ULTRASONOGRAPHY, X RAY, CT, MRI AND ECG

Radek Pikula

Diagnostic Modalities in Radiology

- X ray
- USG
- CT Scan
- MRI
- Doppler
- Radio nucleotide imaging
- PET scan

Role of radiological imaging in emergency surgical situation

- X-ray
  - Perforation of gas containing hollow viscus
  - Intestinal Obstruction
  - Tension Pneumothorax / Hemothorax / Pneumohemothorax
  - Fracture

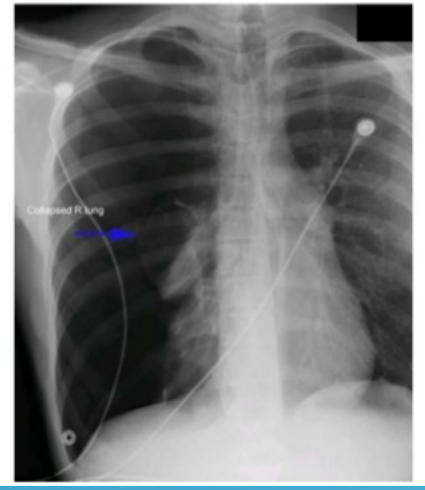
- USG
  - FAST
  - Ruptured ectopic pregnancy
  - High resolution USG in acute appendicitis

- CT scan
  - Pneumocephalus
  - # head
  - Subdural hematoma
  - Intracerebral hematoma

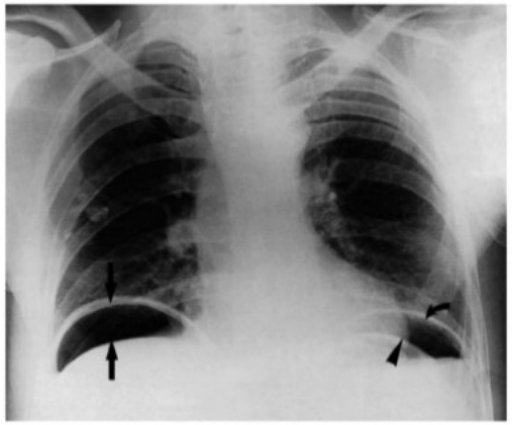
Rib # at left 4th and 5th rib

Hydropneumothorax

Tension pneumothorax



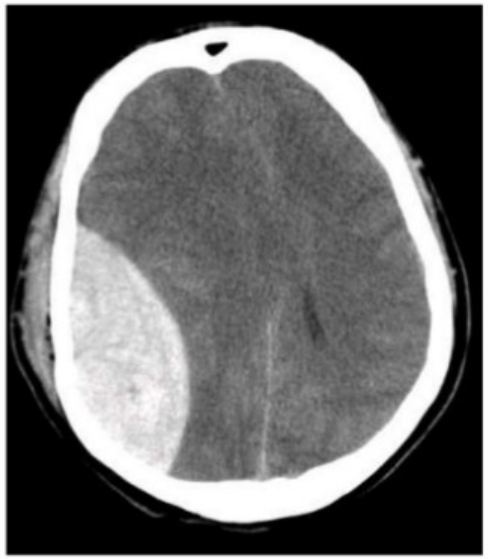
Pneumoperitoneum



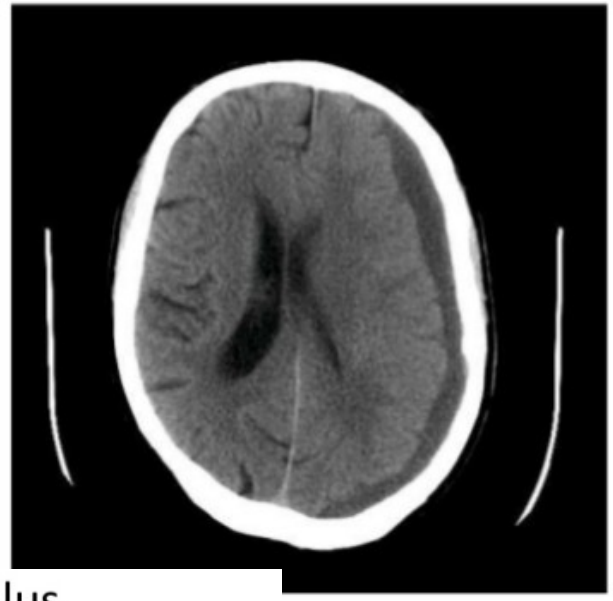
Intestinal Obstruction

Volvulus

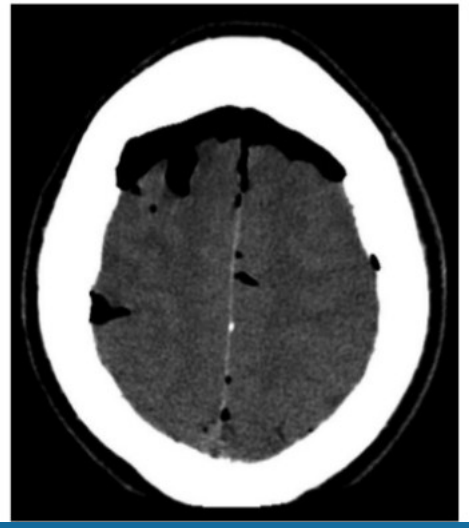
Epidural Hematoma



Subdural hematoma



Pneumocephalus



CT scan showing low density air in the sulci of the brain from a basal skull fracture involving the sinuses.

FAST

- Focused Assessment with sonography in trauma
- View included
  - Hepatorenal recess (morison pouch)
  - Perisplenic view
  - Subxiphoid pericardial window (douglas pouch)
  - Suprapubic window
- E-FAST

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RUQ view

Free fluid in morrison pouch

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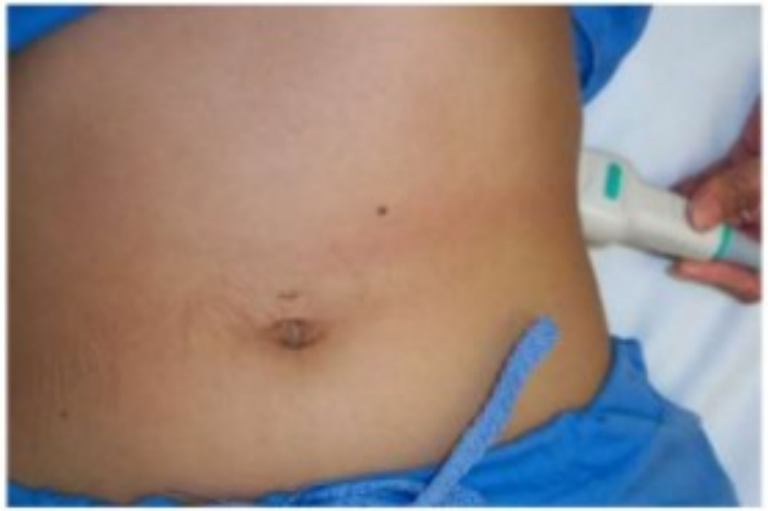
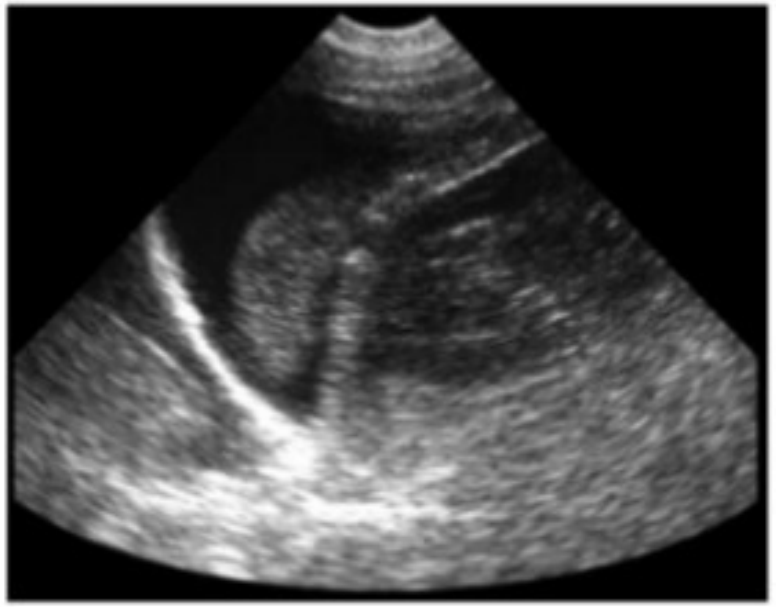


LUQ view



Blood in splenodiaphragmatic recess

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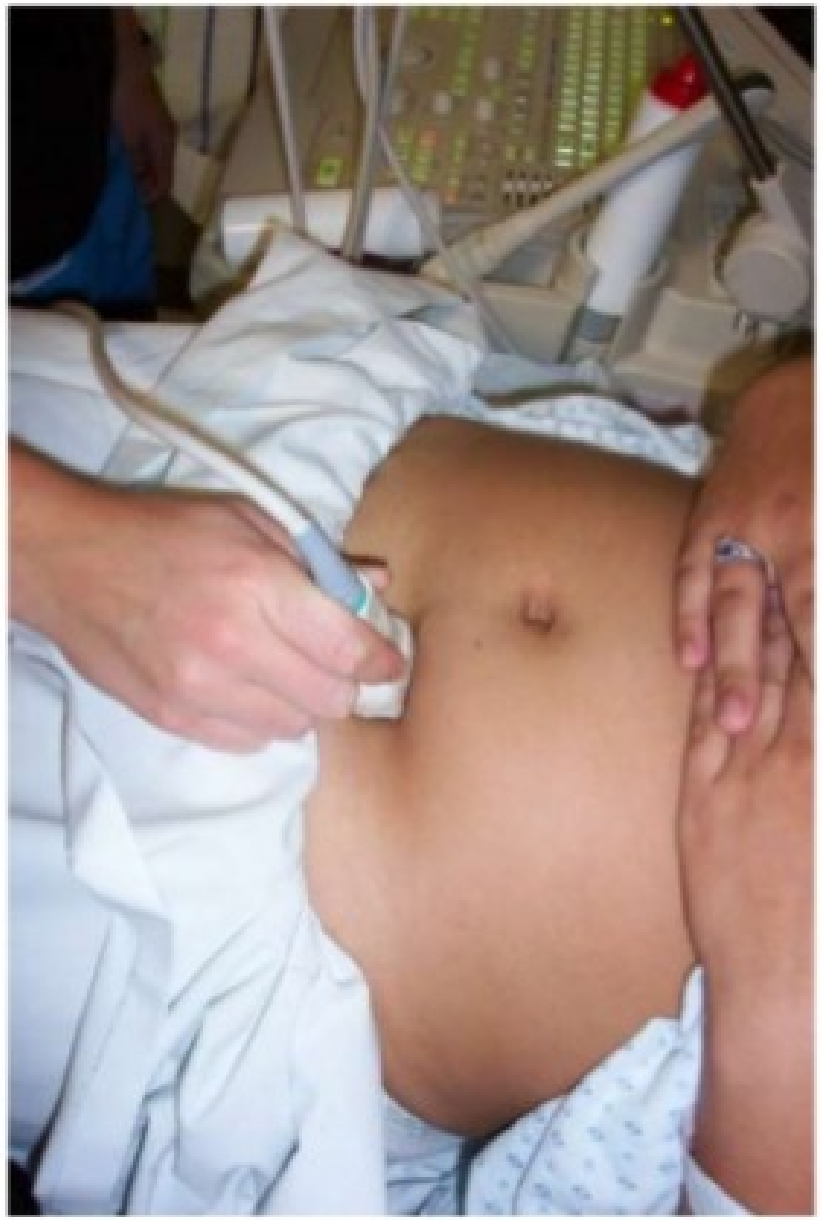

Supra pubic view

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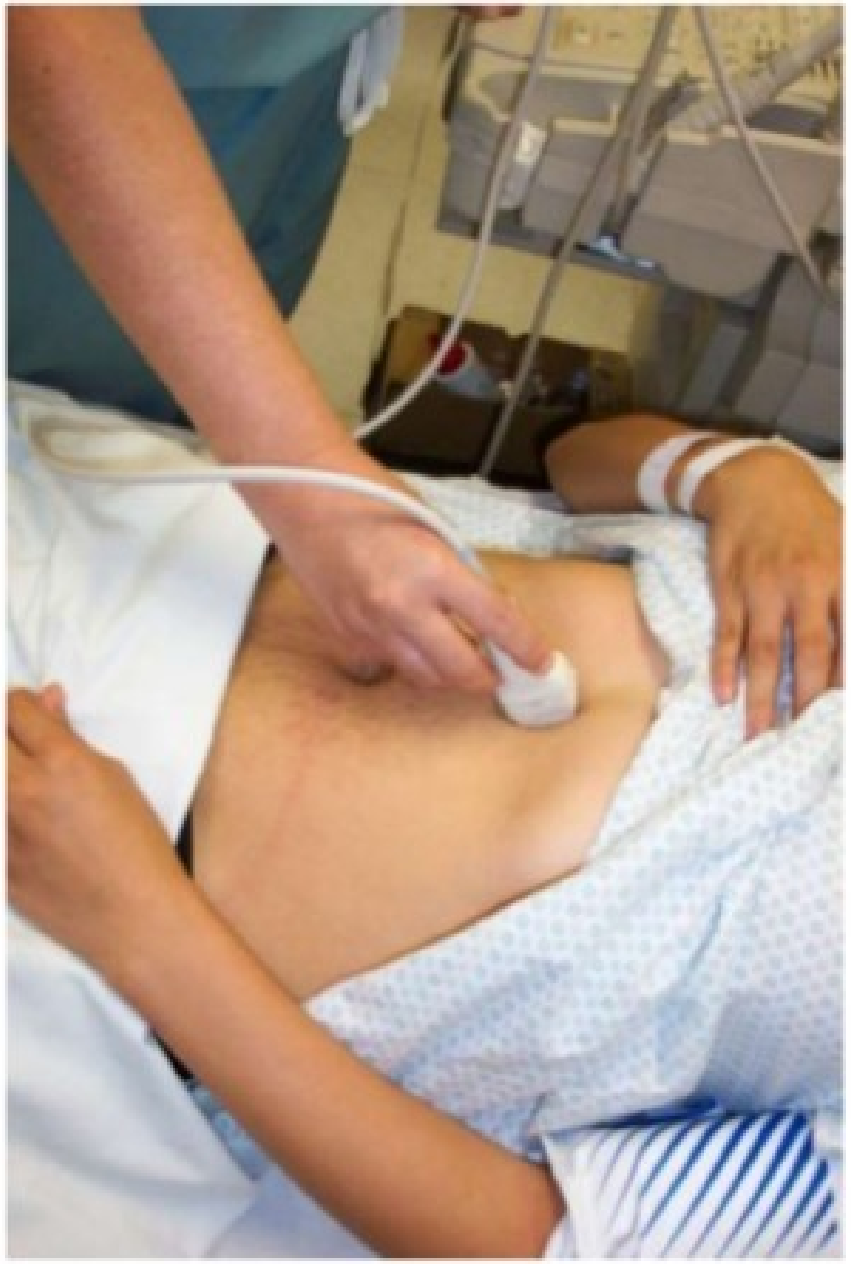


Traumatic tamponade

Indication of FAST

- Evaluation of the torso for free fluid suggesting injury to peritoneal, pericardial, and pleural cavities, particularly in trauma
- Blunt abdominal trauma
- Stable penetrating trauma

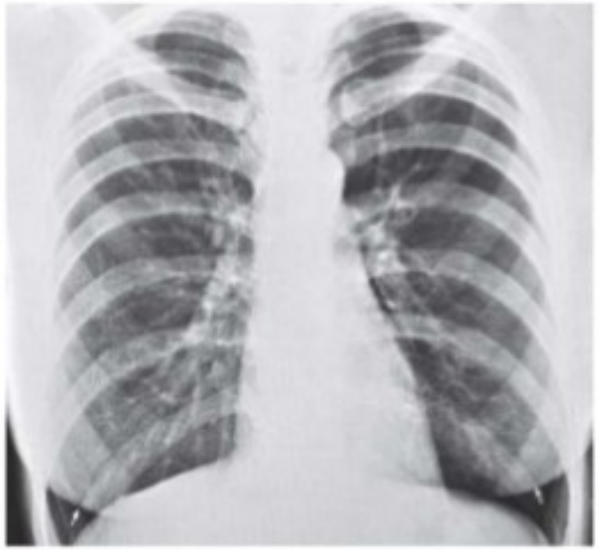
Advantages

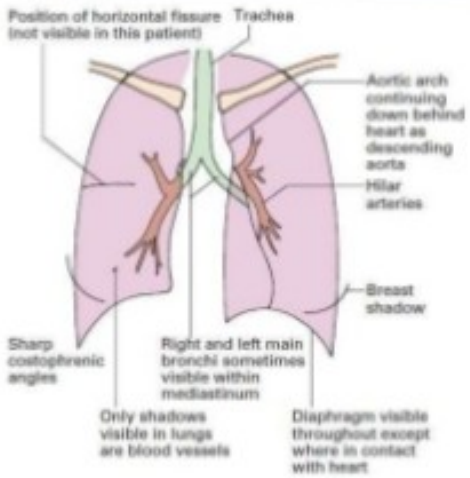
- Decrease the time to diagnosis for acute abdominal injury in blunt abdominal trauma
- Helps accurately diagnose and assess degree of hemoperitoneum
- Noninvasive
- Can be intergrated in 1^0 or 2^0 survey
- Can be performed quickly, in clinical arena
- Safe for children and pregnant woman

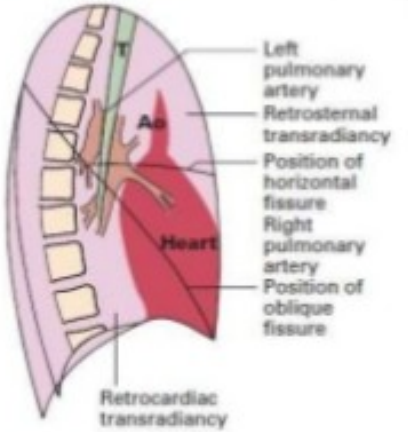
Role of Radiological Imaging in Elective surgical situation

1. Plain
2. contrast

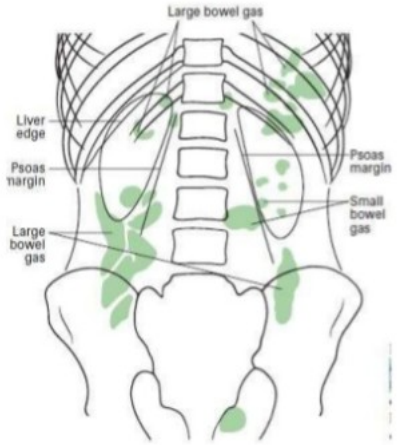
Pneumothorax



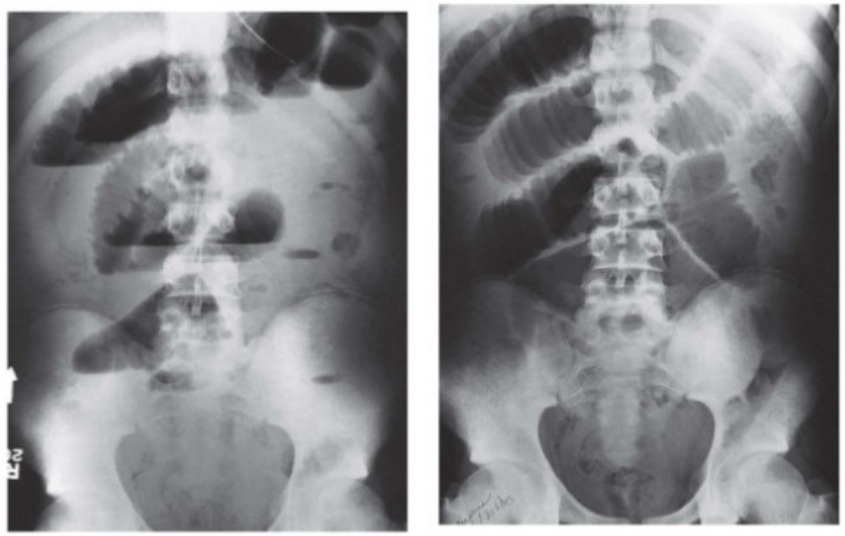




X-ray Abdomen/Pelvis



Small Bowel Obstruction

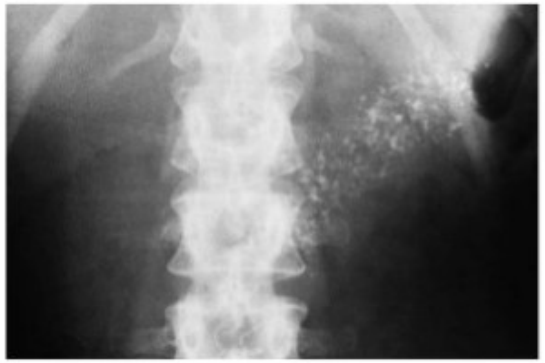


X-ray KUB

Staghorn Calculus

Bladder stone

Paralytic ileus



Pancreatic calcification.

Calcified mesenteric lymph nodes

Contrast x-rays for Urinary Tract

1. Intravenous Urogram(IVU)
2. Intravenous Pyelogram (IVP)
3. Voiding(micturating) cystourethrogram
4. Retrograde urethrogram

IVU

Indications:

- To see anatomy and physiology of urinary system
- Trauma
- Calculi
- Congenital anomalies
- Infective pathology
- Renal tumor
- Unknown hematuria
- Bladder pathology—diverticula, fistula
- Vesicoureteric reflux.

Retrograde /ascending urethrography

Contrast is retrogradely injected with urethral orifice occluded to prevent reflux of contrast.

Indications

- Urethral stricture
- Urethral tear
- Congenital anomalies
- Fistula

Contrast medium: water soluble

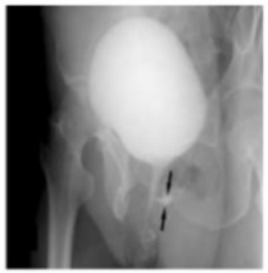
RGU

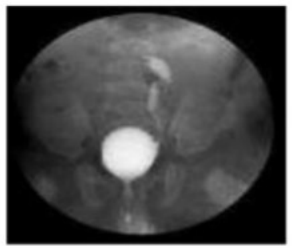
Anterograde urethrography/MCU

- Bladder is filled with contrast via suprapubic or retrograde catheterization
- Bladder and urethra is assessed during voiding.

Indications:

- Voiding difficulties
- VUR
- Trauma
- Anatomical abnormalities of bladder neck
- Fistula





BARIUM SERIES

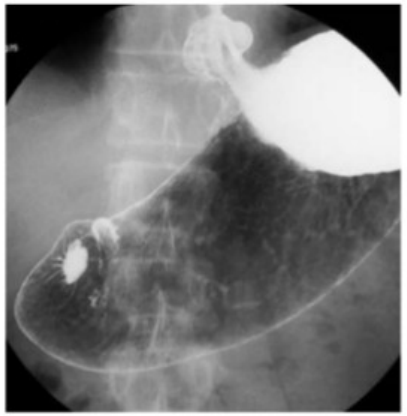
- Barium swallow X-ray -> for oesophagus
- Barium meal X-ray -> for stomach
- Barium follow through -> for small intestine
- Barium enema -> for large intestine

Barium Swallow

Barium Meal

Single contrast

Double contrast



Barium Follow Through

Stricture. Barium enema

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Dilatation from small bowel obstruction. The diameter of the bowel is greatly increased. The feathery mucosal pattern is lost and the folds appear as thin lines traversing the bowel, known as valvulae conniventes (arrows

Drawbacks

- Contrast inadvertently injected outside the vein is painful and should be carefully guarded against.
- A few patients develop an urticarial rash, which usually subsides spontaneously.
- Bronchospasm, laryngeal oedema or hypotension occasionally develop and may be so severe as to be lifethreatening.
- Intravenous contrast agents may have a deleterious effect on renal function in patients with impaired kidneys.

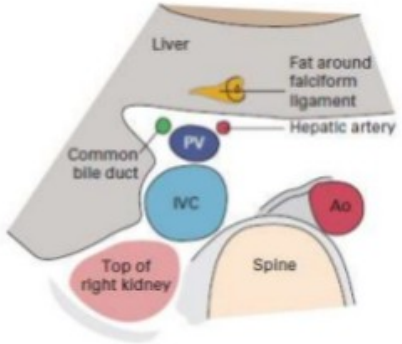
Other uses

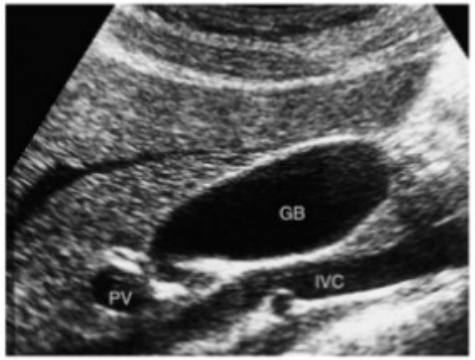
- To determine the appropriate position of central venous line, ET tube and Chest tube

Ultrasonography (USG)

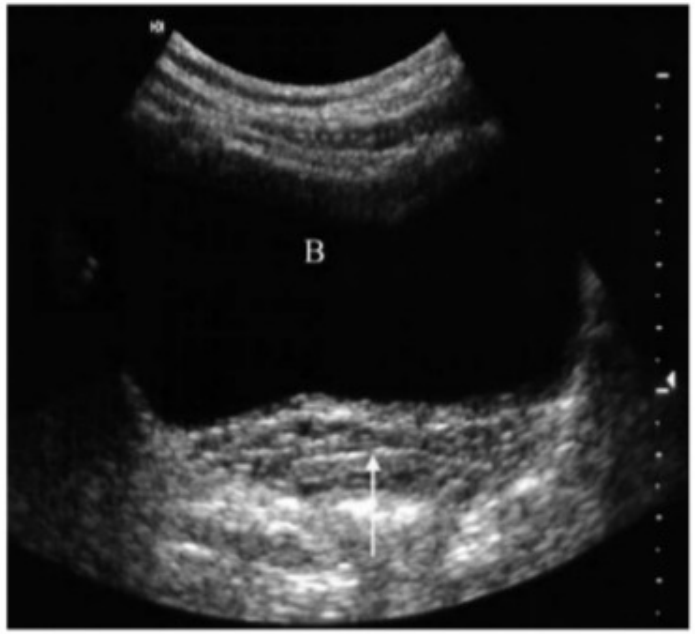
Principle

- Depends on the generation of high frequency sound wave(3 and 7 MHz) by transducer placed on skin
- Sound is reflected by tissue interfaces
- Echoes generated are picked by the same transducer and converted into an image
- Image is displayed in real time on monitor





Normal USG of bladder



THERAPEUTIC USES

- USG guided aspiration of hepatic and pulmonary abscess and cyst
- Focused U/S may be used to break up kidney stone by lithotripsy
- U/S may be used for cataract treatment by phacoemulsification

Ultrasound scan of longitudinal section through the liver and right kidney. A cyst (C) is present in the upper pole of the kidney.

Ultrasound scan of gall bladder showing a la stone inthe neck of the gall bladder (downward pointing arrow). Note the acous shadow behind the stone (horizontal double headed arrow).

Advantages of USG

- No radiation
- Inexpensive
- Allow interaction with patients
- Superb soft tissue resolution in the near field
- Dynamic studies can be performed
- 1st line inv- hepatic, biliary and renal disease
- Excellent resolution for breast, thyroid and testes imaging
- Good for soft tissue, including tendons and ligament
- Excellent for cysts and foreign bodies
- Doppler studies allow assessment of blood flow

Doppler

- To study cardiovascular system.
- To study vascularity of tumours.
- To study blood flow and velocity in arterial diseases so as to assess stenosis (its extent, cause, etc.) like in atherosclerosis, TAO, cervical rib, aneurysm, A-V fistulas.
- To find out deep venous thrombosis (DVT), varicose veins,perforator incompetence.
- To study grade of varicocele in males

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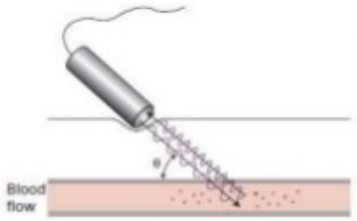
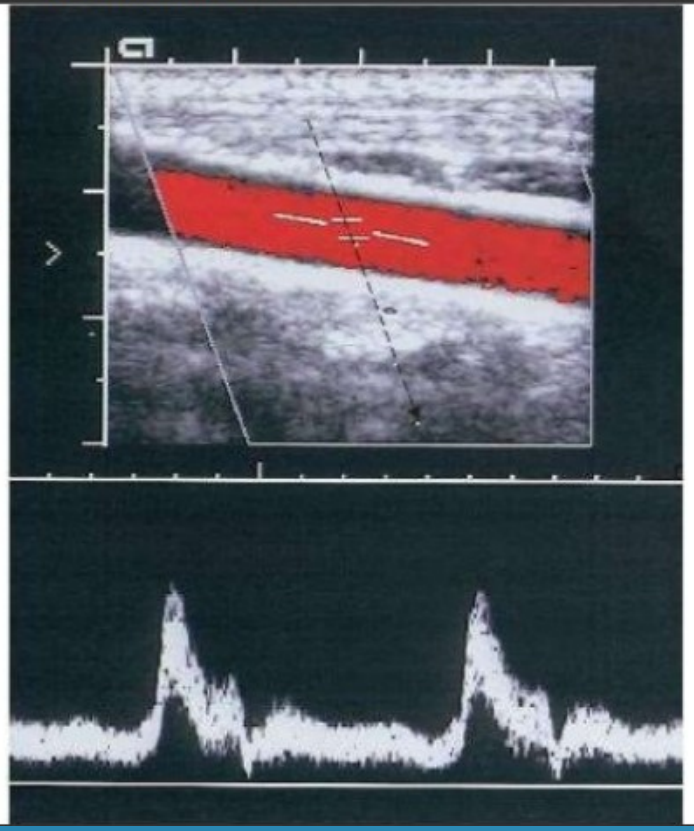
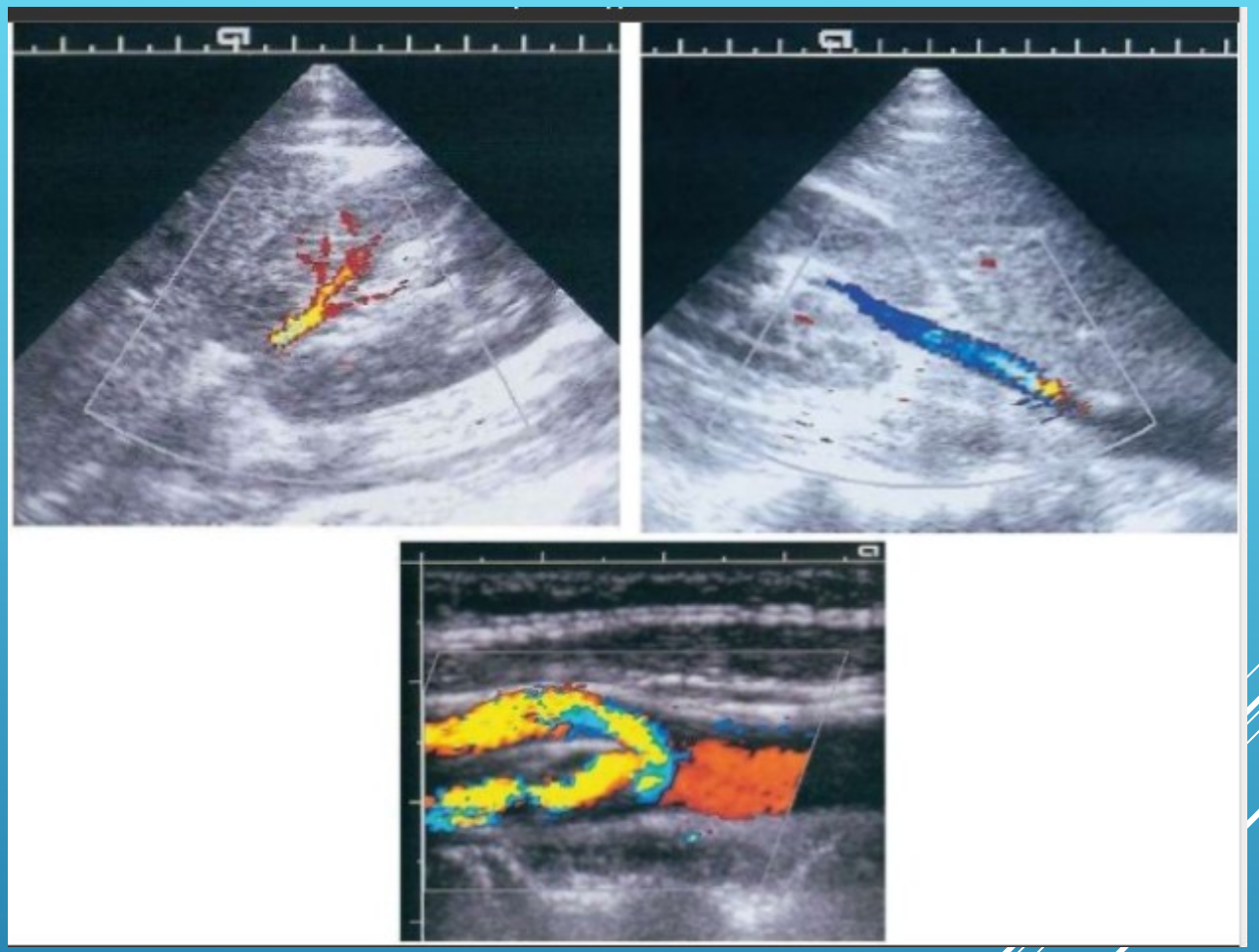


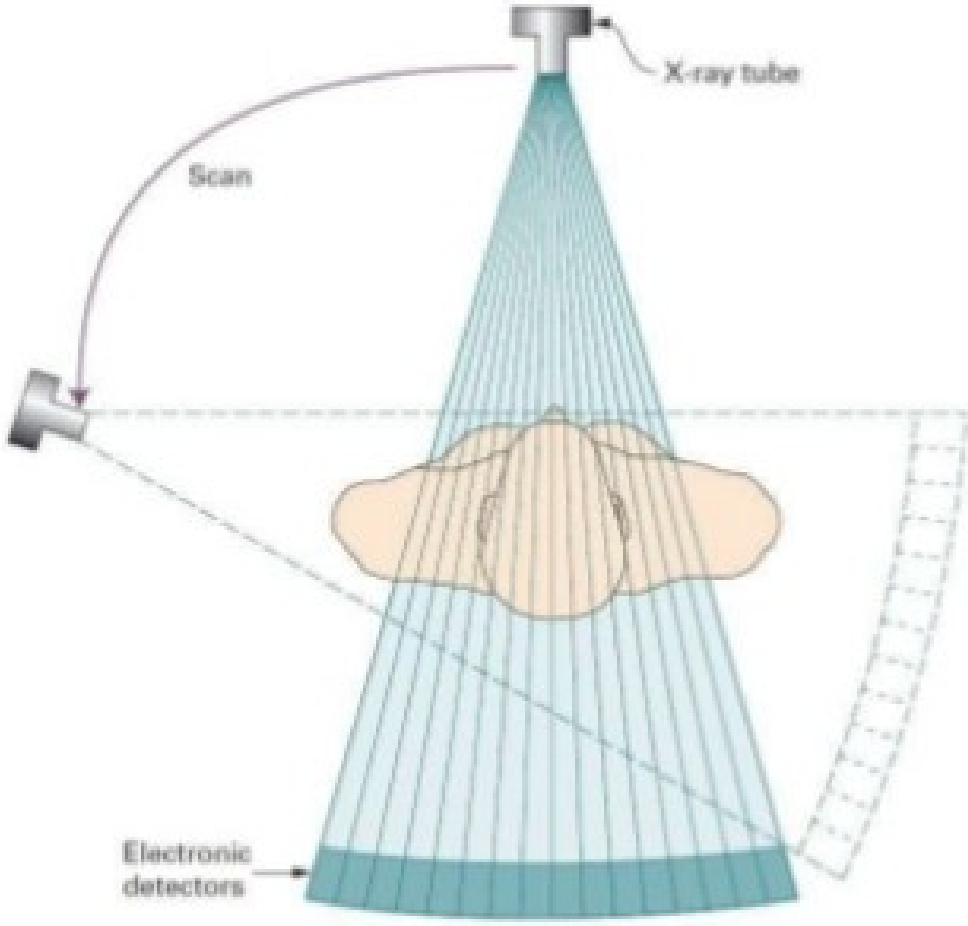


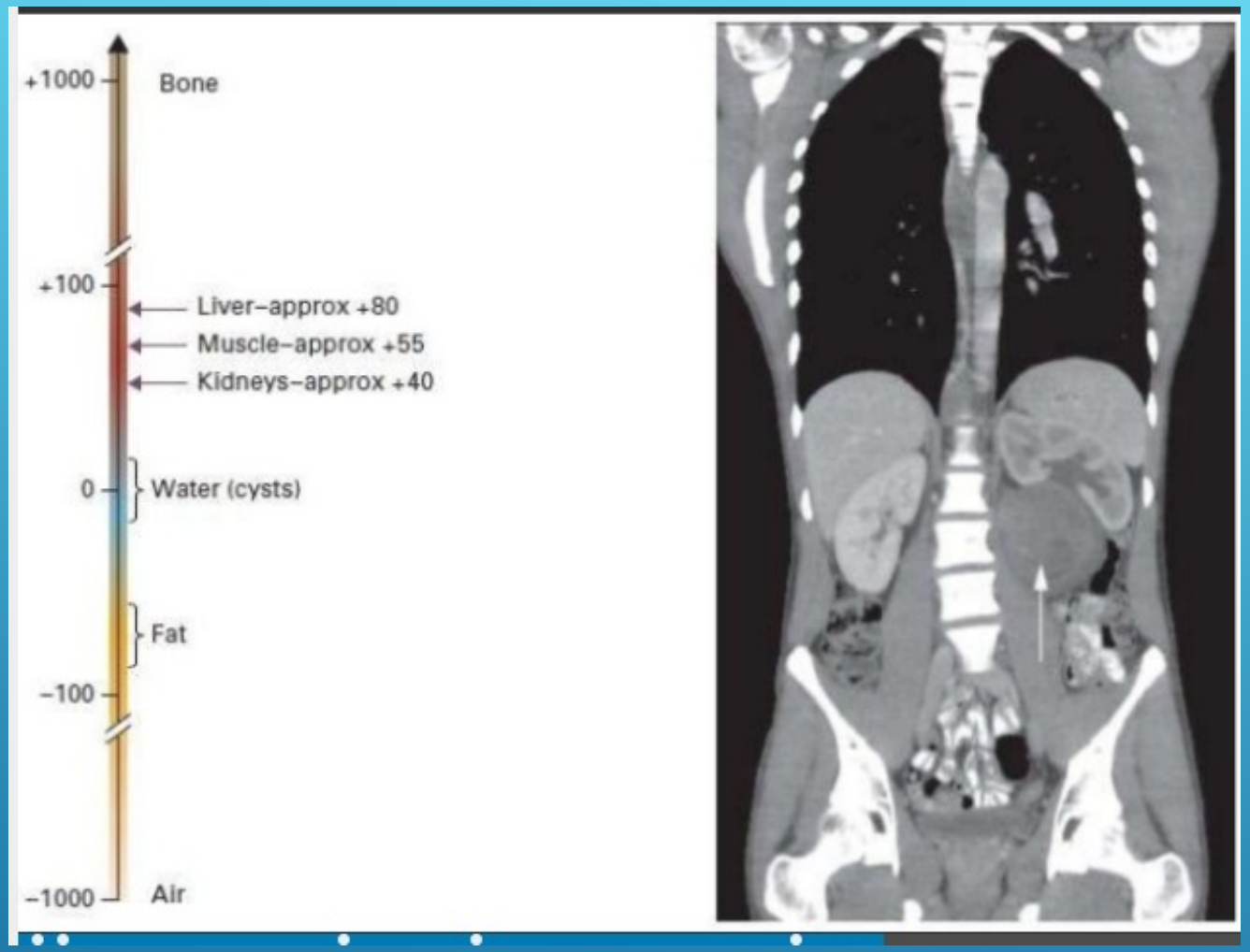


Computed Tomography

- Principle

The x-ray tube and detectors move around the patient enabling a picture of x-ray absorption in different parts of the body to be built up.





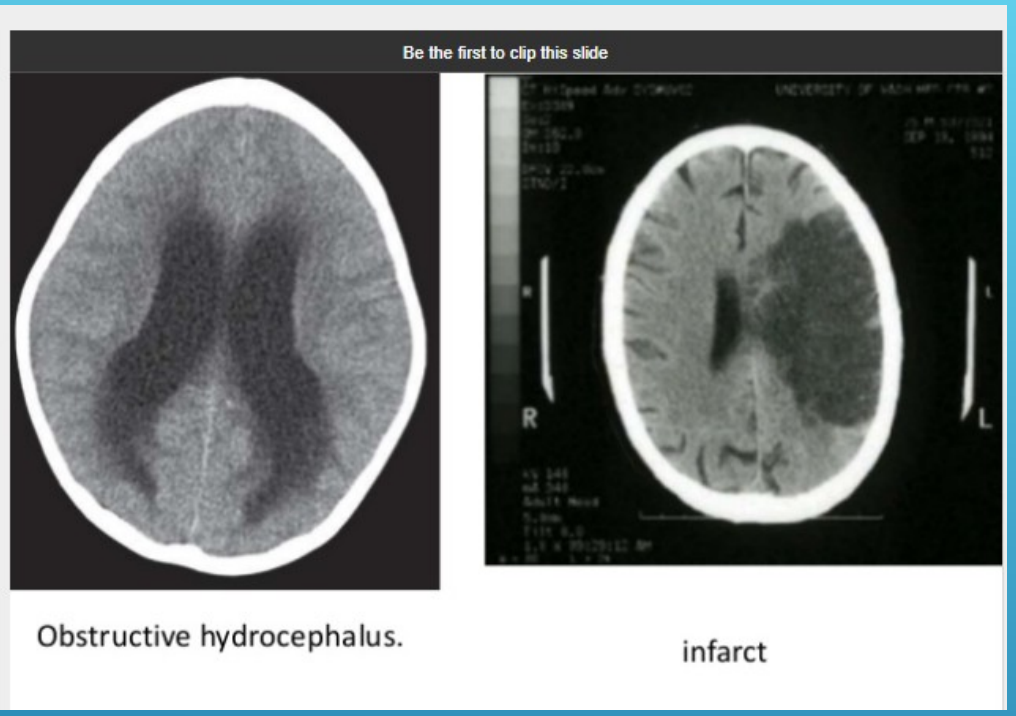
Computed Tomography (CT)

Indications

- **Trauma** like head injury, chest injury, abdomen trauma. In trauma *only plain CT scan* is taken.
- **Neoplasms:** To see the exact location, size, vascularity,extent and operability. For example, brain, abdominal, retroperitoneal, thoracic and spinal tumours.
- **Inflammatory conditions,** in various sites.For example, psoas abscess, pseudocyst of pancreas.

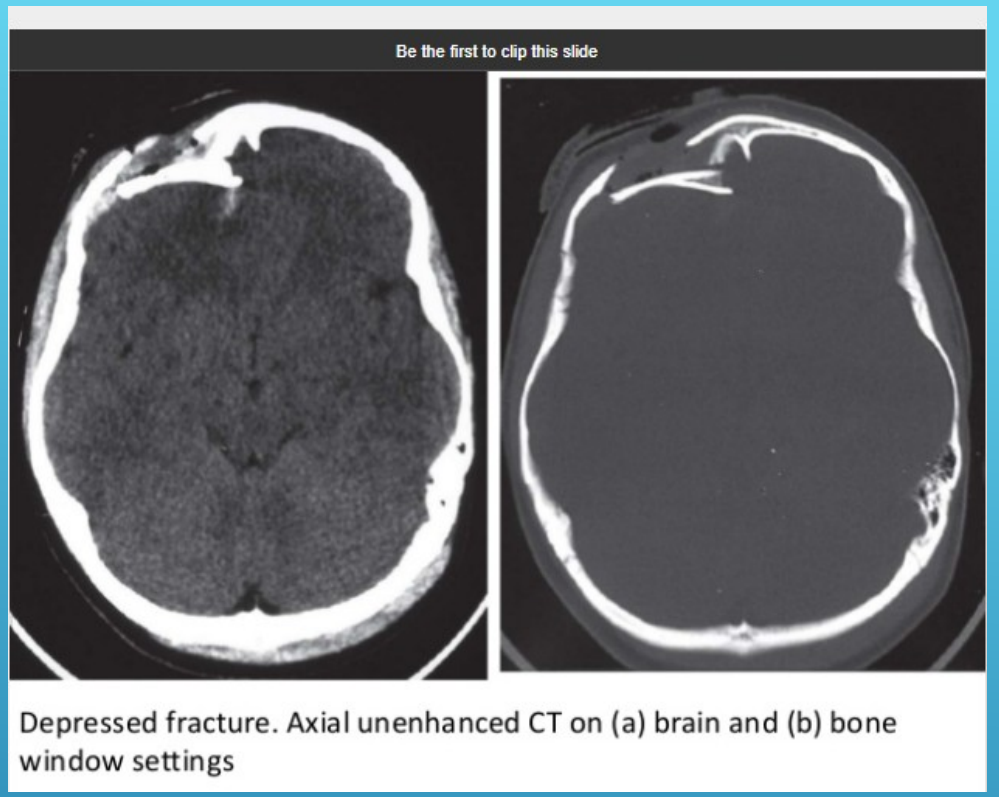
Advantages of CT

- High spatial and contrast resolution
- Contrast resolution enhanced by imaging in arterial and/or venous phases
- Rapid acquisition of images in one breath hold
- Imaging of choice for the detection of pulmonary masses
- Allows global assessment of abdomen and pelvis
- Excellent for liver, pancreatic, renal and bowel pathology
- 3D reconstruction allows complex fracture imaging
- Multiplanar reconstruction and 3D imaging eg CT angiography and coloscopy



Obstructive hydrocephalus.

infarct

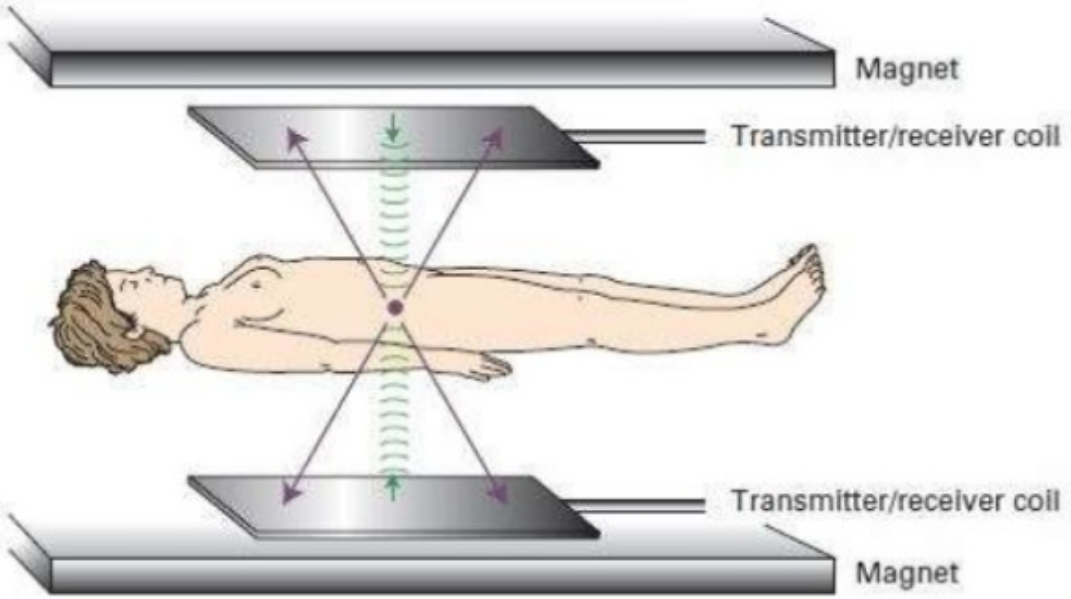


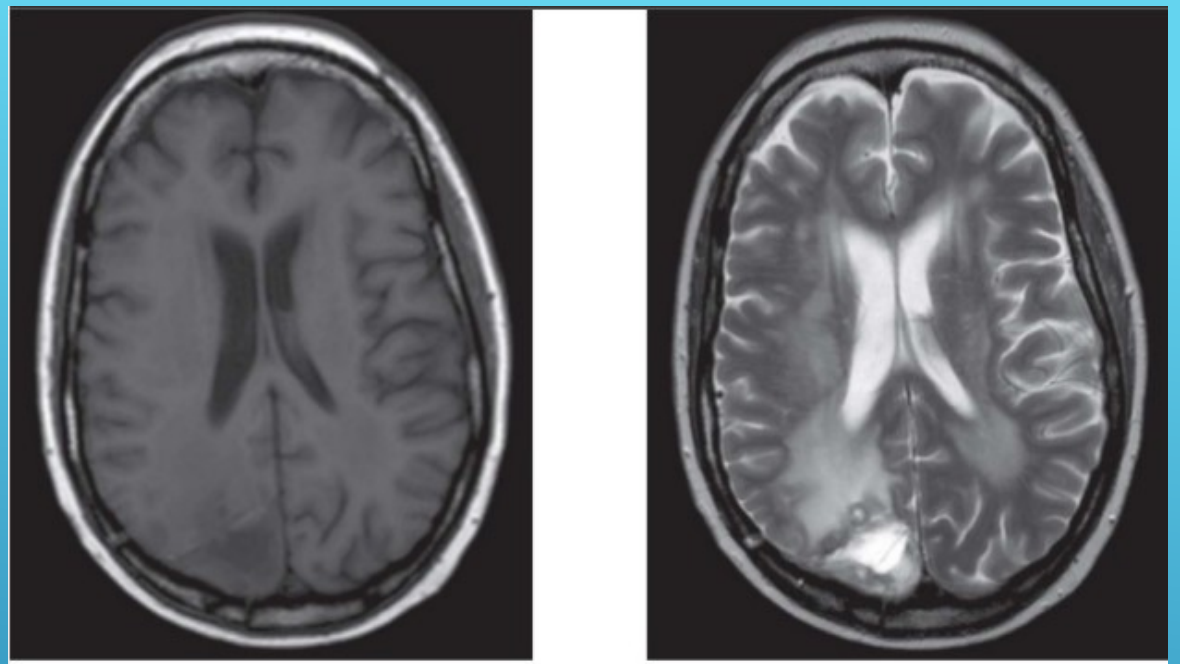
Depressed fracture. Axial unenhanced CT on (a) brain and (b) bone window settings

Plain ct vs contrast ct

Magnetic Resonance Imaging

- radiofrequency pulse at the resonant frequency of hydrogen
- a proportion of the protons change alignment,
- Following this the protons return (realign) to their original positions.
- As the protons realign (relax), they induce a signal
- can be detected and localized by copper coils placed around the patient.
- An image representing the distribution of the hydrogen protons can be built up





Magnetic resonance Imaging (MRI)

- very useful in intracranial, spinal and musculoskeletal lesions including *joint pathologies.*
- It gives direct anatomical sections of the area, with lesions at a high resolution.
- **MR angiogram** : done without injecting IV contrast agents
- **Cardiac MRI**
- **Breast MRI** : used in multifocal recurrent cancers.

- **Magnetic resonance cholangiopancreatography** *(MRCP)*
  - a very useful non contrast diagnostic tool which may replace diagnostic ERCP.

- **MR spectroscopy**
  - chemical analysis of elements in a tissue to differentiate between tumor, inflammation, and degeneration.

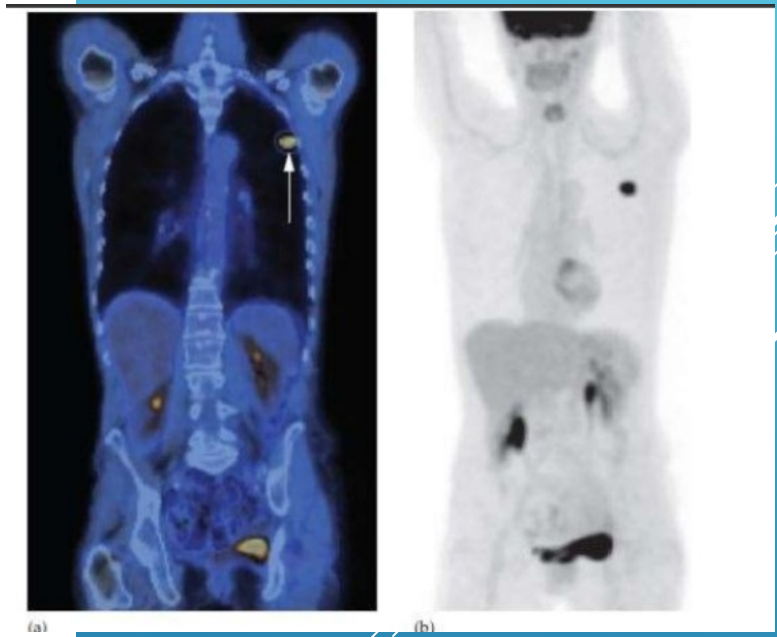
Adnvantages over USG, Xray and CT scan

- No ionizing radiation
- Excellent soft tissue contrast
- Best imaging technique for
  - Intracranial lesions, specially posteriro fossa lesion
  - Spine
  - Bone marrow and joint lesions

PET scan

Uses

- To assess myocardial perfusion (82Rb) and viability (FDG) study.
- Epilepsy—To localize temporal lobe epilepsy (FDG)
- Cancer imaging—Lung cancer (detection and staging)
- Colorectal cancer
- Melanoma
- Head and neck cancer and breast cancer
- Musculoskeletal tumors
- Thyroid cancer (I131)



INTRODUCTION

- ECG is a three letter acronym for ElectroCardioGraphy.
- The word is derived from ***electro****(*greek for electricity*),**cardio****(*greek for heart) and ***graph****(*Greek root meaning "to write“)
- **It is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes.**
- The device used to produce this non invasive record is called the **electrocardiograph.**
- ECG is the gold standard for the noninvasive diagnosis of cardiac diseases and may occasionally be the only marker for the presence of heart disease.

INDICATIONS OF ECG

- Gold standard for diagnosis of cardiac arrhythmias
- Helps detect electrolyte disturbances (hyper- & hypokalemia)
- Allows for detection of conduction abnormalities
- Screening tool for ischemic heart disease during stress tests
- Helpful with non-cardiac diseases (e.g. pulmonary embolism or hypothermia

An ECG is a diagnostic tool, NOT a treatment
No one is ever cured by an ECG!!

BASIC ELECTROPHYSIOLOGY

PHYSIOLOGICAL PROPERTIES OF MYOCARDIAL CELL

- ***Automaticity*:** ability to initiate an impulse
- ***Excitability:*** ability to respond to a stimulus
- ***Conductivity*:** ability to transmit an impulse
- ***Contractility:*** ability to respond with pumping action

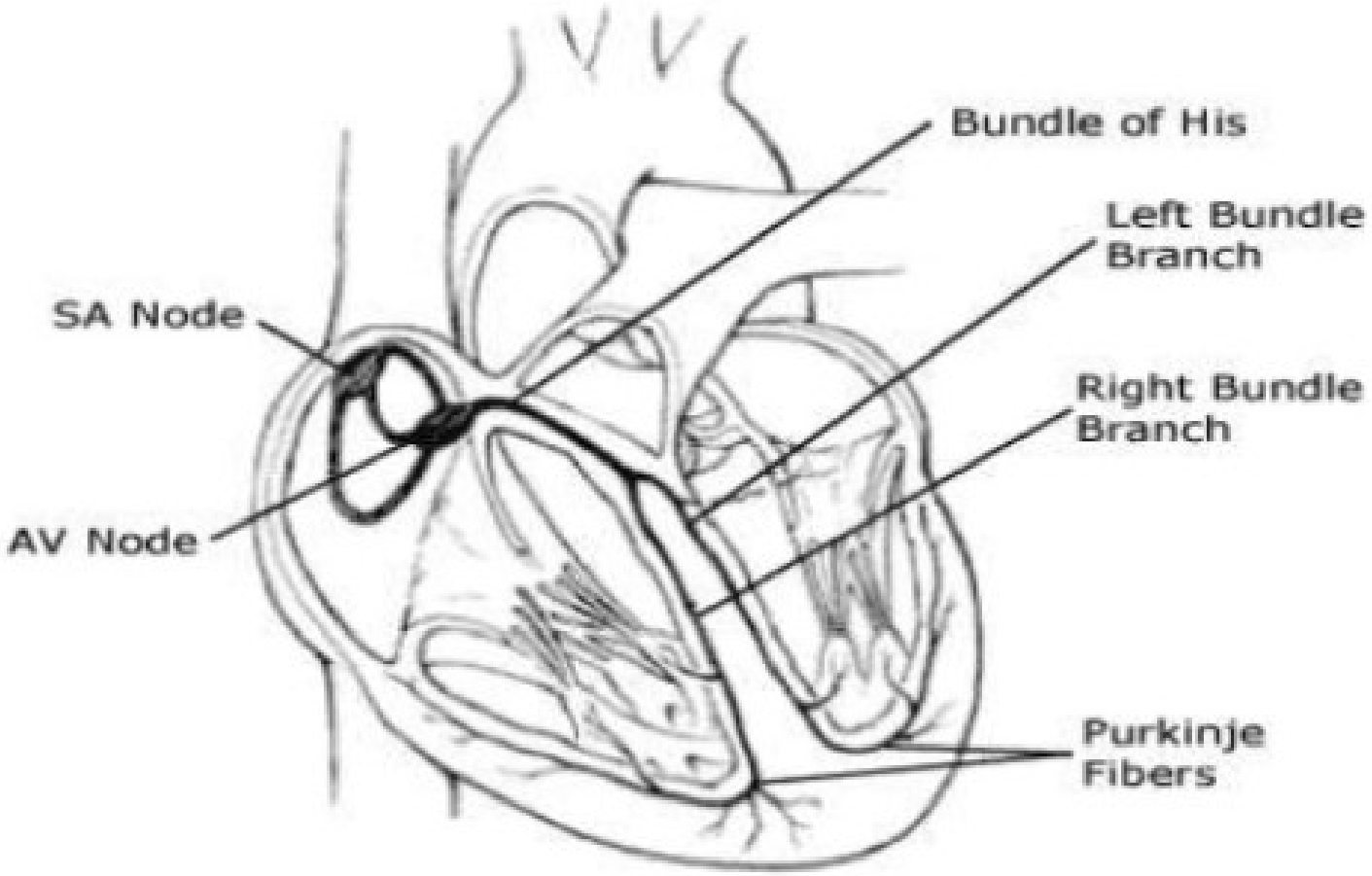
Depolarization and repolarization of a cardiac cell generates action potential

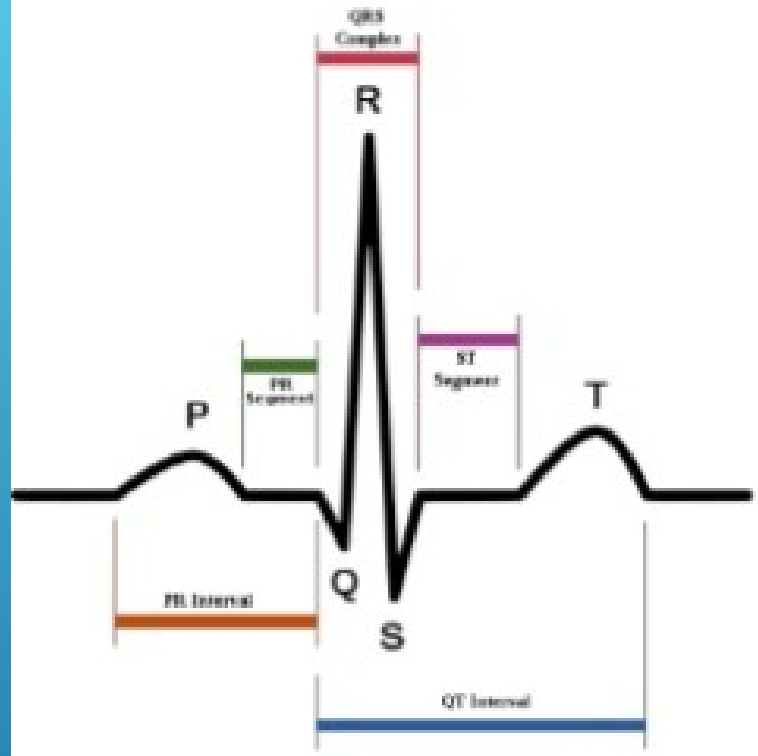
ECG is the composite representation of action potential of all cardiac cell.

ELECTRICAL CONDUCTION SYSTEM OF THE HEART

- The electrical discharge for each cardiac cycle normally starts in a special area of the right atrium called the '**sinoatrial (SA) node**'.
- Depolarization then spreads through the atrial muscle fibres.
- There is a delay while the depolarization spreads through another special area in the atrium, the '**atrioventricular (AV) node'.**
- Thereafter, the electrical discharge travels very rapidly, down specialized conduction tissue: first a single pathway, the '**bundle of His**', which then divides in the septum between the ventricles into **right and left bundle branches.**

- Within the ventricular mass, conduction spreads somewhat moreslowly, through specialized tissue called '**Purkinje fibres**'.





NORMAL SINUS RYTHEM

➢The adjacent figure shows the normal sinus rythem

A normal sinus rythem comprises of the following waves:-

- **P waves-** denotes atrial depolarization(electrical vector is directed from the SA node towards the AV node)
- **QRS complex-** denotes depolarization of ventricles as well as repolization of atrium
- **T waves-** denotes the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the **absolute refractory period**. The last half of the T wave is referred to as the **relative refractory period.**

➢As depicted in the fig:-

- **PR interval-** beginning of the P wave to the beginning of the QRS complex
- **ST segment-** connects the QRS complex and the T wave.
- **QT interval-** the beginning of the QRS complex to the end of the T wave.

RECORDING THE ELECTROCARDIOGRAM

THE E.C.G PAPER

- ECG machines record changes in electrical activity by drawing a trace on a moving paper strip.
- The electrocardiograph uses thermal paper, which is a graph paper & runs normally at a speed of 25mm/sec
- Time is plotted on the X axis & voltage is plotted on the Y axis.
- In X axis, 1 second is divided into 5 large squares each of which represents 0.2 sec. Each large square is further divided into 5 small squares which represents 0.04 sec.
- The ECG machine is calibrated in such a way that an increase of voltage by 1 mVolt should move the stylus vertically by 1cms.

ELECTROCARDIOGRAPHIC LEADS - CONVENTIONAL

- 12 conventional leads, physiologically divided into two groups viz:

  Bipolar leads- 3 Standard limb leads

  Unipolar leads-3 Augmented limb leads and 6 precordial chest leads

- **Bipolar leads** : These record the actual difference in potential across the two electrodes. There are three standard limb lead:-

- Lead I Left arm Right arm
- Lead II Left foot Right arm
- Lead III Left foot Left arm

  - The lead axes form the sides of an equilateral triangle with the heart at the center (Einthoven's triangle)
  - The sum total of the potential in the three leads equals zero and mathematically it co uld be demonstrated that the potential in L II equals sum of the potentials in L I and L III i.e, **Einthoven's law**.

- **Unipolar limb leads**:

- Constituted by the indifferent electrode which forms the negative electrode and the exploring electrode which forms the positive electrode.
- The indifferent electrode is constituted by connecting all limb lead electrodes together through an electrical resistance there by maintaining the zero potential. The positive electrode records the true potential at a given point. Here the record is of low voltage.
- Goldberger augmented these leads for proper recording,came to be known as augmented unipolar limb leads, represented by aVR, aVF, aVL leads

V_I = the voltage of Lead I

V_{II} = the voltage of Lead II

V_{III} = the voltage of Lead III

Φ_L = potential at the left arm

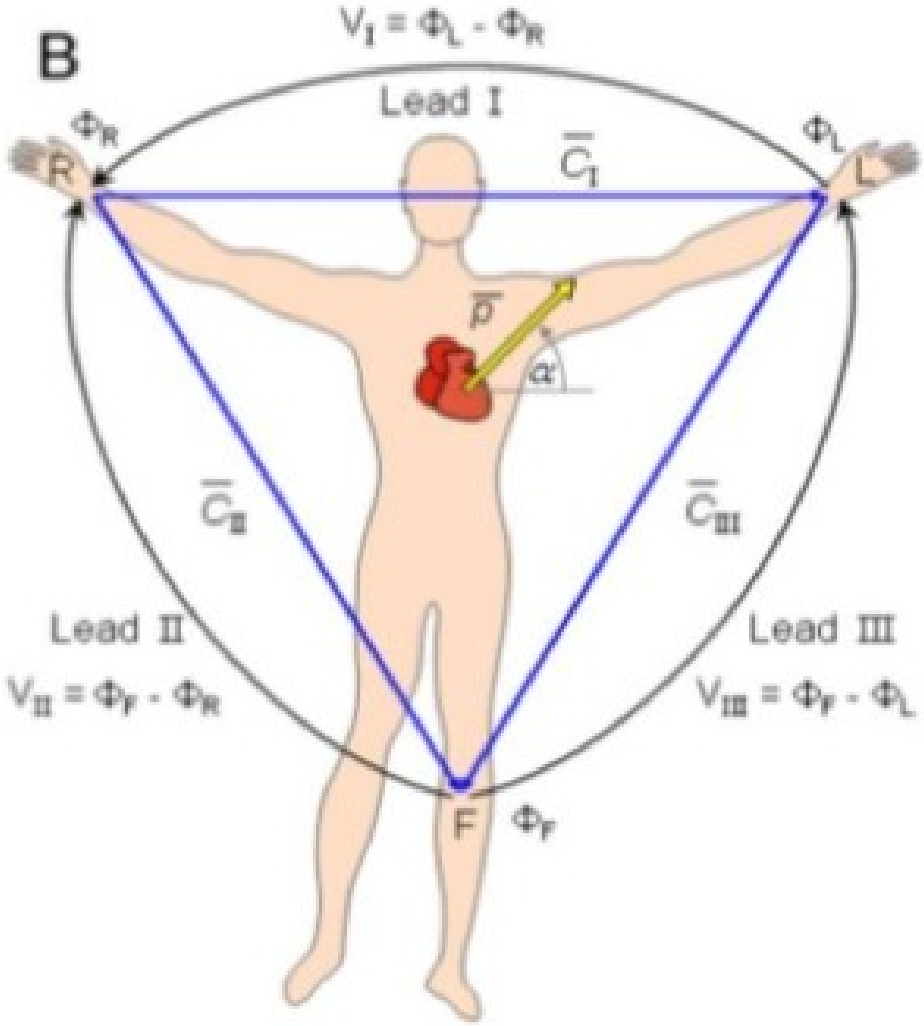
Φ_R = potential at the right arm

Φ_F = potential at the left foot

Lead I: $V_I = \Phi_L - \Phi_R$

Lead II: $V_{II} = \Phi_F - \Phi_R$

Lead III: $V_{III} = \Phi_F - \Phi_L$



According to Kirchhoff's law these lead voltages have the following relationship:

VI + VIII = VII

➢ Unipolar chest leads

- Constituted by an indifferent electrode resulting from a connection between all three standard limb leads and an exploring electrode placed on 6 different points on the chest wall.
- The indifferent electrode forms the negative terminal &the exploring electrode forms the positive terminal.
- Placement of precordial leads.

  V 1 - 4th intercostal space , right of sternum.

  V 2 - 4th ICS left of sternum

  V 4 - 5th ICS midclavicular line

  V 3 - Midway between V2 and V4

  V 5 - 5th ICS anterior axillary line.

  V 6 - 5th ICS mid axillary line.

Diagram depicting the einthoven's Triangle along with the position of various electrodes used in the ECG

Legend:

RA-right arm

LA-left arm

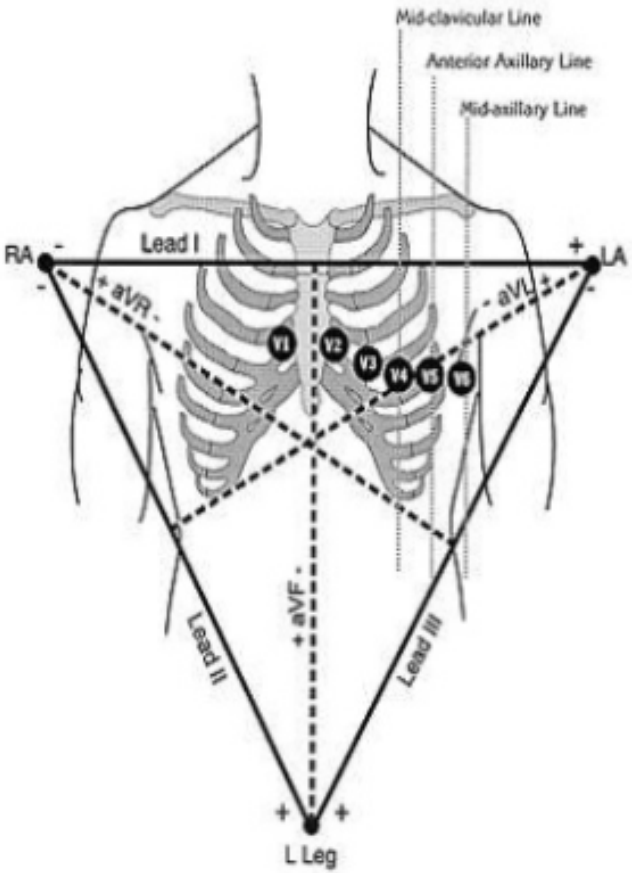
L leg-left leg

V1 to V6-precordial chest lead

aVR-augmented vector right arm

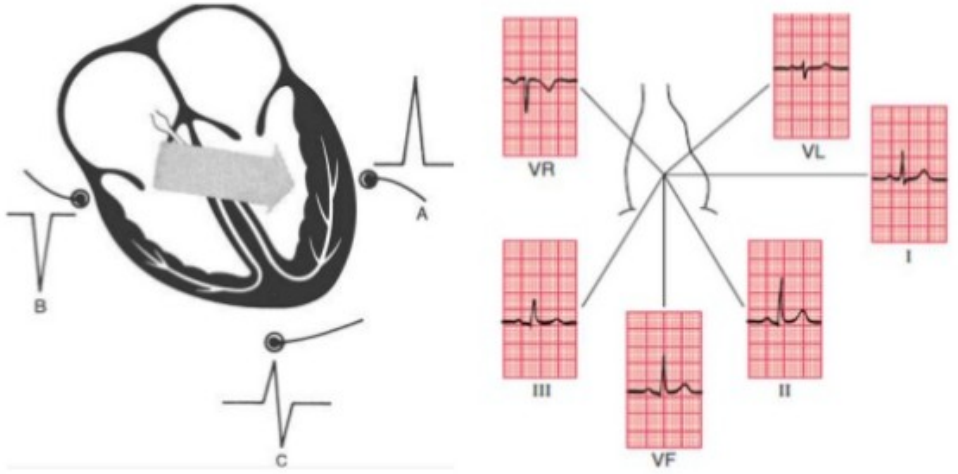
aVL-augmented vector left arm

aVF-augmented vector left foot



MAKING A RECORDING

- Good contact between body surface and electrode is necessary. It might be essential to shave the chest and apply electro cardio graphic jelly
- The patient must lie down and relax to prevent muscle tremor
- Connect up the limb electrodes to the correct limb.limb electrodes have marking on them and also they are colour coded(red –right arm,yellow-left arm,gren left leg and black-right leg)
- Calibrate the record with 1mv signal.There shouldn't be overdamping or underdamping.
- Any metallic object like watch or jwelleary should be removef from the patients body
- 4-5 recording of each lead is recorded



- We can easily apply these concepts to the entire heart.
- Electrodes placed on the surface of the body will record waves of depolarization and repolarization as they sweep through the heart.

HOW TO REPRT AN ECG

- Ecg strip should be correctly labelled(the patients particular and all the lead markings)
- The ecg recording should be described under the following heads:

- Heart rate
- Rythem
- Various conduction intervals (pr interval ,qt interval)
- Description of QRS complex ,ST segment and T waves
- Cardiac axis
- Any abnormal wave like J and U waves

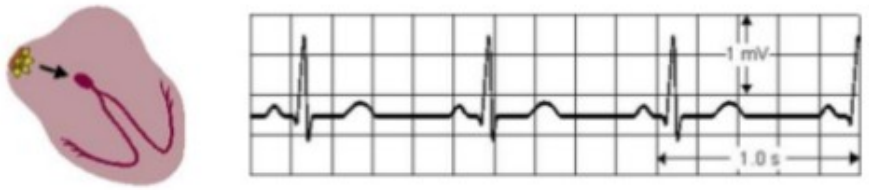
- **Heart rate**:calculated by dividing 1500 by number of small box between two consecutive R waves

- ***Sinus tachycardia***-heart rate more than 100 beats per minute.
- ***Sinus bradycardia***-heart rate less than 60 beats per minute

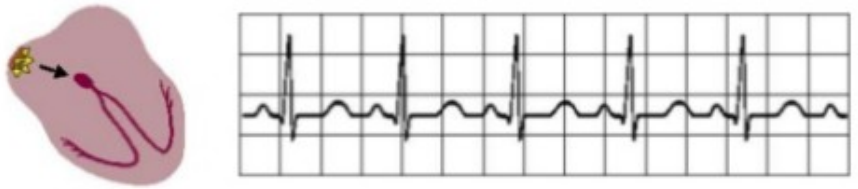
- **Rhythm-** rhythm controlled by sinus node at a rate of 60-100 beats/min; each P wave followed by QRS and each QRS preceded by a P wave.

Specific Arrhythmias

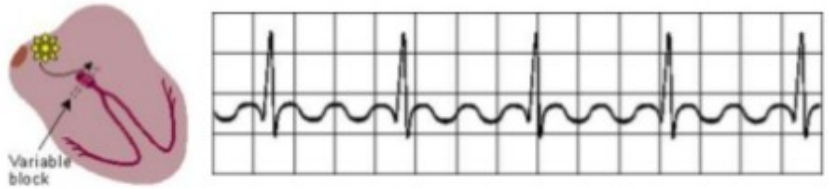
- Sinus bradycardia
- Sinus tachycardia
- Sick sinus syndrome- disturbance of SA nodal function that results in a markedly variable rhythm (cycles of bradycardia and tachycardia).
- Atrial flutter - sinus rate of 250-350 beats/min
- AV nodal blocks - a conduction block within the AV node (or occasionally in the bundle of His) that impairs impulse conduction from the atria to the ventricles.
- Ventricular flutter - very rapid ventricular depolarizations >250/min
- Ventricular fibrillation - uncoordinated ventricular depolarizations; leads to death if not quickly corrected



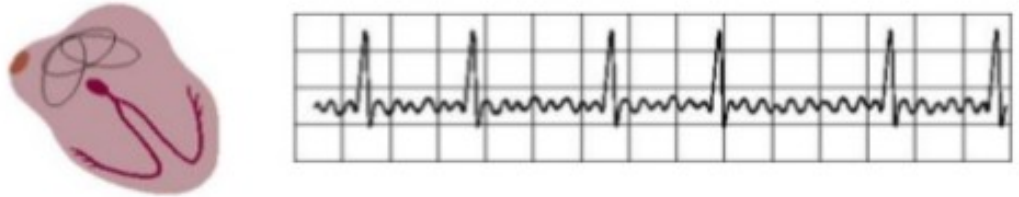
NORMAL SINUS RHYTHM Impulses originate at S-A node at normal rate



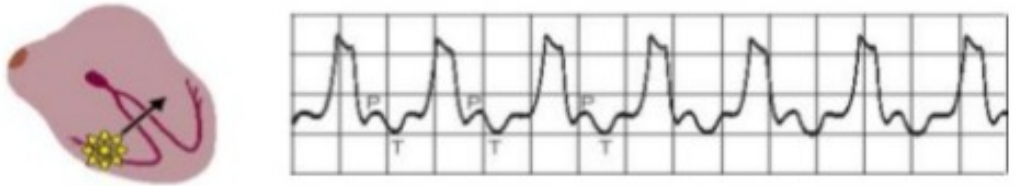
SINUS TACHYCARDIA Impulses originate at S-A node at rapid rate



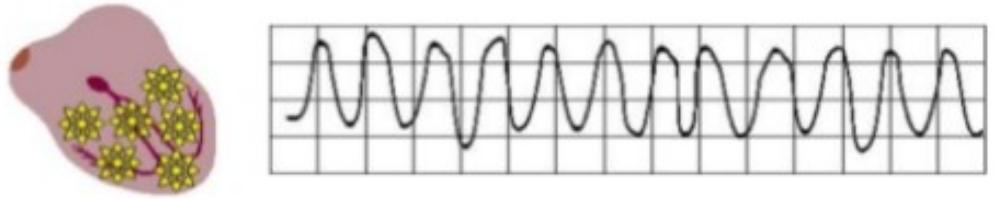
ATRIAL FLUTTER Impulses travel in circular course in atria – No interval between T and P



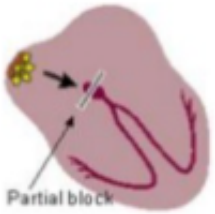
ATRIAL FIBRILLATION Impluses have chaotic, random pathways in atria

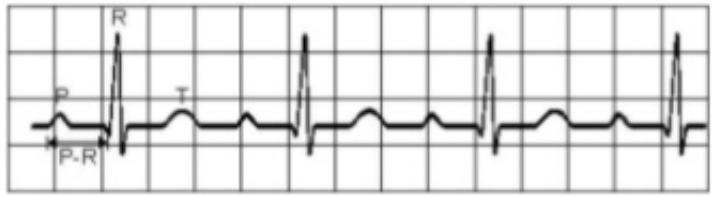


VENTRICULAR TACHYCARDIA
Impulse originate at ventricular pacemaker – odd/wide QRS complex

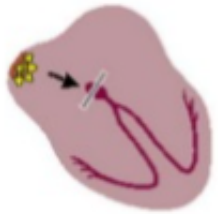


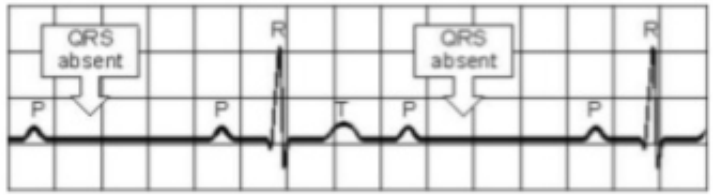
VENTRICULAR FIBRILLATION
Chaotic ventricular depolarization – ineffective at pumping blood – death within minutes





A-V BLOCK, FIRST DEGREE Atrio-ventricular conduction lengthened
P-wave precedes each QRS-complex but PR-interval is > 0.2 s





A-V BLOCK, SECOND DEGREE Sudden dropped QRS-complex
Intermittently skipped ventricular beat

➢ **PR interval and QT interval**

- The **PR interval** extends from the start of the **P wave** to the very start of the **QRS complex**.
- A normal value is 0.12 to 0.20 seconds
- Its significance lies in assessing the nodal blocks
- **QT interval** is a measure of the time between the start of the **Q wave** and the end of the **T wave**
- Normal values for the QT interval are between 0.30 and 0.44 secs
- If abnormally prolonged or shortened, there is a risk of developing ventricular arrythmias

➢ **QRS complex and ST segment**

- The QRS complex is 0.08 to 0.12 sec
- Not every QRS complex contains a Q wave, an R wave, and an S wave
- The duration, amplitude, and morphology of the QRS complex is useful in diagnosing, arrythmias, conduction abnormality, myocardialinfarction, and other disease states.

- **ST segment** connects theQRS complex and theT wave and has a duration of 0.08 to 0.12 sec
- ST segment elevation or depression is associated with various cardiac abnormality

Conditions causing ST segment elevation

Acute myocardial infarction

Pericarditis

Left Ventricular Hypertrophy

Left Bundle Branch Block

hyperkalemia

Conditions causing ST segment depression

Ischemic heart disease

Hypokalemia

Secondary ST segment changes with conduction abnormalities (e.g., RBBB, LBBB, WPW, etc

hypokalemia

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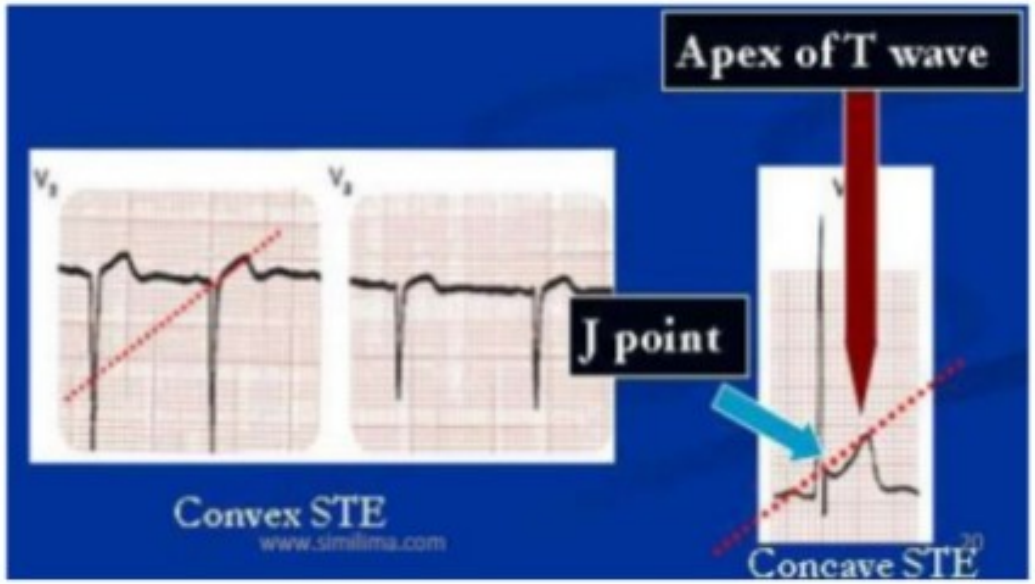
Morphology of ST segment elevation

- AMI usually demonstrate straight/convex STE
- Concave shaped STE-non AMI causes



➢ Cardiac axis

- The electrical axis of the heart is the mean direction of the action potentials traveling through the ventricles during ventricular activation (depolarization)
- The QRS complex, which represents ventricular depolarization, is used for the determination of the electrical heart axis.
- The normal electrical axis of the heart is situated between -30 degrees and +90 degrees (positive 90 degrees) with respect to the horizontal line
- Left axis deviation: the electrical heart axis is between -30 degrees and -90 degrees with respect to the horizontal line.
- Right axis deviation: the electrical heart axis is between +90 degrees and 180 degrees with respect to the horizontal line.
- Extreme axis deviation (also known as northwest axis or no man's land): the electrical heart axis is between +180 degrees and -90 degrees with respect to the horizontal line.

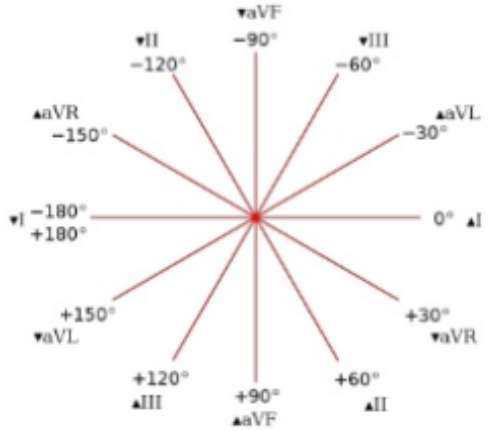


Fig showing the cardiac axis in hexaxial referrance system

causes of right axis deviation

- normal finding in children and tall thin adults
- right ventricular hypertrophy
- chronic lung
- anterolateral myocardial infarction
- left posterior hemiblock
- Wolff-Parkinson-White syndrome - left sided accessory pathway
- atrial septal defect
- ventricular septal defect

causes of left axis deviation

- left anterior hemiblock
- Q waves of inferior myocardial infarction
- emphysema
- hyperkalaemia
- Wolff-Parkinson-White syndrome - right sided accessory pathway
- tricuspid atresia
- ostium primum ASD
- injection of contrast into left coronary artery

causes of a Northwest axis (no man's land)

- emphysema
- hyperkalaemia
- lead transposition
- artificial cardiac pacing
- ventricular tachycardia