

The following neoplasm does not frequently metastasize to bone

- A. Ovary
- B. Prostate
- C. Lung
- D. Lymphoma
- E. Breast

The following neoplasm does not frequently metastasize to bone

- TFFFF

Which of the following commonly cause photopenic lesions on a bone scan

- A. Malignant melanoma
- B. Ewing's sarcoma
- C. Multiple myeloma
- D. Hypernephroma
- E. Colon carcinoma

Which of the following commonly cause photopenic lesions on a bone scan

- FFTTF

What are the potential impurities in
Tc-99m labeled diphosphonate
compounds, based on their
biodistribution.

What are the potential impurities in Tc-99m labeled diphosphonate compounds, based on their biodistribution.

- Activity in the oropharynx, thyroid gland and stomach suggestive of free pertechnetate.
- Activity in the liver suggests of colloidal impurity.
- Rarely, activity is seen in the gut, the result of excretion of activity through the biliary system.

What is the distribution of metastatic deposit from epithelial primary malignancies in the skeleton?

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- 80% at axial skeleton (spine, ribs, pelvis and sternum)
- 10% at skull
- 10% at long bones

What factors distinguish a superscan resulting from metastatic disease or from metabolic disease?

What factors distinguish a superscan resulting from metastatic disease or from metabolic disease?

- Metastatic disease: uptake seen at axial skeleton and proximal parts of the femur and humeri.
- Metabolic disease: entire skeleton is typically effected with increased uptake seen at extremities as well as in the axial skeleton.

What is the mechanism of the flare phenomenon?

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- In some patients treated with chemotherapy for metastatic disease, regression of the tumor burden is associated with increased osteoblastic activity, presumably caused by skeletal healing in response to chemotherapy. This can appear on bone scan as a paradoxical increased “worsening” tracer uptake which up to 6 months after therapy.

What factors contribute to prolonged fracture positivity on bone scan?

What factors contribute to prolonged fracture positivity on bone scan?

- Displaced or comminuted fractures and fractures involving joints tend to have prolonged tracer uptake. Elderly patients have delayed healing.

What is the scintigraphy pattern of
osteomyelitis in children

What is the scintigraphy pattern of osteomyelitis in children

- Hot focus in metaphyseal region

What is scintigraphy finding in RSD

What is scintigraphy finding in RSD

- Increased blood flow and diffusely increased periarticular activity in delayed images

What is the explanation for the abnormal bone scan in RSD

- Loss of sympathetic stimulation
- Results in vasodilatation
- Increased blood flow and bone turnover
- Synovitis contributing diffusely increased periarticular activity

What is shin splint

What is shin splint

- Periostitis along posteromedial angle of tibia
- Tear of tibialis posterior muscle or soleus muscle tendon complex

What is scintigraphic appearance in
shin splint

What is scintigraphic appearance in shin splint

- Longitudinal wavy irregular uptake in the periosteal aspect of the posteromedial tibia

What is the three phase bone scan finding in the acute phase of AVN

What is the three phase bone scan finding in the acute phase of AVN

- Diminish flow and cold defect in delayed view

What is the finding in the chronic
phase of AVN

What is the finding in the chronic phase of AVN

- Increased or normal flow with increased uptake

How is the bone marrow scan used in
AVN

How is the bone marrow scan used in AVN

- A cold defect in the region of increased uptake in bone scan indicates the bone scan abnormality is due to infarct

What are the scintigraphic finding of
cellulitis

What are the scintigraphic finding of cellulitis

- Increased flow and blood pool images in the first and second phase
- Delayed phase normal uptake

What are the scintigraphic finding of
osteomyelitis

What are the scintigraphic finding of osteomyelitis

- Increased flow and blood pool images in the first and second phase
- Increased uptake in delayed phase

Name four primary tumors causing
photopenic metastases

Name four primary tumors causing photopenic metastases

- Renal
- Thyroid
- Multiple myeloma
- Lung

Describe the scintigraphic pattern in
Paget's

Describe the scintigraphic pattern in Paget's

- Expansile or thickening of the bone with sharp demarcation of normal area

How does Paget's affect the bone

How does Paget's affect the bone

- Increased bone resorption accompanied by bone formation

What is the scintigraphic finding of radiation osteitis in bone scan

What is the scintigraphic finding of radiation osteitis in bone scan

- Increased activity in the first few weeks, followed by defect

What is the scintigraphic pattern of early fracture in bone scan

What is the scintigraphic pattern of early fracture in bone scan

- Cold defect in the first few hours

What are the reasons of cold defect in first few hours of fracture in bone scan

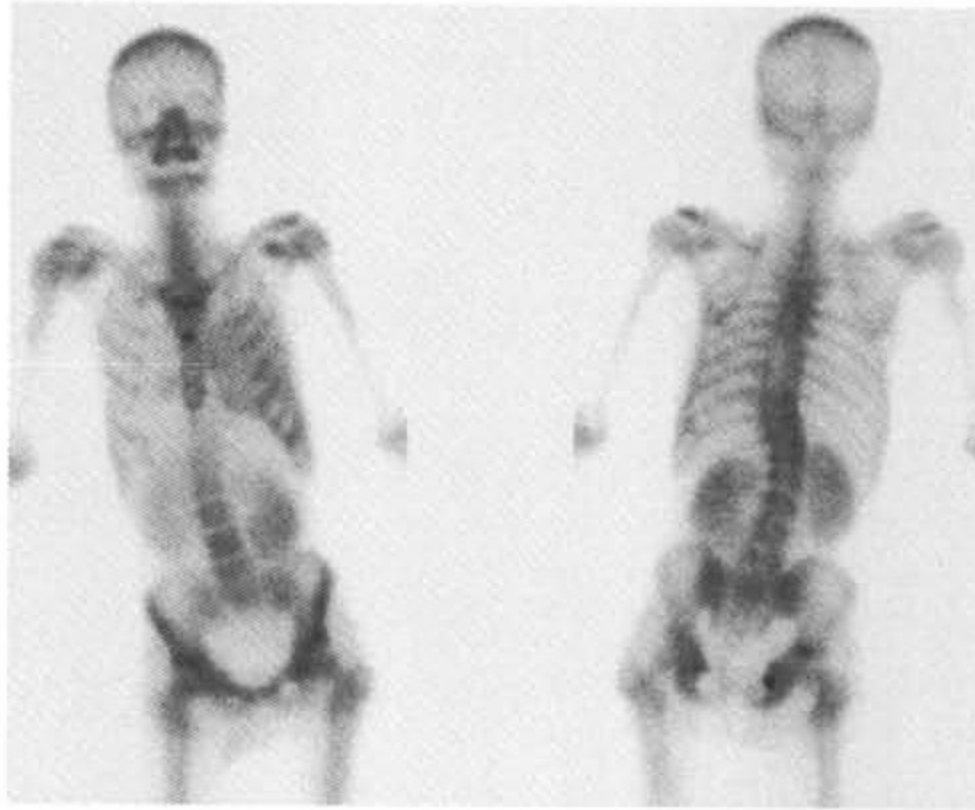
What are the reasons of cold defect in first few hours of fracture in bone scan

- Rupture of vascular supply from fracture and too early for reactive bone formation

How soon will fracture become
positive and what is the time course in
bone scan

How soon will fracture become positive and what is the time course in bone scan

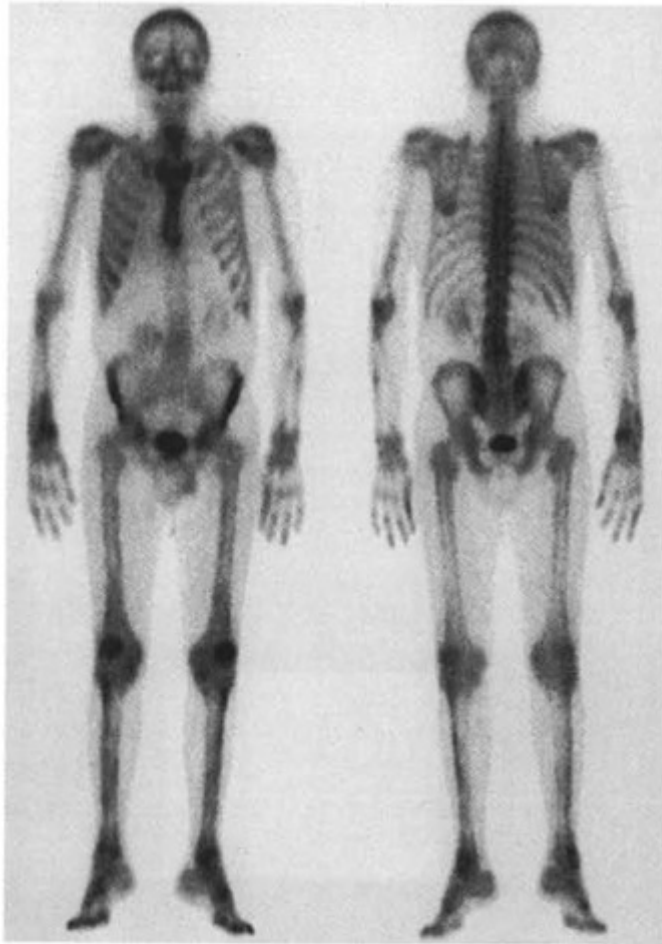
- Cold defect in the first few hours
- Increasing activity up to few weeks or months
- Then tapering off until resolved



1. Describe the bone scan findings.
2. Name structures where the tracer could be deposited.
3. Provide the differential diagnosis.
4. What other information would be helpful?

Pleural uptake

1. Abnormal soft tissue in the anterior left hemithorax, scoliosis and mild arthritic changes in both hips.
2. Starting on the inside working outward, in the lung parenchyma, in a primary or secondary tumor in the lung, in the pleural or pleural effusion, in the soft tissue of the chest wall.
3. Extensive pleural calcification, fibrothorax and prior radiation.
4. History, CXR or SPECT



A patient was referred for bone scan because of joint pain.

1. Describe the scintigraphic bone findings.
2. Describe any soft tissue findings. What is the likely cause?
3. What other imaging study should be ordered?
4. What is the diagnosis and most likely common cause for this scan pattern?

Hypertrophic pulmonary osteoarthropathy (HPOA)

1. Diffuse increased uptake in the upper and lower extremities and periarticular regions of the elbow, wrist and ankle joint. Uptake in the seventh right rib anteriorly.
2. Diffuse uptake in the right thorax. The most common cause is malignant pleural effusion.
3. CXR
4. HPOA. Bronchogenic cancer of the lung.

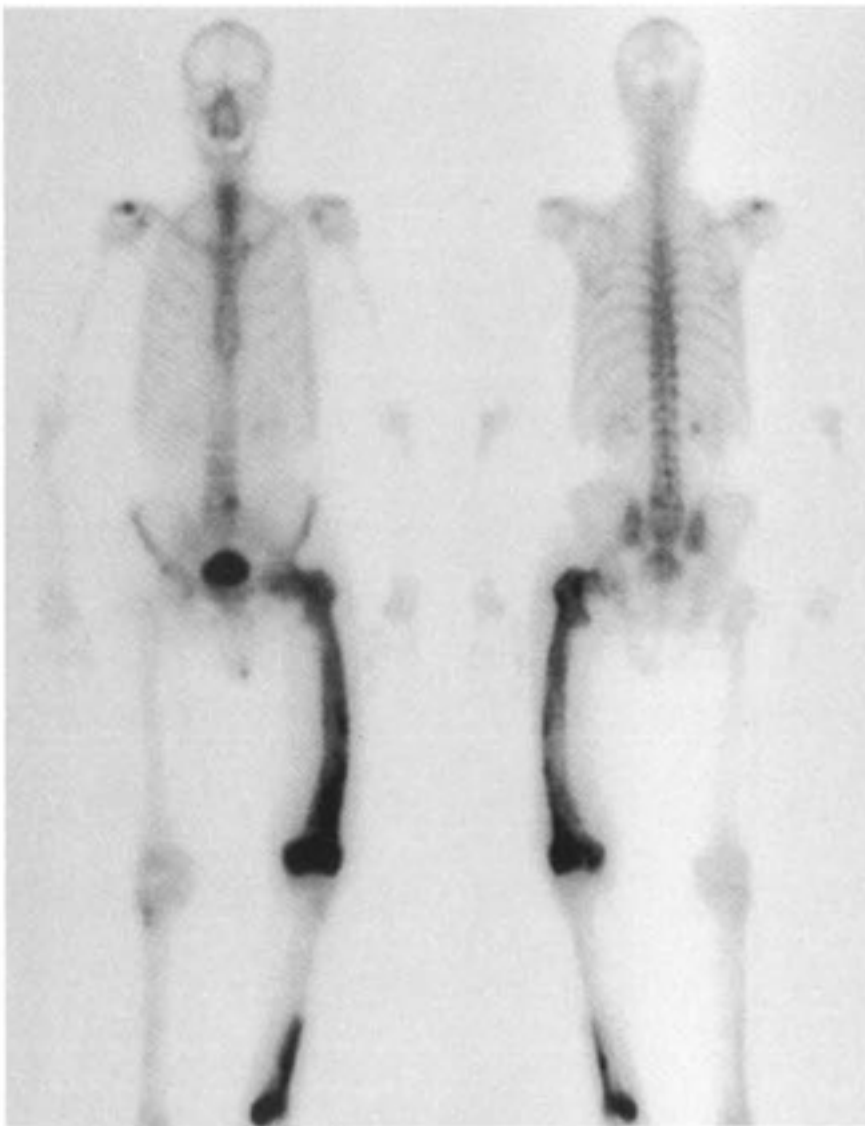
A**B****C**

Lower extremity pain in three different patients (*A*, *B*, *C*), all members of the track team.

1. Describe the findings in Patient *A*.
2. What is the most likely diagnosis?
3. Describe the findings in Patients *B* and *C*.
4. Provide the most likely diagnosis for Patients *B* and *C*.

Stress fractures

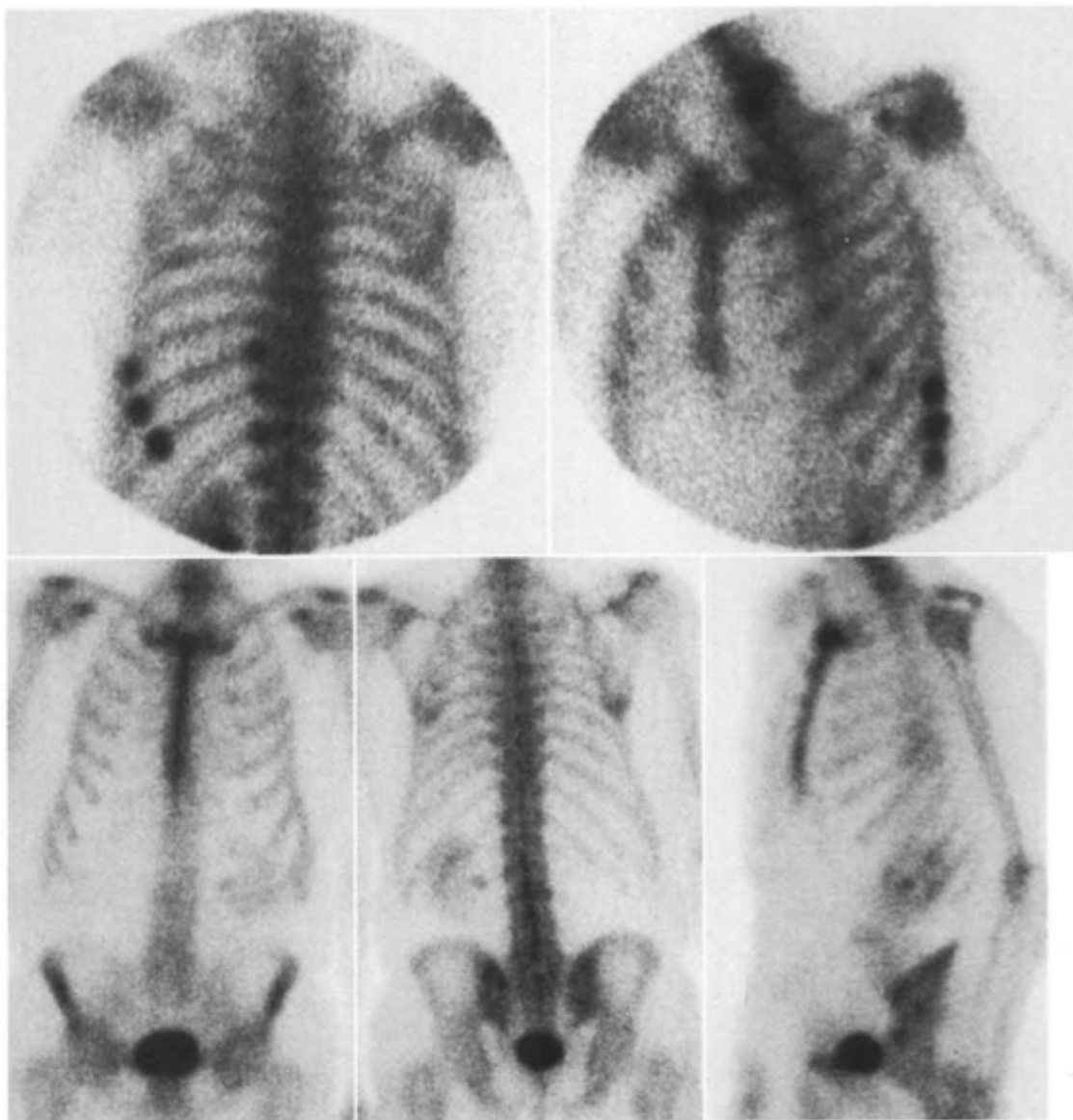
1. Increased activity in a linear pattern along the posterior and medial aspect of both mid tibias.
2. Shin splints
3. B , focal ovoid activity posteromedial right tibia at the junction of the proximal 2/3 and distal 1/3. C, focal fusiform activity posteromedially in the right proximal tibia and linear activity along the posteromedial left tibia proximally and more prominently distally.
4. B, stress fracture. C, stress fracture and shin splints



1. Describe the bone scan abnormality.
2. Provide descriptive terms that could be used to describe the pattern in the tibia.
3. Provide the differential diagnosis.
4. The patient may experience clinical symptoms related to another organ system. Discuss the mechanism.

Paget's disease

1. Abnormal increased uptake in the entire left femur, which appears bowed and widened and the distal third of the left tibia, which tapers proximally.
2. A sharp leading edge, referred to as “flame shaped” or “blade of grass”, may be demonstrated on the lytic phase on radiograph and bone scan.
3. Paget's disease, fibrous dysplasia, chronic osteomyelitis, primary bone tumors.
4. High output congestive heart failure may occur. Once believed to be the result of arteriovenous shunting within the bone lesion, now hyperemia and increased blood flow through the lesion and not shunting are likely the causes.

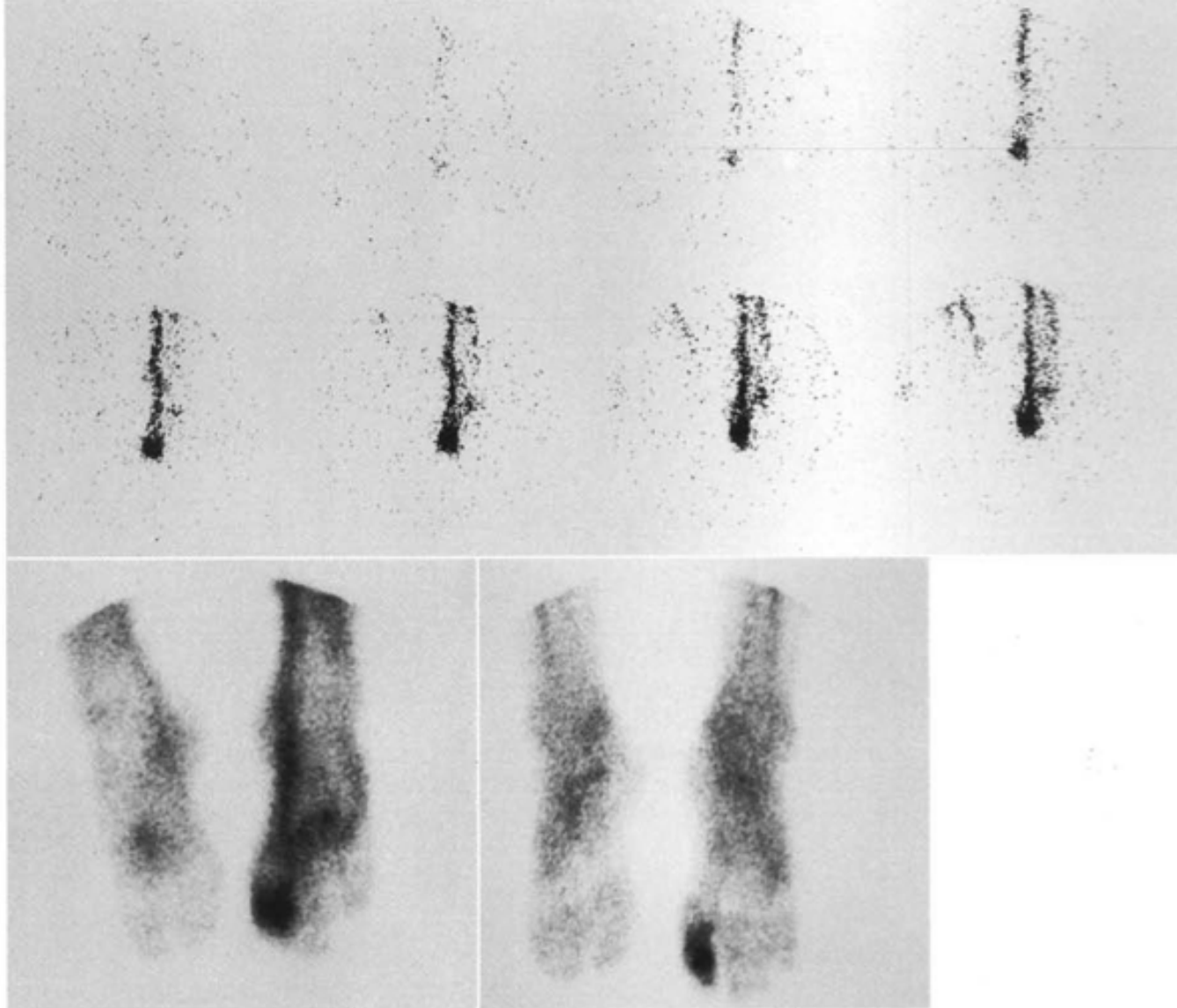


Two patients (*A* and *B*) referred with chest wall pain.

1. Describe the bone scan findings.
2. Is there a pattern to the abnormalities?
3. What causes should be considered?
4. Based on the scan findings, provide the most likely diagnoses.

Rib fractures

1. Patient A; focal increased uptake in multiple ribs posterolaterally and the costovertebral junctions. Patient B; increased vertical linear uptake in the sternum from the manubrium to the xiphoid.
2. The uptake in adjacent (patient A) and the vertical uptake in the sternum both have a geometric and characteristic pattern.
3. Trauma or surgery
4. Patient A; multiple rib fracture. Patient B; median sternotomy for coronary artery bypass grafting (CABG)

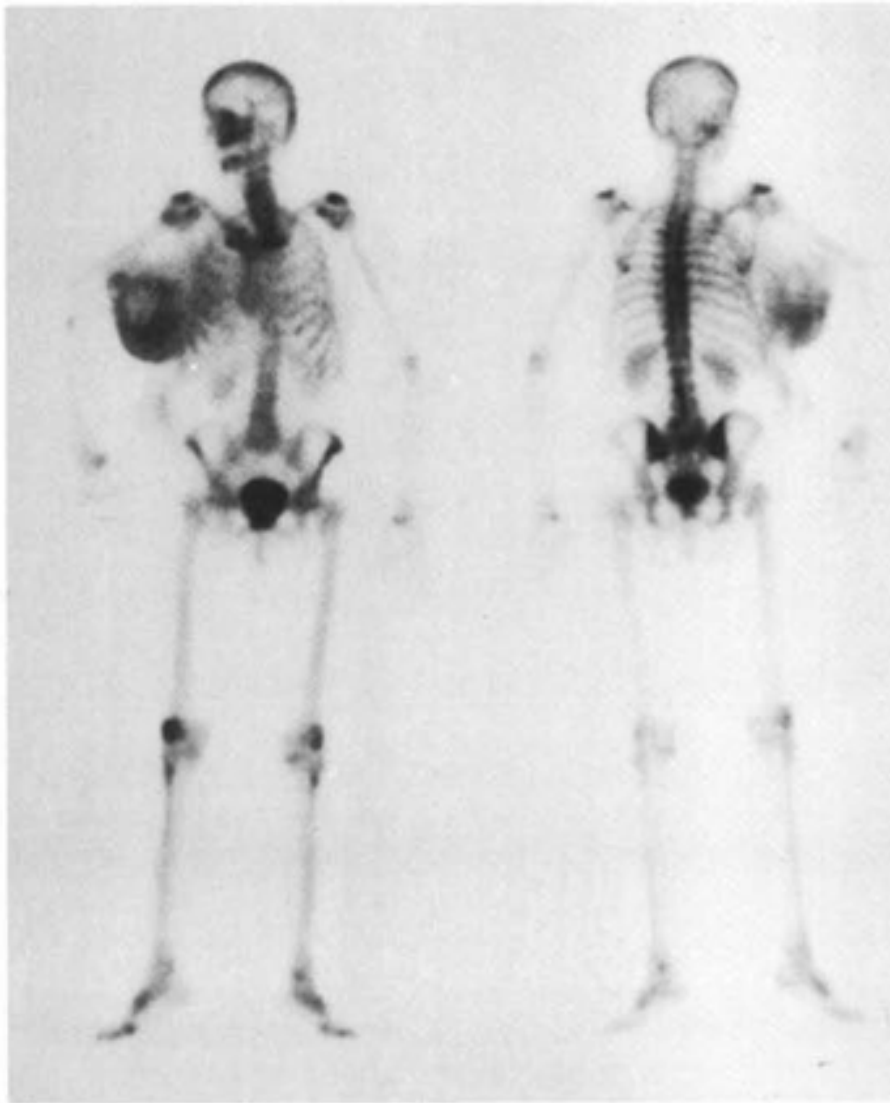


A 60-year-old patient with diabetes with cellulitis of the distal foot, referred to rule out osteomyelitis of the left great toe.

1. Describe the physiology of each of the three phases.
2. Describe the scintigraphic findings in this case.
3. Interpret the study.
4. What is the sensitivity and specificity of the three-phase bone scan for osteomyelitis?

Osteomyelitis

1. First phase; arterial blood flow to the bone. Second phase; blood pool. Third phase; delayed phase or bone uptake at 3 hours after injection. All three phases are typically focally increased with osteomyelitis. With cellulitis only two phases are positive.
2. Increased flow, blood pool and delayed uptake to the left first digit distal phalanx.
3. Consistent with osteomyelitis of the digit.
4. Sensitivity and specificity 95% if the radiograph is normal or has only suggestive changes of osteomyelitis.



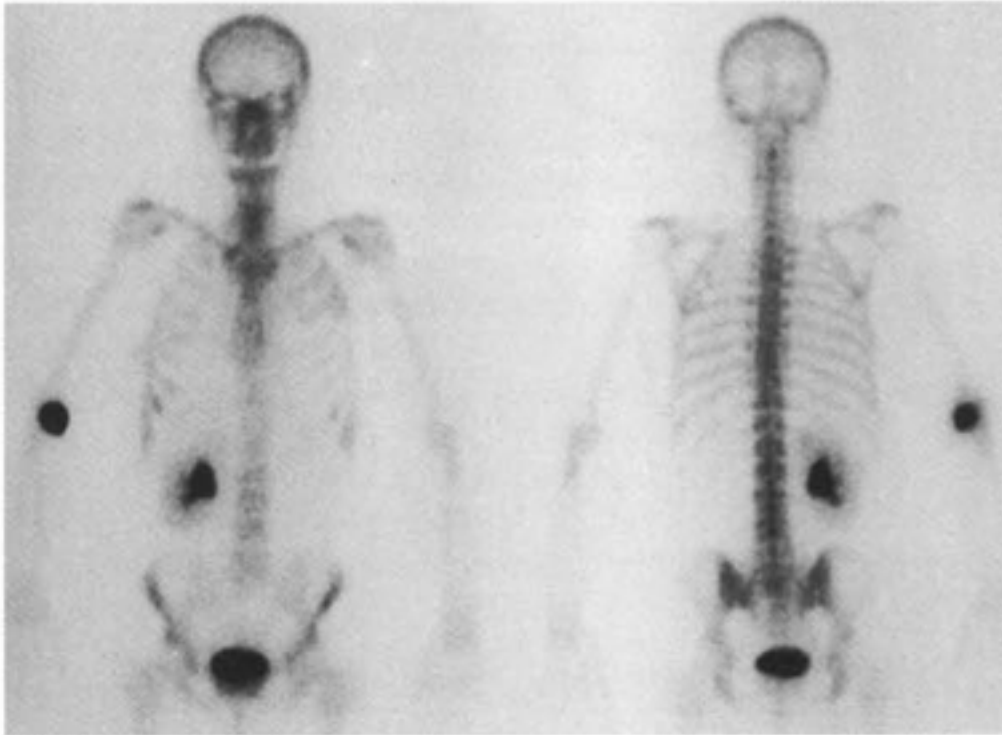
Patient referred for bone scan because of right-sided chest pain.

1. Describe scintigraphic findings.
2. Provide a differential diagnosis.
3. What other examinations may be helpful in this setting?
4. What is the likely reason for ordering the bone scan?

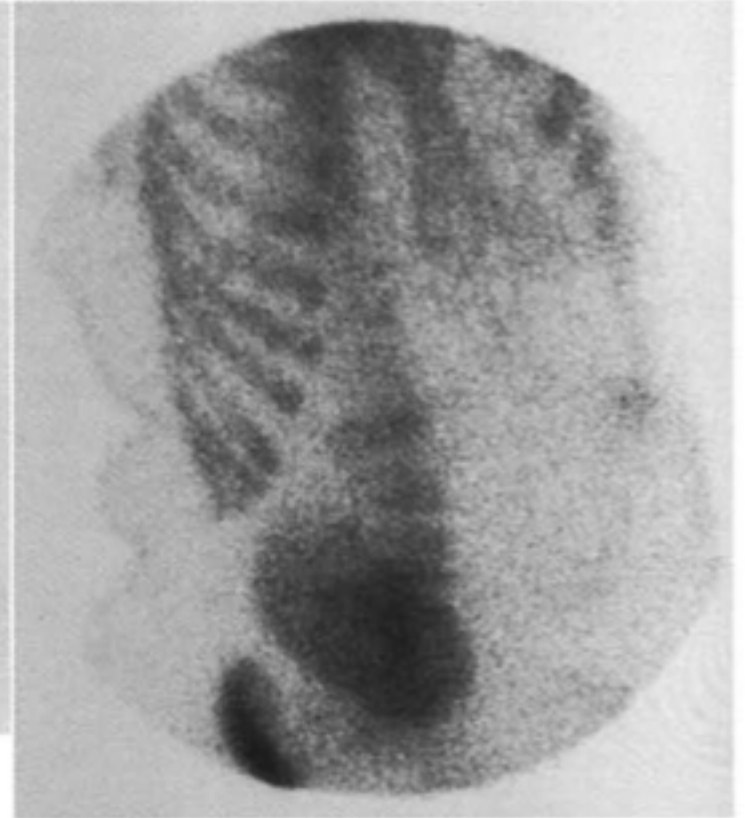
Abnormal breast uptake

1. Nonuniform abnormal soft tissue uptake exists in the soft tissue overlying the chest, likely the right breast.
2. Breast ca, aseptic mastitis or radiation therapy.
3. Breast examination, mammography and possible biopsy.
4. To determine whether breast cancer bone metastases are present.

A



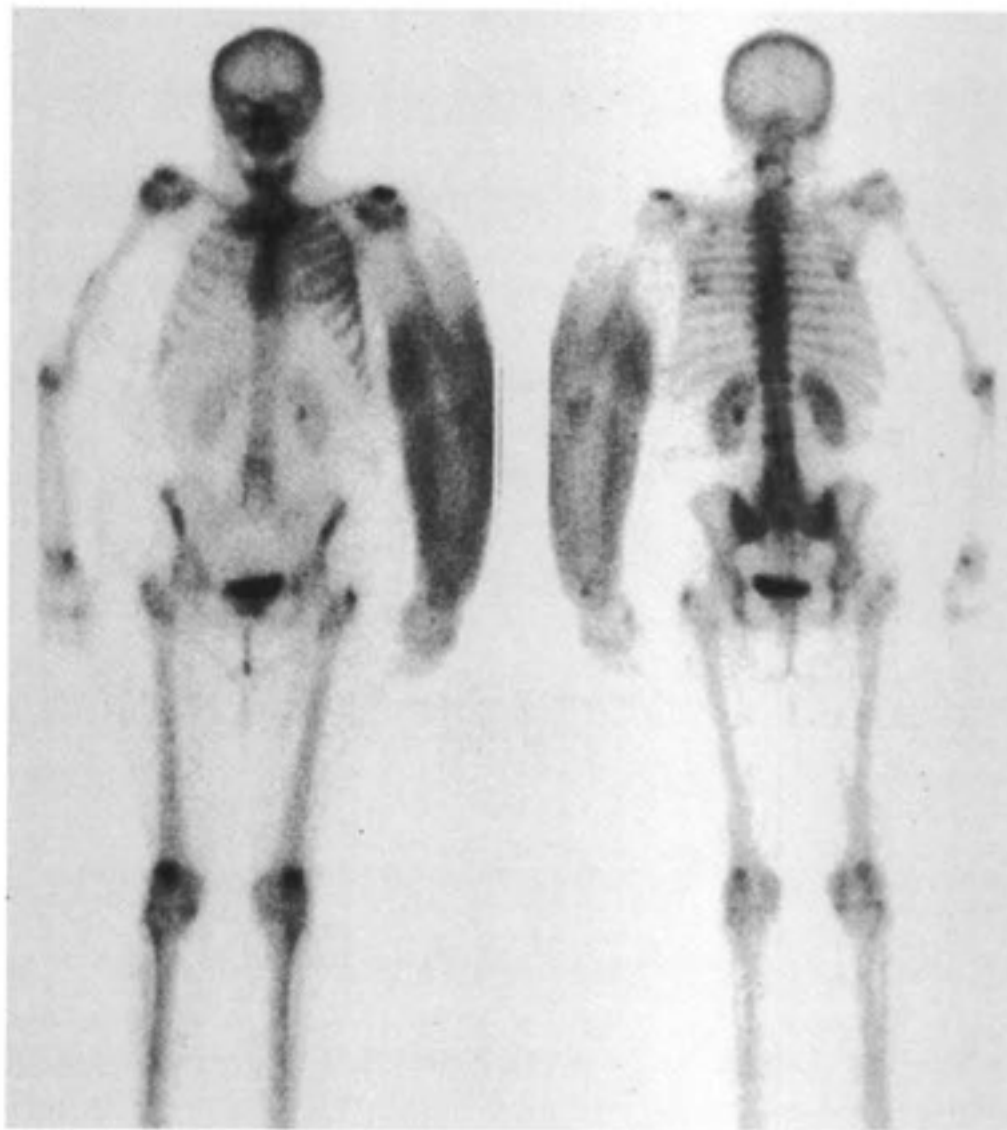
B



1. Describe the abnormal bone scan findings in scan *A*.
2. Provide a differential diagnosis.
3. Describe the findings in scan *B*, a delayed spot image.
4. Explain the change and provide the most likely diagnosis.

Extra renal pelvis

1. Solitary right kidney with prominent renal pelvis. Incidental uptake at antecubital injection site
2. Ureteropelvic junction obstruction or obstruction secondary to other processes, extrarenal pelvis.
3. The renal pelvis has drained and the kidney is now seen inferomedial to its prior location
4. Image B was taken with the patient erect, leading to gravity drainage of an extra renal pelvis. The kidney is mobile (ptotic)

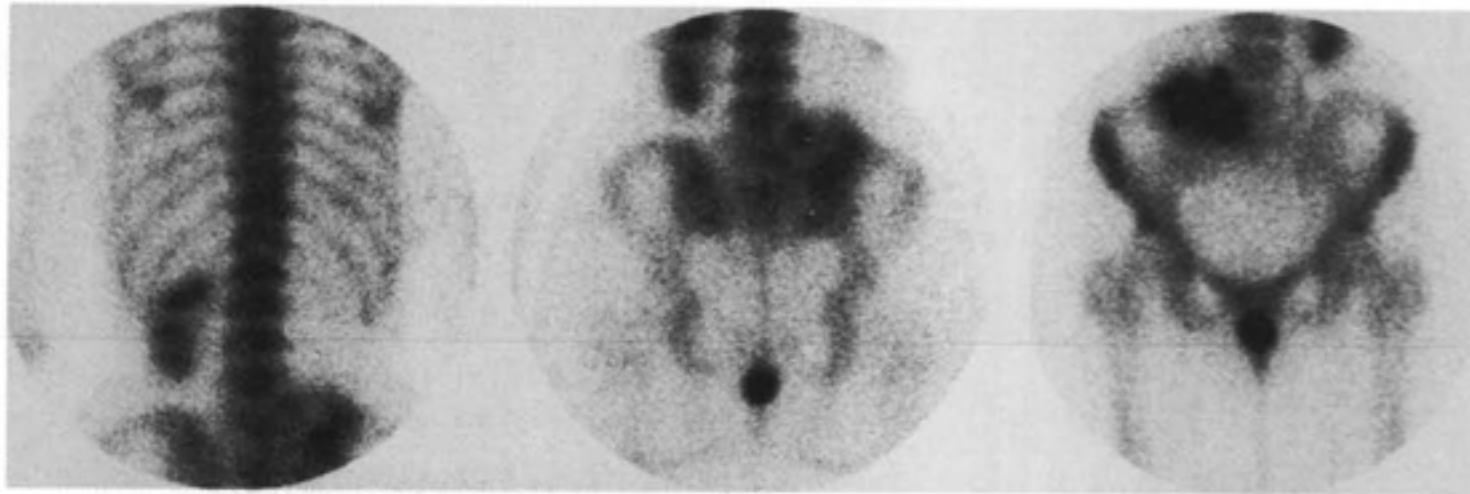


Pain in the left shoulder; rule out metastasis.

1. Describe the findings.
2. Name three general processes that could account for the findings.
3. What is the likely primary tumor for which metastases are being excluded?
4. What is the most likely diagnosis?

Lymphedema

1. The soft tissues of the left arm enlarged and show abnormal increased soft tissue activity, the left anterior ribs are uniformly more intense than the right.
2. Venous or lymphatic obstruction, soft tissue neoplasm, soft tissue injury.
3. Breast cancer.
4. Lymphedema secondary to axillary lymph node dissection and left mastectomy



1. Describe the bone scan findings.
2. Provide the general classification for this finding and the likely diagnosis.
3. Name other conditions that fall into the same spectrum of abnormalities.
4. Are increased risks associated with this condition?

Renal position

1. The right kidney is not in the renal fossa. Nonuniform activity is noted in the right sacroiliac region, which extends beyond the expected superior margin of the bone.
2. Congenital renal anomaly, pelvic kidney.
3. Anomalies of number (supernumerary kidney), position (malrotation) and fusion (horseshoe)
4. Yes. Ureteropelvic junction obstruction, vesicoureteral reflux, decrease function and increase risk of trauma.



A 67-year-old man has an elevated serum prostate-specific antigen (PSA) level.

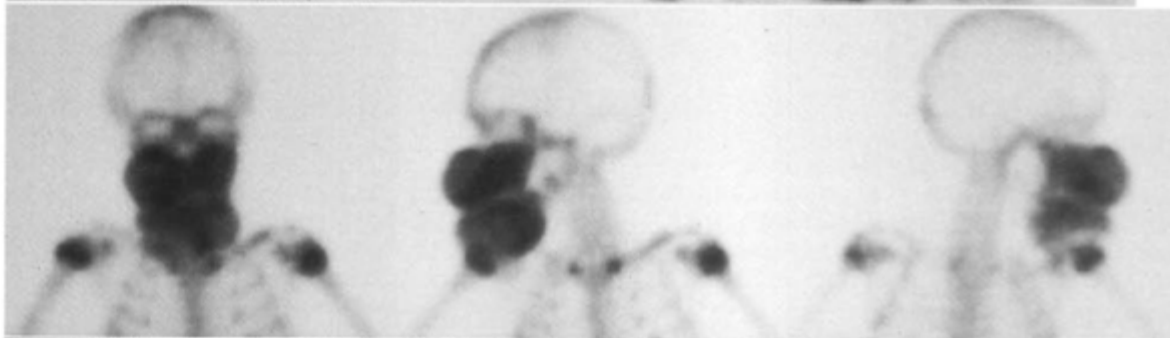
1. Describe the findings on this bone scan and interpret the study.
2. What would you predict the serum PSA level to be?
3. Which metastatic cancers have predominantly lytic lesions in bone and thus lower sensitivity for their detection by bone scanning?
4. If a patient with prostate cancer has a significantly elevated serum PSA level postoperatively but negative bone scan findings, what other imaging options are indicated?

Metastatic prostate cancer

1. Abnormal focal uptake throughout the axial and appendicular skeleton strongly suggestive of metastatic disease.
2. Greater than 20 ng/ml. the prevalence of bone scan – evidence of metastases is $< 1\%$.
3. Multiple myeloma, thyroid ca,, renal cell ca and lymphoma
4. CT and MRI have poor sensitivity for detection of prostate cancer soft tissue/nodal metastases.



A



B

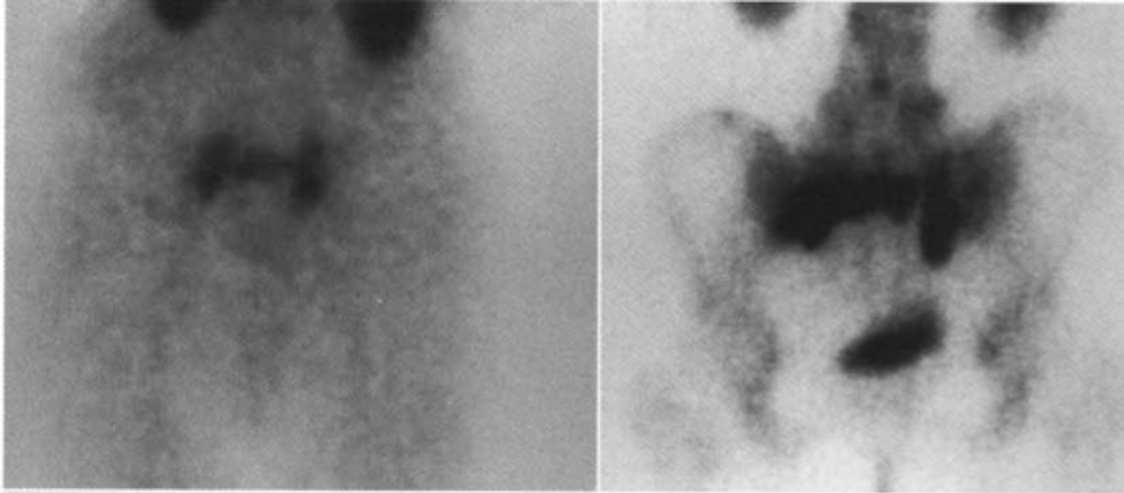


Because of a "jaw problem," a bone scan (*A*) and a bone scan and CT-30 reconstruction (*B*) were obtained in two children.

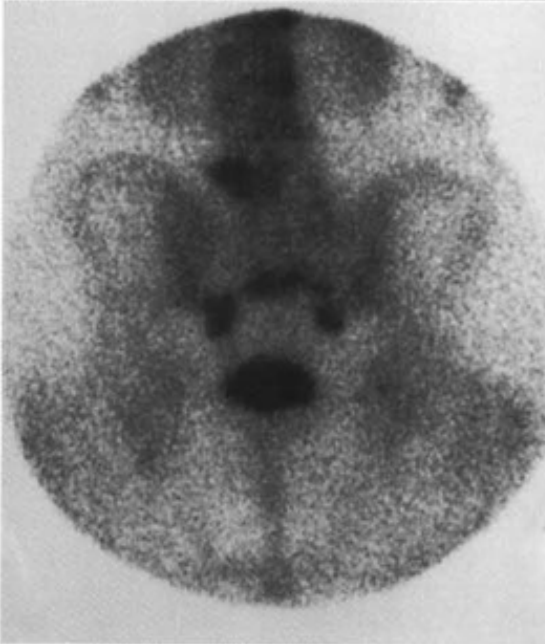
1. Describe the bone scan findings.
2. What additional information would be helpful?
3. Provide a short differential diagnosis.
4. The mother says there is no known disease in the child (*B*) or family. What is the most likely diagnosis?

Fibrous dysplasia

1. A , shows increased uptake in the entire mandible. B, shows intense increased uptake in the mandible and maxilla which appear deformed and overgrown.
2. Check the rest of the bone scan for other sites
3. Fibrous dysplasia, cherubism.
4. Fibrous dysplasia.



A



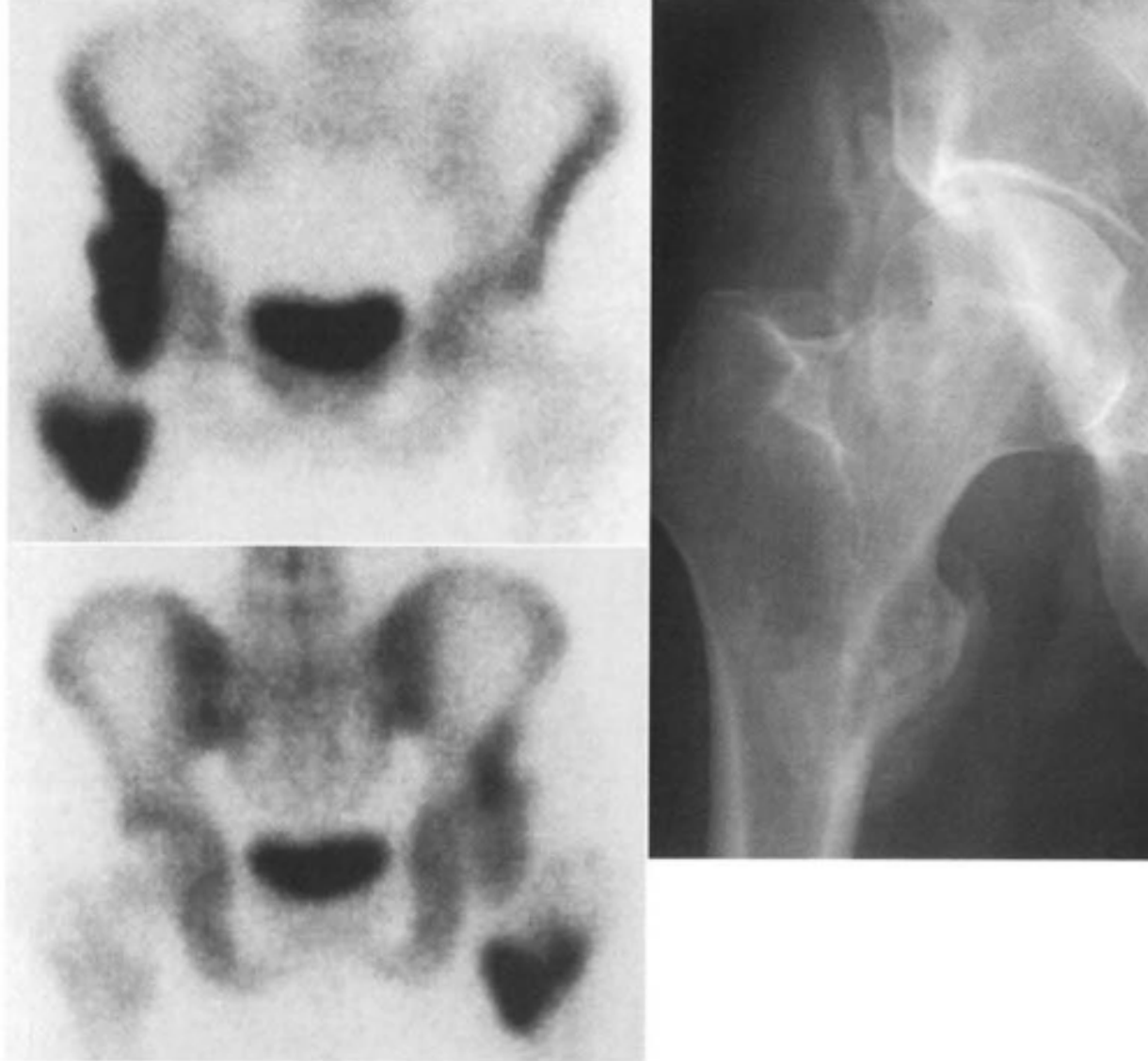
B

Two patients have low back pain. Patient *A* has blood pool (left) and delayed images (right) available; for Patient *B*, only delayed images are shown.

1. Describe the bone scan abnormalities.
2. Provide the differential diagnoses.
3. List three other sites that are at increased risk for the same process.
4. What is the most likely underlying process in both patients?

Sacral insufficiency fracture

1. Patient A has increased blood pooling and delayed uptake bilaterally in the region of the sacroiliac joints and across the sacrum (H pattern). The bone scan for patient B.
2. Both of these are diagnostic of sacral insufficiency fractures.
3. Proximal femur, wrist and proximal humerus
4. Osteoporosis

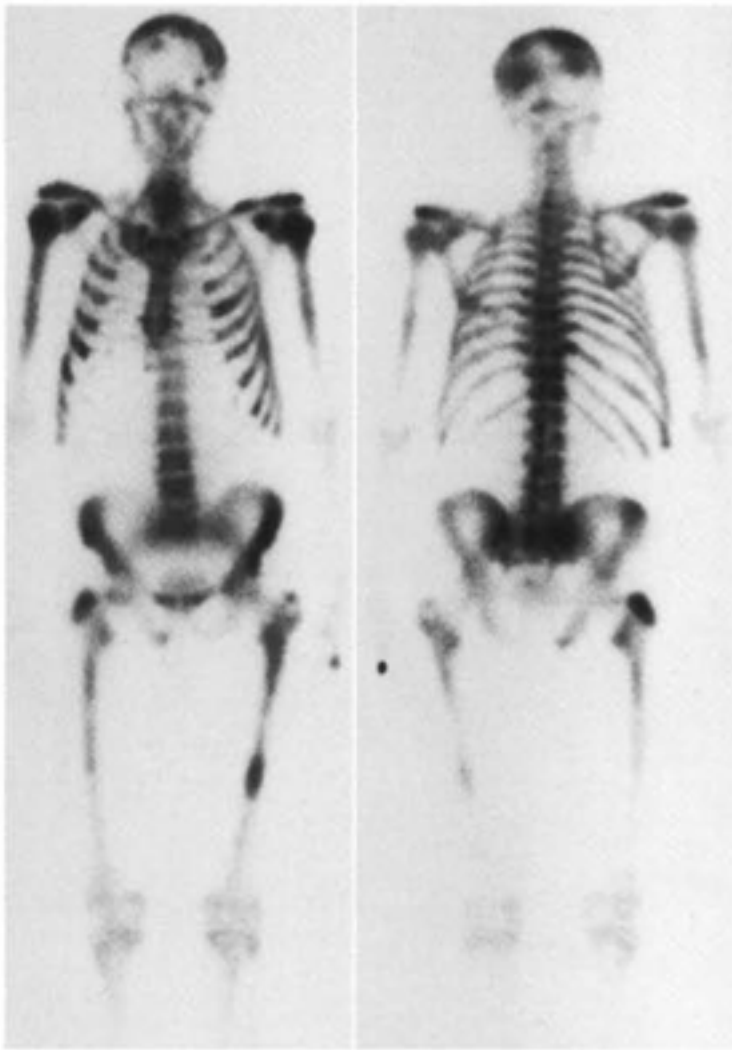


The bone scan image and radiograph of a paraplegic patient are provided.

1. Describe the bone scan findings.
2. Provide a differential diagnosis.
3. What interventions could be performed if artifact is suspected?
4. Radiograph of the right hip was obtained after the bone scan. What is the most likely diagnosis?

Heterotopic ossification

1. Intense activity is seen overlying the right acetabulum with a separate area of uptake overlying the proximal right femur.
2. Urinary contamination; fracture with exuberant callus; heterotopic ossification or myositis ossificans; soft tissue injury (contusion).
3. If urinary contamination is suspected; remove clothing and overlying bed sheets; wash the patient's skin in the area of suspected contamination.
4. Heterotopic ossification.

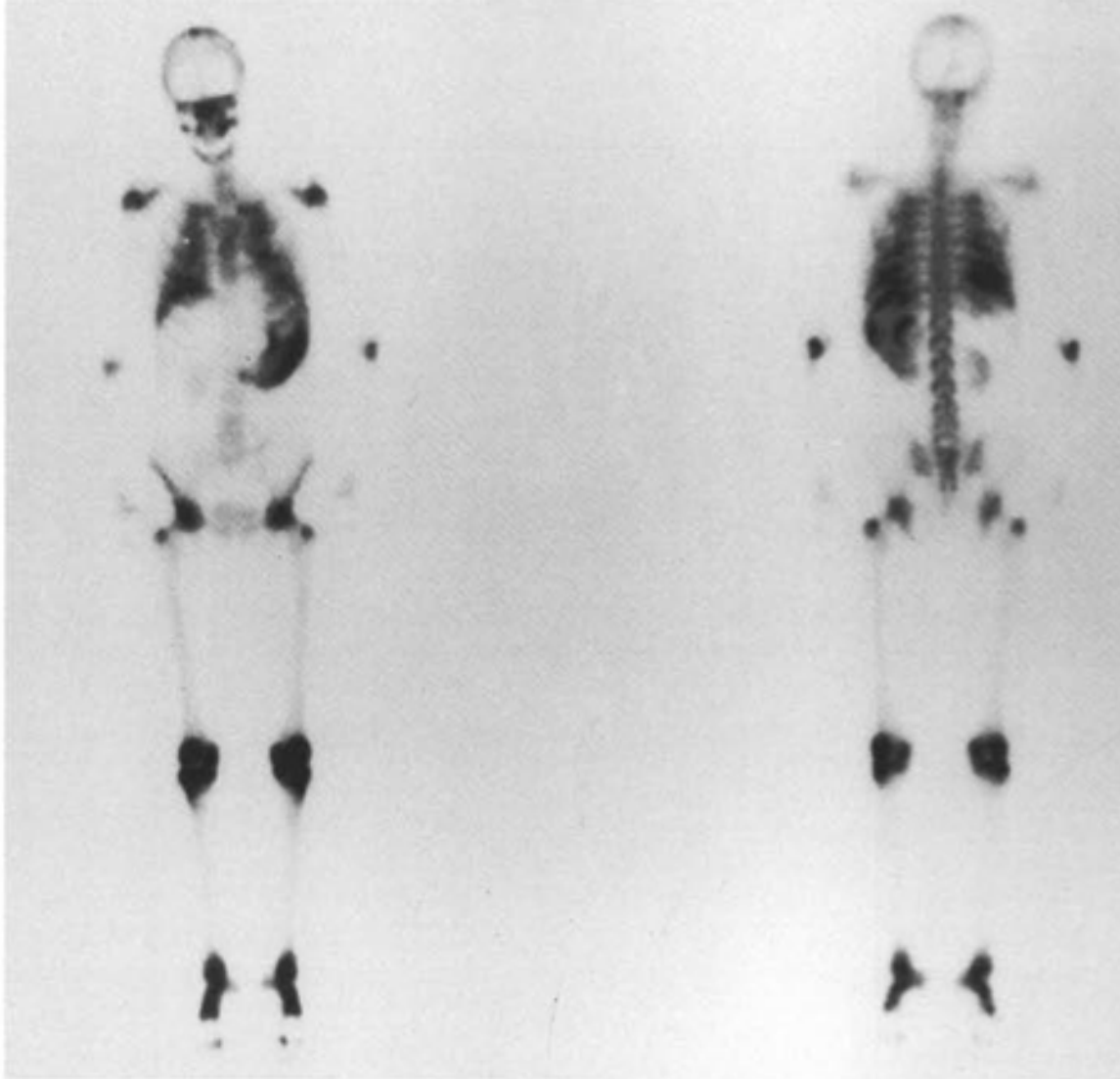


Elevated alkaline phosphatase level.

1. Describe the bone scan findings.
2. Name two other nonosseous systems that should be evaluated on the bone scan.
3. Describe any other findings.
4. What term can be applied to this case?

Superscan

1. Increased tracer in the large majority of the visualized bones, with nonuniform involvement in both femurs, both humeri and skull.
2. Soft tissue and GI tract.
3. The kidneys are not visualized, but faint activity is seen in the urinary bladder. Little soft tissue activity is seen.
4. Superscan.

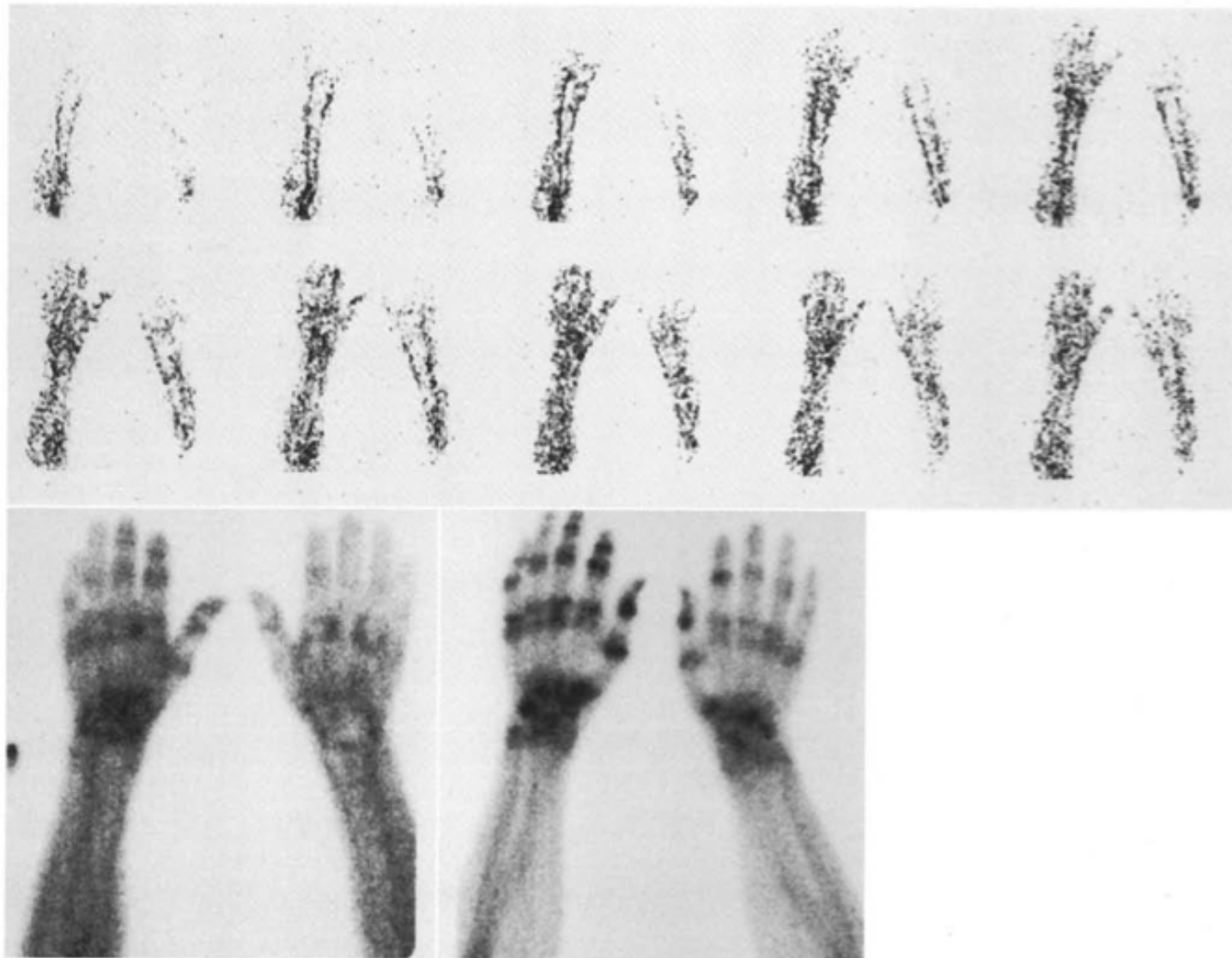


A 53-year-old woman with hypercalcemia was referred to rule out metastatic bone disease.

1. Describe the bone scan findings.
2. Give a differential diagnosis.
3. Provide the most likely diagnosis.
4. Could this pattern be caused by free ^{99m}Tc pertechnetate? Why?

Hyperparathyroidism

1. Abnormal diffuse uptake in the lungs and stomach. Poor visualization of small kidneys and bladder, increased uptake in the shoulders, hips, knees and ankle.
2. Hyperparathyroidism, metastatic calcification caused by hypercalcemia, renal failure or metabolic bone disease.
3. This particular pattern of metastatic calcification is characteristic of long standing hyperparathyroidism.
4. Free Tc-99m pertechnetate has gastric, thyroid and salivary gland uptake. The latter two are not seen in this patient, who also shows large uptake.

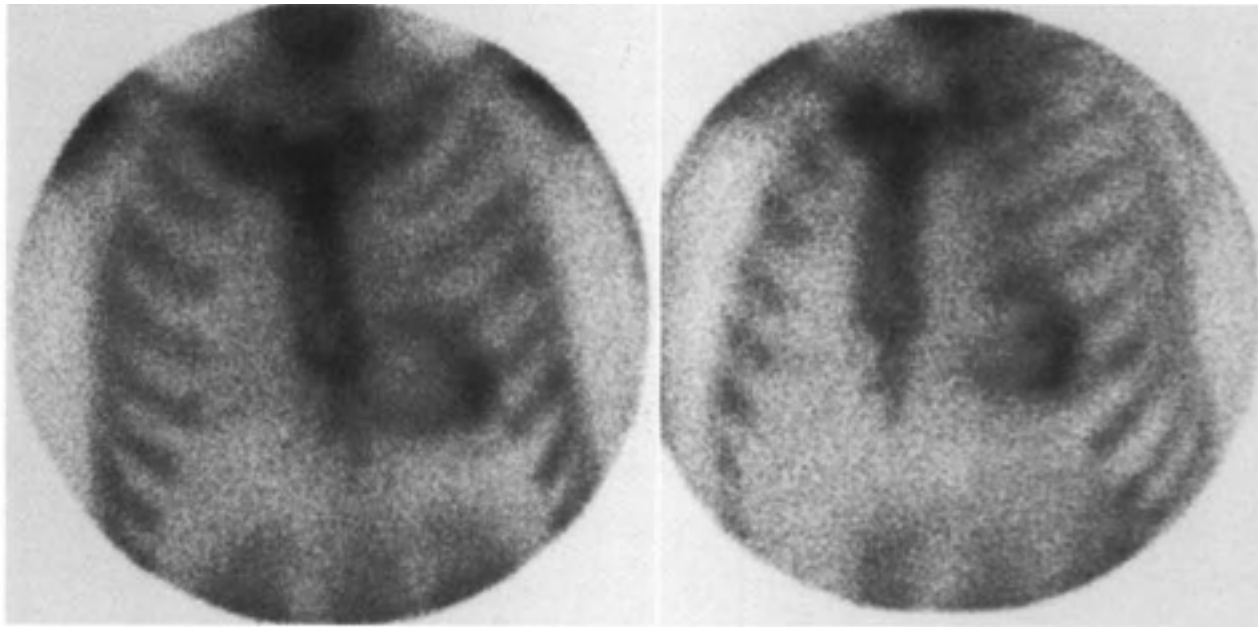


Diffuse upper extremity pain was noted 3 months after thoracotomy. Hand radiographs show normal findings. The remainder of the bone scan is normal.

1. Describe the scintigraphic bone scan findings in this case (palms down on the camera).
2. Provide the differential diagnosis.
3. What is the likely diagnosis in this case?
4. Discuss the pathogenesis.

Reflex sympathetic dystrophy

1. Three phase study demonstrate abnormal increased blood flow and blood pool of the distal right upper extremity. The delayed bone phase shows increased activity in the bones in the same distribution with a striking increased in periarticular activity causing the joints to stand out.
2. RSD. Disuse of a limb of new onset e.g.. recent stroke or immobilization by orthopedic cast or splint.
3. Shoulder hand syndrome, a frequently encountered form of RSD
4. Neurogenic origin with loss of sympathetic autonomic tone is the generally accepted explanation, although not firmly establish.



A bone scan was ordered because an elderly man “hurts all over.” The remaining bone scan (not shown) was otherwise normal.

1. Describe the ^{99m}Tc disphosphonate bone scan findings.
2. In terms of anatomical location, where is the abnormal radiotracer uptake?
3. What other radiopharmaceutical would give a similar appearance?
4. What is the differential diagnosis?

Myocardial uptake

1. Horseshoe pattern of uptake in the anterior chest that does not correspond to normal bony anatomy and therefore is most likely abnormal soft tissue uptake.
2. Cardiac uptake either the myocardium or pericardium.
3. Tc-99m pyrophosphate
4. Idiopathic or secondary cardiomyopathy e.g.. due to cardiotoxic drugs, myocarditis or pericarditis.



Previously resected chondrosarcoma. Evaluate for metastases.

1. Describe the bone scan findings.
2. Provide the differential diagnoses.
3. List at least three conditions that predispose patients to this condition.
4. List two other sites that are subject to the same process.

Avascular necrosis of femoral heads

1. Nonvisualization of the left ilium, leg length discrepancy as a result of high riding left hip and increased uptake both femoral heads, left worse than right.
2. The ilium has been surgically resected. Femoral heads; avascular necrosis, fracture, osteotomies, slipped capital femoral epiphyses in the appropriate group.
3. Trauma, steroid, sickle cell disease, chronic renal disease, alcoholism.
4. Humeral head and tarsal navicular.

Cardiac

Pearls & Pitfalls

Myocardial perfusion imaging

- The common indication for MPI is to determine whether there is normal perfusion, ischemia or infarction.
- Tl-201 photon energy (69 – 81 keV)
- Myocardial uptake of Tl-201 chloride and Tc-99m sestamibi/tetrofosmin is proportional to regional blood flow and requires cell viability.

Pearls & Pitfalls

Myocardial perfusion imaging

- Thallium is actively taken up by Na/K pump in the cells.
- Tc-99m sestamibi/tetrofosmin passively diffuse across the membrane and localize in cytoplasmic mitochondria.
- Thallium redistributes over time, so post stress images must be obtained immediately after injection.

Pearls & Pitfalls

Myocardial perfusion imaging

- Tc-99m sestamibi/tetrofosmin do not redistribute and best images are made 30 to 90 minutes after injection to allow clearance of interfering background activity from the liver but before the activity reaches the transverse colon.
- Infarcts and hibernating myocardium produce perfusion defects on the rest images.

Pearls & Pitfalls

Myocardial perfusion imaging

- Stress images are needed to elucidate ischemia with lesser degree of stenosis (50 – 90%).
- Stenosis less than 50% in diameter are not detected at rest and are variably diagnosed with exercise imaging.
- Stress may be physical or pharmacologic.
- Physical stress should be discontinued with patient exhaustion, claudication, severe angina or hypotension, arrhythmia or severe ECG changes.

Pearls & Pitfalls

Myocardial perfusion imaging

- Dipyridamole and adenosine are used instead of physical stress to dilate normal coronary arteries.
- Vessels in ischemic areas are already maximally dilated and do not dilate further.
- The adverse effect of the dipyridamole are reversed with 100 to 200 mg IV aminophylline.

Pearls & Pitfalls

Myocardial perfusion imaging

- Dipyridamole and adenosine should not be used in patients with asthma.
- Dobutamine is inotropic and chronotropic and is used for pharmacologic stress.
- Adverse effects may be reversed by using short acting beta blocker.
- The most common cause of false negative is submaximal stress.
- The most common cause of false positive is artifact.

Pearls & Pitfalls

Myocardial perfusion imaging

- The myocardium normally thins at the apex, membranous septum and base of inferior wall.
- A high degree of lung activity on exercise Thallium images (>50% of peak myocardial activity) is related to poor prognosis, more extensive disease and LV dysfunction on exercise.
- On Tc-99m sestamibi scans, lung activity is uncommon.

Pearls & Pitfalls

Myocardial perfusion imaging

- Transient LV dilatation with exercise may be related to subendocardial ischemia and less often to real LV dilatation. It is sign of poor prognosis.
- With adequate exercise, the sensitivity and specificity of MPI are about 85%.
- An occluded coronary artery with adequate collaterals or balanced three vessels disease can produce an apparently normal scan

Pearls & Pitfalls

Myocardial perfusion imaging

- Real defects on MPI should be seen on at least 2 views (e.g., short and vertical or horizontal long axes)
- LBBB may produce myocardial p e r f u s i o n f i n d i n g s indistinguishable from stress induced reversible septal ischemia.
- A defect seen at the base of the heart is frequently artifactual unless it extends to the apex.

Pearls & Pitfalls

Myocardial perfusion imaging

- Not all fixed defects are infarcts. They may also be soft tissue attenuation artifacts, hibernating or repetitive stunned myocardium.
- Hibernating myocardium is a chronically hypoperfused area that has reduced cellular metabolism.
- This area has decreased contractility and revascularization is usually needed.

Pearls & Pitfalls

Myocardial perfusion imaging

- Stunned myocardium is due to an acute occlusion with relatively rapid perfusion.
- These area have normal or near normal perfusion and decreased contractility and revascularization is not usually needed.
- LV walls that diverged towards the apex should raise suspicious of a LV aneurysm.

Pearls & Pitfalls

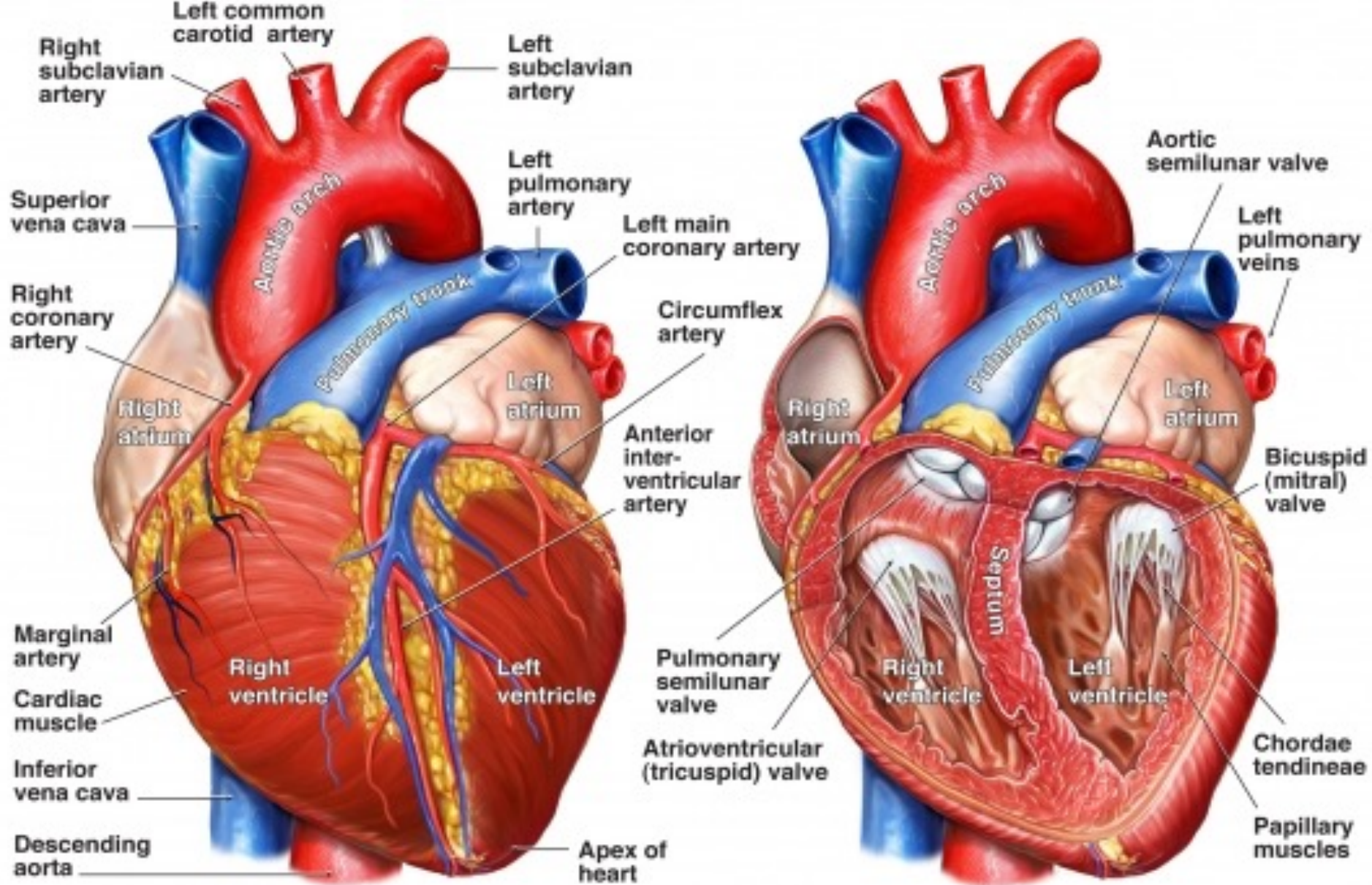
Myocardial perfusion imaging

- Diaphragmatic attenuation looks like an inferior wall defect but it goes away on prone images.
- Relatively intense GI activity adjacent to the inferior wall can cause an apparent inferior myocardial defect on SPECT studies as a result of a reconstruction artifact.
- Breast attenuation usually causes an apparent defect in the anterior or lateral LV wall.

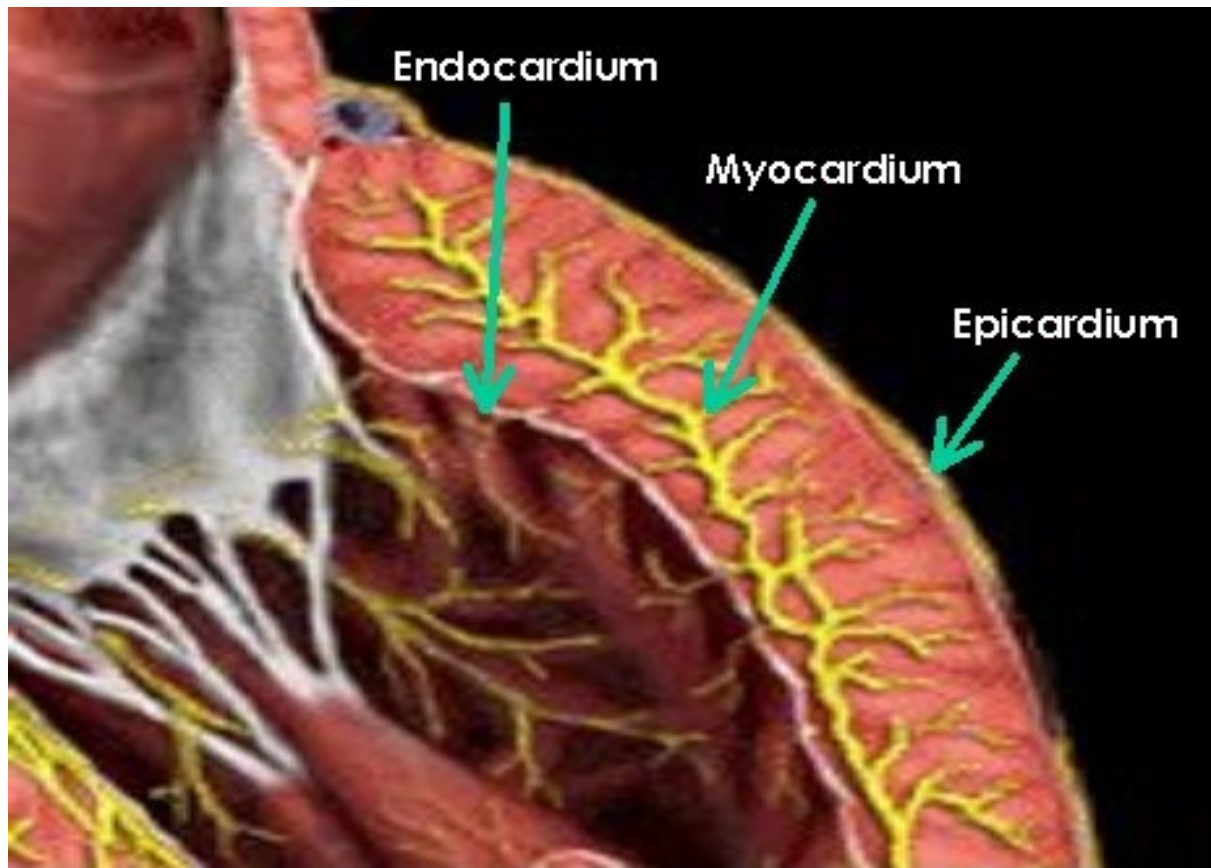
Pearls & Pitfalls

- Bull's eye plot underestimate apical defect and overestimate basal defects.
- The normal LVEF is 50 - 65%.

Myocardial
perfusion imaging



Cardiac Muscle Layers

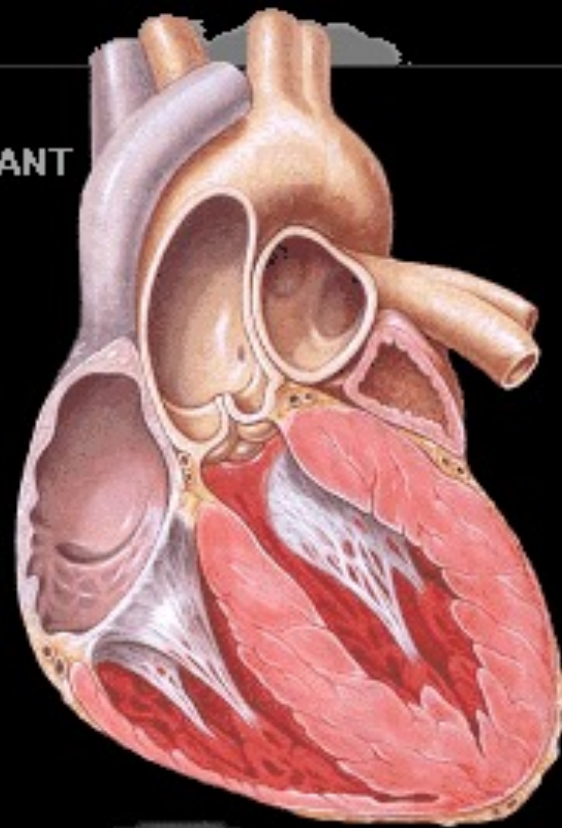
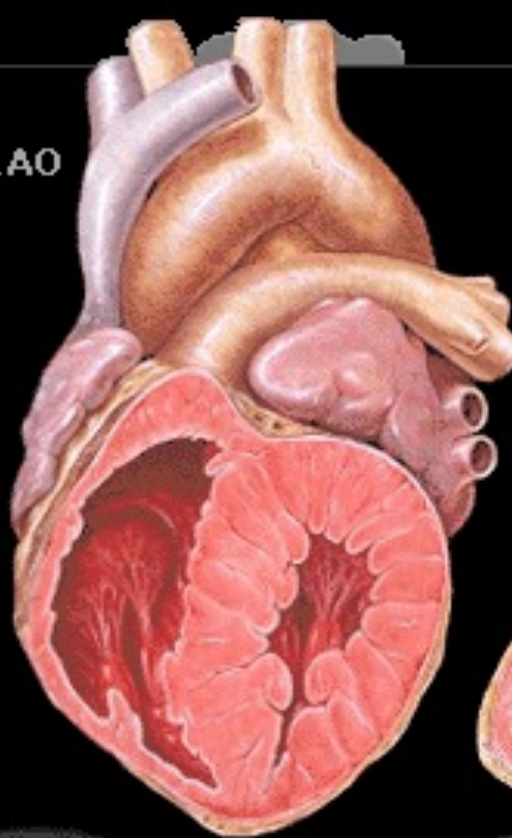
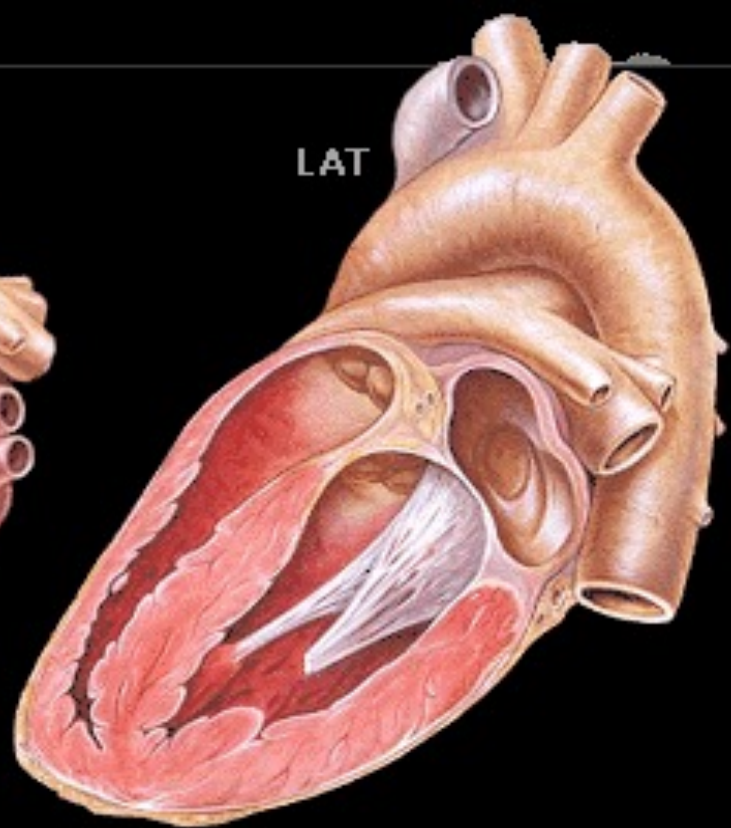
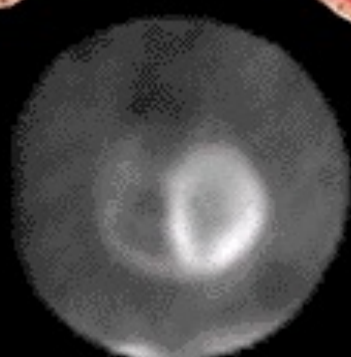
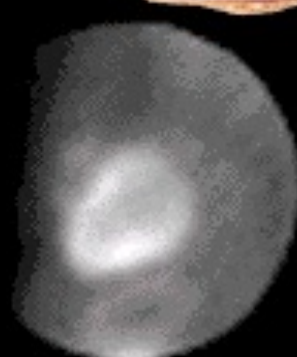


	parasympathetic	sympathetic
SA NODES	↓ heart rate	↑ heart rate (β receptor)
ATRIUM	↓ contractility	↑ contractility and conduction velocity (β receptor)
AV NODES AND CONDUCTION SYSTEM	↓ conduction velocity and block conduction	↑ conduction velocity (β receptor)
VENTRICLE	-	↑ contractility and conduction velocity (β receptor)
CORONARY ARTERY	-	Constriction (α receptor) Dilatation (β receptor)

ANT

LAO

LAT



Anterior view

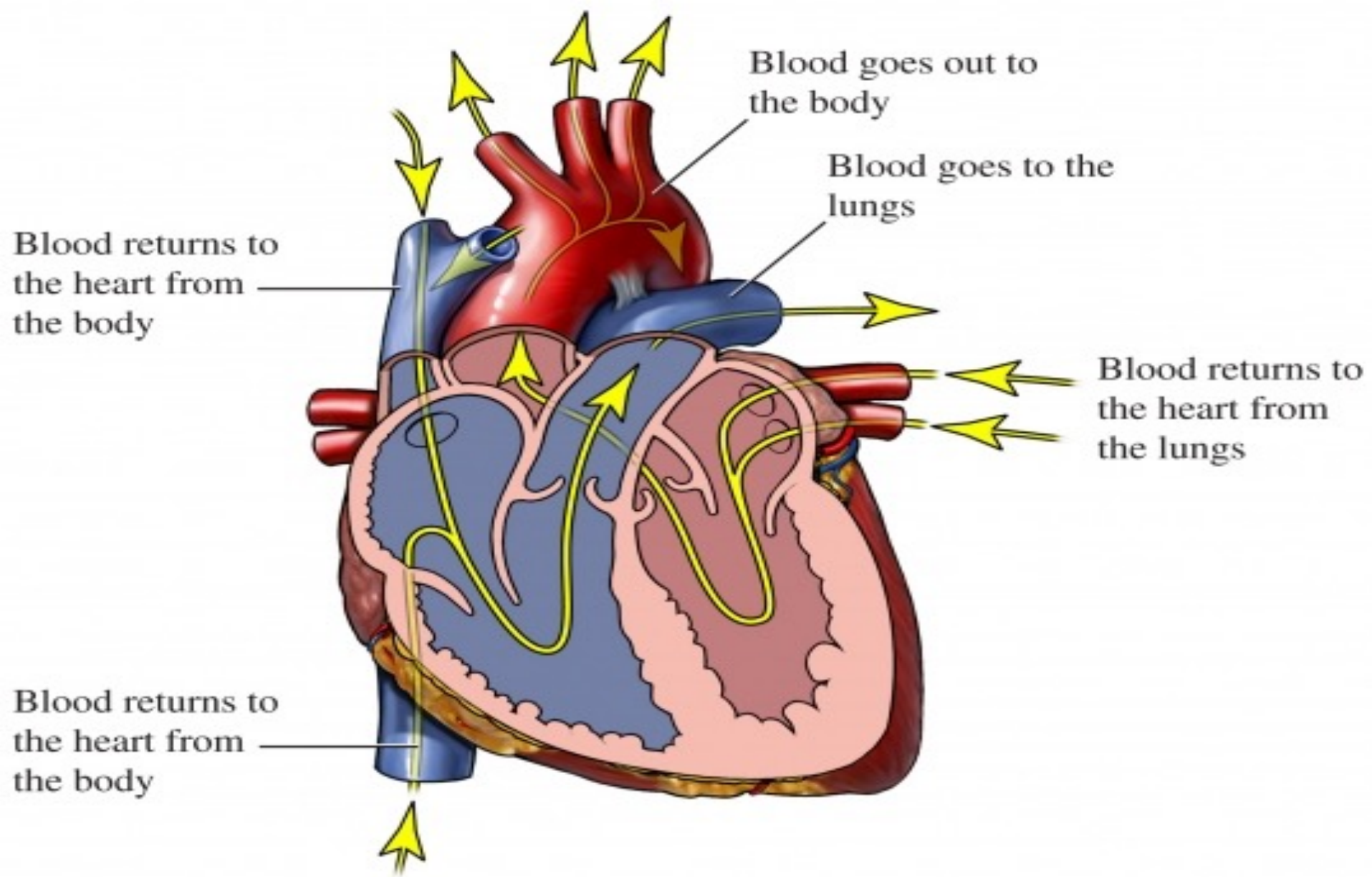
Left anterior oblique view

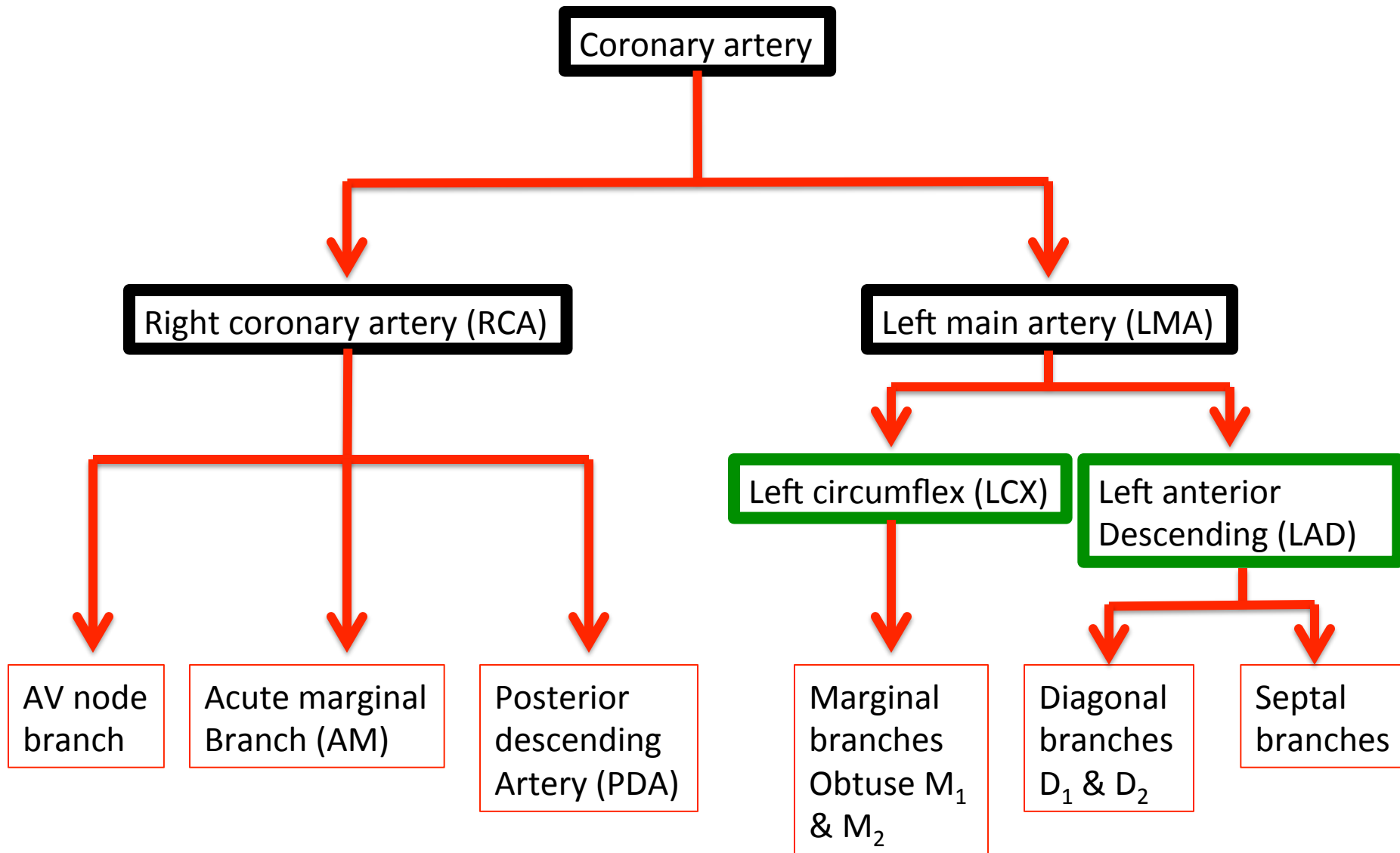
Left lateral view



UNIVERSITI SAINS MALAYSIA

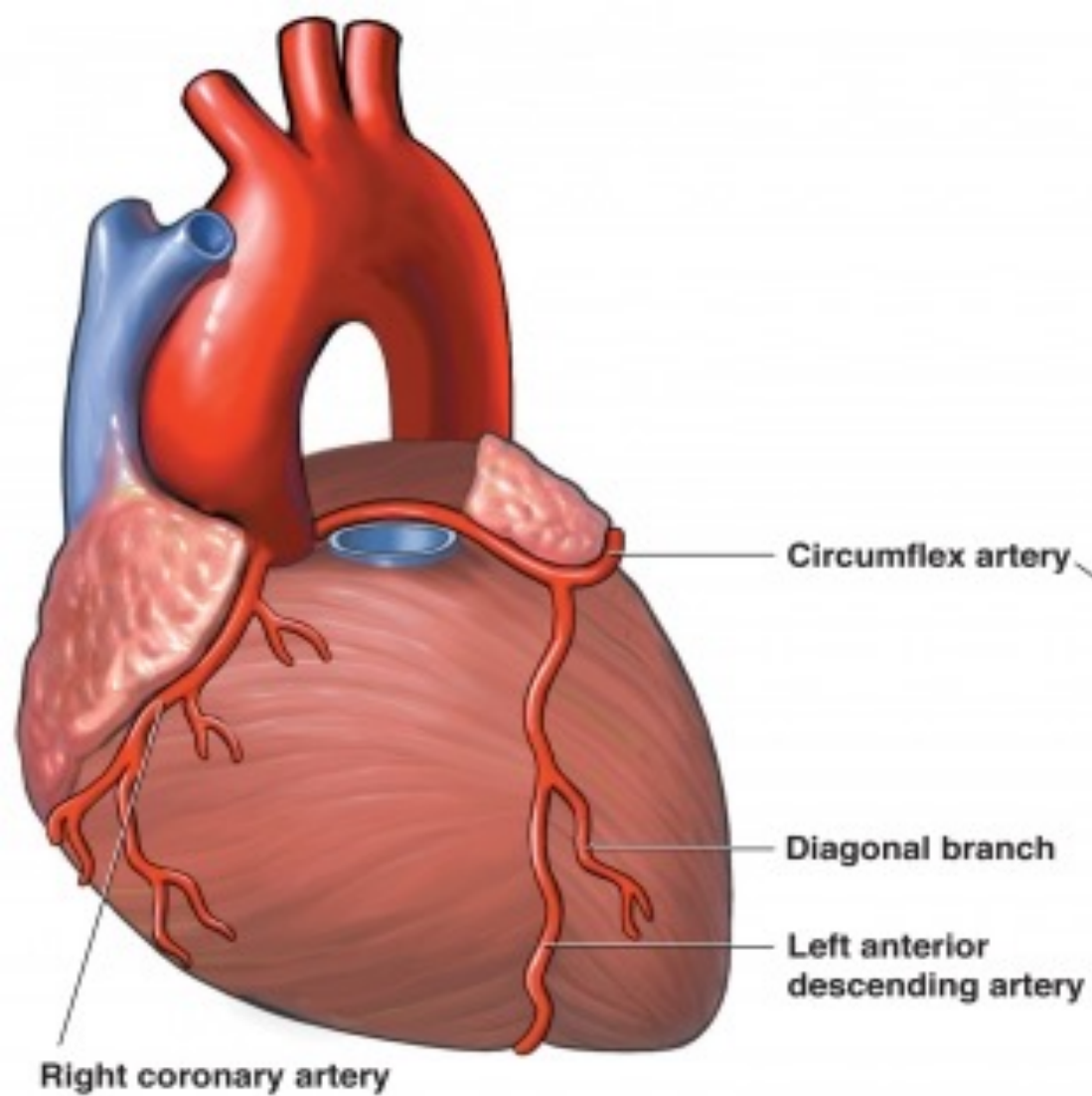
USM



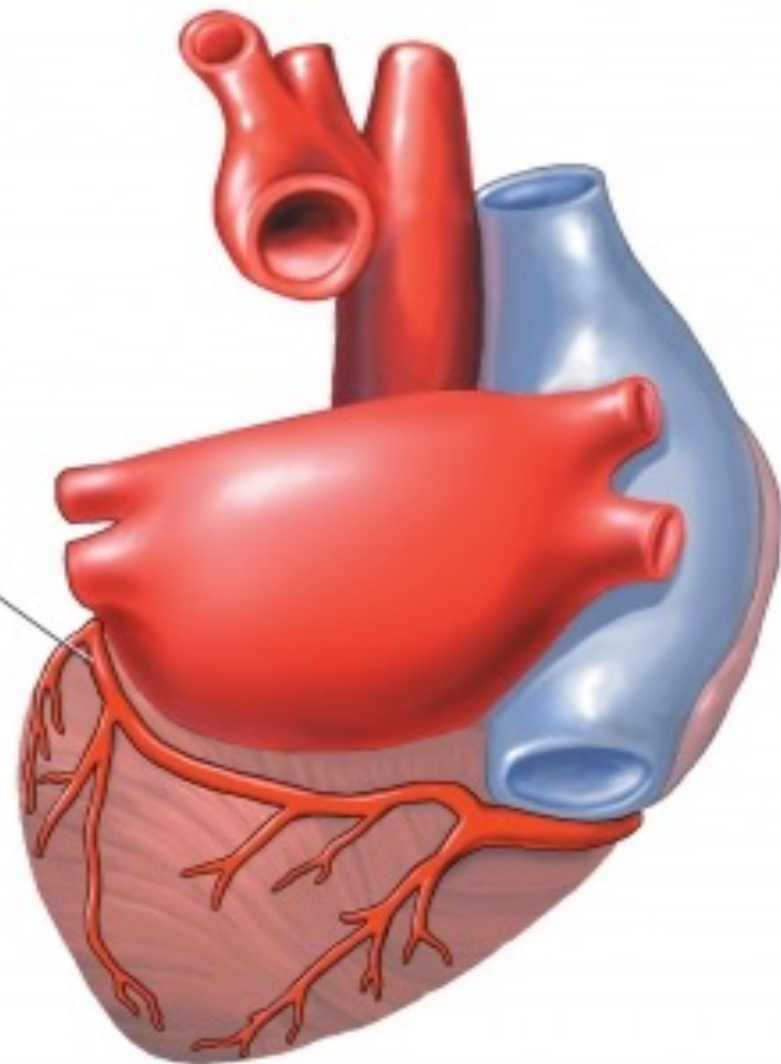


CORONARY CIRCULATION

CORONARY ARTERY	VASCULAR DISTRIBUTIONS
Left anterior descending (LAD)	Septum Anterior wall Apex
Left circumflex (LCX)	Lateral wall Posterior wall Posterior inferior wall Apex
Right coronary (RCA)	Inferior wall Posterior inferior wall Right ventricular wall
Left main coronary	Anterior wall Septum Posterolateral wall



Anterior view



Posterior view

Left pulmonary artery

Left coronary artery

Circumflex branch of coronary artery within coronary groove

Site of AV node

Crux of heart

Anterior interventricular branch

Arch of aorta

Superior vena cava

Sinuatric nodal branch

Right pulmonary veins

Right coronary artery

Atrioventricular nodal branch

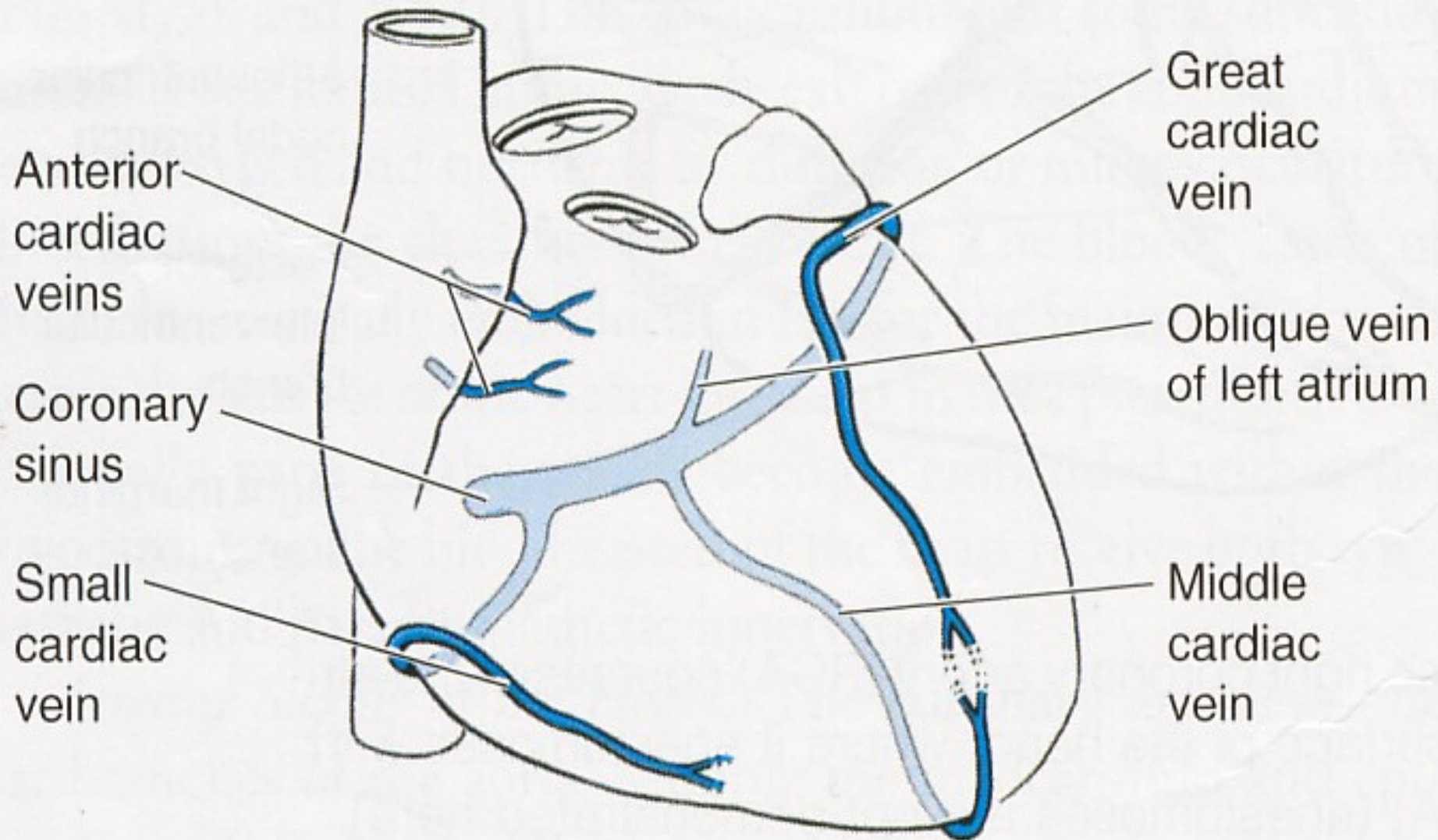
Posterior interventricular branch

Right marginal branch

(B) Posteroinferior view

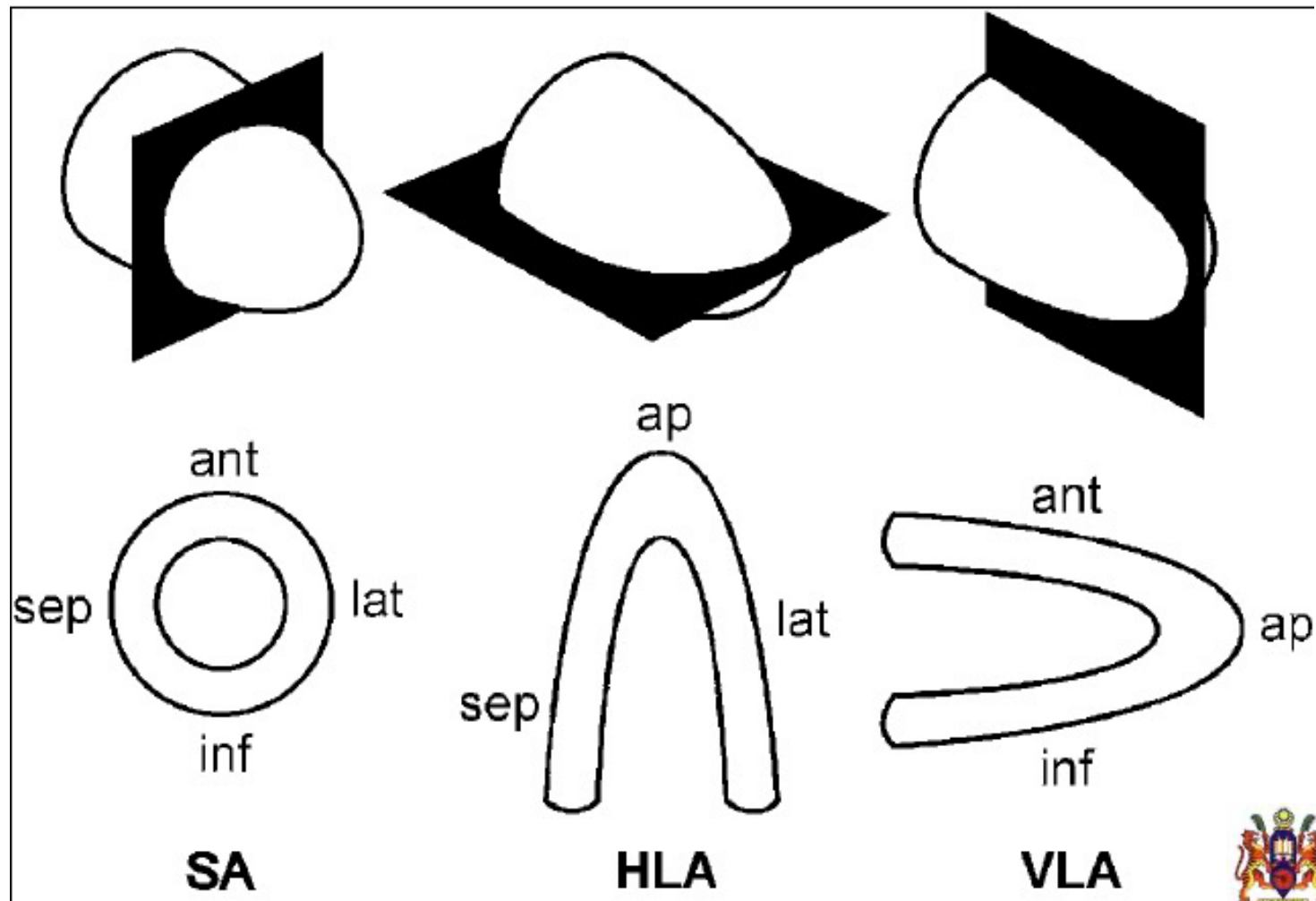


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Anterior view

Planes used for SPECT MPI



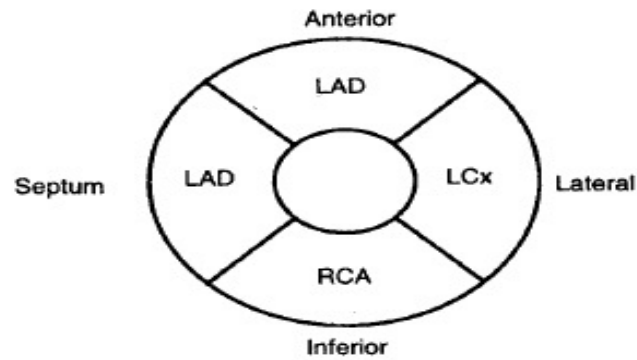
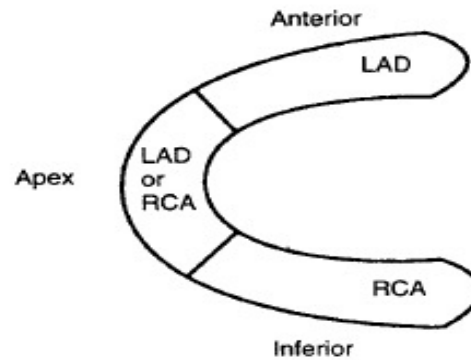
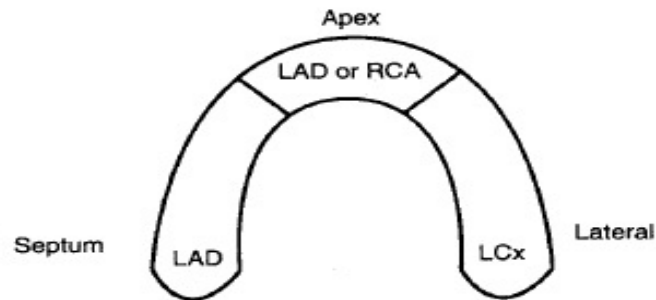


Fig. 5-14 Usual correlation of myocardial wall segments and vascular supply as seen on short-axis, vertical long-axis, and horizontal long-axis SPECT views. *LAD*, Left anterior descending artery; *LCx*, left circumflex branch; *RCA*, right coronary artery.

Coronary Artery Territories

Short Axis

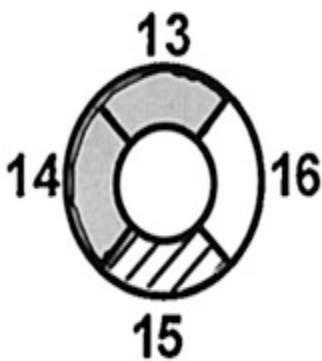
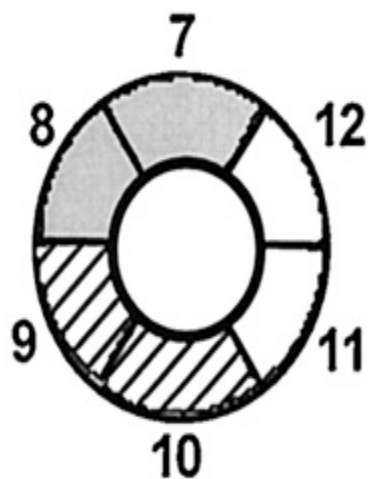
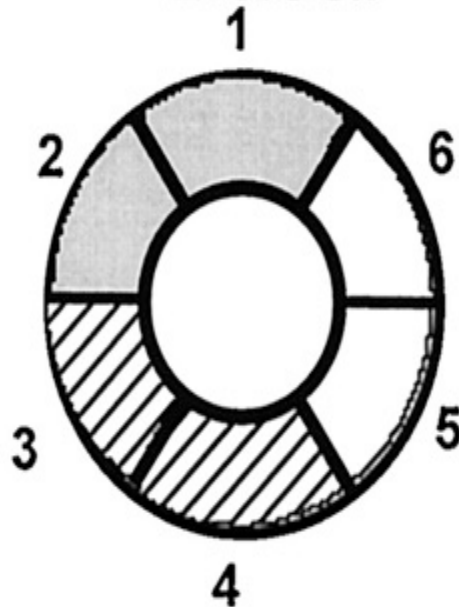
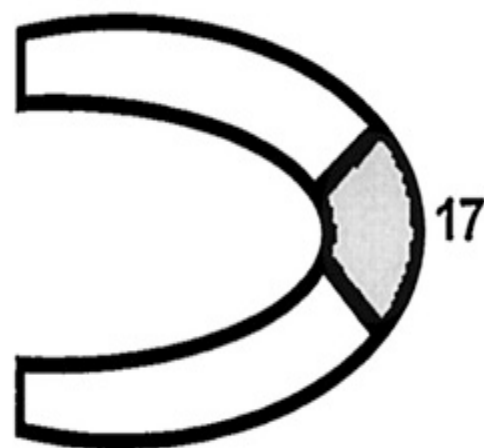
Vertical
Long Axis

Apical

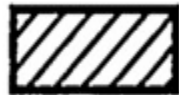
Mid

Basal

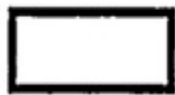
Mid



LAD

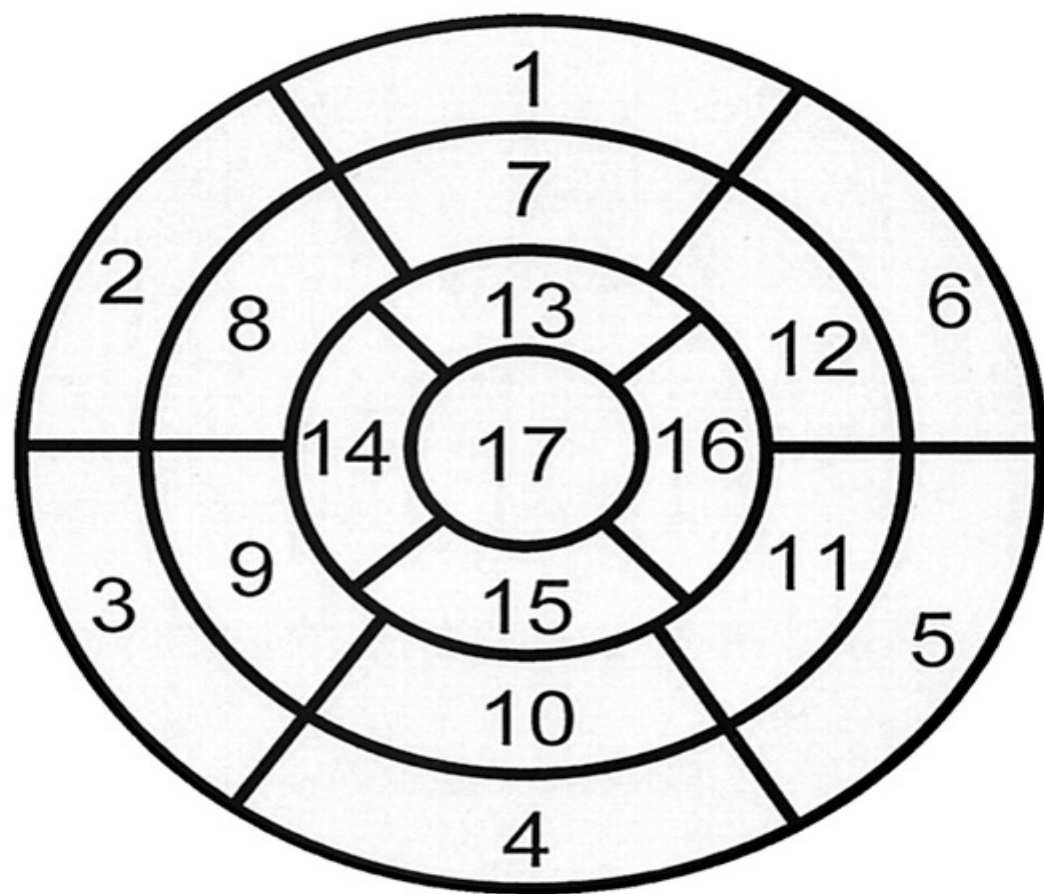


RCA



LCX

Left Ventricular Segmentation



1. basal anterior
2. basal anteroseptal
3. basal inferoseptal
4. basal inferior
5. basal inferolateral
6. basal anterolateral

7. mid anterior
8. mid anteroseptal
9. mid inferoseptal
10. mid inferior
11. mid inferolateral
12. mid anterolateral

13. apical anterior
14. apical septal
15. apical inferior
16. apical lateral
17. apex

CONDUCTION SYSTEM

- Pacemaker of heart
- Posterior wall of right atrium
- Depolarize spontaneously 70-80 time/ min
- Contraction of atrium

SA (sinoatrium node)



(interatrium septum)

AV (atrioventricular node)



(interventricular septum)

(AV bundle)



PURKINJE FIBRES

INNERVATION

	parasympathetic	sympathetic
SA NODES	↓ heart rate	↑ heart rate (β receptor)
ATRIUM	↓ contractility	↑ contractility and conduction velocity (β receptor)
AV NODES AND CONDUCTION SYSTEM	↓ conduction velocity and block conduction	↑ conduction velocity (β receptor)
VENTRICLE	-	↑ contractility and conduction velocity (β receptor)
CORONARY ARTERY	-	Constriction (α receptor) Dilatation (β receptor)

STROKE VOLUME

- volume of blood pumped by left ventricle in 1 minute
- $SV \text{ (STROKE VOLUME) } \times HR \text{ (HEART RATE) }$

VENTRICLE CONTRACTILITY

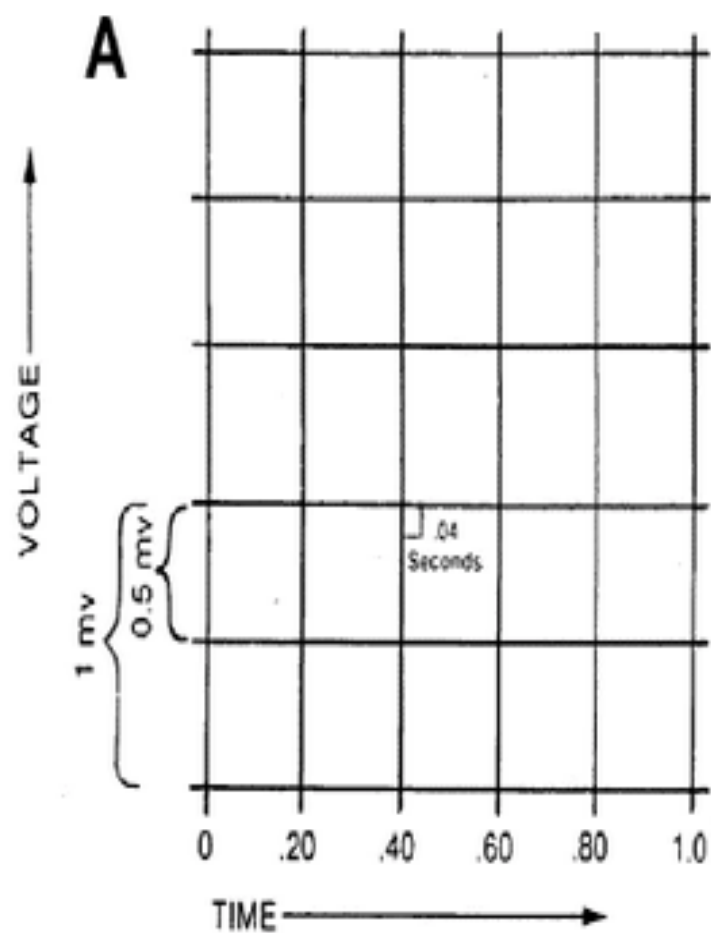
$$EF = \frac{EDV - ESV}{EDV} \times 100$$

- Stroke volume = EDV – ESV
- EF = ejection fraction (%)
- EDV = End diastolic volume (ml)
- ESV = End systolic volume (ml)

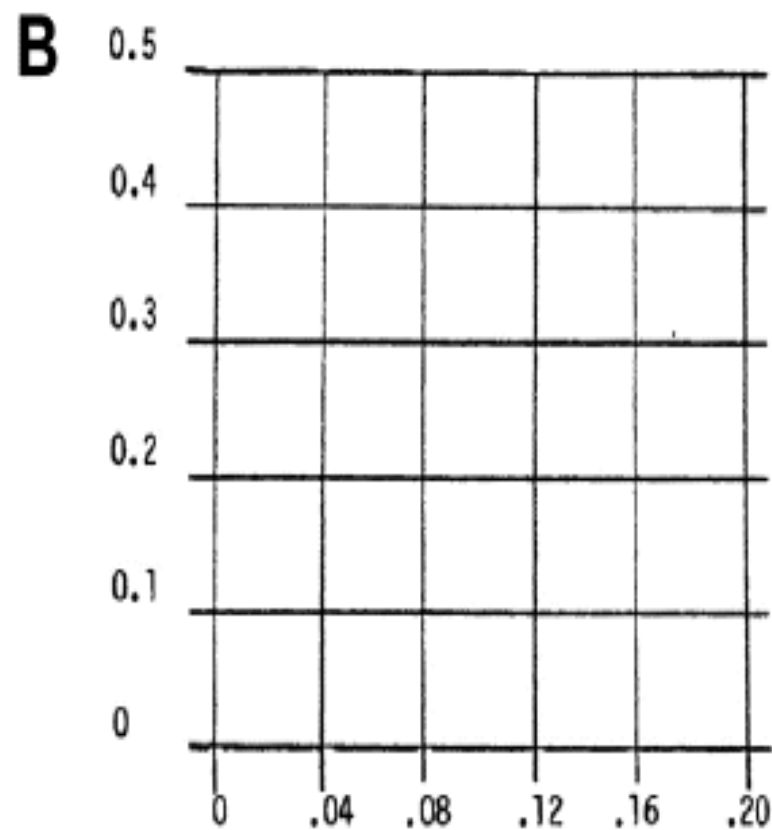
ECG STAT

DR ZOOL HILMI

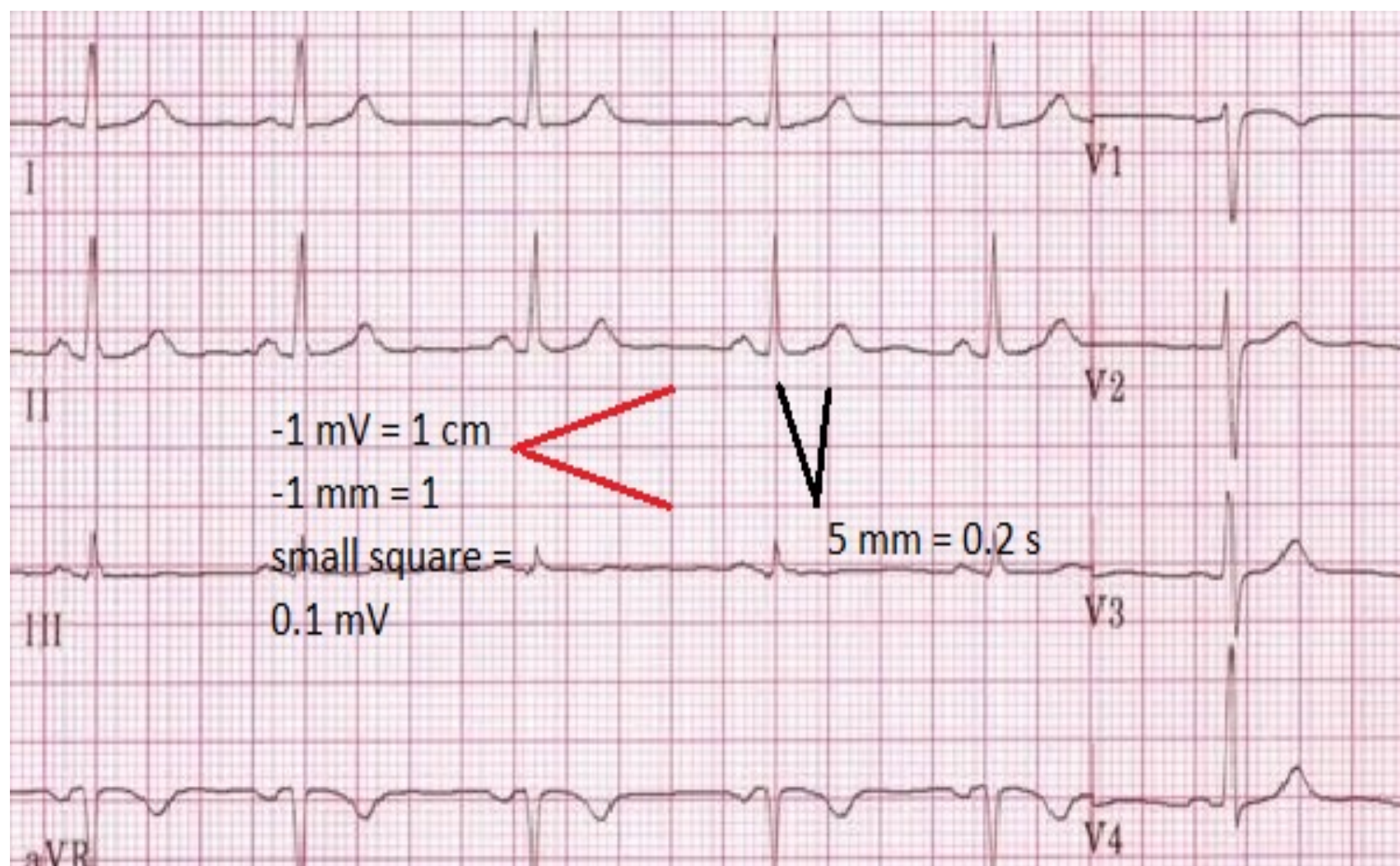
- ECG paper 25 mm/s
- Large square = 5mm = 0.2 s
- Each large square = 5 small square = 1 mm = 0.04 s
- 1 mV = 1 cm vertically
- 0.1 mV = 1 mm = 1 small square



Big Squares



One big square - magnified



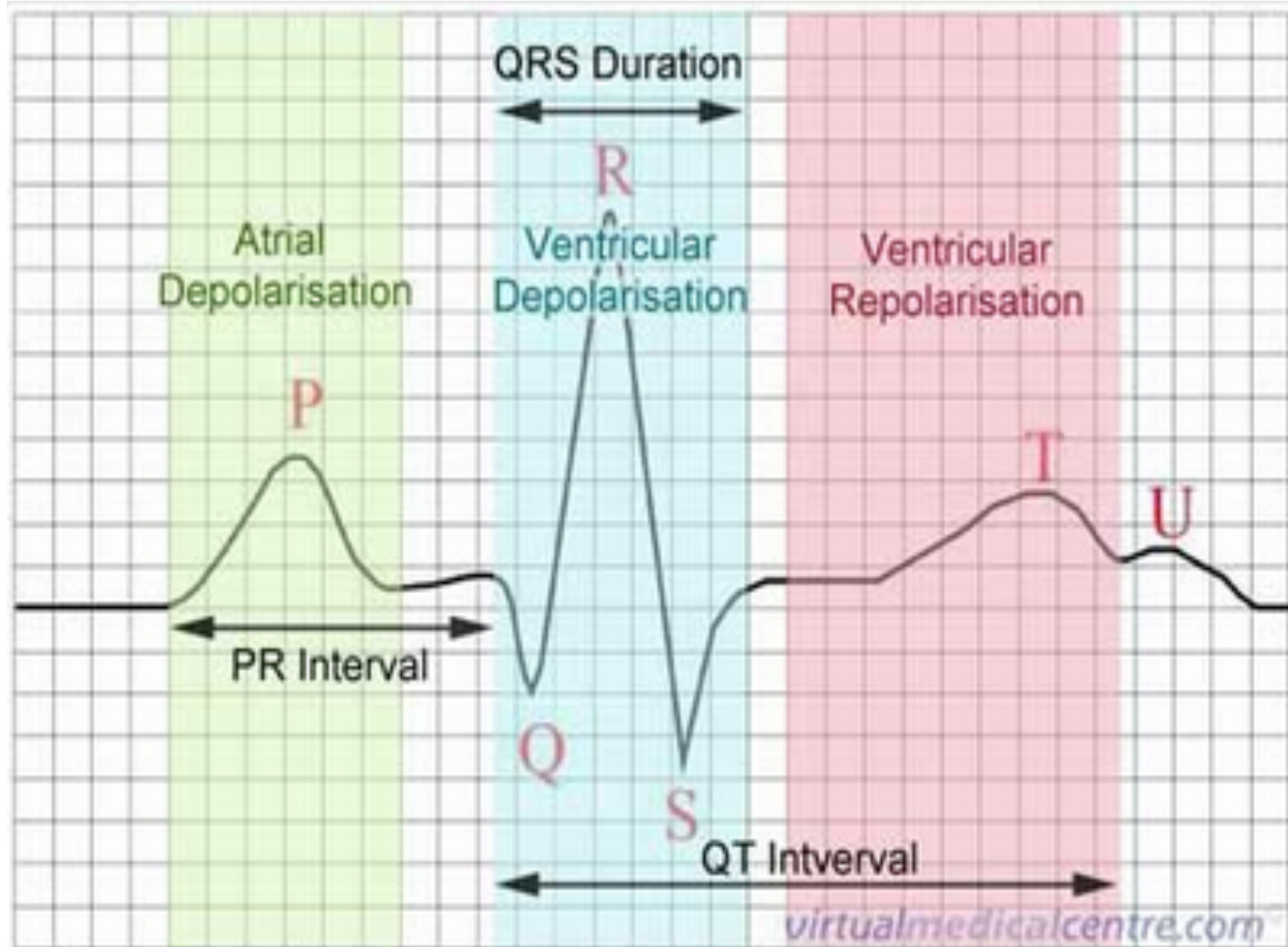
- 6 chest leads = V1 to V6
 - 6 limb leads = I, II, III, aVR, aVL, aVF
-
- II, III, aVF = inferior
 - V1 to V4 = anterior
 - I, aVL, V5 to V6 = lateral
 - V1 and aVR = right atrium and cavity of left ventricle

INTERPRETATION OF ECG

- RATE
- RHYTHM
- AXIS
- P WAVE
- PR INTERVAL
- QRS COMPLEX
- Q WAVE
- ST SEGMENT
- T WAVE
- QT INTERVAL
- U WAVE

RATE

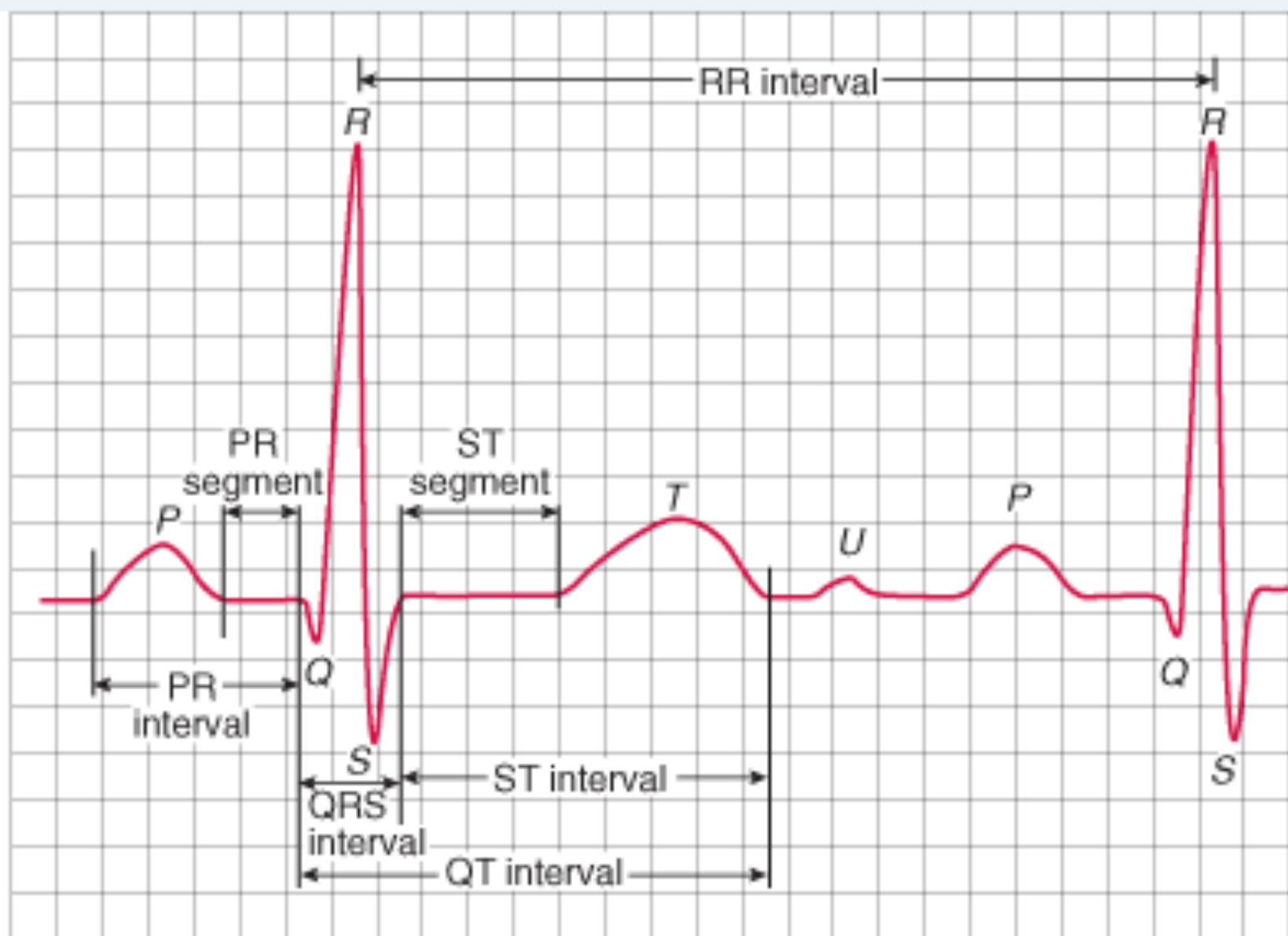
- Tachycardia > 100 beats /min
- Bradycardia < 60 beats/min
- Heart rate = **$300 /$ no of large square btw 2 R**
- Irregular rhythm HR = **no of intervals btw QRS complexes in 10 seconds X 6** (lead II = 25 cm = 10 seconds = 50 large square)



IMPORTANT

- $PR = 3 - 5 \text{ SMALL SQUARE} / 0.12 - 0.2 \text{ SECONDS}$
- $QRS \leq 3 \text{ SMALL SQUARE} / \leq 0.12 \text{ SECONDS}$
- $BBB > 3 \text{ SMALL SQUARE}$
- $QT < 11 \text{ SMALL SQUARE OR } < 0.44 \text{ SECONDS OR } < 0.5 \text{ RR INTERVAL}$
 $\text{CORRECTED QT} = QT/\sqrt{\text{RR}}$

mm/sec.



mm/mV 1 square = 0.04 sec/0.1mV

RHYTHM

- **Lead II**
- Sinus rhythm = originates in the sinus node and conduct to the ventricle

CARDINAL FEATURES OF SINUS RHYTHM

- P wave is upright in leads I and II
- Each P wave is usually followed by QRS complex
- Heart rate between 60 to 99

CARDIAC AXIS

	NORMAL AXIS	RIGHT AXIS DEVIATION	LEFT AXIS DEVIATION
LEAD I	+	-	+
LEAD II	+	+/-	-
LEAD III	+/-	+	-

CARDIAC AXIS

	LEAD I	AVF
NORMAL	+	+
LEFT AXIS	+ & (LEAD II -)	-
RIGHT AXIS	-	+
INDETERMINATE	-	-

CARDIAC AXIS CAUSES

LEFT AXIS	RIGHT AXIS
LVH	RVH
INFERIOR MI	LATERAL MI
LEFT ANTERIOR FASCICULAR BLOCK	LEFT POSTERIOR FASCICULAR BLOCK

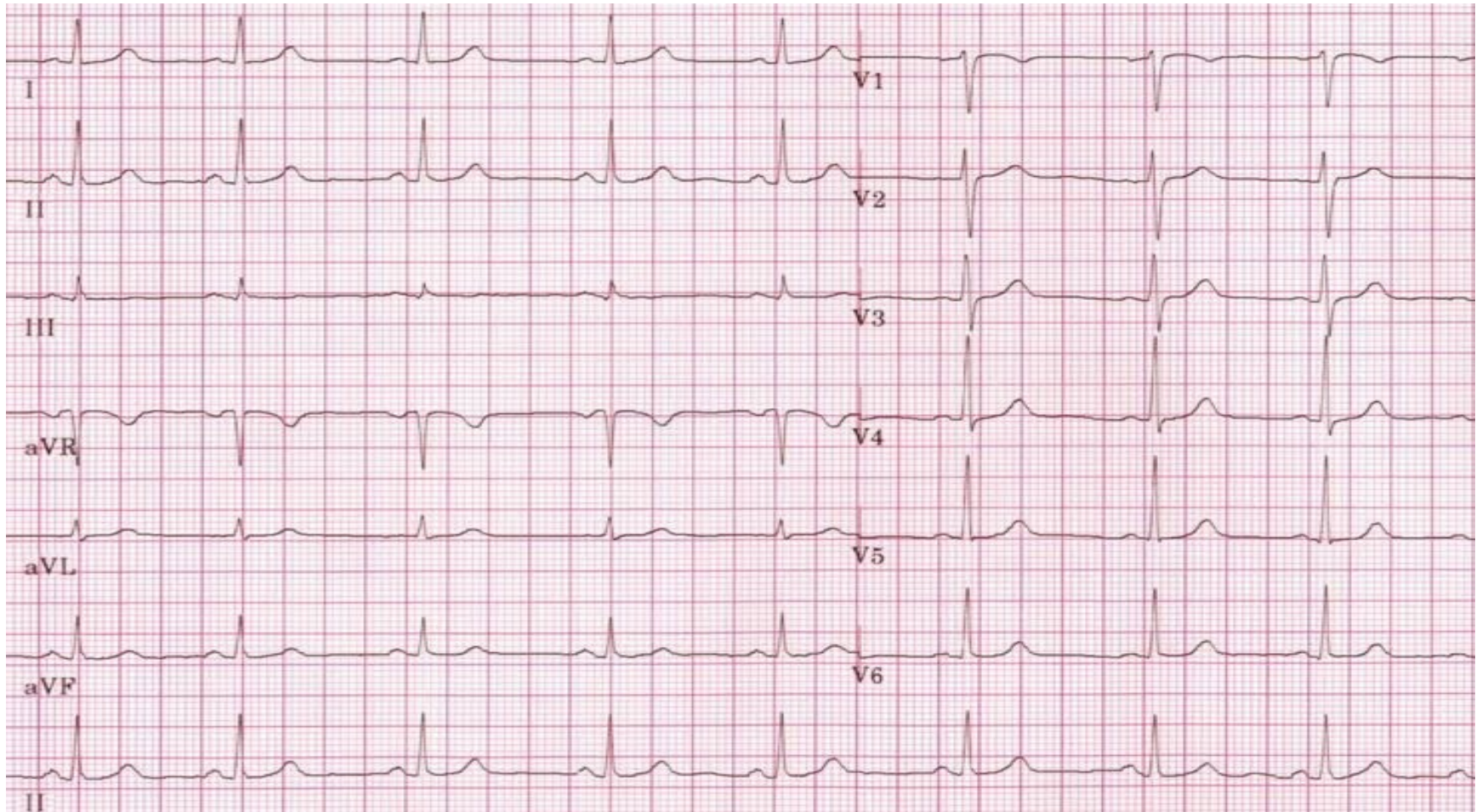
NORMAL FINDINGS ECG

- Tall R waves
- Prominent U waves
- Exaggerated sinus arrhythmia
- Sinus bradycardia
- Wandering atrial pacemaker
- Wenckebach phenomenon
- Junctional rhythm
- 1st degree heart block
- ST segment elevation (high take off, benign early repolarization)

P WAVE

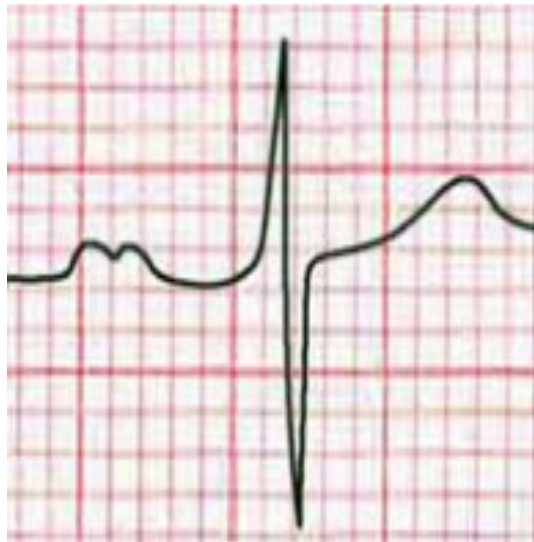
- Atrial depolarization
- Characteristic of the P wave:
 - ❖ positive in leads I and II
 - ❖ Best seen in lead II and V1
 - ❖ Commonly biphasic in lead V1
 - ❖ < 3 small square (0.12s) in duration
 - ❖ < 2.5 small square (0.25mV) in amplitude

NORMAL ECG



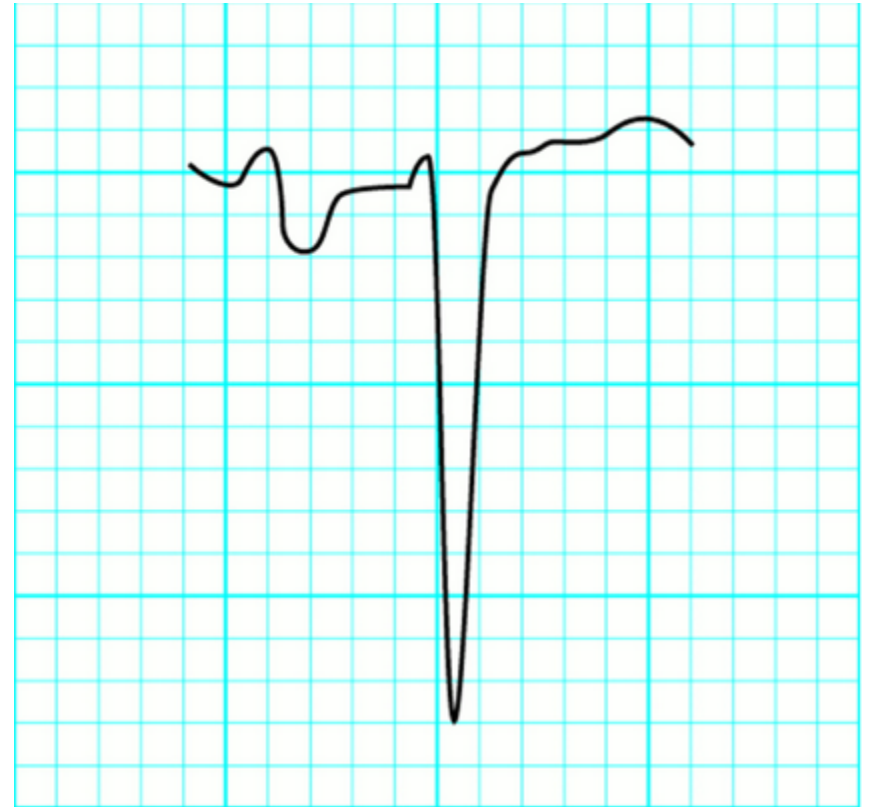
P WAVE

- Bifid P, in lead II , notch with peak to peak interval of > 1 mm = mitral stenosis



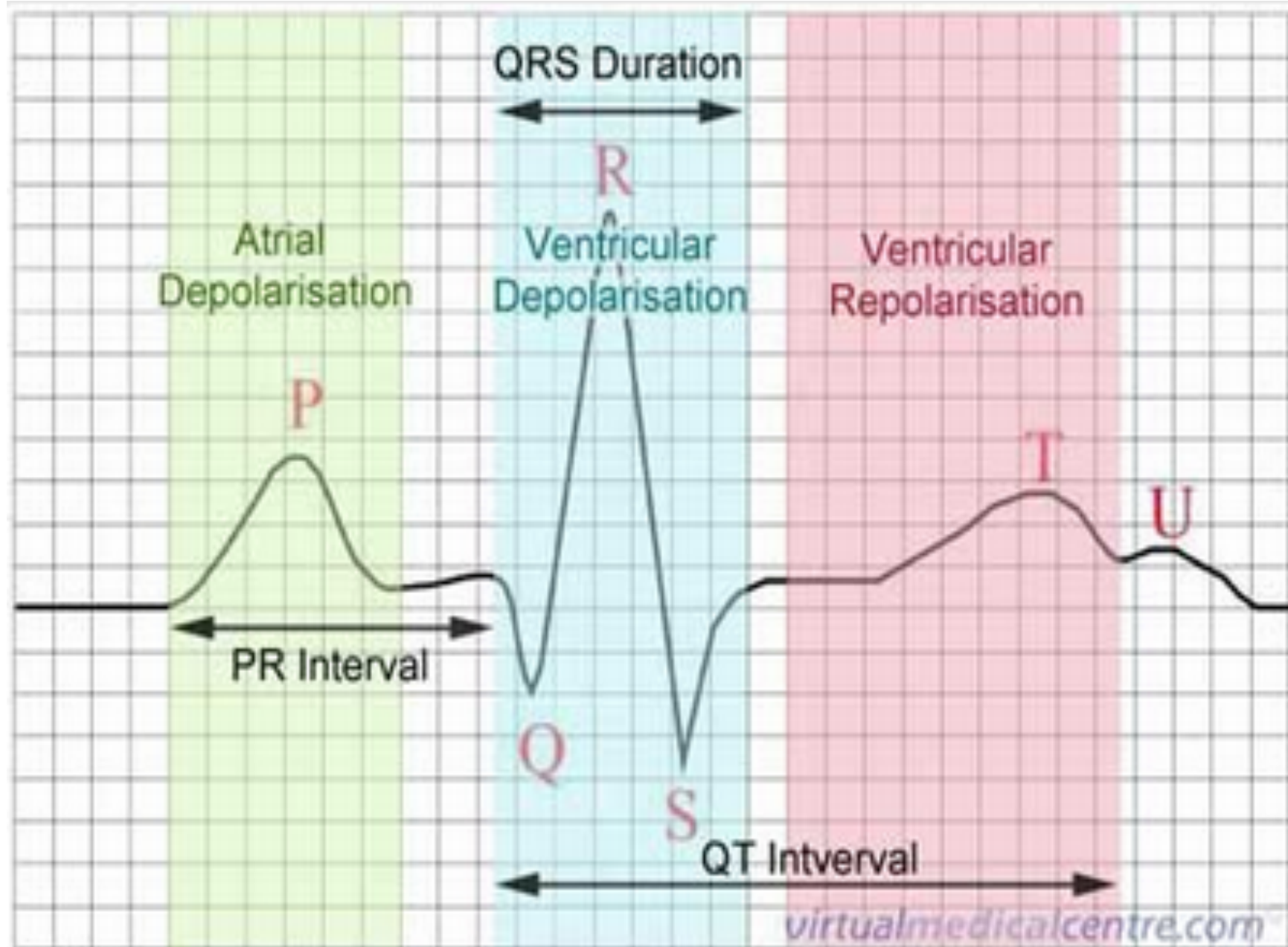
P WAVE

- Large negative deflection = left atrial enlargement



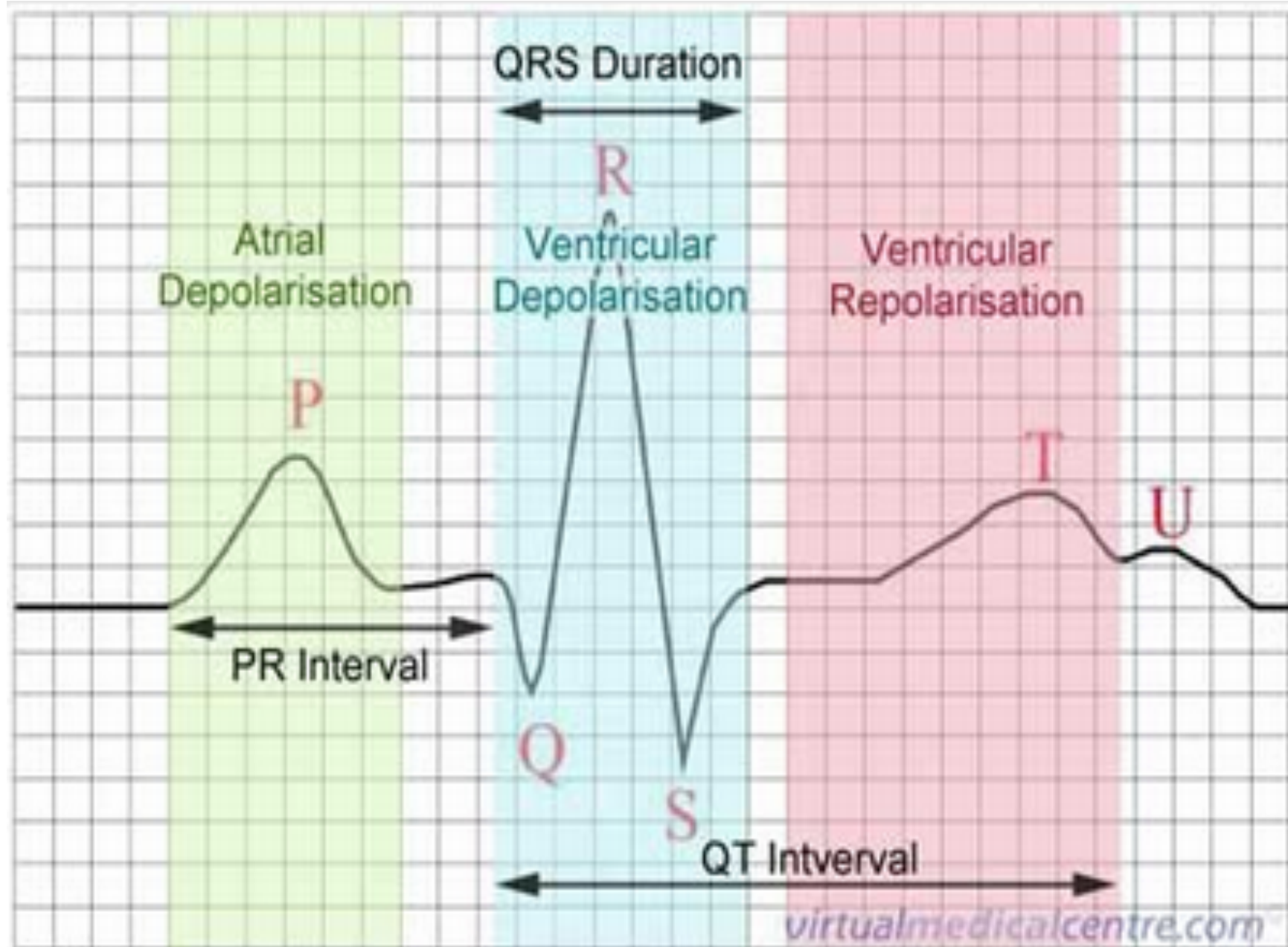
PR INTERVAL

- Electrical impulse conducted through the AV node, the bundle of His and bundle branches and the Purkinje fibers
- Beginning of the P wave to the 1st deflections of QRS complex, whether it is Q or R wave
- 3 to 5 small square (0.12 – 0.20 s)



QRS COMPLEX

- Ventricular depolarization
- Not $> 2 \frac{1}{2}$ small square (0.10 s)
- BBB $> (0.12 \text{ s})$ wide QRS
- ❑ Q wave : any initial negative deflection
- ❑ R wave : any positive deflection
- ❑ S wave : any negative deflection after R wave
- Non pathological Q wave seen at: leads I, III, aVL, V5 and V6



ST SEGMENT

- QRS complex terminates at the J point or ST junction
- ST segment lies between the J point and the beginning of the T wave
- Period between the end of ventricular depolarization and the beginning of the repolarization

ST SEGMENT

- Leads V1 to V3, rapidly S wave merges directly with the T wave, making the J point indistinct and the ST segment difficult to identify
- This produces elevation of the ST segment, and this is known as **high take off**

HIGH TAKE OFF

[CLOSE WINDOW]

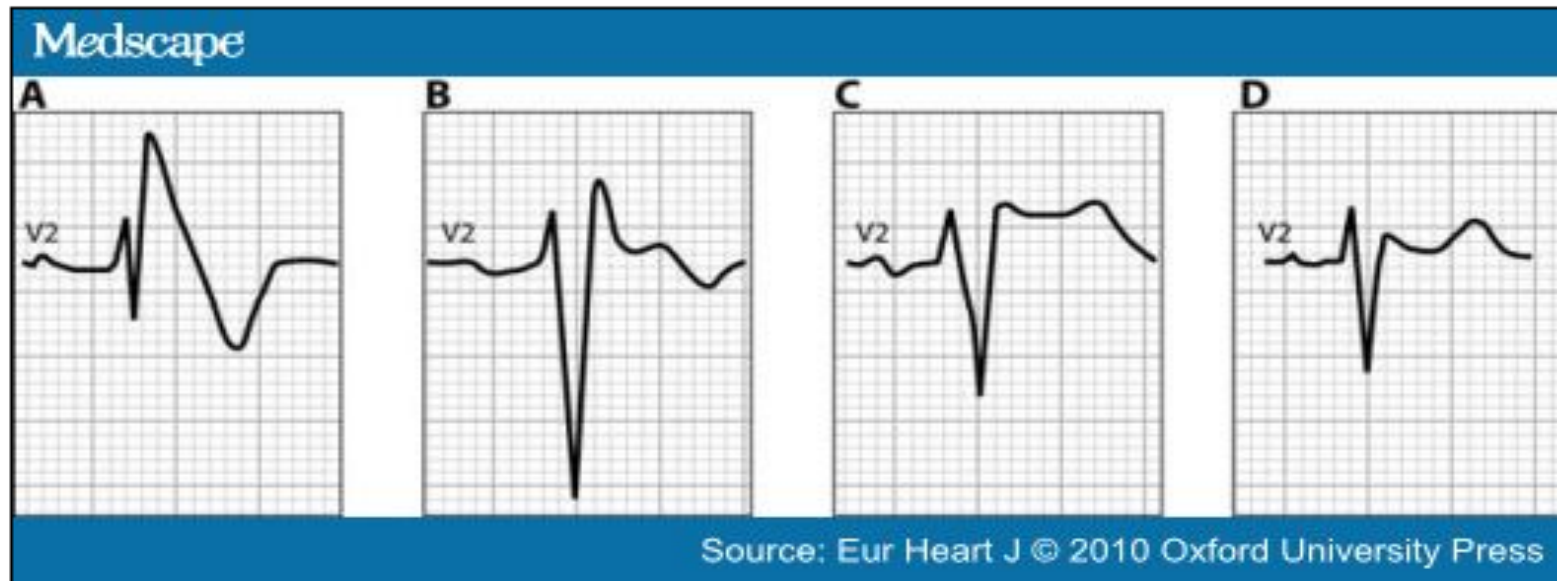
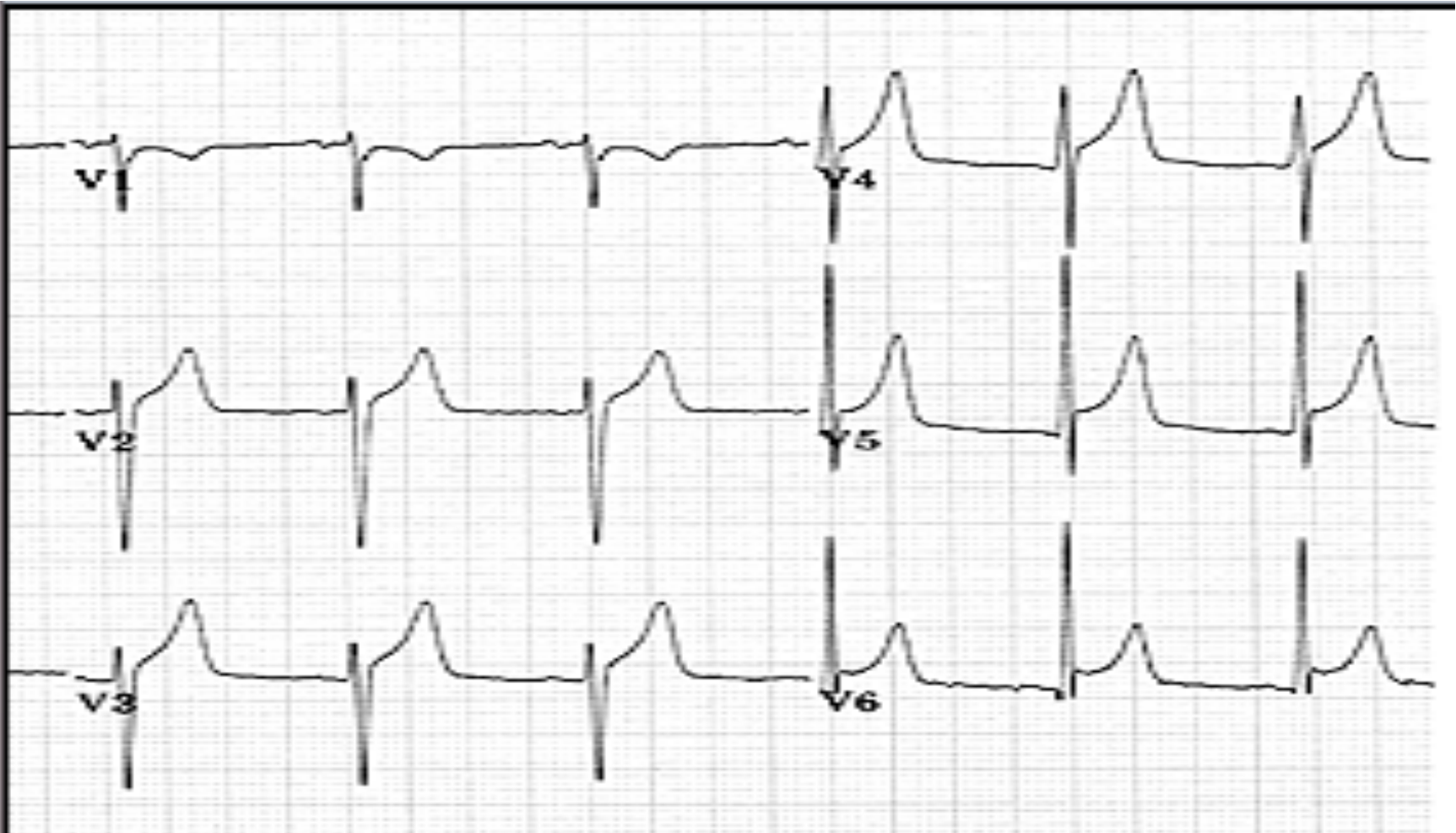
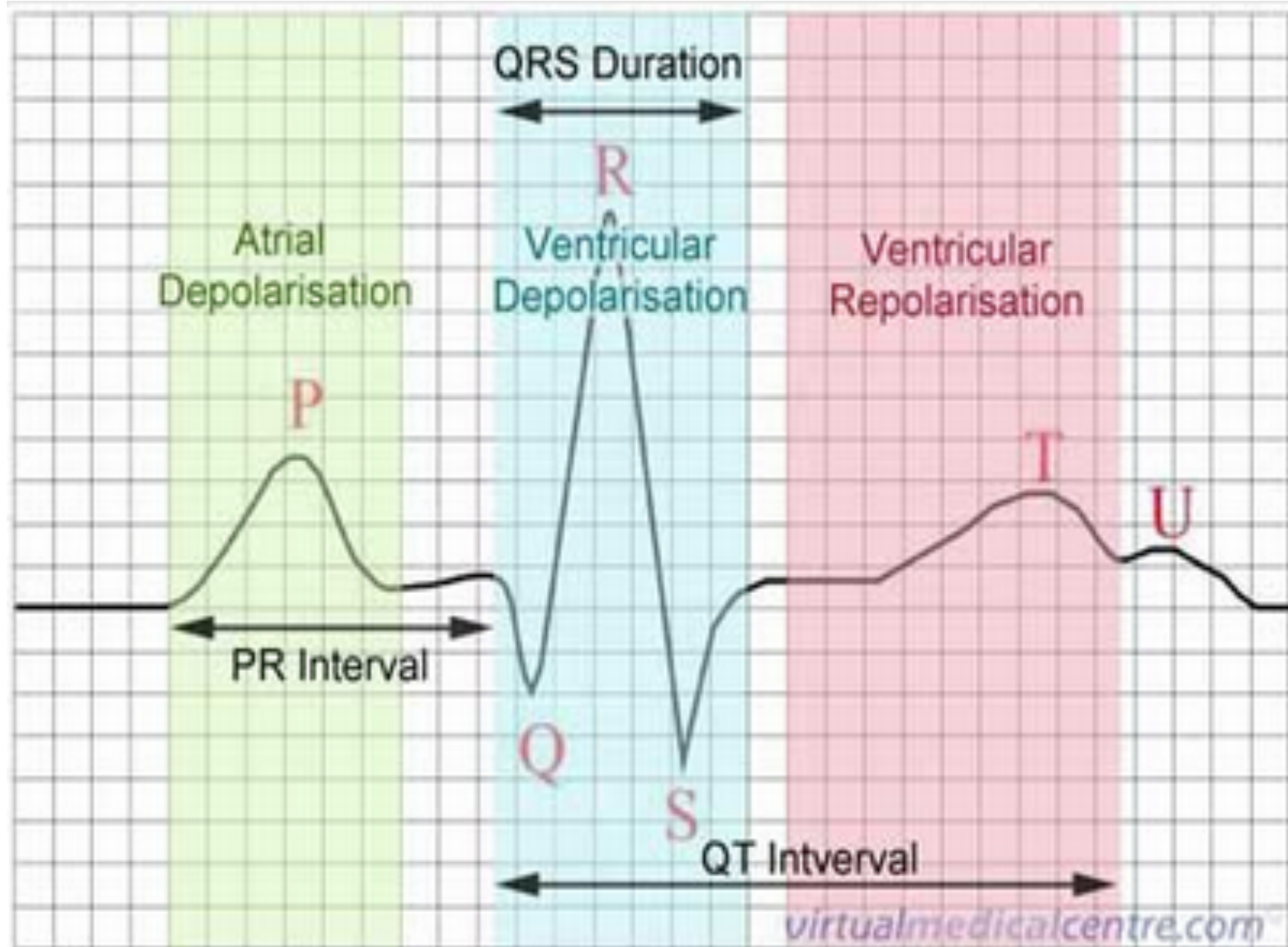


Figure 7.

Patterns of Brugada ECG. Type 1 Brugada ECG is characterized by a 'coved' ST-segment elevation ≥ 2 mm (0.2 mV) followed by a negative T wave (A). The Type 2 Brugada ECG shows a 'saddleback' morphology with a high takeoff (≥ 2 mm) ST-segment elevation, remaining ≥ 1 mm above the baseline, followed by a biphasic (B) or positive (C) T-wave. Type 3 has either a coved or saddleback morphology with J point elevation ≥ 2 mm but the terminal portion of ST-segment < 1 mm (D).

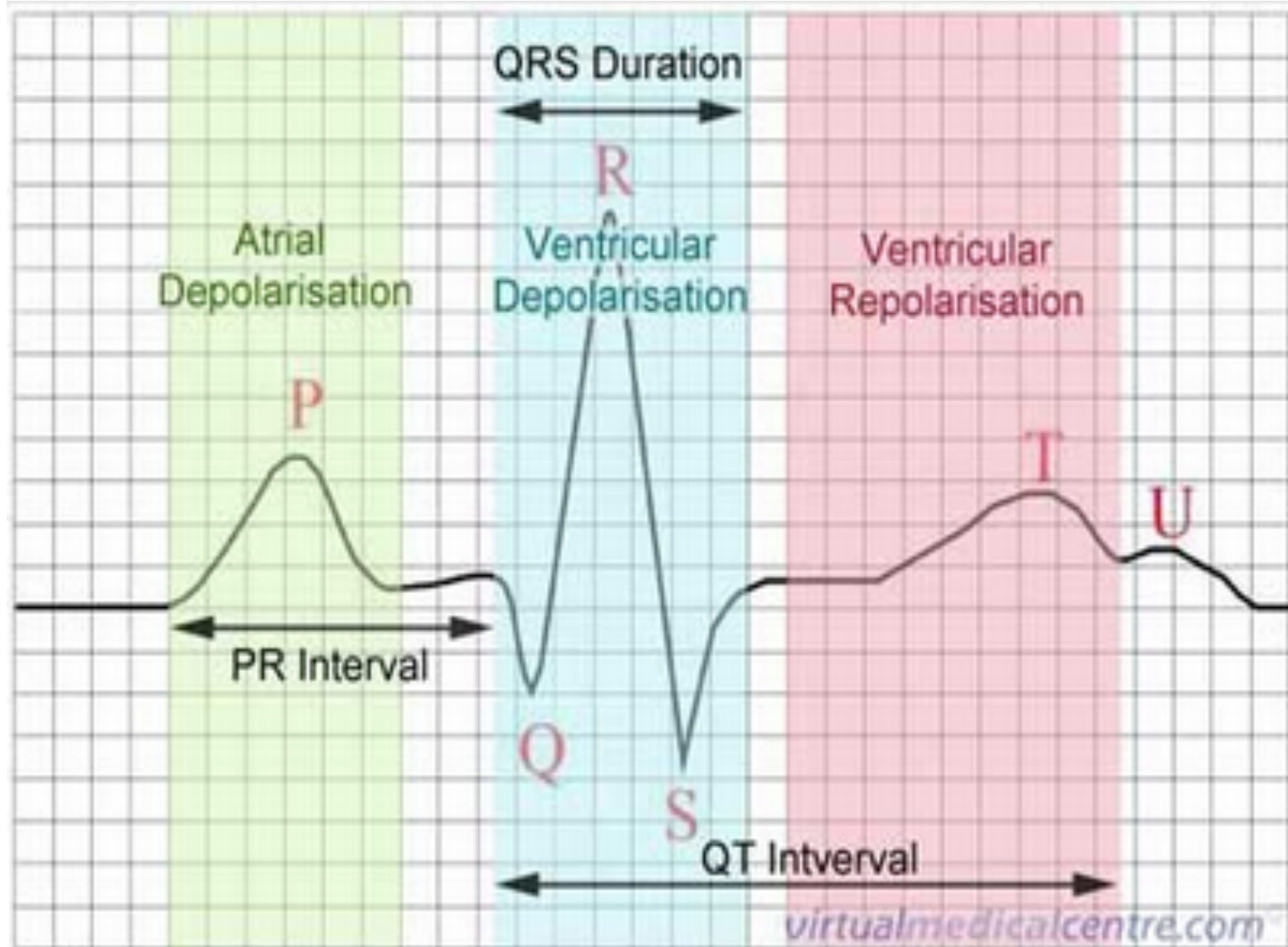
EARLY REPOLARISATION





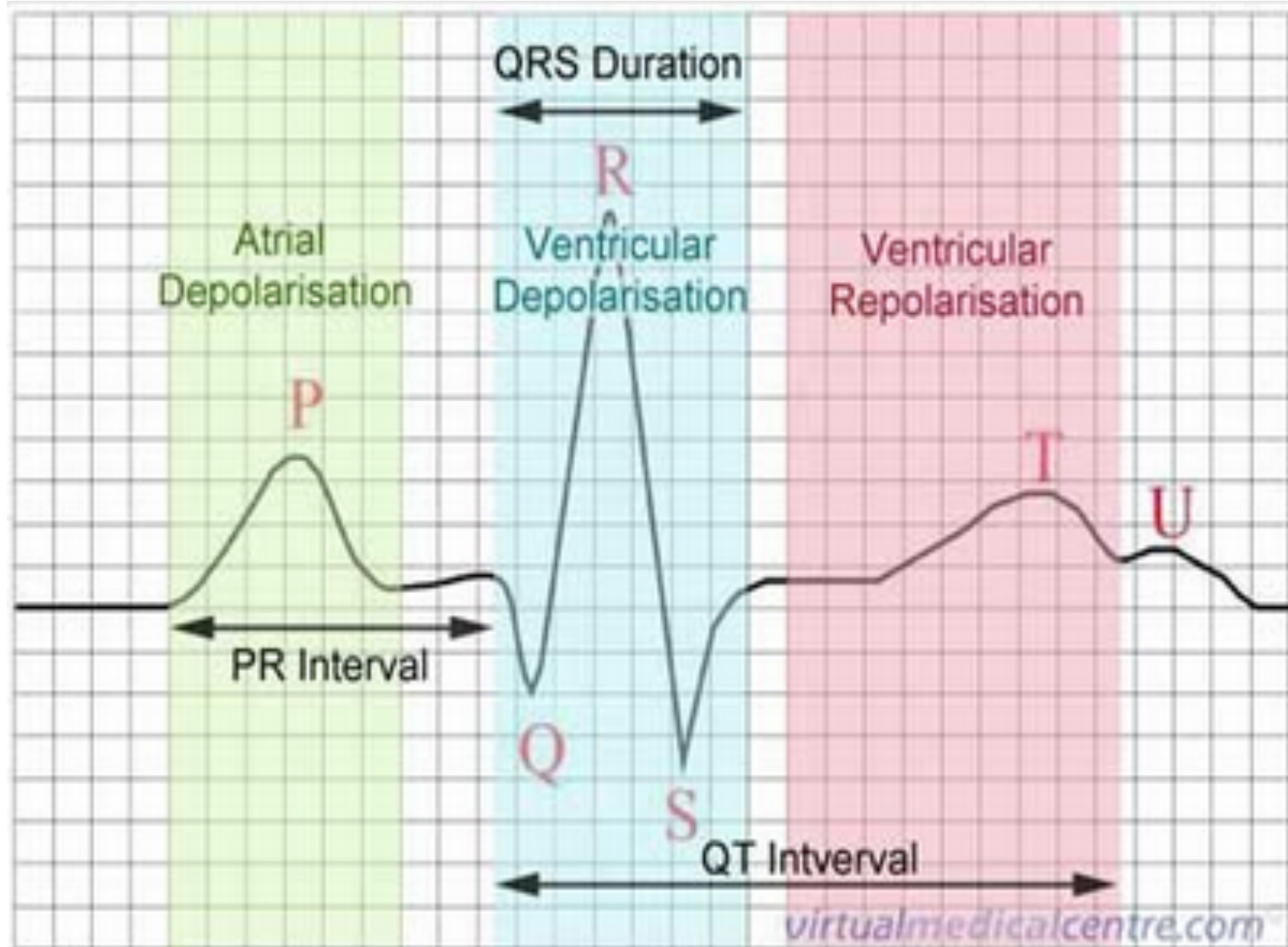
T WAVE

- Ventricular repolarization
- Normal T is ASYMMETRICAL
- SYMMETRICAL, Inverted T = myocardial ischemia
- Tall T wave = MI and hyperkalemia
- T wave $< 2/3$ amplitude of R
- T wave amplitude < 10 mm



QT INTERVAL

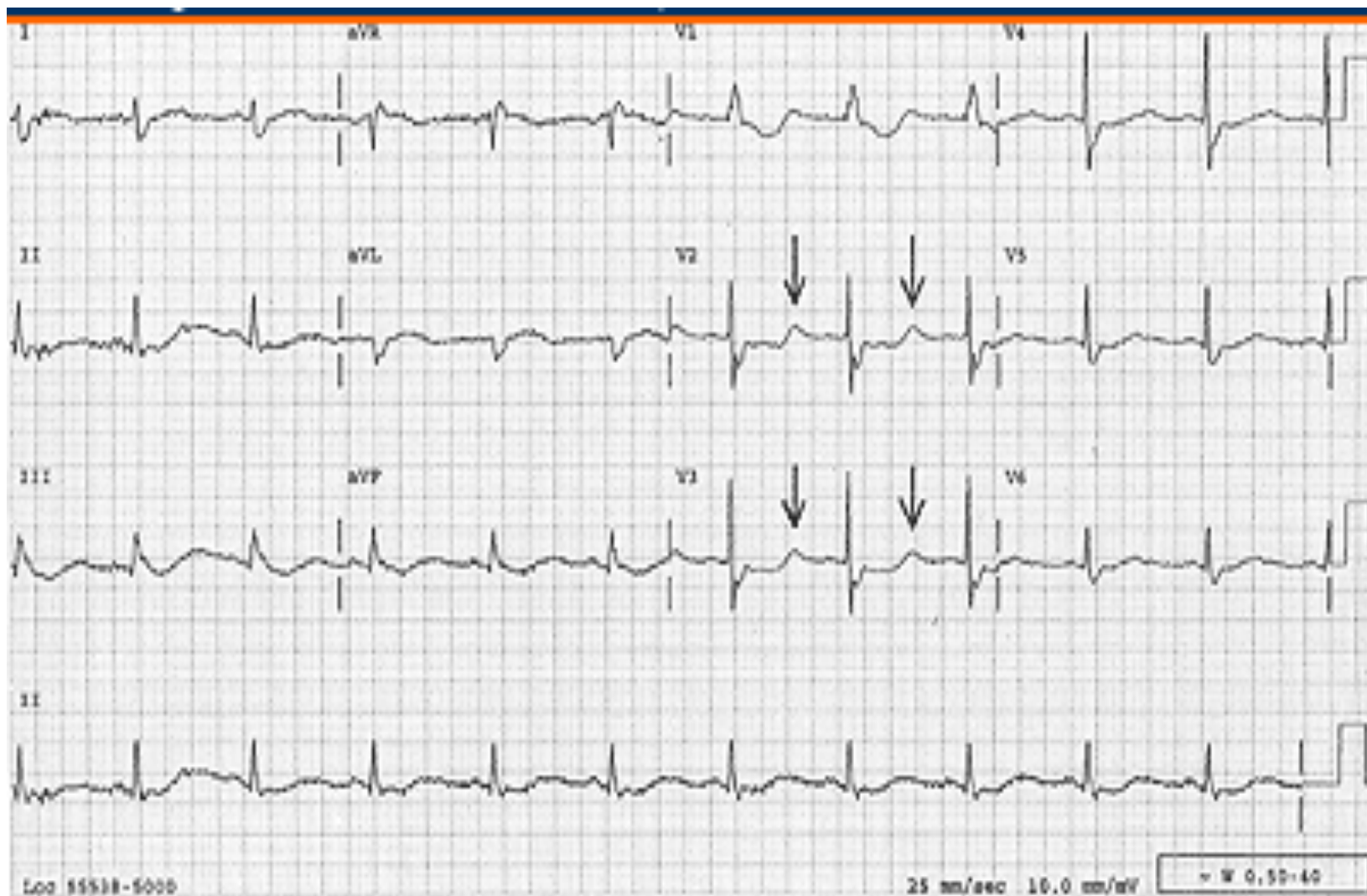
- Total time for depolarization and repolarization of the ventricle
- Beginning of the QRS complex to the end of the T wave
- 0.35 – 0.45 s



U WAVE

- Small deflection that follows the T wave
- Most prominent in leads V2 to V4
- Prominent U = athletes/ hypokalemia/ hypercalcemia

PROMINENT U WAVE



CONDITIONS AFFECTING THE LEFT SIDE OF THE HEART

CONDITIONING AFFECTING LEFT SIDE OF THE HEART

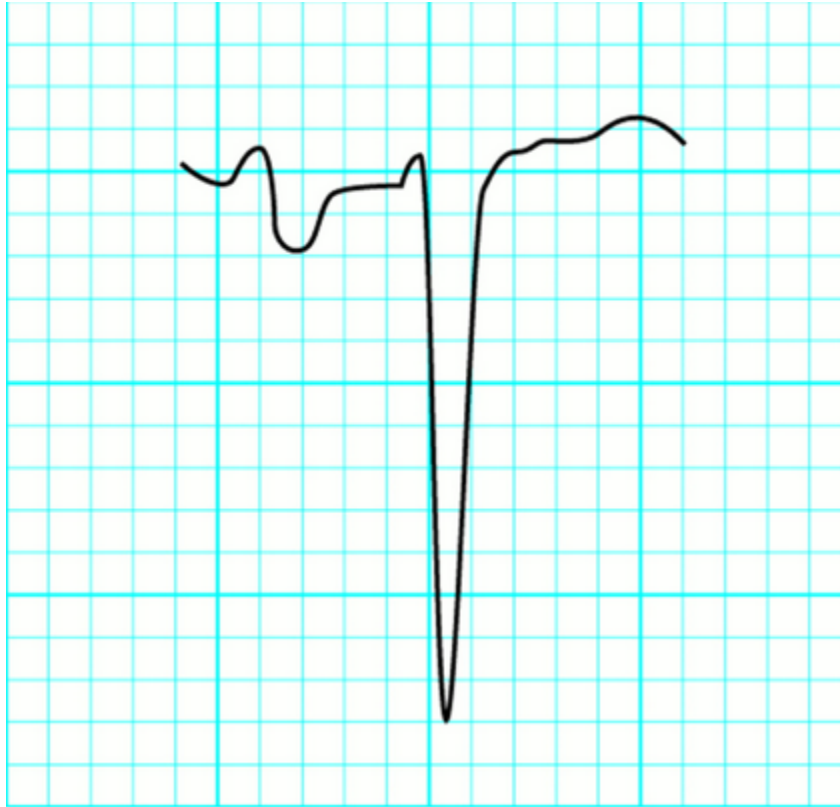
1. Left atrial dilatation and hypertrophy

2. LVH

LEFT ATRIAL ABNORMALITY

- Atrial hypertrophy or dilatation or both
- P wave in lead V1 is often biphasic
- Early right atrial forces giving rise to an initial positive deflection
- These are followed by left atrial forces travelling posteriorly, producing a later negative deflection

LEFT ATRIAL ABNORMALITY



- Biphaseic P wave in V1

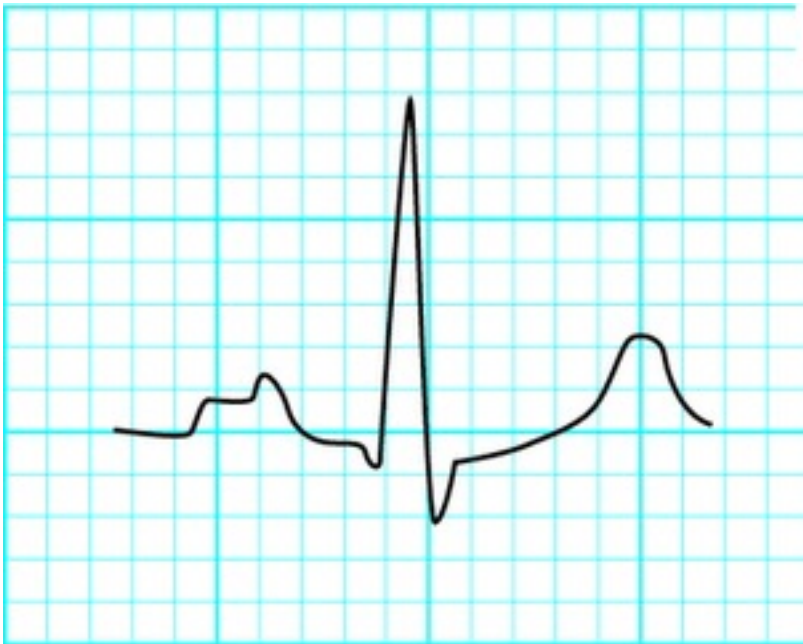
LEFT ATRIAL ABNORMALITY

- A large deflection (>1 small square) suggests a left atrial abnormality
- Prolongation of P wave duration to greater than 0.12 s is often found in association with the left atrial abnormality
- Normal P wave may be bifid

LEFT ATRIAL ABNORMALITY

- Any condition causing left ventricular hypertrophy may produce left atrial enlargement as a secondary phenomenon
- Causes of Left atrial enlargement :
 - ❖ Hypertension
 - ❖ Aortic stenosis
 - ❖ Mitral incompetence
 - ❖ Hypertrophic cardiomyopathy

LEFT ATRIAL ABNORMALITY



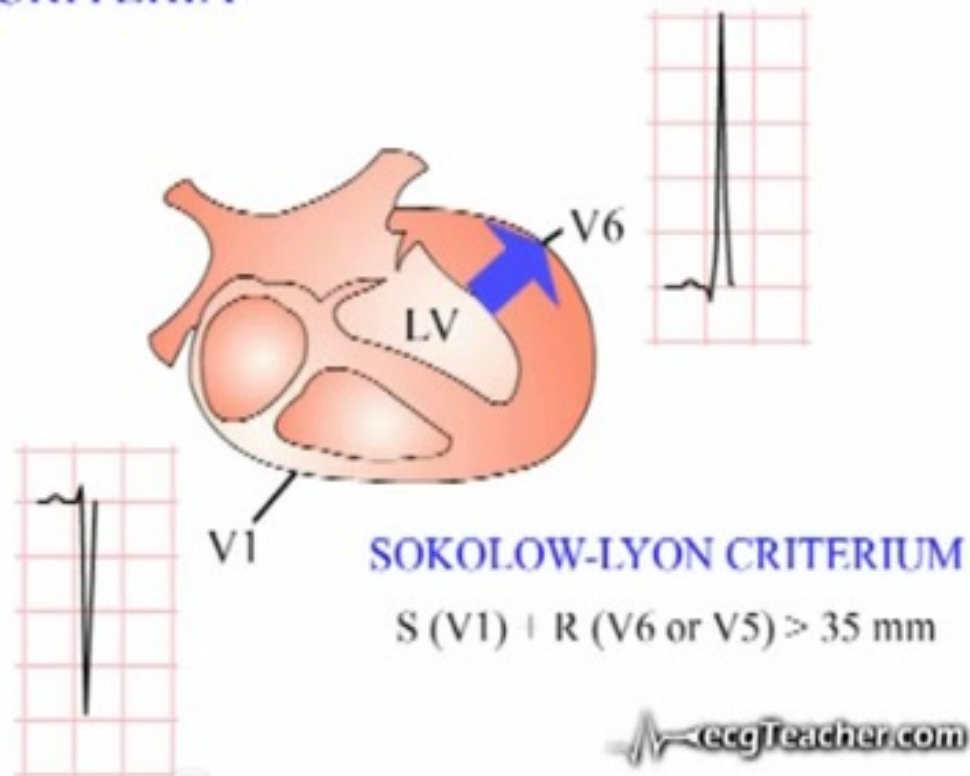
- P mitrale in lead II
- Commonly seen in mitral stenosis

LEFT VENTRICULAR HYPERTROPHY

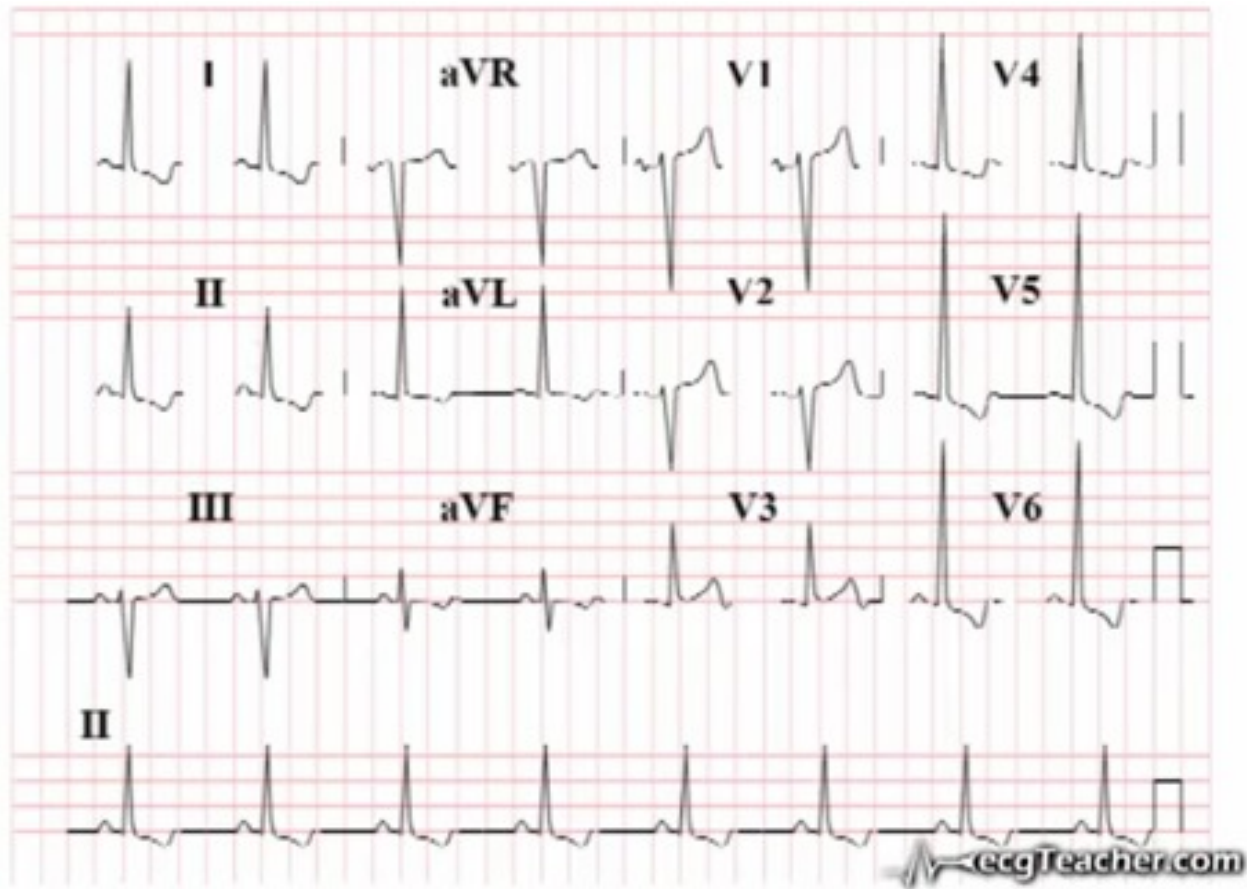
- Difficult to diagnose < 40 with ECG
- Causes:
 1. Hypertension
 2. Aortic stenosis
 3. Co-arctation of aorta

LEFT VENTRICULAR HYPERTROPHY

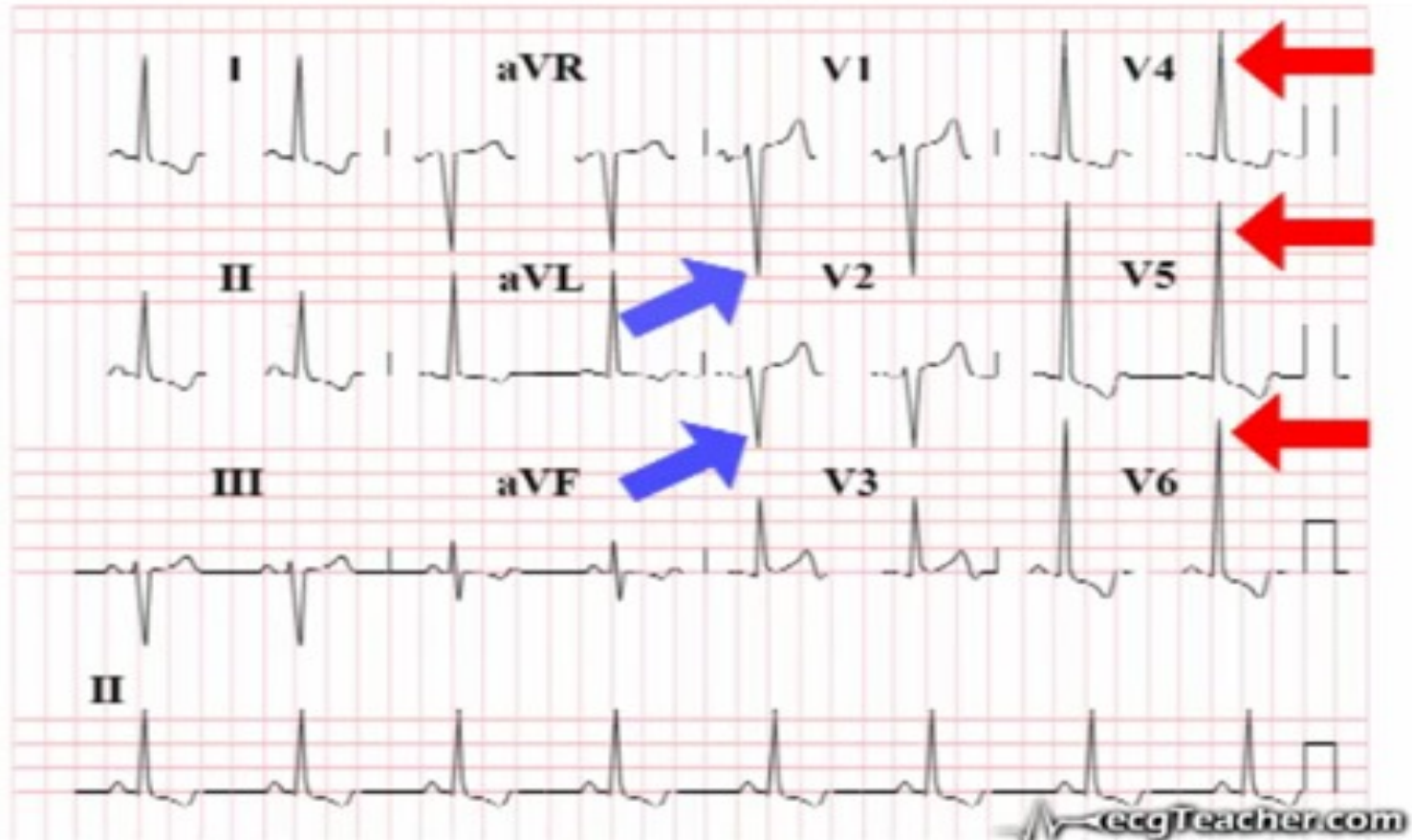
'VOLTAGE CRITERIA'



LEFT VENTRICULAR HYPERTROPHY



LEFT VENTRICULAR HYPERTROPHY



LEFT VENTRICULAR HYPERTROPHY

SOKOLOW-LYON CRITERIUM

$S(V1) + R(V6 \text{ or } V5) > 35 \text{ mm}$

$$25 + 36 = 61 \text{ mm}$$

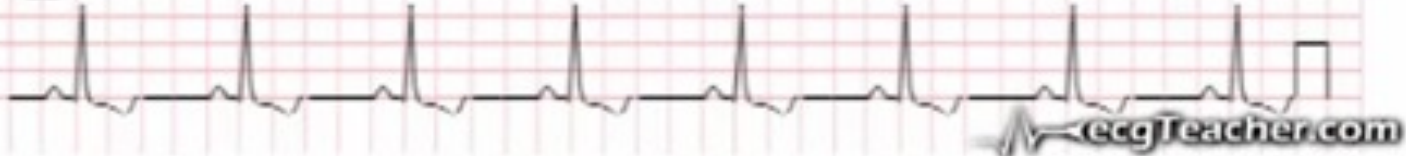
Diagnosis: LVH

Positive Predictive Value 90%

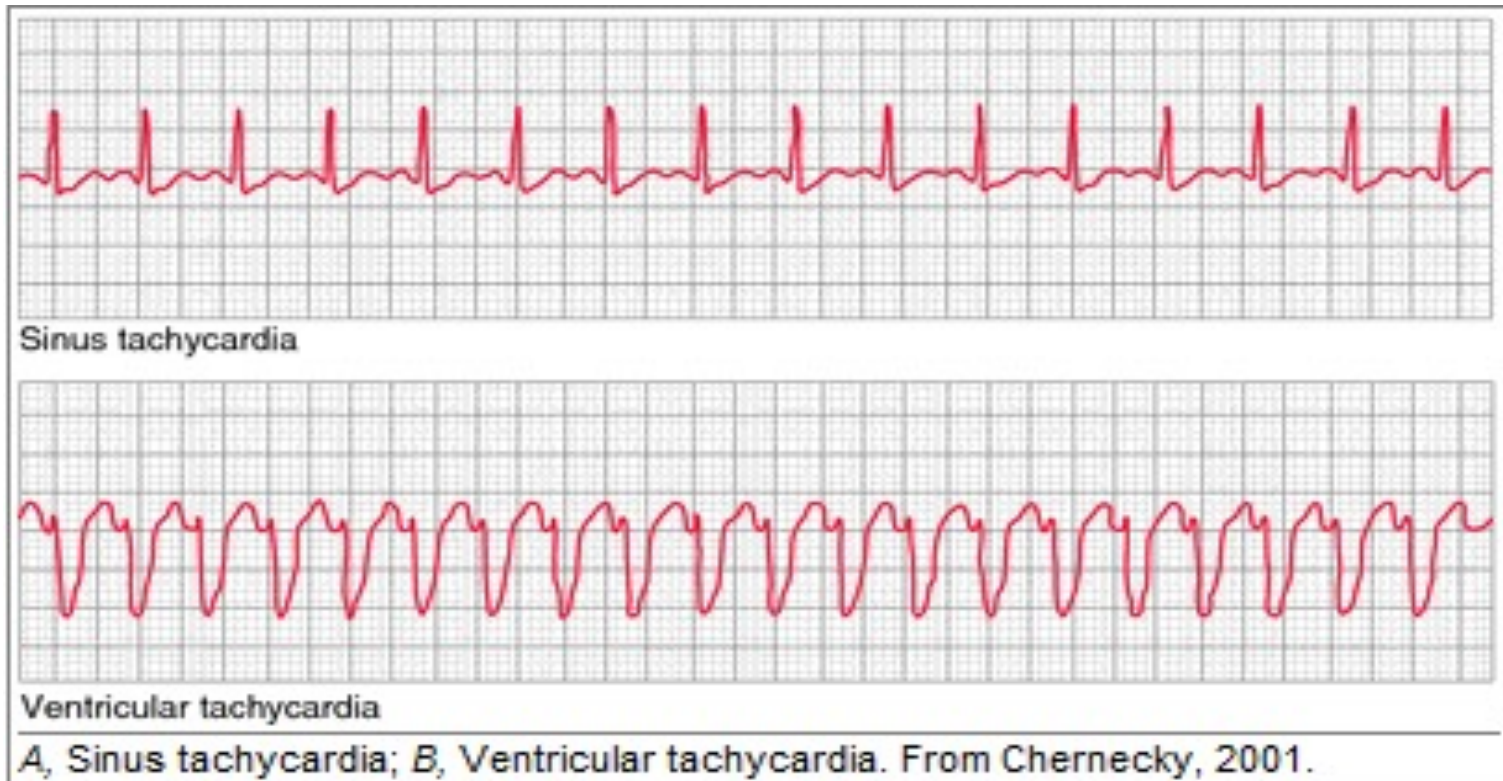
Negative Predictive Value 46%



II

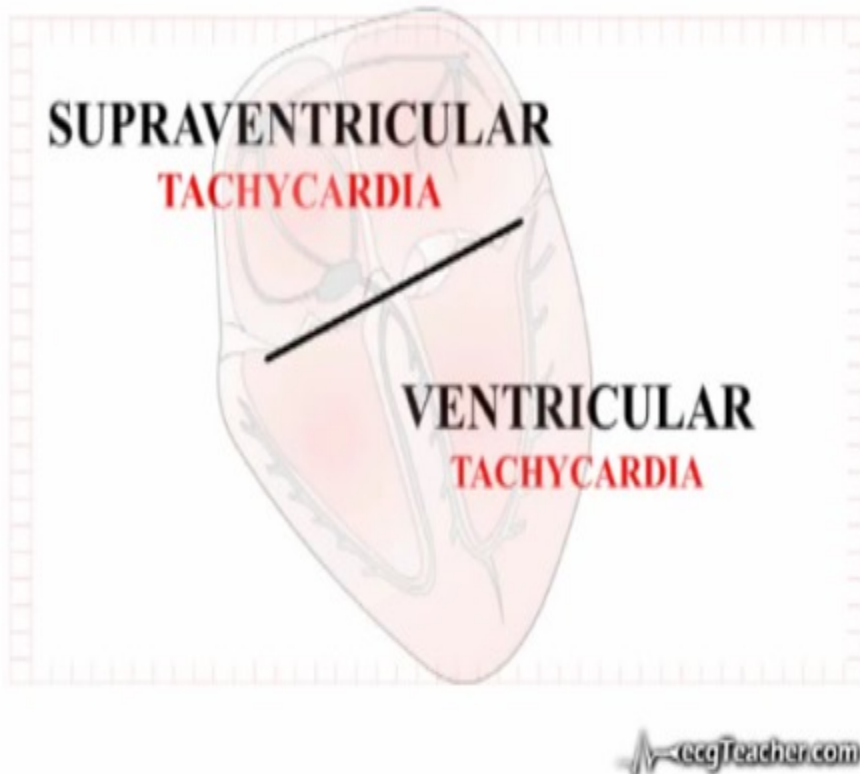


TAHCYCARDIA



- HR > 100 bpm

TACHYCARDIA



- Divided into 2:
 1. Supraventricular tachycardia
 2. Ventricular tachycardia

SUPRAVENTRICULAR TACHYCARDIA (SVT)

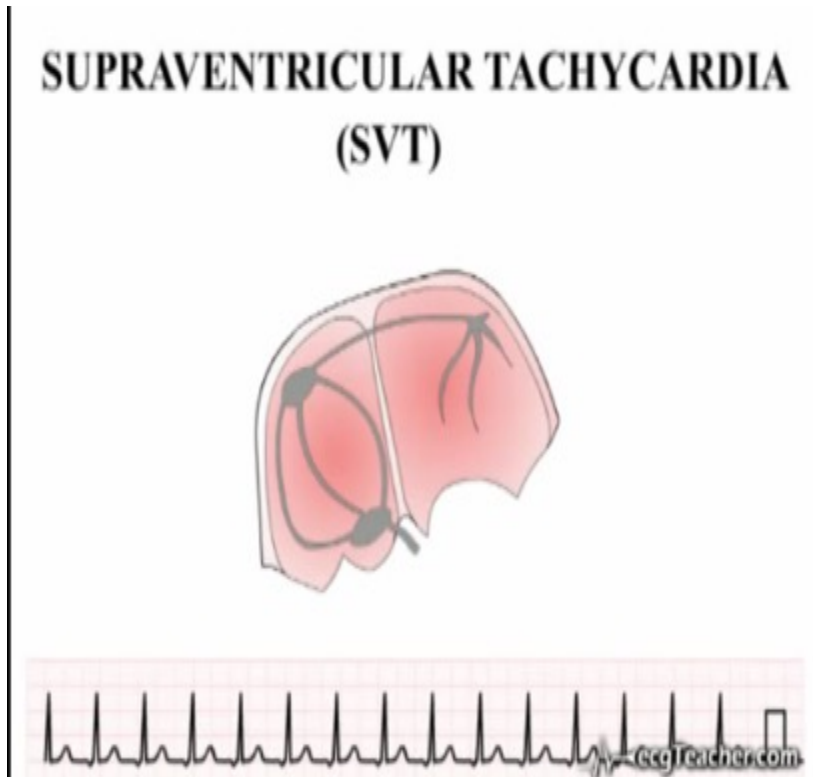
- **From atria or sinoatrial node**

1. Sinus tachycardia
2. Atrial fibrillation
3. Atrial flutter

- **From atrioventricular node**

1. Atrioventricular re-entrant tachycardia
2. Atrioventricular nodal re-entrant tachycardia

SUPRAVENTRICULAR TACHYCARDIA (SVT)



- At the atrium
- Above bundle of His
- Narrow complex tachycardia

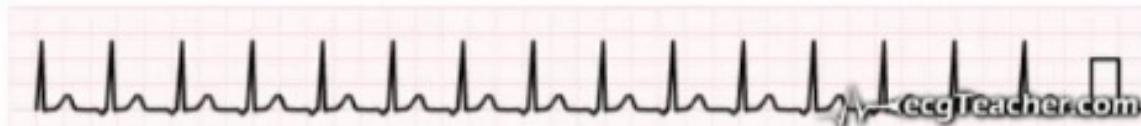
SUPRAVENTRICULAR TACHYCARDIA (SVT)

**SUPRAVENTRICULAR TACHYCARDIA
(SVT)**

qrs < 3 ss



'NARROW COMPLEX'



SUPRAVENTRICULAR TACHYCARDIA (SVT)



- SINUS TACHYCARDIA

SUPRAVENTRICULAR TACHYCARDIA (SVT)



- SINUS TACHYCARDIA

SUPRAVENTRICULAR TACHYCARDIA (SVT)



- SINUS TACHYCARDIA
- Normal P wave in inferior lead II, III and aVF
- Atrial rate 100-200 bpm
- Regular ventricular rhythm
- Ventricular rate 100-200 bpm

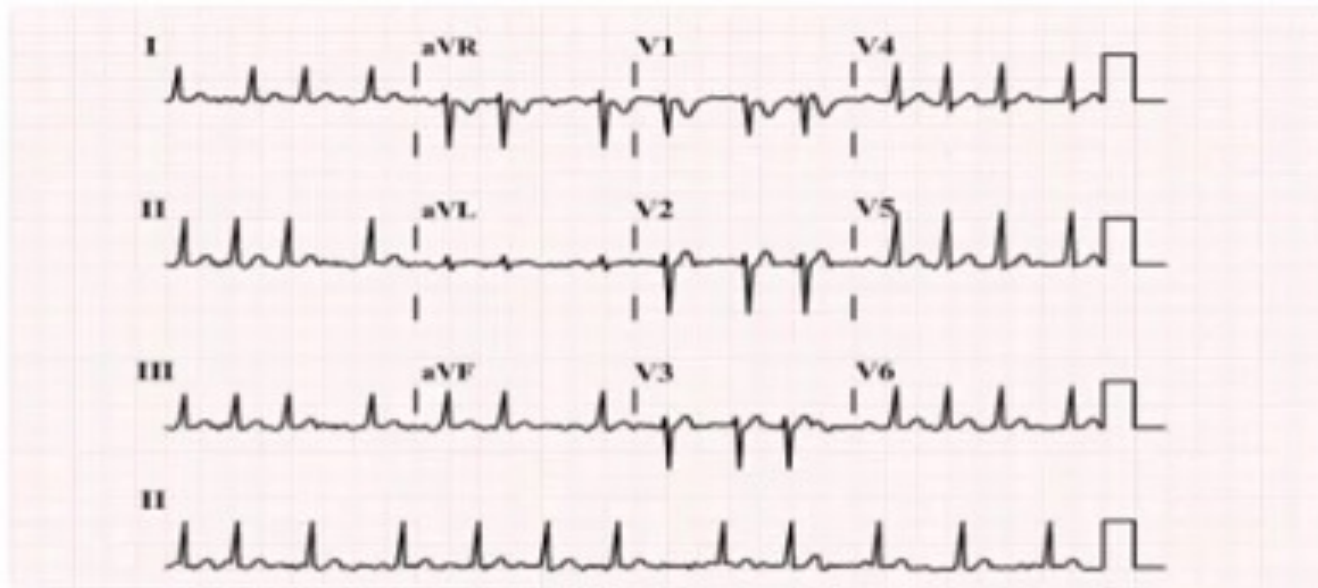
ATRIAL FIBRILLATION AND ATRIAL FLUTTER

ATRIAL FIBRILLATION



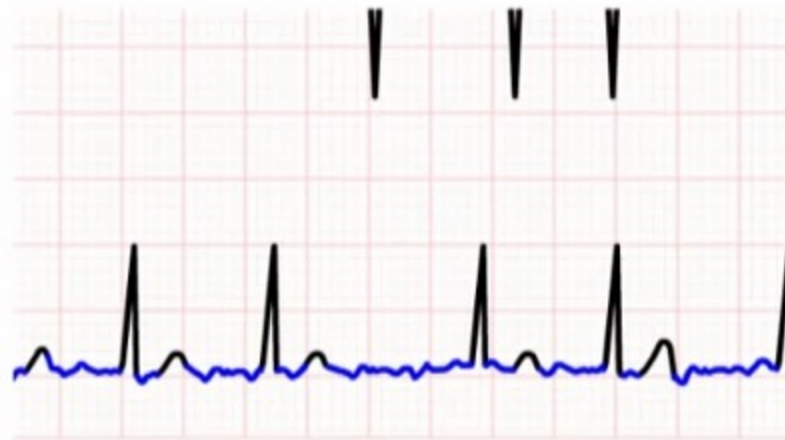
ATRIAL FLUTTER

ATRIAL FIBRILATION



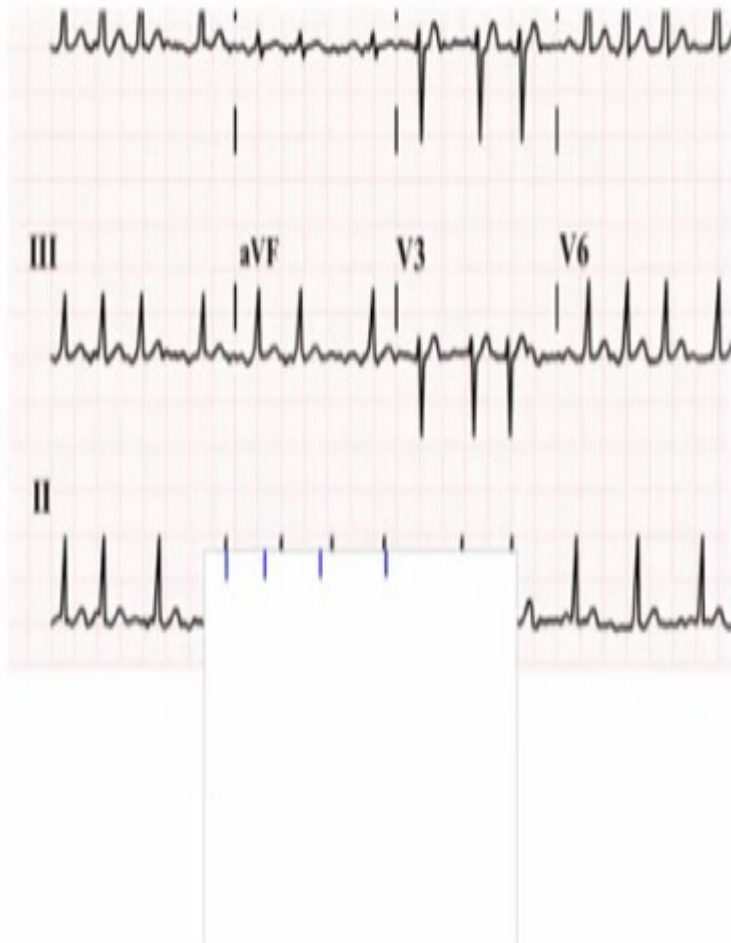
'...irregularly irregular...'

ATRIAL FIBRILATION



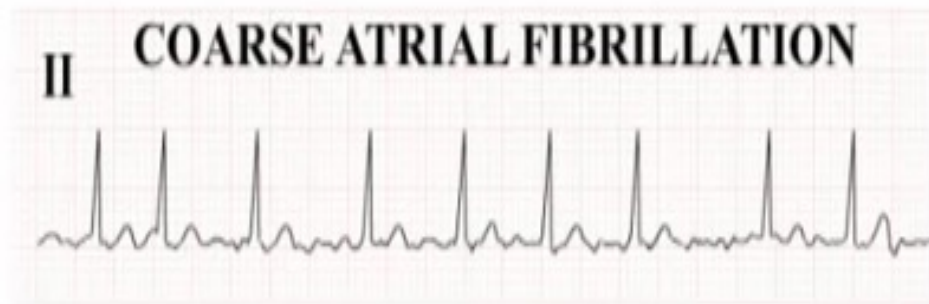
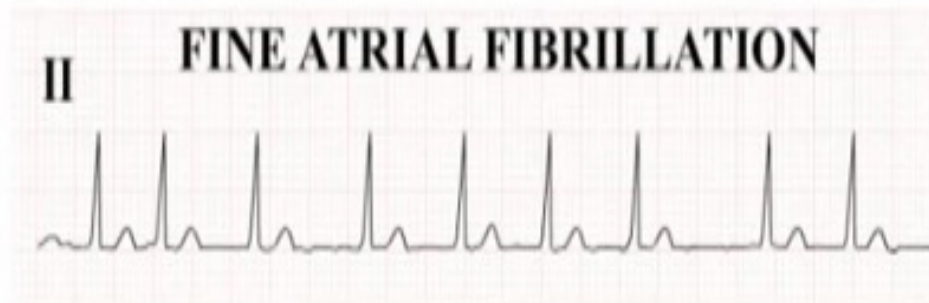
- NO P WAVES IN AF

ATRIAL FIBRILATION



- Mapping R waves against a piece of paper usually confirm diagnosis
- May be paroxysmal, persistent or permanent
- Treatment : Digoxin

ATRIAL FIBRILLATION

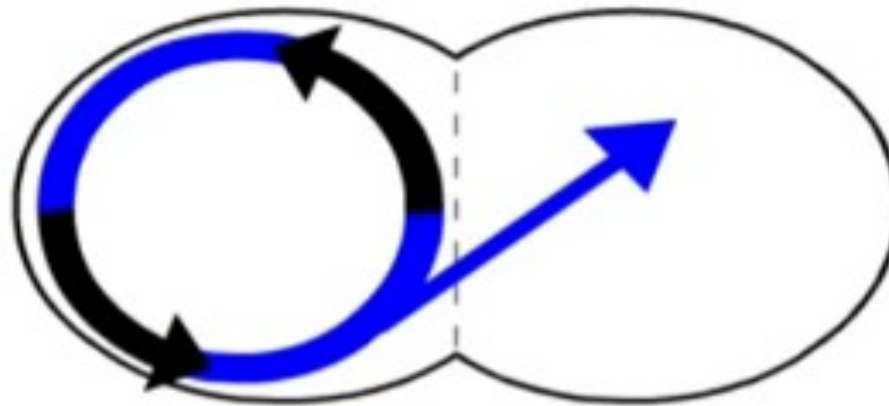


ATRIAL FIBRILATION

- IRREGULARLY IRREGULAR
- NO P WAVE

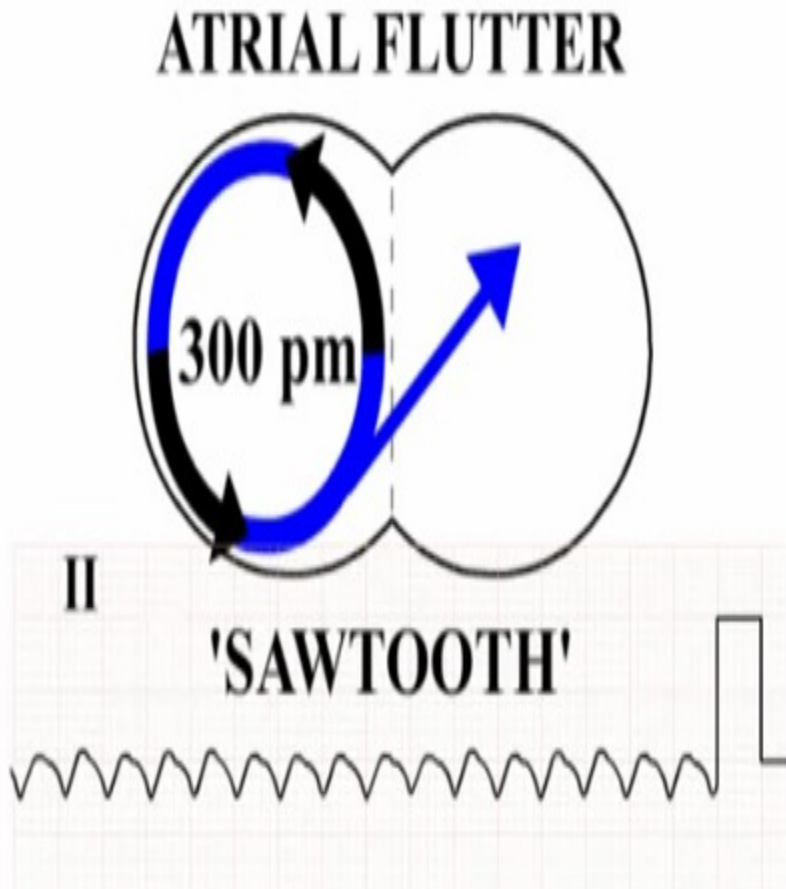
ATRIAL FLUTTER

ATRIAL FLUTTER



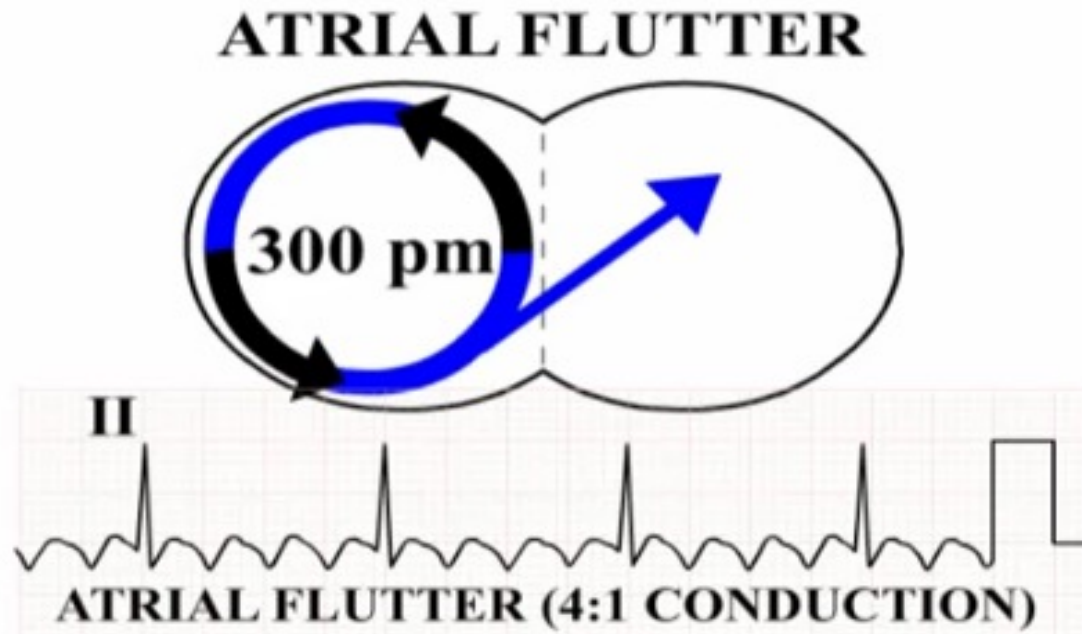
'RE-ENTRY'

ATRIAL FLUTTER

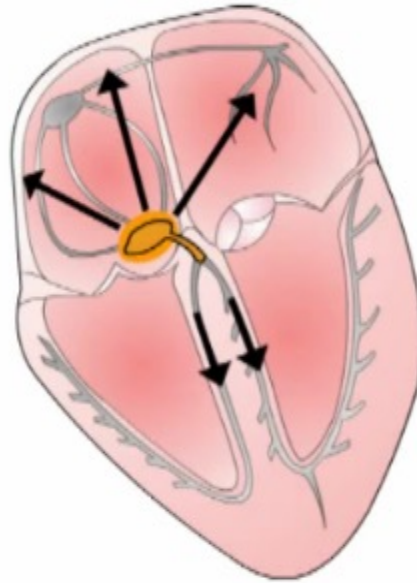


- Re-entry circuit in the right atrium with secondary activation of left atrium
- Atrial contraction 300 bpm
- Broad and appear sawtooth best seen at **inferior leads and V1**

ATRIAL FLUTTER



JUNCTIONAL TACHYCARDIA



1. Atrioventricular re-entrant tachycardia
2. Atrioventricular nodal re-entrant tachycardia

JUNCTIONAL TACHYCARDIA

- Negative P waves in inferior leads

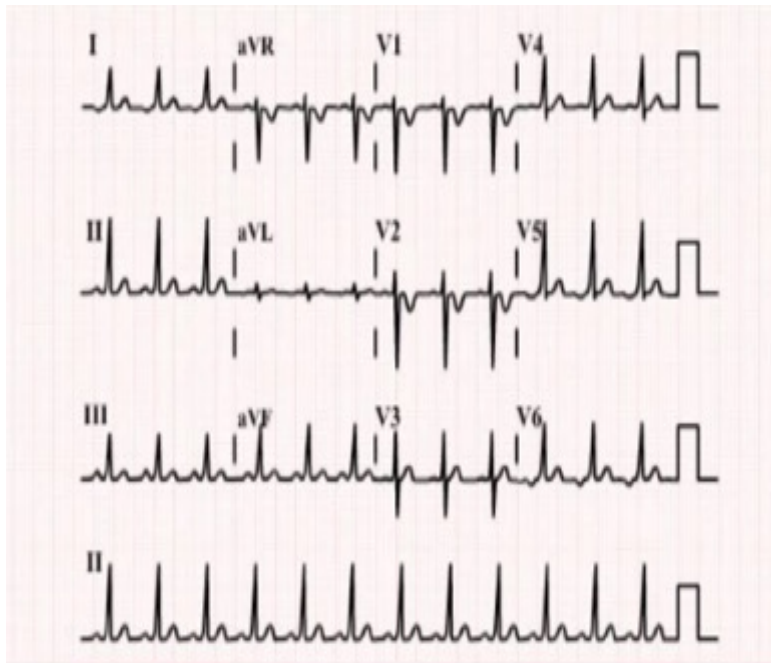


JUNCTIONAL TACHYCARDIA



- PR interval < 3 ss
- P wave negative deflection in lead II

ECTOPIC ATRIAL TACHYCARDIA



DIAGNOSIS: ECTOPIC ATRIAL TACHYCARDIA

**NEGATIVE P WAVE IN
LEAD I OR II OR III OR
V5 AND V6**

**DEPOLARISATION NOT
SINUS**

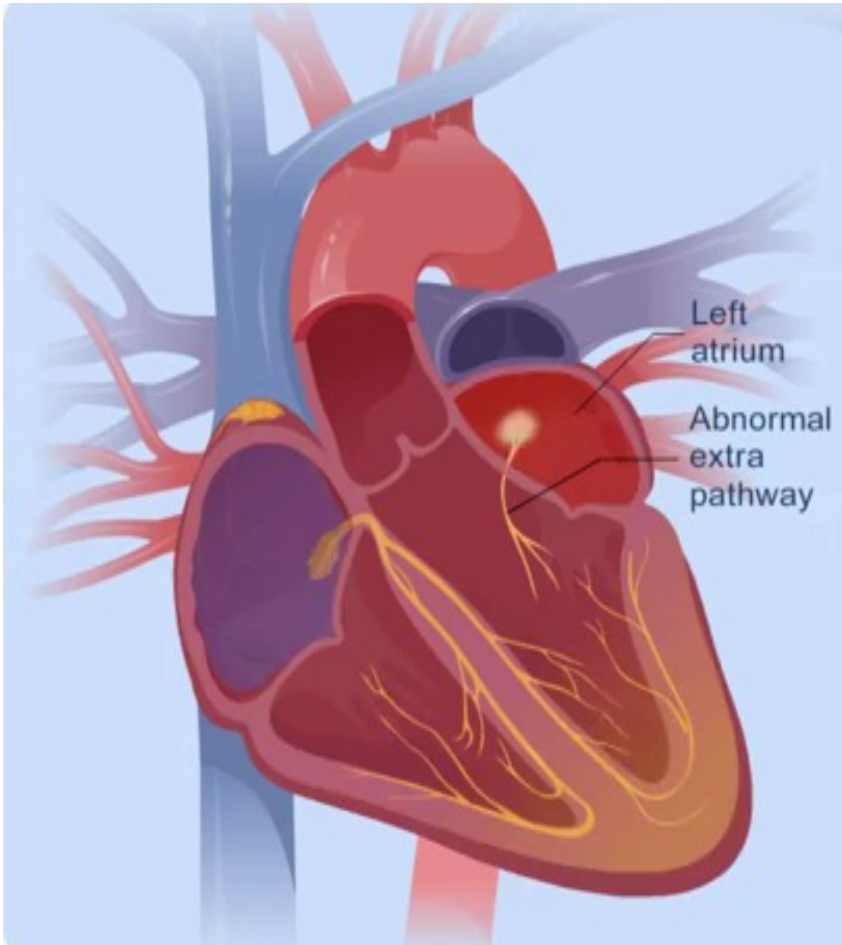
DIAGNOSIS: ECTOPIC ATRIAL TACHYCARDIA

SUPRAVENTRICULAR TACHYCARDIA (SVT)



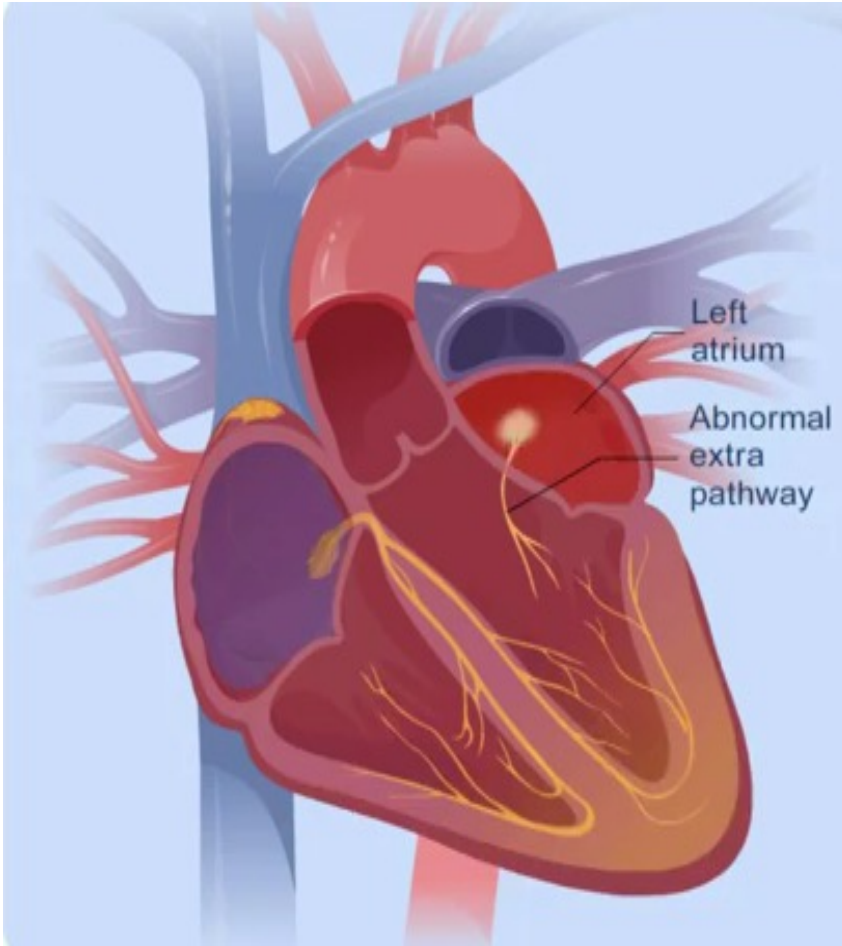
	<i>PR INTERVAL</i>	<i>P WAVE AXIS</i>
●	NORMAL	DIRECTED INFERIORLY
●	NORMAL	VARIABLE
●	SHORTENED OR NEGATIVE	DIRECTED SUPERIORLY

JUNCTIONAL TACHYCARDIA



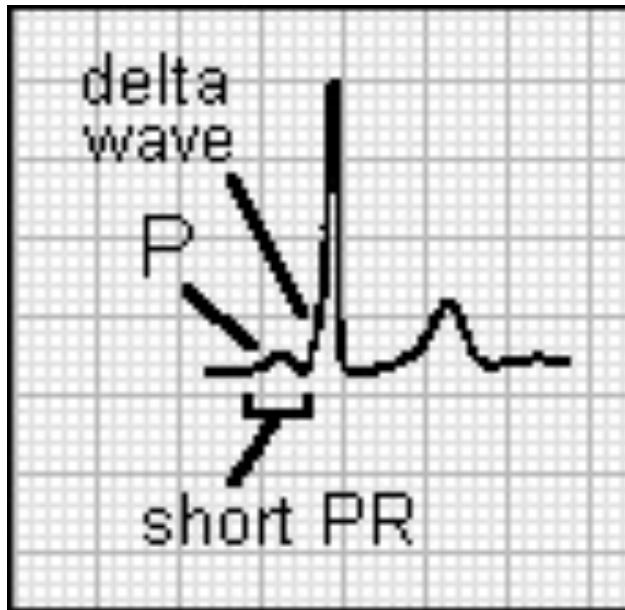
- **WOLF PARKINSON WHITE SYNDROME**
- Atrioventricular re-entrant tachycardia
- Electrical signal re-enters the atria over an abnormal extra pathway

JUNCTIONAL TACHYCARDIA



- **WOLF PARKINSON WHITE SYNDROM**
- This extra pathway allows electrical signals to pass between the ventricles and atria
- Signals on this extra pathways causing the atria and ventricles to beat too fast

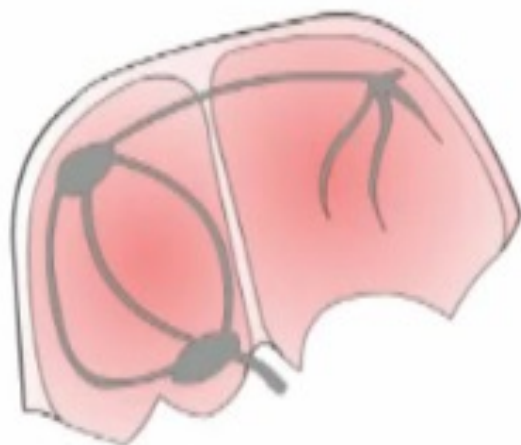
JUNCTIONAL TACHYCARDIA



- **WOLF PARKINSON WHITE SYNDROM**
- Short PR interval < 3 small square
- Slurred upstroke to the QRS indicating pre-excitation (delta wave)
- Broad QRS

SVT

$\text{qrs} < 3 \text{ ss}$



'NARROW COMPLEX'

VT

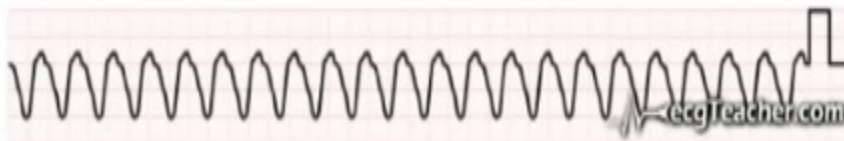
$\text{qrs} > 3 \text{ ss}$



'BROAD COMPLEX'

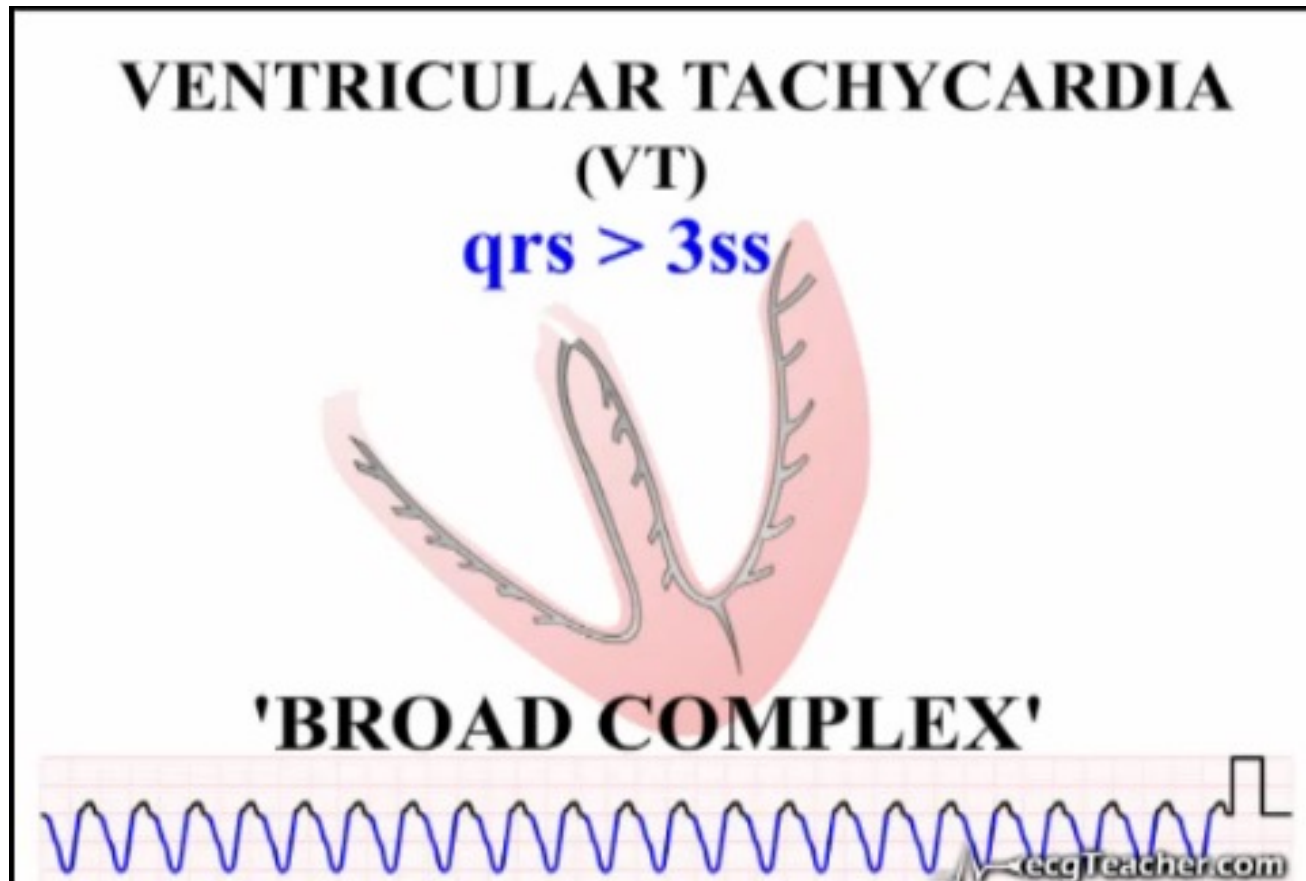
VENTRICULAR TACHYCARDIA

VENTRICULAR TACHYCARDIA (VT)

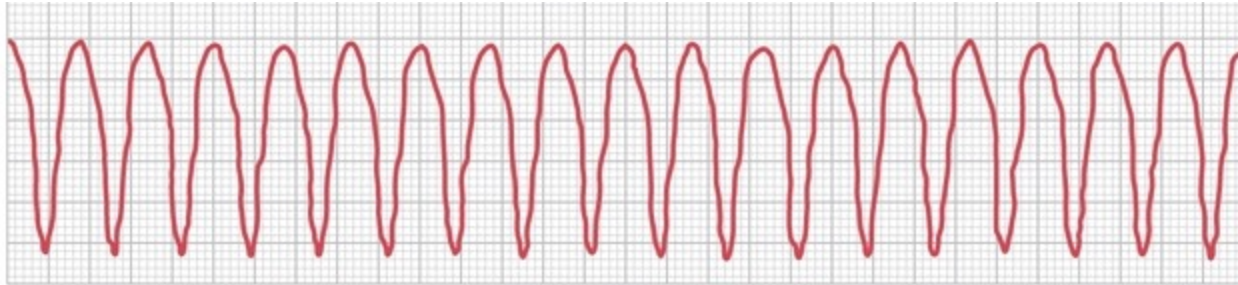


- At the ventricle
- Below bifurcation bundle of His
- B r o a d Q R S
c o m p l e x
tachycardia

VENTRICULAR TACHYCARDIA



VENTRICULAR TACHYCARDIA

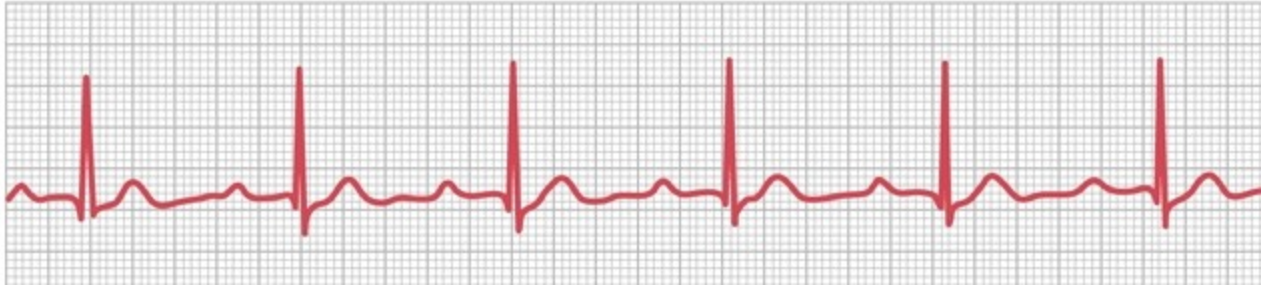


- Define as 3 or more ventricular extrasystoles in succession at rate > 120 bpm
- **Causes :**
 1. IHD
 2. Cardiomyopathy
 3. Myocarditis
 4. Drugs: guanidine

ATRIOVENTRICULAR CONDUCTION BLOCK

- Delayed 1st degree block
- Intermittently blocked – 2nd degree block
- Completely blocked – 3rd degree block
- **Causes:**
 1. MI
 2. Degeneration of His Purkinje system
 3. Lyme disease, diphtheria
 4. Surgery
 5. Congenital disorder

1st DEGREE BLOCK



- A delay conduction of atrial impulse to ventricle
- At level of atrioventricular node
- Prolonged PR interval > 0.20 s
- A QRS complex follows each P wave, and PR interval remains constant

1st DEGREE BLOCK

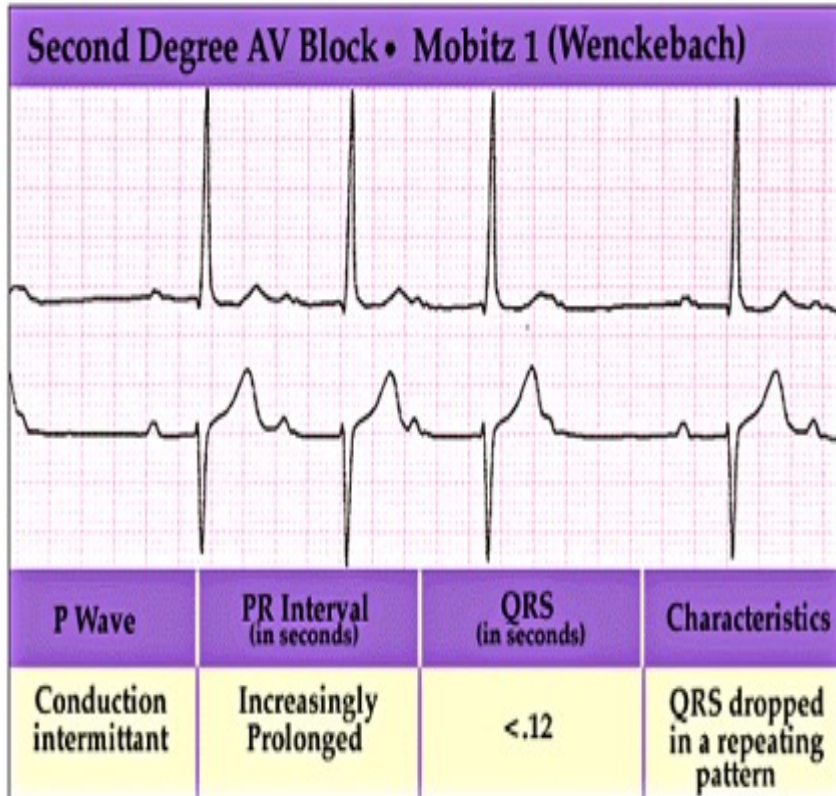


- Prolonged PR

2nd DEGREE BLOCK

- MOBILZ TYPE I BLOCK (WENCKEBACH PHENOMENON)
- MOBILZ TYPE II BLOCK

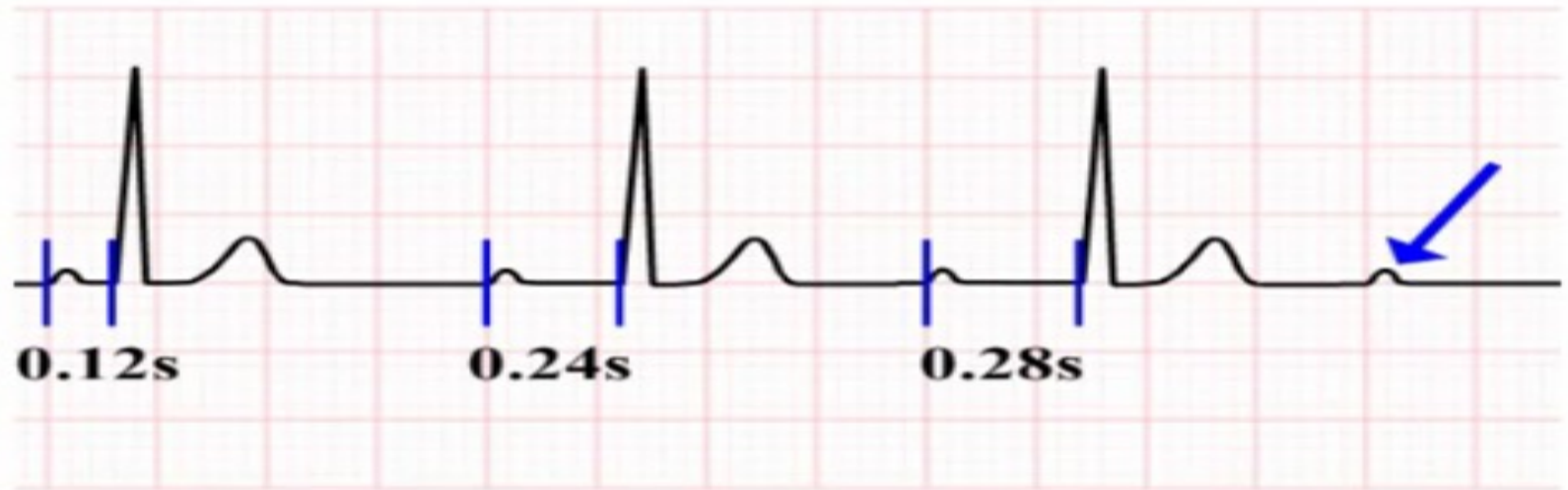
2nd DEGREE BLOCK



2nd Degree AV Block, Type I (Wenckebach)-KH

- At the level of atrioventricular node
- Intermittent failure of transmission of the atrial impulse to the ventricles
- Initial PR interval is normal but progressively lengthens with each successive beat until AV transmission is blocked completely and the P wave is not followed by QRS complex
- PR interval then return to normal and cycle repeats

MOBITZ TYPE I (WENCKEBACH)



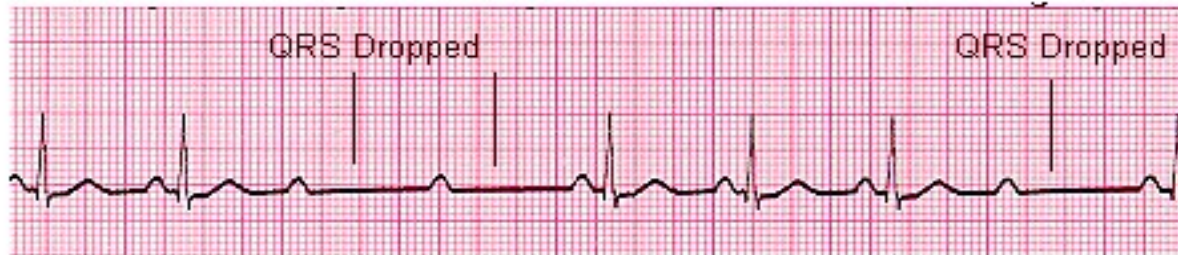
2nd degree AV block

 ecgteacher.com

- **Progressive prolongation of PR interval within group**

2nd DEGREE BLOCK

2nd Degree Block Type 2



- Less common but is more likely to produce symptoms
- Intermittent failure of conduction of P wave
- PR interval is constant, though it may normal or prolonged
- Block is often at the level of the bundle brunches and is therefore associated with wide QRS complexes