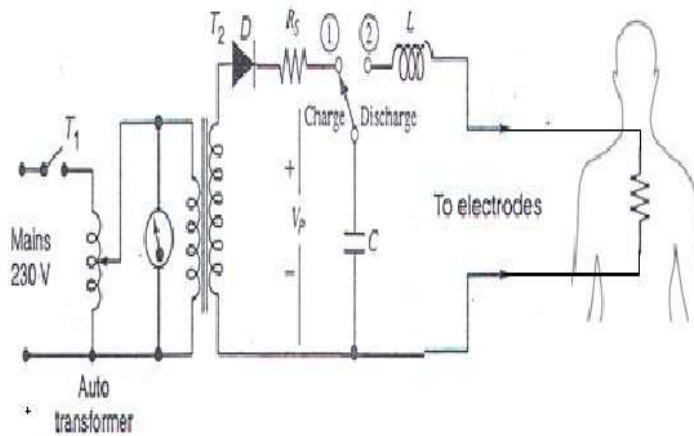
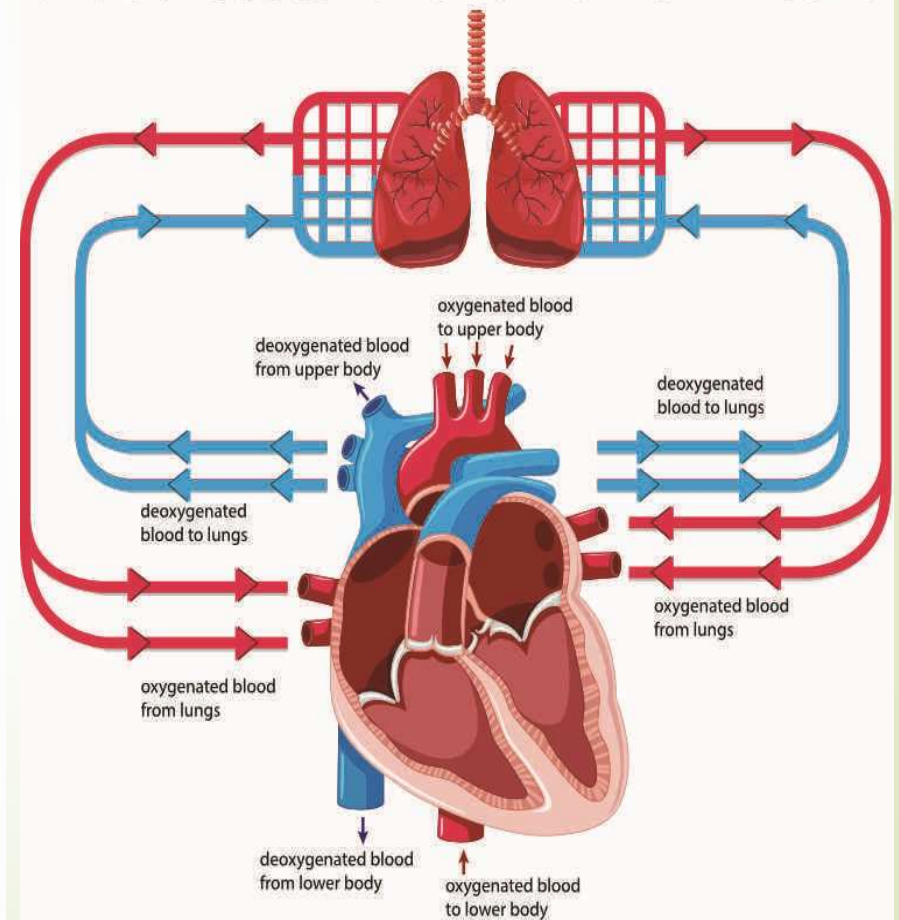
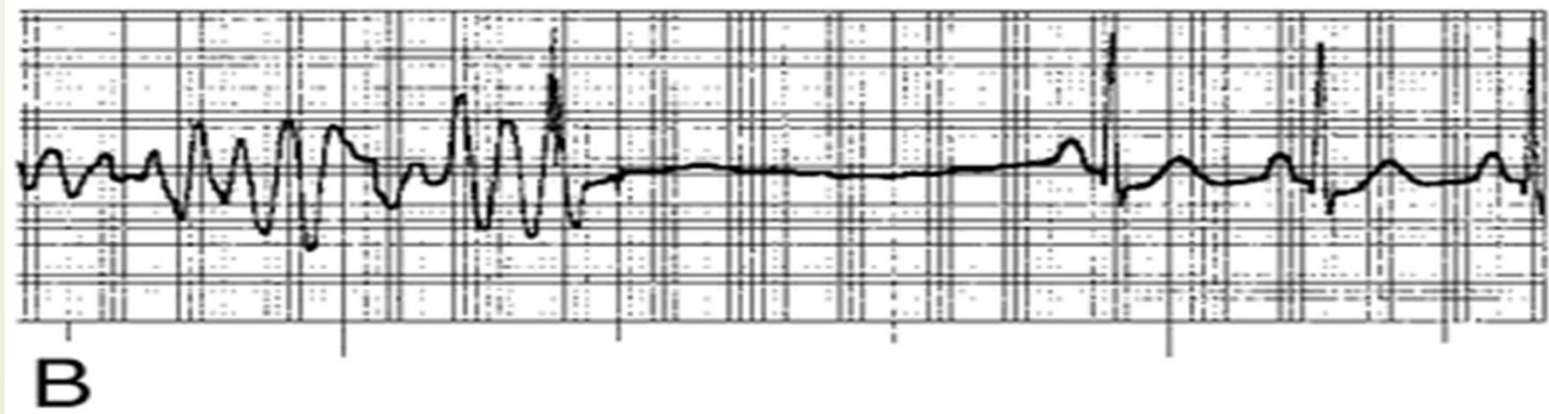


Fig: Schematic diagram of a defibrillator

Blood Flow of the Human Heart



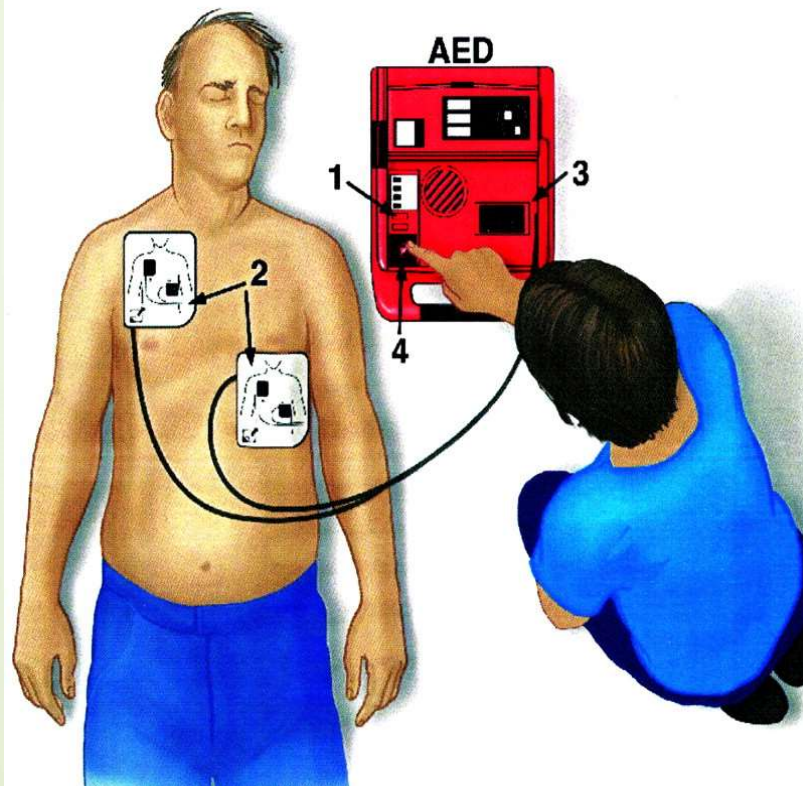
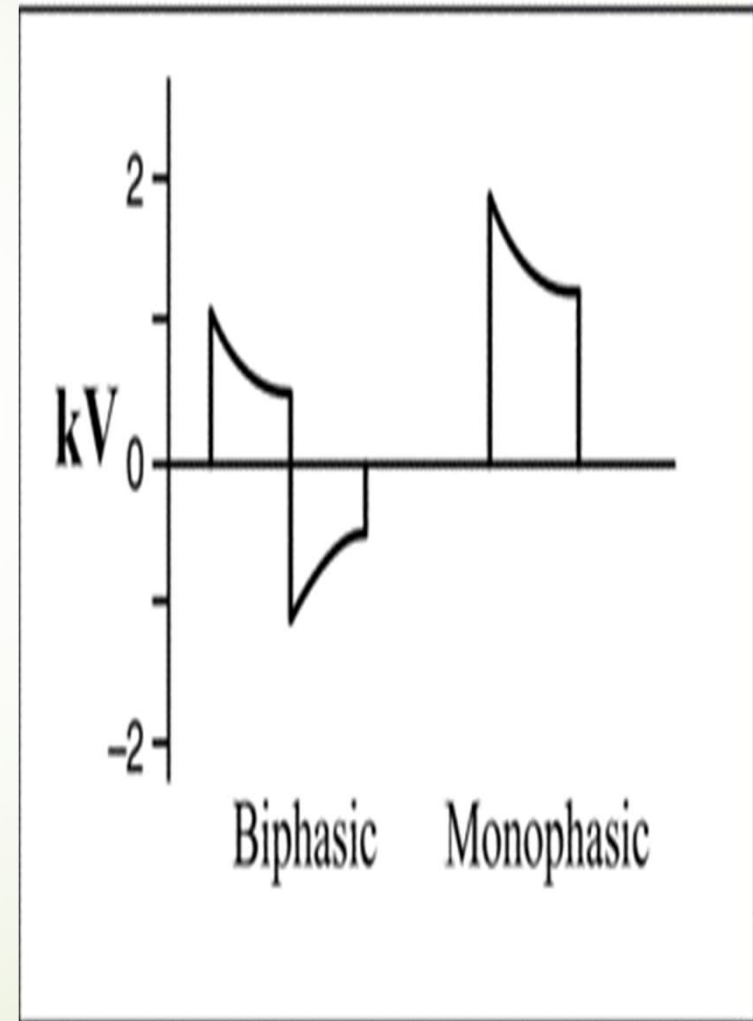


Automatic External Defibrillator

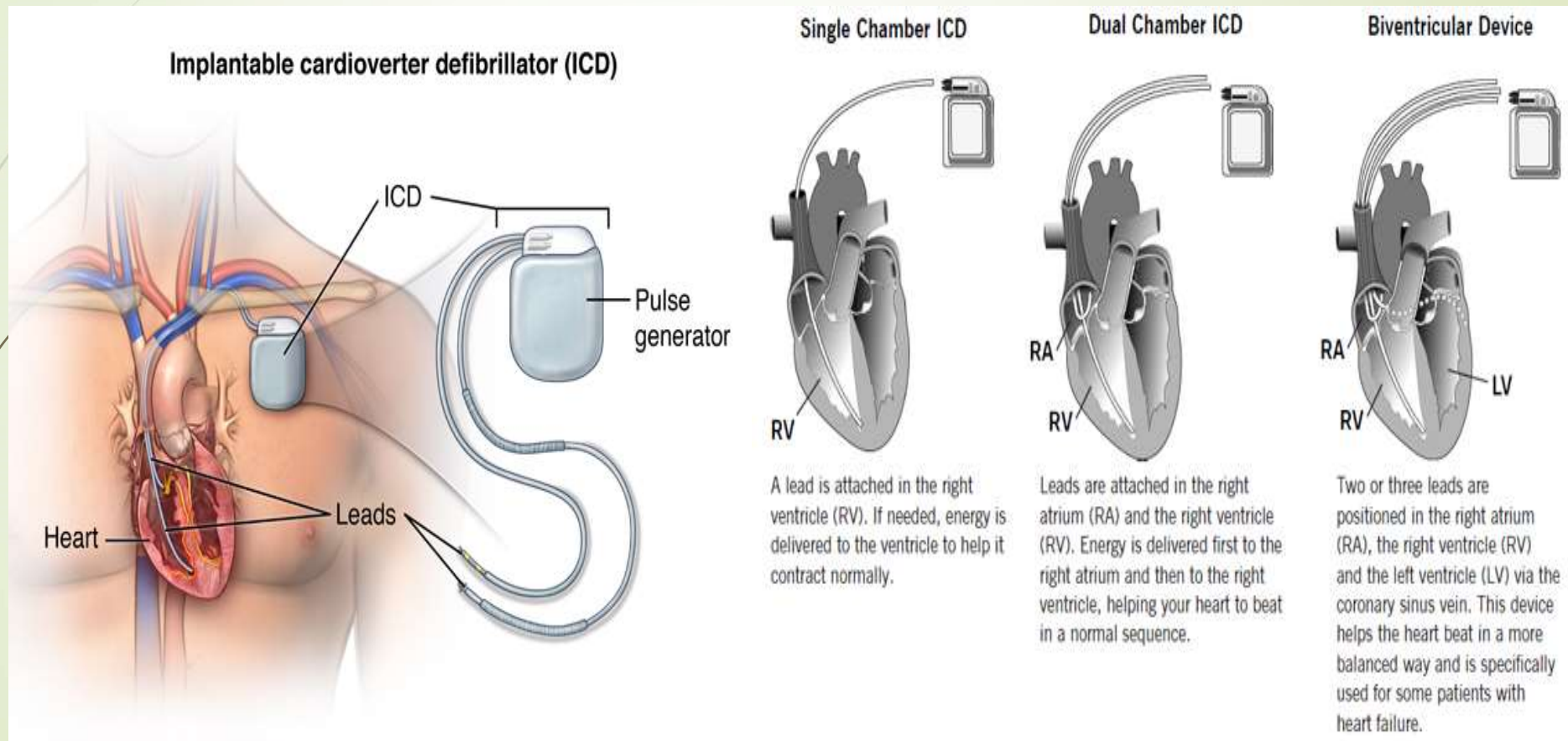


How to Use an AED

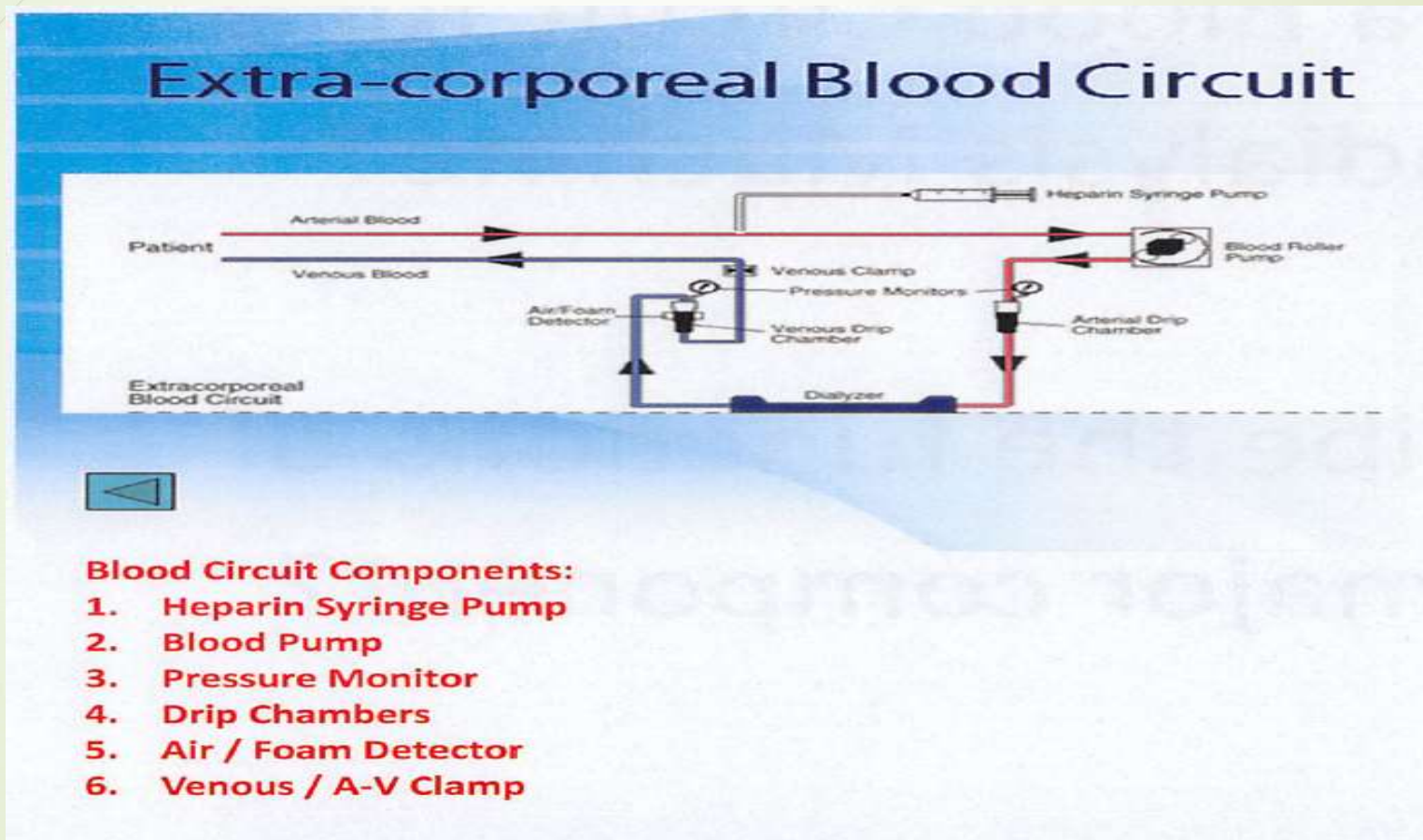
1. Activate AED.
2. Apply pads.
3. AED analyzes heart rhythm.
4. When prompted by voice command, press shock.



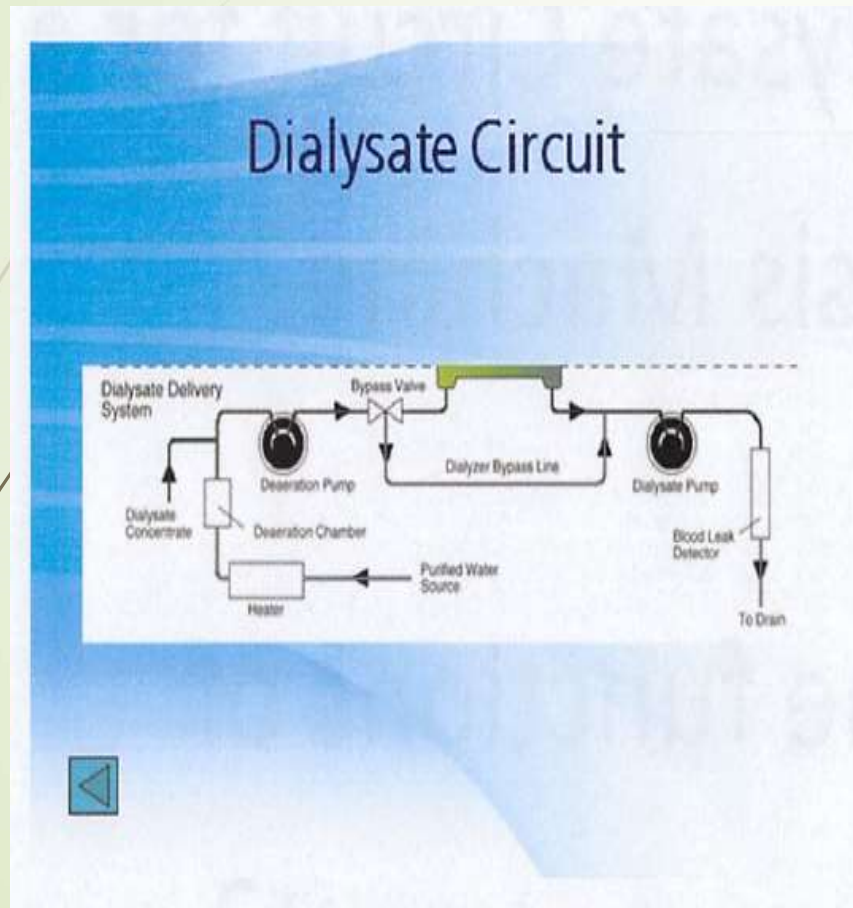
Implantable Cardioverter Defibrillator(ICD)



Blood Circuit for a Hemodialysis Machine?



Dialysate Circuit for a Hemodialysis Machine?



Dialysate Circuit Components:

1. Heater
2. Deaeration Chamber / Pump
3. Bypass Valve
4. Dialysate Pump
5. Blood Leak Detector

PARTS AND FUNCTIONS:

S.NO	PARTS	FUNCTION
1	Dialysis Machine Blood Pump and Tubing	A blood pump simply pumps the blood from the body into the machine through specially made tubes.
2	Syringe	The syringe contains a drug called Heparin which prevents the blood from clotting in the tubes.
3	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	Alarms	in order to protect the patient from any errors in functioning. The things that are monitored with alarms include: <ul style="list-style-type: none">•Blood pressure within the machine•Blood pressure of the patient•Blood flow•Temperature•Dialysate mixture

High temperature alarm:

- Determine temperature of dialysate in the line actually high
- Check to ensure incoming water temperature is below 90 F.

Low Temperature alarm:

- Determine temperature of dialysate to dialyzer in the line is actually low.
- Turn the mode selector switch to dialyzer
- Allow adequate time for the system to stabilize and come to proper temperature range.
- Check to ensure incoming water temperature is above 40 F.

High Conductivity alarm:

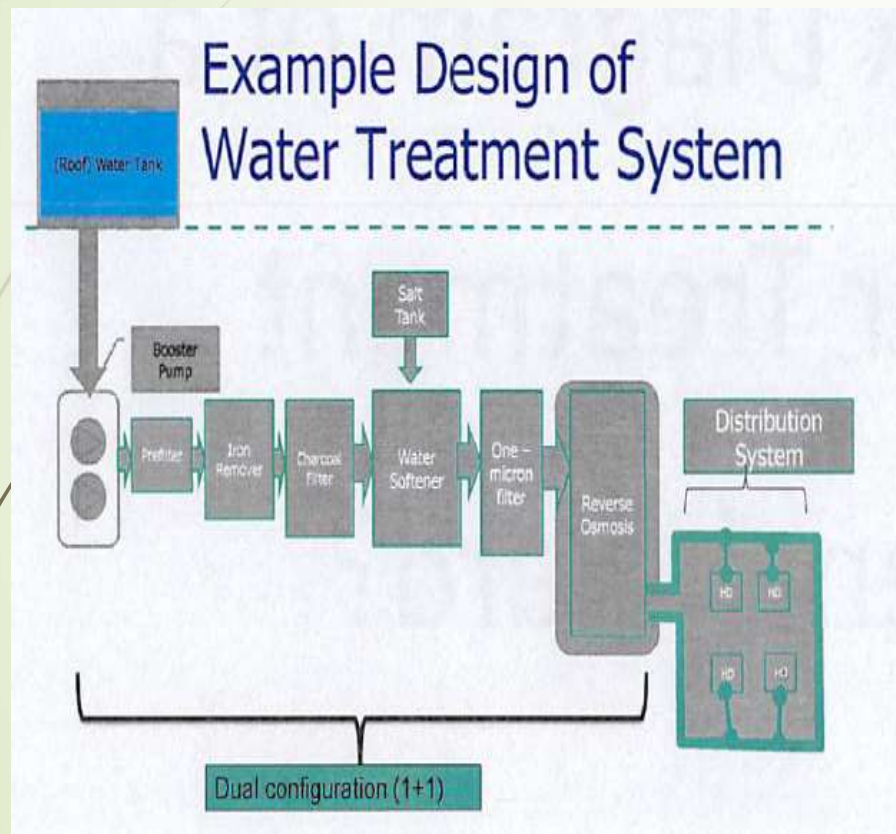
- Check to see if water is flowing too slowly or turn off.
- Check for kink in the concentrate out line.
- Make sure that the system has had time to stabilize
- Analyze the dialysate to confirm high conductivity at the to dialyzer line connection:

- a. If normal there is malfunction in the machine itself (change it)
- b. If high again concentrate before resuming dialysis.
- c. Be certain that the dialysate flow rate is proper.

Low conductivity alarm:

- o Turn the mode selector switch to dialyze.
- o Connect the concentrate line to the system
- o Drop the concentrate line into the concentrate container
- o Check for kinks in the concentrate in line
- o Make sure the filter on the concentrate in is clean
- o Allow adequate time for the system to stabilize
- o Change the concentrate container if it is dry
- o If the concentrate container has not run dry a sample of dialysate should sent to the laboratory for sodium and chloride.
- o Analyze the dialysate to conform low conductivity at drain
- o If low conductivity is conformed change the concentrate bottle.

Block diagram of a typical Water Treatment System in Renal Ward?

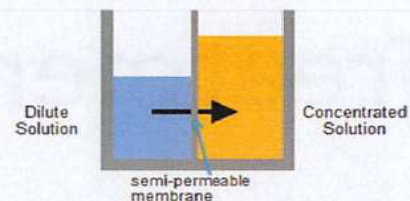


1. Water Tank : Provide a water reservoir for Water Treatment System
2. Booster Pump: Additional Pressure for Downstream water
3. Prefilter: First line filtration (Larger Particles)
4. Iron Remover: Remove Fe ion
5. Charcoal Filter: Remove Chlorine and Chloramines
6. Water softener: Remove Ca^{2+} and Mg^{2+} (hardness) by NaCl
7. Salt Tank: Provide NaCl (Na^+ ion) for regenerate process of softener.
8. One Micro Filter: Filtration of fine particulates and protect RO
9. Reverse Osmosis: Provide pure water to Hemodialysis Machine

Reverse Osmosis Principle in Water Treatment System?

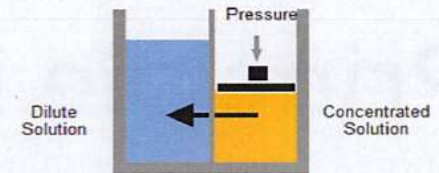
RO Principle

Osmosis



Spontaneous flow of water from a **dilute solution** to a **concentrated solution**, when the two solutions are separated by a semipermeable membrane.

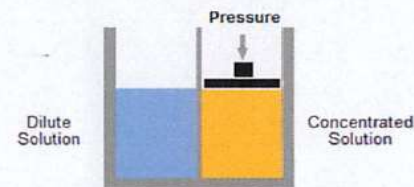
Reverse Osmosis



Pressure $> \Delta\pi$ (200 – 250 PSI)

Reversing osmotic flow by applying a pressure **in excess** of the osmotic pressure

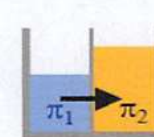
Osmotic Pressure



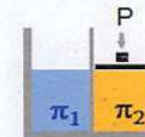
Pressure $= \Delta\pi$

A pressure that must be applied to a concentrated solution to prevent osmosis. (equilibrium state)

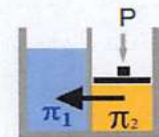
Summary of the three cases



osmosis
 $\pi_1 < \pi_2$



equilibrium
 $P = \Delta\pi$



reverse osmosis
 $P > \Delta\pi$

Infusion Pump/Syringe Pump

Standard gravity drip

Infusion set
May include drip chamber, tubing, roller clamp and a connection to a cannula



Fluid container
Bottle or bag which holds the fluid



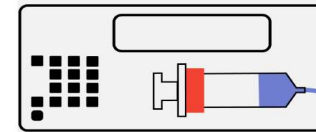
Drip chamber
Physically counting drips gives indication of flow rate



Roller clamp
Adjustable for different flow



The two main types of infusion pumps



Syringe pumps
Deliver (smaller) volume of fluids through a syringe



Large Volumetric Pumps (LVPs)
Deliver fluid from bags or bottles, like the drip shown

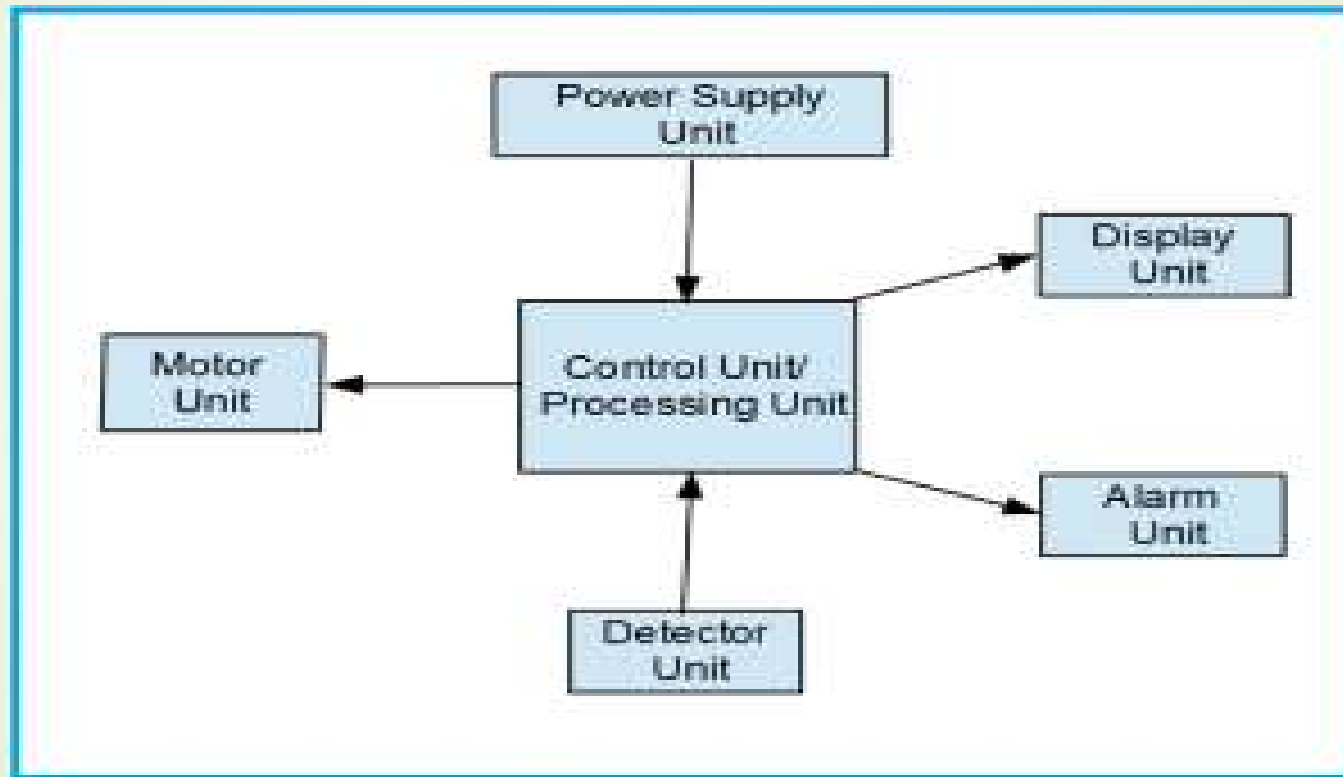


DIAGRAM REVERSE OSMOSIS WATER PURIFICATION SYSTEM

For Hemodialysis Machines



Block Diagram of Infusion Pump



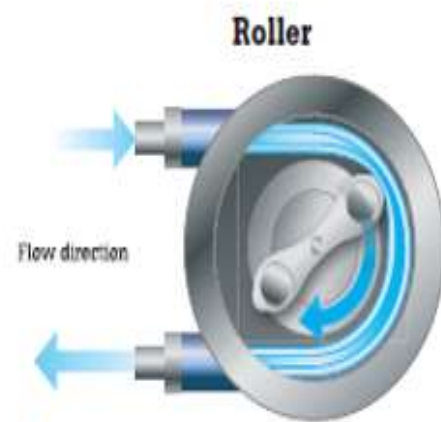


Figure 1

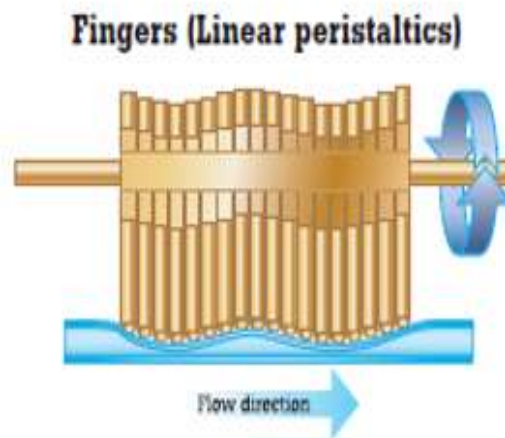


Figure 2

Syringe pump
(driven by threaded row mechanism)



Figure 3



The function of Infusion Pump?

State some common alarm in infusion pump.

What is KVO in infusion pump and the typical rate?

- ▶ In control manner-accuracy control flow rate and dose.
- ▶ Occlusion, air in line, door open, battery low, AC power fail, drop sensor not connected, empty bottle.
- ▶ keep vein open, an order indicating that the patency of an intubated vessel be maintained so that subsequent intravenous solutions or medicines can be administered. (5ml/hr)



What is the meaning of the Occlusion Alarm in the Infusion Pump?

What is the typical value to trigger the Occlusion Alarm?

- The infusion path is blocked by any reasons such as infusion set, infusion tubing or driving mechanism misaligning.
- The typical value to trigger the occlusion alarm is between 675 mmHg to 875 mmHg (900 to 1100 Mbar)



What is PCA pump?

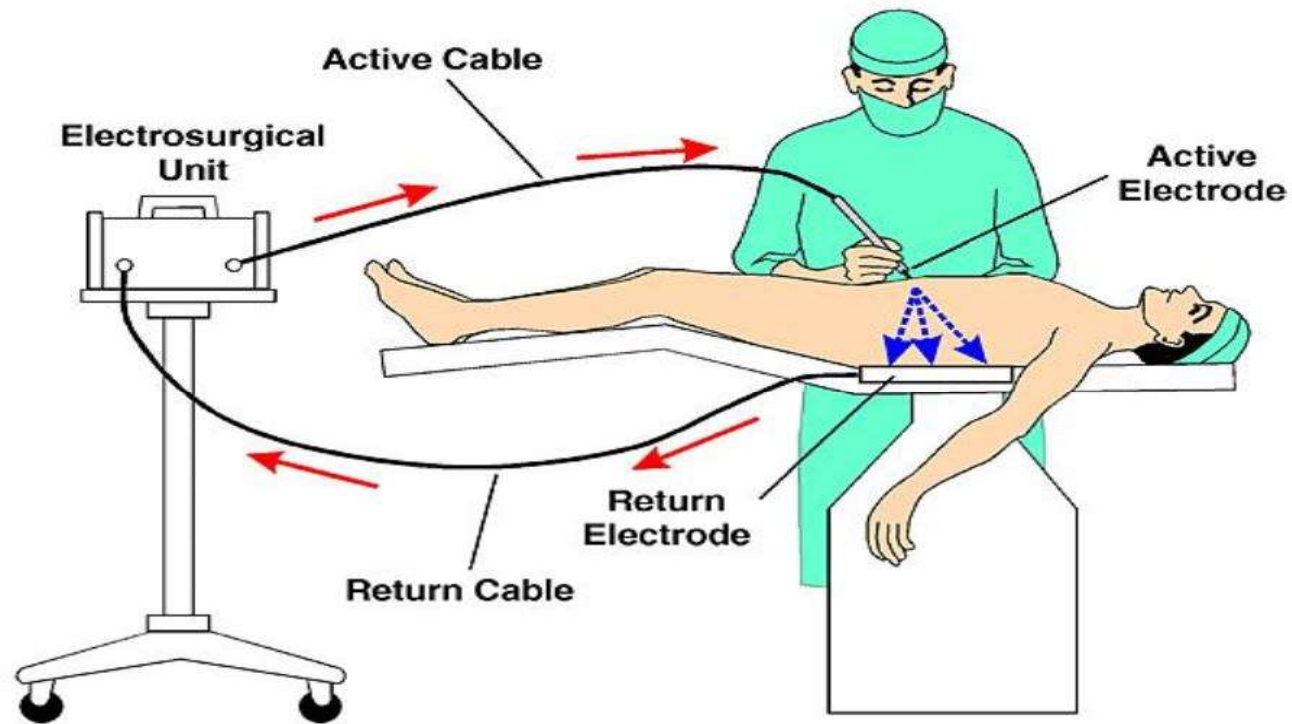
- The patient-controlled analgesia (PCA) pump is a computerized machine that gives you a drug for pain when you press a button. In most cases, PCA pumps supply opioid pain-controlling drugs such as morphine, fentanyl, and hydromorphone.

Electrosurgical Units

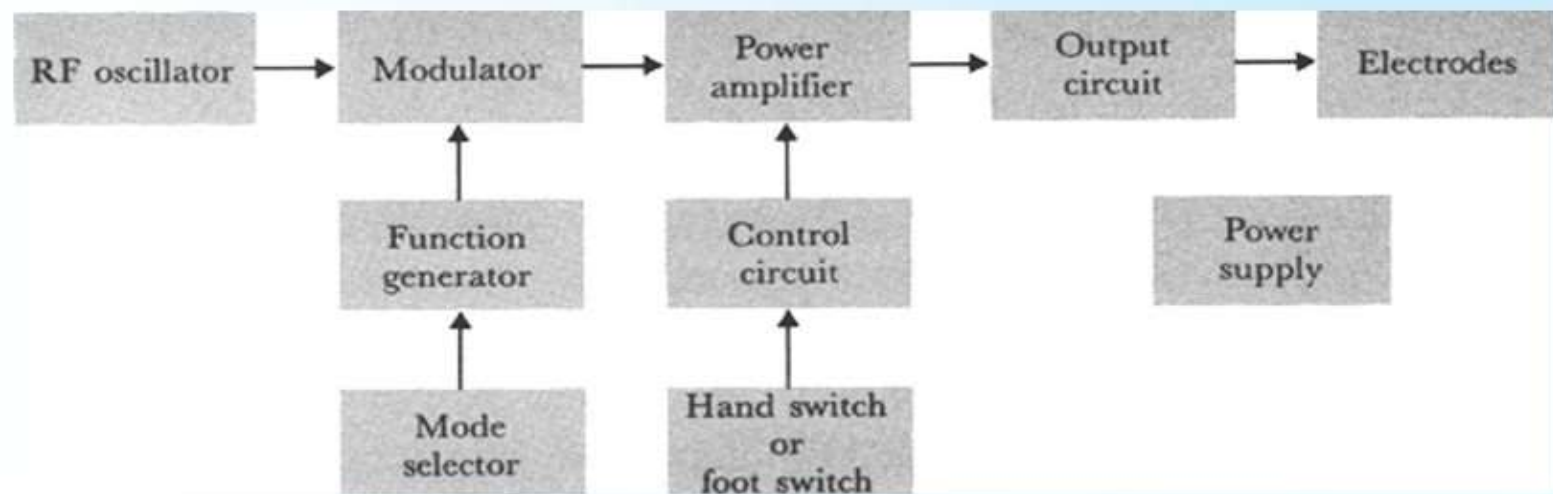
- ▶ Electrosurgical Basics
- ▶ Electrosurgical Burns
- ▶ Laparoscopic Accidents
- ▶ Injuries to Medical Staff
- ▶ Fires

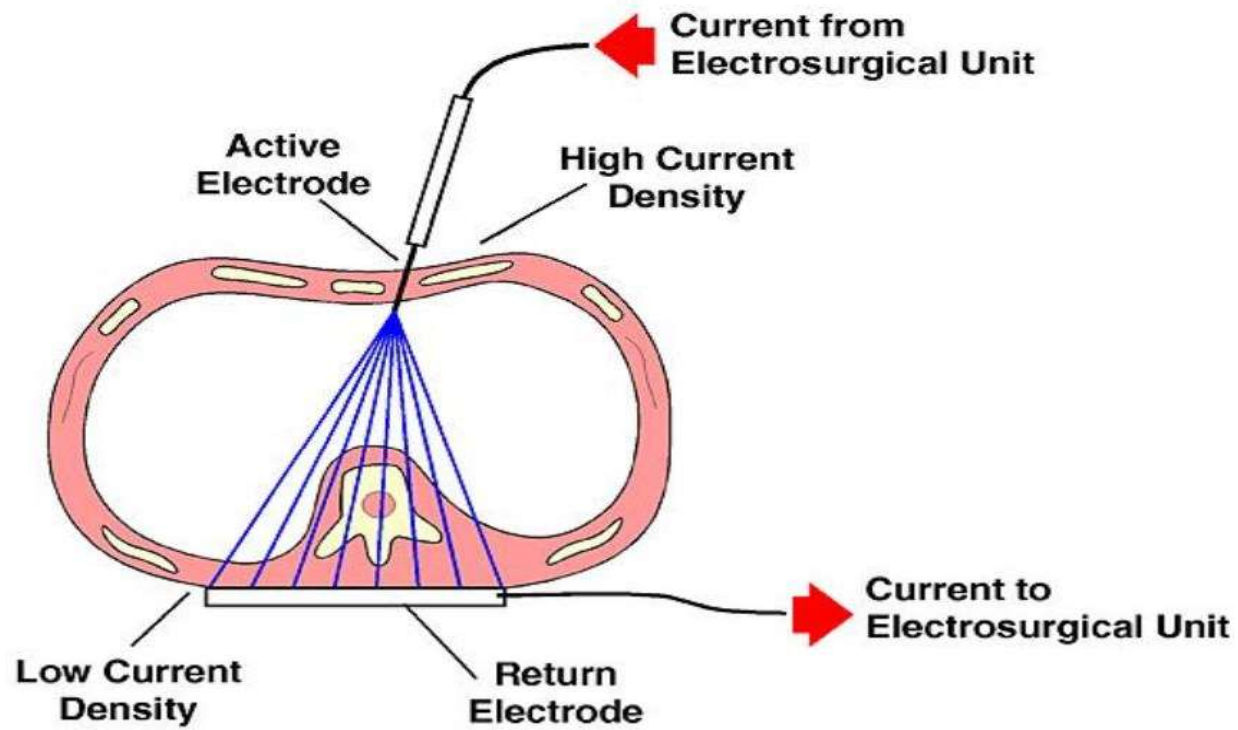
Electrosurgery Facts

- ▶ Used in about 80% of all surgical procedures
- ▶ Very effective surgical tool
 - Cutting
 - Coagulation
 - Fulguration
- ▶ Not well understood by clinicians
- ▶ Commonly seen in FDA and ECRI problem reporting databases



Block diagram of a typical electrosurgical unit

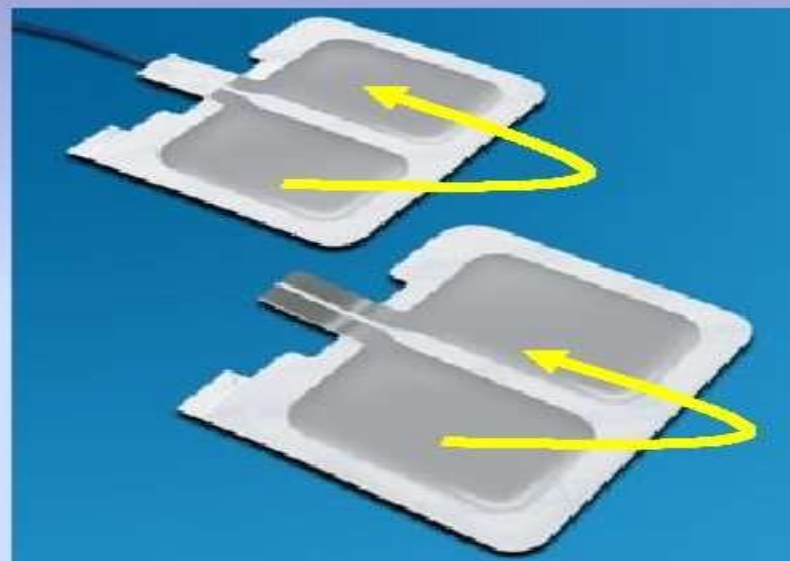






Dual Plate Return Electrodes

Interrogation current flows between each plate of the electrode and the patient. If one side is partially detached from the patient, an alarm will sound.



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9



Monopolar VS. Bipolar Electrosurgery

- **What is Electrosurgery?**
- Electrosurgery is a surgery that uses the electrical current to cut, coagulate, desiccate, and/or fulgurate tissue. During the process, a high-frequency electrosurgical unit (ESU) is used to convert 60 Hz to more than 300,000 Hz high-frequency current, which can pass through human body safely without causing nerve or muscle reactions.
- Electrocoagulation is a common method of surgical hemostasis. HF current heats, dehydrates and shrinks the blood vessel, coagulates and melts the blood vessel and clots, so as to achieve the purpose of effective hemostasis.
- There are two basic types of electrosurgery depends on electrical circuits: monopolar and bipolar.

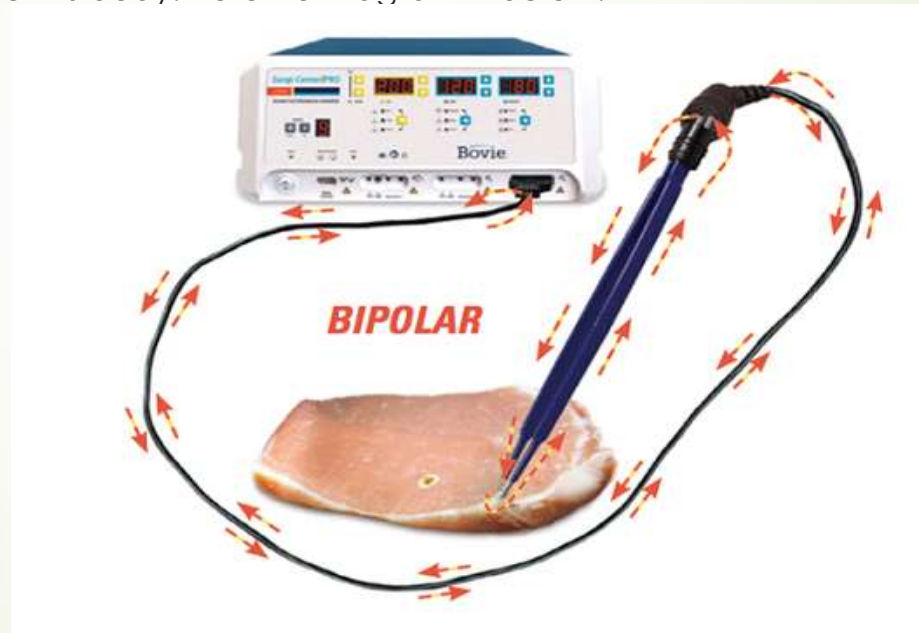
Monopolar Electrosurgery

In monopolar electrosurgery, the current flows through from the ESU to the active electrode, the patient, the patient return pad (aka dispersive pad or neutral electrode) which is placed on patient body, and finally back to the ESU. A dispersive electrode is required to complete the circuit.



Bipolar Electrosurgery

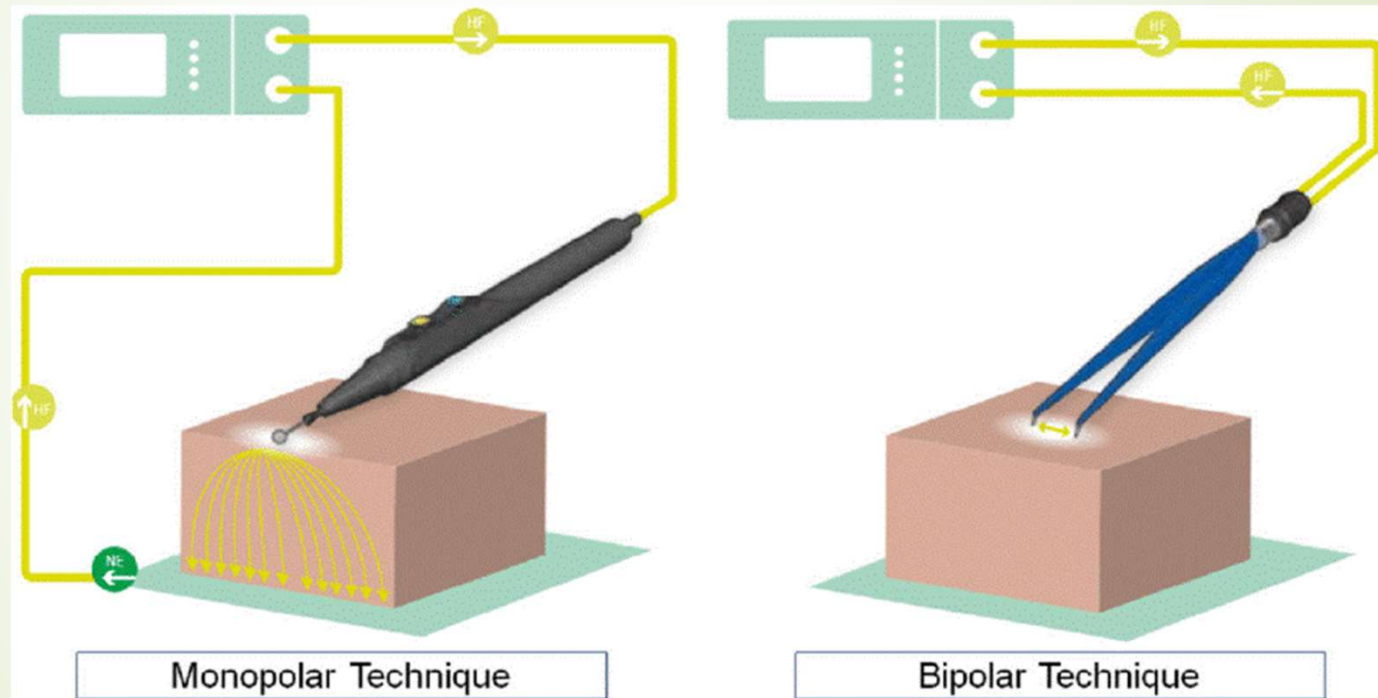
In bipolar electrosurgery, a patient return pad is not needed. Current flows from ESU to active electrode, the patient, and then returns back from the active electrode. It passes mainly between the two tines positioned on the desired tissue to complete the circuit. Current does not flow to any other part of the patient's body. Refer to Diagram 2 below.



Electrosurgical Accidents

- ▶ Skin Burns
- ▶ Fires, Explosions
 - Fuels/Gases/Oxygen Enriched Atmospheres
- ▶ Power Delivered
 - Too much (Eyelid; Testicle)
 - Too little (Fallopian tube)
- ▶ Organ Perforations

Monopolar Electrosurgery vs. Bipolar Electrosurgery



Electrosurgical Injuries

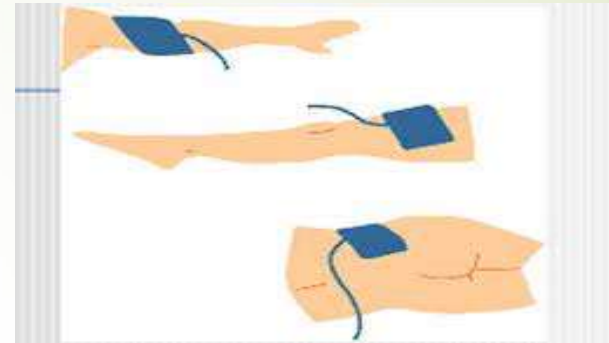
▶ Return Electrode Issues

- Poor electrode placement
- Lack of skin prep
- Complete or partial removal of return electrodes
- Skin reactions to adhesives
- Edge effects
- Patients with limited viable skin surface area
- High electrosurgical currents and long activation times

Electrosurgical Injuries

▶ Return Electrode

- Poor Site Preparation
- Poor Application technique
- Non-uniform Conductivity
- Repositioning
 - Patient
 - Electrode





Q&A



Thanks!