CBET Certification Review

Medical Equipment Function & Operation

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Topics of Discussion

A. Equipment Types
1. Test Equipment
2. ECG/EEG Monitors
    a. Frequency Response
    b. Lead Configurations
    c. Telemetry
3. Blood Pressure Monitors
4. Pulse Oximeters
5. Infusion Devices
    a. Controlling
    b. Syringe
    c. Peristaltic
6. Defibrillators
7. Fetal Monitors
8. Hypo-Hyperthermia Units
9. Infant Warmers and Incubators
10. Nerve/Muscle Stimulators
11. Dialysis
12. ESUs
13. Anesthesia Machines
14. Ventilators
15. Intra-aortic Balloon Pumps
16. Centrifuges
17. Sterilizers
18. Lasers
19. Ultrasounds
a. Diagnostic
b. Therapeutic
20. Capnographs
21. Concentrators
22. Other

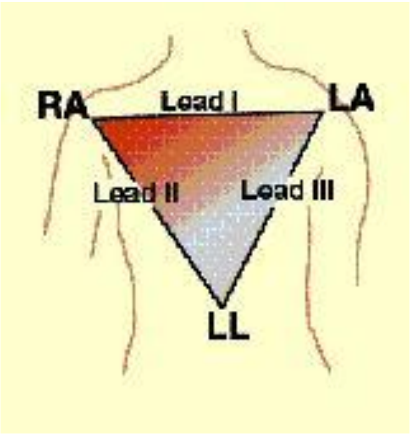
B. Systems
1. Computers
    a. Hardware
    b. Software
2. Networks
    a. Topologies
    b. Operating Systems

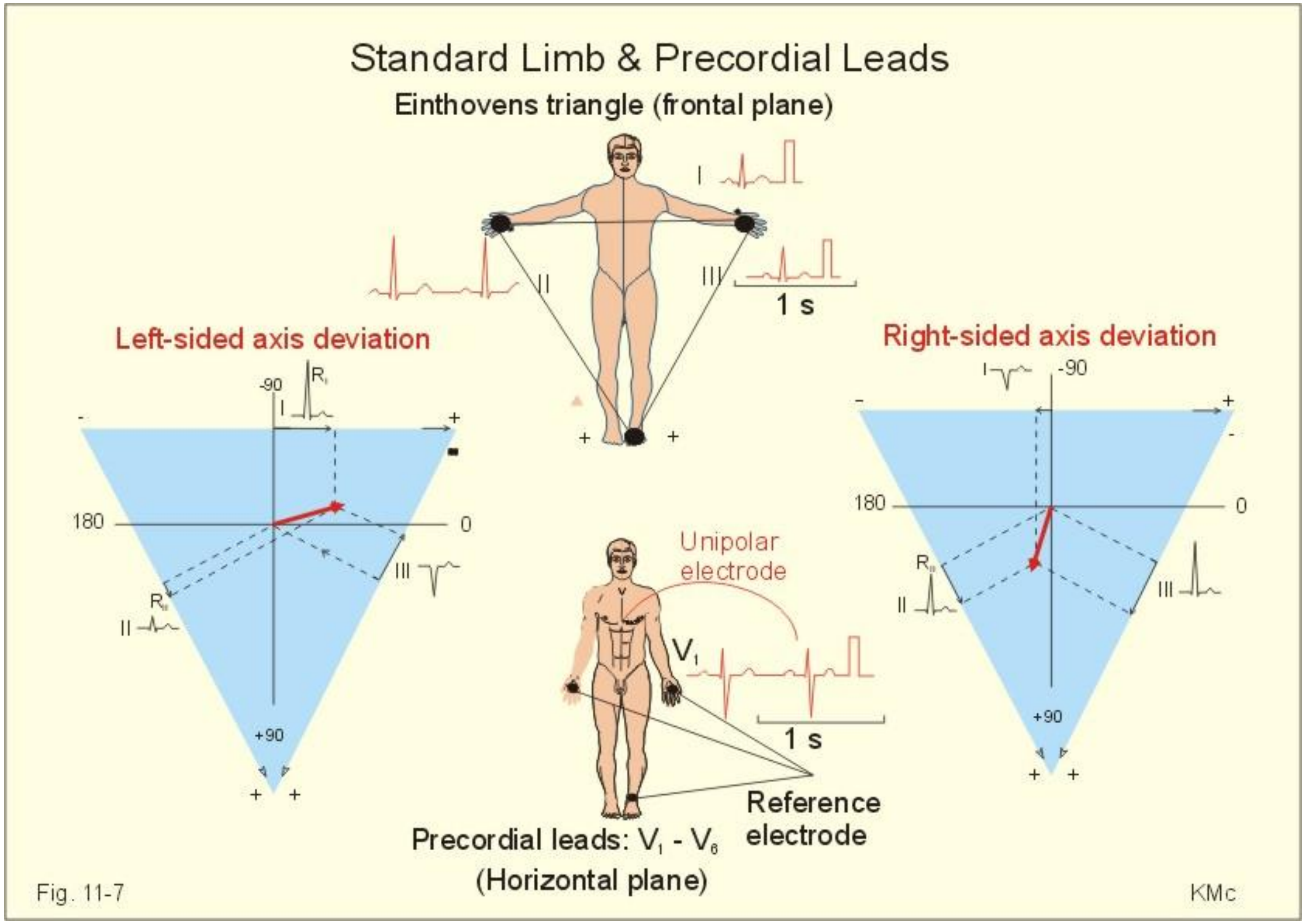
C. Terminology

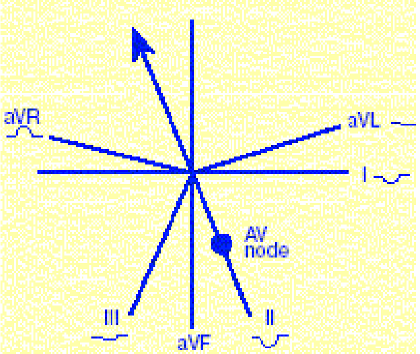
ECG Monitor


P wave
QRS complex
T wave

CBET Review – Medical Equipment Function & Operation







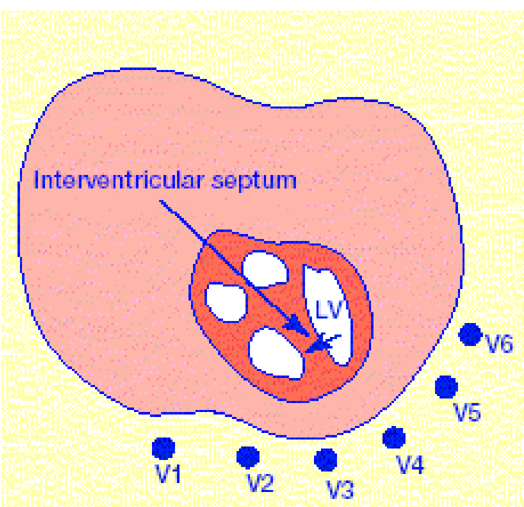
ECG Leads - Views of the Heart

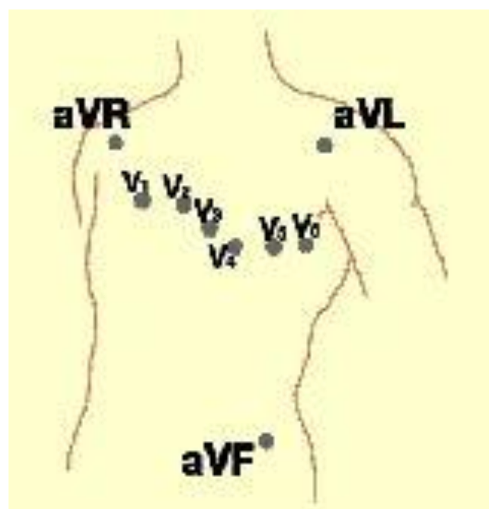
<u>Chest Leads</u>

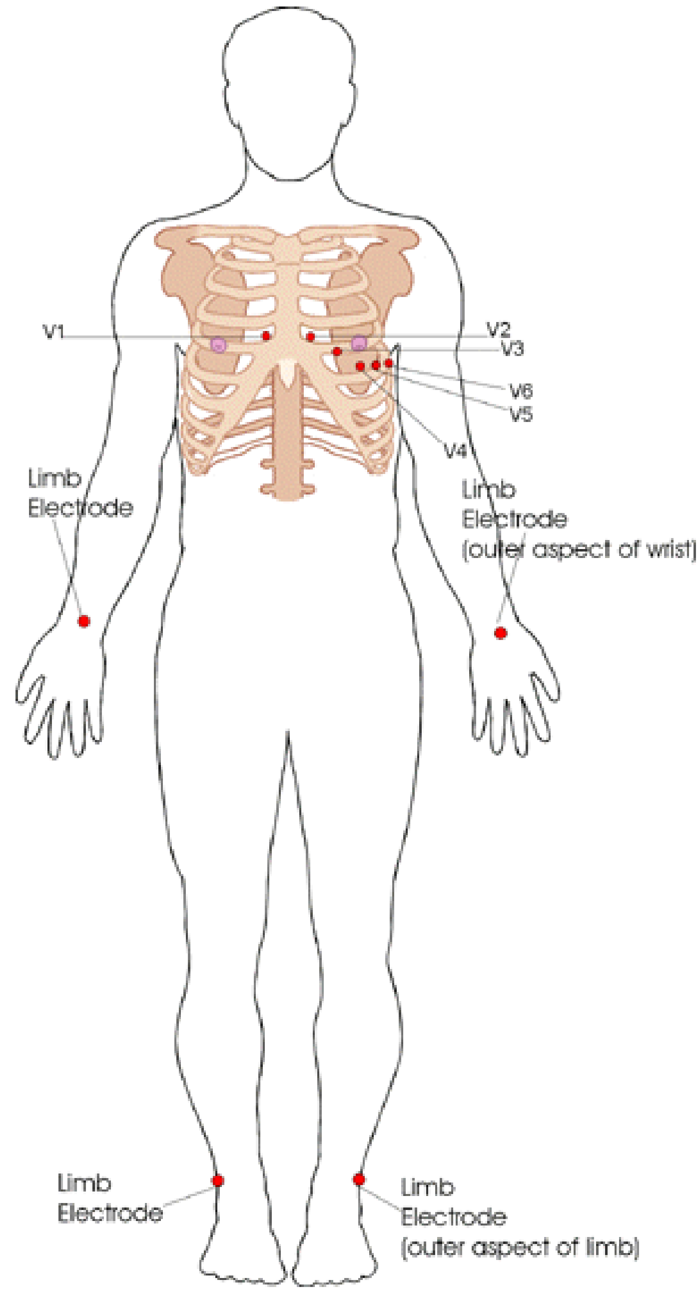
V1 & V2 - Right Ventricle

V3 & V4 - Septum/Lateral Left Ventricle

V5 & V6 - Anterior/Lateral Left Ventricle



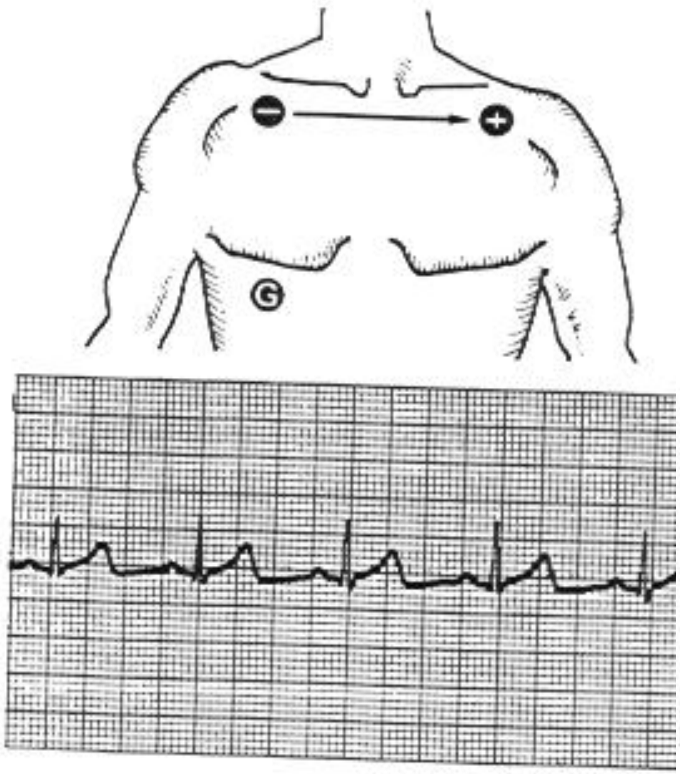




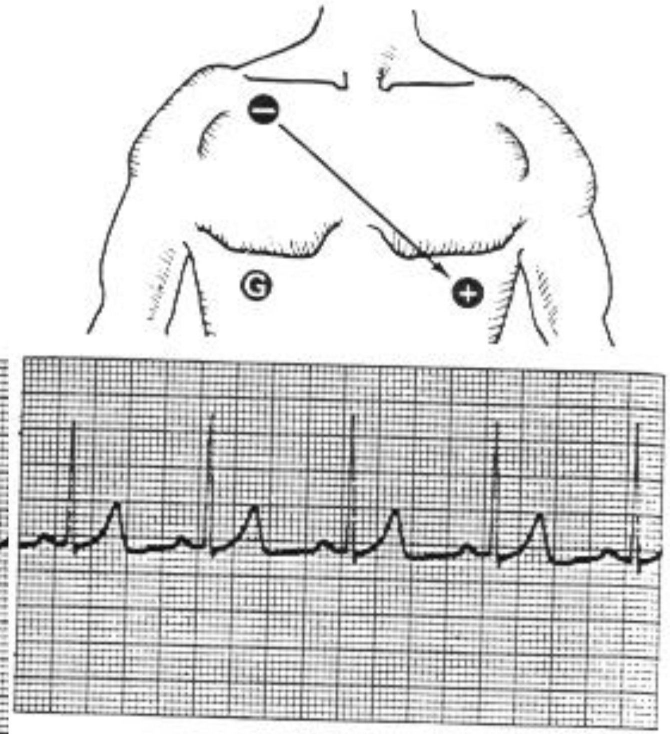
Three Main Lead Views of Heart

- 1. Bipolarized Leads
  - Lead I RA (-) to LA (+)
  - Lead II RA (-) to LL (+)
  - Lead III LA (-) to LL (+)
- 2. Unipolar Limb Leads
  - AVR AVL AVF
- 3. Unipolar Chest Leads
  - V1 V2 V3 V4 V5 V6

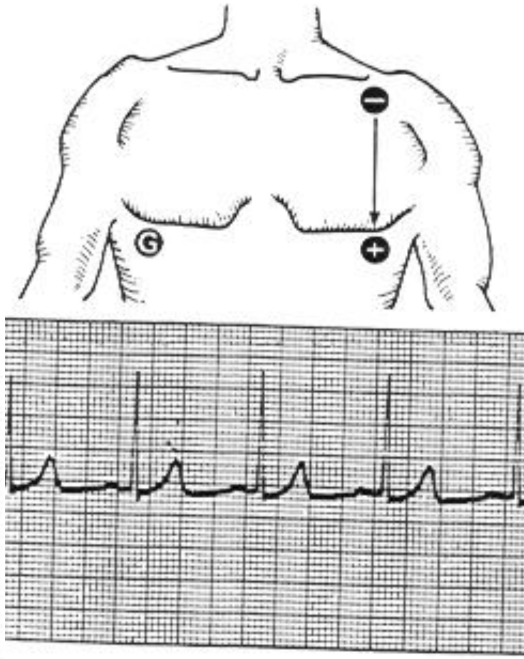
Lead I



Lead II



Lead III



ECG Monitors

- Freq. Resp. 0.5 to 50 Hz Monitor Mode
- Freq. Resp. 0.05 to 100 Hz Diagnostic Mode
- Electrode used are a Ag-AgCl prevents chemical skin burns
- Color Codes of ECG Wires
  - White - RA Black - LA
  - Red - LL Green - RL
- Sweep Speed (mm/sec) = Heart Rate (Beats/Sec) X Distance (mm)

1. Lead Selection

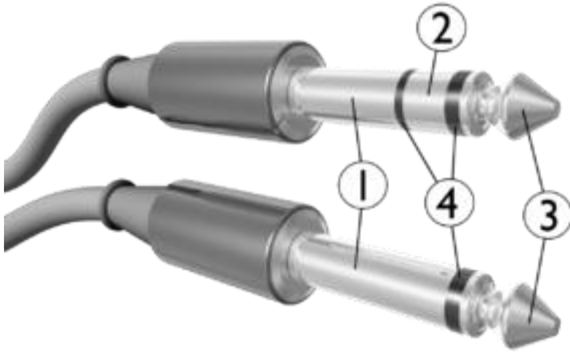
- Standard (no signal, flat line)
- 3 Lead (bipolar)
- Full Lead (bipolar, augmented & chest)

2. Calibration Pulse

- 1 mv
- Square Wave

3. ECG Size or Gain

- Variable control
- ½ X, 1X, 2X, ….
- Increases size of ECG and 1 mv wave



4. External Output to Defib or IABP

- Normally ¼ inch phone jack

5. Sweep or Paper Speed

- Normal 25 mm/sec
- Additional possible:
  - 12.5 mm/sec
  - 50 mm/sec

Sweep Speed (mm/sec) = Heart Rate (Beats/Sec) X Distance (mm)

6. ECG Beep

Audio tone volume can be increased or decreased that generates a beep for each QRS

7. Filter

- Diagnostic (0.05 – 100 Hz)
- Monitor (0.5 – 50 Hz)
- Others filters per manufacturer

8. Inop- Leads Off Alarm

An alarm in the event that the leads come off the patient. Normally ECG signal goes straight line

9. Heart Rate Alarms

- High Alarm Low Alarm

10. Arrhythmia Alarms

The monitor does continuous analysis of the ECG waveform, then alarms, records, and identifies the condition

11. Alarm Types

The monitor may have several alarm sounds and volumes for different patient alarms.

- Asystole & V-fib – Highest Level V-tach, runs – Medium level
- Low/High alarm – Lowest level

12. Alarm Suspend-Silence

A mode to place the monitor in a temporary alarm suspension status

13. Full Disclosure

The monitor records every heart beat and alarms for a predefined period of time (24-48 hours)

14. Trend Analysis

The monitor creates graphs, providing a summary of the heart events

15. Latching or Non-latching Alarms

- Latching – Once alarm is activated, if the patient condition goes back to normal, the alarm will continue to alarm till the caregiver responds and manually resets the alarm

- Non-Latching – Once alarm is activated, if the patient condition goes back to normal, the alarm will automatically reset

Note: Regardless of the latching type, if it has full disclosure, the alarm event and time/date will be recorded.

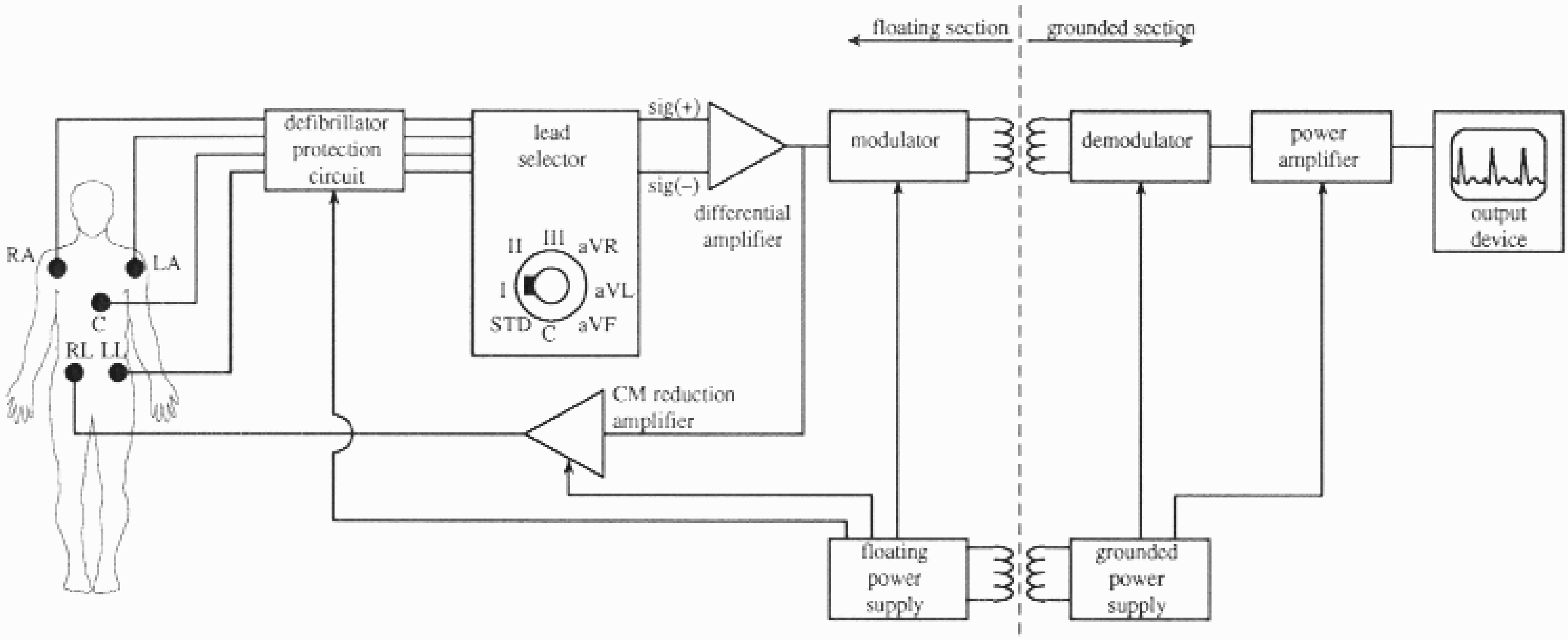
16. Pacemaker Rejection & Count

- The heart rate does not count any pacemaker spikes, only heart activity
- The monitor may have a pacer count feature that can be turned on to count the pacer spikes

ECG "Front End"

- Lead Selector - Wilson Network
- High Voltage Protection
- Differential Amplifier
  - CMRR > 30K
  - Very High Input Impedance (10-20 M ohms)
- Isolated Power Supply
- 1 mv Calibration Pulse

Simplified ECG Block Diagram



Preventive Maintenance Tests

- Paper/Sweep Speed
- Rate Calibration
- Rate Alarms
- Frequency Response (low and high)
- 1mv Calibration
- Electrical Safety
- Pacer Spike Rejection

Blood Pressure

Review Blood Flow Through Heart

- Blood returns to heart through Superior Vena Cava (upper body) and Inferior Vena Cava (lower body)
- Enters Right Atrium (RA)
- Passes through Tricuspid Value
- Enters Right Ventricle (RV)
- Passes through Pulmonary Valve
- Enters Pulmonary Artery and goes to Left and Right Lungs
- Lungs perform respiration

Review Blood Flow Through Heart

- Enters Pulmonary Vein from Left and Right Lungs
- Enters Left Atrium (LA)
- Passes through Mitral Value
- Enters Left Ventricle (LV)
- Passes through Aortic Valve
- Enters Aorta
- Blood supplied to upper & lower body, and coronary arteries back to heart

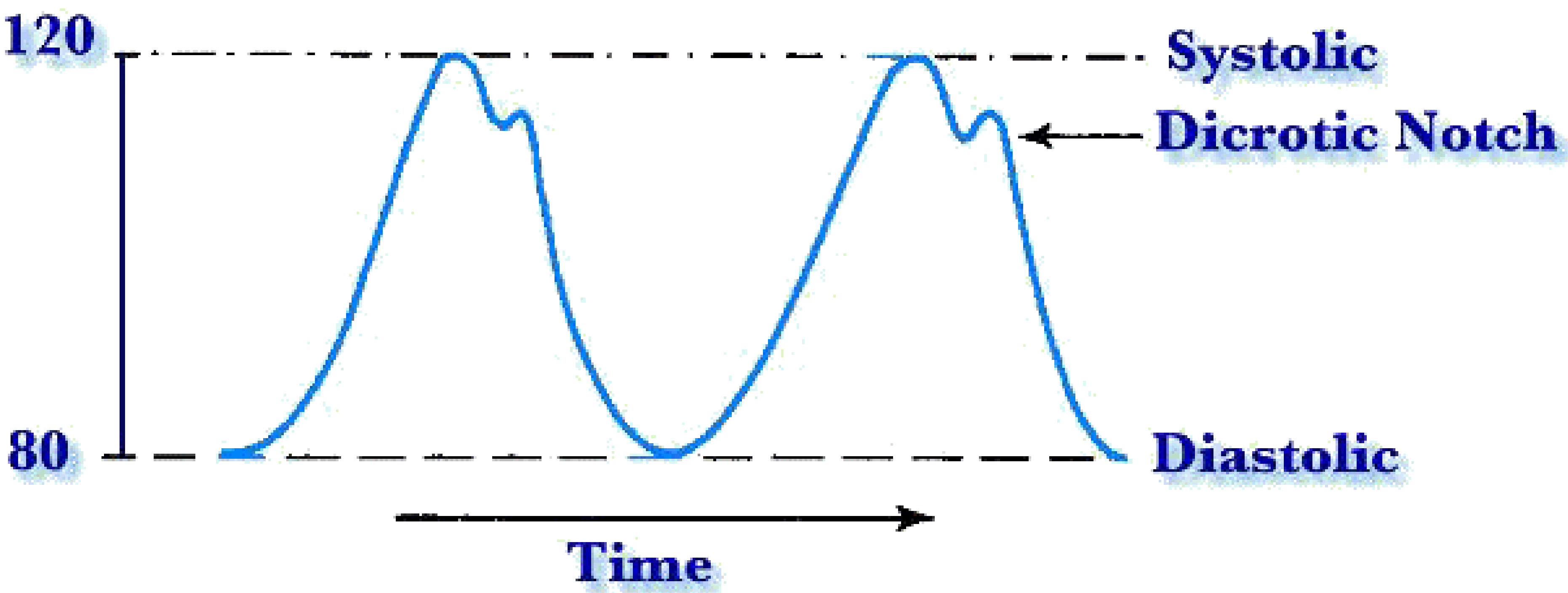
Arteries - Carry blood away from heart. Most all times blood is enriched with oxygen (bright red in color), except for the pulmonary artery, CO_2 enriched

Veins - Carry blood back to the heart. Most all times blood is enriched with carbon dioxide (dark red/blue color), except for pulmonary vein, O_2 enriched

Systolic Pressure - is the Peak pressure during the time that the ventricles are contracting & aortic valve is open

Diastolic Pressure - is the Resting Pressure during the time that the ventricles are re-polarizing & the aortic valve is closed

Dicrotic Notch – A pulse in the arterial blood pressure waveform caused by the closing of the aortic valve



Mean Pressure - is the mean average pressure that the arteries see all of the time.

- *MAP* is considered to be the perfusion pressure seen by organs in the body.
- It is believed that a *MAP* that is greater than 60 mmHg is enough to sustain the organs of the average person.
- If the *MAP* falls significantly below this number for an appreciable time, the end organ will not get enough blood flow, and will become ischemic.

Mean Pressure (MAP) can be approximated by one the following formulas:

MAP(mmhg) = ((S-D)/3) + D

OR

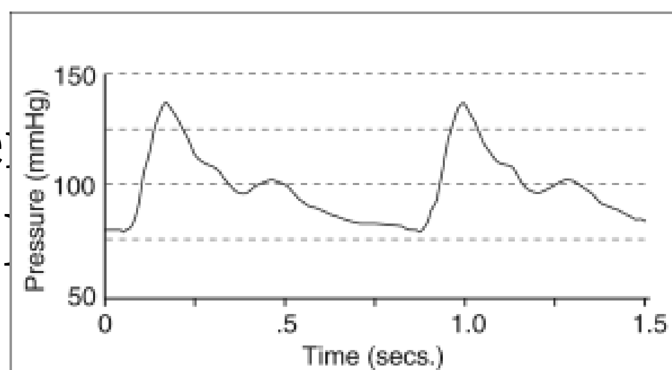
MAP(mmhg) = [(2 x D) + S] / 3

OR

MAP(mmhg) =2/3 D + 1/3 S

Whe … sure (mmhg)

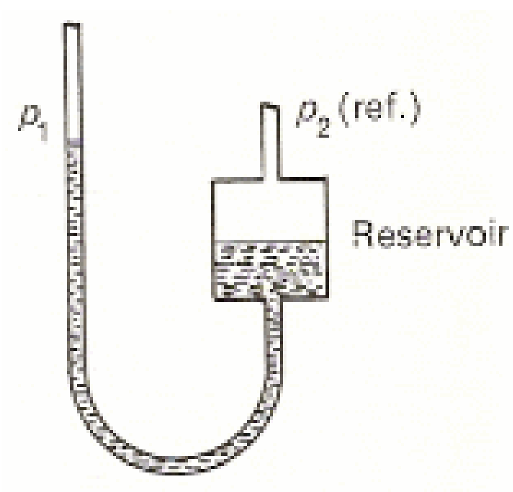
… re (mmhg)



- Pressure = Force / Area

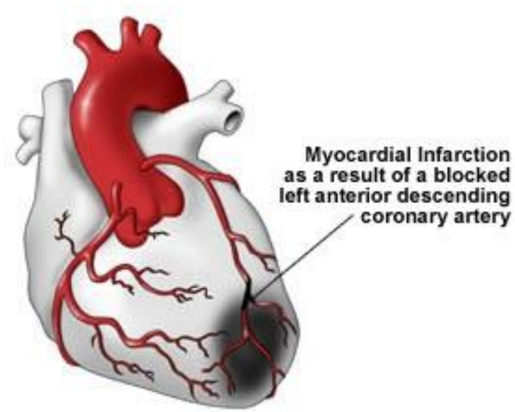
- 1 ATM = 760 mmhg = 14.7 lbs/in2

- Blood Pressure is normally measured in units of mmhg



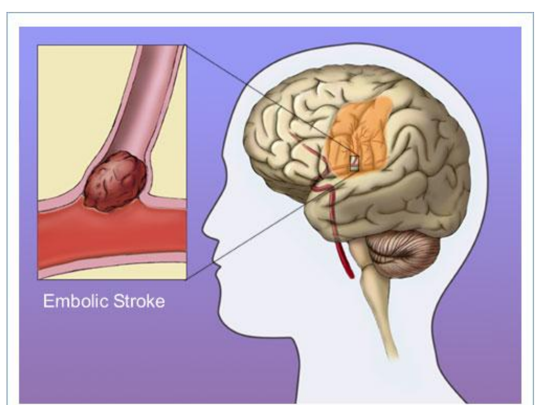
Heart Attack

- Can also be called a coronary or a myocardial Infarction (MI)
- This is when the blood supply from the coronary arteries to the heart muscle is blocked, and the heart muscle or tissue is starved of blood and dies
- Depending on severity, this can cause death, or permanent damage to heart muscle.



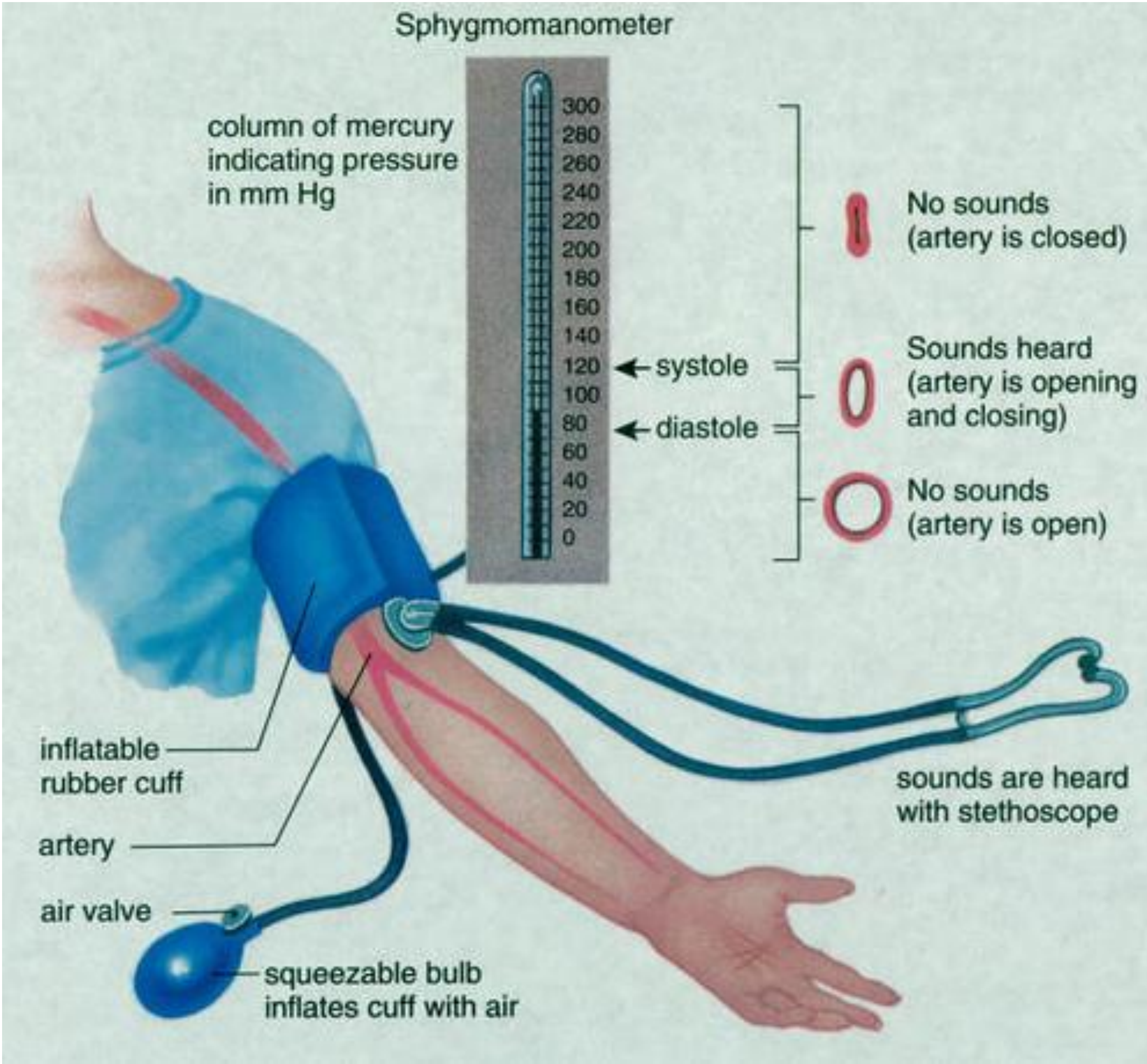
Stroke

- A condition in which the blood supply to the brain is blocked
- The brain cells are then starved for oxygen, and will begin to die within several minutes
- This blockage can occur by deposits formed on the inside of the arteries, and thus reducing the flow, or by an embolism, or blood clot

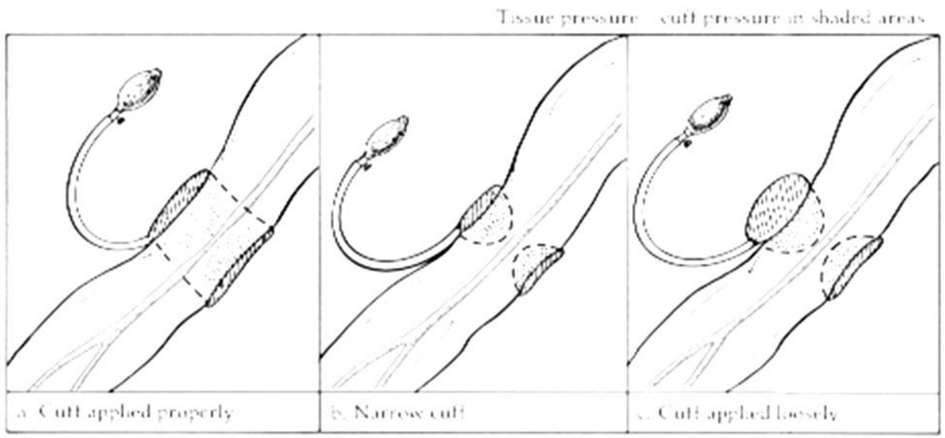


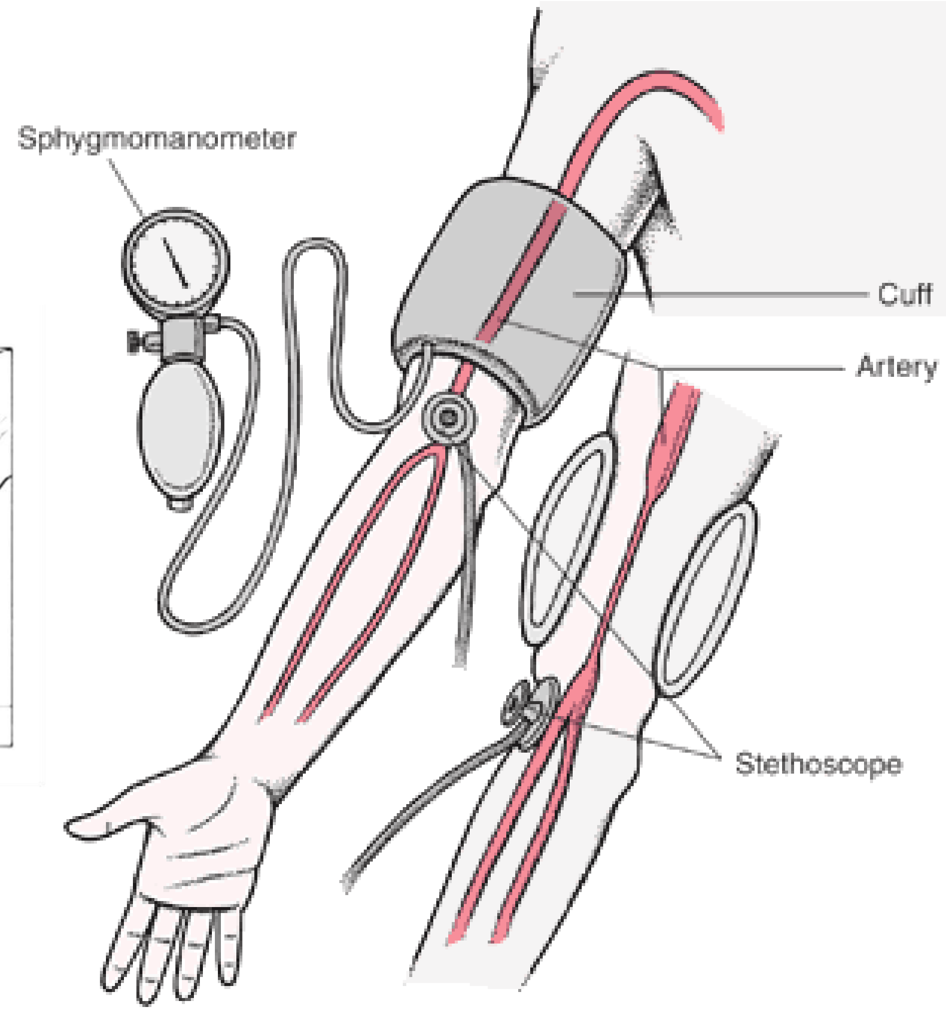
Non-Invasive Measurements (Indirect)

- Sphygmomanometer & Stethoscope
  - Cuff Placed on Arm (Bladder over artery)
  - Pressure increased to stop blood flow
  - Pressure slowly released, observe gauge
  - Blood begins to flow in artery
  - Korotkoff Sounds
    - First sound is systolic pressure
    - Last sound is diastolic pressure

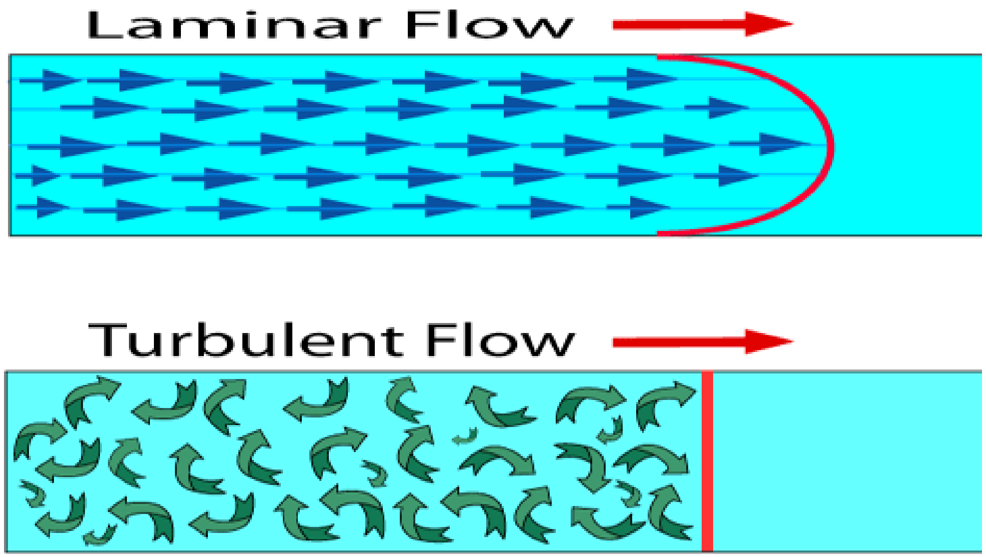

Sphygmomanometer
column of mercury indicating pressure in mm Hg
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
systole
diastole
No sounds (artery is closed)
Sounds heard (artery is opening and closing)
No sounds (artery is open)
inflatable rubber cuff
artery
air valve
squeezable bulb inflates cuff with air
sounds are heard with stethoscope

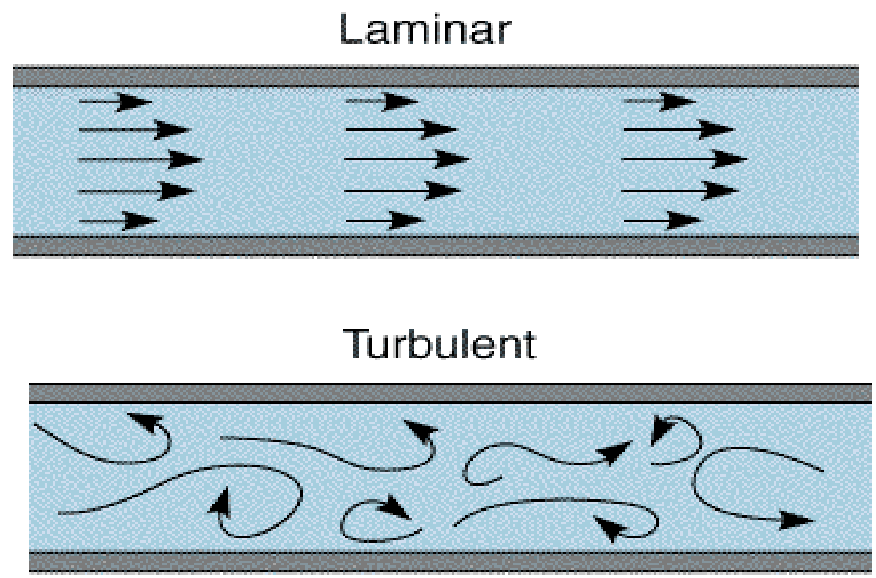
CBET REVIEW – MEDICAL EQUIPMENT FUNCTION & OPERATION





Laminar & Turbulent Flows



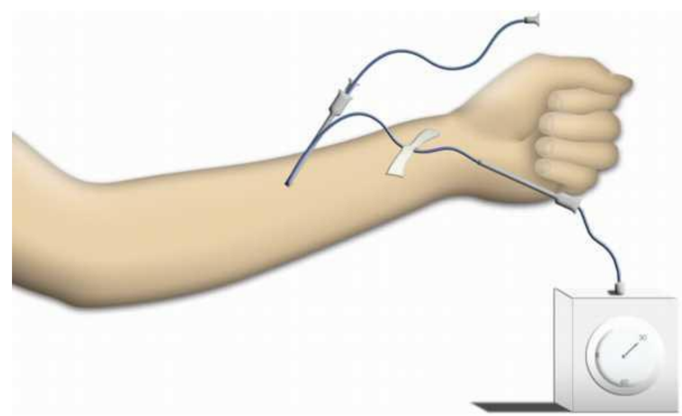


- Non-Invasive Measurements (Indirect)
  - Automatic Unit (Auscultatory Units)
    - This is an automatic or manual BP monitor. A cuff is placed on the patients arm, it pressurizes the cuff, measures and displays the BP. To get the Kortokoff sounds, a microphone is located in the cuff, and the BP unit listens for the blood sounds. Location of the microphone over the artery is critical for accurate measurements.

- Non-Invasive Measurements (Indirect)
  - Automatic Unit (Oscillometric Units)
    - This is an automatic or manual BP monitor. A cuff is placed on the patients arm, it pressurizes the cuff, measures and displays the BP. To get the S/D readings, the unit looks at the incremental change in pressure. When the pressure is lower than the systolic, the pressure in the cuff will slight increase with each heart beat. This will continue until the diastolic pressure is reached.

Invasive Measurements (Direct)

- Here a catheter must be inserted into the patients artery or vein, is coupled by fluid in a tubing to a pressure transducer, the transducer converts the pressure to an electrical signal, and the monitor displays the BP waveform/readings. This is the most accurate method of blood pressure measurement.

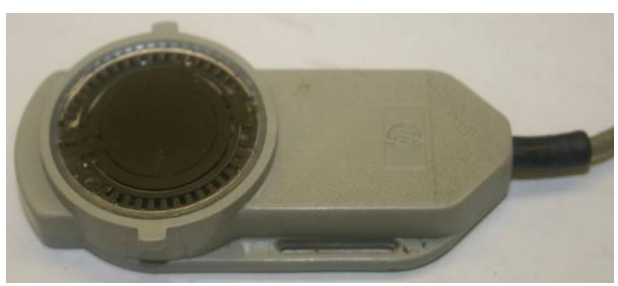


Invasive Measurements (Direct)

- Strain Gauge Pressure Transducer
  - Uses a small wire placed on a surface so that when pressure is exerted on the surface, the wire length changes, thus proportionally changing the resistance of the wire. A bridge circuit is used to detect change in resistance.
  - Transducer is sensitive to temperature changes and scratches on it's surface
  - Sensitivity = 5uv/v/mmhg

Invasive Measurements (Direct)

- Quartz Pressure Transducer
  - A quartz crystal is used so that when pressure is exerted on the surface, the frequency of the crystal proportionally changes. An electronic circuit is used to detect change in frequency, and display readings
  - Transducer is Not sensitive to temperature changes and scratches on it's surface
  - Sensitivity = 40uv/v/mmhg



Invasive Measurements (Direct)

- Disposable Pressure Transducer
  - A small drop of silicone material is used so that when pressure is exerted on the surface, the gain of the silicon proportionally changes. An electronic circuit is used to detect change, and display readings
  - Transducer is Not sensitive to temperature changes and scratches on it's surface
  - Used only one time on patient
  - Sensitivity = 5uv/v/mmhg

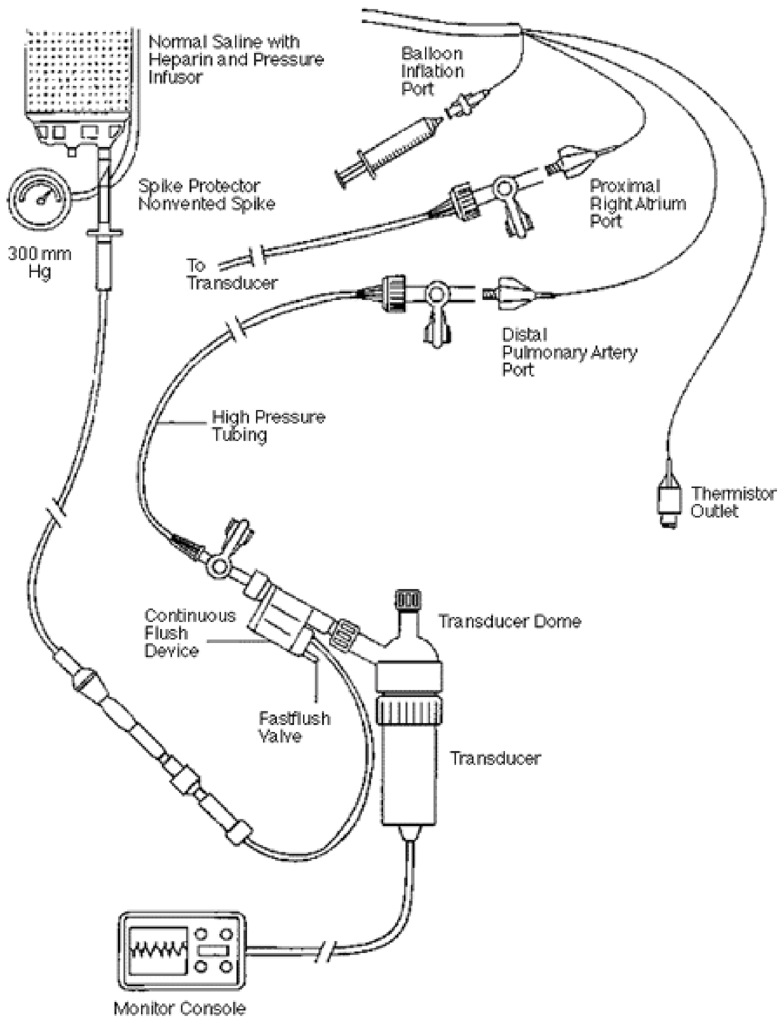
Transducer Output

- To calculate the output of the pressure transducer, multiply the sensitivity times the applied DC voltage times the pressure

- Example:
- Sensitivity = 5uv/v/mmhg
- DC Power Supply= 12 V
- Pressure = 120 mmhg
- Calculate output Voltage =
  - 5uV x 12 V x 120 mmhg = 7.2 mV

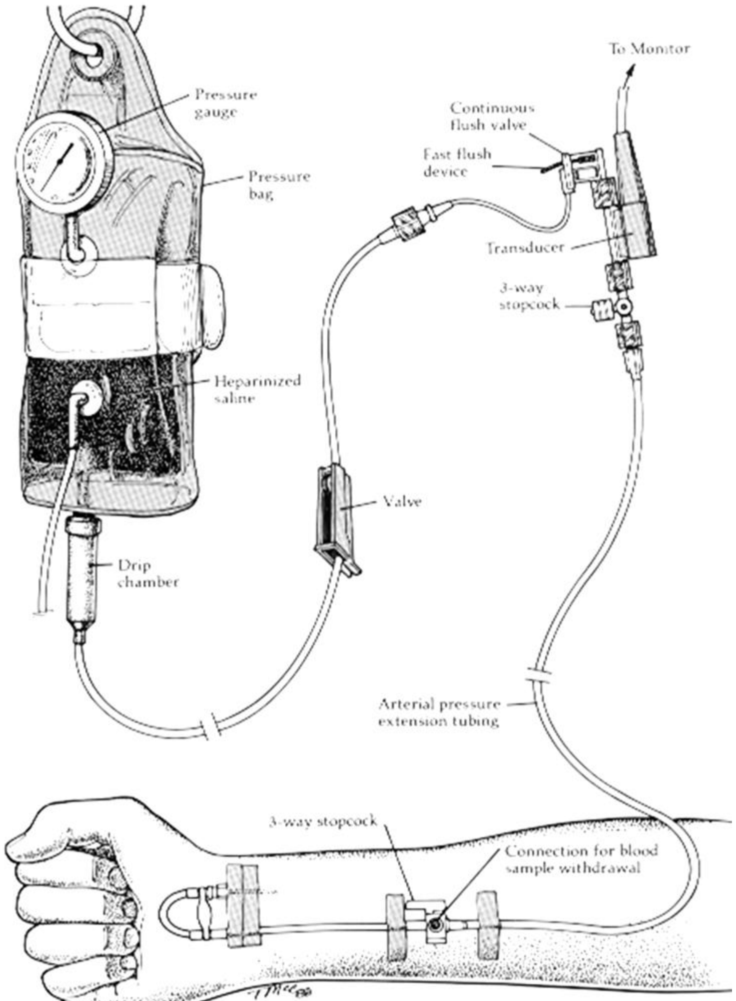
Invasive Measurements (Direct)

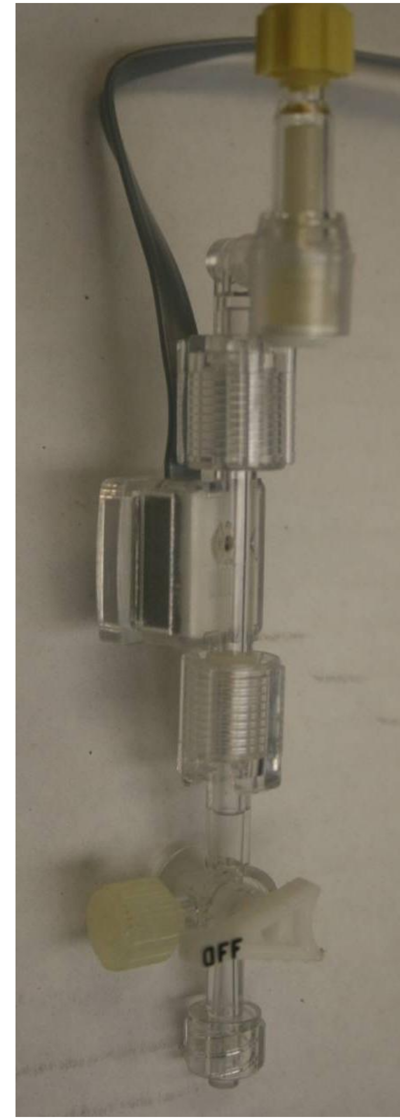
- Intravenous Tubing (IV) Sets



Invasive Measurements (Direct)

- Intravenous Tubing (IV) Sets

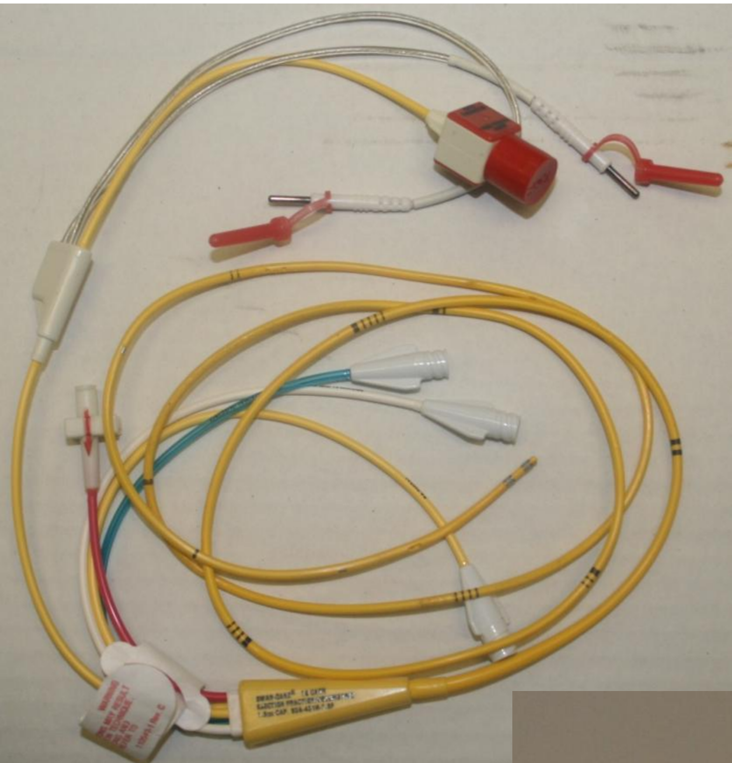


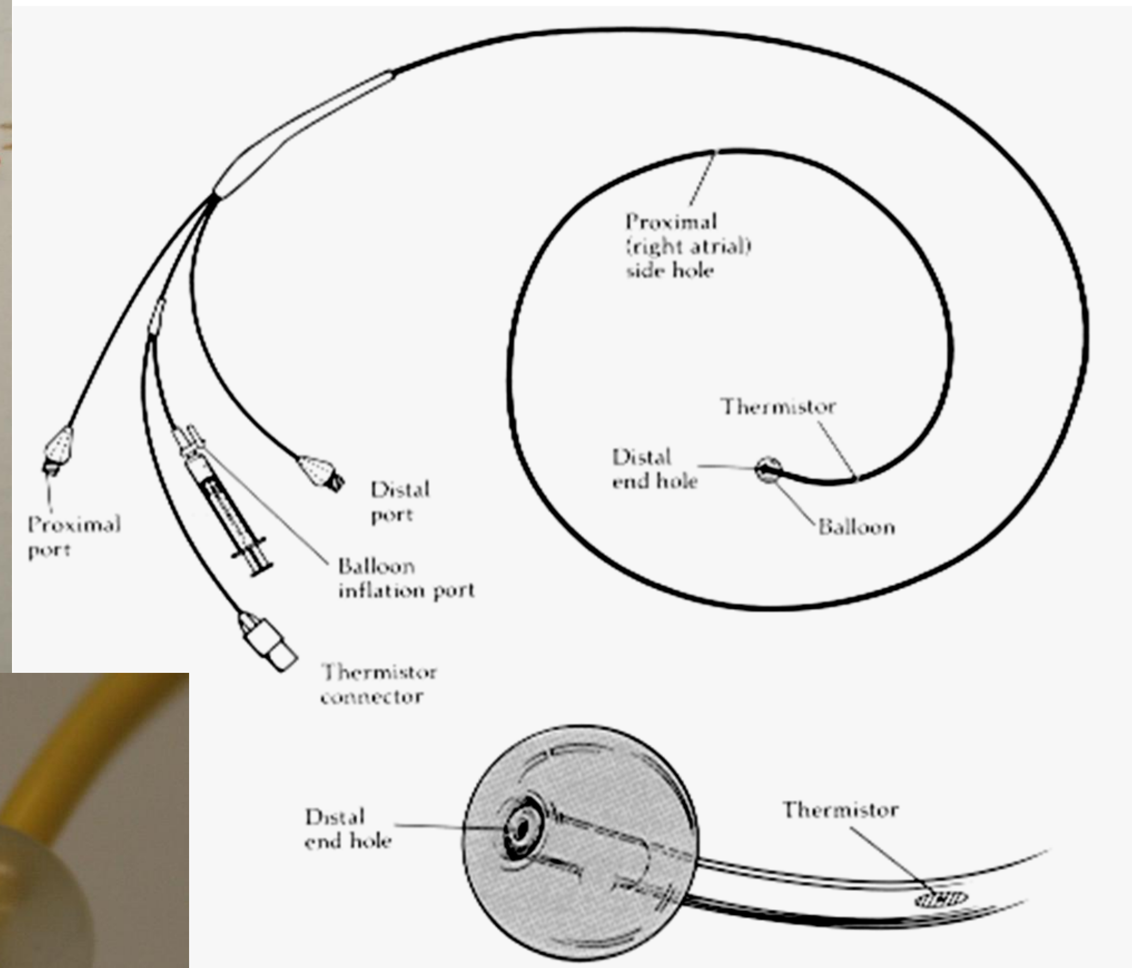


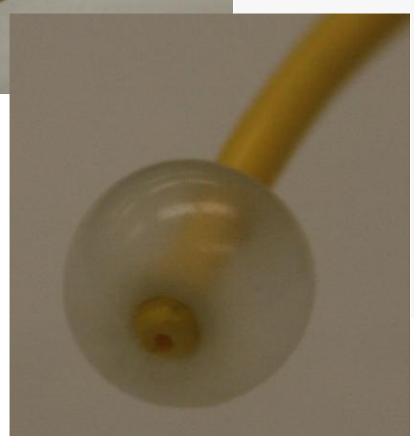
Swan-Ganz Catheter or Pulmonary Artery Catheterization (PAC)

- The pulmonary artery catheter allows direct, simultaneous measurement of pressures in the
  - right atrium
  - right ventricle
  - pulmonary artery
  - filling pressure ("wedge" pressure) of the left atrium.
- The pulmonary artery catheter is frequently referred to as a Swan-Ganz catheter, in honor of its inventors Jeremy Swan and William Ganz
- Despite the widespread use of their names for the flow-directed balloon-tipped PA catheter, neither the physicians nor the original manufacturer could obtain a patent

Swan-Ganz Catheter







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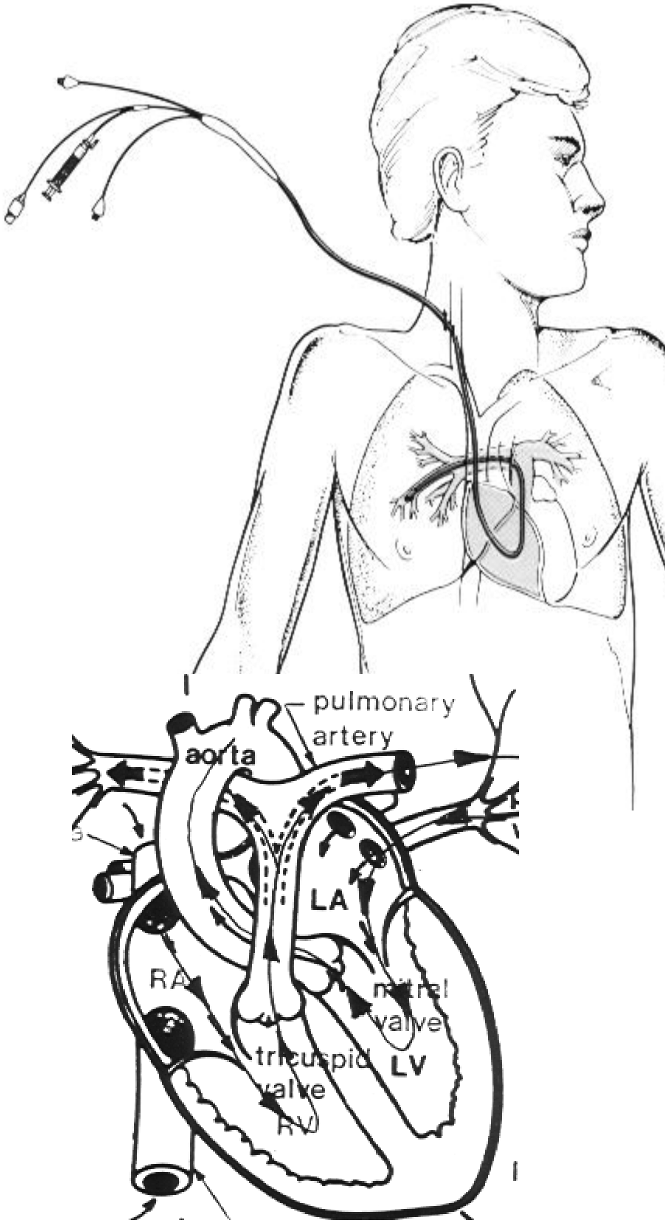
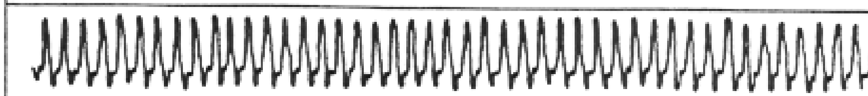
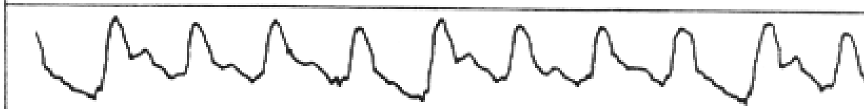


P.A. PATTERNS

PA WAVE	PRESSURE INTERPRETATION	NORMAL PRESSURE	SIGNIFICANCE OF INCREASED PRESSURE
Right atrium	Mean right atrial (RA) filling pressure (diastolic) and right ventricular end diastolic pressure (RVEDP)	1 to 6 mmHg	Volume overload, tricuspid stenosis or regurgitation, pulmonary hypertension



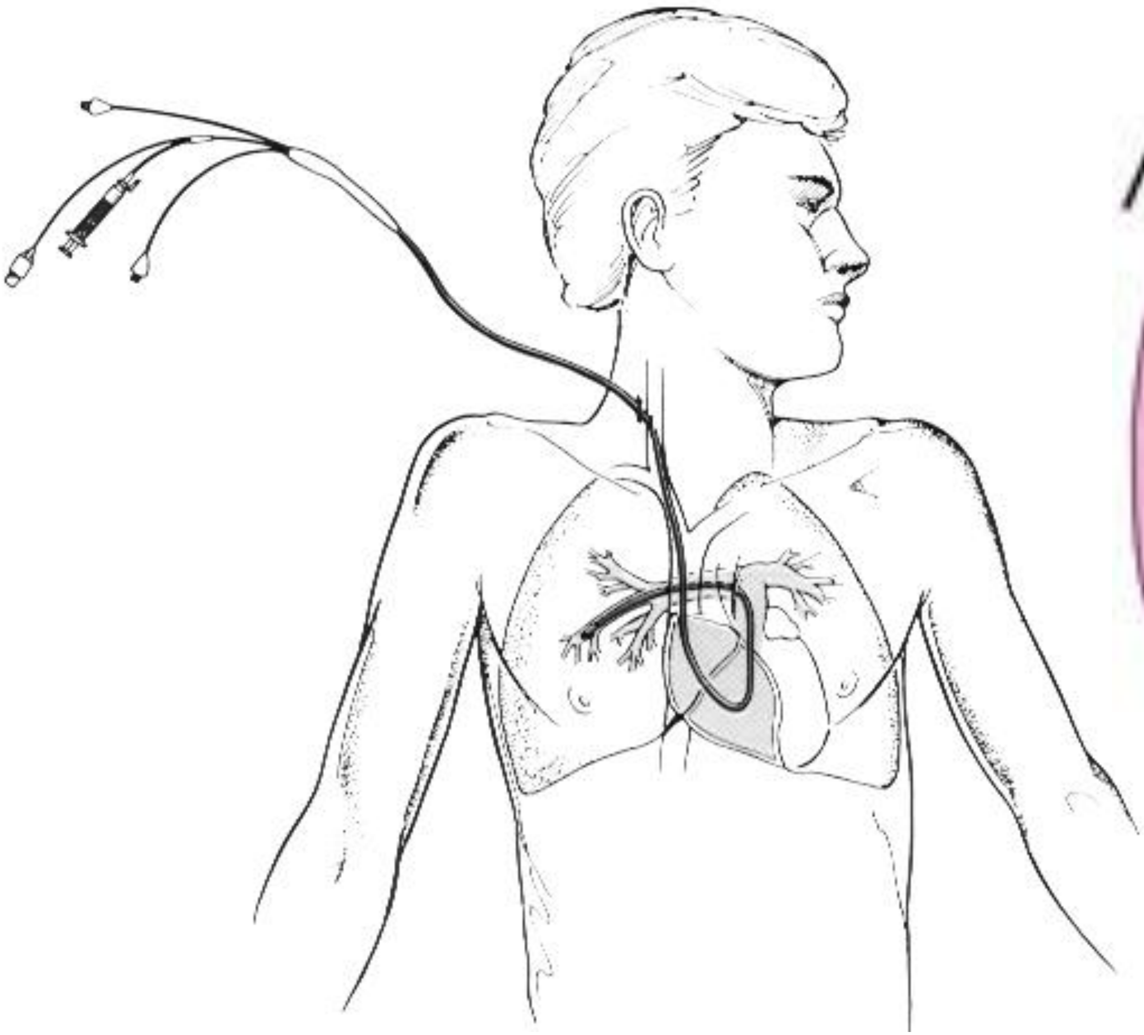
PA WAVE	PRESSURE INTERPRETATION	NORMAL PRESSURE	SIGNIFICANCE OF INCREASED PRESSURE
Right ventricular	Right ventricular pressure (RV)	20 to 30 mmHg systolic, 0 to 5 mmHg diastolic	Mitral stenosis or mitral insufficiency, pulmonary disease, hypoxemia, constrictive pericarditis

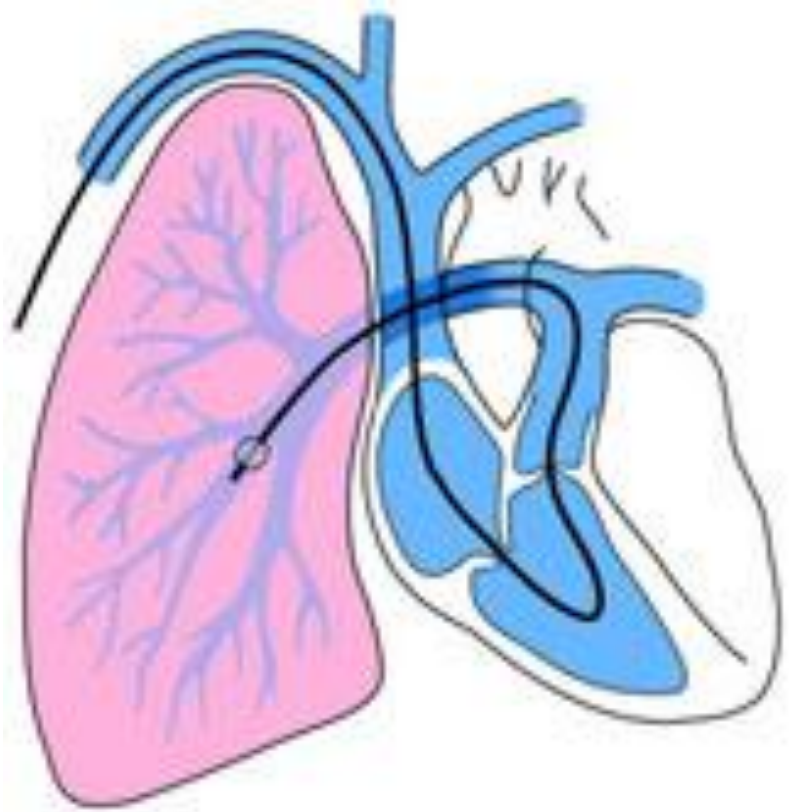


PA WAVE	PRESSURE INTERPRETATION	NORMAL PRESSURE	SIGNIFICANCE OF INCREASED PRESSURE
Pulmonary artery	Venous lung pressure, mean filling pressure of the left atrium (LA), left ventricle (LV), and right ventricle (RV). Pulmonary artery systolic pressure equals RV filling pressure. Pulmonary artery end diastolic pressure reflects left ventricular end diastolic pressure (LVEDP)	20 to 30 mmHg systolic, 8 to 12 mmHg diastolic	Left ventricular failure, atrial septal defect or ventricular septal defect, pulmonary hypertension or stenosis, mitral stenosis

PA WAVE	PRESSURE INTERPRETATION	NORMAL PRESSURE	SIGNIFICANCE OF INCREASED PRESSURE
Pulmonary wedge	Pulmonary artery end diastolic pressure. Good index of left ventricular heart function	8 to 12 mmHg	Left ventricular failure, mitral stenosis or insufficiency

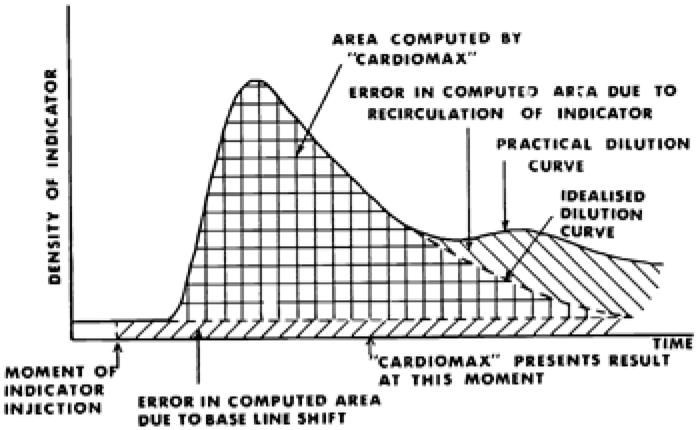
Swan-Ganz Catheter

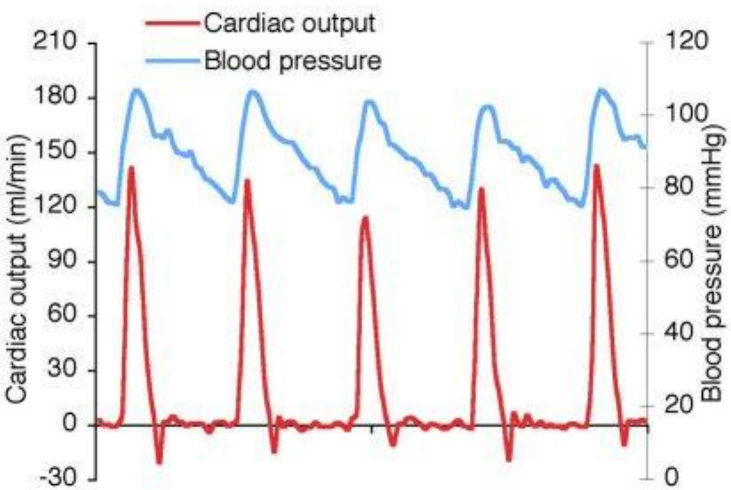




Cardiac Output Measurement

- Cardiac output is the measurement of how much blood is being pumped by the heart per some unit of time (L/min).
- CO = Heart Rate(Beat/Min) X Stroke Volume (L/Beat)
- Normal adult male approximately 5 L/Min





Cardiac Output Measurement

- Stroke Volume (SV) = EDV – ESV (70-120 ml)
- Ejection Fraction (EF) = (SV / EDV) × 100%
- Cardiac Output (CO or Q) = SV × HR
- Cardiac Index (CI) = Q / Body Surface Area (BSA)
- Cardiac Index (CI) = SV × HR/BSA

  EDV – End Diastolic Volume (LV max blood capacity)

  ESV – End Systolic Volume (LV min blood capacity)

  SV – Stroke Volume (Volume of blood per heart beat)

  HR - Heart Rate (Beats Per Minute)

  BSA - Body Surface Area (square meters)
- Cardiac Output (CO) Normal Range
  - 5 - 8 L/min
  - 4 - 8 L/min for hemodialysis patients

Cardiac Index Measurement

- Cardiac Index takes the Cardiac Output measurement and places it on a scale that is meaningful for the patients size
- The patients surface area is approximated by knowing the weight and height
- The patient's weight and height are entered into the physiological monitor at the time of admission and are then used for estimating the Body Surface Area, needed for the CI calculation
- Manual calculation can be performed by using a hand held scale (slide ruler) or calculator if desired

Cardiac Index Measurement

- Cardiac Index (CI) Normal Range is 2.5 - 4.2 L/min/meter2
- A Cardiac Output value is dependent on body size; in general, the larger the person the greater the cardiac output (more liters of blood per minute)
- To account for the changes in cardiac output that occur in patients with different body size, cardiac output is divided by body surface area (units are square meters)
- Body surface area is automatically calculated by the software from the values entered for height and weight of the patient

Pulse Oximeters

Probe

- Applied to finger, toe, or ear lobe
- Uses 2 different wavelengths of light
  - 660 nm (red) – oxy-hemoglobin
  - 930 nm (infrared) – deoxy-hemoglobin
- Photo-detector converts light transmitted light into electrical signal back to microprocessor

Pulse Oximeter Monitor

- 95 – 98% - healthy saturation levels
- 85 – 90% - respiratory failure
  - (a) provide appropriate airway and supplemental oxygen
  - (b) monitor carefully for further changes
- < 90% - inadequate amounts of oxygen will reach body cells
  - (a) positive pressure ventilations
  - (b) high flow oxygen administration

Problems

- Motion at sensor location
- Inadequate signal, which can occur under conditions of low blood flow (poor perfusion).
- Spot checks should not be used as a basis for clinical guidelines or treatment determination
- Interferences from environment:
  - ESUs
  - Fluorescent Lights
  - Surgical Lights
  - Radiant Warmers
  - Bilirublin Lights
  - Sunlight
  - Ambient Light Changes

Problems

- Burns with incompatible probes
- Burns from use during MRI studies
- Can not detect CO poisoning (older units)
- Nail polish
- Intravenous dyes
- Anemia
- Heavily pigmented skin

Defibrillators

3 Types of Modern DC Defibrillators

1. Implantable Cardioverter Defibrillators (ICDs)
2. Automated, External Defibrillators (AEDs)
3. Defibrillator, External (Professional)

Two Waveform Types

1. Monophasic
2. Biphasic

Two Operating Modes

1. Defibrillation
2. Cardio Version (Synchronized)

Defibrillator, External (Professional)

- High DC voltage to 5KV (from capacitor)
- Energy Discharge 0-360 watt-sec or joules
- Various Output Waveforms (2.5 to 5.0 ms)
- Must be a licensed professional to use
- Two Operating Modes
  - Defibrillation
  - Cardio Version (Synchronized)

Patient Paddles (External, Adult)

- 3 - 4 inches in diameter to reduce burns
- Apex Paddle - Left side of abdomen (-)
- Sternum Paddle - Center of chest (+)
- 25 lbs of force to reduce resistance
- Depress discharge buttons on both paddles at same time to discharge energy
- Conductive gel to decrease resistance and prevent burns
- ECG signal pick-up for quick view

Patient Paddles (External, Pediatric)

- 2 - 3 inches in diameter for smaller patients
- Apex Paddle - Left side of abdomen (-)
- Sternum Paddle - Center of chest (+)
- Small force applied to paddles to prevent injury
- Depress discharge buttons on both paddles at same time to discharge energy
- Conductive gel to decrease resistance and prevent burns
- May be a sub assembly of adult paddles

Defibrillate Mode

- ECG signal is evaluated by physician
- Based upon condition, the energy is discharged to patient without regard to heart signal
- Start at smaller energy setting, work to higher
- Children/Infants much lower energy (1 watt/pound) and smaller paddle pressure
- Discharge - evaluate, Drug - evaluate. Repeat
- Clear area for discharge, all muscles contract

Cardioversion Mode

- ECG signal is evaluated by physician
- Based upon condition, the energy is discharged to patient by synchronizing output energy with ECG R wave signal (within 30-60 ms {manufacturer specification} of R wave detection)
- Stay away from T wave (repolarization)
- Start at smaller energy setting, work to higher
- Patient maybe conscious or sedated
- Non-life threatening, elective procedure

Output Waveforms

- Monophasic
  - Truncated Exponential
  - Trapezoidal
  - Tapered Delay
  - Monopulse
  - Damped Sinusoidal or Lown
- Biphasic
- Under Development
  - Triphasic and Quadaphasic

CBET Review – Medical Equipment Function & Operation

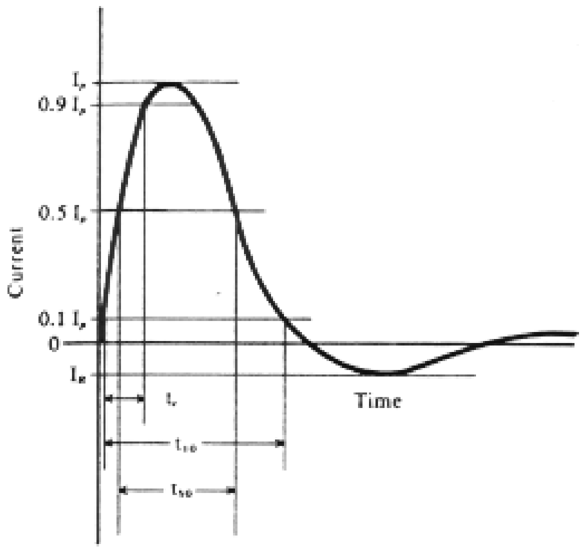


Figure 1. Damped sinusoidal waveform parameters.

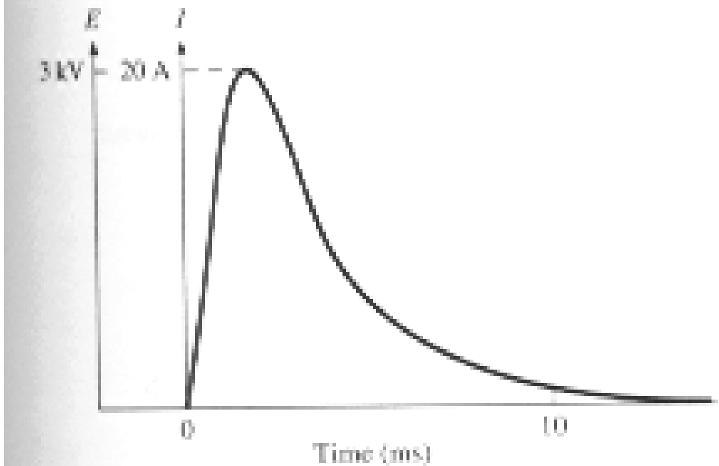


Figure 9-44
Monopulse defibrillator waveform.

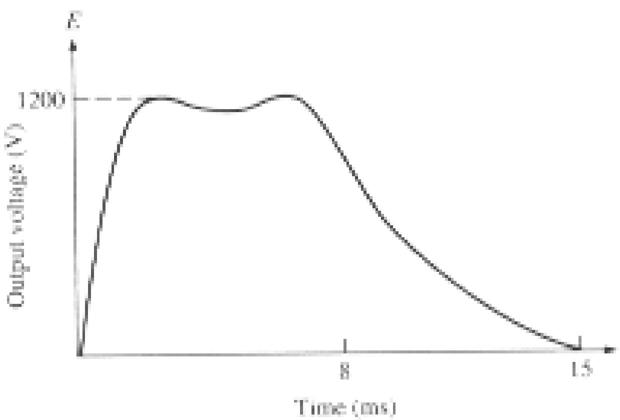


Figure 9-45
Tapered dc delay defibrillator waveform.

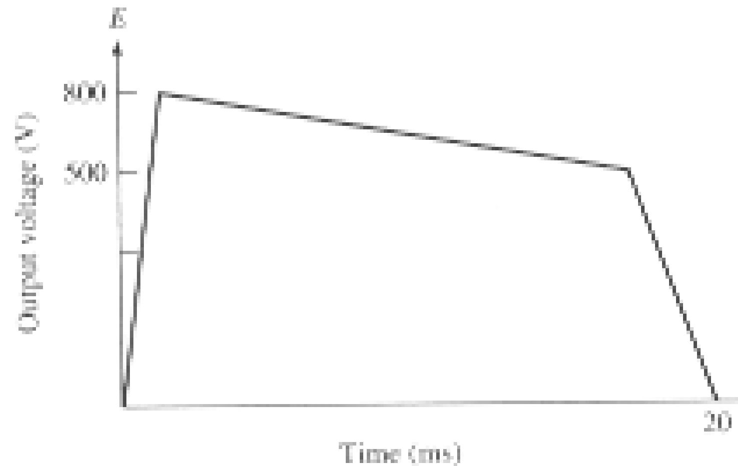
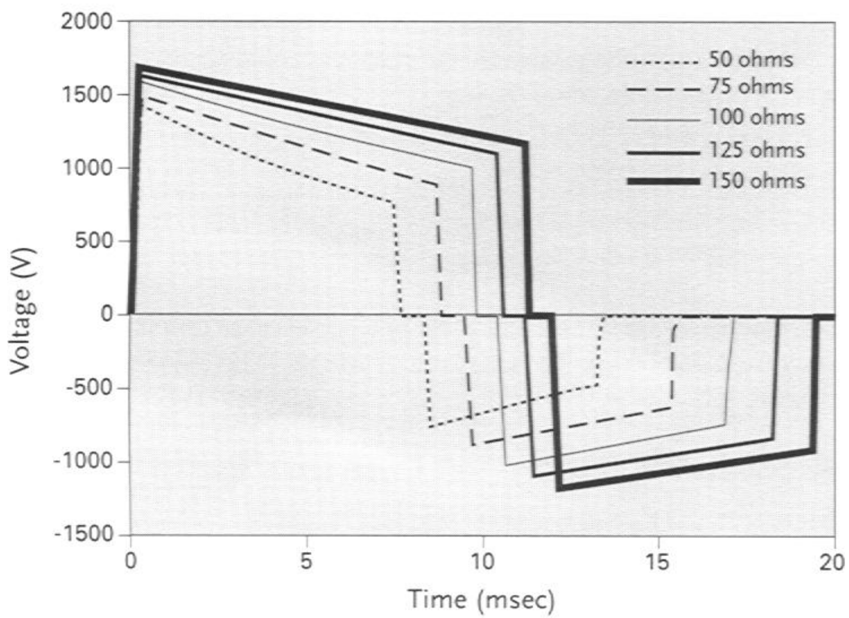


Figure 9-46
Trapezoidal defibrillator waveform.

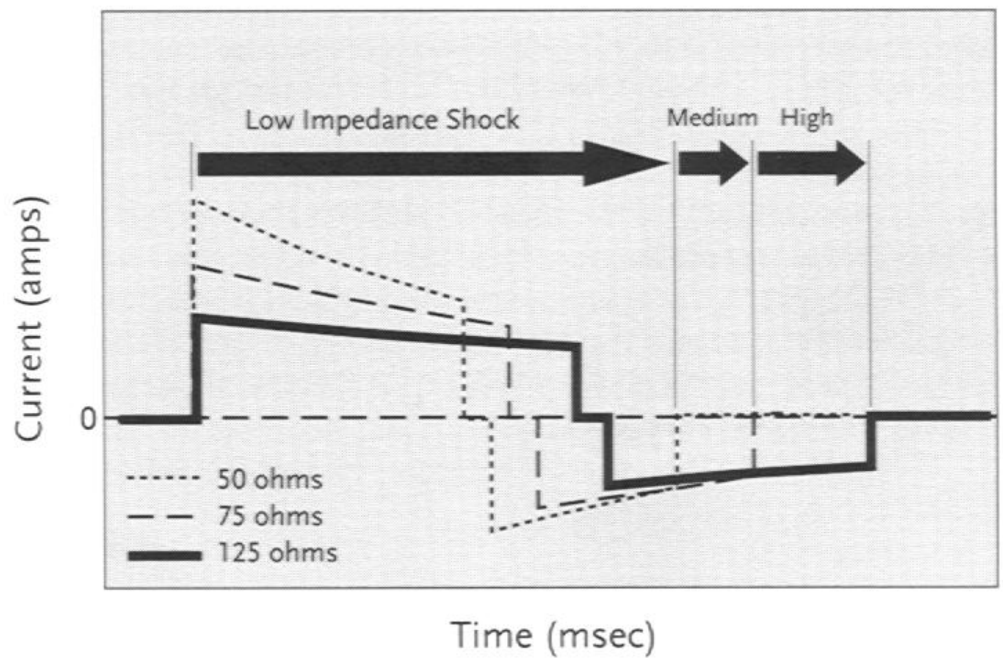
Biphasic

VOLTAGE COMPENSATION



Voltage Waveforms for 200J Shocks

CURRENT DURATION ADJUSTMENT



Biphasic waveform duration adjusts for impedance

Patient Impedance

- 50 Ohms

Lest Load

- 50 Ohms (pure resistive)
- Never test open or short circuit

Output Energy(Q) = $0.5 \times C \times V^2$

Storage Capacitor 30uf @ 5KV

Preventive Maintenance Tests

- Output Energy Accuracy (15%)
- Charge Time to Max Energy (< 15 Sec)
- Synchronizer Operation (< 30 msec)
- Energy after 60 seconds (< 15%)
- Paddle Continuity (< 0.5 ohms)
- Internal Paddle Limit (< 50 J)
- ECG Tests
- Electrical Safety Tests

Pacemakers

Pacemaker

- Used to control arrhythmias (irregular heart rhythms) by applying a repetitive electrical stimuli to the heart.
- Patients with MI, blocks, or slow ECG rhythms
- Can be used as a temporary or permanently installed device

Pacemaker

1. External, Non-Invasive
   - Temporary Use (< 24 hours)
   - AC/Battery Powered with ECG display
   - Adhesive electrodes are placed on patients chest and back to pass current
   - Asynchronous Mode
   - Demand Mode
   - Higher Output Currents (100s ma)

Pacemaker

2. External, Invasive
   - Temporary Use (< 5 days)
   - Battery Powered (9 volt)
   - Catheter/Lead Wire from Heart to Pacemaker
   - Asynchronous Mode
   - Demand Mode
   - A/V Sequential Pacing
   - Sensing
   - Waveform Output

Pacemaker

2. External, Invasive

- 2 Button Operation
  - Prevents accidental change of settings
- Asynchronous Mode (fixed rate)
  - Fixed output regardless of cardiac activity
  - Often used to initially connect or test pacer
  - Sometimes used if heart is unlikely to revert to normal sinus rhythm during operation
- Demand Mode
  - Senses heart signal, output is based upon min. rate setting and cardiac activity

Pacemaker

2. External, Invasive

- A/V Sequential Pacing
  - This is a 2 or 3 channel pacemaker
    - Channel 1 – Right Atrium
    - Channel 2 – Right Ventricle
    - Channel 3 – Left Ventricle
  - The pacemaker is set to deliver impulses to each channel based upon sensing of the hearts electrical activity, time from Atrium to Ventricle and minimum heart rate settings for that channel

Pacemaker

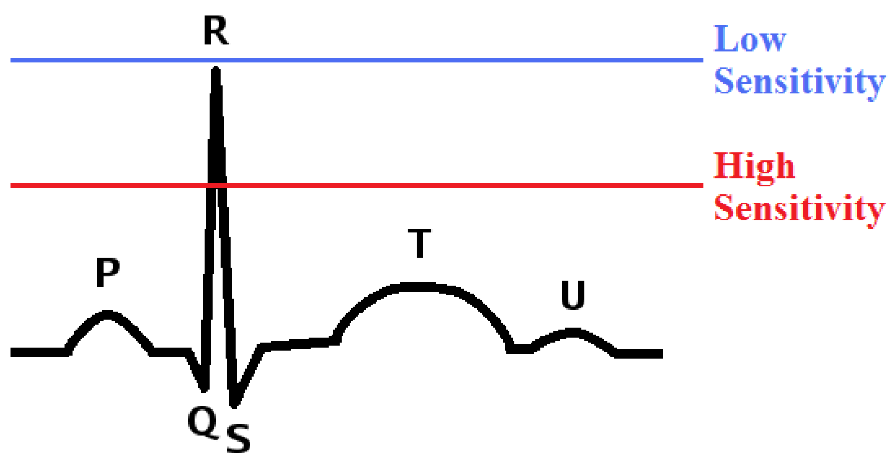
2. External, Invasive

- Sensing
  - Is a mode in which the pacemaker is detecting the heart's normal electrical activity (QRS)
  - If the pacemaker senses the heart, the pacemaker will be inhibited, and no pulse will be generated
  - If the pacemaker does not sense the heart, the pacemaker will output a pulse to the heart

Pacemaker

2. External, Invasive

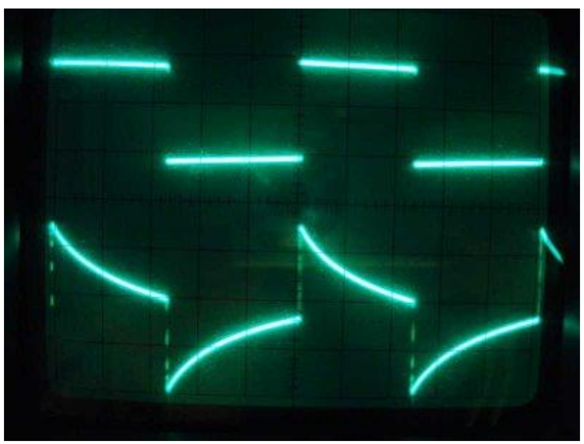
- Sensing
  - Increasing (High) sensitivity - decreases the voltage level detector setting so that smaller heart QRS signals can be detected
  - Decreasing (Low) sensitivity - increases the voltage level detector setting so that larger heart QRS signals must be detected



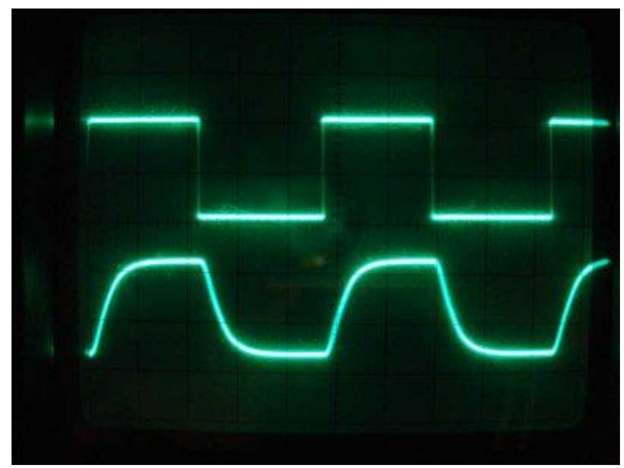
Pacemaker

2. External, Invasive

- Output Waveform
  - Square (No under or over-shoot)
  - Pulse Width (0.5 - 2.0 m sec)



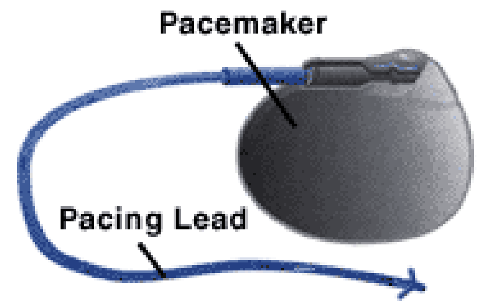
Over-shoot



Under-shoot

Pacemaker

3. Internal, Non-Programmable
   - Implanted in patient
   - Batteries determine life of unit (lithium and nuclear - plutonium)
   - Fixed output rate, current, and sensitivity
   - Lead wire from pacer to heart
   - Developed battery units in late 50's
   - Units are phased out



Pacemaker

4 .Internal, Multi-Programmable

- Implanted in patient
- Batteries determine life of unit (lithium)
- Variable output rate, current, and sensitivity
- Can be reprogrammed from ultrasound transmitter/receiver placed over patients chest
- Lead wire from pacer to heart
- Patient parameters input to pacer for decision making and output changes

Pacemaker

4 .Internal, Multi-Programmable

Rate Modulated Pacing

The pacemaker senses one or more of the following body functions then makes changes to the pacing rate

- body motion
- blood temperature
- respiration rate
- blood ph
- blood PO_2
- PCO_2
- Intra-cardiac pressure
- Intra-cardiac volume

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

- NBG code, stands for the *NASPE (North* American Society of Pacing and Electrophysiology)/*BPEG (British Pacing and Electrophysiology Group*) *Generic Code, is commonly used to identify* pacing modes.

- This coding system was originally devised by the Inter-Society Commission for Heart Disease Resources and was formerly known as the ICHD code.

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

- The NBG code consists of letters in five positions (e.g., DDDRO).
- Each position represents a particular function or characteristic of the pacemaker. Positions I through III, which are used exclusively to describe antibradyarrhythmia function, are frequently used alone (e.g., VVI).
- In each position, a variety of letters can appear, each with a particular meaning. For each position, we list the letters that can be used and the function or characteristic they designate.

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

Position I: Chamber(s) Being Paced

V — Ventricle

A — Atrium

D — Dual chamber (ventricle and atrium)

S — Single chamber (ventricle or atrium — manufacturer designation only)

O — None

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

Position II: Chamber(s) Being Sensed

V — Ventricle

A — Atrium

D — Dual chamber (ventricle and atrium)

S — Single chamber (ventricle or atrium — manufacturer designation only)

O — None

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

Position III: Response to Sensing

T — Triggered

I — Inhibited

D — Dual (triggered and inhibited)

O — None

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

Position IV: Programmability; Presence or Absence of Rate Modulation

P — Simple programmable (rate and/or output)

M — Multiprogrammable

C — Communicating

R — Rate modulation

O — None

Pacemaker

4 .Internal, Multi-Programmable

Pacing Modes

Position V: Antitachyarrhythmia Function(s)

P — Pacing (antitachyarrhythmia)

S — Shock

D — Dual (pacing and shock)

O — None

Pacemaker

4 .Internal, Multi-Programmable Pacing Modes

- Single-chamber ventricular inhibited pacing (i.e., VVI) is commonly applied using either implantable or external invasive pacemakers.
- The most commonly used dual-chamber pacing mode is DDD. This mode allows pacing and sensing in both the atrium and the ventricle.
- Rate-responsive pacemakers are typically used in the VVIR or DDDR mode.
- (Reference: ECRI "**Pacing Modes and the NBG Code,**" https://members2.ecri.org/Components/HdJournal/Articles/ecri-hd199607-p226-nbg.pdf)

Pacemaker

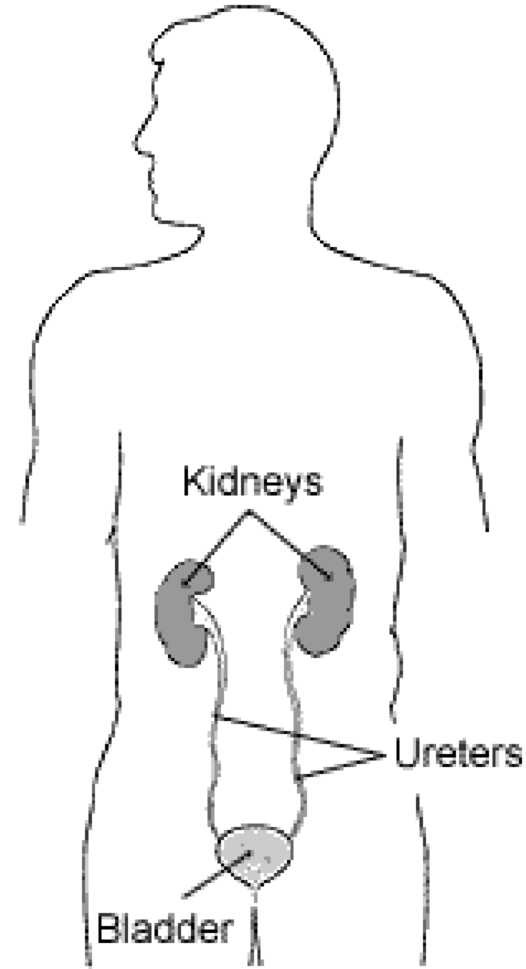
Preventive Maintenance Tests

- Rate (BPM)
- Pulse Width (0.5 - 2.0 m sec) and shape (square)
- Current Amplitude (0 - 20 ma)
  - 100 ohms @ 5 ma
  - 500 ohms @ 1 ma
  - 500 ohms @ 5 ma
  - 500 ohms @ 10 ma
  - 1000 ohms @ 5 ma

Dialysis Equipment

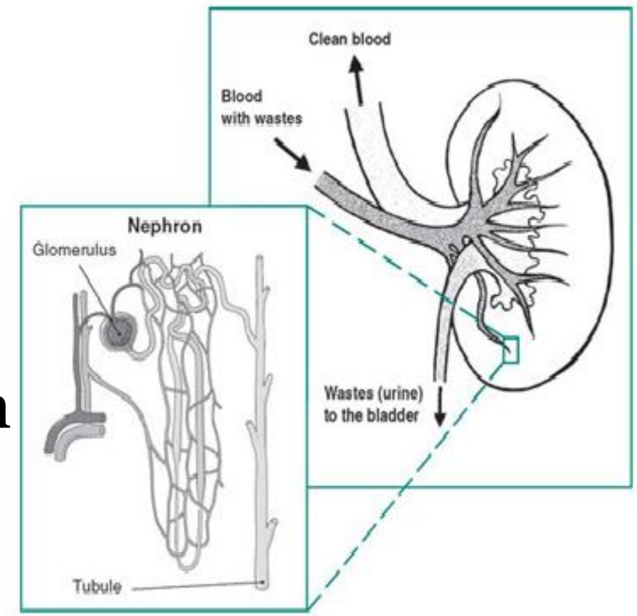
Kidney Function

- Your two kidneys are vital organs that perform many functions to keep your blood clean and chemically balanced.
- Every day, your kidneys process about 200 quarts of blood to sift out about 2 quarts of waste products and extra water.
- The kidneys maintain the body's fluid, electrolyte, and acid/base balance
- The waste and extra water become urine which flows to your bladder through tubes called ureters.



Kidney Function

- The actual filtering occurs in tiny units inside your kidneys called nephrons.
- Every kidney has about a million nephrons. In the nephron, a glomerulus—which is a tiny blood vessel, or capillary—intertwines with a tiny urine-collecting tube called a tubule.
- A complicated chemical exchange takes place, as waste materials and water leave your blood and enter your urinary system.



In the nephron (left), tiny blood vessels intertwine with urine-collecting tubes. Each kidney contains about 1 million nephrons.

Renal Function

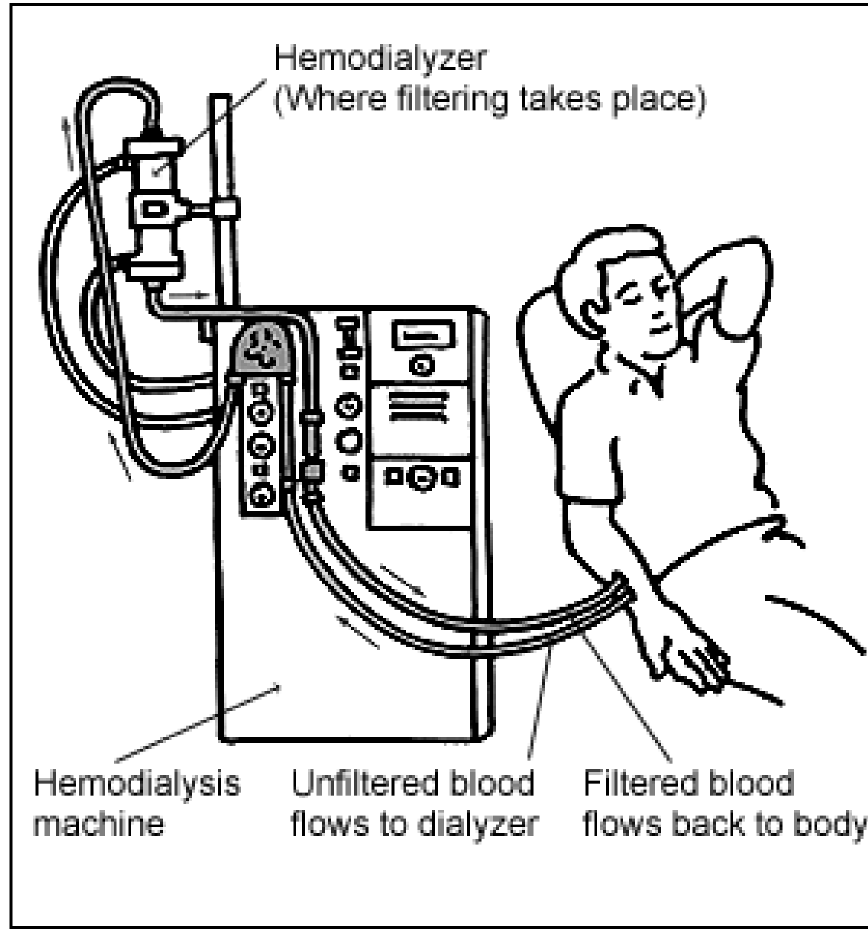
- If you have two healthy kidneys, you have 100 percent of your renal function. This is more renal function than you really need.
- Some people are born with only one kidney and some donate a kidney for transplantation. Small declines in renal function may not cause a problem.
- People with reduced renal function have a kidney disease that will get worse. You will have serious health problems if you have less than 25 percent of your renal function. If your renal function drops below 10 to 15 percent, you cannot live long without some form of renal replacement therapy—either dialysis or transplantation.

Kidneys Failure

- Most kidney diseases attack the nephrons, causing them to lose their filtering capacity.
- Damage to the nephrons may happen quickly, often as the result of injury or poisoning.
- Most kidney diseases destroy the nephrons slowly and silently. Only after years or even decades will the damage become apparent. Most kidney diseases attack both kidneys simultaneously.
- Impaired kidney function causes the body to retain metabolic wastes and water
- The two most common causes of kidney disease are:
  - Diabetes
  - High blood pressure

Hemodialysis

- In hemodialysis, your blood is sent through a filter that removes waste products. The clean blood is returned to your body. Hemodialysis is usually performed at a dialysis center three times per week for 3 to 4 hours.



Hemodialysis

Hemodialysis

- Hemodialysis therapy removes metabolic wastes and water, as well as ions and organic salts, from the bloodstream
- It does not restore renal function or promote healing of the kidneys
- There are three major components, the:
  - Dialysate delivery system
  - Extracorporeal blood-delivery circuit
  - Dialyzer
- Blood is taken via the extracorporeal circuit, passed through a dialyzer for solute and fluid removal, and returned to the patient. Each system has its own monitoring and control circuits

Hemodialysis

- Blood is taken via the extracorporeal circuit, passed through a dialyzer for solute and fluid removal, and returned to the patient. Each system has its own monitoring and control circuits

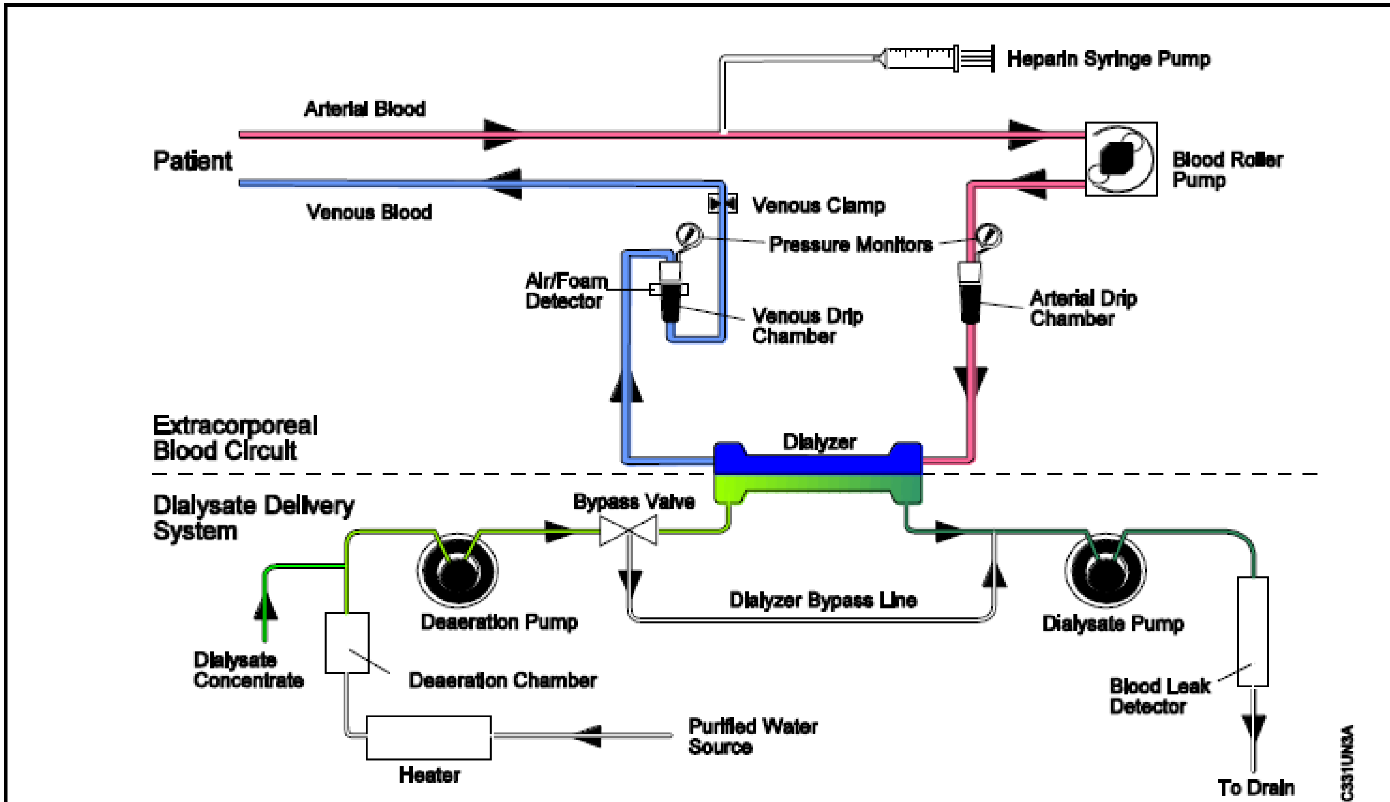
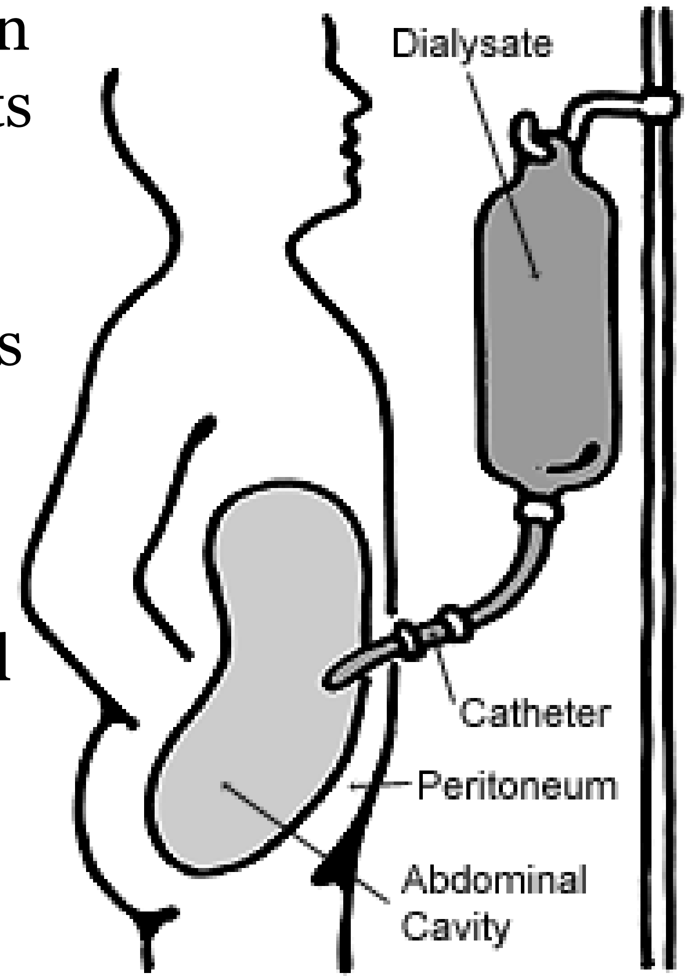


Figure 1. Components of a typical hemodialysis unit.

Peritoneal Dialysis

- A fluid is put into your abdomen that captures the waste products from your blood.
- After a few hours, the fluid containing your body's wastes is drained away. A fresh bag of fluid is dripped into the abdomen.
- Patients can perform peritoneal dialysis themselves.



Peritoneal Dialysis

- Patients using continuous ambulatory peritoneal dialysis (CAPD) change fluid four times a day.

- Another form of peritoneal dialysis, called continuous cycling peritoneal dialysis (CCPD), can be performed at night with a machine that drains and refills the abdomen automatically.

Peritoneal Dialysis

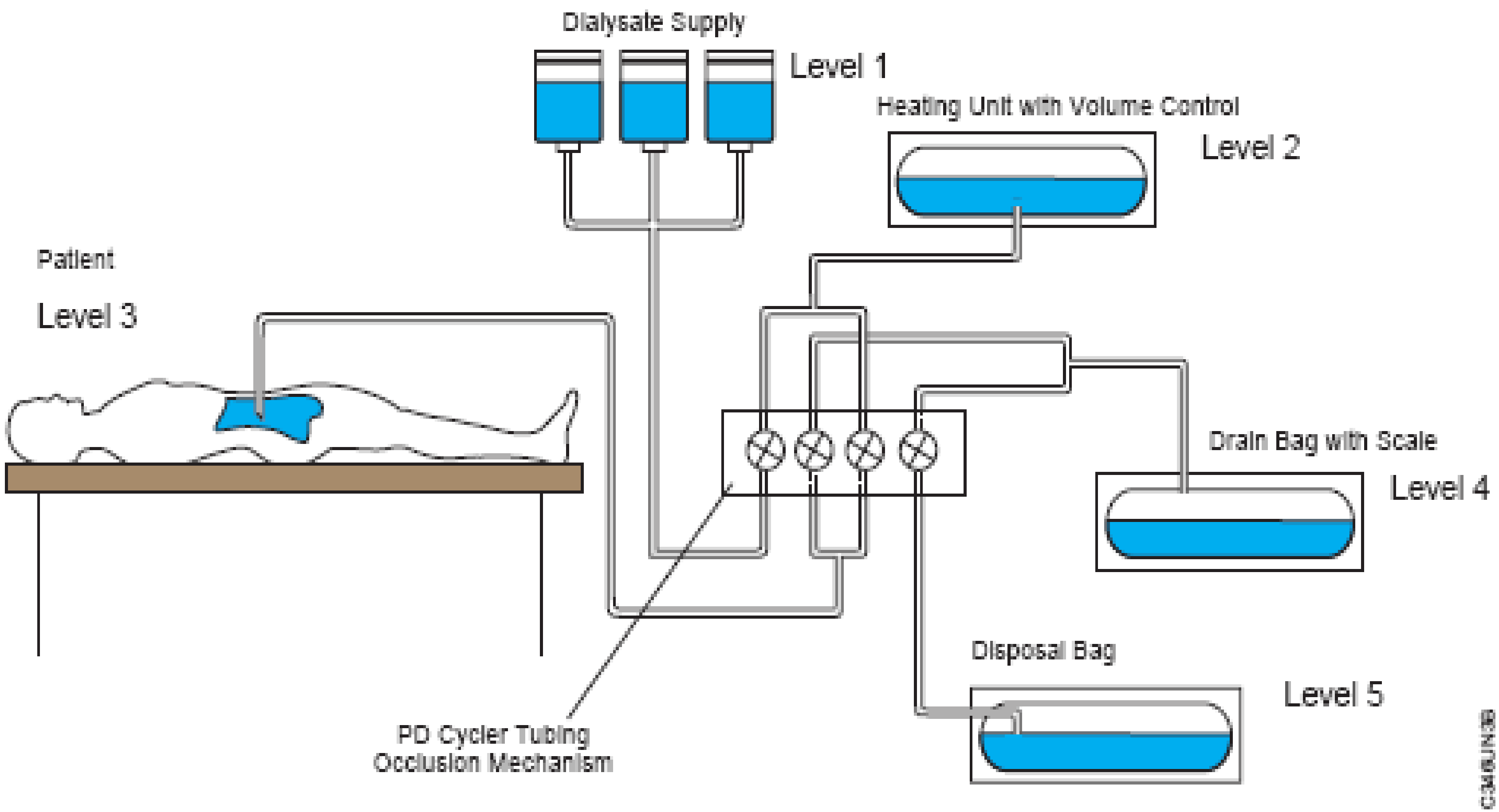


Figure 3. Automated PD showing the various hydrostatic pressure levels that allow fluid movement

Electrosurgical Units

- Active Electrode (Hand piece)
  - The electrode where the power is dissipated to the tissue on the patient/ It has a high current density.
- Blend
  - A cut waveform with intermittent bursts of coagulation to achieve cutting and coagulation at the same time.
- Desiccate
  - A form of coagulation in which dehydration and necrosis of the tissue occurs. The active electrode must be in good contact with the tissue.
- Dispersive or Return Electrode
  - The electrode in which current is returned back to the ESU and no cutting effect is desired. Large surface area with low current density

- Duty Cycle
  - The portion of time (%) in which the ESU current is turned on verses one complete cycle time. ESUs range from 25% to 100%.
- Electrocautery Unit
  - The searing or destruction of tissue by the direct use of heat delivered to the tissue. Electrical current does not pass through the tissue, but rather the electrode.
- Electrosurgery
  - The generation and delivery of RF energy from an active electrode to the patient, to achieve dehydration of the tissue.
- Current Density
  - The amount of current flowing across a given area, expressed in amps per square meter.
- Fulgurate
  - The process of coagulating tissue by using an ESU. Here the active electrode is not in contact with the tissue to stop the bleeding.

- Homeostasis
  - The desired effect to tissue to stop bleeding of cut vessels.
- Monoploar Output
  - The traditional mode of an ESU which uses an active and return electrodes for energy delivery to the patients tissue.
- Bipolar Output
  - A mode in which the active and return electrodes are on the same instrument. Used at low power, delicate procedures.
- Return Electrode Monitor (REM)
  - A circuit that measures the impedance of the return electrode and if its is greater than approximately 30 ohms, an alarm activates and the ESU will not operate.
- Return Fault Monitor
  - A circuit that measures the RF current leaving and returning from the ESU. If all of the current leaving does not return, the alarm activates, and the ESU will not operate.

Argon-Enhanced Electrosurgery

- Argon-enhanced electrosurgery incorporates a stream of argon gas to improve the surgical effectiveness of the electrosurgical current.
- Argon gas is inert and noncombustible, making it a safe medium through which to pass electrosurgical current.
  - Inert — Noncombustible
  - Easily ionized by RF energy — Creates bridge between electrode and tissue
  - Heavier than air — Displaces nitrogen and oxygen
- There are many advantages to argon-enhanced electrosurgical cutting and coagulation.
  - Decreased smoke, odor
  - Decreased blood loss & rebleeding
  - Flexible eschar
  - Noncontact in coagulation mode
  - Decreased tissue damage

Surgical Smoke

- Surgical smoke is created when tissue is heated and cellular fluid is vaporized by the thermal action of an energy source.
- Surgical plume is created from a lasers.
- Research studies have confirmed that this smoke & plume can contain toxic gases and vapors such as benzene, hydrogen cyanide, and formaldehyde, bioaerosols, dead and live cellular material (including blood fragments), and viruses.

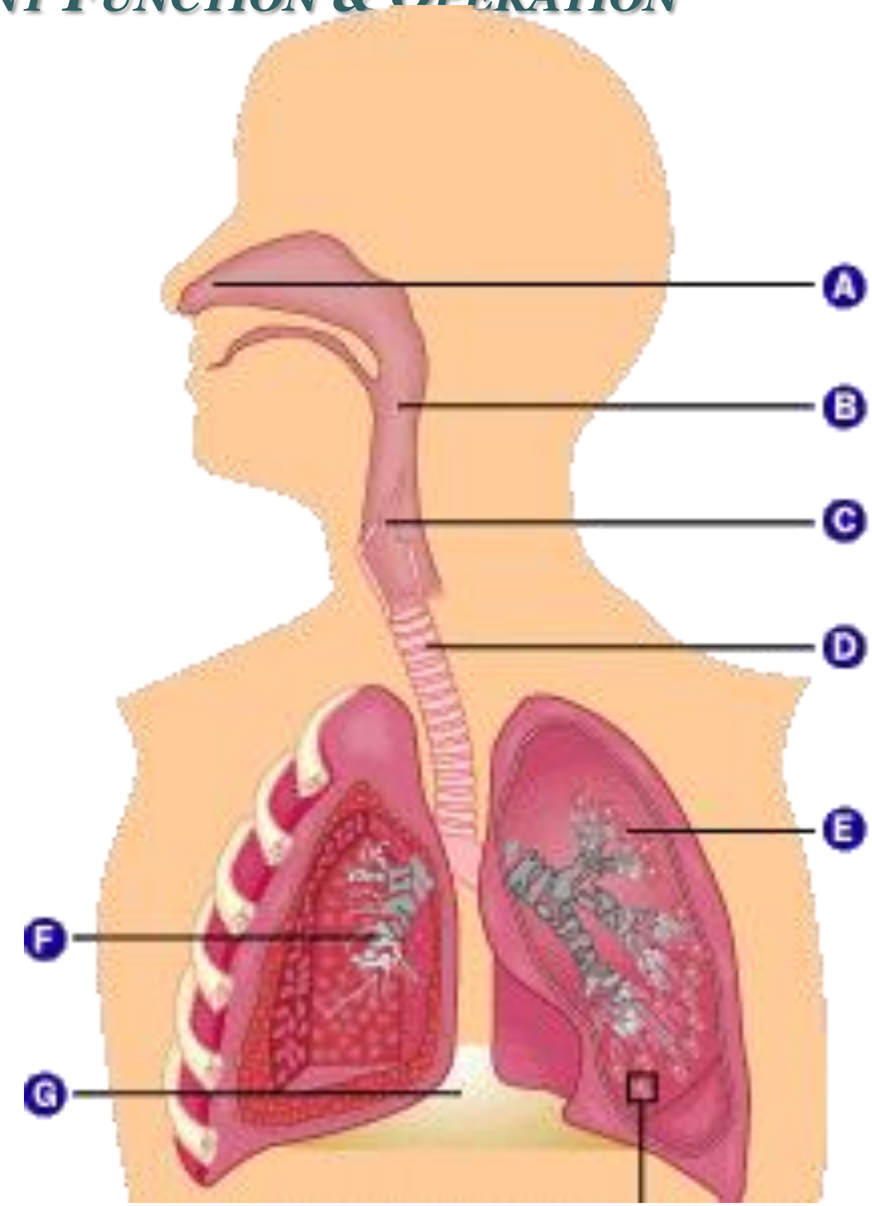
Patient Impedance (Ohms)

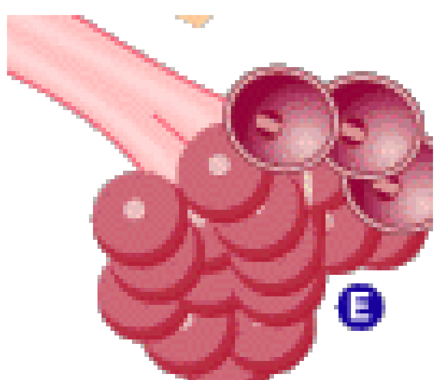
- Total opposition (resistance, inductance, and capacitance) that the ESU current passes through.
- A normal range for an ESU is 100 - 1000 ohms, with an average of 300 ohms (used for calibration).

Ventilators

Anatomy of Lung

A. Nasal Cavity
B. Pharynx
C. Larynx
D. Trachea
E. Alveoli
F. Bronchial Tree
G. Diaphragm





Anatomy of the Lung

- **Alveolus** - tiny, thin-walled air sac at the end of the bronchiole branches where gas exchange occurs (plural - alveoli).
- **Bronchioles** - numerous small tubes that branch from each bronchus into the lungs. They get smaller and smaller.
- **Bronchus** - a branch of the trachea that goes from the trachea into the lung (plural - bronchi)
- **Diaphragm** - muscle at the base of the chest cavity that contracts and relaxes during breathing
- **Epiglottis** - a flap of tissue that closes over the trachea when you swallow so that food does not enter your airway

Anatomy of the Lung

- **Intercostal Muscles** - muscles along the rib cage that assist in breathing
- **Larynx** - voice box where the vocal cords are located.
- **Nasal Cavity** - chamber in from the nose where air is moistened and warmed
- **Pleural Membranes** - thin, membranes that cover the lungs, separate them from other organs and form a fluid-filled chest cavity.
- **Pulmonary Capillaries** - small blood vessels that surround each alveolus
- **Trachea** -rigid tube that connects the mouth with the bronchi (windpipe)

Physiology of the Lung

- As you breathe air in through your nose or mouth, it goes past the epiglottis and into the trachea
- It continues down the trachea through your vocal cords in the larynx until it reaches the bronchi
- In the bronchi, air passes into each lung
- The air then follows narrower and narrower bronchioles into it reaches the alveoli
- Within each air sac, the oxygen concentration is high, so oxygen passes or diffuses across the alveolar membrane into the pulmonary capillary
- At the beginning of the pulmonary capillary, the hemoglobin in the red blood cells has carbon dioxide bound to it and very little oxygen

Physiology of the Lung

- Oxygen binds to hemoglobin and the carbon dioxide is released
- Carbon dioxide is also released from sodium bicarbonate dissolved in the blood of the pulmonary capillary
- The concentration of carbon dioxide is high in the pulmonary capillary, so carbon dioxide leaves the blood and passes across the alveolar membrane into the air sac
- This exchange of gases occurs rapidly (fractions of a second)
- The carbon dioxide then leaves the alveolus when you exhale and the oxygen-enriched blood returns to the heart

Physiology of the Lung

- Respiration rate is 15 to 25 times per minute
- When you inhale, the diaphragm and intercostal muscles contract and expand the chest cavity
- This expansion lowers the pressure in the chest cavity below the outside air pressure
- Air then flows in through the airways and inflates the lungs
- When you exhale, the diaphragm and intercostal muscles relax and the chest cavity gets smaller
- The decrease in volume of the cavity increases the pressure in the chest cavity above the outside air pressure
- Air from the lungs (high pressure) then flows out of the airways to the outside air (low pressure)

Diseases/Conditions Influencing Ventilation

- **Asthma:** The bronchioles constrict, reducing the size of the airways. This cuts down on the flow of air and makes the respiratory muscles work harder.
- **Emphysema:** The lungs become stiff with fibers and become less elastic, which increases the work of the respiratory muscles.
- **Bronchitis:** The airways become inflamed and narrower, which restricts the flow of air and increases the work of the respiratory muscles
- **Pneumothorax:** Air in the chest cavity equalizes the pressure in the chest cavity with the outside air and causes the lungs to collapse. This is usually caused by trauma or injury.

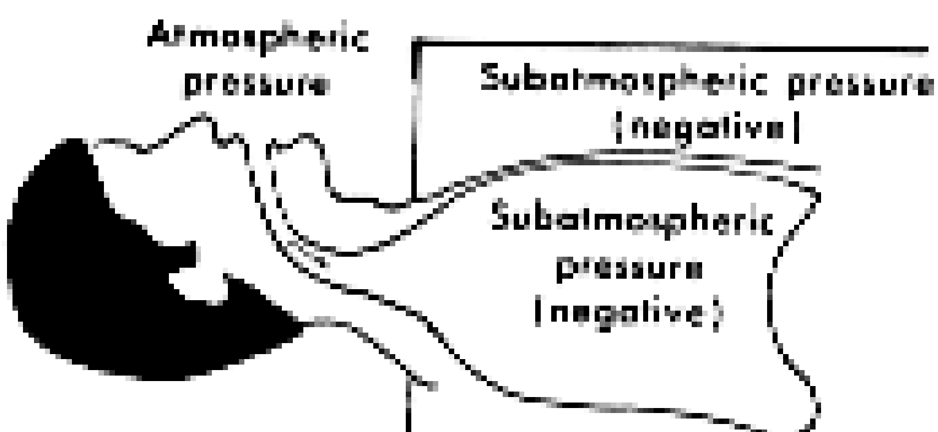
Diseases/Conditions Influencing Ventilation

- **Apnea:** Breathing slows or stops under a variety of conditions. There are many types of apnea, and they are usually caused by problems in the respiratory centers of the brain.
- **Pulmonary edema:** Fluid between the alveolus and pulmonary capillary builds up, which increases the distance over which gases must exchange and slows down the exchange.
- **Smoke inhalation:** Smoke particles coat the alveoli and prevent the exchange of gases.
- **Carbon monoxide poisoning:** CO binds to hemoglobin more tightly than either oxygen or carbon dioxide, which minimizes the delivery of oxygen to all the tissues of the body, including the brain, the heart and muscles.

Methods to Generate Inspiratory Force

Negative Extra thoracic Pressure

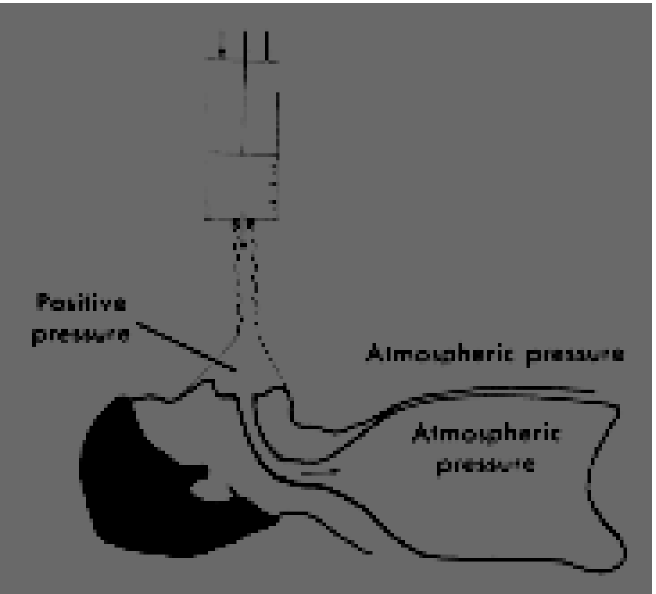
- A negative pressure around the chest causes the chest to expand, thus causing air to enter the lungs. Atmospheric pressure is more positive in the lungs. First generation ventilators were called “Iron Lung” and “Cuirrass Ventilators”

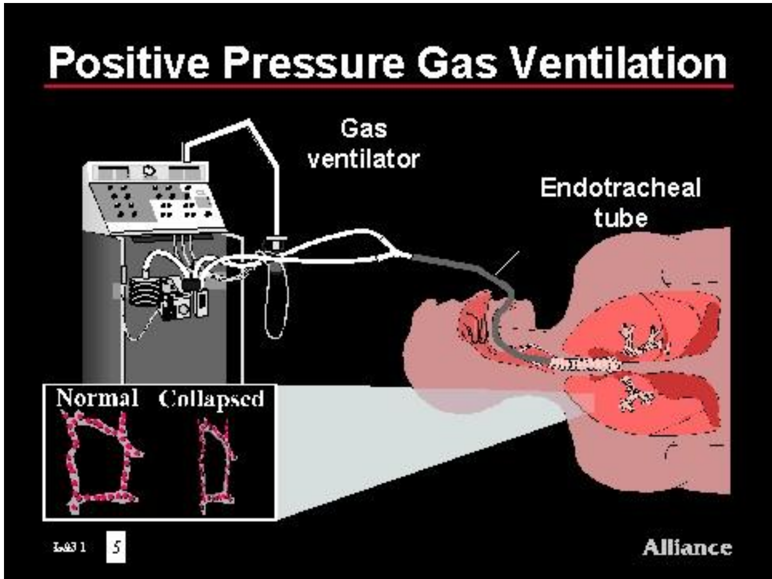


Methods to Generate Inspiratory Force

Positive Intra-Pulmonary Pressure

- A positive (higher that atmospheric pressure) pressure is applied to the lungs, thus causing the lungs to fill. This positive pressure is created by a machine called a respirator or ventilator. The two major categories of ventilators are pressure and volume controlled





Cycles for all Ventilators

- Patient Cycle – Created by a flow or a negative pressure by the patient. Also called “Assist Mode”
- Manual Cycle – Created by the patient or operator by depressing a button, causing the machine to cycle
- Time Cycle – Respiration rate set on the ventilator (Breaths per Minute BPM), causing the machine to cycle
- Assist/Controller – Combination of patient initiated by flow or pressure, with a guaranteed respiration rate on a time cycle

Ventilator Types

- IPPB – Intermittent Positive Pressure Breathing
  - Device that assists the breathing of the patient by creating a positive pressure during inspiration and on release of the pressure, expiration occurs passively.
  - Device are used to assist and provide a more uniform ventilation to have respiration occurring more efficiently
  - Uses could include: PACU, ED, trauma, therapy,…
  - Most units are powered from 50 PSI oxygen

Ventilator Types

- IPPB – Intermittent Positive Pressure Breathing
  - Unit delivers air at a specific inspiratory pressure to the patient
  - Once that pressure is achieved the unit releases and expiration (exhale) occurs passively
  - Several factors are considered in setting pressure levels (size, age, and condition of patient) to reduce risk of causing injury to patient’s lungs
  - Pressure is measured by centimeters of water (cmH_2O)

Ventilator Types
Continuous Positive Airway Pressure (CPAP)

Nasal CPAP delivers air into your airway through a specially designed nasal mask or pillows. The mask does not breathe for you; the flow of air creates enough pressure when you inhale to keep your airway open. CPAP is considered the most effective non-surgical treatment for the alleviation of snoring and obstructive sleep apnea.

Patient Resistance

- The opposition to air flow in to the patient.
- The inside diameter of the passageway is the primary cause for restriction

Lung Compliance

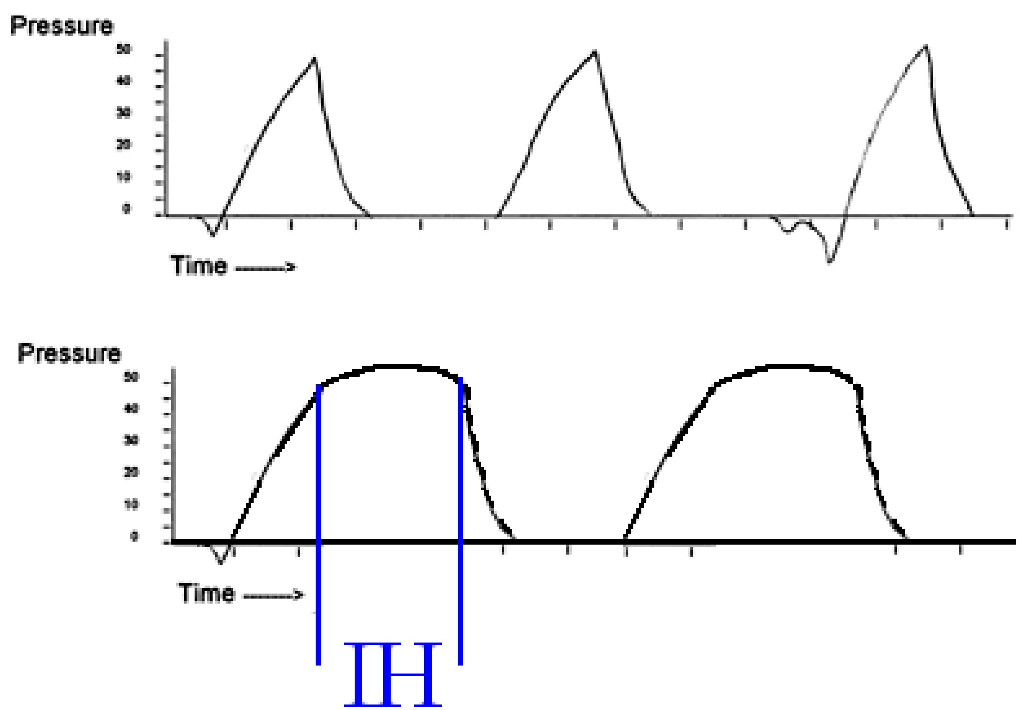
- Opposition to flow due to the expansion of the lung.
- This effect is similar to a spring expanding and relaxing.
- Specification for lung compliance are at a certain volume and pressure

I:E Ratio

- Inspiratory Time to Expiratory Time Ratio
- What is the time given for delivering the breath and the time required for exhalation.
- This works directly in ratio with the Breaths per minute, example: 10 BPM with 1:2 I:E Ratio
  - 10 BPM = 1 breath every 6 seconds
  - 1:2 IE ratio proportions the 6 seconds so the initiation time is 2 seconds and exhalation time is 4 seconds
- Flow and volume have greatest effect on I:E ratio
  - Higher flow = shorter inspiration time
  - Higher volume = increased inspiration time

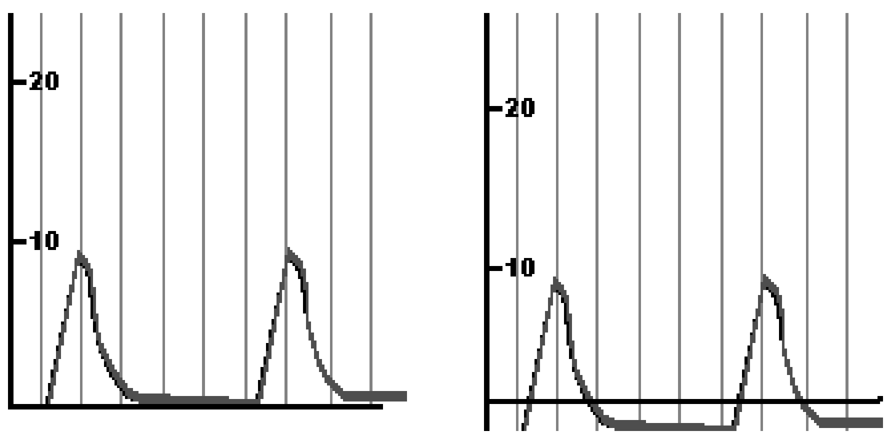
Inspiratory Hold

- Holds the inspiration pressure, up to 2 seconds



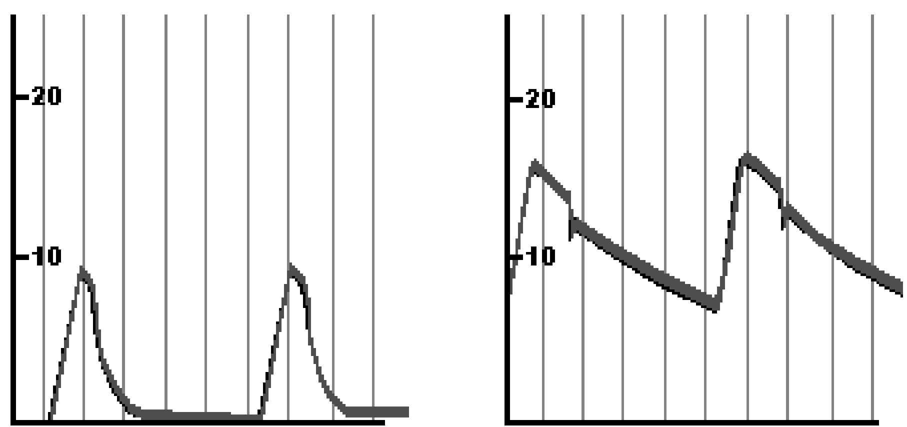
NEEP

- Negative End Expiratory Pressure – When the patient is at rest, there is a negative pressure (lower that atmospheric pressure) created on the lungs



PEEP

- Positive End Expiratory Pressure – When the patient is at rest, there is a positive pressure (higher that atmospheric pressure) created on the lungs.
- This increases functional residual capacity
- Can assist from having lungs collapse



IMV

- Intermittent Mandatory Ventilation – To wean patients off a ventilator by providing source gas to the patient for spontaneous breathing, with ventilator providing controlled breaths.

Sigh

- A deeper than normal breath, used to clean the lungs of residual volume

Patient Lung Volumes

- Tidal Volume (TV)
  - The volume of air inspired or expired with each normal breath. A typical range for an adult is 500 – 750 ml per breath with a rate of 12 to 15 breaths per minute.

- Inspiratory Reserve Volume (IRV)
  - The extra volume of air that can be inspired beyond the normal tidal volume. A typical range is about 3000 – 3500 ml.

- Expiratory Reserve Volume (ERV)
  - The volume of air that can be expired after the end of a normal tidal volume. A typical range is about 1000 – 1200 ml.

Patient Lung Volumes

- Residual Volume (RV)
  - The volume of air that remains in lungs after expiratory reserve volume is forcefully expired from the lungs. It is also considered the functional dead space.

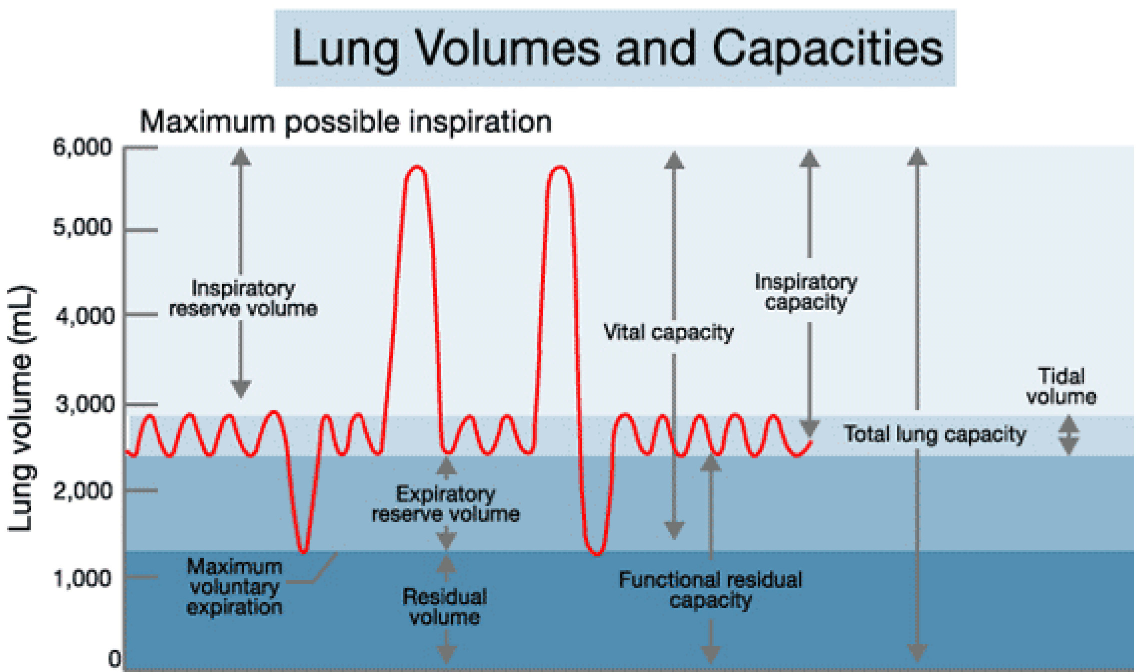
- Inspiratory Capacity (IC)
  - The volume of air equal to the tidal volume and inspiratory reserve volume IC = TV + IRV. This is measured by having the patient breath normally and then force themselves to the maximum inspiration from the end of a normal expiration.

- Vital Capacity (VC)
  - The volume of air that a patient can maximum forcefully inspire and then maximum forcefully expire. VC = IRV + TV + ERV or VC = IC + ERV

Patient Lung Volumes

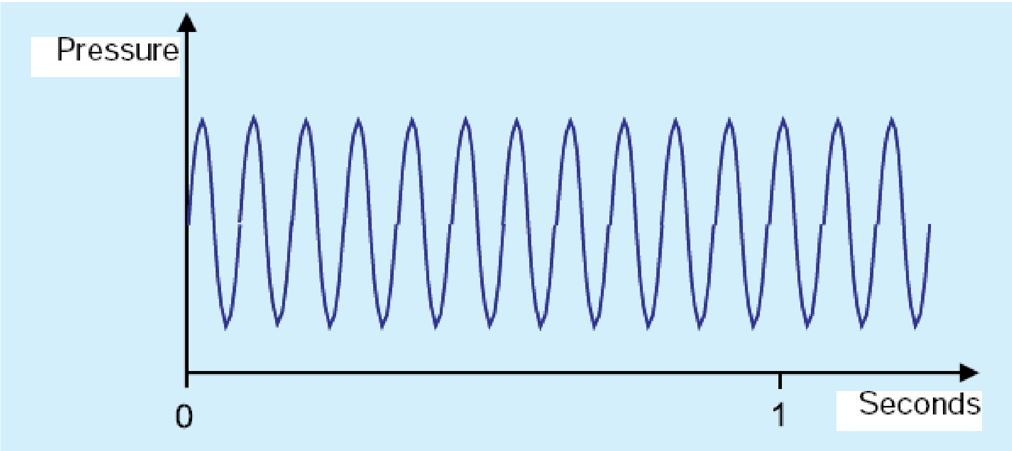
- Total Lung Capacity (TLC)
  - The volume of air in which the lungs can be expanded with the maximum inspiration effort. TLC = RV + VC

- Functional Residual Capacity (FRC)
  - The volume of air that remains in the lungs from the end of a normal expiration.   FRC = RV + ERV



High Frequency Ventilation

- Application - Some neonates who cannot be adequately ventilated with even sophisticated conventional ventilation.
- Three distinguishing characteristics of high-frequency ventilation:
  - Frequency range from 5 to 50 Hz (300 to 3000 bpm)
  - Active inspiration and active expiration
  - Tidal volumes about the size of the dead space volume



Miscellaneous Respiratory Equipment

- Spirometer – used to measure volume
- Incentive Spirometer – used for breathing treatments/therapy to have patient achieve a desired volume
- Oxygen Analyzer – use to measure and monitor oxygen levels being delivered to the patient
- Nebulizer – use to deliver medications to the patient (meds are still in liquid state)
- Humidifier – Provides moisten air

Miscellaneous Respiratory Equipment

- Flow Meter – controls the flow of 100% oxygen being delivered to the patient
- Ventilator Alarm – Measures volume (tidal and minute), pressure, and respiratory rate
- Oxygen blenders – Mixes house 50 PSI oxygen and house 50 PSI medical air for a 50 PSI concentration between 21-100%
- Pulse Oximeter – measures the oxygen saturation in the blood hemoglobin

Miscellaneous Respiratory Equipment

- Blood Gas Analyzer – Measures blood parameters for respiratory therapist to give an indication of the performance of respiration and cardiac output of the heart. Some units are a Point of Care (POC) that can be used at the patient bedside for faster results. Parameter measured include:
  - pH (acid/base level, normal 7.35 - 7.45)
  - PO2 (partial pressure oxygen)
  - PCO2 (partial pressure carbon dioxide)

Medical Gas & Vacuum

- Oxygen (Green)
- Medical Air (Yellow)
- Nitrous Oxide (Blue)
- Carbon Dioxide (Grey)
- Nitrogen (Black)
- Helium (Brown)
- Vacuum (White)
- Waste Anesthetic Gas Disposal (Violet)

Sterilizers

Sterilizers

- **Aeration**: The method by which absorbed ethylene oxide gas is allowed to dissipate from sterilized items by the use of warm air circulation in a specially designed enclosed cabinet.
- **Asepsis**: Absence of infectious organisms.
- **Bioburden**: Contamination with microorganisms and organic debris.
- **Biological indicator**: A sterilization process monitoring device that is commercially prepared with a known population of highly resistant spores to test the effectiveness of a sterilization method. The indicator is used to demonstrate that conditions necessary to achieve sterilization were met during the cycle being monitored.

Sterilizers

- **Chemical indicator**: A sterilization monitoring device (e.g., chemically treated paper, pellets sealed in a glass tube, pressure-sensitive tape) that is used to monitor certain parameters of a sterilization process by means of a characteristic color change.

- **Contamination**: The presence of pathogenic microorganisms; generally refers to a specific object, substance, or tissue that contains microorganisms, especially disease-producing microorganisms.

- **Event-related sterility**: Shelf life based on the quality of the packaging material, storage conditions during transportation and amount of handling of the item.

Sterilizers

- **Hydrogen peroxide plasma sterilization**: A hydrogen peroxide gas cloud or low-temperature plasma produced by a strong electrical field, similar to neon lights, that performs as a sterilant.

- **Infection**: The invasion and multiplication of microorganisms in body tissues that cause cellular injury.

- **Microbe**: Microorganism.

- **Nonwoven materials**: Combination of processed synthetic fibers randomly oriented in sheets and held with binders, or fabric produced by bonding fibers; they are designated as single-use materials.

Sterilizers

- **Pathogen**: Any disease-producing microorganism or agent.

- **Peel package**: A flexible bag or receptacle, made from paper and plastic or Tyvek and Mylar, used to package items for sterilization.

- **Rigid container system**: Specifically designed heat-resistant metal, plastic, or anodized aluminum receptacles used to package items for sterilization.

- **Sterilization**: The process by which items are rendered free of viable microorganisms, including spores.

Sterilizers

- **Sterilization process monitoring device**: A device, either biological, chemical, or mechanical used to monitor the sterilization process.
- **Surgical site infection**: Infection involving body wall layers that have been incised.
- **Terminal sterilization**: a) procedures performed at the end of the surgical procedure to render instruments free of bioburden and safe for handling b) sterilization of wrapped instruments in preparation for storage.
- **Woven fabrics**: Nondisposable, reusable, memory-free flexible fabric

Method	Capital Cost	Cycle Cost	Time	Prime Factors
Steam	$35-60K	$1	10 min	Time, Temp Press
ETO/CFC	$35-55K	$80	12-14 Hr	Time, Temp, Concentration, Humidity
ETO/100%/4 cf	$15-20K	$8	12-14 Hr	Time, Temp, Concentration, Humidity
ETO/100%/8 cf	$20-25K	$10	12-14 Hr	Time, Temp, Concentration, Humidity
Hydrogen Peroxide	$110K	$6	60-75 Min	Time, Concentration
Peracetic Acid	$14-16K	$5	30 Min	Time, Concentration, Temp
Glutaraldehyde	$0	$1	10 Hr	Time, Concentration, Temp

Monitoring the Sterilization Process

Chemical Indicators

- Class 4 - multi-parameter indicators, i.e., those that will respond to one or more sterilization parameters
- Class 5 - integrating indicators - i.e., these will respond to all sterilization parameters over a specified range of temperatures

If there is a problem with an indicator, such as not reaching the expected end point (e.g., complete color change), the cause of the failure must be investigated. Other packages from the load should be opened and evaluated to determine if the indicators have reached the expected end point, then handled accordingly.

Monitoring the Sterilization Process

Biological Indicators

- Although sterilization process indicators do not verify sterility, they help detect procedural errors and equipment malfunctions.

A biological indicator (BI) is defined as: A preparation of a specific population of microorganisms, in spore form, resistant to a set of measurable and controlled parameters of a particular sterilization process.

Lasers

Laser Safety

- **CLASS 1 -** is safe under all conditions of normal use. This means the maximum permissible exposure (MPE) cannot be exceeded. This class includes high-power lasers within an enclosure that prevents exposure to the radiation and that cannot be opened without shutting down the laser.

- **Class 1M -** is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes. Class 1M lasers produce large-diameter beams, or beams that are divergent

- **Class 2 -** is safe because the blink reflex will limit the exposure to no more than 0.25 seconds. It only applies to visible-light lasers (400–700 nm). Class-2 lasers are limited to 1 mW continuous wave, or more if the emission time is less than 0.25 seconds or if the light is not spatially coherent. Intentional suppression of the blink reflex could lead to eye injury. Many laser pointers are class 2.

- **Class 2M -** is safe because of the blink reflex if not viewed through optical instruments. As with class 1M, this applies to laser beams with a large diameter or large divergence, for which the amount of light passing through the pupil cannot exceed the limits for class 2.

Laser Safety

- **Class 3R -** is considered safe if handled carefully, with restricted beam viewing. With a class 3R laser, the MPE can be exceeded, but with a low risk of injury. Visible continuous lasers in Class 3R are limited to 5 mW. For other wavelengths and for pulsed lasers, other limits apply.

- **Class 3B -** is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other matte surfaces are not harmful. Continuous lasers in the wavelength range from 315 nm to far infrared are limited to 0.5 W. For pulsed lasers between 400 and 700 nm, the limit is 30 mJ. Other limits apply to other wavelengths and to ultrashort pulsed lasers. Protective eyewear is typically required where direct viewing of a class 3B laser beam may occur. Class-3B lasers must be equipped with a key switch and a safety interlock.

- **Class 4 -** include all lasers with beam power greater than class 3B. By definition, a class-4 laser can burn the skin, in addition to potentially devastating and permanent eye damage as a result of direct or diffuse beam viewing. These lasers may ignite combustible materials, and thus may represent a fire risk. Class 4 lasers must be equipped with a key switch and a safety interlock. Most entertainment, industrial, scientific, military, and medical lasers are in this category.

Laser Safety

In the U.S., guidance for the use of protective eyewear, and other elements of safe laser use, is given in the ANSI Z136 series of standards. A full copy of these standards can be obtained via ANSI or the secretariat and publisher of these standards, the Laser Institute of America. The standards are as follows:

- ANSI Z136.1 - Safe Use of Lasers
- ANSI Z136.3 – Safe Use of Lasers in Health Care Facilities

The U.S. Food and Drug Administration (FDA) requires all class IIIb and class IV lasers offered in commerce in the US to have five standard safety features:

1. a key switch,
2. a safety interlock dongle,
3. a power indicator,
4. an aperture shutter, and
5. an emission delay (normally two to three seconds).

Laser Safety

Maximum permissible exposure (MPE) - is the highest power or energy density (in W/cm^2 or J/cm^2) of a light source that is considered safe, i.e. that has a negligible probability for creating a damage. It is usually about 10% of the dose that has a 50% chance of creating damage under worst-case conditions. The MPE is measured at the cornea of the human eye or at the skin, for a given wavelength and exposure time.

Wavelength range	pathological effect
180–315 nm (UV-B, UV-C)	photokeratitis (inflammation of the cornea, equivalent to sunburn)
315–400 nm (UV-A)	photochemical cataract (clouding of the eye lens)
400–780 nm (visible)	photochemical damage to the retina, retinal burn
780–1400 nm (near-IR)	cataract, retinal burn
1.4–3.0μm (IR)	aqueous flare (protein in the aqueous humour), cataract, corneal burn
3.0 μm–1 mm	corneal burn

- Absorption Coefficient – A factor in determining the ability of light to be absorbed. Different types of tissue have varying properties of absorption.
- Coherence – The ability of waves to maintain a fixed phase in time and space by adding orderliness to the wave pattern.
- Collimation – The ability of a laser beam not to spread with distance.
- Combiner Mirror – A mirror for the joining of 2 or more laser wavelengths beams into a single coaxial beam.
- Contact Probe – A probe constructed of synthetic ceramics materials used with laser fibers, allowing probe contact to tissue directly. This creates a greater degree of control for low powers to vaporize, coagulate and cut tissue.
- Continuous Wave (CW) – The steady state delivery of laser power, ANSI regards beams > 0.25 sec as CW.
- Diffraction – The ability to deviate part of the beam, specific to the radiation wavelength as it passes the edge of an opaque barrier.
- Divergence – or beam spread is the increase in diameter of a laser beam with distance from the exit aperture.

- Eximer – a method of using a gas mixture as the basis of emitting ultraviolet light with lasers.
- Fail Safe Interlock – A system that allows for a laser to be placed in a safe mode, should the interlock system be violated.
- Fiberoptic – the use of glass fibers or flexible quartz as a medium by which light is transmitted for communication data, images and therapeutic laser beams.
- Focal Length – A distance measurement from the secondary nodal point of a lens to the primary focal point.
- Focal Point – A point which radiation converges or diverges. In laser applications is the point where the smallest spot diameter occurs.
- Gaussian Curve – A normal statistical curve used to show power distribution in a beam. The curve is used for identifying the geometry of a laser beam which then controls the laser effects.
- Infrared Radiation – Electromagnetic radiation that resides within the range of 0.7 – 1 mm.

- Laser Safety Officer – is an authorized individual who has the responsibility to evaluate, monitor and ensure that proper control of laser hazards are being maintained.
- Maximum Permissible Exposure (MPE) – is a level of laser radiation exposure less than what would cause harmful effects to the skin or eyes or to other biological changes. Reference ANSI Z-136.1 "Safe Use of Lasers"
- Mode – used to describe how the power of a laser beam is distributed within the geometry of a laser beam (pulsed or continuous)
- Normal Hazard Zone (NHZ) – an area that during normal laser operation exceeds maximum permissible exposure (MPE) level. The hazard may be caused by reflected or scatted radiation.
- Normal Ocular Hazard Distance (NOHD) – is the distance along an axis of the unobstructed beam from the laser to the human eye beyond which the irradiance or radiant exposure during normal operation is expected to exceed the appropriate MPE.

- Optical Cavity – is required to provide the amplification desired in the laser and to select the photons traveling in the desired direction.
- Optical Coupler – is a mirror that partially transmissive, allowing the laser output from the optical cavity.
- Power Density – is expressed in watts per square centimeter.
- Pulsed Laser – is a laser operating mode that delivers energy in the form of single pulses or an on going chain of pulses that are less than 0.25 seconds.
- Single Pulsed (normal mode) – is a pulse duration of a few hundred u sec to a few m sec.
- Ultraviolet Light – is electromagnetic radiation with a wavelength between 0.2 – 0.4 um.
- Visible Radiation (Light) – is electromagnetic radiation with a wavelength between 0.4 – 0.7 um and the human eye can detect.

Type	Application	Wavelength
Argon	Ophthalmology, photocoagulation (superficial), and dermatology	488—514 nm, CW
Nd: YAG	Photo coagulation	1.06 um (several operating modes)
CO2	Gynecology, bronchoscope	10.6 um, CW
Eximers	Ophthalmology, photoablation (dermatology), and plastic surgery Ultraviolet:	
	Argon fluoride	193 nm
	Krypton fluoride	248 nm
	Xenon chloride	308 nm
	Xenon chloride	351 nm
Dye-tunable	Dermatology, photodynamic therapy, plastic surgery	400—900 nm, CW
Gold Vapor	Photodynamic therapy	628 nm, pulsed
HeNe	HCLS, aiming and photoradiation	633 nm, CW
Laser Diode (GaAs)	Photoradiation	840 nm, pulsed

CO2 Lasers

CO_2 surgical lasers are used primarily to create surgical incisions, to excise or vaporize deeper tissues (e.g., to remove tumors) after incisions, to coagulate very small bleeding vessels, to vaporize surface anomalies (e.g., warts), and to excise or vaporize tissue accessible by both rigid and flexible endoscopes.

CO_2 lasers are free-beam lasers; that is, the laser's tip remains several millimeters away from the tissue during operation.

Use of CO_2 surgical lasers offers several advantages over conventional surgery, including reduced mechanical trauma to and increased preservation of surrounding tissue and more easily maintained sterility.

Nd:YANd:YAG Lasers

- Nd:YAG surgical lasers are in general use, particularly in gastroenterology, urology, gynecology, and general surgical applications, to photocoagulate, cut, or vaporize tissue.
- Nd:YAG surgical laser energy (1,064 nm wavelength) can be delivered through flexible silica fibers and can pass through clear fluids, unpigmented tissue, and the top layer of the skin, making Nd:YAG lasers more effective than other types of lasers in treating certain medical conditions.
- There are two types of Nd:YAG lasers
  - general surgical
  - ophthalmic

Ho:YAG Lasers

- Ho:YAG lasers are used in orthopedics, ophthalmology, otolaryngology, cardiology, urology, oral/maxillofacial surgery, and pulmonary medicine.
- Ho:YAG lasers emit energy near the absorption peak of water (approximately 2,100 nanometers [nm]), they can cut or ablate tissue with moderate hemostasis, little charring, and a thin zone of necrosis.
- Ho:YAG energy is delivered through a small-diameter silica quartz fiber in air or liquid that either contacts tissue or is a short distance away from it.
- Ho:YAG laser fiber can be more readily maneuvered than a carbon dioxide (CO_2) laser delivery device to perform procedures in the gastrointestinal tract, such as removal of sessile polyps.

Diode Lasers

- High-power surgical diode lasers are used to cut or vaporize soft tissue with hemostasis and to photocoagulate soft tissue in surgical specialties such as general surgery, gastroenterology, gynecology, neurology, otorhinolaryngology, plastic surgery, and urology.
- At lower power settings, surgical diode lasers have been used for interstitial laser photocoagulation—a minimally invasive technique for tumor destruction—and various tissue-welding applications.

Ophthalmic Lasers

- **Photocoagulating ophthalmic lasers** use argon, dye, krypton, diode, and frequency-doubled Nd:YAG lasers to coagulate abnormal vascular tissue in the retina.

- **Photodisrupting ophthalmic lasers or** Q-switched Nd:YAG ophthalmic lasers are used to perform microsurgery in the anterior portions of the eye, primarily for posterior capsulotomy, but also for iridotomy, iridectomy, transscleral cyclophotocoagulation, laser trabeculoplasty, anterior vitreolysis, and pupillary membranectomy.

- **Photoablating ophthalmic lasers or** Excimer (a contraction of "excited dimer") lasers are used in phototherapeutic keratectomy (PTK) to smooth over corneal scarring and remove calcification plaques, in photorefractive keratectomy (PRK) to shape the cornea to correct myopia (nearsightedness), and in automated lamellar keratoplasty to correct both myopia and hyperopia (farsightedness).

Infusion Devices

Infusion Terms

Volume to be Infused – is the volume (liters – L) of the solution desired to be infused. When the volume is reached, the machine will either go to piggyback or KVO

Rate – is the volume over time (ml/hr) of how fast the solution is to be infused to the patient

Keep Vein Open (KVO) – is an alarm that sets flow rate at 5 ml/hr that prevents blood clots at the catheter tip

Back Pressure – is the pressure that a solution must overcome to pass through a lumen. Influences of back pressure include: viscosity, tubing diameter, catheter diameter, fluid height and flow rate.

Infusion Terms

- Bolus – is a dose of fluid injected all one time.
- Infusate – is the fluid infused into the patient over some period of time.
- Intravenous (IV) – is pertaining to the inside of a vein, as in an injection, infusion or catheter
- Occlusion – is a blockage in a canal, vessel or passage.
- Drip or Optical Sensor – is a optical sensor attached to the drip chamber used to measure the drips, providing a feedback to the controller

Infusion Terms

- Piggybacking – is a secondary volume rate different than the primary rate. When the primary volume level is reached, the machine will automatically change to the secondary rate

Needless Intravenous Tubing - Intravenous tubing with connectors designed to work with syringes that do not require a needle on the syringe for it to connect to the IV tubing.

In Line Filters – Fluid filters designed to work in series with IV tubing to remove pathogens and particulates from IV solutions in order to reduce infusion phlebitis.

Needless Intravenous Tubing

- Stop Cock (3 way) – An IV tubing connector that has three (3) tubing connections with an adjustable rotating handle to change the flow of the fluid between two (2) connectors with the third connection not having flow.

- Flush – The action of causing fluid to flow through an IV tubing set in order to remove all air from the tubing prior to connecting to the patient.

Needless Intravenous Tubing

- Flush Valve – An IV tubing valve designed to permit flow of an IV solution into an IV tubing set when the clinical caregiver manually opens the valve by pulling on an rubberized actuator. When the valve is at rest, the rubberized actuator will act as a closed valve and check into it's seat, thus closing the valve. The valve is opened only when sufficient pulling force is provided to the valve assembly, pulling it away from its seat, and thus permitting fluid flow.

- Typically the flush valve is used by the clinical caregiver to flush IV solutions through the IV tubing in order to remove all air prior to connecting to patient or to force IV fluid pressure against catheters that may have blood backing into the IV tubing.

Free Flow Protection

- The free-flow protection devices are operative in occluding a pumping tube to prevent free-flow of a mendicant to a patient.

Tubing Flow Rate

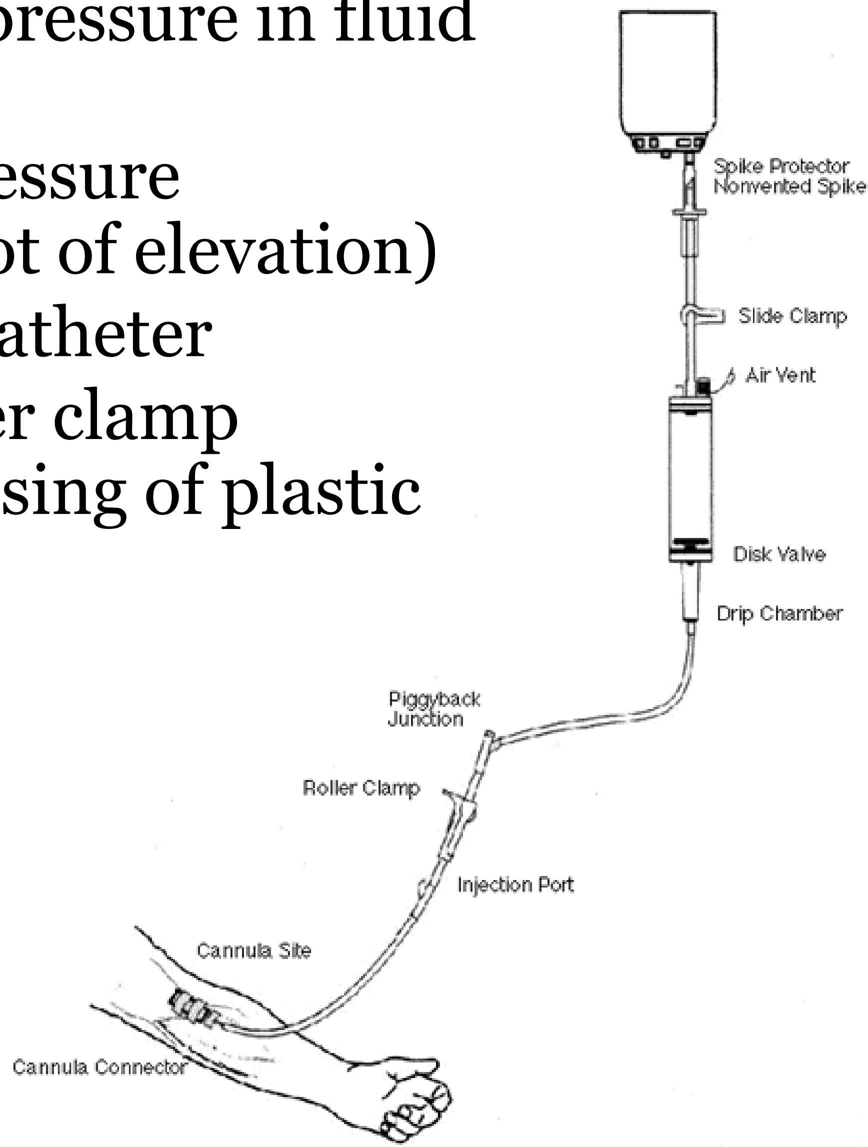
- Tubing is rated for:
  - 20 drop/ml
  - 60 drop/ml
  - Other sizes are available based on flow rate
- Patients requiring very high flow rates per hour with lower accuracy will use lower drops/ml tubing sets (20 drops/ml)
- Patients requiring very low flow rates and high accuracy will use higher drops/ml tubing sets (60 drops/ml)

Tubing Flow Rate

- Flow rate is calculated by:
  - Select tubing set of 20 or 60 drop/ml (20 drop/ml)
  - What is desired flow rate to patient (example 150 m/hr)
  - Multiply 20 drop/ml x 150 ml/hr = 3000 drops/hour
  - Divide by 60 sec/min and then divide by 60 min/hr and then multiply by some time interval (5, 10 or 15 sec)
  - 3000 drops/hr ÷ 60 sec/min ÷ 60 min/hr X 5 sec = 4.1 drops/5 sec
  - 3000 drops/hr ÷ 60 sec/min ÷ 60 min/hr X 10 sec = 8.3 drops/10 sec
  - 3000 drops/hr ÷ 60 sec/min ÷ 60 min/hr X 15 sec = 12.5 drops/15 sec

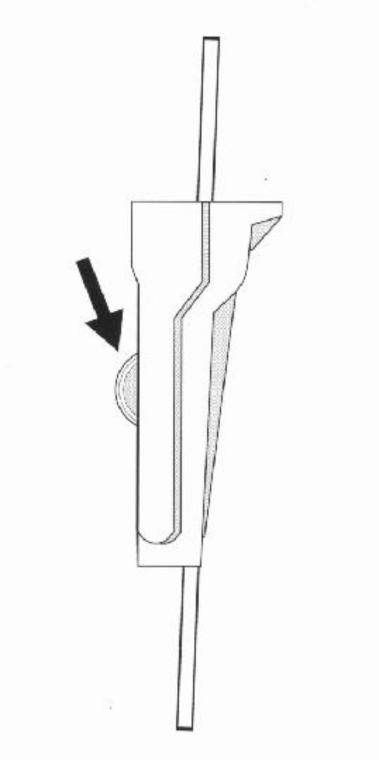
Gravity Drip – IV Bag & Roller Clamp

- Gravity is used to create pressure in fluid to infuse into patient
- IV bag height controls pressure
  (25 mmhg for each 1 foot of elevation)
- Veins are used to locate catheter
- Rate is controlled by roller clamp placement and partial closing of plastic tubing



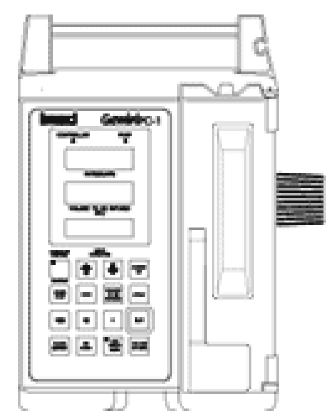
Gravity Drip – IV Bag & Roller Clamp

- Fluid type, viscosity, specific gravity, filters, and tubing types will have an effect on the flow rate
- Drip chamber is used to measure flow rate
- Flow rate is calculated by:
  Drop volume/1drop X 60 min/hour
  Note: typical tubing is 20 drops/1ml
- Free flow can be a problem
- No air detection systems
- Needle-less systems are now available



Infusion Controller – General Use

- Gravity is used to create pressure in fluid to infuse into patient
- IV bag height controls pressure
  (25 mmhg for each 1 foot of elevation)
- Veins are used to locate catheter
- Rate is controlled by infusion controller device and provides a higher level of control that just IV tubing & roller clamp

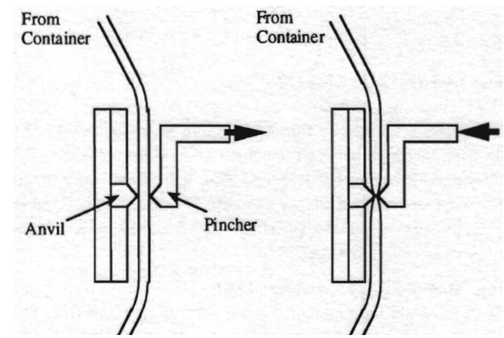


Infusion Controller – General Use

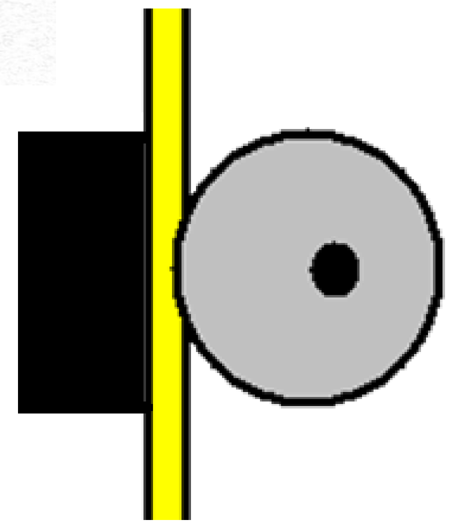
- Fluid type, viscosity, specific gravity, filters, and tubing types will have an effect on the flow rate
- Flow Restricting Mechanisms
  - Pincher-anvil - partially occludes the IV tubing by pinching and releasing the tubing
  - Rotary Valve Cassette – turns a rotary knob to increase or decrease the valve opening size
  - Diaphragm/Orifice – diaphragm partially occludes an inlet orifice at the drip chamber

Infusion Controller – General Use

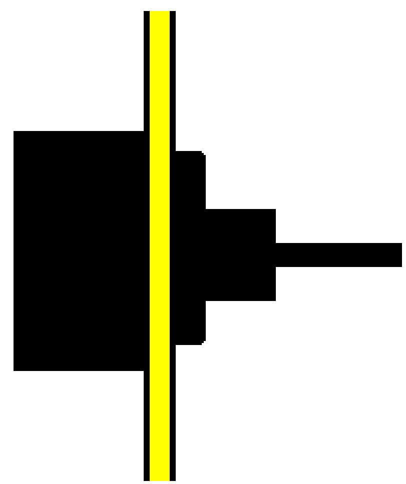
- Pincher-anvil



- Rotary Valve Cassette



- Diaphragm/Orifice



Infusion Controller – General Use

- Older units were drop counter
- Newer unity are volumetrically set
- Special IV sets are required for controllers
- Secondary (piggyback) is possible
- AC and DC battery powered
- Microprocessor controlled
- Drip chamber sensor for feedback of flow (counts drips)

Infusion Controller – General Use

- Keep Vein Open (KVO) alarm that sets flow rate at 5 ml/hr that prevents blood clots at the catheter tip
- Free flow can be a problem (new tubing can correct problem and prevent)
- Air detection systems and alarms
- Needle-less systems are now available
- Units are being phased out and replaced with infusion pumps

Infusion Pump - General Use

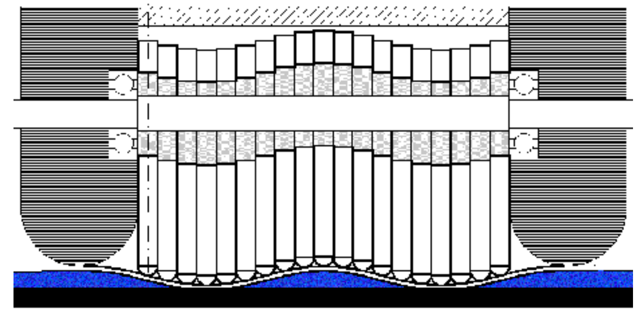
- Pressure of IV solution is generated and controlled by the infusion pump device
- Veins or arteries are used to locate catheter
- Provides higher level of control than IV tubing and IV controller
- Volume and pressure is controlled by the pump's mechanical operation
- Higher level of accuracy of fluid delivery and greater range of control
  (0.1 ml/hr – 1,000 ml/hr)

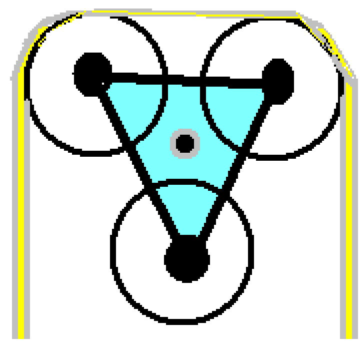
Infusion Pump - General Use

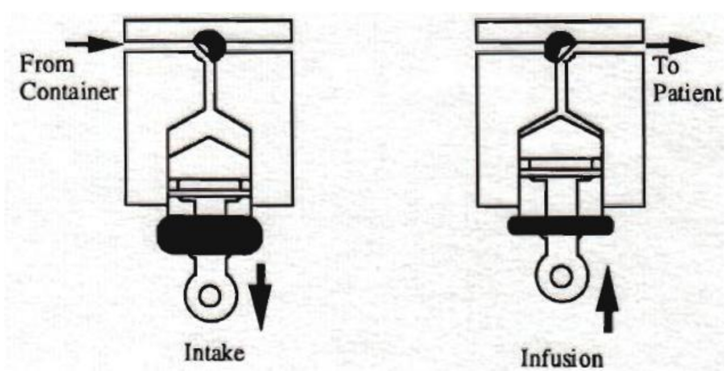
- Flow Restricting Mechanisms
  - Linear Peristaltic – finger like disks create a rippling like motion of the tubing that is held fixed
  - Rotary Peristaltic – rubber tubing wrapped around rollers that rotate
  - Syringe Cassette – syringe has a plunger moved to force fluid out of the syringe
  - Piston Cassette – piston displaces the fluid
- Units are volumetrically set with limits
- Special IV sets are required for pumps

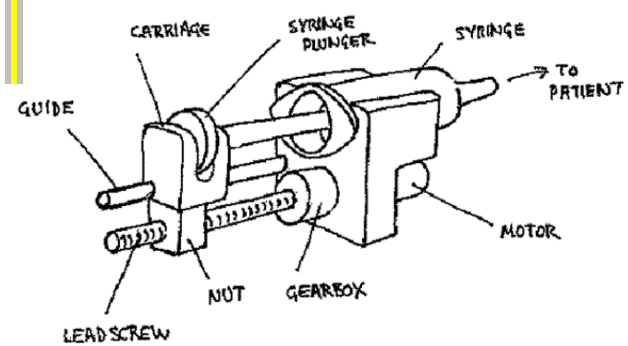
Infusion Pump - General Use

- Linear
- Rotary Peristaltic
- Syringe Cassette
- Piston Cassette









Comprehensive Dug Library

- A computer database used by Dose Error Reduction System (DERS) infusion devices. The database contains specific medications and limits for infusing that medication in an infusion device. The list is prepared by the medical device manufacturer in collaboration with the healthcare provider (For example: Pharmacy and Nursing representatives).
- Drug libraries are updated on a regular basis and then uploaded to infusion pumps by various technologies.

Dose Error Reduction System (DERS)

- Is an automated software based system incorporated into an infusion device designed to limit specific medication dose delivery. The system will alert and possibly prevent flow or volume rates that exceed preprogrammed specific medication limits prior to starting the delivery of the medication.
- Also called a smart pump

Dose Error Reduction System (DERS)

- Infusion devices with DERS must be updated on a regular basis, as new medications are introduced and limits may change with existing medications. To update the drug library, infusion devices may incorporate technologies such as: wireless communication and barcode readers. DERS systems may also log usage profiles of medications for post-analysis of caregivers to assist them in making revisions to their drug libraries.

Continuous Quality Improvement Database

- A database/log recording all key strokes/alerts performed prior to, during and after the operation of the device (infusion). This allows a hospital to track programming errors, or “near misses,” that have been averted and could have resulted in patient harm. Continuous quality improvement (CQI) data also provide a new source of information to assist in assessing infusion practices and identifying opportunities for process improvements.

Critical Alarms

- Audible and visual alarms alerting the operator of the device that the pump has encountered an abnormal operation which could result in an adverse event to the patient or the caregiver.

Micro Infusion Pump

- Same general specifications as infusion pumps
- Syringe pump sometimes called a Harvard pump
- Cam be implantable
- Can control small volumes of IV fluid
  (0.1 ml/hr to 99.9 ml/hr)
- Typical use in neonatal care units

Ambulatory Infusion Pump

- Smaller pump, typically worn by patients to control the delivery of medications, chemotherapy, nutrition, antibiotics, etc.
- Typical use is an outpatient setting
- IV solution volume is controlled by mechanism pressing the plunger of a syringe
- Same general specifications as infusion pumps

Insulin Pump

- Typically a syringe pump designed to deliver insulin
- Smaller pump, typically worn by patients to control the delivery of insulin
- Typical use is an outpatient setting
- Volume is controlled by micro-volume pulses
- Open loop design does not monitor blood glucose and therefore must be monitored by other means
- Closed loop measures blood glucose about 4 times a day and makes adjustments to the volume of insulin being delivered
- Must be capable to deliver a bolus dose of insulin

Multi-Channel Pump

- Space saver – one device can control up to 4 independent IV tubing sets
- Each IV tubing can have their own settings
- Requires special IV tubing, specific for multi-channel pumps
- Same general specifications as infusion pumps

Patient Controlled Analgesia (PCA)

- A syringe pump designed to deliver a pain medication to the patient upon the request of the patient via a corded button
- Pain medication comes pre-loaded in a syringe that is inserted into the pump and connected to the patients IV
- Most units are AC and battery powered
- Controls and access to syringe is under lock-key

Patient Controlled Analgesia (PCA)

- Unit is programmed by nurse on specific orders by a physician as to the individual dose, number of doses and total dose available in a specific period of time (hour/day)
- Upon need of pain medication, the patient depresses a button to request a dose
- All requests are time/date stamped, whether a dose is delivered or not
- Most units have a printer to document all activities (patient requests and doses delivered)

Clinical Laboratory

A clinical laboratory is a laboratory where tests are done on clinical specimens in order to get information about the health of a patient.

Laboratory tests are an integral part of the workup of any patient, and constitute up to 80% of a physician's diagnosis and treatment choice.

Departments

Laboratory medicine is generally divided into four major sections with sub-sections within each area:

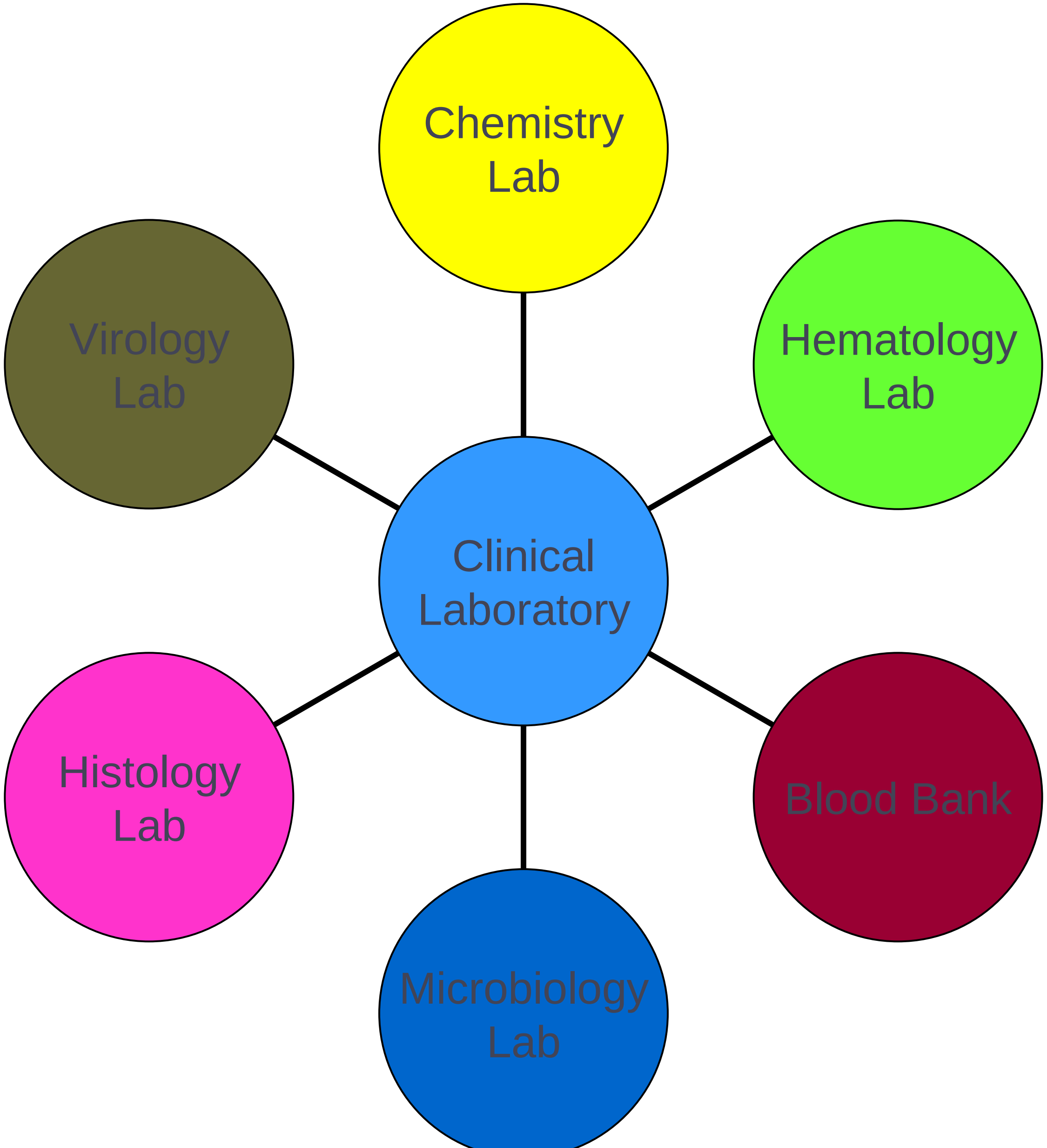
1. Anatomic Pathology:
   - Histopathology
   - Electron Microscopy
   - Physiology
   - Pathology
   - Cytopathology
   - Anatomy
   - Histology
   - Pathophysiology

2. Clinical Microbiology: This is the largest section in laboratory medicine
   - Bacteriology
   - Parasitology
   - Mycology
   - Virology
   - Immunology

Departments

3. Clinical Biochemistry
   - Enzymology
   - Toxicology
   - Endocrinology

4. Hematology: This small, yet busy, section consists of two units:
   - Coagulation
   - Blood Bank


Chemistry Lab
Virology Lab
Hematology Lab
Clinical Laboratory
Histology Lab
Blood Bank
Microbiology Lab

Clinical Laboratory Personnel

- Medical Director
- Pathologist, Clinical Biologist, Microbiologist, or Biochemist
- Resident in Pathology or Clinical Biology
- Pathologist assistant, Microbiologist assistant, Medical Biochemist assistant
- Laboratory Director/Manager
- Department Supervisor
- Chief Technologist (lead technologist)
- Cytotechnologist, Medical Technologist, Histotechnologist
- Medical Laboratory Technician
- Medical Laboratory Assistant (lab aide)
- Phlebotomist
- Transcriptionist
- Specimen Processor (secretary)

Lab Measurement Basic Operating Fundamentals

Reflectance Photometry

- Uses dry reagent films or reagent strips and measures the amount of light reflected from the surface of the strip or film.
- In these systems, a light source transmits a beam of light onto the test specimen.
- Some manufacturers use light-emitting diodes (LEDs) or fiberoptic light sources to produce monochromatic light

Photometers

- Uses a monochromatic light by passing transmitted light through an interference filter that allows only a specific wavelength to reach the sample

Lab Measurement Basic Operating Fundamentals

Spectrophotometric

- Use monochromatic light by passing transmitted light through a grating that bends it at various angles characteristic of its component wavelengths and by directing a narrow portion of the diffracted light to the sample

Ion-Selective Electrodes (ISEs)

- ISEs are solid-state electrodes covered by a selectively permeable membrane that allows passage of only the analyte being measured
- The electrode registers changes in the electrical current passing through it; this current is proportional to the concentration of analyte in solution

Lab Measurement Basic Operating Fundamentals

Amperometric

- Electrodes that use immobilized enzymes (complex catalyst proteins) that have a high degree of substrate specificity
- Amperometry measures the current through an electrochemical cell while a constant electric potential is applied to the electrode

Chemistry Lab

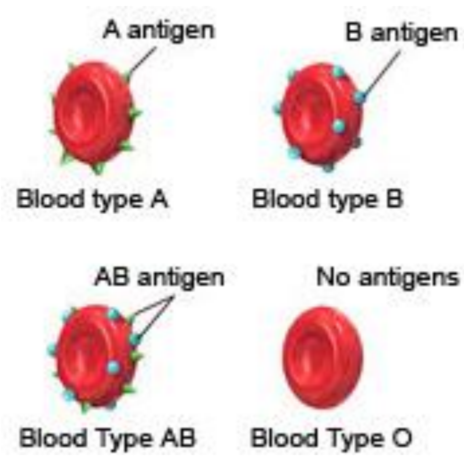
- Performs analysis on blood, urine and other body fluids
- High volume of testing
- Most analyzers are automated or semi-automated, with back-up machines for failures
- Examples of tests performed:
    - Blood gases (SpO2, SpCO2, Ph)
    - Potassium
    - Sodium

Hematology Lab

- Performs analysis on blood cell structure, function and concentration
- Types of diagnosis and diseases studied:
    - Anemia
    - Leukemia
- Examples of tests performed:
    - Cell Counter
        - Red Blood Cell count (RBC)
        - White Blood Cell count (WBC)
    - Hemoglobin concentration (Hgb)
    - Platelet count (PLT)
    - Hematocrit (Hct)

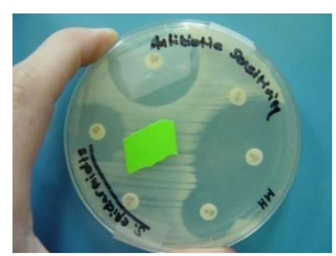
Blood Bank

- Performs analysis and storage on blood products
- Examples of tests performed:
  - ABO Blood Rh typing and screening
  - Polyspecific Antiglobulin test
  - Antibody Screening Test



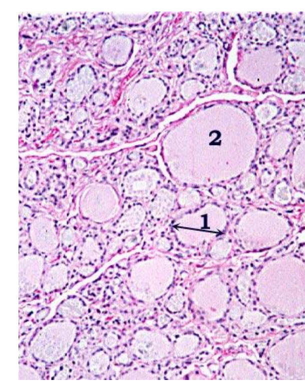
Microbiology Lab

- Performs analysis for identification of infectious diseases. Samples are cultured from the patient, then cultured, grown and tested to identify the microbe. The microbe is then subject to testing and further analysis.
- Equipment used in this area include:
    - Incubators
    - Sterilizers
    - Microscopes
    - Automated microscan



Histology Lab

- Performs analysis on tissue and bone samples for identification of disease and cancers. Sample tissue is imbedded in paraffin blocks, then sliced into very thin slices using a microtome. The tissue slices are then placed on a microscope slide and process through a slide staining system. This process adds dyes and chemicals to the tissue to more easily identify structures. The slides are then examined by microscope by a pathologist.
- Equipment used in this area include:
  - Microtomes – Cutting thin slices of tissue
  - Microscopes
  - Paraffin baths
  - Slide stainers

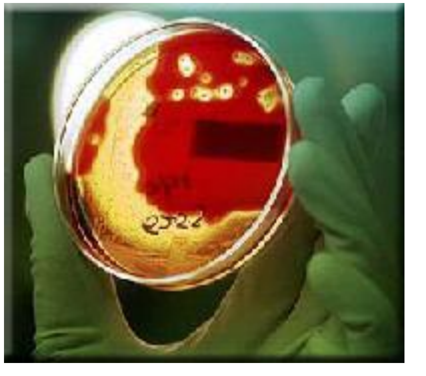


Virology Lab

Performs rapid detection of viral antigens in clinical samples, molecular tests, conventional and rapid virus isolation techniques, and determination of viral antibody response.

Types of diagnosis and diseases studied:

- Seasonal viruses
- Influenza
- Hepatitis
- Herpes
- HIV
- Lyme disease
- Mumps



Water Bath

- Are used for specific seriological or biochemical reactions
- Uses de-ionized water at a maintained temperature of 37 C with adjustable temperature.

Refrigerators and Freezers

- Are used for maintaining lab specimens at specific cool temperatures, such as: blood, blood products, biological samples, reagents vacations and medications.
- Temperature accuracy and alarms are critical in maintaining exact temperatures.

Incubators

- Are used for maintaining lab specimens at specific warm temperatures.
- These are used for cultures, where growth of a microorganism is desired in a culture.
- Some incubators have a CO2 atmosphere that allows cells to be grown in culture by emulating a cell's normal environment in an organism

Sterilizers

- Are used for cleaning instruments and killing all microorganism that have been grown in a culture.
- Most sterilizers are steam
- There are table top sterilizers called “Incinerators” that sterilize metal instruments by inserting the instrument into the front chamber

Microscopes

- Are used for visual magnification of microscopic lab specimens.
- Microscopes can be a single user, multiple user or video display.

Microtome

- Microtomes are precision instruments designed to cut uniformly thin sections of a variety of materials for detailed microscopic examination.
- The thickness of a section can vary between 1 and 10 microns (thin sections).
- For electron microscopy the thickness of a section is usually of the order of 10 nanometres (ultra-thin sections).

Slide Stainers

A slide staining system adds dyes and chemicals to the tissue samples to more easily identify structures.

Most have the capability to to program (in minutes and seconds) up to four 24-step staining procedures

Centrifuge

- Used to separate liquid heaver particles from lighter particles
- Primarily used in clinical labs
- Must be balanced
- Speed accuracy is checked with a photo-tachometer or reed tachometer
- Critical speed is when the motor shaft and rotor move from a geometric balance to a centrifugal balance (vibrates during this phase)

Drucker Model 613

Blood Gas/pH Analyzers

- measure pH, *P*O2, and *P*CO2, typically in an arterial blood sample
- They are used in
  - respiratory therapy departments
  - clinical and cardiopulmonary laboratories
  - critical care units
  - surgical suites
  - physician offices
  - hospital nurseries
- use three types of electrode systems

Anesthesia Gas Machines

General Anesthesia produces an unconscious state. In this state a person is:

1. unaware of what is happening
2. pain-free
3. immobile
4. free from any memory of the period of time during which he or she is anesthetized

General anesthesia can be administered as an inhaled gas or as an injected liquid. There are several drugs and gases that can be combined or used alone to produce general anesthesia. The potency of a given anesthetic is measured as **minimum alveolar concentration (MAC)**.

General Anesthesia

Inhaled Anesthetics Many adults may remember having **ether** for their anesthetic when they were young. Ether is a flammable anesthetic that is no longer used in the United States. Today, the commonly used inhaled anesthetics are **nitrous oxide** (also known as laughing gas), **sevoflurane, desflurane, isoflurane** and **halothane.**

General Anesthesia

Injected Anesthetics

A liquid anesthetic drug is delivered to the brain by injecting it directly into the bloodstream usually through an intravenous catheter. Examples of injected drugs are **barbiturates, propofol, ketamine**, and **etomidate,** as well as larger doses of **narcotics** (such as morphine) and **benzodiazepines** (Valium-like drugs). These drugs quickly reach the brain and their effect is dependent on several factors including the volume in which the drug is distributed in the body, the fat-solubility of the drug, and how quickly the body eliminates the drug.

A commonly used injected barbiturate anesthetic is **sodium thiopental,** also known as Pentothal.

Regional Anesthesia is so named because a "region" of the body is anesthetized without making the person unconscious. One example of this is spinal anesthesia, which is often used on woman during childbirth. A local anesthetic is injected into the spinal fluid and causes a loss of sensation of the lower body. Spinal anesthesia can be used for surgery on the legs or lower abdomen (below the bellybutton).

Local Anesthesia involves numbing a small area by injecting a local anesthetic under the skin just where an incision is to be made. When used alone, this type of anesthesia has the least number of risks. Local anesthetics are thought to block nerve impulses by decreasing the permeability of nerve membranes to sodium ions. There are many different local anesthetics that differ in absorption, toxicity, and duration of action.

Sedation - Some of the drugs that produce general anesthesia in large doses can be used to produce sedation or "twilight sleep" in lower doses. Sedation can be given in many ways. A common example of an anesthetic gas that is used for sedation is nitrous oxide or laughing gas. Liquid sedating drugs are usually given by injection but some can also be given by mouth. **Ketamine** and **Versed** are examples of sedating drugs that can be given by injection or by mouth. The oral route is particularly useful for sedating children who do not like injections.

Consciousness is being clearly aware of yourself and your environment.

Unconsciousness is when you are completely or partially unaware of yourself and your environment, or you don't respond to sensory stimuli.

Conscious sedation is caused when anesthesiologist administers depressant drugs and/or analgesics in addition to anesthesia during surgery. Consciousness is depressed and you may fall asleep, but are not unconscious

.

Sleep is a state of reduced consciousness, depressed metabolism, and little activity of the skeletal muscles. Strong stimuli such as a loud noise, bright light or shaking can arouse the sleeper.

Oxygen has six (6) "tasks" in the Anesthesia Gas Machine; it powers the

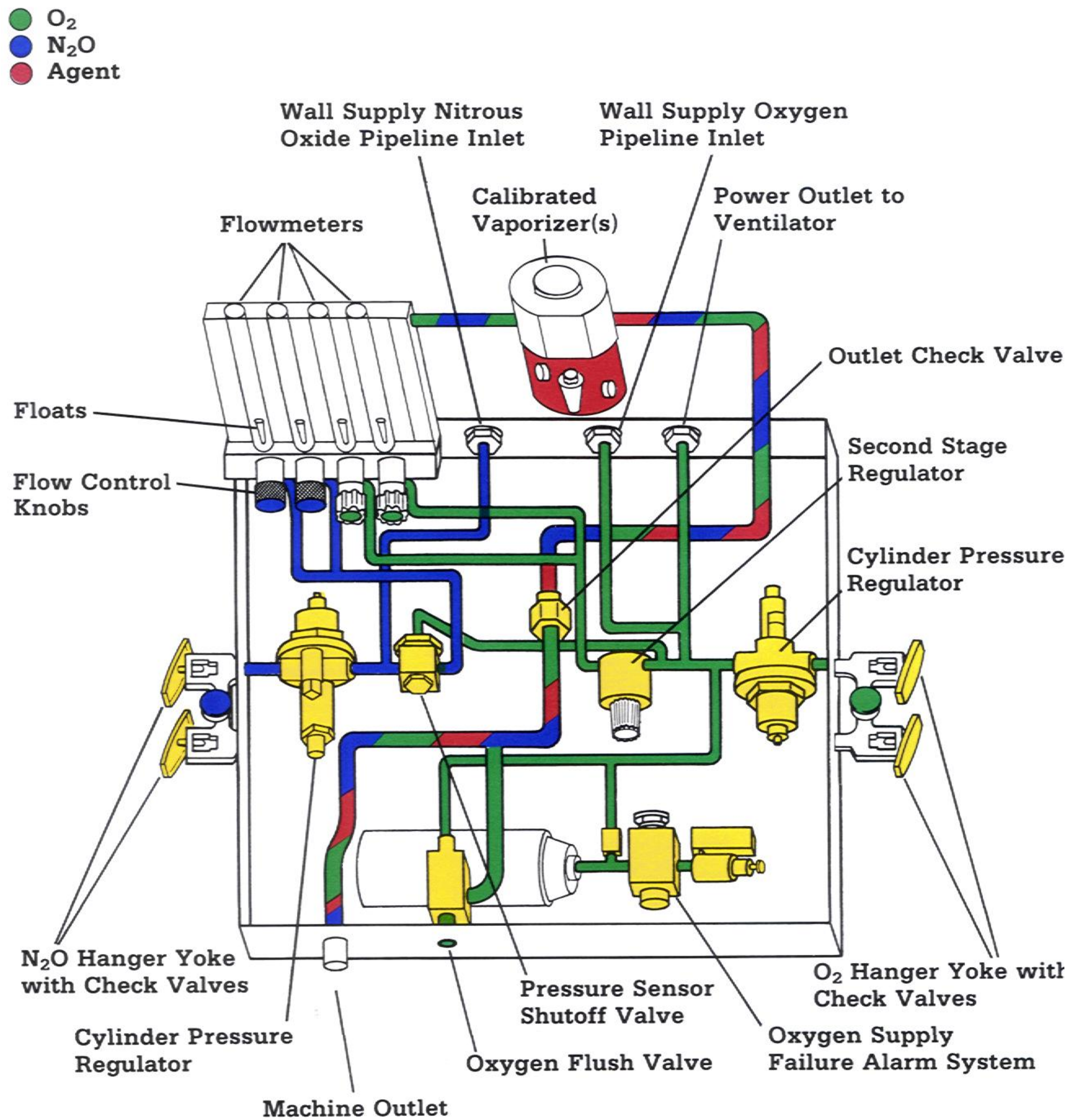
1. ventilator driving gas
2. flush valve
3. oxygen pressure failure alarm
4. oxygen pressure sensor shut-off valve ("fail-safe")
5. flowmeters
6. a role in the hypoxic guard system, which maintains the correct proportion between flows of oxygen and nitrous oxide.

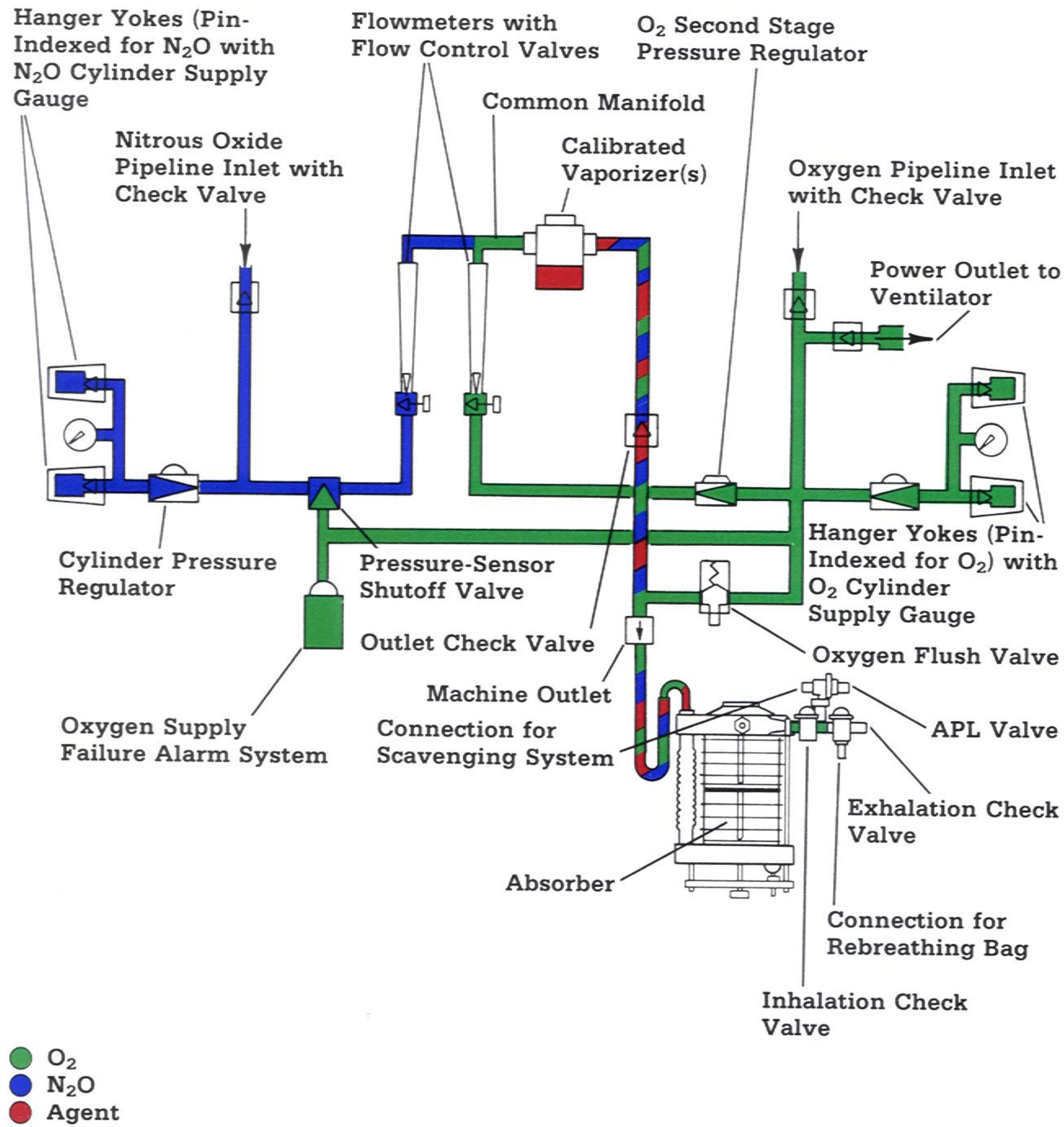
Required monitors

- Exhaled volume
- Inspired oxygen, with a high priority alarm within 30 seconds of oxygen falling below 18% (or a user-adjustable limit).
- Oxygen supply failure alarm
- A hypoxic guard system must protect against less than 21% inspired oxygen if nitrous oxide is in use.
- Anesthetic vapor concentration must be monitored.
- Pulse oximetry, blood pressure monitoring, and EKG are required

Alarms

- Grouped into high, medium, and low priority.
- High priority alarms may not be silenced for more than 2 minutes.
- Certain alarms and monitors must be automatically enabled and functioning prior to use, either through turning the machine on, or by following the pre-use checklist: breathing circuit pressure, oxygen concentration, exhaled volume or carbon dioxide (or both).
- A high-priority pressure alarm must sound if user-adjustable limits are exceeded, if continuing high pressure is sensed, or for negative pressure.
- Disconnect alarms may be based on low pressure, exhaled volume, or carbon dioxide.

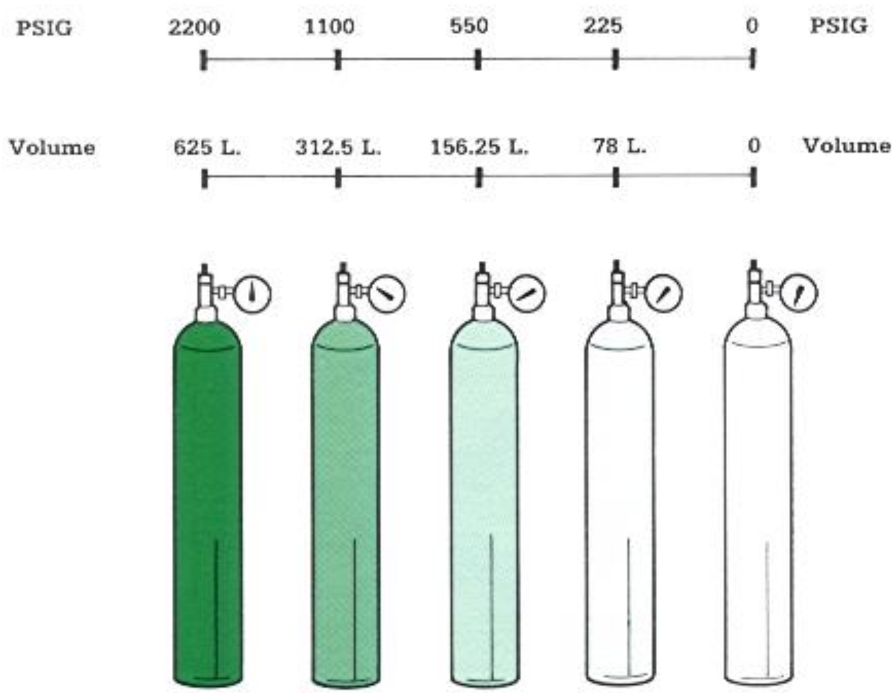

O_2
N_2O
Agent
Wall Supply Nitrous Oxide Pipeline Inlet
Wall Supply Oxygen Pipeline Inlet
Calibrated Vaporizer(s)
Power Outlet to Ventilator
Flowmeters
Outlet Check Valve
Floats
Flow Control Knobs
Second Stage Regulator
Cylinder Pressure Regulator
N_2O Hanger Yoke with Check Valves
Cylinder Pressure Regulator
Machine Outlet
Pressure Sensor Shutoff Valve
Oxygen Flush Valve
O_2 Hanger Yoke with Check Valves
Oxygen Supply Failure Alarm System



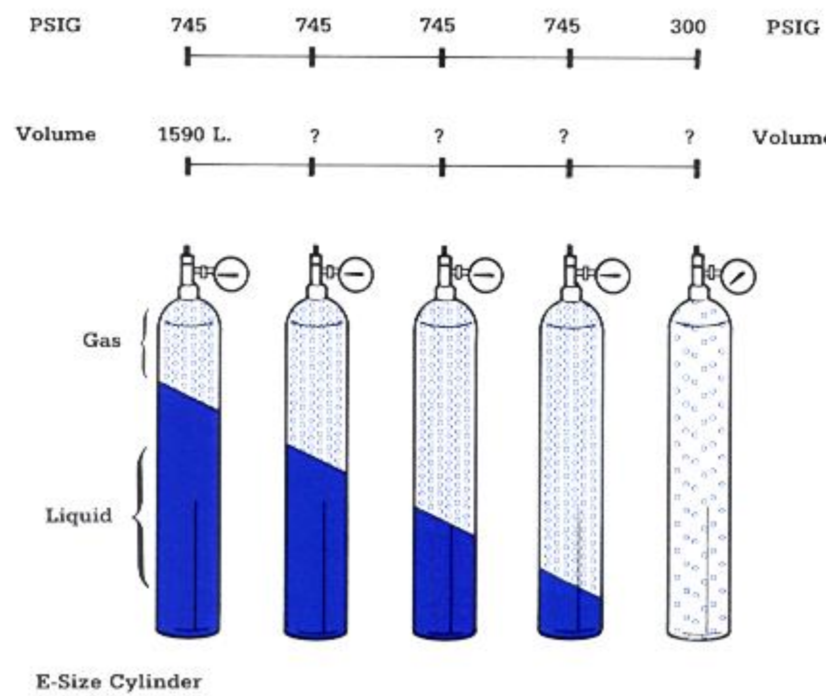
Hanger Yokes (Pin-Indexed for N_2O with N_2O Cylinder Supply Gauge
Flowmeters with Flow Control Valves
O_2 Second Stage Pressure Regulator
Common Manifold
Nitrous Oxide Pipeline Inlet with Check Valve
Calibrated Vaporizer(s)
Oxygen Pipeline Inlet with Check Valve
Power Outlet to Ventilator
Hanger Yokes (Pin-Indexed for O_2) with O_2 Cylinder Supply Gauge
Cylinder Pressure Regulator
Pressure-Sensor Shutoff Valve
Outlet Check Valve
Oxygen Flush Valve
Machine Outlet
APL Valve
Oxygen Supply Failure Alarm System
Connection for Scavenging System
Exhalation Check Valve
Absorber
Connection for Rebreathing Bag
Inhalation Check Valve
O_2
N_2O
Agent

Gas Supply

- House Gas Supply (recommended)
  - Oxygen (Green) - 50 PSI
  - Medical Air (Yellow) – 50 PSI
  - Nitrous Oxide (Blue) - 50 PSI
- House Gas Supply (Hartman recommended)
  - Oxygen (Green) – 53-55 PSI
  - Medical Air (Yellow) – 51-53 PSI
  - Nitrous Oxide (Blue) – 48-51 PSI
- Cylinder Gas Supply
  - Oxygen (Green) – 2200 full – 500 replace
  - Nitrous Oxide (Blue) – 745 full – 0 replace



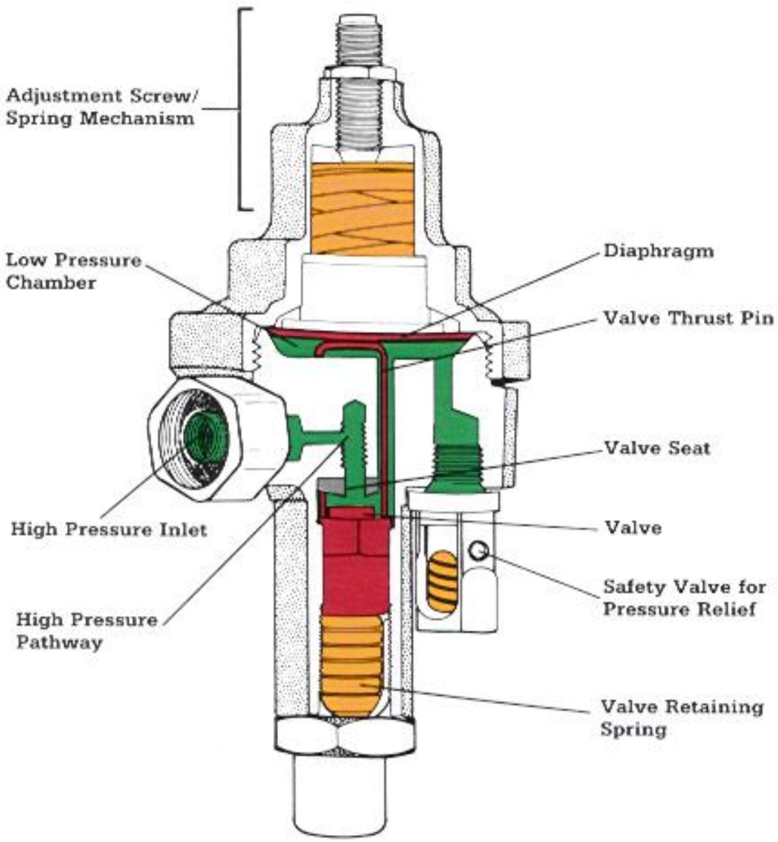
Oxygen



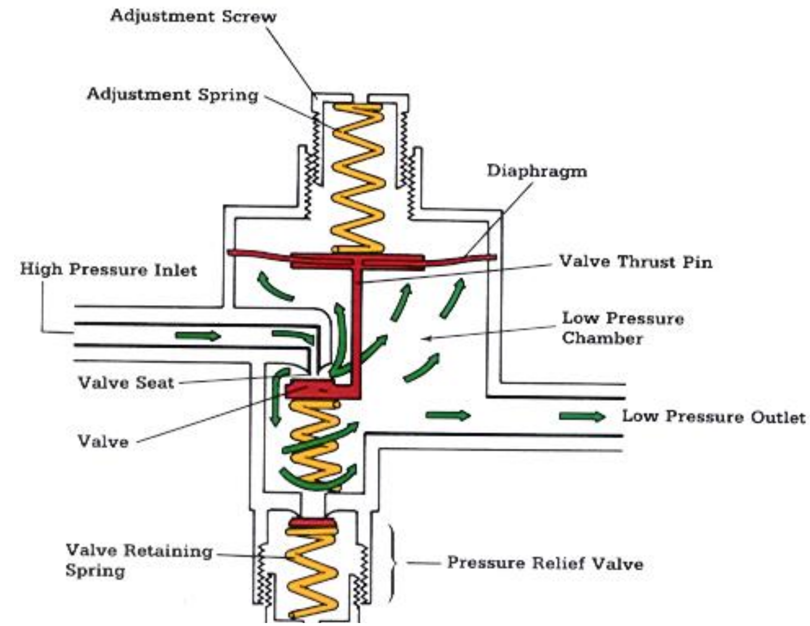
Nitrous Oxide

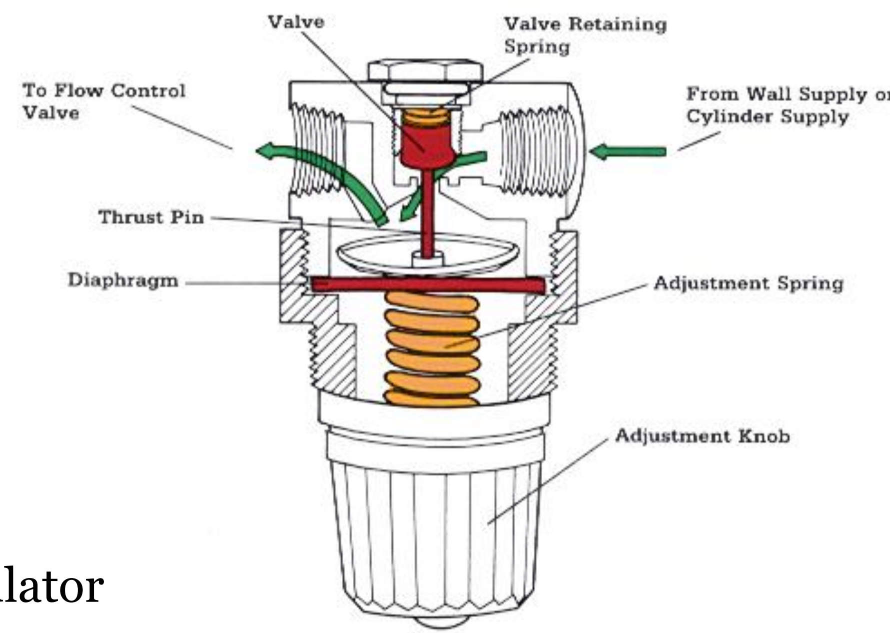
Pressure Regulators

- Reduce gas pressure from high pressure to low pressure
- Regulator will only maintain outlet pressure in set flow (L/min) range
- As gas enters regulator, the diagram is pushed outward closing off the inlet gas flow
- As gas exits the pressure regulator, the tension spring pushes down on the diagram, opening gas to flow into the regulator
- Over time, the pressure stabilizes, creating a constant output gas pressure
- To increase outlet pressure, the spring tension is increased
- To decrease outlet pressure, the spring tension is decreased
- Some regulators have a pressure relief valve to open in the event of regulator failure, preventing high pressure gas to the regulator outlet



Pressure Regulator





Secondary Regulator

Pressure-Sensor Shutoff Valve

- If 50 PSI oxygen pressure is not available, then all other gases (nitrous oxide, medical air,…) is turned off and not available to flow meters
- Valve opening/closing is controlled by 50 PSI oxygen pressure
- 50 PSI oxygen pressure pushes down on diaphragm, moving thrust pin, causing the valve to open
- If oxygen pressure is less than 50 PSI, the valve seat sets and closes off the other gas

Flow Meters

- Single control for each gas
- Each flow control next to a flow indicator
- Uniquely shaped oxygen flow control knob
- Valve stops (or some other mechanism) are required such that excessive rotation will not damage the flow meter.
- Oxygen flow indicator is to the right side of a flow meter bank
- Oxygen enters the common manifold downstream of other gases
- Read top of float or center of ball
- Gas concentration of oxygen is based upon the ratio of all gasses flowing - Examples:
  - 3 L/min Oxygen, 2 L/min N_2O O_2 Concentration = 3/5 X 100 = 60%
  - 2L/min Oxygen, 2 L/min N_2O O_2 Concentration = 2/4 X 100 = 50%
  - 1 L/min Oxygen, 2 L/min N_2O O_2 Concentration = 1/3 X 100 = 33%

Hypoxic Gas Flow Control

- A hypoxic guard system must protect against less than 21% inspired oxygen if nitrous oxide is in use.
- With oxygen and nitrous oxide flowing:
  - If the nitrous oxide is increased, the system must increase the oxygen flow to maintain 21% oxygen to the patient
  - If the oxygen is decreased, the system must decrease the nitrous oxide flow to maintain 21% oxygen to the patient
- One method uses a mechanical system, using gears and a chain drive system
- Another method uses a pneumatic control valve – Oxygen Ratio Controller (ORC) valve

Common Manifold

- The common manifold is located at the top of the flow meters
- The first location where oxygen and other gases (nitrous oxide, medical air, ….) are mixed together
- Mixed gasses leave the common manifold and travel to the vaporizers
- Oxygen enters the common manifold downstream of other gases

Vaporizers

- Controls the narcotic gas (agent) concentration being delivered to the patient
- Vaporizer is designed for one specific agent
- Never mix different agents in a vaporizer
- Agent is in a liquid form, then converted to a gas in the vaporizer
- Concentration range is 0-10%, normally used in the 2-4% range
- Concentration-calibrated
- An interlock must be present
- Liquid level indicated, designed to prevent overfilling
- Keyed-filler devices are recommended
- No discharge of liquid anesthetic occurs from the vaporizer even at maximum fresh gas flow

Oxygen Flush Valve

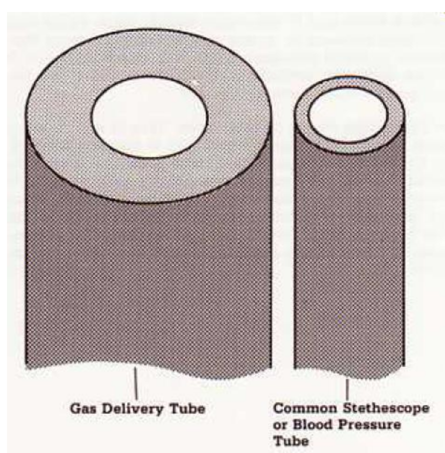
- Valve creates a high oxygen flow to the machine outlet
- Oxygen flow at the common gas outlet is capable of 35-75 L/min
- The valve is manually operated
  - Depressing it will create the flow
  - Resting position will have the spring close the valve
- When depressed, the oxygen flow will check the check valve, thus preventing any mixed gas flow to the common gas outlet (Nitrous Oxide and Agent gas flow will be stopped)

Check Valve

- Only permits gas flow in one direction
- Prevents any gas flow from the patient circuit from going back into the gas machine
- When the oxygen flush valve is depressed, the pressure and flow from the oxygen flush valve will check the valve, thus preventing and flow from the vaporizers to exit the machine

Machine Fresh Gas Outlet

- The outlet of the gas machine that supplies the gas to the patient circuit.
- Gases are mixed (Oxygen, Nitrous Oxide and Agent)
- Only one common gas outlet at 22 mm outer diameter, 15 mm inner diameter, which is designed to prevent accidental disconnection
- Tubing sizes - scavenger 19 or 30 mm, ETT or common gas outlet (CGO) 15 mm, breathing circuit 22 mm.



Patient Circuit

- The patient circuit is external to the gas machine.
- It provides a closed re-circulating circuit that allows anesthetic gases to be reused.
- It contains an absorber which removes carbon dioxide (CO_2) from the patient's exhaled gas.
- It controls the patient lung pressure.
- It contains inhalation and exhalation valves that are connected to the patient tubing circuit.
- It contains the sampling ports for: O_2 concentration patient supply, end title CO, and title volume
- It has connections for manual and automatic ventilation
- Pressure in the breathing circuit is limited to 125 cm water.

Patient Circuit

- Additional monitoring sensors/controls are located within the patient circuit
  - Oxygen Concentration – the Oxygen concentration being delivered to the patient, located on the inhalation valve
  - End Title Carbon Dioxide (CO_2) – The patients exhaled carbon dioxide level, measured at the tubing "Y" connector
  - Volume Flow – The volume (Liters) of gas delivered to the patient lungs, measured at the exhalation valve
  - Manual/Automatic Selector Valve – Selects the patient bag or ventilator for mechanical ventilation of the patient
  - Pressure Gauge – Indicates the patient lung pressure, measured at either the absorber or patient tubing circuit
  - Positive End Exhalation Pressure Valve – Controls the maximum patient lung pressure and vents the excessive gas to the scavenging system, located by the exhalation valve
  - Absorber Granules – Remove carbon dioxide exhaled from the patient

Scavenging System

- Waste gases from the patient (patient circuit) are safely removed from the circuit and evacuated from the room. This prevents the waste gas from being mixed with the room air and exposing workers to the patient's waste gases.
- OSHA Fact Sheet (1991) on Waste Anesthetic Gases (WAGs) gives the NIOSH recommendation to OSHA - occupational exposure should be limited to (an eight hour time-weighted average of) not more than 2 ppm halogenated agents (0.5 ppm if nitrous oxide in use), and not more than 25 ppm nitrous oxide.

General Medical Equipment

Apnea Monitor

- Used to measure the absence of breathing
- ECG electrodes are placed on the patient's chest (very similar to an ECG monitor)
- Respiration is measured by the changes in the chest impedance as the diaphragm is extended and relaxed
- A minimum respiration rate is set, and any rate below that will cause an alarm
- First medical device to require protected lead wires
- Could be used in acute care, long term care, or outpatient setting

Audiometers

- Measure and characterize hearing loss by determining an individual's hearing threshold (the lowest audible sound to which the individual will respond 50% of the time) for pure tones and speech and then comparing that threshold with a standard range of normal threshold values

Audiometers

- Tests would include:
  - Frequency
  - Sound pressure (db meter)
- Background noise must me minimized while doing testing
- Portable Units and Sound Booths

Bed (electric)

- Features
  - Low Height for Patient Ingress/Egress
  - Head/Knee/Foot position
  - Patient Position Monitor
  - Sleep Surface
  - Side rail and foot board controls
  - In-Bed Scale
  - Trendelenburg – Head lower than the feet
  - Reverse Trendelenburg – Head higher than the feet
  - Communication (phone/TV/Nurse call/light)
  - Casters with locks
  - Powered drive wheels
  - Accessories – IV pole, Shelf, Oxygen Cylinder storage

Bone Densitometers

- Unit that assess bone mineral content (BMC) in the axial skeleton
- Primarily used to detect quantitative decreases in bone mass related to metabolic bone diseases such as osteoporosis
- Non-invasive measurement
- Measurement can be done by:
  - Dual-energy x-ray absorptiometry (DXA or DEXA) uses a dual-energy x-ray source
  - Ultrasonic that measures broadband ultrasonic attenuation (BUA) speed of sound (SOS)
  - CT Scanner

Cast Cutter

- Used to remove plaster and fiberglass web casts
- Blade does not rotate, it oscillates
- Vacuum canister for dust
- High leakage current possible from dust
- Brushes may require cleaning or replacement on regular schedule

Capnographs - Carbon Dioxide Monitors (CO_2)

- Used to measure:
  - carbon dioxide (CO_2) using infrared (IR) spectroscopy (End-tidal carbon dioxide)
  - nitrous oxide (N_2O)
  - oxygen (O_2)
- CO_2 monitors are used primarily in the operating room to monitor patients during anesthesia, alerting clinicians to inadequate ventilation, patient-circuit disconnections, and airway leaks.
- CO_2 monitoring can also detect ventilator failure and the inadvertent placement of the endotracheal tube in the esophagus and can assess the adequacy of perfusion during cardiopulmonary resuscitation.

Capnographs - Carbon Dioxide Monitors (CO_2)

- The two basic types of CO_2 monitors
  - Capnometers continuously measure CO_2 and display discrete numeric values, usually $ETCO_2$ and respiration rate
  - Capnographs measure CO_2 during each inspiratory/expiratory cycle and display both a CO_2 waveform and numeric data.

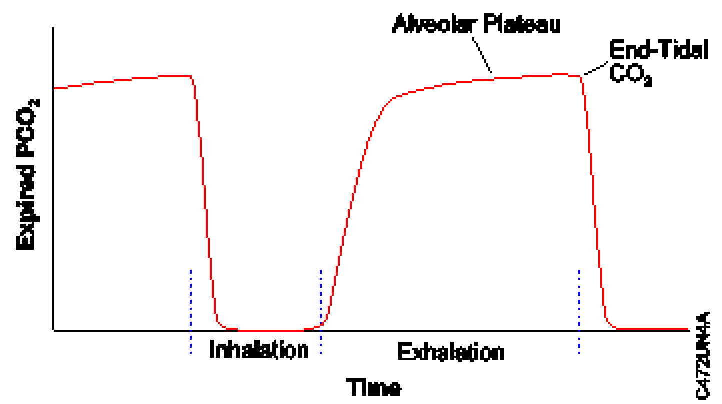
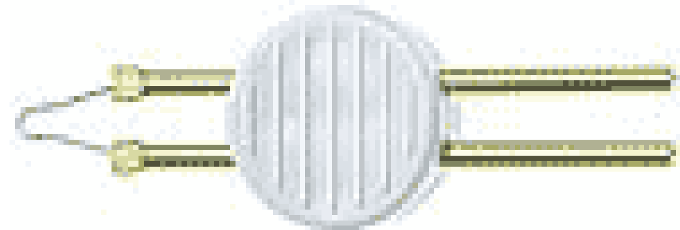


Figure 1. A normal CO_2 waveform.

Capnographs - Carbon Dioxide Monitors (CO_2)

- CO_2 monitors use IR absorption spectroscopy to measure partial pressure of carbon dioxide (PCO_2) in an exhaled breath.
- Of the commonly respired gases, only CO_2 and water vapor selectively absorb specific wavelengths of IR light.
- Because the amount of IR light absorbed is proportional to the absorbing molecule's (CO_2) concentration, the sample's CO_2 concentration can be determined by comparing its absorbance to that of a standard of known concentration.
- The CO_2 measured by the monitor is usually expressed as a partial pressure in mm Hg or torr
- Some units display the percentage of CO_2 by dividing the PCO_2 by the atmospheric pressure. For example, if the PCO_2 is 38 mm Hg and the atmospheric pressure is 760 mm Hg, the percentage of CO_2 is 5.



Electrocautery Unit

- Used for coagulation
- Tip is heated several hundred degrees and is placed on tissue to stop bleeding
- Low voltage is supplied to the heating element to prevent electrical shock and reduce leakage current

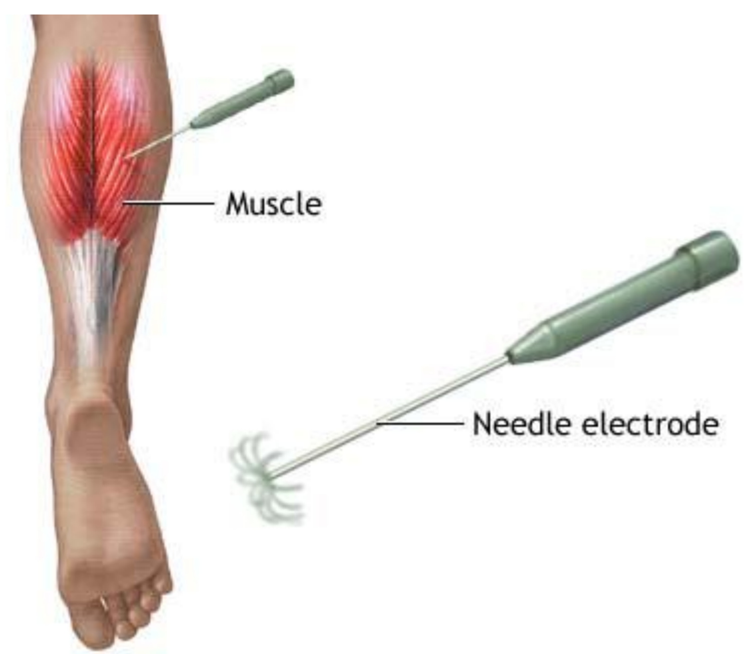
Electromyography (EMG)

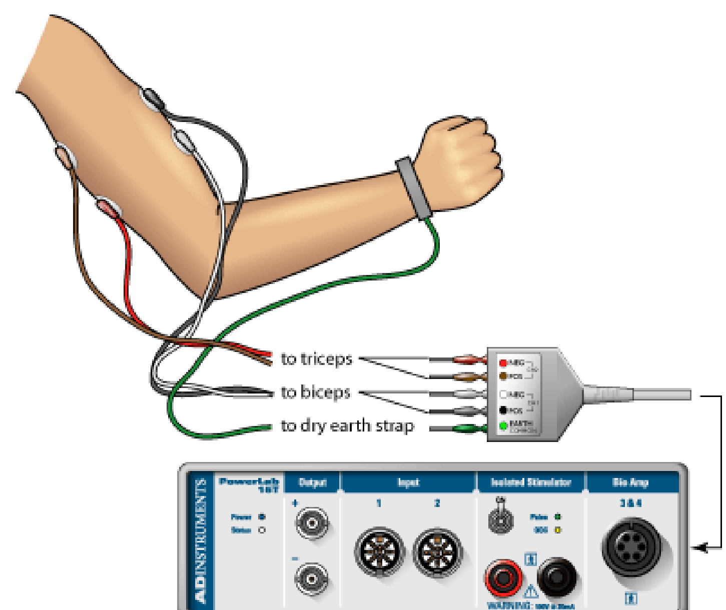
- Used for nerve conduction analysis
- Electrodes are inserted on or in the skin at both sides of the nerve in question
- The distance between the electrodes is measured
- A stimulus is generated at one electrode, the nerve is stimulated and the travel time is measured to the second electrode
- Measured time is then compared to normal travel time

Electromyography (EMG)

There are several types of nerves but generally speaking, the 2 major types:

- Motor nerves carry signals from the brain to the muscle to enable contraction and movement
- Sensory nerves relay information to the brain



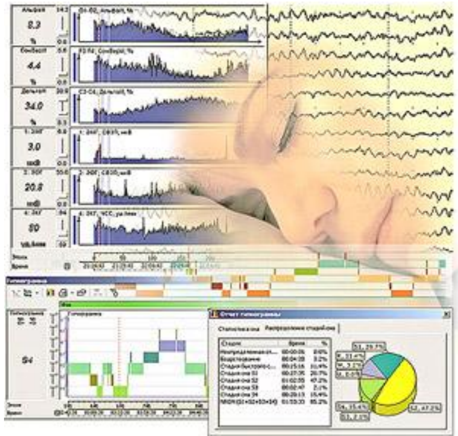


Electroconvulsive Therapy (ECT)

- ECT is a medical procedure in which a small, carefully controlled amount of electric current is passed through the patient's brain
- It is usually used to treat symptoms associated with certain mental disorders
- Electric current produces a convulsion for the relief of symptoms associated with such mental illnesses as major depressive disorder, bipolar disorder, acute psychosis, catatonia, major depression, mania, and occasionally for schizophrenia

Electroencephalographs (EEG)

- Electrodes are placed on a patient's scalp to measure, amplify, display in graphic form, and record the weak electrical signals generated by the brain
- EEG is useful in observing and diagnosing a variety of neurologic conditions, including epilepsy, related convulsive disorders, and brain death.



Electroencephalographs (EEG)

- It can also be used to evaluate psychiatric disorders and differentiate among various psychiatric and neurologic conditions.
- In addition, EEG studies can assist in localizing tumors or lesions on or near the surface of the brain.
- Diagnostic EEG studies are usually performed in an outpatient laboratory or neurology suite.

Fetal monitors

- Used to detect, display, and print a record of fetal heart rate.
- monitoring can be performed indirectly, by applying an ultrasound transducer to the mother's abdomen
- Monitoring can also be done directly, by attaching an electrode assembly to the fetus after rupture of the amniotic membranes
- Uterine contractions can be recorded simultaneously by placing a pressure transducer on the mother's abdomen or by directly measuring the change in pressure within the uterus with a catheter.

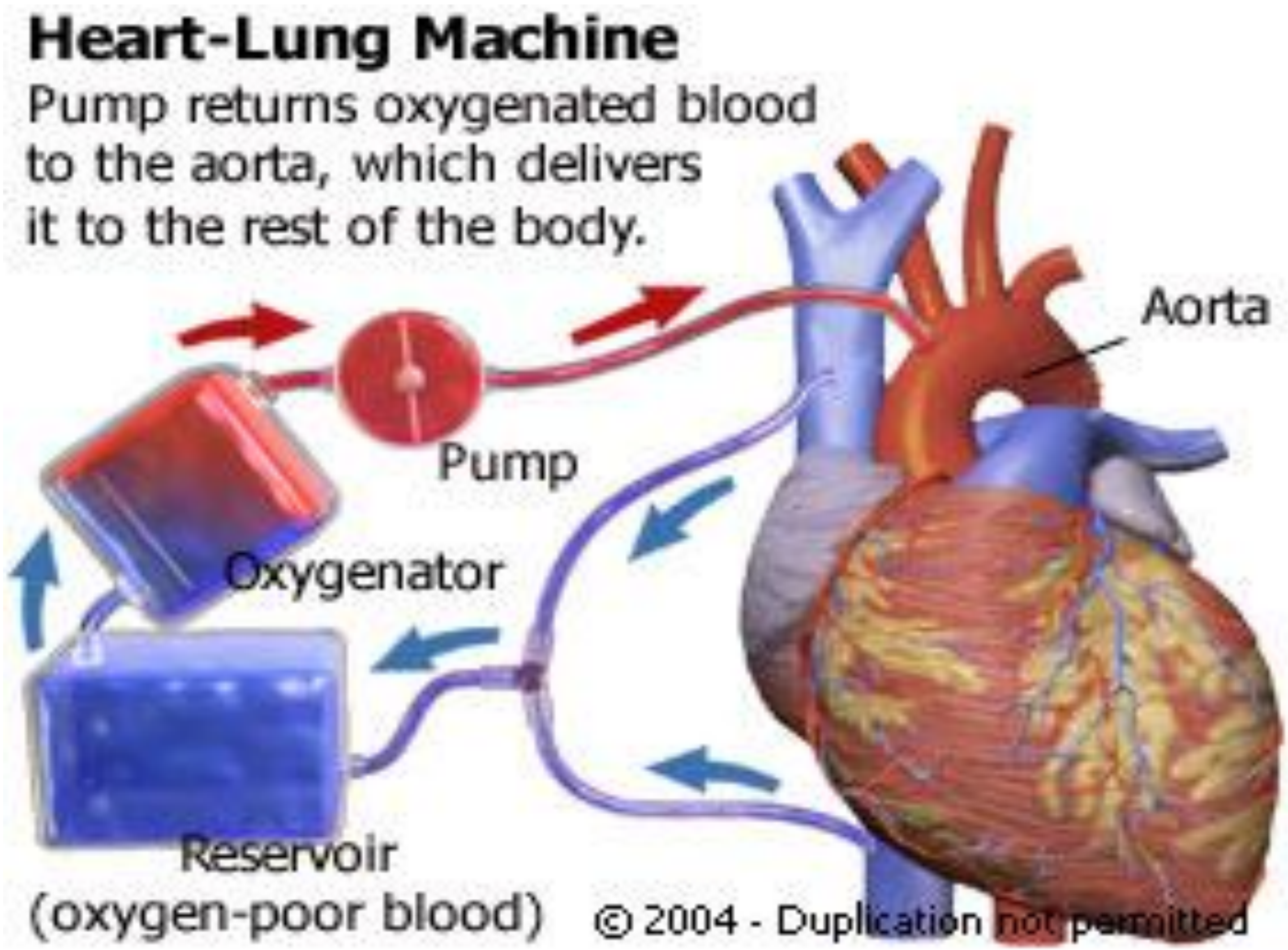
Heating Pads

- Used to warm a hypothermic patient
- Unit circulates water in a disposable pad placed under the patient
- The water is heated in the unit with a simple electric heating element and controlled by a thermostat
- There is a pump to circulate the water
- Alarm for high water temperature
- Water used should be distilled

Heart-Lung Bypass Machines

- Machines are used for cardiac surgery, when the surgeon needs the heart to remain still
- The machine performs 2 main functions:
  - Circulation of the blood in the patient (replaces heart)
  - Respiration – Oxygen/Carbon Dioxide exchange (replaces lungs)
  - Blue blood withdrawn from upper chambers of heart and sent to reservoir.
  - Blood travels from reservoir to artificial lung for oxygenation.
  - Newly re-oxygenated red blood pumped back to patient with tube connected to the arterial circulation.

Heart-Lung Bypass Machines



Hot (Hydrocollator)/Cold Pack Units

- Heats or cools packs used in physical therapy departments
- Uses a 150 Volt heating coil, controlled by a thermostat
- Cool pack units use a refrigeration system
- High leakage current could result from water mineral buildup

Hypo/Hyperthermia Units

- Used to warm or cool a patient
- A blanket is placed under the patient and warm/cool water is circulated through it
- Automatic mode – Temperature probe placed on the patient and the device is set to a desired temperature. It produces more or less heating/cooling to achieve the desired set point

Hypo/Hyperthermia Units

- Manual mode – The device simply heats/cools with out regards to a set point
- Over temperature alarm point prevents excessive heat and burns to the patient
- Tubing must mot be pinched to stop the flow of water
- Distilled water is desired to reduce the mineral content buildup on the internal components

Intermittent Compression Units

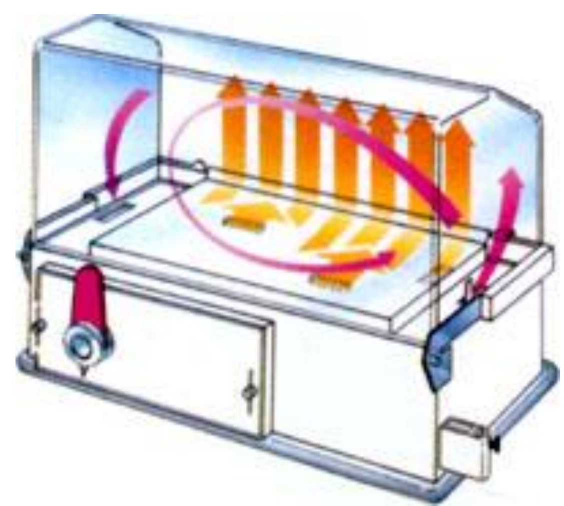
- Unit alternately apply and release pressure on a patient's arms, legs, or feet
- They can be used to minimize venous stasis during and immediately following surgery as well as during long periods of immobility, such as for a bedridden patient.

Incubators

- Provides a controlled environment for infants
  - Temperature
  - Humidity
  - Oxygen concentration
  - Air inlet filtration
- AC and DC powered (transport)
- Automatic mode – Temperature probe placed on the patient and the device is set to a desired temperature. It produces heating to achieve the desired set point

Incubators

- Oxygen concentration must be controlled with alarms and override switches in order to prevent oxygen concentration from exceeding 35%, this will prevent blindness to the patient
- Audible and visual alarms for over/ under temperature, power failure and other monitored features



Injectors (contrast Media)

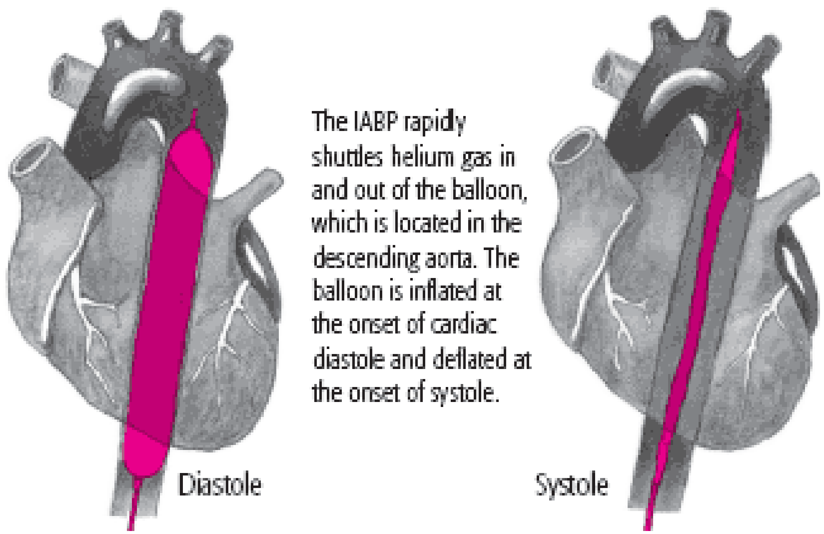
- Used for imaging to place a large bolus of a contract media into a patient for improved imaging
- Devices can be used in an automatic mode, where they are connected to the imaging equipment and signal to deliver the bolus is generated from the imaging system
- A large syringe is loaded into the injector, and a mechanical movement causes the plunger to be depressed, forcing the contrast out

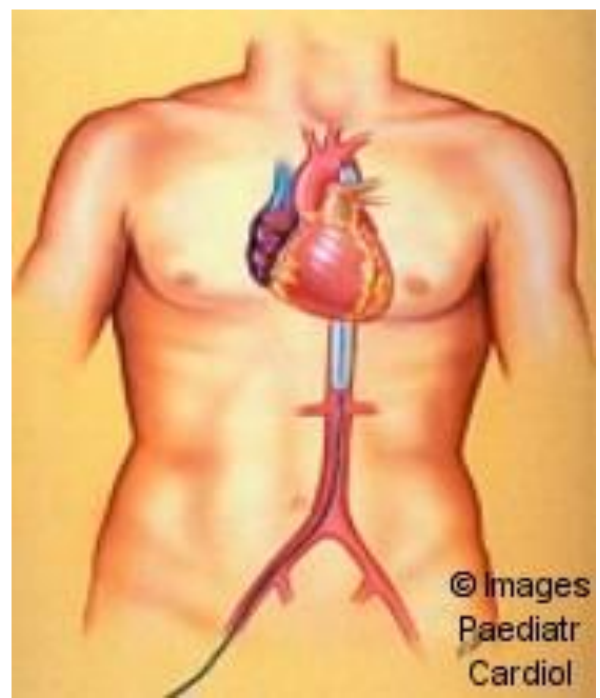
Intra-Aortic Balloon Pumps (IAPB)

- The IABP is a mechanical counterpulsation device that benefits the patient by reducing afterload (i.e., the pressure the heart must pump against) as well as increasing coronary and systemic blood flow
- A balloon is placed in the aorta, and its inflation and deflation results in a more favorable myocardial supply-and-demand balance
- This balance reduces afterload and augments the heart's diastolic pressure, leading to an increased cardiac output
- The balloon is cyclically inflated and deflated using helium shuttle gas kept in a storage compartment in the console.

Intra-Aortic Balloon Pumps (IAPB)

The IABP forces the blood toward the heart during each diastolic phase of the cardiac cycle. During this phase, the aortic valve is closed, and the blood is channeled into the coronary and carotid arteries, increasing coronary and cerebral perfusion





Linear Accelerator – Radiation Therapy

- Used to deliver a large dose of non-invasive radiation to a patient in order to destroy a very specific grouping of cells while saving others
- This is a non-invasive treatment system that requires the patient to receive several doses of radiation treatment over several days to several weeks
- Due to the intensity of the radiation beam, special design is required to shield the radiation from others

Linear Accelerator – Radiation Therapy

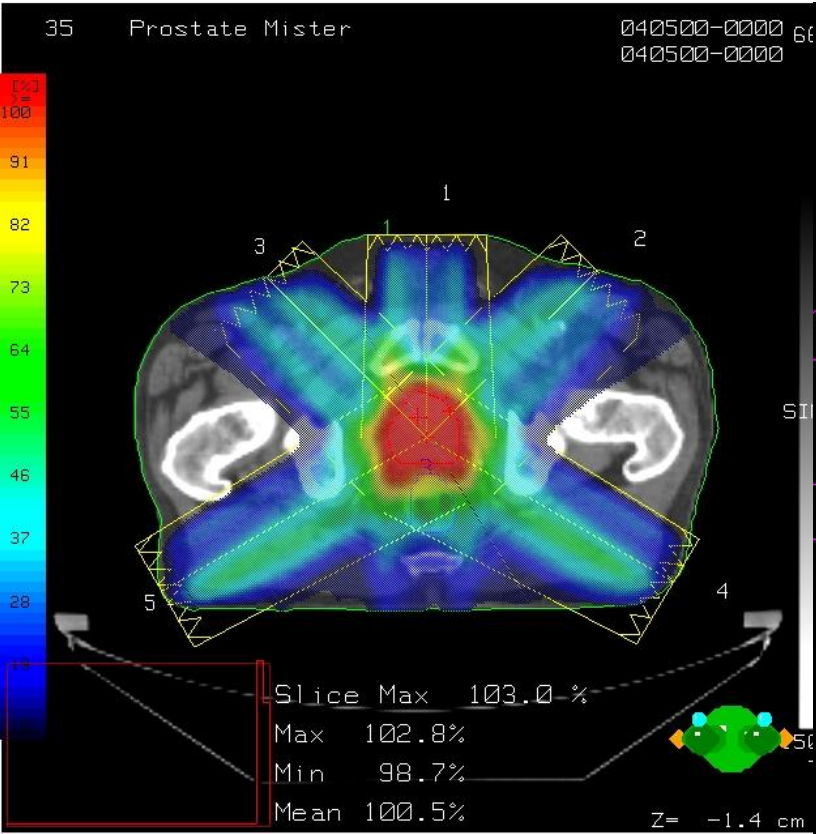
- There are 5 major components to radiation therapy:
  1. Simulator
  2. Treatment Planning
  3. Room Design
  4. Linear accelerator
  5. Intensity Modulated Radiotherapy (IMRT)

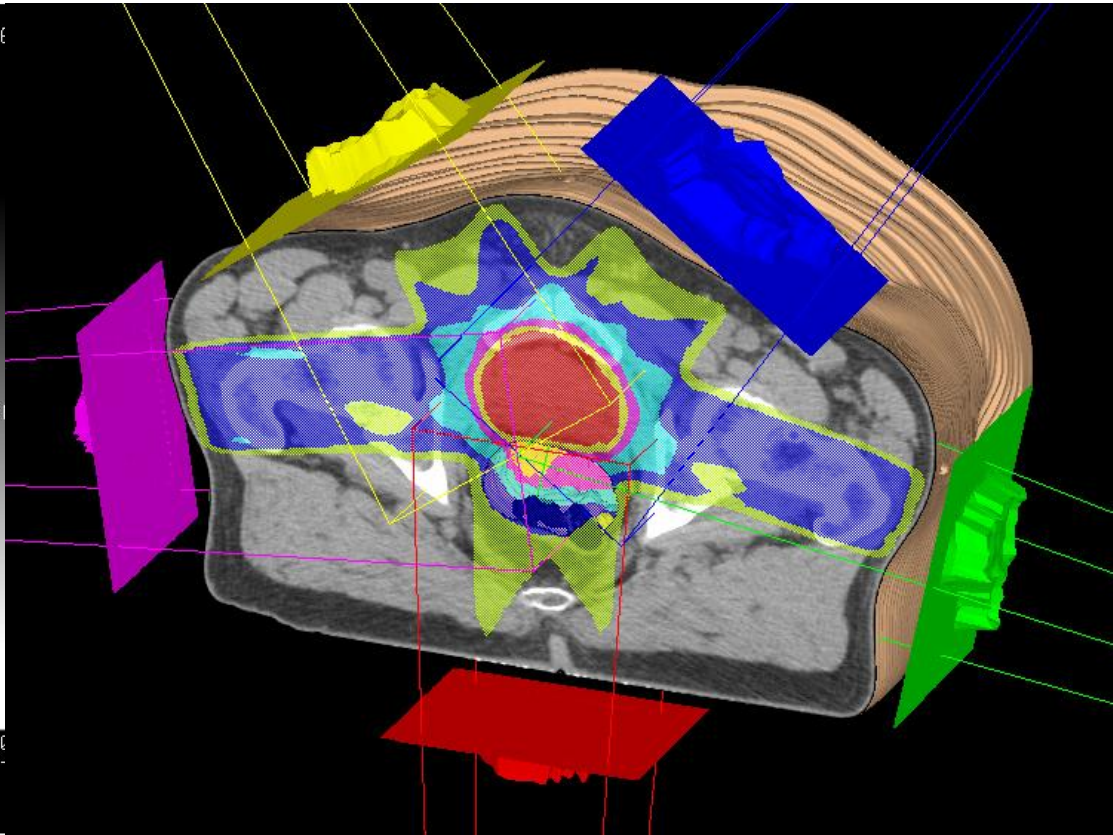
Linear Accelerator – Radiation Therapy

- Simulator: used to locate the tumor, with coordinates, shape and dimensions outputted to the linear accelerator and treatment planning system

Linear Accelerator – Radiation Therapy

- Treatment planning system: is a software based system that provides 3D modeling to determine dose, type and plan for radiation delivery



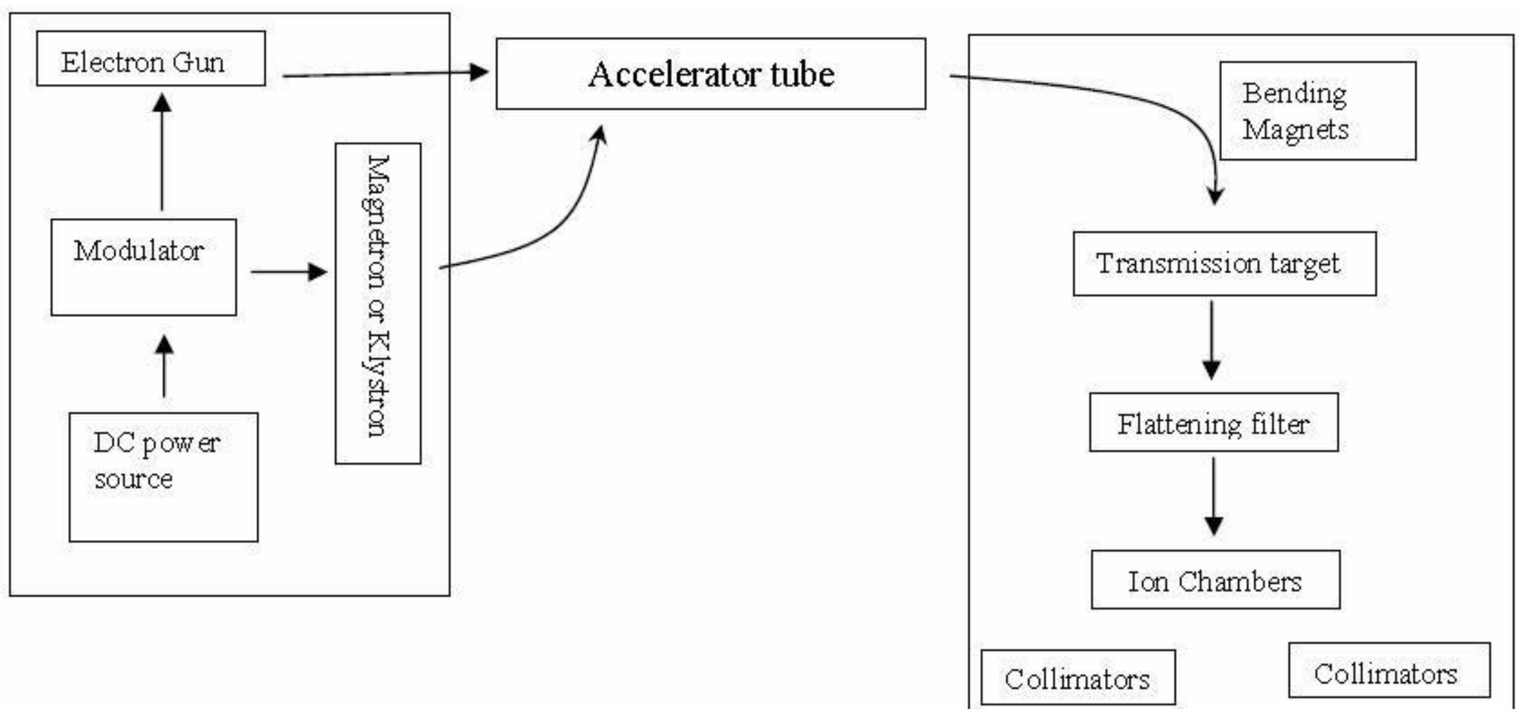


Linear Accelerator – Radiation Therapy

- Linear accelerator: is the machine that delivers the radiation to the patient

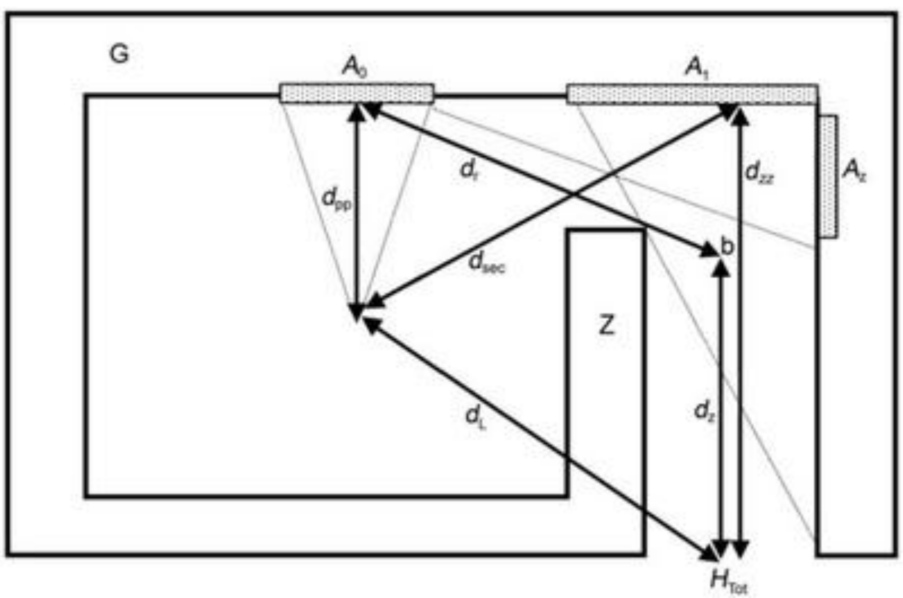
Linear Accelerator – Radiation Therapy

- Linear accelerator: is the machine that delivers the radiation to the patient



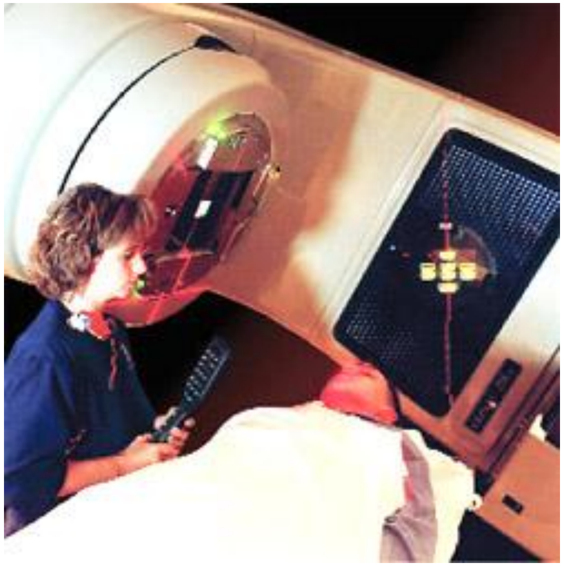
Linear Accelerator – Radiation Therapy

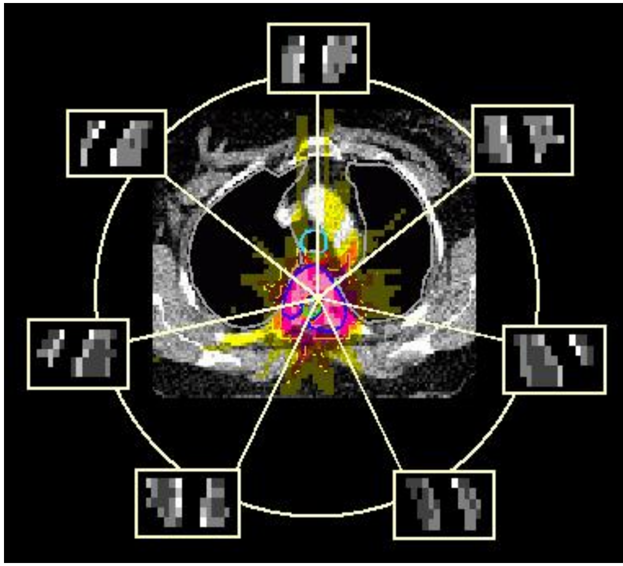
- Room Design: due to the extremely high intensity of the radiation beam, the room must be shielded to prevent radiation from leaving the room. Walls can be up to 6-10 feet wide concrete.



Linear Accelerator – Radiation Therapy

- Intensity Modulated Radiotherapy (IMRT) is a component that controls the delivery of the radiation, similar to a collimator for an x-ray machine





Article with Photos

Lithotripters

- Used to provide therapeutic delivery non-invasive energy to a patient by the use of extracorporeal shock wave to disintegrate kidney and urinary tract stones safely and effectively
- Imaging of the stones are required to verify size and position prior to use

Muscle Stimulator

- Used in physical therapy department to relax muscles
- Applies an electrical current that pulses the muscle, causing it to contract
- When removed, the muscle is no longer stimulated and should relax
- Could also be used for muscle development

Nebulizer

- Provides a moist air or aerosol medication for the patient to breath
- Water or medication is suspended in air and is still in the liquid state
- Ultrasound crystal is a common mode to "vibrate" liquid then suspend in air
- Used for breathing treatments

Nerve Stimulator

- Used to stimulate nerves during and after surgery
- Nerve responses give indication on amount of anesthetic and depth of sleep of patient
- Battery powered
- Portable hand held device
- Electrodes can be attached on device or electrodes/lead wires to patient
- Current output is in the 10's of ma
- Output can be bursts of pulses or single pulse

Oxygen Concentrators

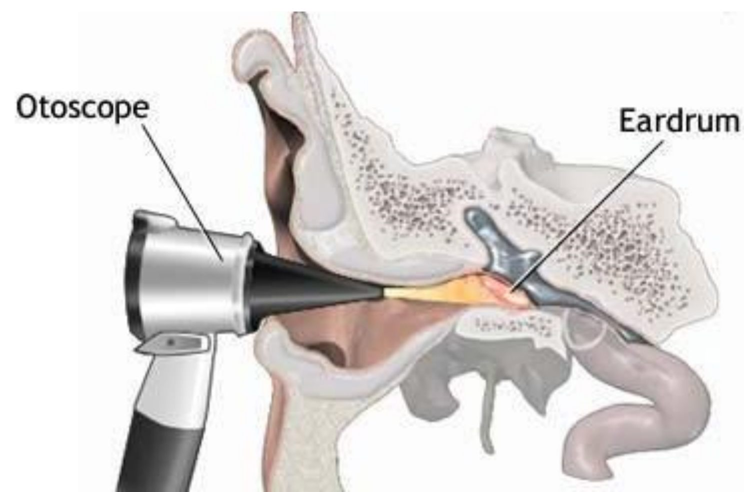
- Used to create pure oxygen (> 95%) from air
- Primarily used in the patients home or nursing home
- Saves on the cost of oxygen cylinders
- Several liters/minute can be achieved from an oxygen concentrator

Oxygen Monitor

- Measures the concentration of oxygen
- Normal air is at 21% oxygen
- Most use a disposable oxygen sensor, lasts several months
- Calibrate at 21% and 100%
- Alarms (low/high) are available on some models

Otoscope

- Used for examination of the ear
- Also used for the eyes and throat
- Can be wall mounted (AC) or portable (DC battery)



Oxygen-Air Proportioners

- Delivers a concentration of oxygen between 21-100%
- Connected to oxygen and medical air supplies (usually house supplies)
- Inlet and outlet pressure is 50 PSI
- Audible alarms for loss of either oxygen or medical air inlet pressure

Phacoemulsification Systems

- Phacoemulsification systems are used to break up and remove cataractous lenses of the eye
- A cataract is a foggy area in the normally transparent lens that inhibits the transmission of light to the retina and causes a painless blurring of vision
- The surgeon inserts a phacoemulsification probe, which consists of a hollow, cylindrical tip surrounded by an irrigation sleeve
- The probe tip, when electrically activated, oscillates rapidly, creating ultrasonic waves that cut tissue
- The surgeon emulsifies the cataractous lens using shaving or scooping motions of the probe
- The lens fragments are then aspirated from the eye through the hollow tip of the phacoemulsifier

Picture Archiving & Communication Systems

- A computerized network that provides data (image) display, storage, print and other networking functions
- Preferred communication method is the Digital Imaging and Communications in Medicine (DICOM) Standard that permits medical imaging equipment interconnection of devices on standard networks

Slit Lamps

- A slit lamp is a binocular microscope for detailed stereoscopic examination of the structures of the eye

- Used for routine eye examinations and emergency situations to examine and monitor normal eye health, observe and identify disease processes, fit contact lenses, aid in eye surgeries, and take ocular photographs

Smoke Evacuators

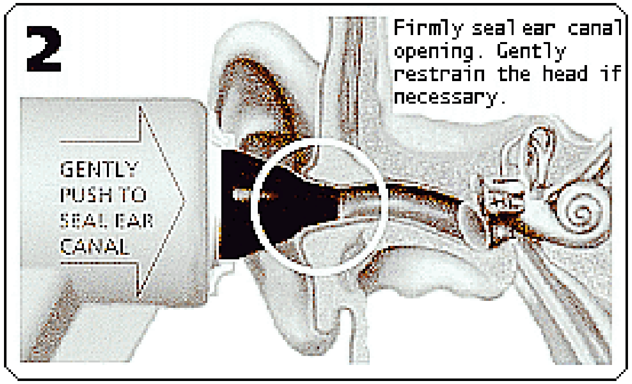
- Effectively removes and filters surgical smoke without creating excess noise in the OR
- Heppa-filters are used to remove the smoke
- Portable and house systems
- A small hood or small adapter attached to the ESU pencil captures smoke and odors directly at the surgical site

Thermometer

- Thermistor/thermocouple
  - Red probe – rectum
  - Blue probe – oral
  - Probe cover
  - 10's of seconds required for accurate probe to adjust to the temperature
  - Battery powered
  - Sensor to return to base (anti-thief)
  - Battery charger can be electrically connected or use transformer flux
  - Some have minute timer for nurse to measure heart rate

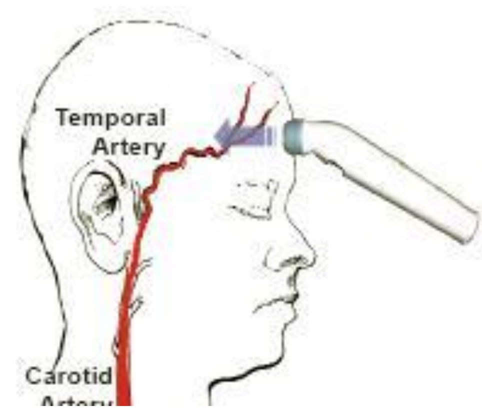
Thermometer

- Tympanic – Infrared (ear)
  - Probe cover
  - Battery powered
  - Measurement taken in several seconds, good for children and fast measurements
  - Sensor position and location is critical for reading
  - Sensor to return to base (anti-thief)



Thermometer

- Temporal Artery Thermometer
  - The temperature that you read is called "arterial temperature" and is the most accurate of all temperatures, since it comes from the heart
  - Infrared Sensor - thermopile sensor, silver-ion antimicrobial probe head
  - Fast response
  - As accurate as rectal temperatures



Traction Unit/Table

- Used in physical therapy department for stretching the patient's body
- Used to relax muscles
- Timers and force are checked on PM

Treadmill

- Provides a variable speed and variable slope walking surface
- Used for cardiac evaluation studies and cardiac exercise
- Manual speed control
- Automatic – preprogrammed settings for walker warm-up, work/demand and cool down, interfaces with patient ECG system
- Emergency stop
- Weight limit, belt with and speed/slope calibration
- Interface/control with ECG evaluation system

TENS Units

- Transcutaneous electrical nerve stimulation (TENS) units
- TENS units relieve acute and chronic pain associated with surgery, trauma, musculoskeletal problems, bursitis, and dental problems and procedures
- TENS units also provide pain relief in the course of physical therapy, during labor and delivery, and before and during menstruation
- These portable, battery-powered units are lightweight and are commonly worn on a belt or carried in a pocket

Ultrasound, Therapy Device

- Used in physical therapy to produce an ultrasonic sound wave used on the patient for providing therapy to injured soft tissue (muscle, tendons, ligaments, etc.)
- Control panel and display signal show treatment modes, times, power units and power output intensity.
- Self-tuning circuitry continuously tunes the generator to the transducer applicator crystal
- Output energy must be measured with a specific ultrasound analyzer using de-gassed water

View Boxes

- Device used to view x-ray film by the use of back lighting film
- Various types
  - Fixed panel
  - Multi-viewer
  - Digital
  - Mammography specific
- Light output, quality, distribution
- Shutters to block excess light
- Film held with roller gravity grips

Whirlpool

- Used in physical therapy departments
- Can be full size body or portable unit
- AC powered (Class W – GFCI required)
- Impeller circulates water and has a high pressure discharge output
- Air mix port for additional force
- Bearings are common failure, do not run out of water
- Cleaning of impeller is routinely required

Networking

TCP/IP Protocol

- The Transmission Control Protocol/Internet Protocol (TCP/IP) was created that set standards fro the basic requirements of:
  - How networked computers are named and addresses
  - How messages are routed across multiple sub networks
  - How diverse networks are connected together
- Early use of the network was limited to:
  - Universities
  - Government agencies
  - Defense contractors

World Wide Web

- The World Wide Web (WWW) was created in the mid 80's and growth shifted towards commercial sites
- Commercial networks began to take control
- The original network was phased out in the mid 90's
- Today the WWW is the most popular Wide Area Network (WAN)

LAN - Local area network

- When the personal computers started, they were designed for homes and small offices, not massive corporate networks
- LANs became the network of choice for the small and medium sized business
- 3Com and Novell were the two companies who created the hardware for connecting computers to a network by using Ethernet cards
- IBM created their own LAN method, called Token Ring
- AT&T created it's StarLAN and other protocols

WAN - Wide area network

- This refers to the connection of many different LAN networks
- The Internet is simply a connection of many different networks, which becomes a WAN
- The internet is the umbrella to identify every computer connected to it and help determine the routes between computers
- Ethernet is the most common method used to transmit the data
- TCP/IP is the most common protocol (language) used

Public network – Internet

- This is a public network of computers
- In most cases, this is the Internet
- You need access to the network by some provider
- The Internet requires the TCP/IP protocol
- Additional equipment will be required to protect your private network from the public network, such as routers and firewalls

Pieces of a network

- Media - physical medium for transporting information from one point to another.
- Examples of media include:
  - Wire — Fiber-optics
  - RF Wireless — Satellite
  - Hubs — Switches
  - Routers — Modems

- Protocols - sets of rules for managing data
  - They define when each side of a communication can send and receive data
  - How errors are dealt with
  - Must understand addresses
  - TCP/IP - Transmission Control Protocol / Internet Protocol is how data is sent on the Internet

Pieces of a network

- Applications
  - Are what use the network to communicate
    - WEB browsers Email Chat programs
  - Network applications perform by making a request for service

- Client – is the application that makes a requests for a service

- Server – is the application that receives the requests and supplies information

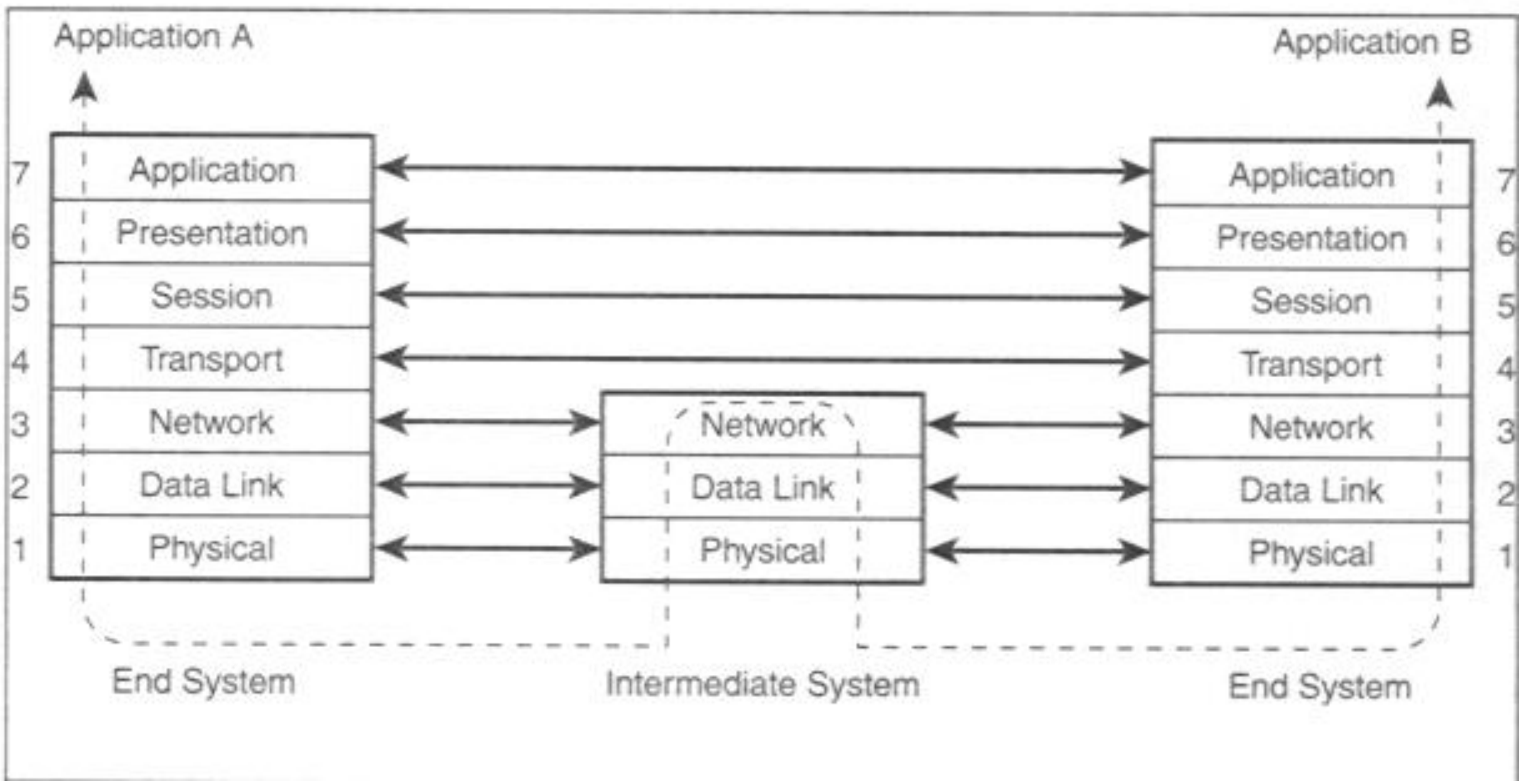
- Client Computer - is also a workstation that makes the request. This could be many different people from many different locations.

- Server Computer – is the computer that provides the data. This could be one or more servers in a computer center

Client - The application that requests a service. Workstation is a client.

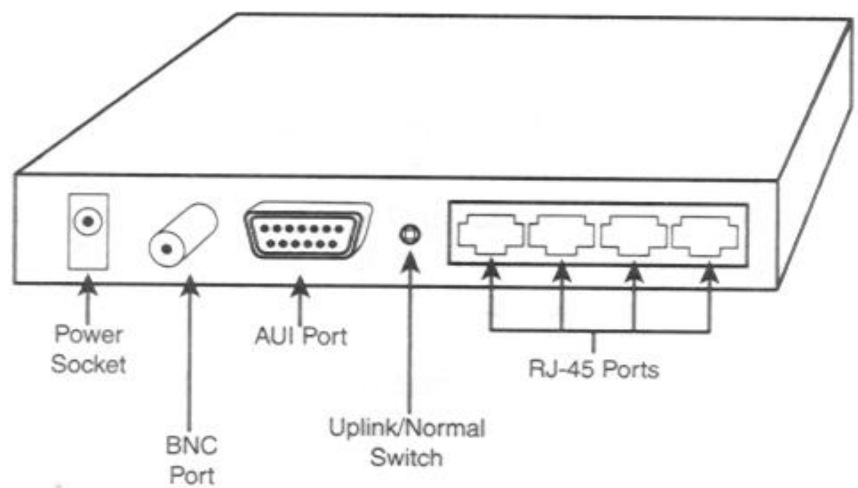
Provider - The computer that receives the request for information. A server is a provider.

Network Layering and the OSI Model



Having your own network LAN

HUB – Is the connecting point for the wires from the computer's NIC cards. It is the most common method of joining wires that make up a small LAN. A HUB could be optional, as you could connect one computer to another or in a chain using coax cable. Most LANs connect using HUBs.



NIC for each computer

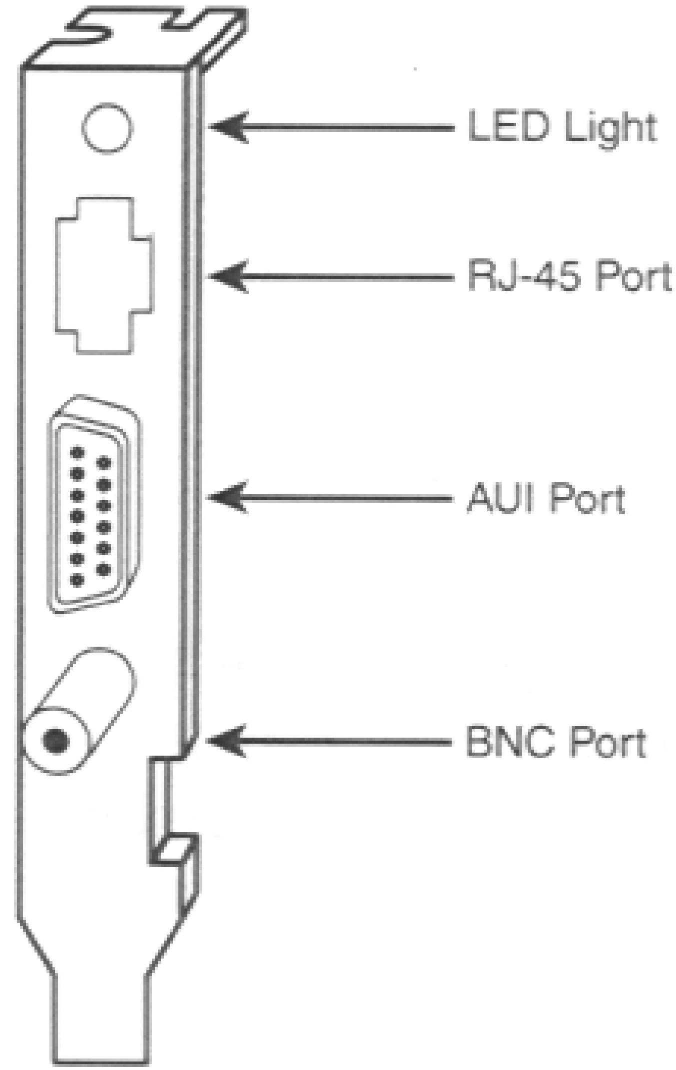
NICs are defined for each computer by their:

- Transmission speed – the most common speeds are 10/100 M Bits per second (MBPS), with new technology operating at faster speeds. If a card is marked at 10/100, it has the auto sensing capability to work at either speed.
- Connections/Cabling – the most common connection is an RJ-45 port, but it could have an AUI or BNC port in addition to or stand alone.
- NICs – can be a stand alone card that is installed into the computer, or most new PCs have a network port built directly into the

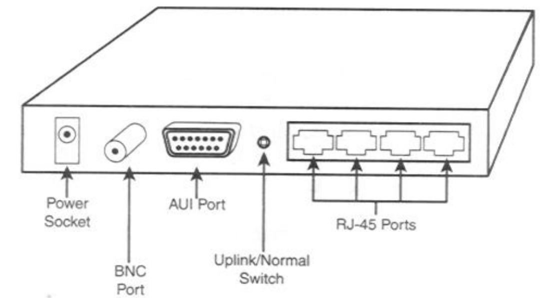
NIC for each computer

- Led Indicates that data is being sent or received
- Three types of ports could be available:
  - RJ45
  - AUI
  - BNC
  - Fiber Port (more expensive)

- There maybe software drivers required to operate the NIC. This is based upon the operating system type.



HUB for a LAN



- Ports
  - Most have between 2 to 24
  - Most popular are RJ45 ports
  - May have one AUI or BNC to connect to other HUBS
  - Could have fiber ports (more expensive types)
- Leds
  - One for each port
  - Indicates that data is being sent or received – blinks on-Off or changes color
- Uplink Switch
  - Changes one of the ports from a normal to a cross-over connection. This allows:
    - Connection of several HUBs with out special cross over cables
    - Connection to a cable modem without a cross over cable

How an Ethernet Works

- Preamble – Verifies that this is a frame
- Destination address – Where is the frame going
- Source address – Where the frame came from
- Type – What protocol will get the data after it arrives

Ethernet Frame

8 bytes	6 bytes	6 bytes	2 bytes	46-1500 bytes	4 bytes
Preamble	Destination Address	Source Address	Type	Data	FCS

How an Ethernet Works

- Directing Traffic: CSMA/CD – Makes rules on how information is transmitted and errors are managed on Ethernet LAN
  - Carrier Sense: Is it safe to jump in – The NIC checks the status of the network an makes sure no other computer is using the network. There are 3 possible states:
    - Transmission State – If the network is in this state, the computer will wait till the transmission is completed, plus a propagation time (transmission time and quiet for a while)
    - Idle State – If the network is in this state, it begins transmission
    - Contention State – When 2 computer have transmitted data at the same time and both transmissions have been damaged, the network goes into a contention state.

How an Ethernet Works

- LAN Speeds
  - 10 million bits per second (10 Mbps)
  - 100 million bits per second (100 Mbps)
  - 1,000 million bits per second (1,000 Mbps)
- Base (method in which the signals are sent)
  - Baseband – one signal at one time (most common)
  - Broadband – multiple signals at one time
- Type of Physical Media
  - T is for Twisted Pair
  - 5 is for thicknet
  - 2 is for thinnet
  - FX is point to point fiber-optic cable

Table 2.1 Names of Ethernet Standards

Standard Name	Description
10BaseT	10Mbps on unshielded twisted-pair cable
100BaseFX	100Mbps on two-strand multimode fiber-optic cable
1000BaseT	1,000Mbps on Category 5 Unshielded Twisted Pair (UTP) wiring

How an Ethernet Works

- Measuring Distances for a LAN
  - Three most popular LANs at the 10 Mbps are:
    - 10BaseT – Twisted pair (RJ45)
    - 10Base2 – Buss style using a thinnet coxable cable (BNC connector)
    - 10Base5 - Buss style using a thicknet coxable cable (BNC connector)

The Internet

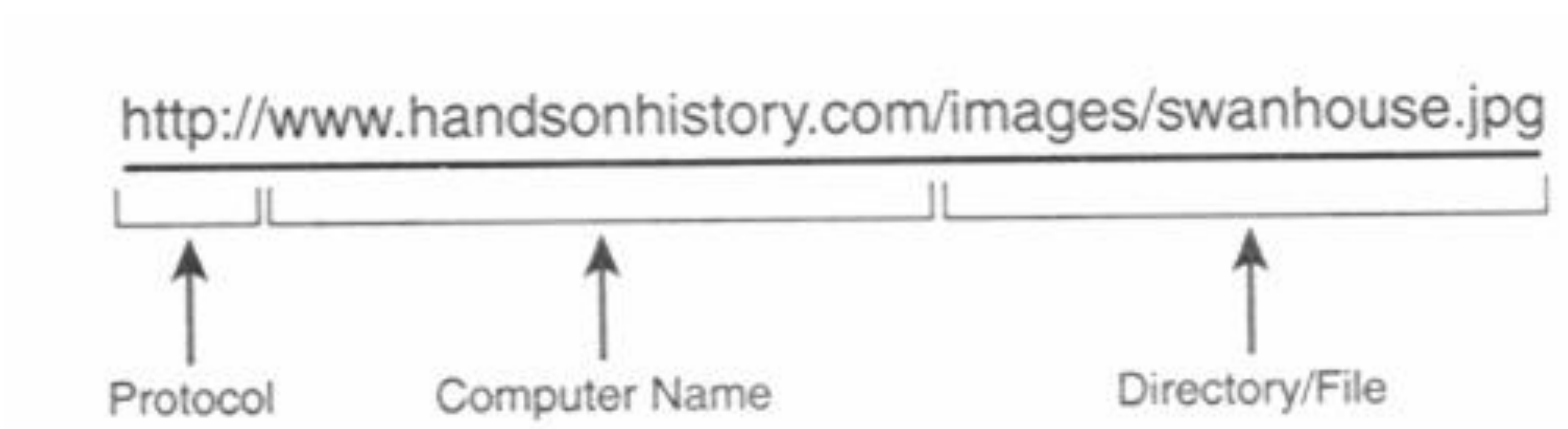
- The internet is a massive computer network consisting of thousands of subnetworks and millions of computers worldwide
- It started as a US military project in the 1960s and today it can be used by just about anyone

The World Wide Web

- The WEB is a simplified framework over the Internet that enables non-technical people to use the Internet
- The WEB was created in 1989 as a project to organize documents at the European Lab for Particle Physics.

The World Wide Web

- Access to the WEB is by: Hypertext Markup Language (HTML) – This enables users to build graphical documents that contain images, formatted text and links to other documents. Now HTML can include, sound, video and other content.
- Created a simple way of identifying WEB resources – Using uniform resources locators (URLs) a user can as for a resource directly from a server.
- The WEB relies on the Internet's computer naming system, called the domain name system (DNS) and the basis for URLs.



The World Wide Web

- The first part of the URL identifies the protocol needed to display the WEB content. For WEB pages,
  - Hypertext Transfer Protocol (http://) appears in the front of the address
  - File Transfer Protocol, the prefix ftp:// is used.
  - Simple Mail Text Protocol (smtp://)

Differences between:

- Internet – is a wide open network made up from many public and private networks joined together. Most of the resources are intended for public access.
- Intranet – is a private network that is controlled by a business or organization. It is intended for use by the organization and is generally not access able to the public.
- Extranet – is an internet that is privatelly maintained that extends its network to remote users, suppliers or other business or organizations. These are secure connections and are established with Virtual Private Networks (VPNs)

The World Wide Web

Assigning IP Addresses

- The IP address is actually used to communicate with other computers on the internet. Domain names are translated into IP addresses
  - A DNS server uses a list of domain names and addresses
  - The computer does the actual translation
- The IP address is made up of four sets of numbers (0 to 255) separated by dots, with each number called an octet (8 bits) 123.077.023.076

The World Wide Web

IP Address Classes

The 4 parts of the IP address actually represent 2 logical parts:

- 1^{st} logical part is the subnetwork
- 2^{nd} logical part is the computer on the subnetwork

- Class "A" contains more than 16 million host addresses (the last 3 of the 4 octets)

- Class "B" contains 65,536 hosts (the last 2 of the 4 octets)

- Class "C" contains 256 hosts (the last l octet)

Choosing Your Networking Hardware

Types of Computers

- Standalone Computers
  - Personal Computers – most common today with most working on a Windows operating system
  - Laptop Computers – portable personal computer. Most have PCMCIA slots for NICs
  - Macintosh Computers – popular computers for multimedia applications such as: arts, audio and video applications. Most have Ethernet ports built in and run the 10/100BaseTX Ethernet cards.
  - UNIX Workstations – computers that use UNIX operating systems, such as Solaris, SCO Open Desktop and Linux. Powerful applications, more expensive and used for many medical applications.

Choosing Your Networking Hardware

Hardware for a Network

- DSL Modem – Digital Subscriber Line (DSL) technology is a popular way to get high speed internet access using existing phone lines.
  - HDSL – High Bit Rate DSL is an earl version of DSL that used the same speed for transmission and receive rates)
  - SDSL – Symmetric DSL is the same as HDSL except for a high transmission speed
  - VDSL – Very High bit Rate DSL. Much faster speeds, but requires shorter distances
  - ADSL – Asymmetric DSL a larger portion is available for downstream rather than upstream communication
  - IDSL – Higher transmission rates, acts more like ISDN service

Choosing Your Networking Hardware

Hardware for a Network

- Cable Modem –Uses the coax cable for Internet service and in most cases, it is the same cable for cable TV programming.
- A cable modem can receive data downstream at rates up to 3Mbps and upstream rates at 1 Mbps
- The output connection of the cable modem is an Ethernet connection (most likey an RJ45 jack)
- The computer will need a NIC card or port to communicate to the cable modem
- An alternative connection is to connect the cable modem to a HUB or Router, then connect the PCs to the HUB or Router.

Choosing Your Networking Hardware

NICs – Network Interface Card

- The type of network you are connecting to is the first criteria. Most cases, it is Ethernet.
- Ethernet can have 1024 nodes
- It can communicate at either 10, 100, 1,000 or above Mbps
- The type of bus connection with in the computer is also important. Most use
  - ISA for 8 and 16 bit cards
  - EISA for 32 bit cards
  - PCMCIA for laptops and notebook computers
  - PCI for 32 and 64 bit computers
  - Check for micro-channel for some older PCs
- Type of connector to the Ethernet: BNC, RJ45 and AUI

Choosing Your Networking Hardware

Other Network Equipment

Routers – are used to route messages around subnetworks on a computer network.

- A small network in a home or small office may have a HUB, and that HUB is connected to the Router which is connected to the Internet.
- The Router passes information between the internet and the small LAN
- The Router can be set-up to provide protection, as only desired signals can pass through it

Gateways – is similar to a router, except that it routes information from one type of a network architecture to a completely different type of network architecture.

- It can be thought of as a language interpreter, changing one protocol to another
- Information from a TCP/IP network could be sent to an IBM System Network Architecture (SNA) network.
- It translates the data from one system to another

Network Servers and Clients

Peer to Peer Networks – all computers are considered equals. Requests are made specifically from one computer to another computer

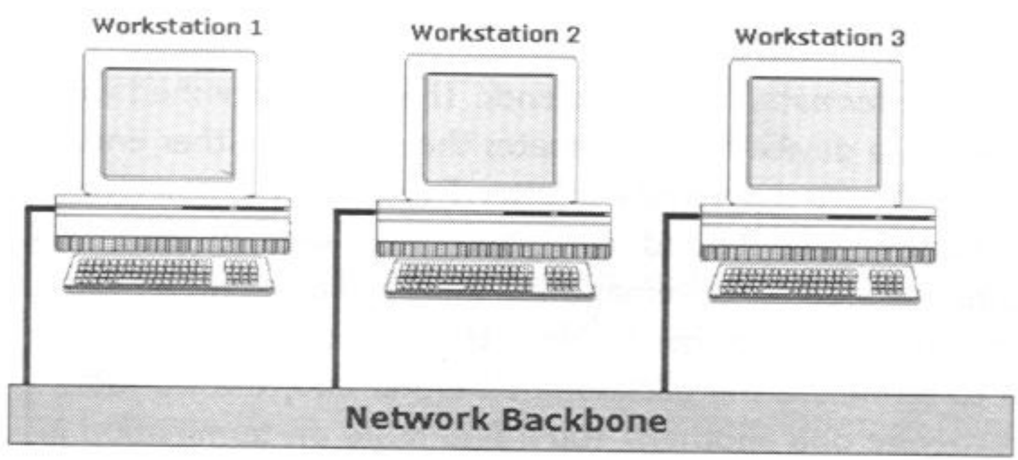
Client/Server Networks – in this network, shared files, printers, applications and other items are connected to a central server computer that is accessed by client computers

A client is typically a single-user workstation PC

A server is a high powered, multi-user dedicated server application

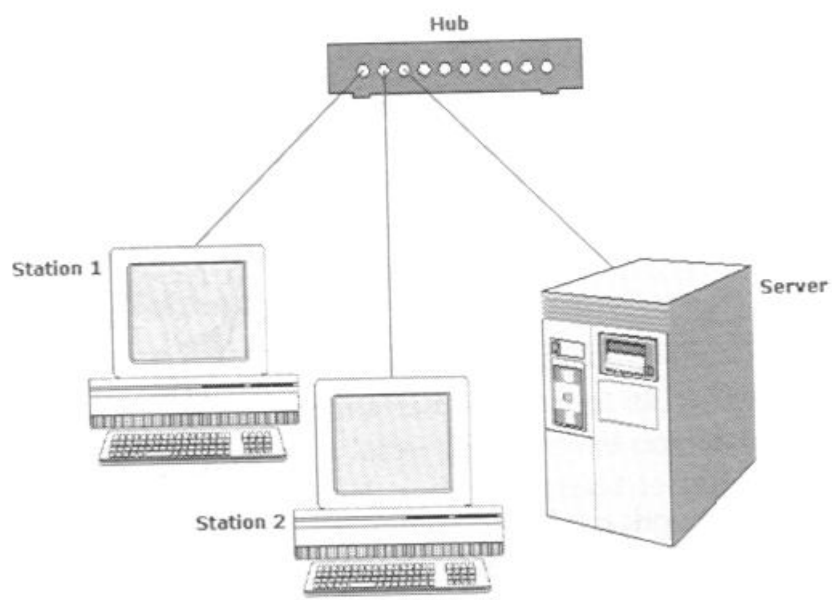
Network Topologies

- Topology Types
  - Buss Topology – is also called the linear bus topology. The network is supported by a long, uninterrupted cable called a backbone. All devices connect to this backbone.



Network Topologies

- Topology Types
  - Star Topology – is significantly more structured that bus topology and focus on centralization. Each device (PC, printer, scanner) is connected to a central point. If one fails, it will not affect the others.



Network Topologies

- Topology Types
  - Ring Topology – is a single cable to which all workstations and devices are connected. It is very similar to bus topology, except that the ring is closed and not open as it is in bus topology. In the ring, data travels around the ring from one workstation to the next. Each workstation acts as a repeater and passes the signal on.