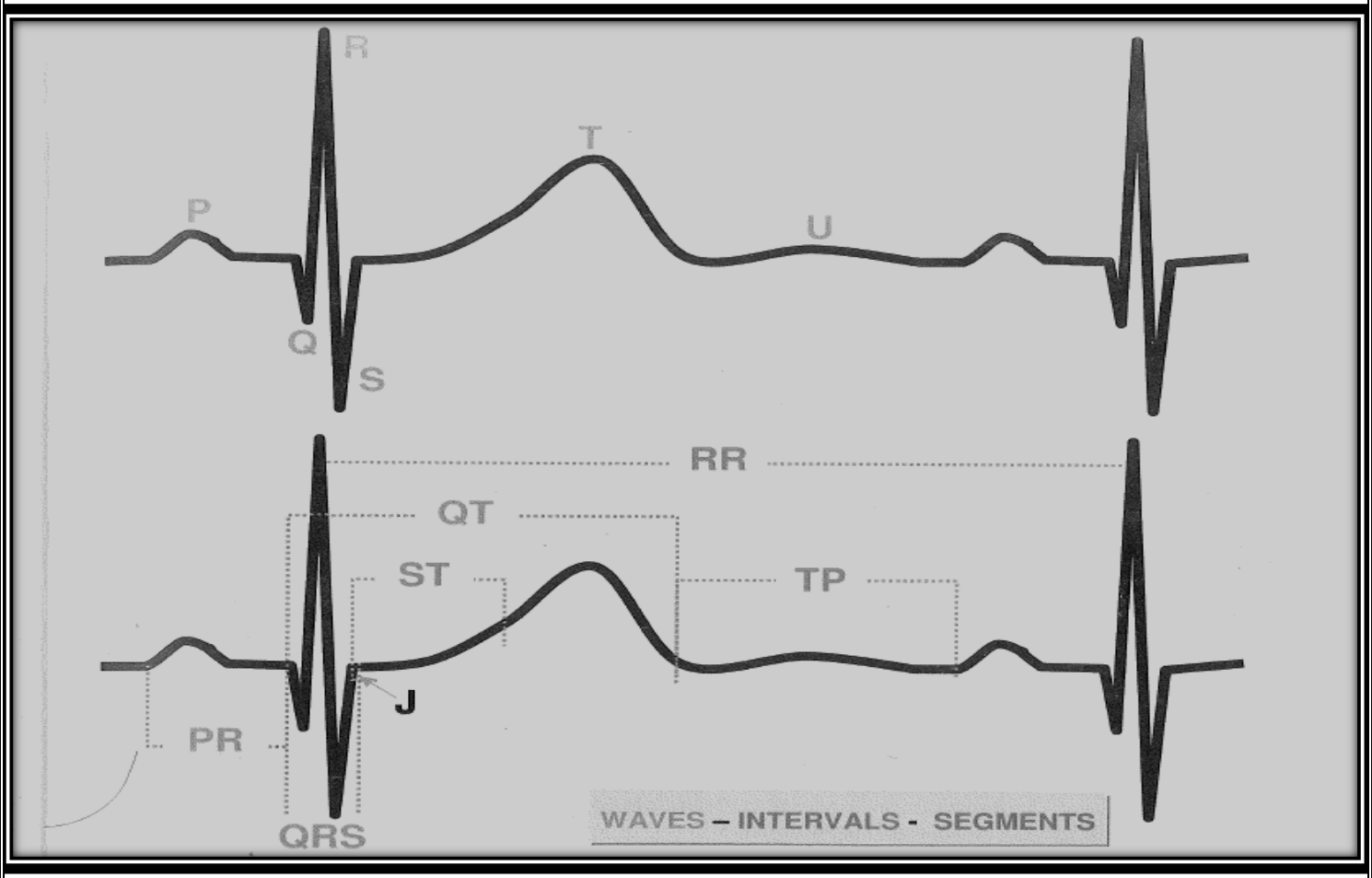
HOW TO READ THE ECG?



By

DR. HOSAM MOKHTAR

SIMPLE AND PRACTICAL

شرح مبسط عن القواعد العامه لقراءة رسم القلب بدون تفاصيل دقيقه

➢ You must take a good focused history upon which the ECG is done

مثال

- Acute chest pain searching for

  STEMI, NSTEMI, UA, Pericarditis

- Palpitation searching for

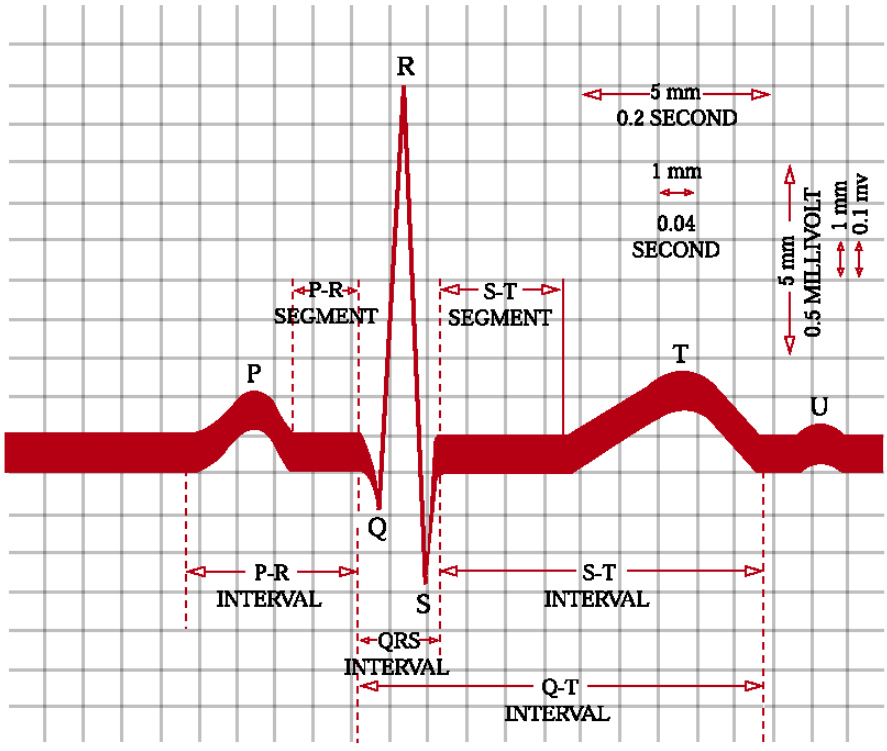
  Tachyarrhythmia like AF, SVT etc

- Syncopal attack searching for Hear block

➢You should comment on the following items

لابد من اتباع هذة ال **scheme** لتجنب الخطأ خصوصا المبتدأئين

1. Rhythm
2. Rate
3. Axis
4. P wave
5. P R interval
6. P R segment
7. QRS complex
8. ST segment
9. T wave
10. QT interval



Recording Conventions, Waveform Nomenclature, and Normal Values for the Electrocardiogram.

1) Rhythm

➢ **Sinus or not**

↳ If not sinus --> detect the rhythm, (details of arrhythmias will be discussed later)

↳If Sinus = One upright P wave before each QRS complex with fixed P-R interval, best seen in Lead II Otherwise, Any other abnormality like abscent P or inverted P or multiple Ps is arrhythmias خلى بالك

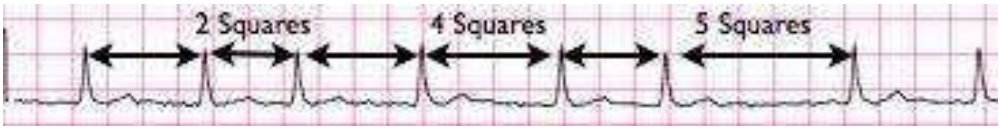
➢Regular or irregular (best seen in long strip)

↳ Regular = fixed R -R interval distance

المسافه بين كل R والتى تليها واحده فى كل ال ECG

↳Irregular = R - R interval is not the same in the long strip

المسافه بين كل R والتى تليها ليست واحده



2) Rate

➢This depends on whether the rhythm is regular or irregular

↳If regular --> divide 300/number of large squares between 2 consecutive R

Or 1500/number of small squares between 2 consecutive R

مثلا ٣٠٠ ÷ ٣ مربعات = ١٠٠

او 1500 ÷ 30 = 100

↳If irregular --> do long strip and count R in 50 large squares then multiply × 6

Or count in 30 large squares then multiply × 10

نعمل long strip ونعد R فى ٣٠ مربع كبير ونضرب فى ١٠ أو نعد R فى ٥٠ مربع كبير ونضرب فى ٦

➢ Normal heart rate: 60 - 100

↳ > 100 --> tachycardia

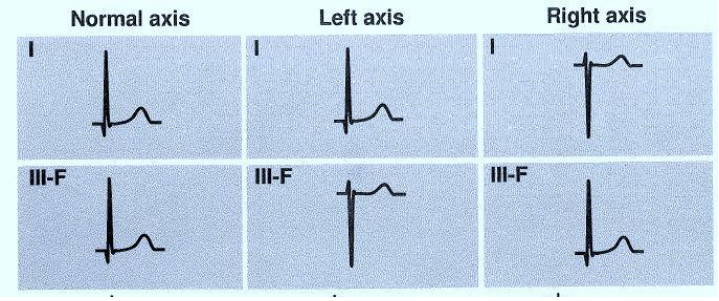
↳ < 60 --> Bradycardia

امثله مشهوره لل abnormal rhythms& rate ...

Irregular R - R interval + abscent normal P (F waves) --> AF

Regular R - R interval + absent normal P waves + HR > 140 --> paroxysmal supraventricular tachycardia (SVT)

3) Axis



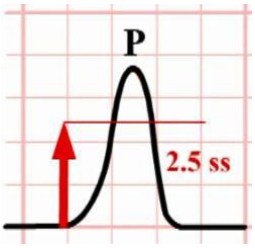
➢Look for the deflection in lead I & III & aVF

- If it positive in both معظمه فوق الخط
  - -> Normal axis deviation
- If is positive in Lead I
  and Negative in Lead III & aVF معظمه تحت الخط
  ---> Left axis deviation
- If it is negative in Lead I and positive in Lead III & aVF
  --> Right axis deviation

4) P wave

= Atrial depolarization

➢ Comment on

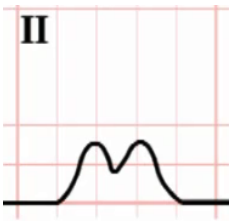


1- **Amplitude** الطول (Normally up to 2.5 mm or SS)

↳If long peaked ---> P pulmonale (RT atrial enlargement)

2- **Width (duration)** العرض والزمن

Normally up to 3 small squares (120 m.sec)
(Every small square duration= 40 m.sec)



↳ If wide P (> 3 ss either notched or not)

---> It is considered P mitrale: left atrial enlargement)

3- Abnormal P waves

Examples

- AF

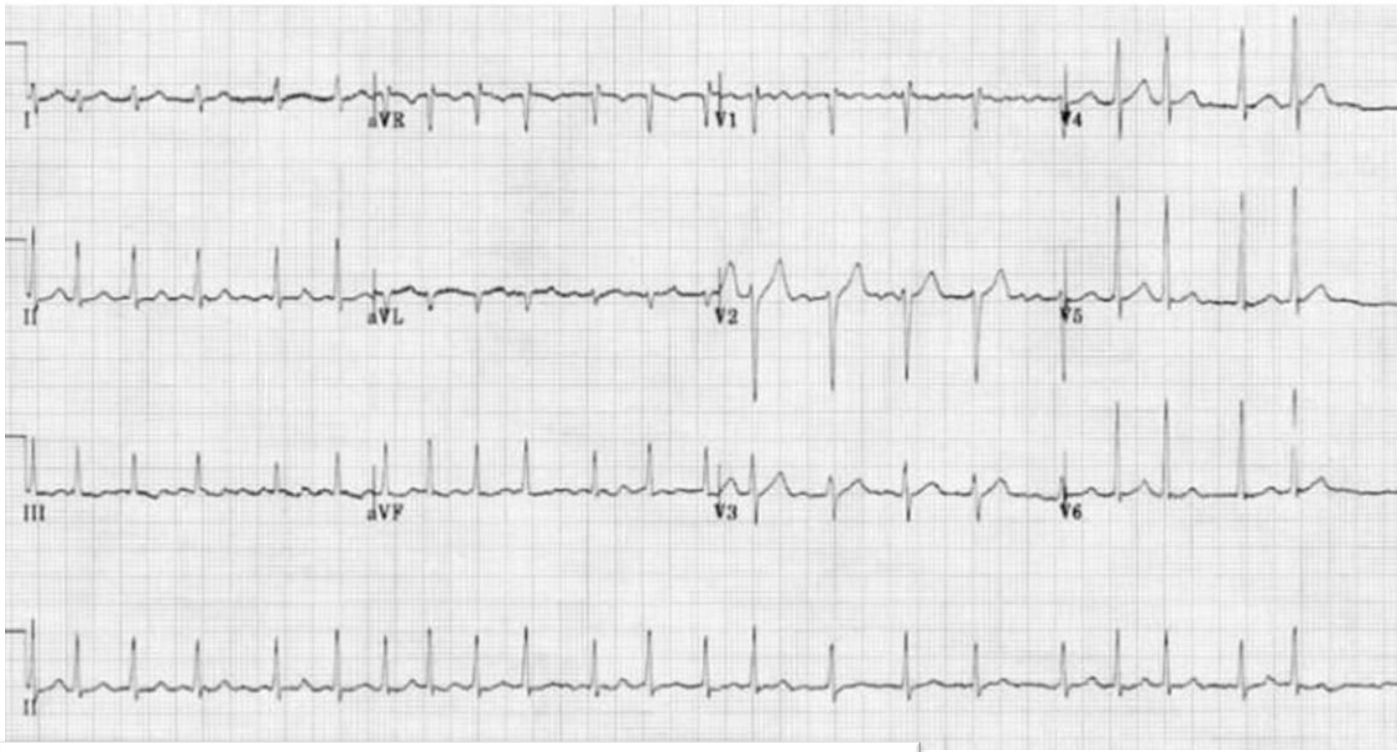
  (Abscent P waves with fibrillatory F waves + irregular rhythm

  N.B

  Fibrillatory waves may be present and can be either fine (amplitude <0.5 mm) or coarse (amplitude >0.5mm)

  Fibrillatory waves may mimic P waes leading to misdiagnosis

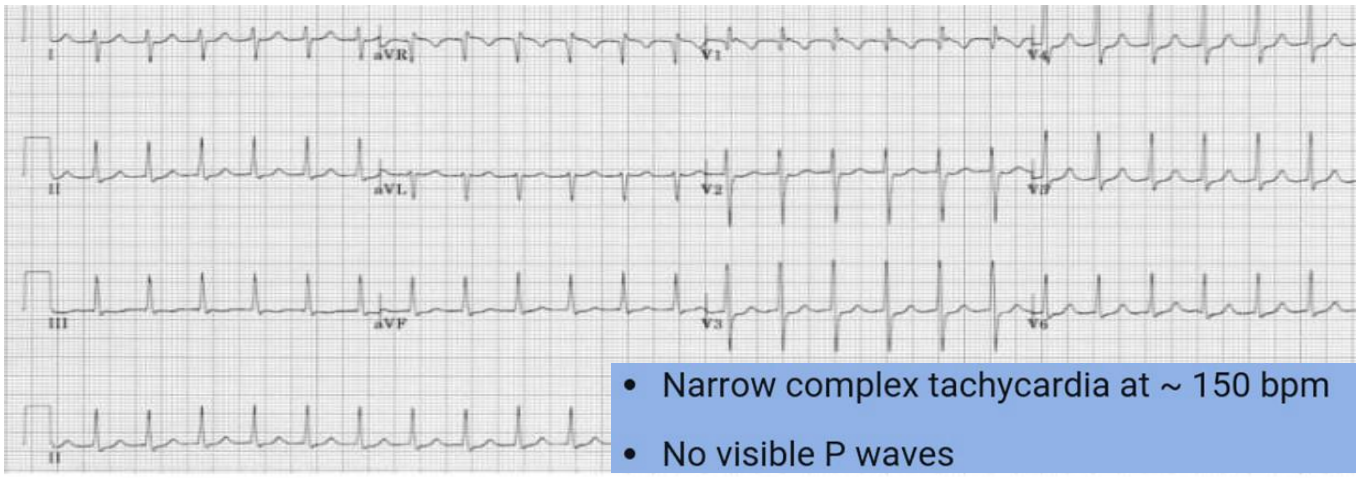
Atrial fibrillation: Irregularly irregular ventricular rate without visible P waves



AF with rapid ventricular response

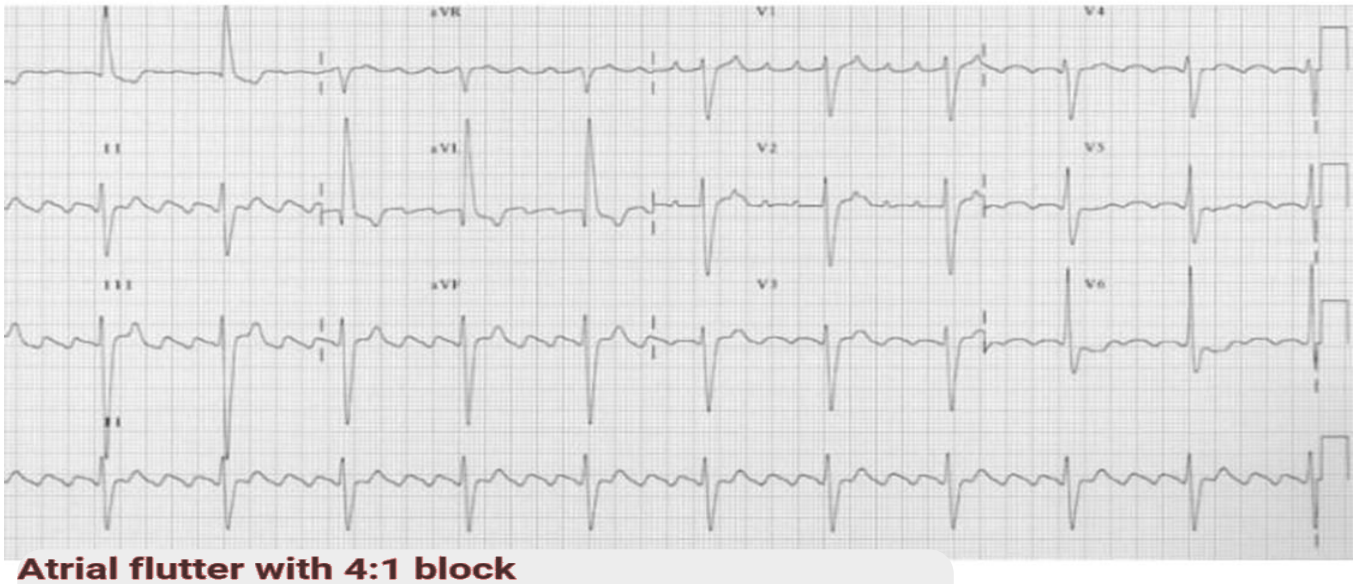
- Irregular narrow-complex tachycardia at ~135 bpm
- Coarse fibrillatory waves in V1

- SVT (Abscent visible P waves + narrow QRS + ↑HR)



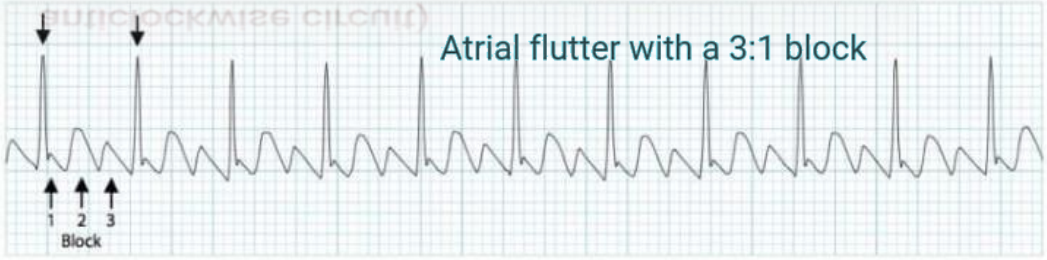
- Narrow complex tachycardia at ~ 150 bpm
- No visible P waves

- Atrial flutter (Flutter Waves with sawtooth appearance)



Atrial flutter with 4:1 block

- There are inverted flutter waves in II, III + aVF at a rate of 260 bpm
- There are upright flutter waves in V1-2 (= anticlockwise circuit)



- Multifocal atrial tachycardia (MAT) :(Irregular rhythm + ≥ 3 distinct P morphologies)

Multifocal atrial tachycardia:

- Rapid irregular rhythm > 100 bpm.
- At least 3 distinctive P-wave morphologies (arrows).

5) P R interval

= A- V conduction

➢Measure the distance (duration) from the beginning of P wave until the beginning of R wave

الطبيعى انها من ٣ - ٥ مربعات صغيرين (لا تتعدى مربع كبير) ،،

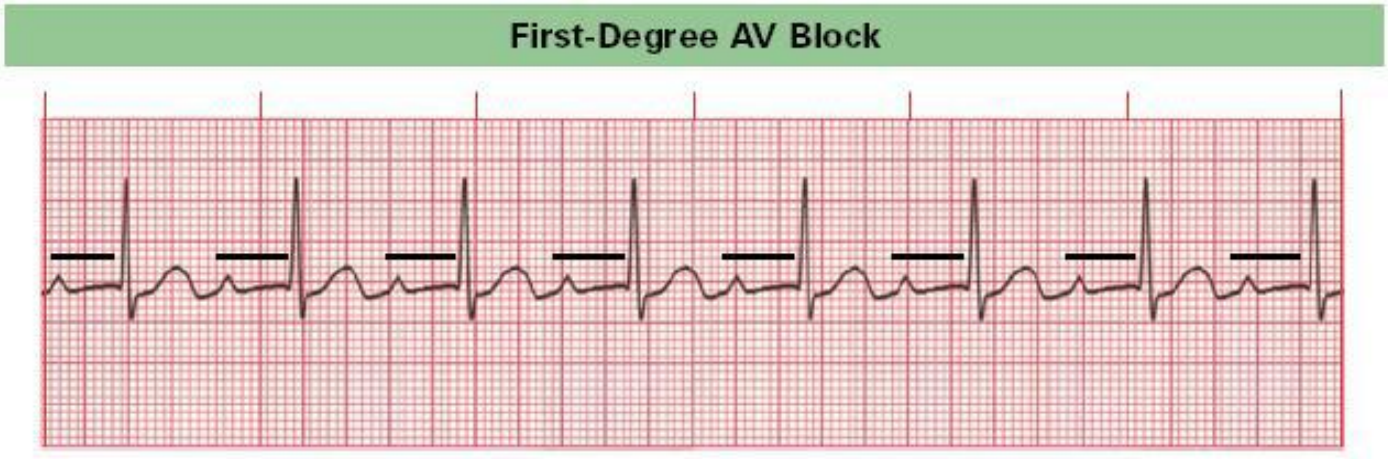
المربع الكبير = ٥ مربعات صغيرين

3 - 5 SS = 120 - 200 m.sec

① Normal fixed P - R interval = normal A V conduction

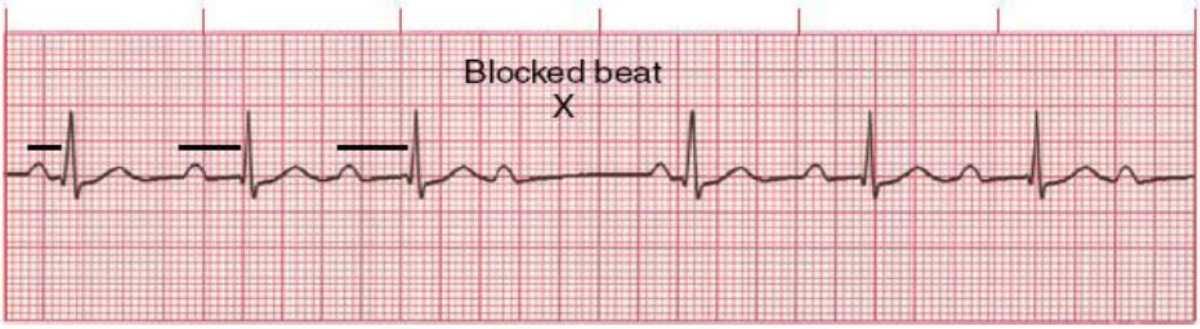
If PR interval is > 5 small squares (one large square)

---> A degree of heart block is present



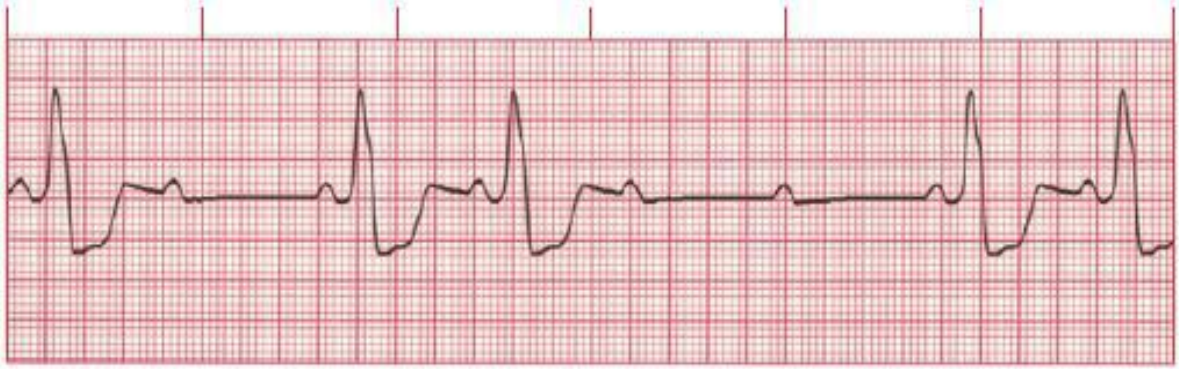
Second-Degree AV Block—Type I (Mobitz I or Wenckebach)

- PR intervals become progressively longer until one P wave is totally blocked and produces no QRS complex. After a pause, during which the AV node recovers, this cycle is repeated.



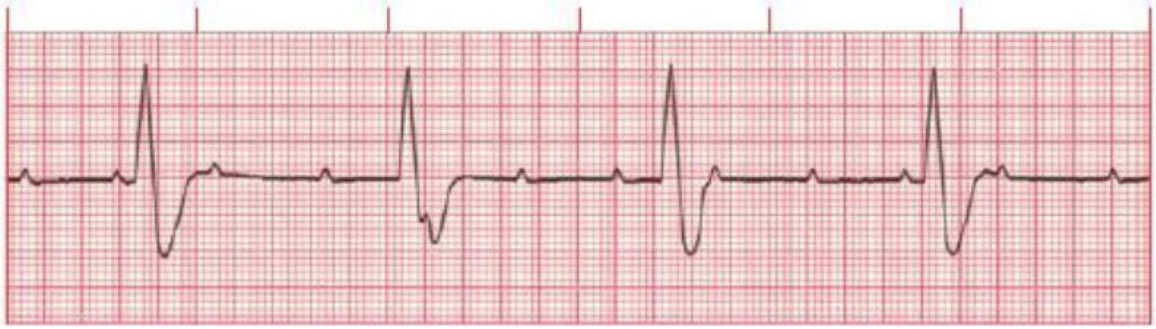
Second-Degree AV Block—Type II (Mobitz II)

- Conduction ratio (P waves to QRS complexes) is commonly 2:1, 3:1, or 4:1, or variable.
- QRS complexes are usually wide because this block usually involves both bundle branches.



Third-Degree AV Block

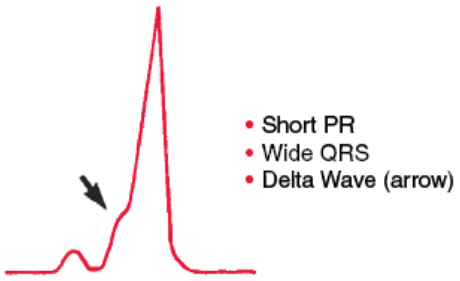
- Conduction between atria and ventricles is totally absent because of complete electrical block at or below the AV node. This is known as AV dissociation.
- "Complete heart block" is another name for this rhythm.



If PR interval is short (< 5 small squares or one large square)

---> Pre-exitation syndrome is present

e.g. **W P W Syndrome**



6) P R segment

➢The distance between the ends of P wave until the beginning of R wave

من نهاية ال P الى بداية الR

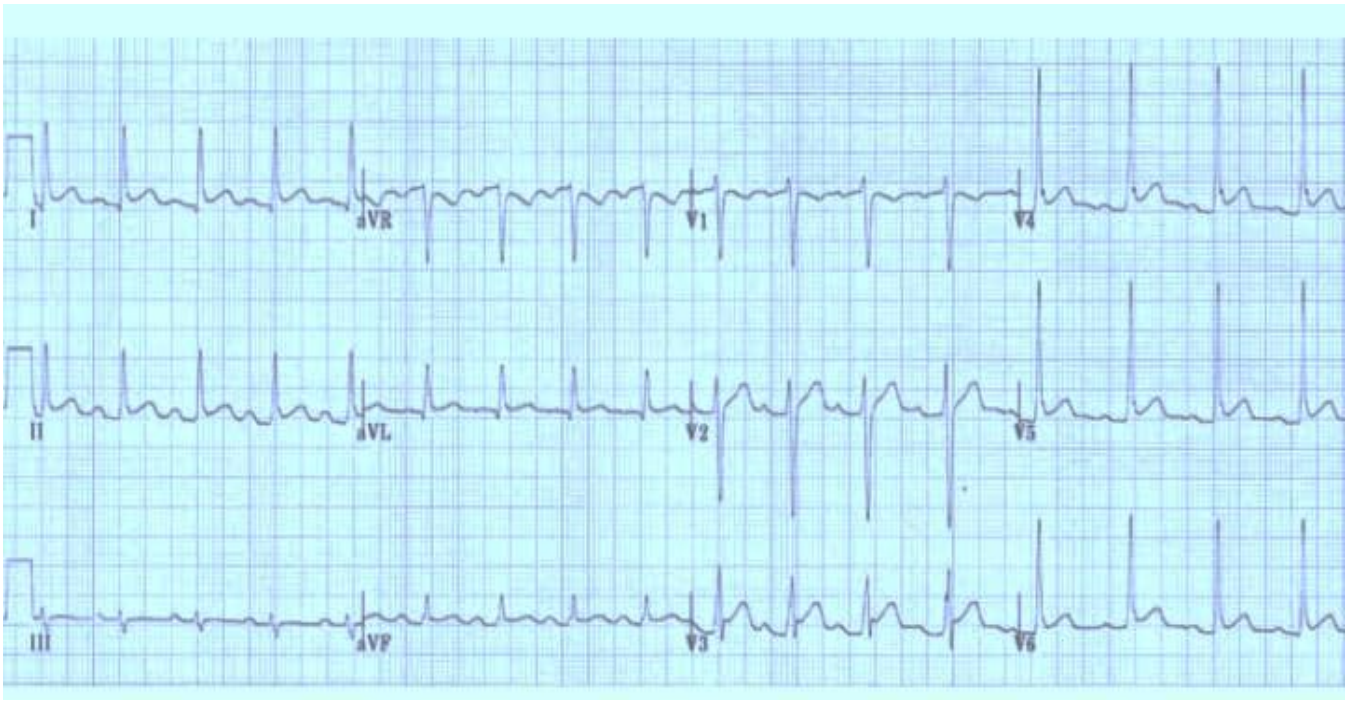
Normally, it iso-electric

بمعنى ان القطعه دى فى نفس مستوى

T - P interval

وهو الخط المستقيم الممتد من نهاية ال T بتاعة Cycle الى بداية ال P بتاعت ال Cycle اللى بعدها

- The only abnormality,
  If P R segment is depressed + diffuse ST Segement elevation with upward concavity
  --> **Pericarditis**

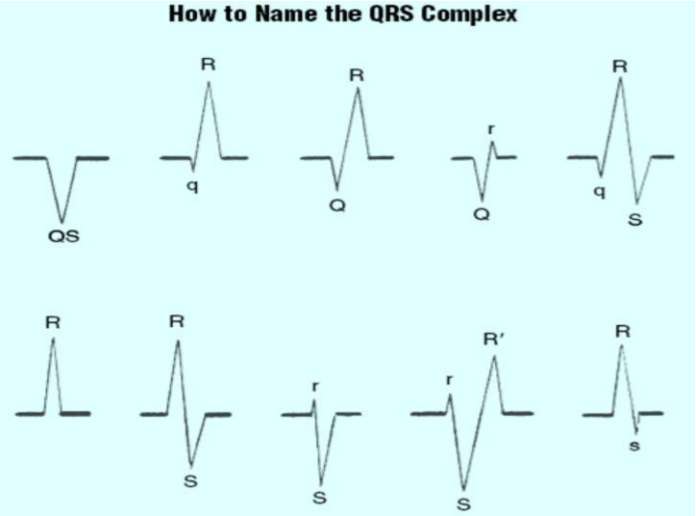


typical example of pericarditis with:

- Widespread ST elevation and PR depression
- Reciprocal ST depression and PR elevation in V1 and aVR

7) QRS complex

= Ventricular depolarization



➢Comment on

- Shape
- R progressin
- Amplitude
- Width (duration)
- Abnormal wave

Shape :

Q wave

تعريفها هى اول negative wave قبل ال R ،، اذن هيا تحت الخط

➢ It is present in some leads, and normally it might be abscent

➢ If it is present, comment on

Amplitude: doesn't exceed 2 small squares (2 mm)
Width (duration): doesn't exceed 1 small square (1 s)

Physiological لو انطبق عليها القواعد السابقه اذن هيا

➢If > 2 mm in amplitude ± > 1 small square in width --> Pathological Q wave (sign of MI) مهم

R wave

تعريفها هى اول positive wave فوق الخط وترتيبها بعد ال Q ان كانت موجوده ،،

ولو ال Q مش موجوده ،،هتبقى هيا اول wave فى ال QRS complex فى ال cycle دى

➢Normally,

R wave (the only upright wave that must be present in all leads even if it is small e.g in V1

فى الطبيعى : لازم ال R تبقى موجوده فى كل leads سواء كانت طويله وواضحه زى lead V6 او صغيره زى lead V1

S wave

تعريفها اول negative wave تحت الخط بعد ال R wave ولازم تكون موجوده فى كل leads حتى لو كانت صغيره جدا ،،

R progression:

In {Chest leads or precordial Leads}

الطبيعى ان طول ال R بيبدأ صغير فىV1 ويزيد تدريجيا فى الطول حتى يصل الى اقصى طول ليه فىV6 ،،

وبالتالى هيكون

In V 1 & V 2 --> r < S (small r and deep S)

&

In V5 & V6 --> R > s (Tall R with small s)

فطبيعى هيكون V3 & V4 مرحلة انتقاليهtransition zone

بيكون طول ال R فيهم مقارب لطول ال S وده اسمه Normal R progession

If R wave is still small in V 3 & V4 and S wave is still clear in V6

--> Poor R progression (sign of ischemia) مهمه

ملحوظه هاااامه جداااا

==========

لو QRS deflection كان كله negative تحت الخط ومش ظاهر ليك اى R wave نهائى ،،

فدى مش S wave بس ، هتكون Q معاها واندمجوا مع بعض QS (pathological Q + S)

وده علامة MI ،،

وهتلاقى معاها raised ST segment غالبا ،، وطبعا هتنقى مجموعة leads من نفس النوع

E.g inferior, lateral etc...

Amplitude of QRS الطول

الطبيعى ان طول ال QRS من اعلى نقطه فى ال R الى اعمق نقطه فى ال S ،، لابد ان يتعدى مربع كبير فى

ال limb leads ،، ومربعين كبار فى ال chest leads

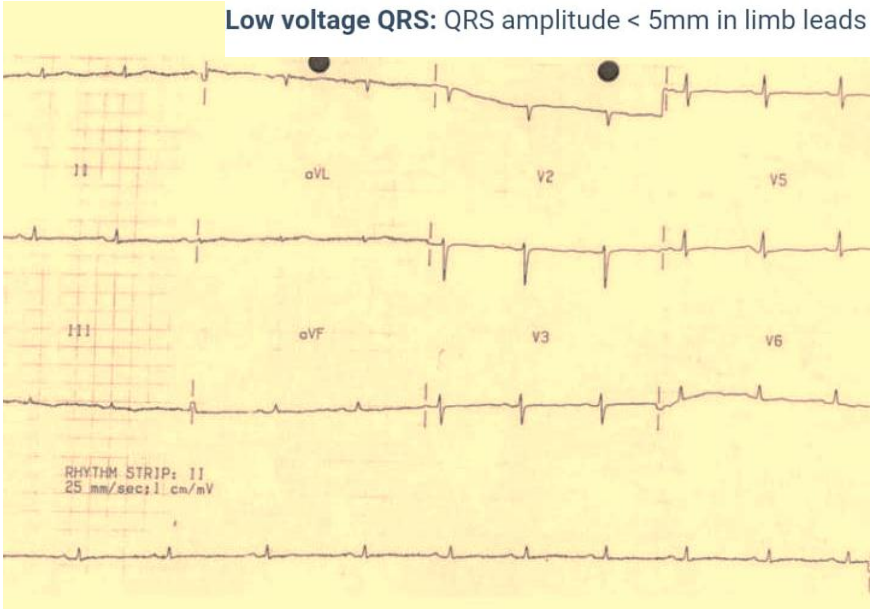
If QRS amplitude is

< 1 large square in limb leads and

< 2 large squares in chest leads

---> Low amplitude

Or low voltage ECG مهمه



ملحوظه هاااامه

Low voltage ECG is defined as QRS amplitude less than 5mm in limb leads and less than 10mm in chest leads.

Low voltage ECG DD:

1- Pericardial Effusion, Tamponade, supported by sinus tachycardia in ECG and Electrical Alternanis.

2- Myxedema, supported by sinus bradycardia

3- Infiltrative heart disease, Amyloidosis, Sarcoidosis etc.., supported by presence of pseudo Q wave or AF or conduction abnormalities.

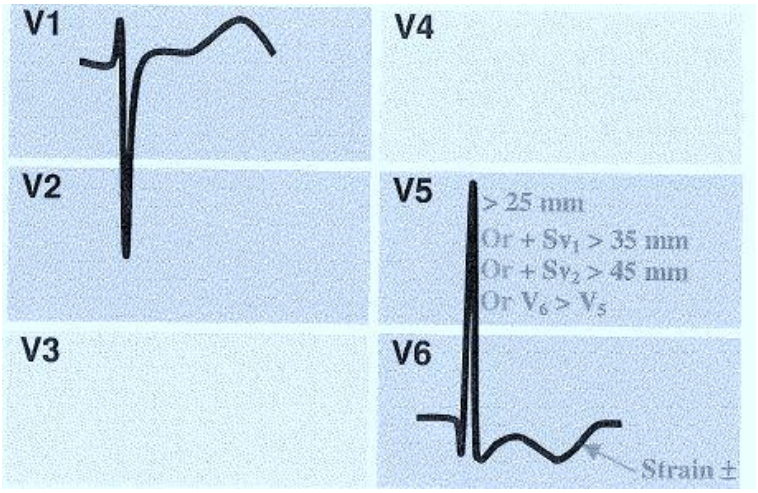
4- Dilated cardiomyopathy

5- Old massive MI

6- Obesity

7- Emphysema

With ECG we use clincal exam to support a diagnosis.



If amplitude of QRS is apparently high, Measure

Amplitude of S in V 1 or V2

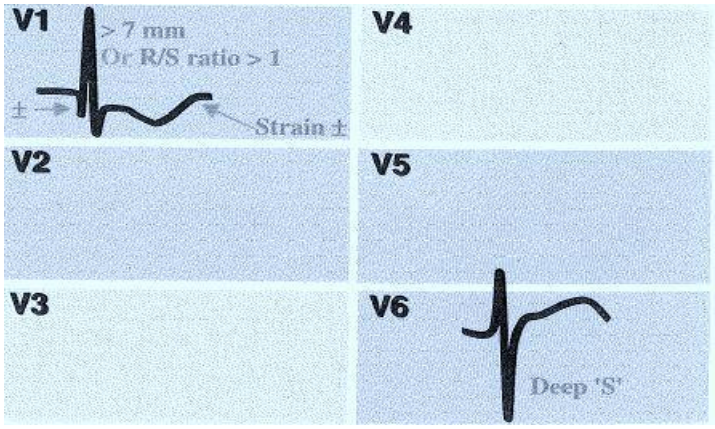
✚

Amplitude of R in V5 or V6

If sum of them > 7 large squares (35mm)

--> Voltage criteria, suggestive of LVH

(**Left ventricular hypertrophy**)



If R > S in lead V1 ± deep S in Lead V6

يبقى ده احتمال يكون تضخم فى

right ventricle <--ال

Right ventricular hypertrophy (RVH)

يعنى تشوف هل ال R wave اطول من S فى V1 ولا لا

** ملحوظه

Ventricular hypertrophy is abnormal QRS amplitude

Width (duration of QRS)

الطبيعى ان ال Width او ال duration بتاع ال QRS complex ككل ابتداءا من بداية ال Q الى نهاية ال S لا يزيد عن ٢.٥ مربعين صغيرين

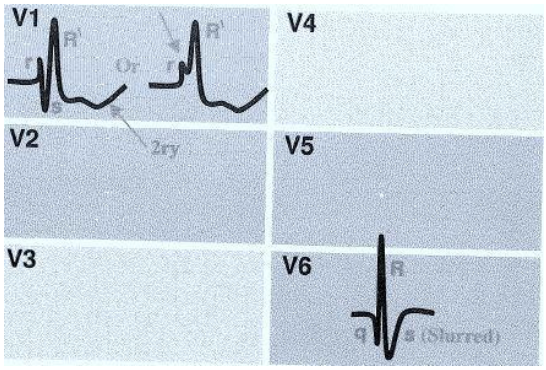
If QRS duration > 3 small squares it is either

Bundle branch block (RBBB or LBBB)

Or

Ventricular arrhythmia

If the rhythm is sinus, so Wide QRS is likely Bundle branch block

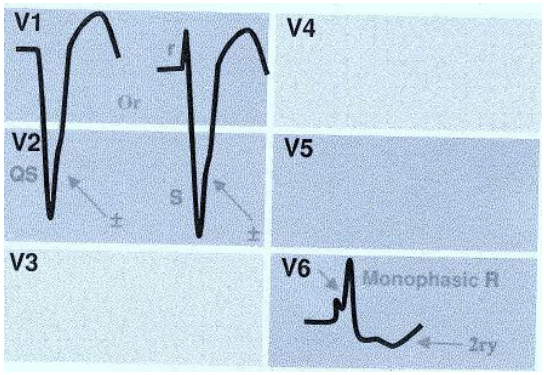


بص على V1 & V6

لو لقيت `rSR او M pattern فى V1

تبقى دى

← **Right bundle branch block (RBBB)**



لو لقيت wide R فى V6 سواء كانت notched او لا

+

Deep wide S in V1

تبقى دى

← **Left bundle branch block (LBBB)**

If rhythm is not sinus (no identified normal P waves) + heart rate > 140

It is wide complex tachycardia

هتكون ما بين

Ventricular tachycardia (V tach) →

وده الغالب والاشهر

او SVT + BBB

Supra-ventricular tachycardia + bundle branch block (LBBB or RBBB)

ده اقل فى الحدوث ،، طبعا دول ليهم معايير معينه عشان نميزهم من بعض ،، هنشرحها بعدين
لو مش قادر تميز بينهم ،، اعتبرها V tach

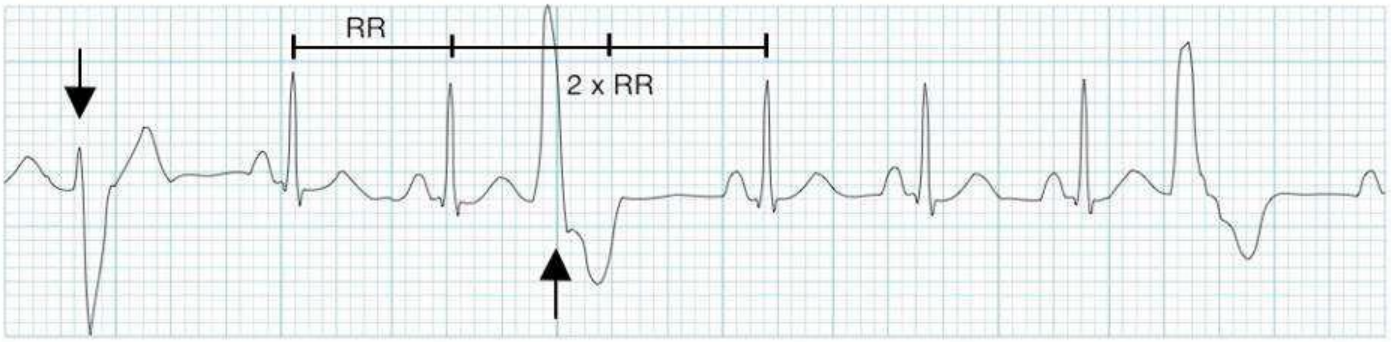
ملحوظه هاااااااامه :

لو لقيت ال width (duration) فى كل ال QRS complexes طبيعى ولا يزيد عن ٣ مربعات ،، ولقيت واحده QRS او اكتر شكلها wide & bizzare ومختلفه تماما عن الطبيعى <-- تبقى دى
Ventricular extra-systole (PVCs)

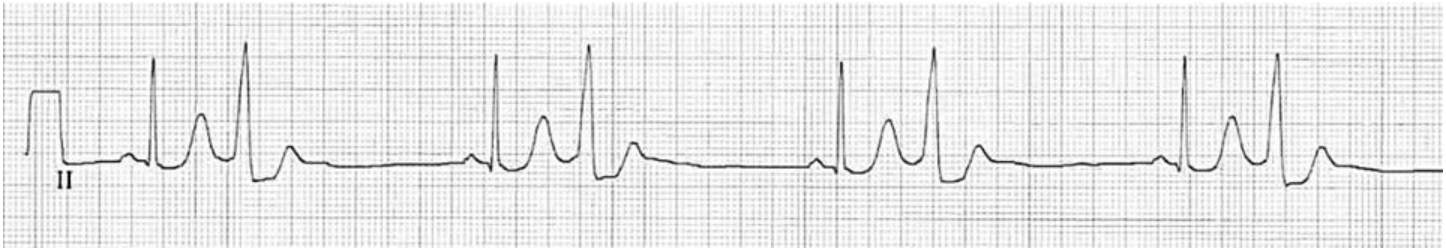
➲Premature ventricular contraction (wide)

1- Sinus rhythm with PVCs of two different morphologies (Arrows).

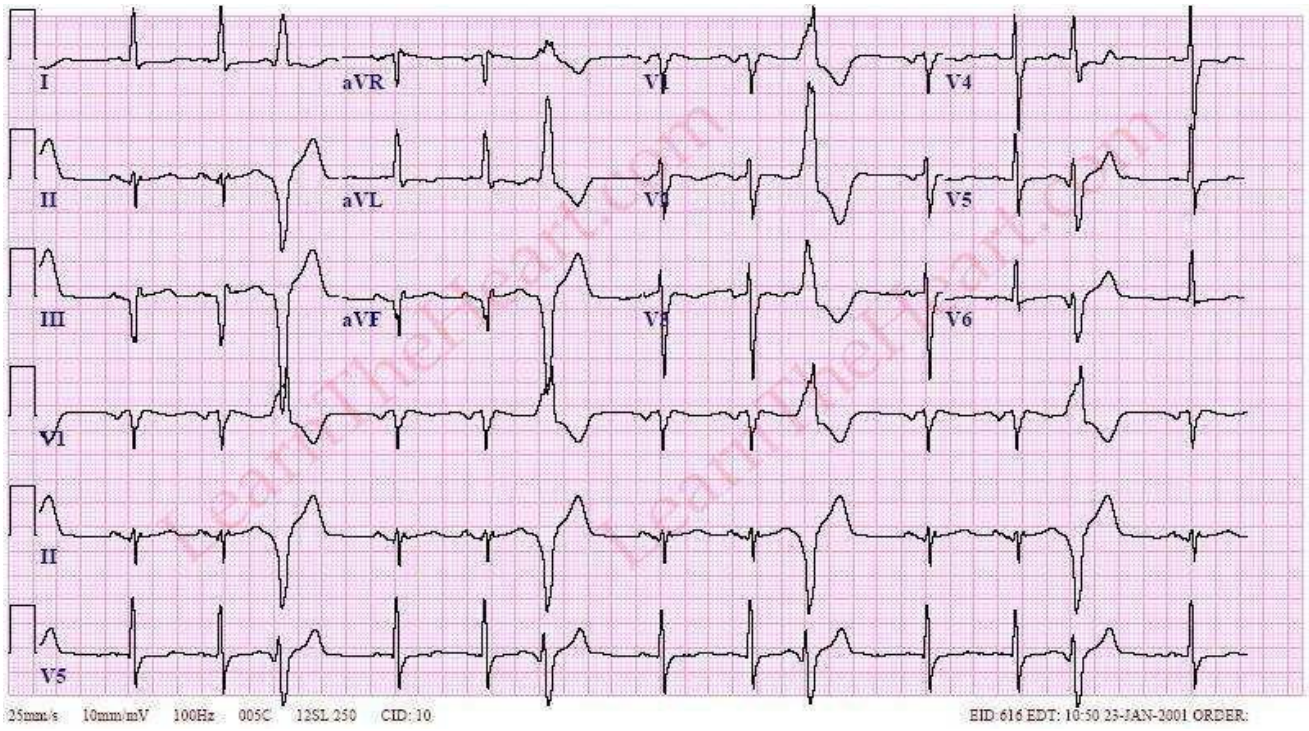
The pause surrounding the PVC is equal to double the preceding R-R interval (= a full compensatory pause).



2- Ventricular bigeminy واحدة وواحدة



3- Ventricular trigeminy كل تالت كومبلكس



Abnormal waves

- لو لقيت `R بعد RS فى lead V1 مع wide QRS

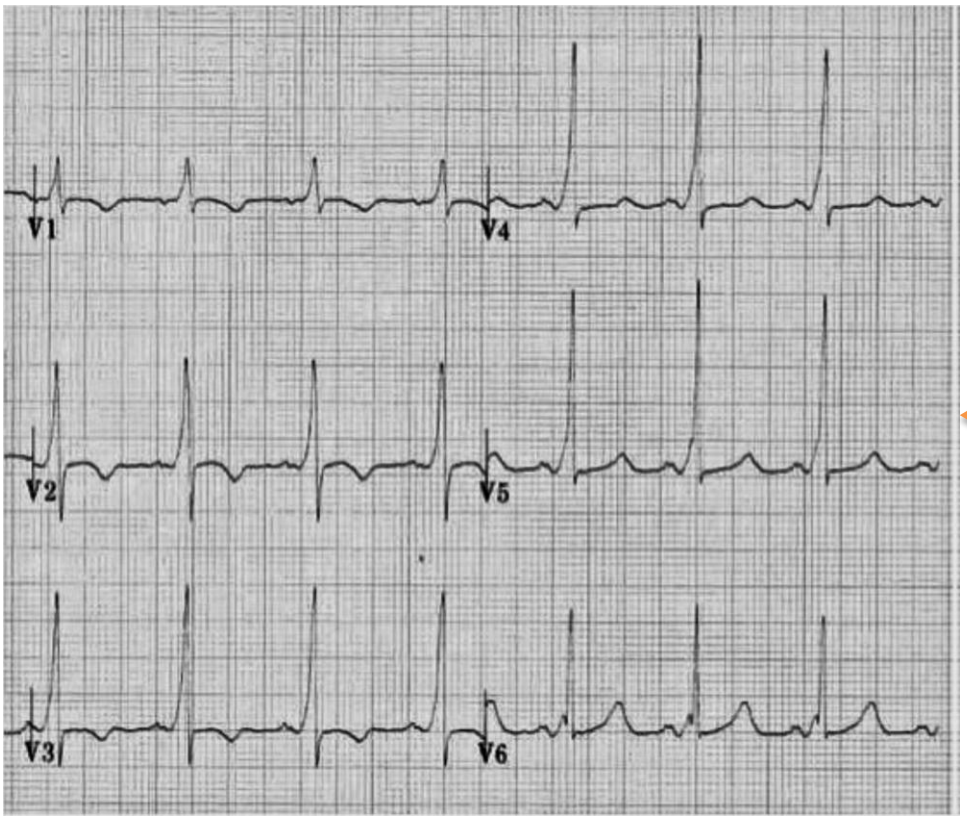
تبقى دى RBBB

- لو لقيت delta wave ودى wave بتسبق ال R مباشره مع

Short P R interval

تبقى دى

Wolf Parkinson White Syndrome (WPW)

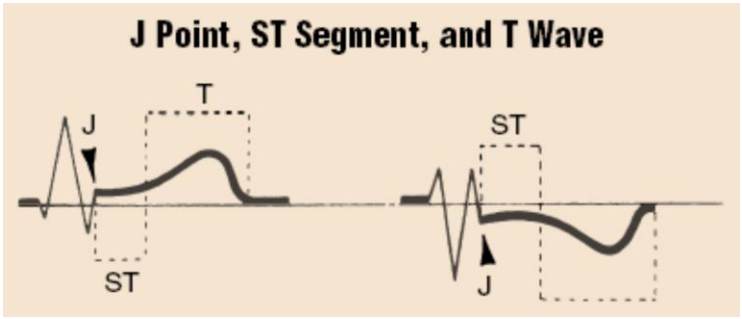


8) S T segment

وتعريفها هى ال distance ما بين نهاية ال S wave وبداية ال T wave

نهاية ال S wave دى نقطه اسمها ال **J point** ودى على اساسها بيتحدد ما اذا كانت الST segment

Raised (elevated) Or Depressed



الطبيعى ان ال ST segment دى بتكون isoelectric بمعنى انها فى نفس مستوى ال T - P interval

الطبيعى ان ال ST segment تبقى

Iso-electric with normal J point

ما عدا Lead V1

ممكن تبقى عاليه بمقدار لا يزيد مربع واحد صغير

How to recognize ST elevation?

الخطوه الاولى:

هنبص على ال J point

ونقارنها بال Isoelectric line

لو طلعت اعلى من مستواها ،، يبقى فيه

ST segment elevation

وهنسميه STE

الخطوه التانيه :

هأشوف كل ال leads

اللى فيها STE

واخد بالى منهم اوى

الخطوه التالته :

لو المريض بيشتكى من

Acute chest pain suspicious to be ischemic
يبقى انا بادور على ال MI

وبالتحديد من النوع

ST segment elevation MI

وخصوصا فى الناس اللى عندهم Risk factors

باشوف الاتى

ST elevation in contiguous leads

المتجاوره ومن نفس المجموعه زى ال

1- Lead II, III & aVF --> **inferior leads**

2- Lead I, aVL, V5 & V6 --> **lateral leads**

3- Lead V1 - V4 --> **anteroseptal leads**

وباشوف ال STE ده واخد كام lead وكام مجموعه ، وفى نفس الوقت بادور معاهم على حاجتين مهمين

Pathological Q and Reciprocal changes

لو فيه

Pathological Q

In the same leads with STE

وبالتالى يبقى

1- STE + path .Q in II, III and aVF --> Inferior STEMI

2- STE + path Q in I, Avl --> High lateral STEMI

3- STE ± path Q in V5 & 6 --> Lateral STEMI

4- STE ± path Q in V1 – 4 --> Anteroseptal MI

5- STE ± path Q in V1 - V6 --> Extensive anterolateral STEMI

لو فيه **Reciprocal changes**

ده يبقى

Associated ST depression

±

T wave inversions in other group

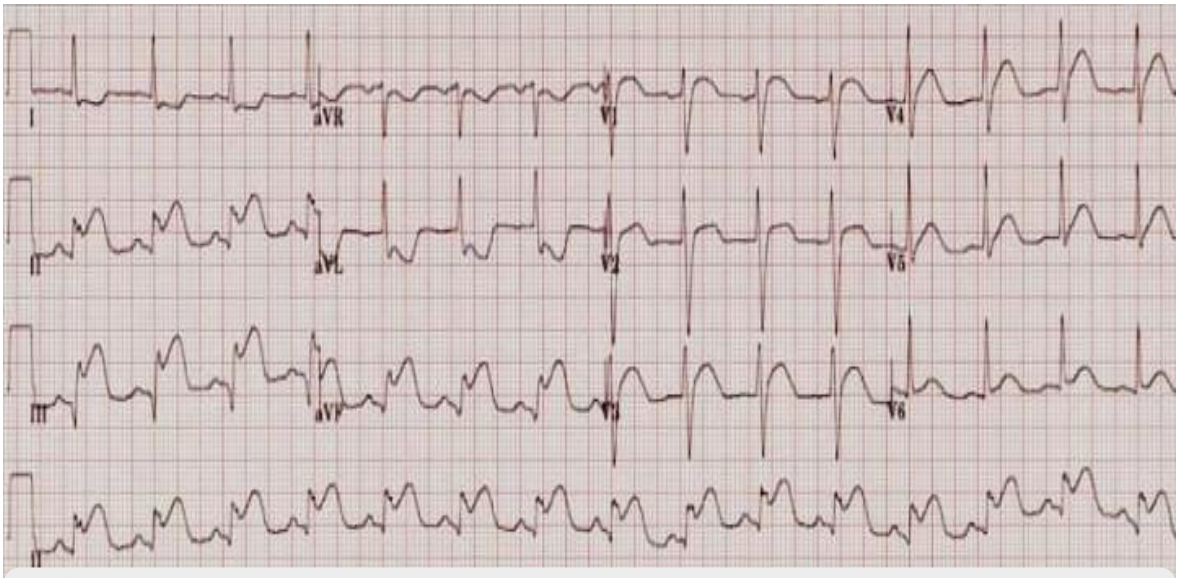
EXAMPLES:

Inferior STEMI

---> Reciprocal changes

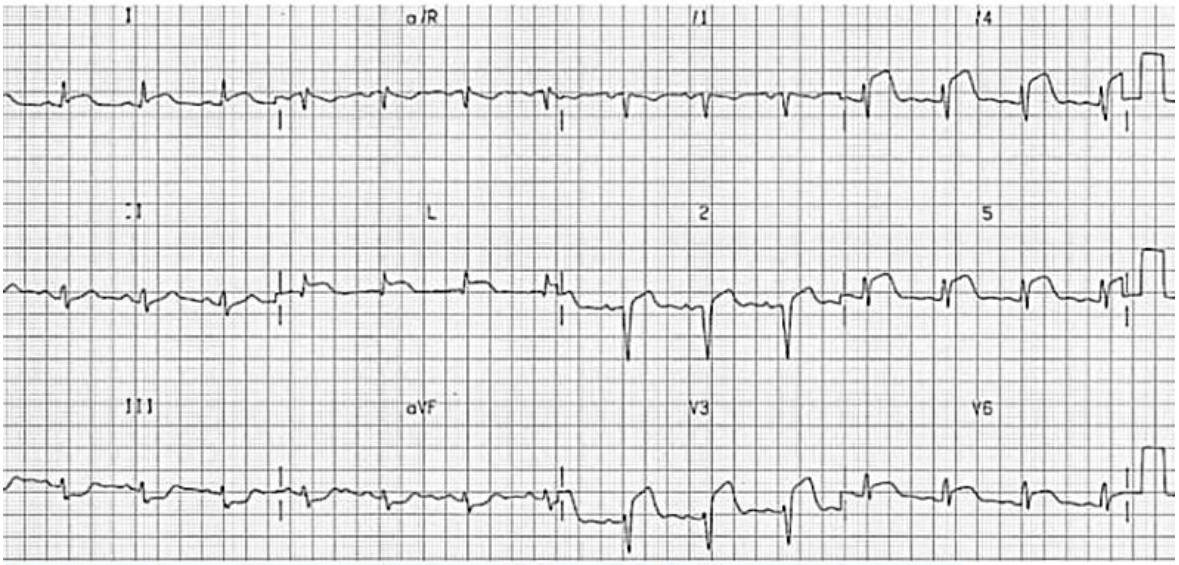
In

Lateral (aVL ± I)



Inferior STEMI:

- Marked ST elevation in II, III and aVF with early Q-wave formation.
- Reciprocal changes in aVL.



Lateral & Anterolateral STEMI

--> Reciprocal changes in inferior leads

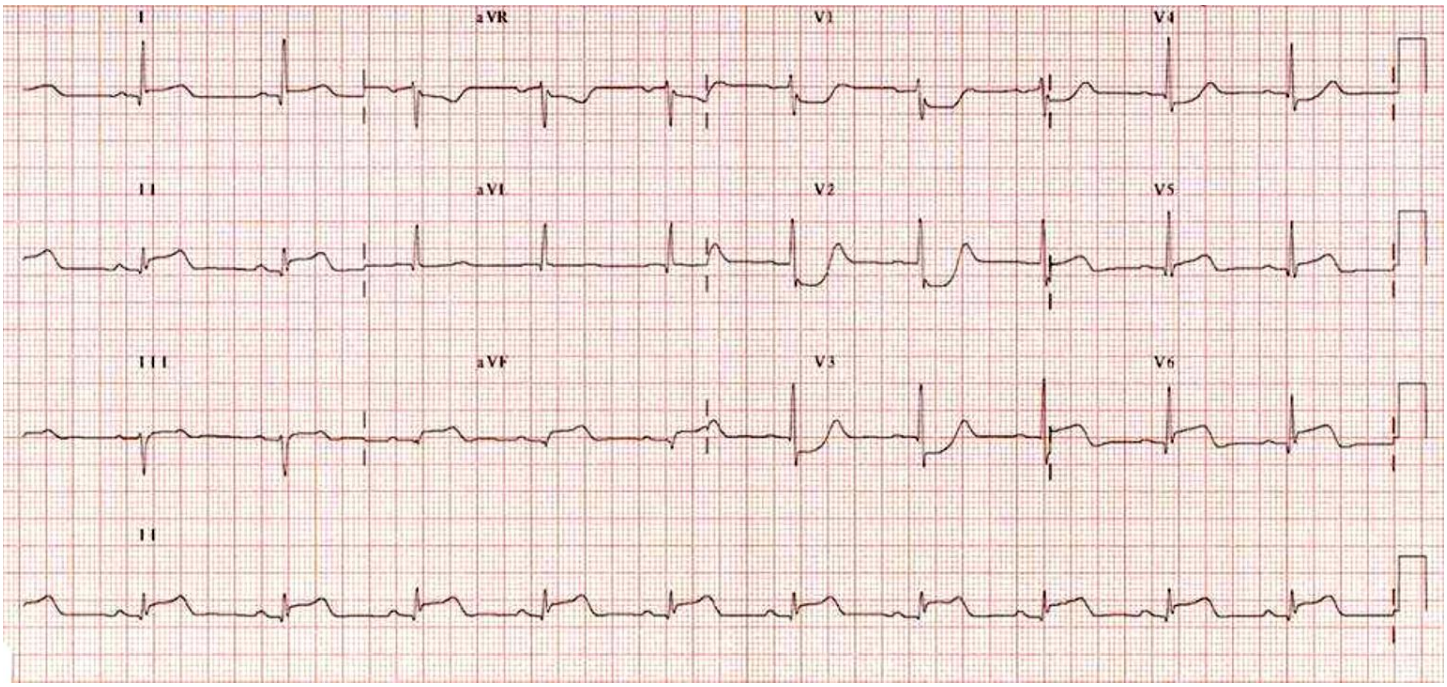
Extensive Anterolateral STEMI (acute):

- ST elevation in V2-6, I and aVL.
- Reciprocal ST depression in III and AVF.

ملحوظه هاااامه جدااا

➢ Any patient C/O ischemic chest pain with positive R in V1 - V3 with horizontal depression and upright T wave --> Posterior MI

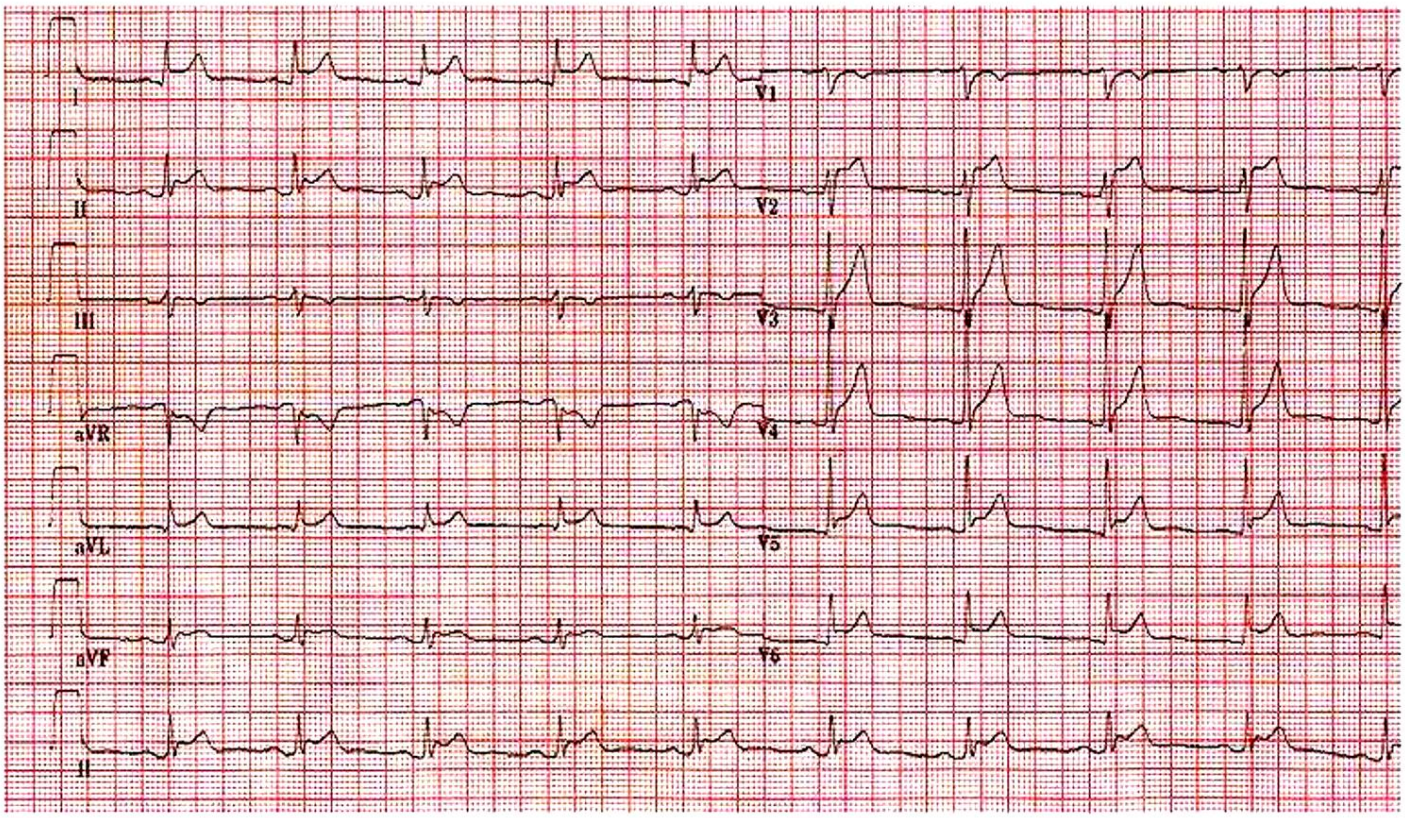
وما تنساش تدور عليها مع ال inferior MI

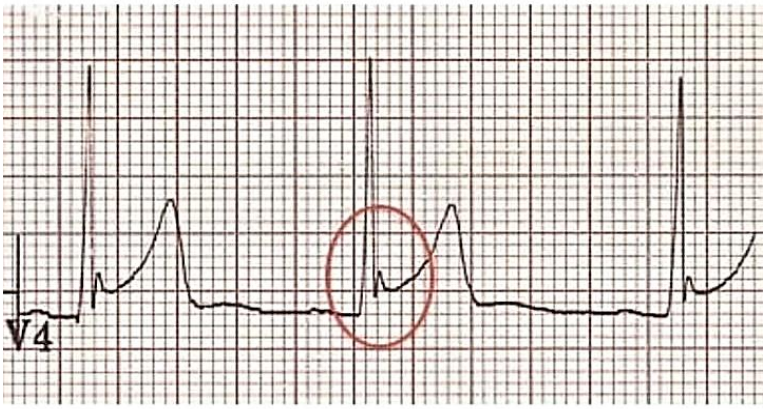


➢ لو المريض جاى ب chest pain ويشبه ال pleuritic pain و المريض ما عندوش risk factors
لمرض الشريان التاجى ومش شايف pathological Q ومفيش reciprocal changes
وفى نفس الوقت فيه ⬇⬇⬇⬇

Diffuse STE with upward concavity + depressed P R segmen

---> Pericarditis🡇🡇🡇





- Notched J-point elevation in V4 with a “fish hook” morphology, characteristic of BER.

➢ لو مريض اكتشفت بالصدفه ان عنده

Diffuse STE in ECG

بص على نهاية ال S wave

لقيتها عامله منظر السنارة

Fish hook

ده حاجه اسمها

Being early repolarization (high take off)

N.B

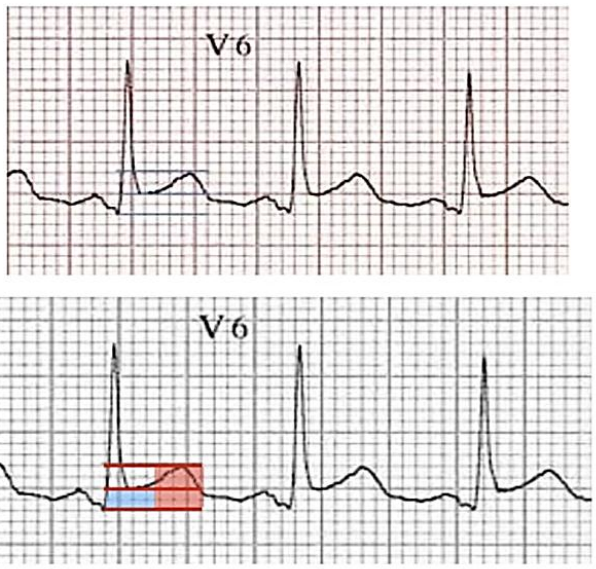
➢**Pericarditis VS Beingn early repolarization**

Pericarditis can be difficult to differentiate from Benign Early Repolarization (BER) as both conditions are associated with concave ST elevation. One useful trick to distinguish between these two entities is to look at the ST segment / T wave ratio and the *Fish hook Pattern*

➢ **ST Sement / T Wave ratio:**

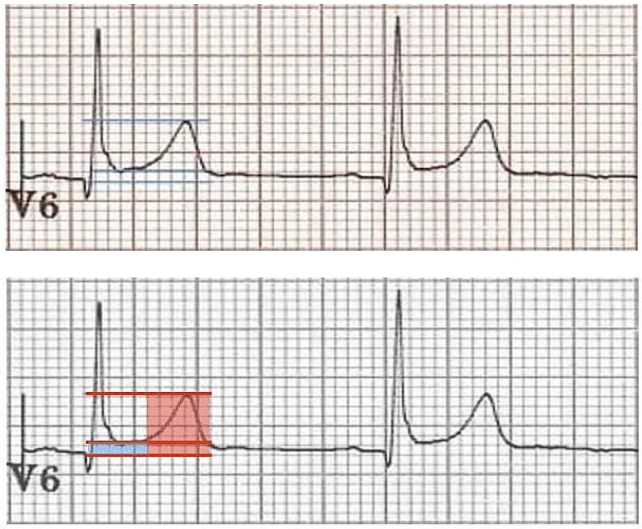
Te vertical hieght of the ST segment elevation (from the end of the PR sement to the J point) is measured and compared to the amplitude of the T wave in V6

- Aratio of >0.25 suest pericarditis
- A ratio of < 0.25 suest BER



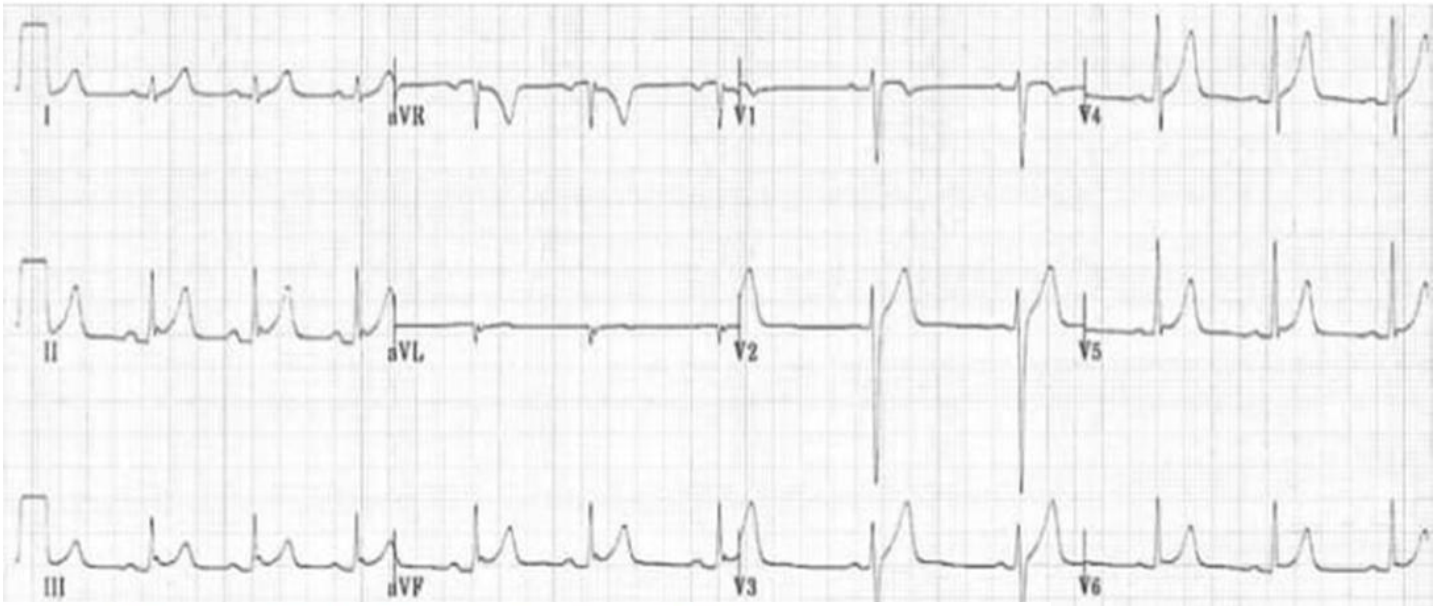
Pericarditis

- ST segment height = 2 mm
- T wave height = 4 mm
- ST / T wave ratio = 0.5
- The ST / T wave ratio > 0.25 is consistent with pericarditis.



Benign Early Repolarisation

- ST segment height = 1 mm
- T wave height = 6 mm
- ST / T wave ratio = 0.16
- The ST / T wave ratio < 0.25 is consistent with BER.



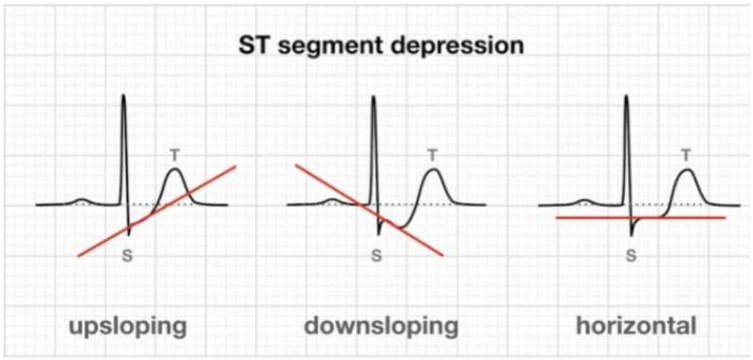
ECG of **Benign Early Repolarisation (BER)**, demonstrating:
1) Generalised concave ST elevation in precordial (V2-6) and limb leads (I, II, III, aVF)
2) J-point notching is evident in the inferior leads (II, III and aVF)
3) ST elevation : T wave ratio < 0.25 in V6

How to recognise S T depression?

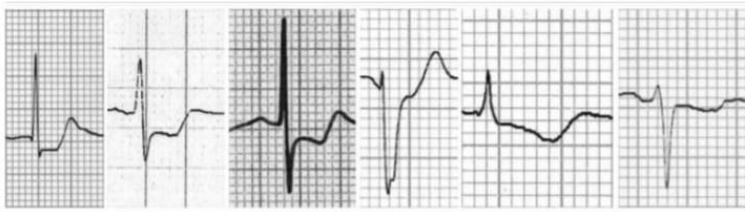
J point is depressed in comparison to isoelectric line

Morphology of ST Depression

- ST depression can be either upsloping, downsloping, or horizontal (see diagram below).
- **Horizontal or downsloping ST depression ≥ 0.5 mm at the J-point in ≥ 2 contiguous leads** indicates myocardial ischaemia (*according to the 2007 Task Force Criteria*).

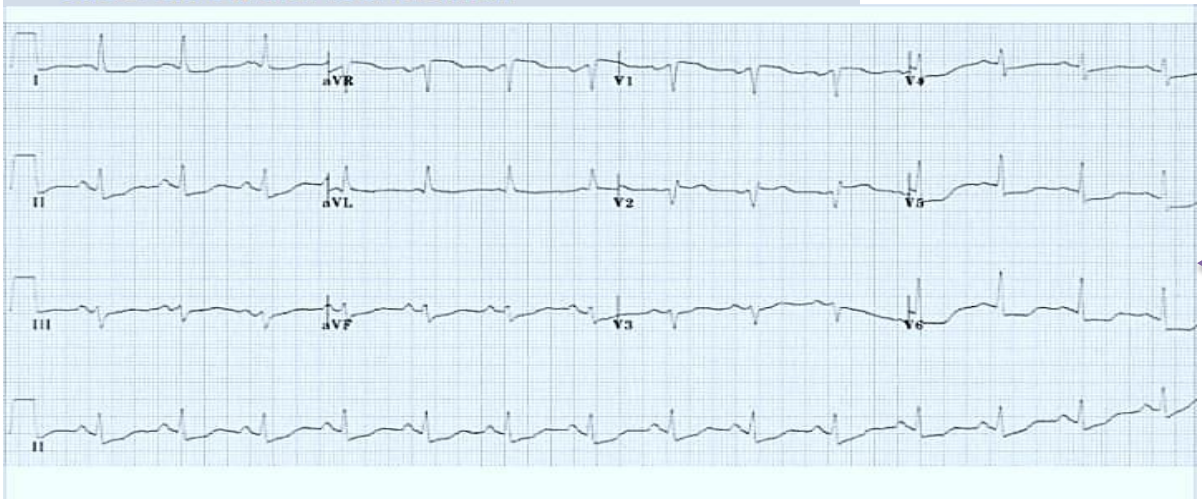


Examples of ST segment morphology in myocardial ischaemia



Subendocardial ischaemia:

- The most striking abnormality is the widespread ST depression, seen in leads I, II and V5-6. This is consistent with widespread subendocardial ischaemia.



لو مريض جاى ب

Ischemic chest pain

ورسم القلب فيه

ST depression

±

T wave flattenin or inversion

غالبا ده

ischemia (NSTEACS)

N.B

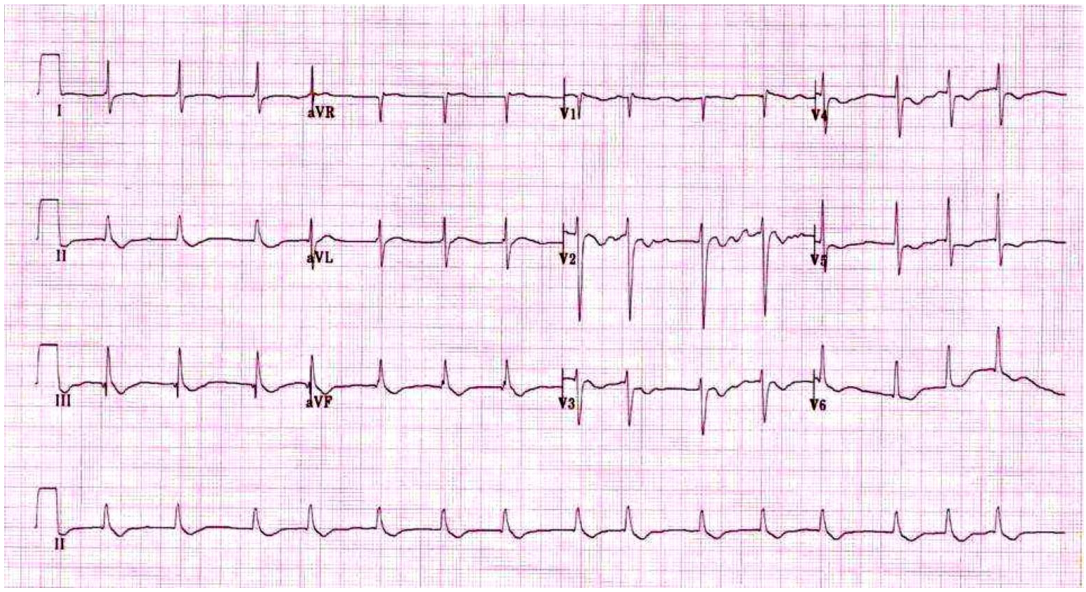
While there are numerous conditions that may simulate myocardial ischemia (e. left ventricular hypertropy, digoxin effect), dynamic ST segment and T wave changes (i.e. different from baseline ECG or changing over time) are strongly suggestive of myocardial ischemia

➢ **Digoxin effect:**

Sagging of the ST segment and Twave

"Salvador Dali's moustache" appearance عصاية شكوكو بالمصري

This happens in therapeutic doses of dogoxin.



9) T wave

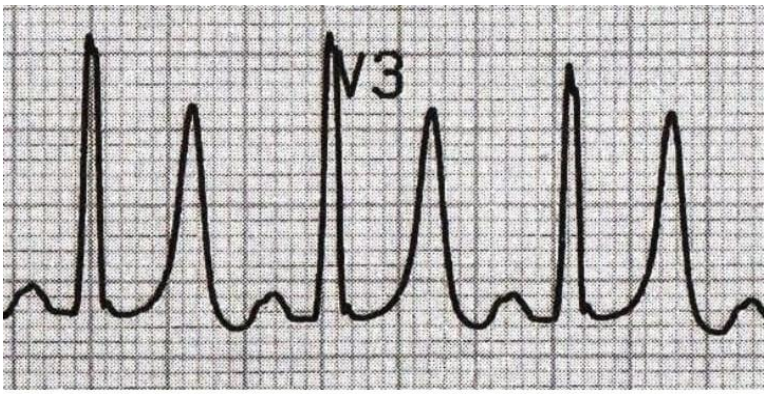
- Normally, it is upright in leads, but it might be inverted normally in aVR, III and V1
- T wave often follows the preceding QRS
- **Amplitude**:

طولها المفروض انه لا يتعدى مربعين فى ال chest leads او مربع واحد فى ال Limb leads

اذا زاد عن كده يبقى

Either Tall peaked Or Hyperacute

Tall peaked (tented)



Tall, narrow, symmetrically peaked T-waves are characteristically seen in hyperkalaemia

طويله وعاليه اوى والضلعين اد بعض تقريبا والتغيرات دى واخده معظم او كل الleads

وده غالبا سببها

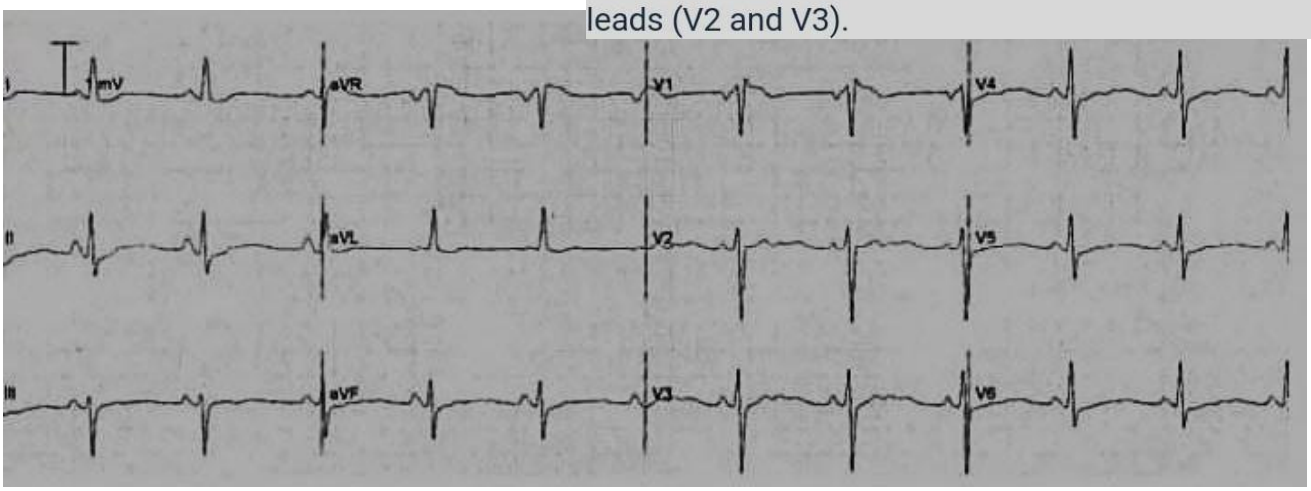
← **Hyperkalemia**

Flat T waves:

If all T waves are flat ± u wave after it

---> **Hypokalemia**

Note global T-wave flattening in hypokalaemia associated with prominent U waves in the anterior leads (V2 and V3).



Hyperacute:

طويله وعاليه والضلعين مش قد بعض ،، كمان غالبا بيكون معاها

STE ± path Q (Lead III &AVF)

ودى علامة الMI

Inverted T waves :(Lead I &AVL)

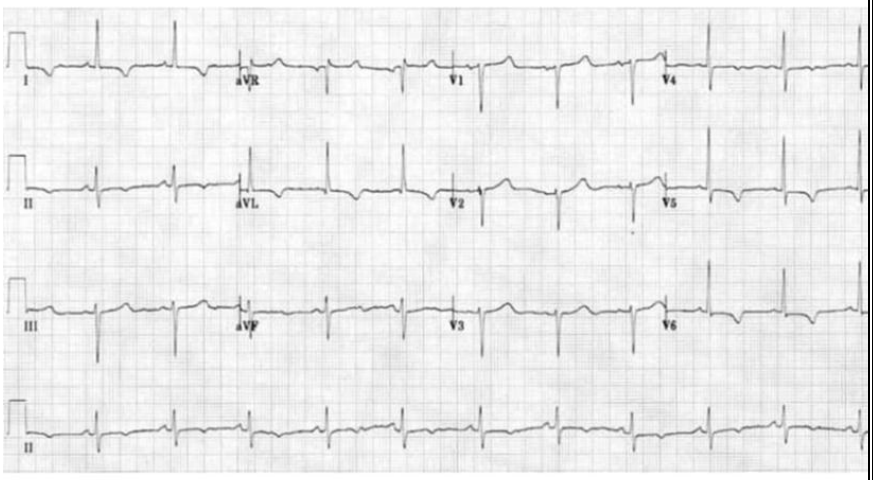
اهم سبب ليها هو ال ischemia ،،

وغالبا بتكون بتنقى مجموعة معينه زى

Inferior, Lateral, anterolateral

وممكن يكون معاها ST Depression

فى نفس ال leads

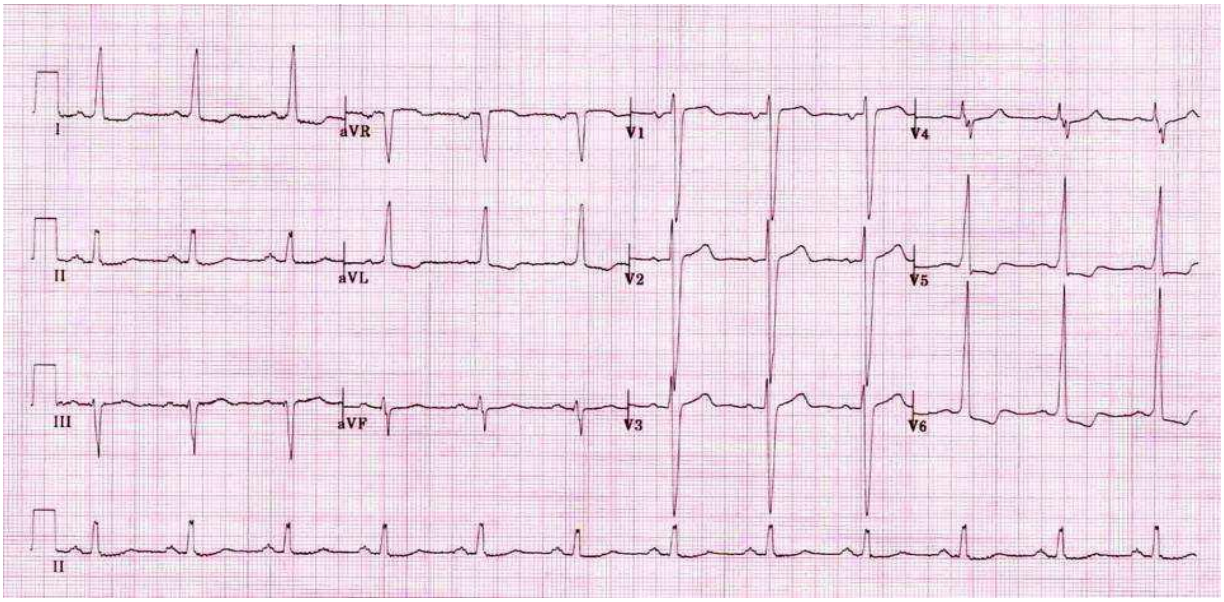


Widespread T wave inversion due to myocardial ischaemia (most prominent in the lateral leads)

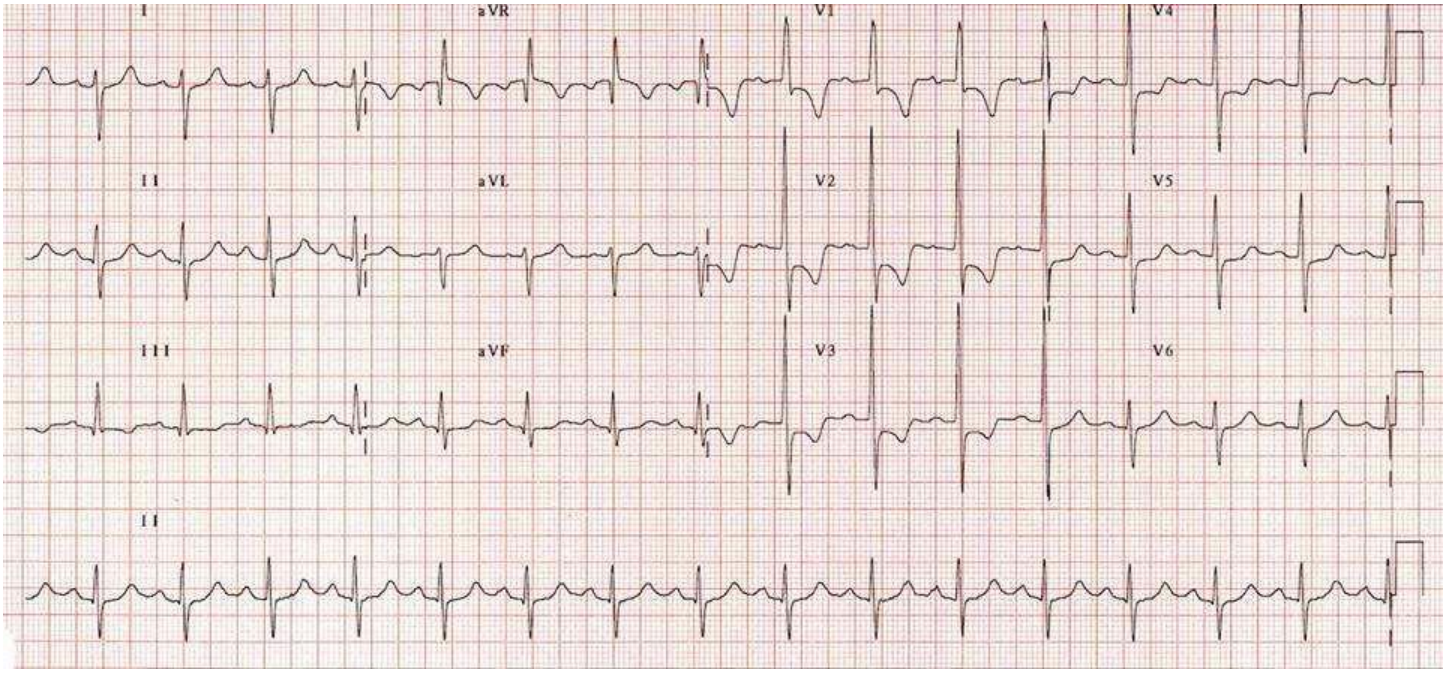
ملحوظه هاااامه

➢ Both LVH and RVH are often associated with inverted T wave's ± abnormal ST segment --> **Strain pattern**

LVH --> inverted T in lateral leads I, AVL, V5&V6

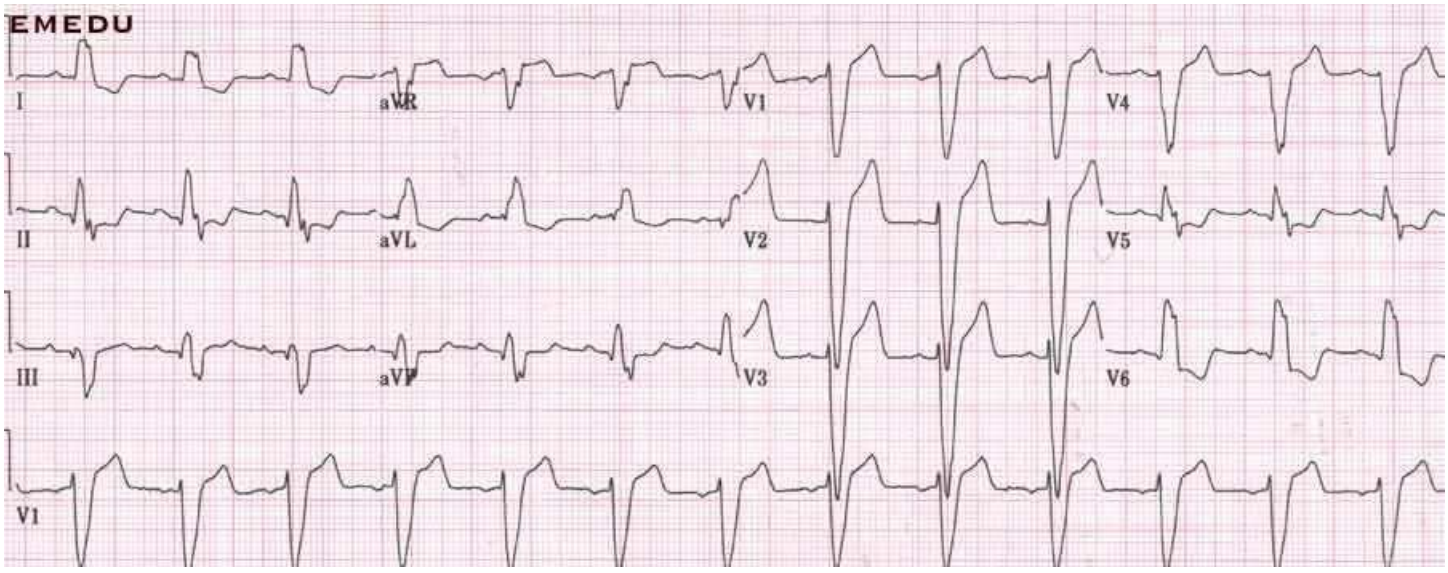


RVH --> inverted T in V1 & V2 ⮷⮷

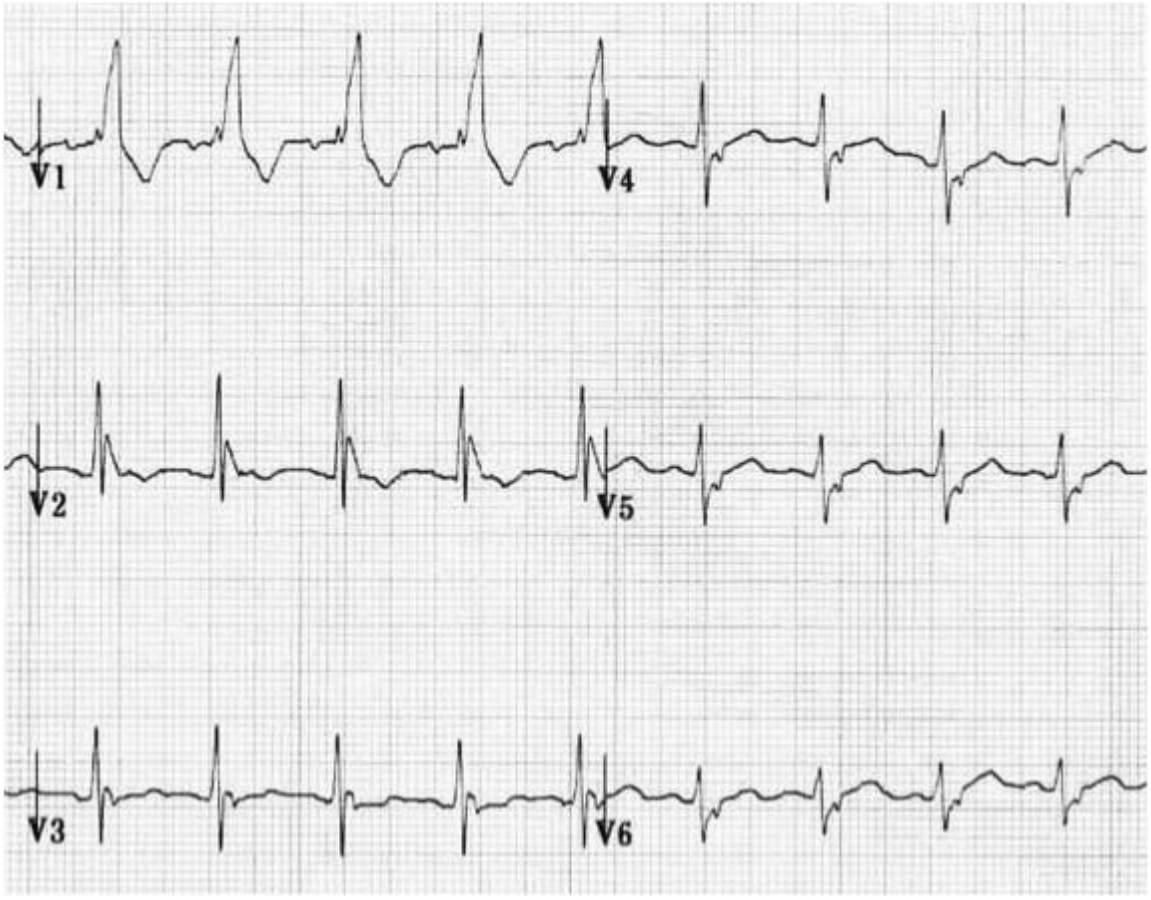


➢ Both LBBB and RBBB often have associated T wave inversions + abnormal ST segment

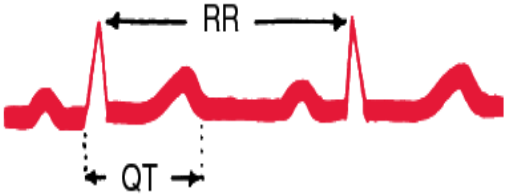
LBBB --> inverted T in V6 + broad R pattern (m)⮷⮷



RBBB --> inverted T in V1+ M pattern (RSR') 🡻🡻



10) Q T interval



المسافه من بداية ال Q الى نهاية الT

Normally, it is up to 440 m.sec in males

مربعين كبار ومربع صغير
Up to 420 m.sec in females

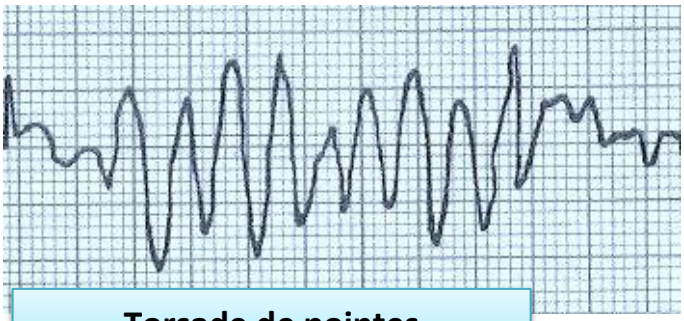
لو اكتر من كده يبقى

Long QT

ويبقى فيه خطر حدوث ال

Polymorphic V tach (torsade de pointes)

If QT > 500 m.sec
مربعين ونص كبار

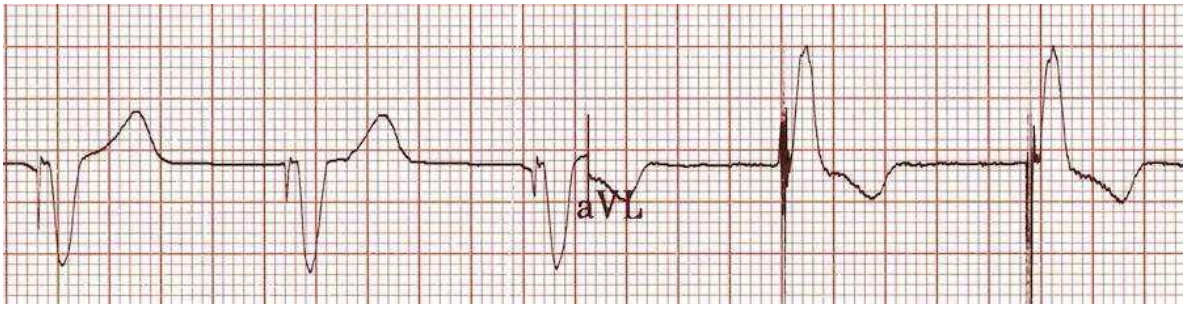


Torsade de pointes

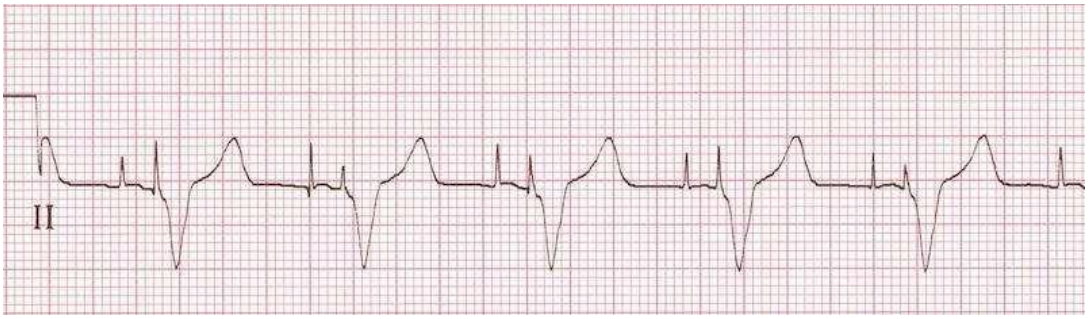
N.B

➲ **Ventricular pacing**

Notice the pacemaker spike just before the complex



➲**Atrial and ventricular pacing,** a spike before the P and another one before the complex



➲**Dextrocardia**:

The common findings in lead I is all negative … The P, the QRS and the T waves

Look at lead aVR all positive here

There is tall R in v1 and it's gradually getting smaller

No R wave progression.