Family Medicine
436 Team

Basic ECG interpretation

Color Index	IMPORTANT	NOTES	GOLD	EXTRA

OBJECTIVES

- Calculate Heart rate
- Determine the axis deviation
- Determine type of the rhythm
- Diagnose all degrees of heart block (1st, 2nd type 1, 2nd type2, and third-degree heart block)
- Diagnose bundle branch block (Rt and Lt)
- Diagnose main types of arrhythmia: Atrial fibrillation, Atrial flutter, Ventricular tachycardia, Ventricular Fibrillation, WBW, SVT, sinus tachycardia, prolong QT-interval, sinus arrhythmia and bradycardia.
- Diagnose ischemic changes with determining heart anatomy involved.
- Diagnose pericarditis and LVH.

DONE BY

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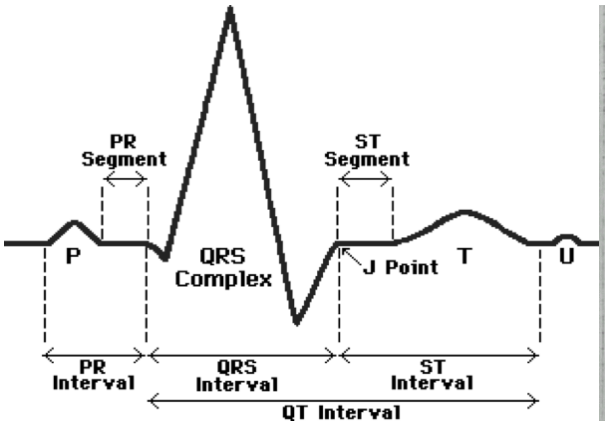
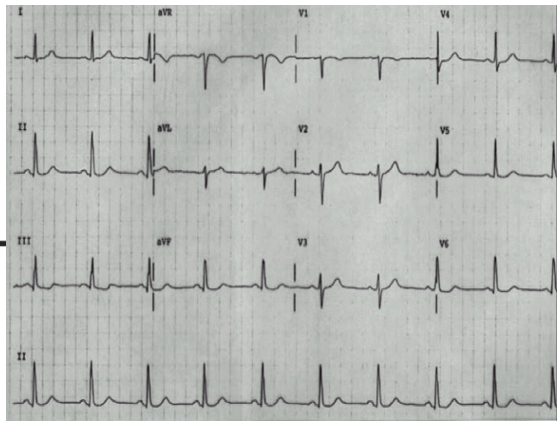
Sources	**435 Teamwork**





Recall the approach

1) Take a deep breath.
2) Analyze rate.
3) Analyze rhythm.
4) Look at axis.
5) Look for injury/strain/ischemic patterns.
6) Look for conduction deficits (RBBB, LBBB).
7) Hypertrophy, meds, toxic effects.
8) Make your measurements (PR, QT/QTc, QRS).

Another approach

After checking the name and ID of the patient, **Look at:**

1) Rhythm.

Regular or irregular? Look at the R-R interval and see whether it is constant or changing.

2) Rate.
3) Axis.
4) P wave, P-R interval, Q wave, QT interval, QRS complex, ST segment, T-wave.

Introduction

ECG is a quick, cheap, non-invasive diagnostic tool.

- If you suspect any acute diseases from the ECG, repeat the test again and compare.
- One big square on the ECG paper = 0.2 sec. It contains 5 small waves.
- The best lead to assess the sawtooth appearance (if you are suspicious) is V1.

AV Block (Heart block): What is heart block? Video 2:49

Electrical block at the level of AV node causing delayed conduction. P wave reflects the signal from the SA node but doesn't mean that a contraction happened, while the P-R interval (which is the beginning of P wave to the beginning of Q) reflects the duration of the electrical conduction from SA to AV node. So, any blockage usually will cause delay and therefore prolongation in the P-R interval on the ECG.

- Normal P-R interval = 0.2 sec (one big square).

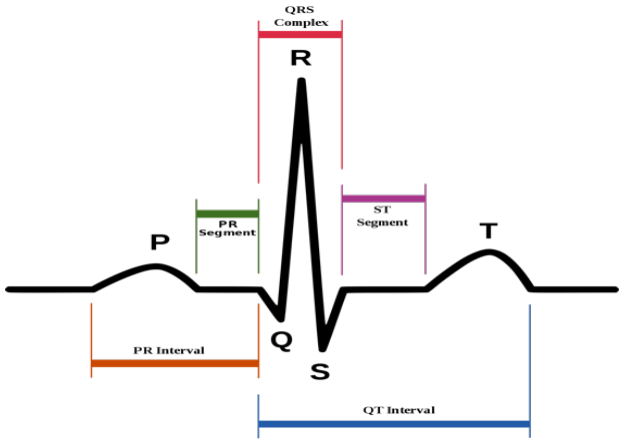
Amazing video explains each type in details 9:16

First degree: The electrical impulses pass, but in a lower conduction velocity. So, we will have fixed prolonged P-R interval (regular rhythm).

Second degree: Not every impulse will pass. It contains 2 types:

1) Type 1: Progressive prolongation of P-R wave with sudden dropped beat (Dropped beat: P wave is not followed by QRS complex), irregular rhythm.
2) Type 2: Fixed P-R interval (could be prolonged or normal in duration), but sudden beat drop, and this type is riskier and have higher chance to become complete heart block (3rd degree heart block).

Third degree (complete heart block/AV dissociation) video: Most of the impulses doesn't get through. In such case, AV node can generate its own independent impulses (QRS waves) which will be in slower rate in comparison to the P waves. So, the two waves will be separated and not related to each other. Keep in mind that although the rate is different between the P waves and QRS complex but the duration between each two QRS complexes is the same as well as for the P waves on the same lead. يعني كلًا يغني على ليلاه. Here the rhythm will be regular (as we said the rhythm is decided upon the duration between the R-R interval no matter what's its relation to the P wave), but the P-R interval is variable.



Amplitude	**P wave**	Atrial depolarization	0.25 mV
	R wave		1.60 mV
	Q wave		25% of Q wave
	T wave	Ventricular repolarization	0.1 to 0.5 mV
Duration	PR interval		0.12 - 0.20 sec
	PR segment	Filling of ventricles	
	QT interval	Beginning of V depolarization	0.35 - 0.44 sec
	ST segment		0.05 - 0.15 sec
	P wave interval	Ventricular depolarization	0.11 sec
	QRS interval		0.09 sec

Irregular rhythm

❖ There are many causes but the most important and common are:

1) Atrial fibrillation (absent P wave).
2) Atrial flutter (sawtooth shape).
3) Second degree heart block type 1 (Mobitz 1).
4) Second degree heart block type 2 (Mobitz 11).
5) Sinus arrhythmia (It is a diagnosis of exclusion of all the previous DDx: no sawtooth appearance, no dropped beat) common in pediatric.

Rate

❖ If regular rhythm:

1) **calculate big square between R-R:**

if > 5 big square (bradycardia)
if < 3 big square (tachycardia)
if between 3 and 5 big squares (normal heart rate)

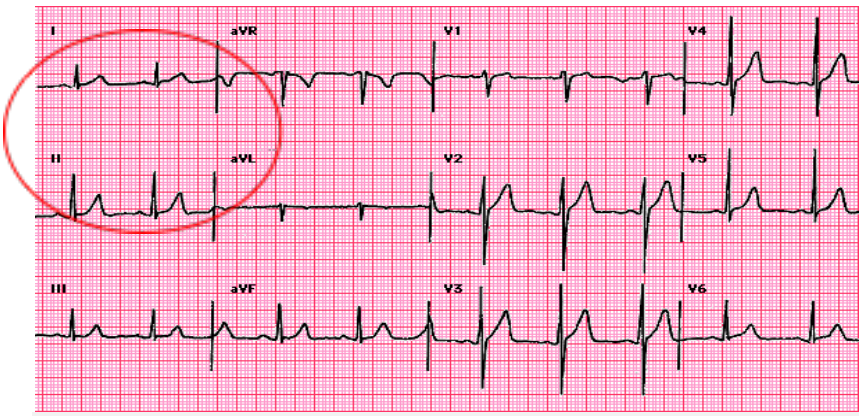
Number of squares	1 square	2 squares	3 squares	4 squares	5 squares	6 squares
Heart rate	300	150	100	75	60	40

3) **In standard ECG: calculate the number of QRS complex** (on the strip lead, usually from lead 2) **in ECG and multiply by 6** (because the ECG lasts 10 seconds and we want the heart rate in one minute) **= HR.**

4) **Method working for regular and irregular rhythm:** measure 30 big square on ECG strip, then calculate how many QRS complex within this 30 big square, then multiply the number of QRS complex by 10 then you will get the heart rate. And usually the rate is already written on the ECG sheet.

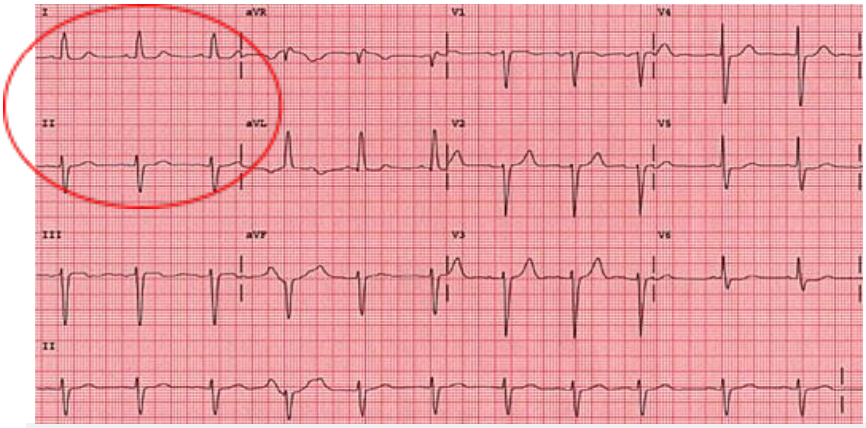
Axis trick

Look at lead 1 & 2 and decide. Extra video if you like to have more infos



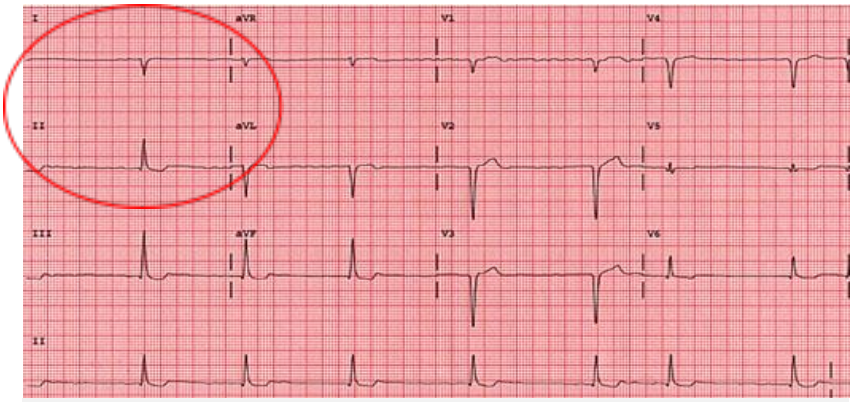
Positive in I and II = normal

Everything is going up



Positive in I and Negative in II = LAD (Left axis deviation)

The waves are opposite to each other



Negative in I Positive in II = RAD (Right axis deviation)

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ECG components interpretation

P-Wave

- **P wave:** better seen in lead II. If you didn't find it in lead 2 check the other leads.

❖ Absent P wave can be seen in many disorders, the most important and common causes are:

1. **Atrial Fibrillation:** (if absent P wave + irregular rhythm = consider it as Atrial Fibrillation).
2. **SVT (supraventricular tachycardia):** regular narrow complex tachycardia with absent P wave.
3. **VT (V tach) (Ventricular tachycardia):** any wide QRS complex tachycardia is considered VT until proven otherwise.
4. **VF (V fib) (ventricular Fibrillation):** An ECG finding of a rapid grossly irregular ventricular rhythm with marked variability in QRS cycle length, morphology, and amplitude. Patient is coded!!

Sometimes you have absent P wave so when you see the QRS complex followed by a wave you may be confused weather it is P or T wave. A GENERAL RULE, if the whole lead contains only one wave, for ex: (QRS,QRS,Wave,QRS) this is a **T wave** and the P wave is absent. But if only one wave is absent this is a flattened T wave with presence of **P wave**.

P-R interval

- From the beginning of P wave until the beginning of QRS complex. It reflects the traveling time of the impulse from the SA to the AV node.
- Prolong PR interval >0.2 sec (> 200 ms) (>5 small boxes) = AVB atrioventricular block (1st, 2nd type1, 2nd type2 or 3rd degree heart block) or hyperkalemia. Any blockage on its way can cause prolongation.
- Short PR interval <0.120 sec (120 ms) (< 3 small squares) = most important cause is WPW which is associated with delta wave (due to the re-entry of the signal through the AV node causing a delta wave just before the QRS complex which decreases the PR segment). Remember 3rd degree heart block causing Variable P-R interval length, so it will cause short and prolong P-R interval. WBW almost always have shortened P-R interval but not necessarily contains a delta wave.

Q-Wave

- Q waves: >1 small square in width and >25% height of R wave in >2 contiguous leads suggest old MI.

QRS complex

- Wide, normal or narrow QRS complex. Wide QRS if more than 0.12 sec (120 ms) (more than 3 small squares), and the wide is the most important finding of QRS complex among the others.
- Most important causes of wide QRS complex:

1. Ventricular tachycardia.
2. Hyperkalemia.
3. Bundle branch block (Rt or Lt).
4. Some drug toxicity like TCA.
5. WPW wolf-parkinson-white syndrome (not always wide QRS complex).
6. 3rd degree heart block (not always wide QRS complex).

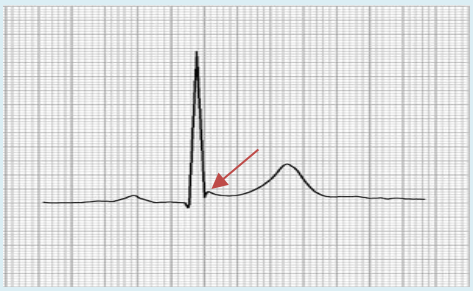
S-T segment

- Either elevated or depressed.
- Better determined by J point (The meeting point between the QRS wave and ST segment).
- The best isoelectric line to measure the ST segment elevation or depression is TP segment, so we compare it with the J point.

❖ Most important and common causes of ST-elevation:

1) Acute STEMI.
2) Acute pericarditis (Widespread ST elevation and PR depression in most leads, expect lead AVR will be ST depression and PR elevation).
3) LBBB.
4) Benign early repolarization.

- If you find a notch in ST-segment, then very less likely to be ischemia



- **When do we consider the elevation significant?** If it is more than 1 small square in all leads (limb leads, because it is away from the heart) except for the chest leads (because it is near the heart).

❖ Most important cause of ST segment depression:

1. Ischemia (either as part of non-STEMI or as a reciprocal changes).
2. LVH with repolarization abnormality.

Q-T interval

- It is the time between the start of the Q wave and the end of the T wave
- normal value for the QTc in men is ≤0.44 sec (440 ms) and in women is ≤0.45 (450 ms)
- if QT interval > half (50%) the RR interval; then consider prolonged QT interval.
- Q-T interval is a marker for the potential of ventricular tachyarrhythmias like Torsadesdepointes and a risk factor for sudden death.

T-Wave abnormality

- Peaked, Inverted, biphasic or flattened.
- May be ischemia / injury but NONSPECIFIC.

Bundle Branch Block

- LBBB: terminal deflection in lead I (+); bunny ears in V5-V6 (WiLLiaM). LL = Left bundle.
- RBBB: terminal deflection in lead I (-); bunny ears in V1-V2 (MaRRoW). RR= Right bundle.
  i.e., with LBBB, there is a W in lead V1 and an M in lead V6, whereas, with RBBB, there is an M in V1 and a W in V6.

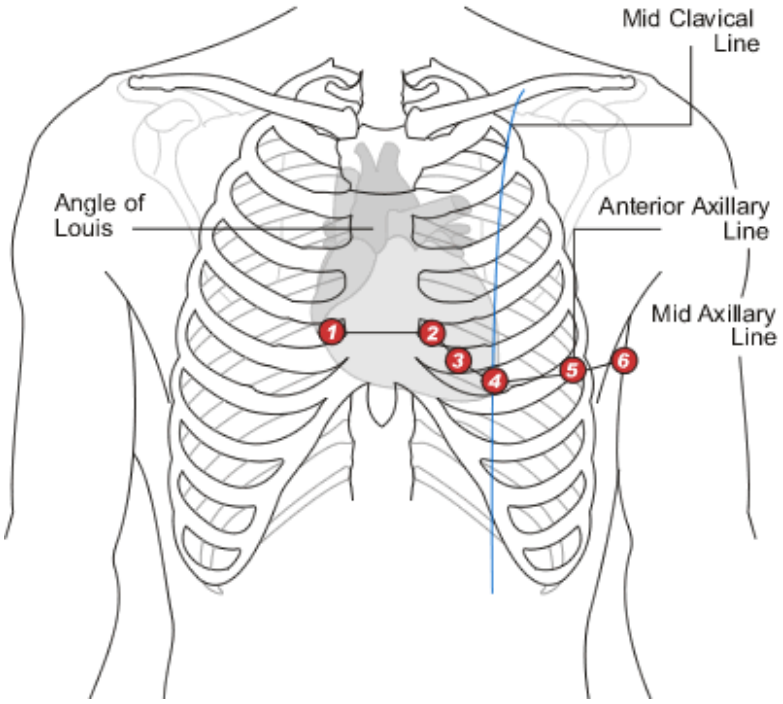
Left Ventricular Hypertrophy

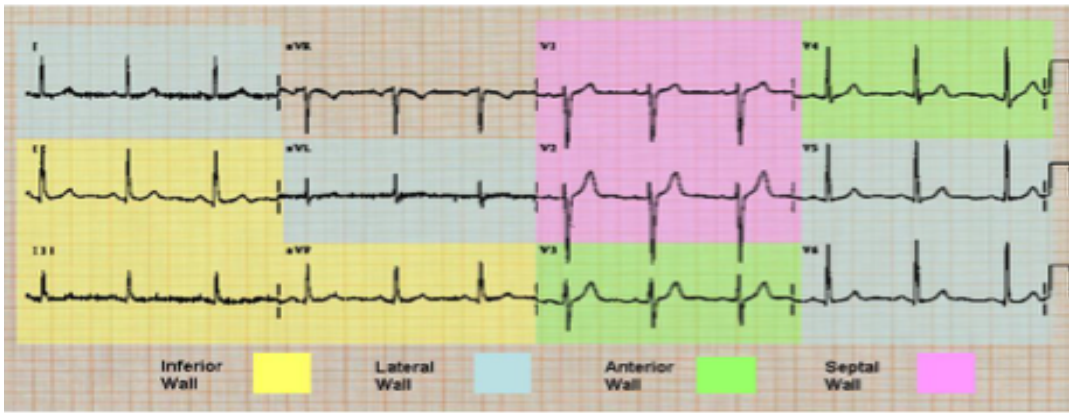
- Hypertrophy (more muscle -> more voltage).
  LVH = SV1 or SV2 (The longest) + RV5 or RV6 (The longest) >35 small squares (>7 big boxes).

Precordial leads

I	aVR	V1	V4
II	aVL	V2	V5
III	aVF	V3	V6

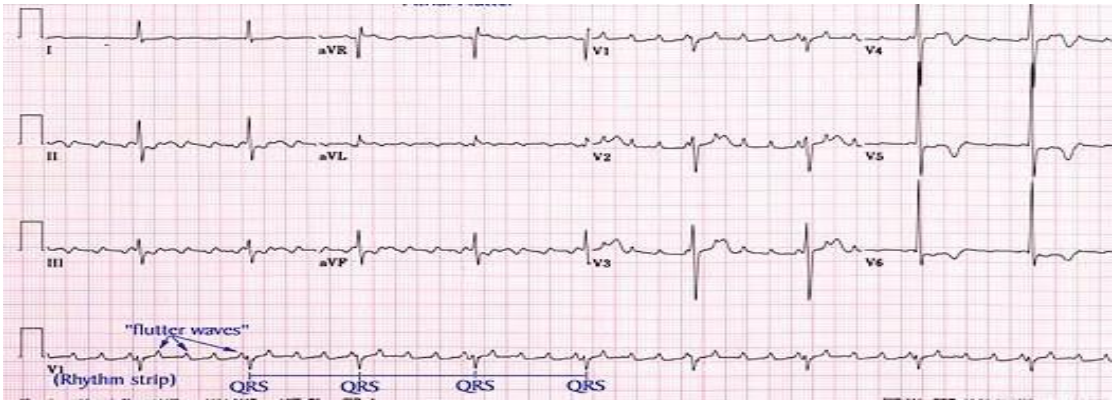
Limb leads **Chest leads**





To say that ST elevation or depression is significant it has to be present in at least 2 leads of the same wall. Even if we have ST elevation in two leads of different heart walls, we do not consider it significant.

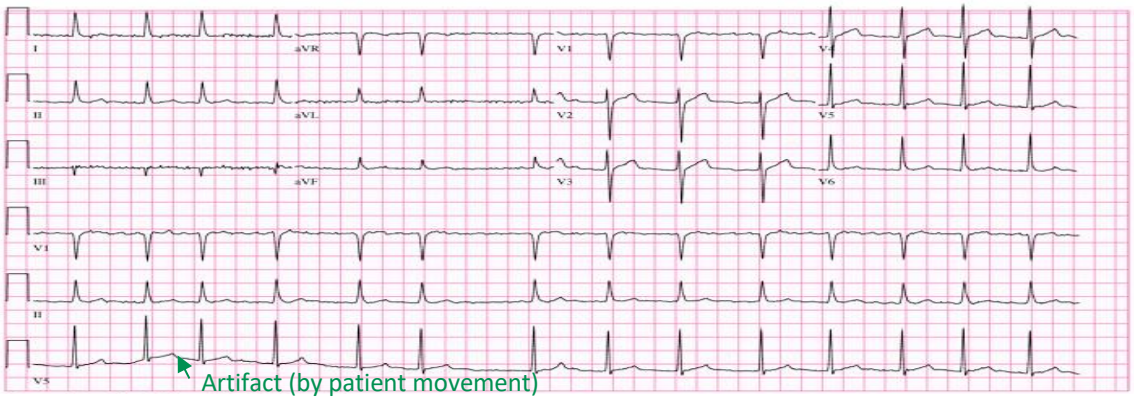
Let’s interpret the following ECG:



Interpretation:

Regular rhythm, Normal heart rate (5 small squares between every 2 RR intervals), Multiple P waves (flutter waves), depressed QT interval on lead V4,V5 and V6, left ventricular hypertrophy.

- Important finding:
  Flutter waves (“saw-tooth” pattern).
- Diagnosis:
  Atrial flutter.



Interpretation:

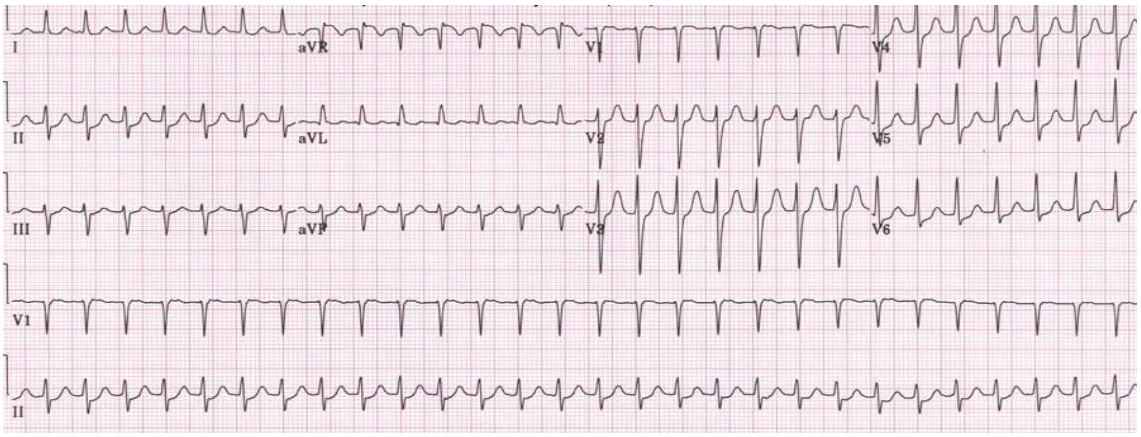
- Important finding:
  Irregular rhythm.
  Absent P-wave.

- Diagnosis:
  Atrial Fibrillation. Even if you said atrial fibrillation in the exam it will be correct.

Interpretation:

- Important finding:
  Irregular rhythm.
  Present P-wave with normal PR interval. No dropped beat. No flutter waves.

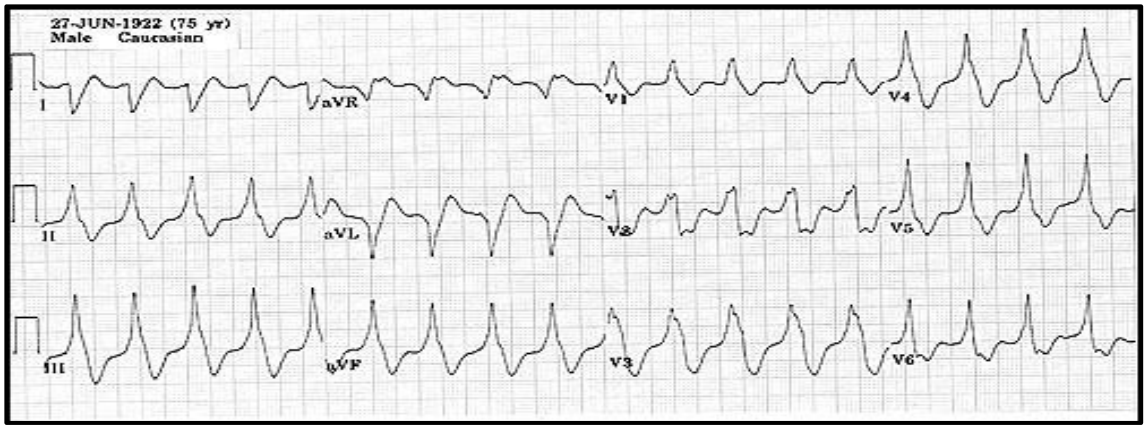
- Diagnosis:
  Sinus arrhythmia.



Interpretation:

- Important finding:
  Regular tachycardia.
  Absent P wave. Remember when we said if only one wave is absent this is a flattened T wave with presence of **P wave**.
  Normal QRS complex.
  ST depression in lateral and anterior leads (so I cannot rule out ischemia) but in such case it is due to tachycardia (rate dependent ischemia) but I MUST assess for ischemia, and manage the patient depending on my assessment.

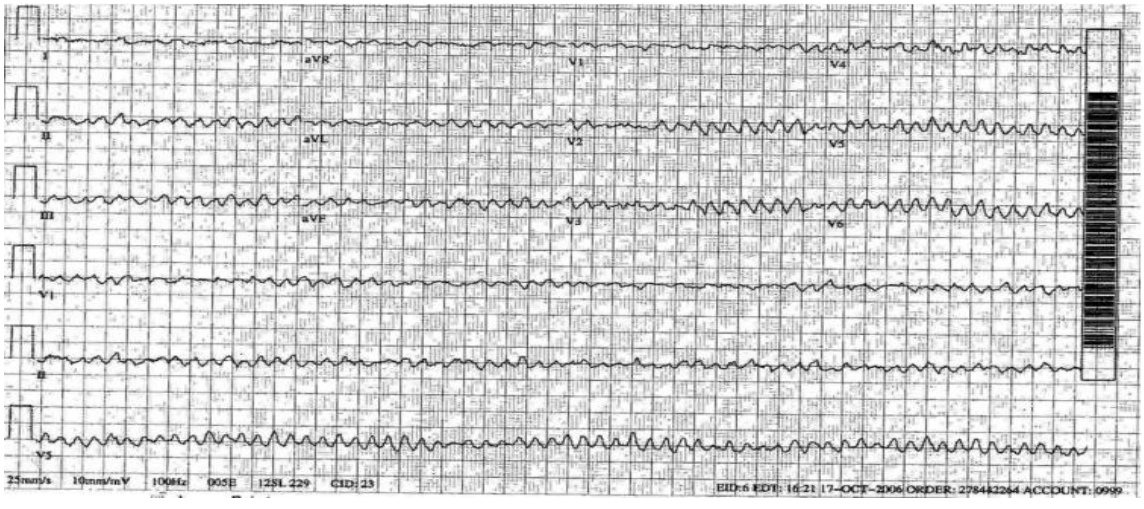
- Diagnosis:
  SVT.



Interpretation:

- Important finding:
  Regular tachycardia (regular rhythm).
  Absent P wave.
  Wide QRS complex.
  Inverted T waves.

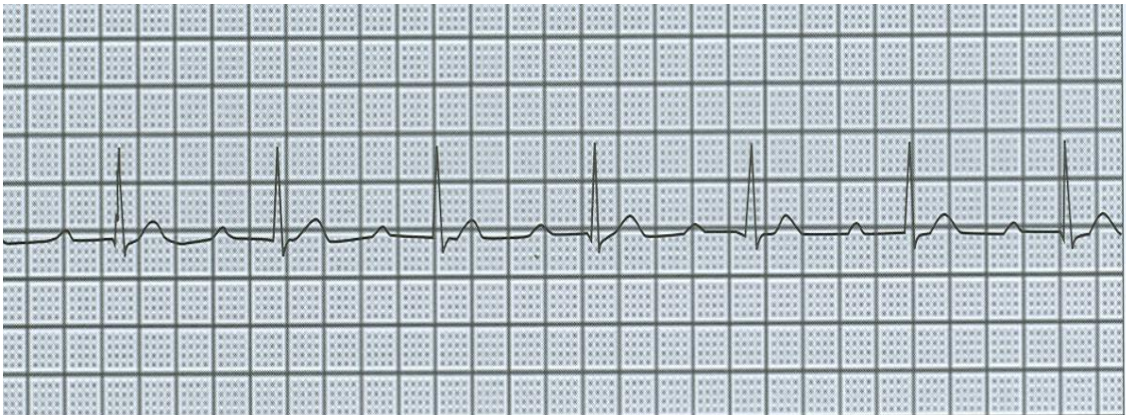
- Diagnosis:
  Wide QRS complex tachycardia most likely: Ventricular Tachycardia.



Interpretation:

There is nothing! It's just multiple small QRS complexes.شخاميط

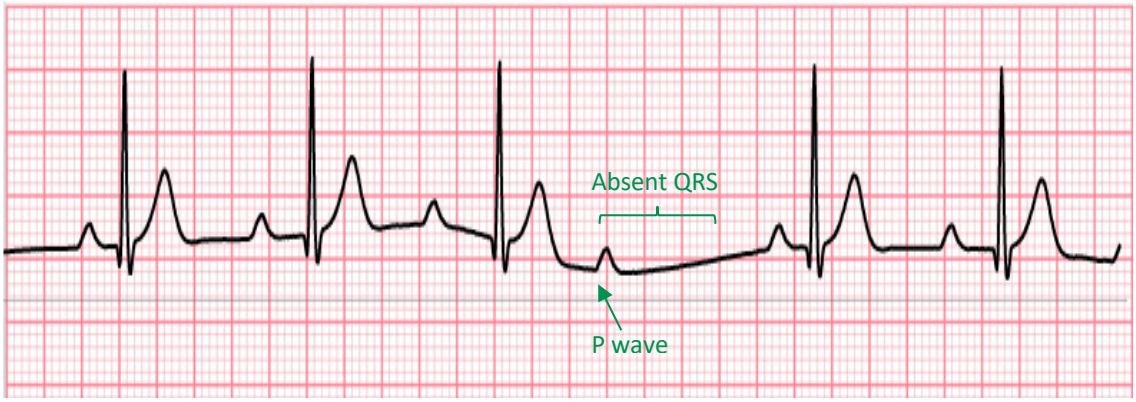
- Diagnosis:
  Ventricular Fibrillation.



Interpretation:

- Important finding:
  Normal rate, Regular rhythm, P wave is present.
  Fixed prolonged PR interval without QRS complex drop.

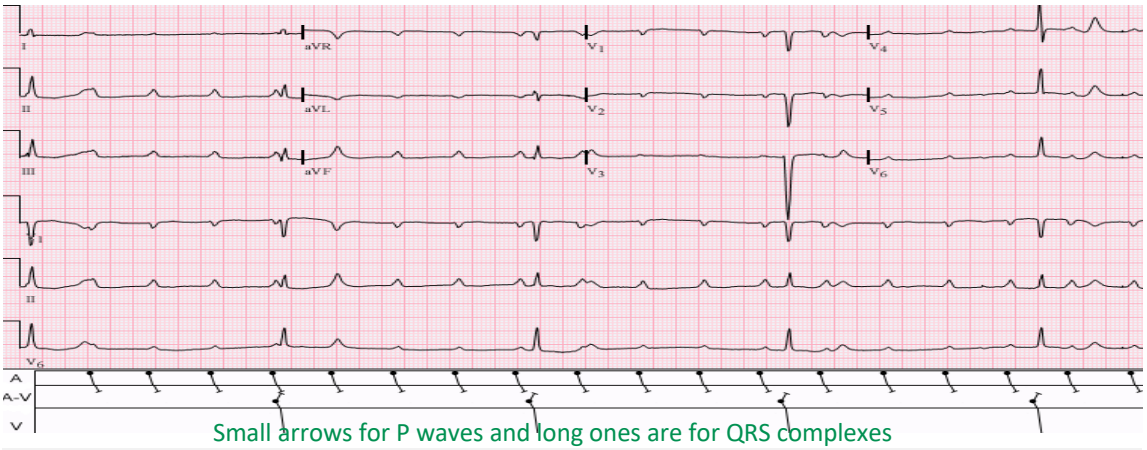
- Diagnosis:
  1st degree heart block.



Interpretation:

- Important finding:
  Irregular rhythm.
  Progressive prolongation of PR interval followed by a drop in QRS complex.

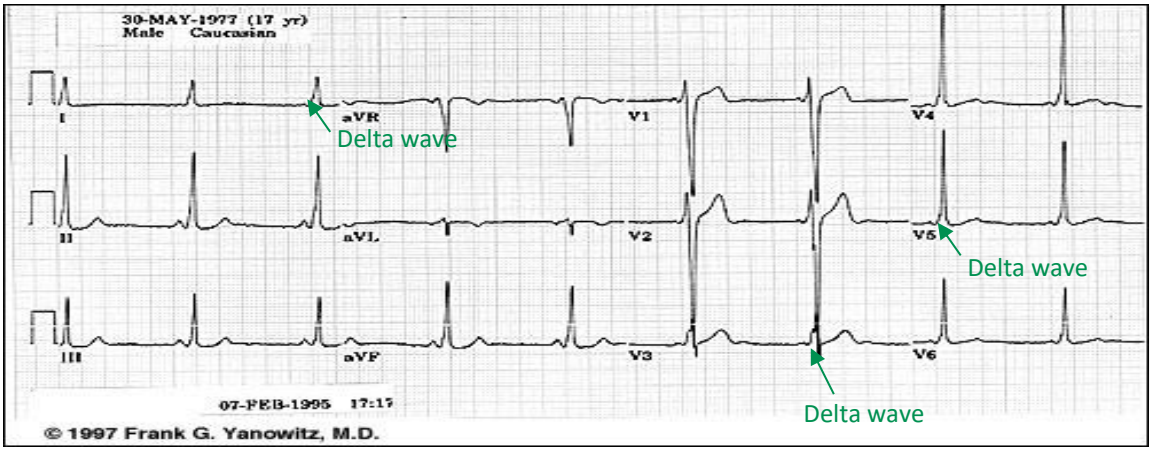
- Diagnosis:
  2nd degree heart block type 1 (Mobitz 1)



Interpretation:

- Important finding:
  Regular rhythm.
  Bradycardia.
  The P wave with a regular P-to-P interval.
  The QRS complex with a regular R-to-R interval.
  The PR interval will Be variable.
  As the hallmark of complete heart block is lack of any apparent relationship between the P waves and the QRS complex. Because when AV node generates its own rhythm it generates it in a slower rate.

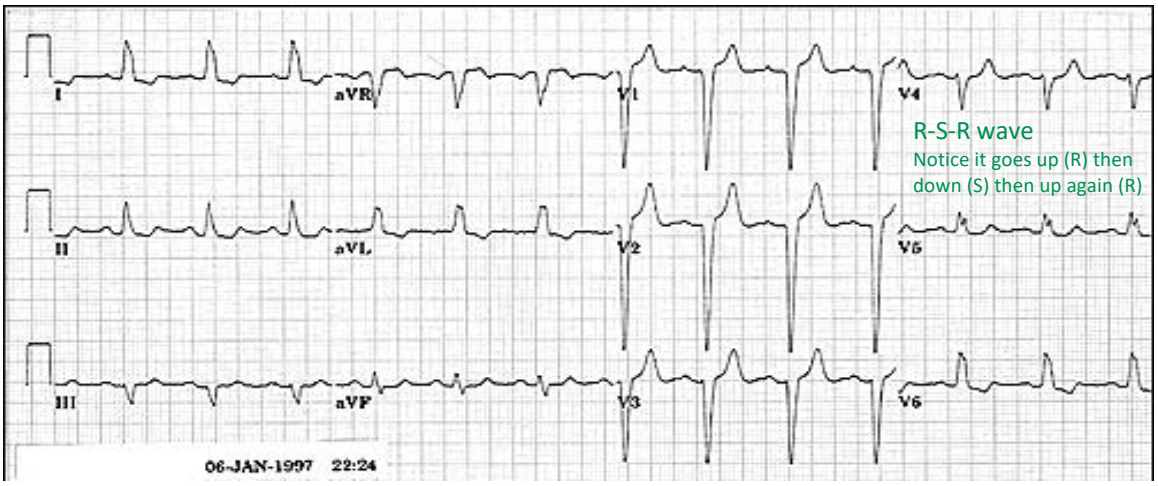
- Diagnosis:
  3rd degree heart block (complete heart block).



Interpretation:

- Important finding:
  Short PR interval.
  Delta waves.

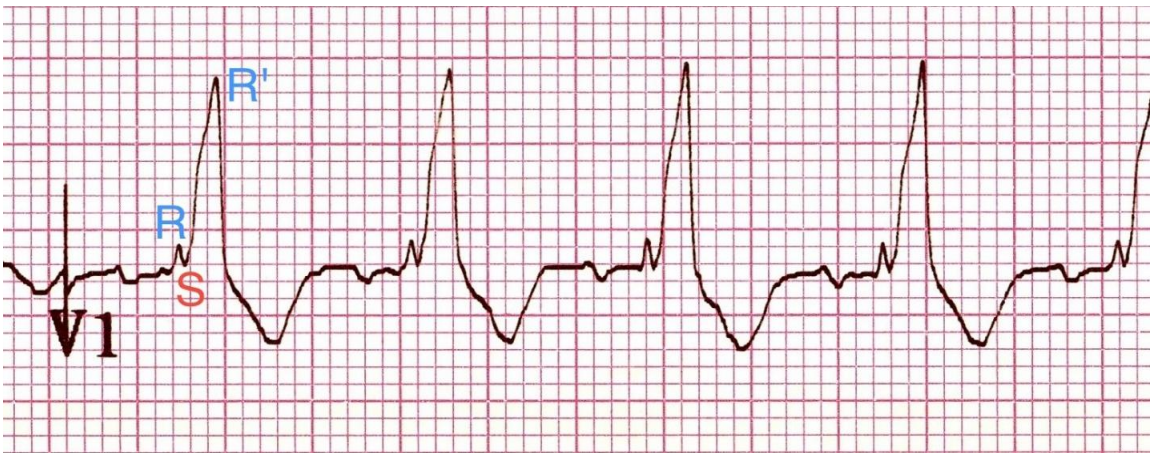
- Diagnosis:
  WPW.



Interpretation:

- Important finding:
  Wide QRS complex.
  ST elevation V1-V2 (LBBB have ST elevation only in V1-V2). RBBB doesn't have the ST elevation which makes LBBB more significant clinically. Any new onset LBBB is treated as MI.
  Notched ('M'-shaped) R wave in lead V5 and V6.
- Diagnosis:
  Left Bundle Branch Block.

Note that when you have negative QRS complex, as in lead V1,V2,V3 we don't have R wave only S. So, R wave is a positive wave where S is a negative one.

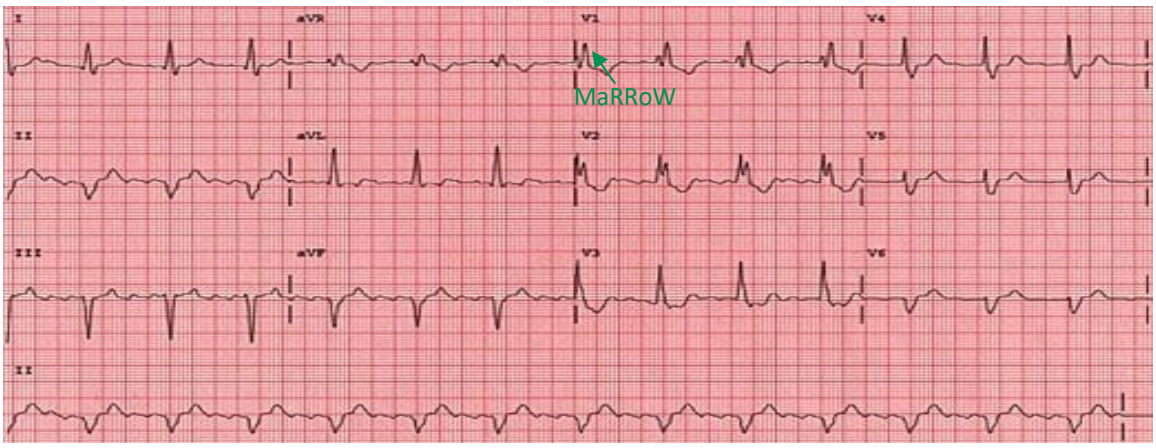


Interpretation:

- Diagnosis:
  Left Bundle Branch Block.

Interpretation:

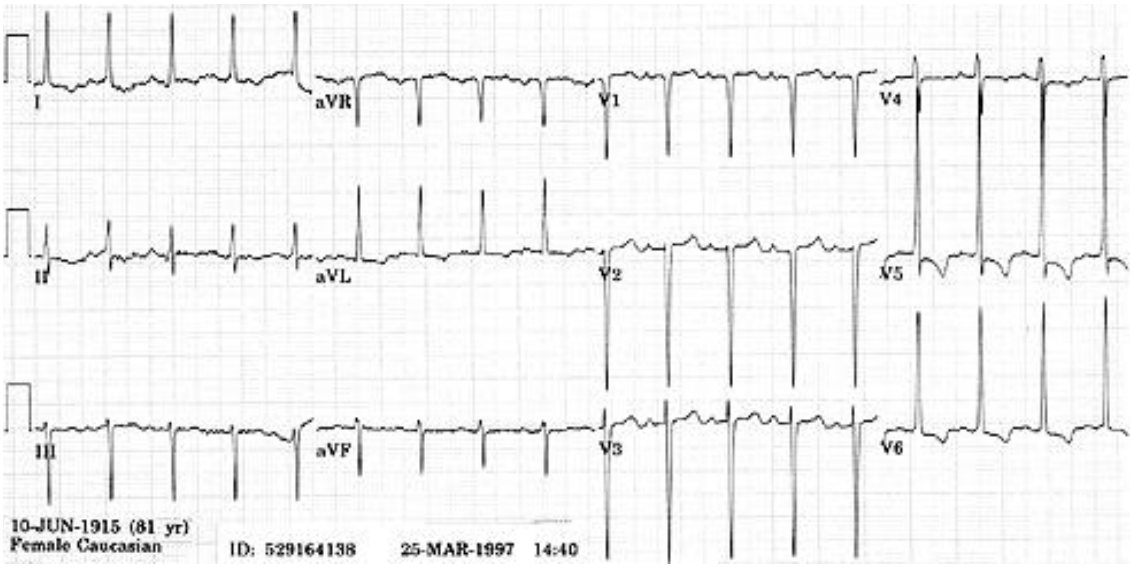
- Diagnosis:
  Right Bundle Branch Block.



Interpretation:

- Important finding:
  Wide QRS complex
  Notched ('M'-shaped) RSR wave in lead V1.

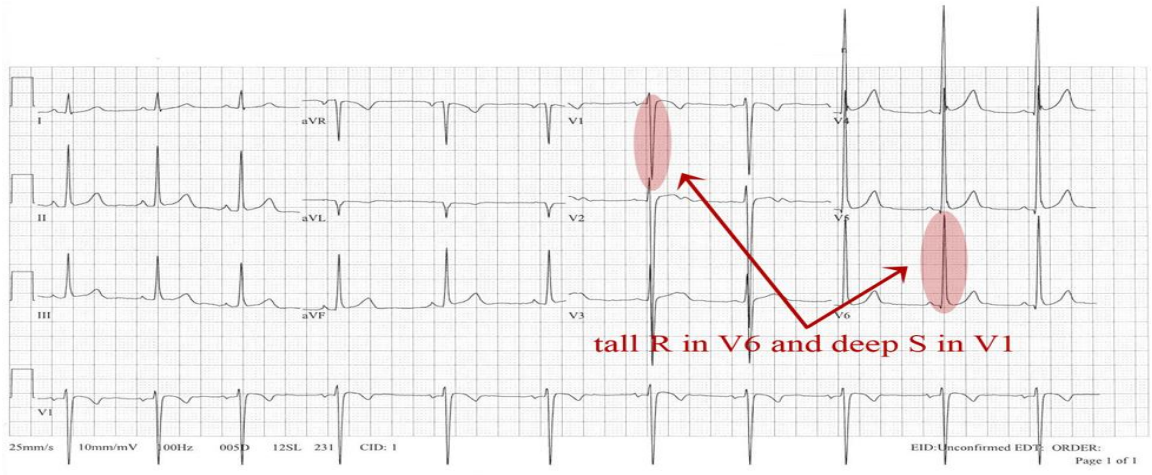
- Diagnosis:
  Right Bundle Branch Block.



Interpretation:

- Important finding:
  SV1 + RV5 or 6 >35 small squares (>7 big squares).
  ST segment depression with T wave inversion in V5-V6 (not always present).

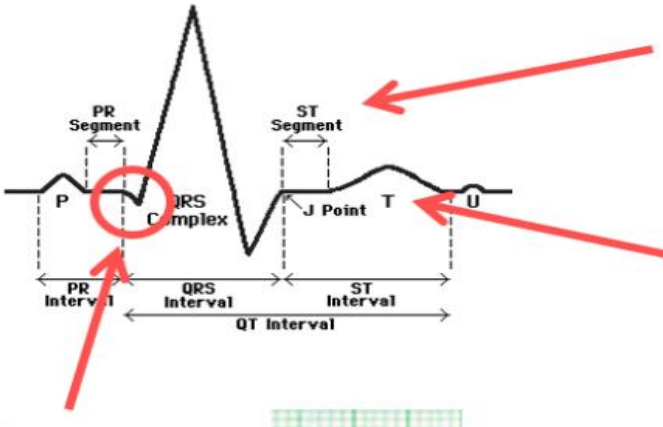
- Diagnosis:
  Left Ventricular Hypertrophy (LVH).



Interpretation:

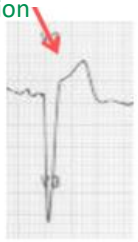
- Diagnosis:
  Left Ventricular Hypertrophy (LVH).
  This is wrong, they didn't choose the longest wave, they should've bee choosing V2 and V5.

Ischemic ECG changes



ST elevation & depression

ST Elevation



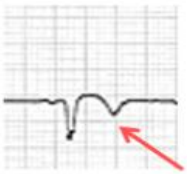
ST Depression

T-waves

peaked

flattened

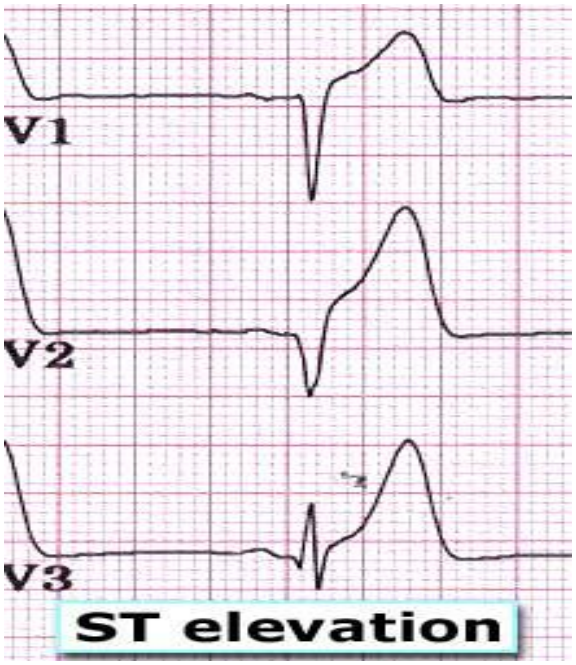
inverted



DDx:
Hyperkalemia.
Ischemia.

Appearance of pathologic Q-waves

We have to have two pathological Q wave in the same anatomy

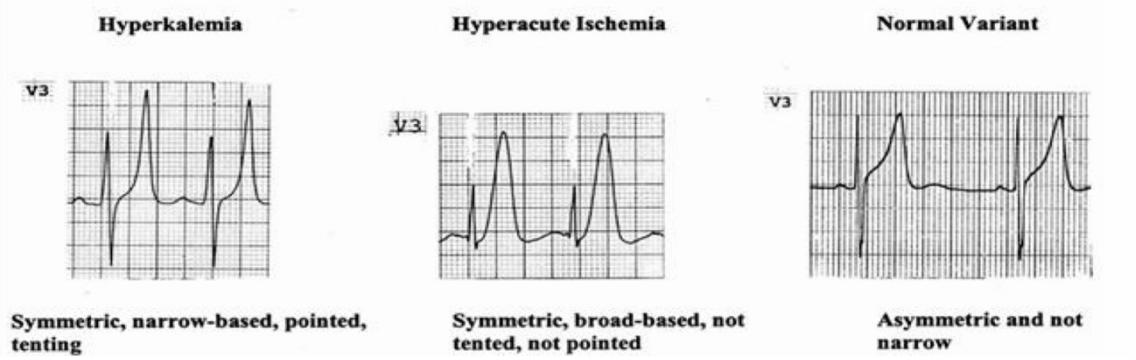


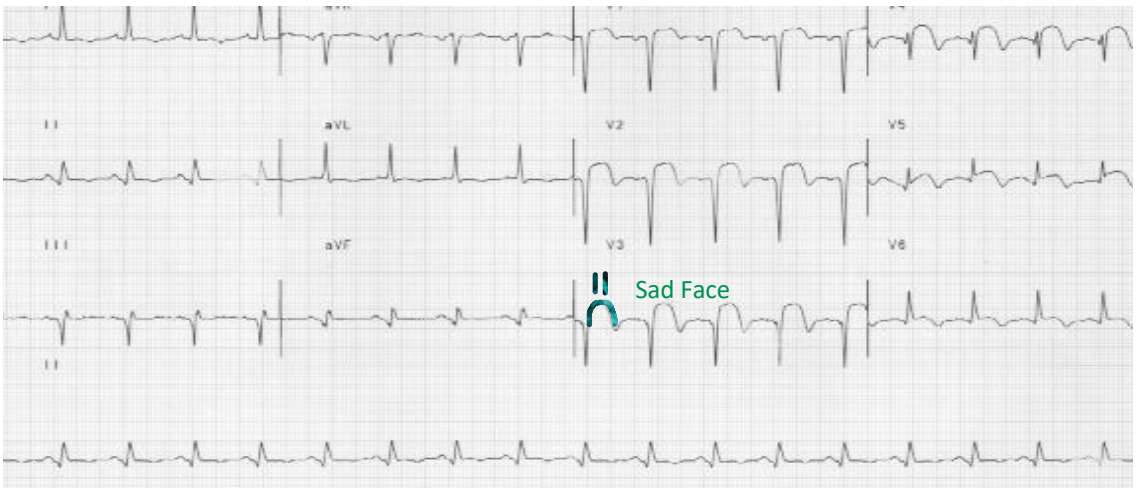
J point

Isoelectric line

Different Causes of Tall T Waves

Hyper acute T wave



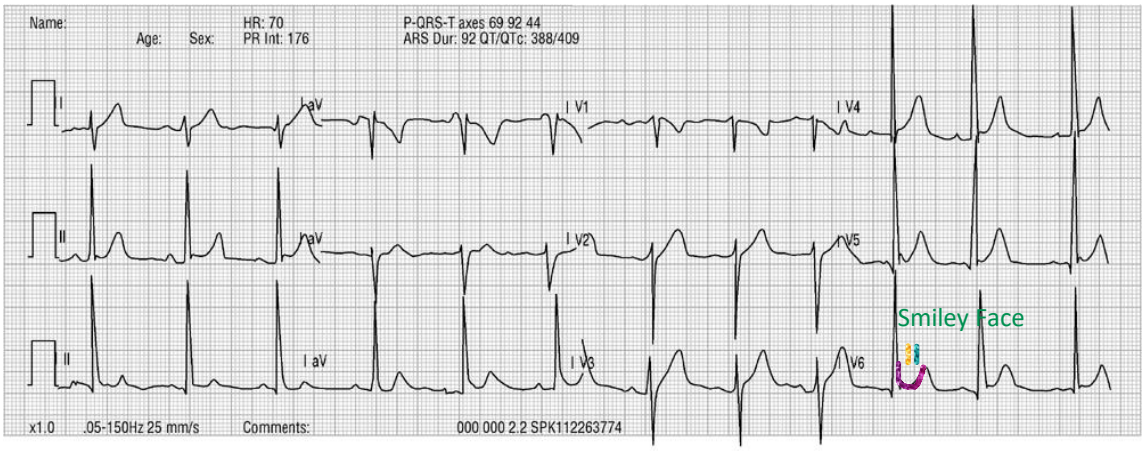


Interpretation:

Regular rhythm, Normal PR interval.

- Important finding:
  ST segment elevation in V1 to V6.
  Flattened T wave in inferior lead.
- Diagnosis:
  Most likely anterior MI (based on the Hx and complete picture).

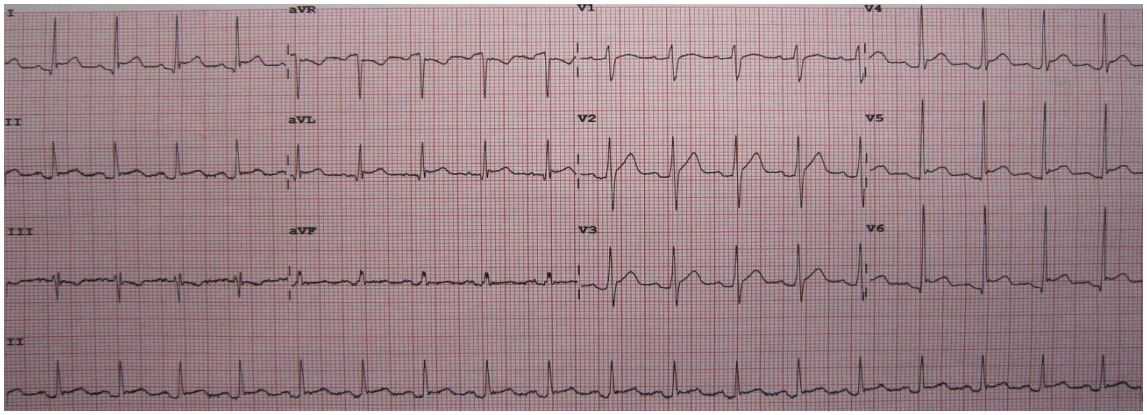
How to differentiate whether the cause of ST elevation is MI or other DDx? Look for the notch (decreases the probability of MI), Sad face = Worry more!!, Smiley face = Less worried**.** If the ST elevation is diffused = more likely it is pericarditis (where we will usually have PR segment depression and ST segment elevation -in comparison to TP segment-).



Interpretation:

- Important finding:
  Wide spread ST elevation.
  There is a notch in ST segment which it less likely to be ischemia (V4,V5,V6).

- Diagnosis:
  Benign early repolarization.

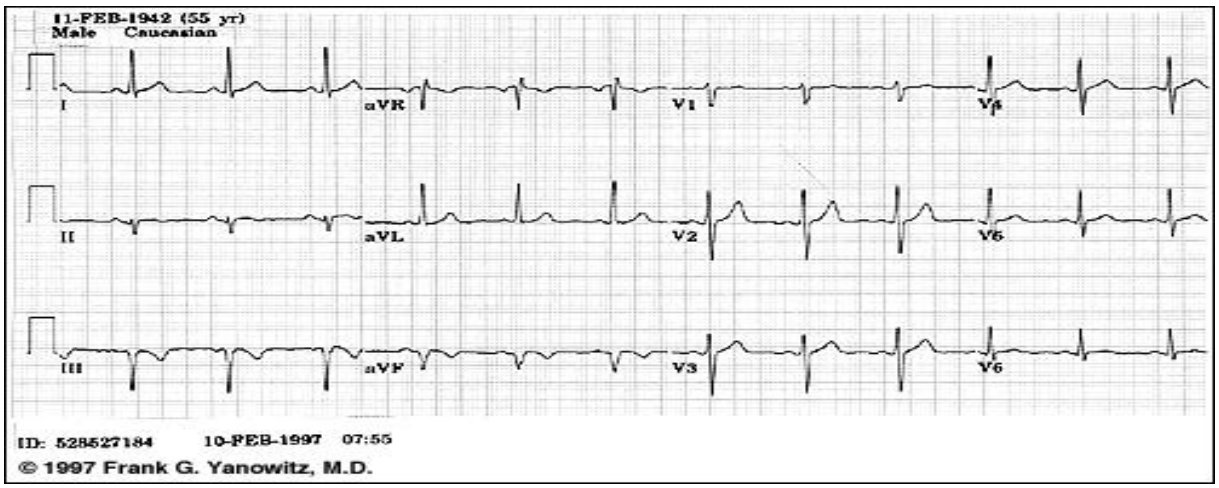


Interpretation:

- Borderline tachycardia, PR depression (From V2 to V6 & lead1,2).
- Important finding:
  Widespread ST elevation.
  In AVR lead there is reciprocal changes (ST depression + PR segment elevation - Knuckle sign-) the electricity is pulled from part of the heart to another, while this part is normal but reflects segment depression due to the reciprocal change, so the anterior pulls from the posterior and the inferior from the high lateral and vice versa. AVR lead usually says a lot about the patient's condition, so whenever see. This sign we think more of pericarditis and less of MI.
- Diagnosis:
  Acute pericarditis.

Interpretation:

- Important finding:
  ST depression.

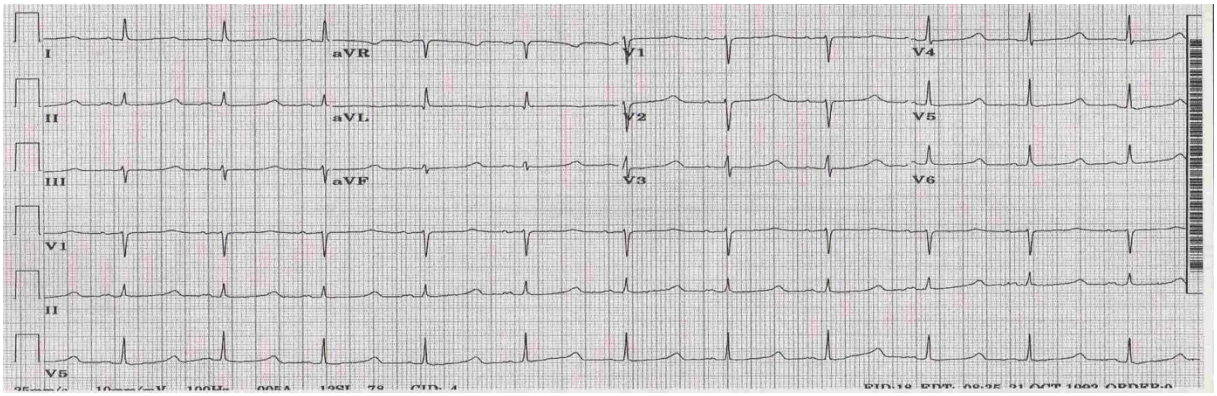


Interpretation:

Regular rhythm.

- Important finding:
  There is T wave inversion in inferior leads. Normal PR interval.

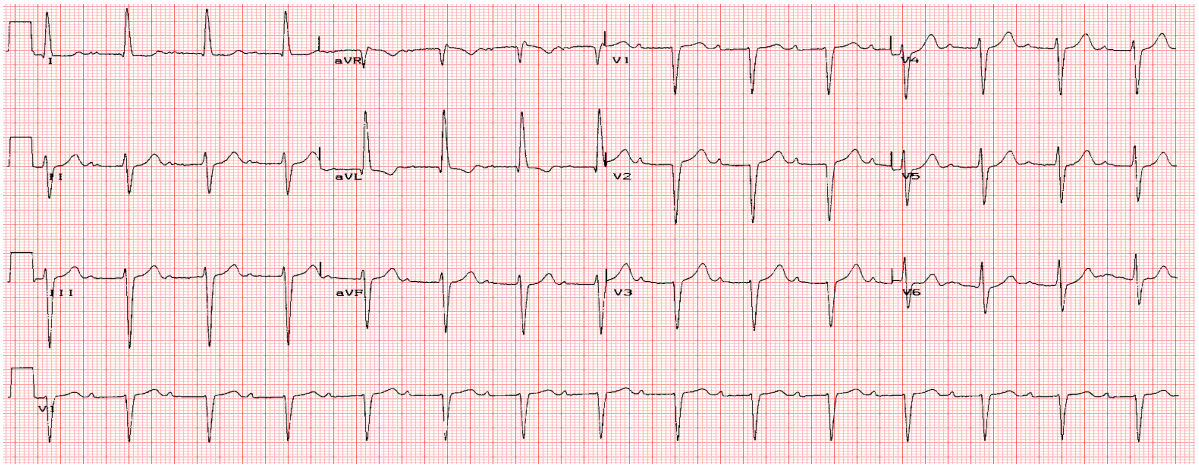
- Diagnosis:
  Ischemia (most likely NON-STEMI which depend on Hx and complete picture).



Interpretation:

- Important finding:
  QT interval in >50% of R-R interval.

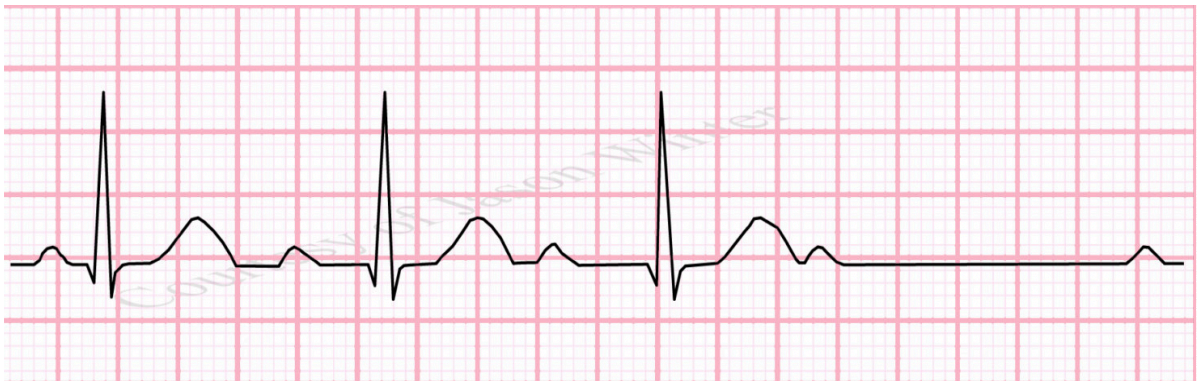
- Diagnosis:
  Prolonged QT interval.



Interpretation:

- Important finding:
  Regular rhythm. Present P wave.
  Fixed prolonged PR interval without QRS complex drop.

- Diagnosis:
  1st degree heart block.



Interpretation:

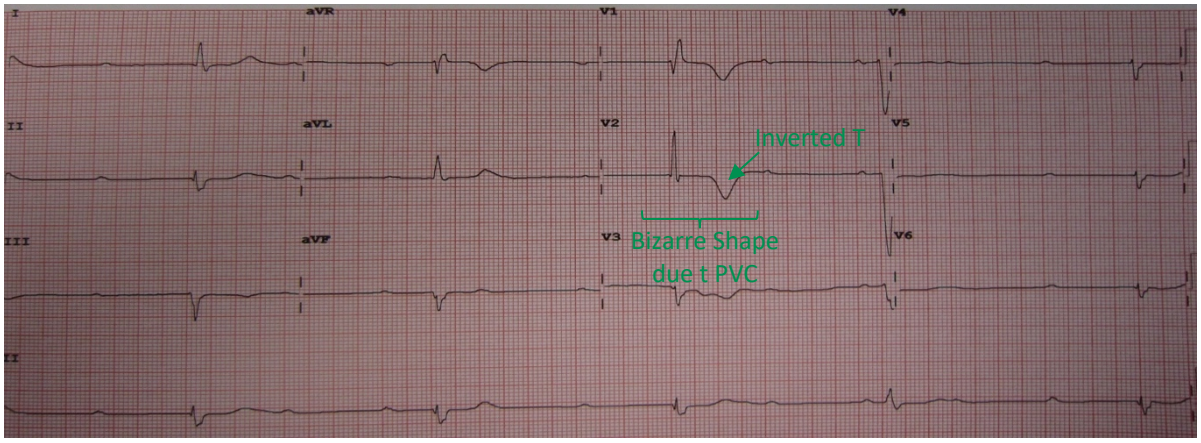
- Important finding:
  Irregular rhythm.
  Progressive prolongation of PR interval followed by a drop in QRS complex.

- Diagnosis:
  2nd degree heart block type 1 (Mobitz 1)

Interpretation:

- Important finding:
  Irregular rhythm.
  Progressive prolongation of PR interval followed by a drop in QRS complex.

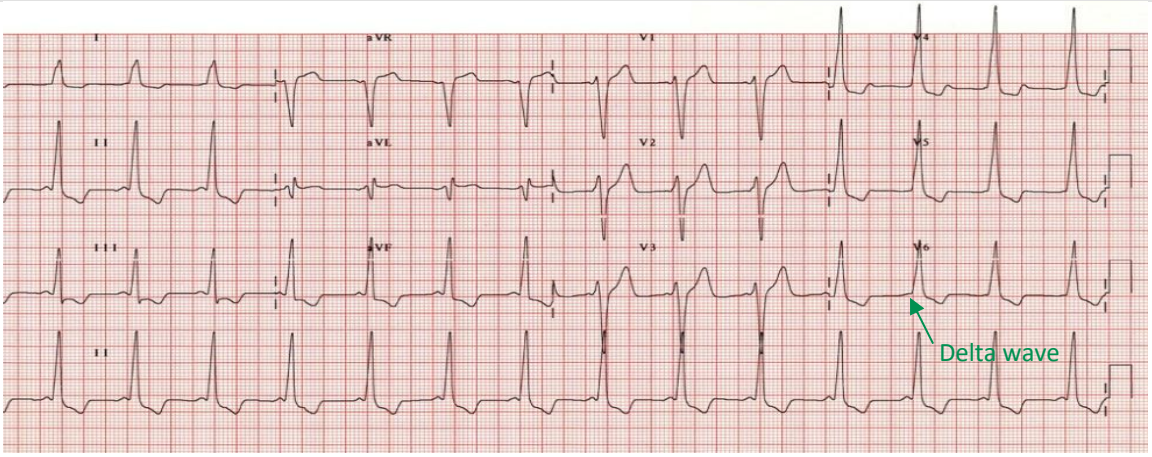
- Diagnosis:
  2nd degree heart block type 2 (Mobitz 2).



Interpretation:

- Important finding:
  Regular rhythm.
  Bradycardia.
  Wide QRS complex.
  The P wave with a regular P-to-P interval.
  The QRS complex with a regular R-to-R interval.
  The PR interval will Be variable.
  As the hallmark of complete heart block is lack of any apparent relationship between P waves and QRS complex.

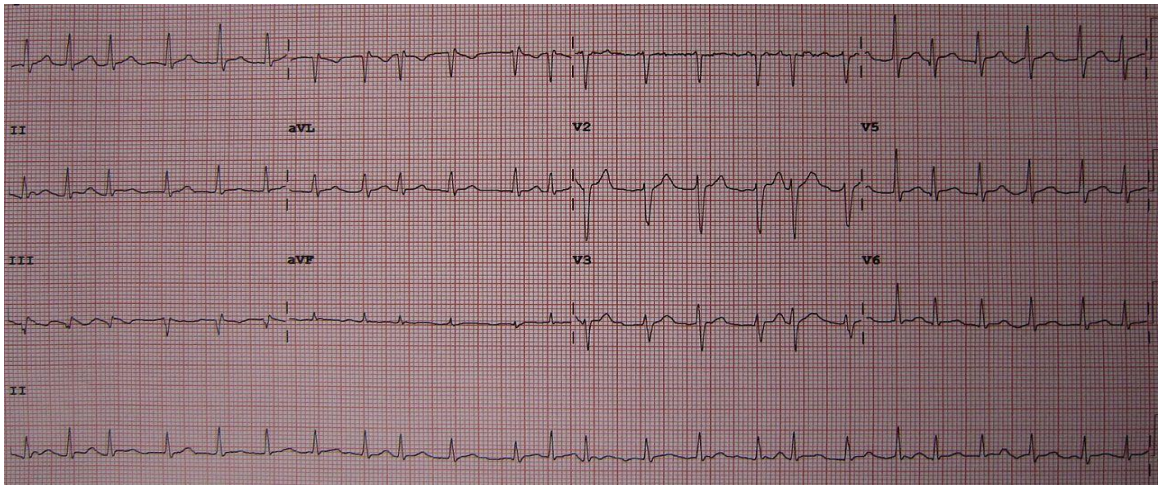
- Diagnosis:
  3rd degree heart block (complete heart block).



Interpretation:

- Important finding:
  Short PR interval.
  Delta wave.

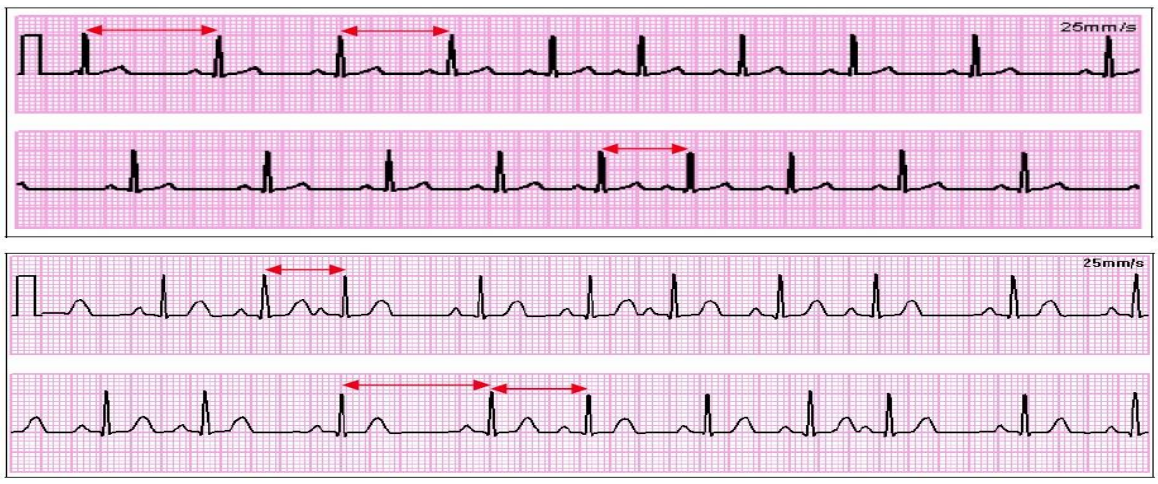
- Diagnosis:
  WPW.



Interpretation:

- Important finding:
  Irregular rhythm.
  Absent P-wave.

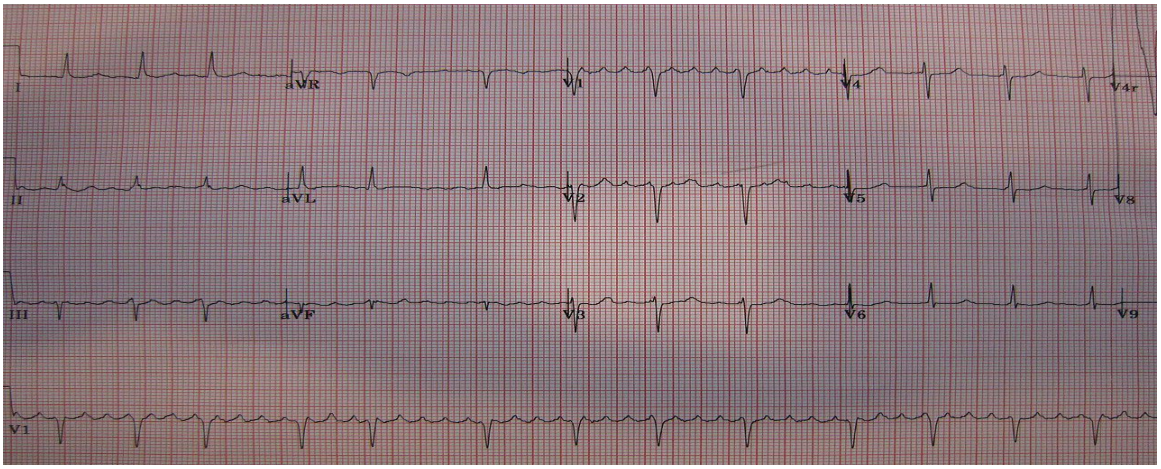
- Diagnosis:
  Atrial fibrillation.



Interpretation:

- Findings:
  Irregular rhythm.
  Present P-wave with normal PR interval.

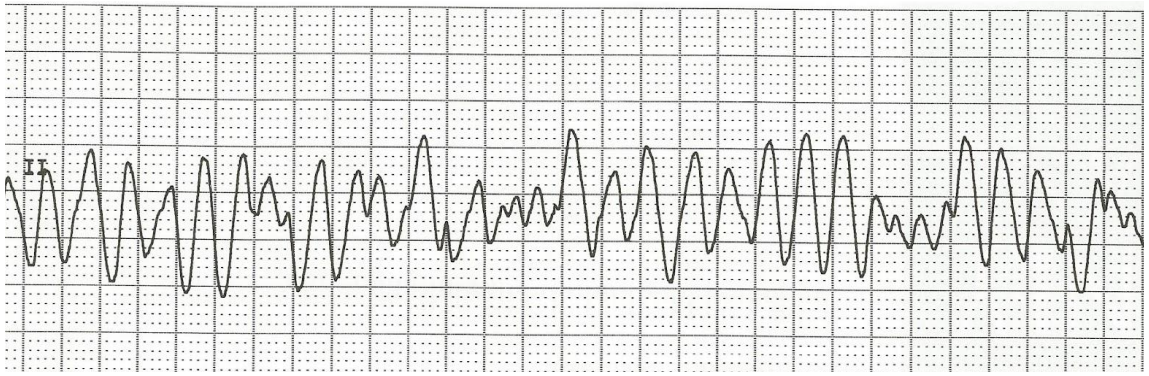
- Diagnosis:
  Sinus arrhythmia.



Interpretation:

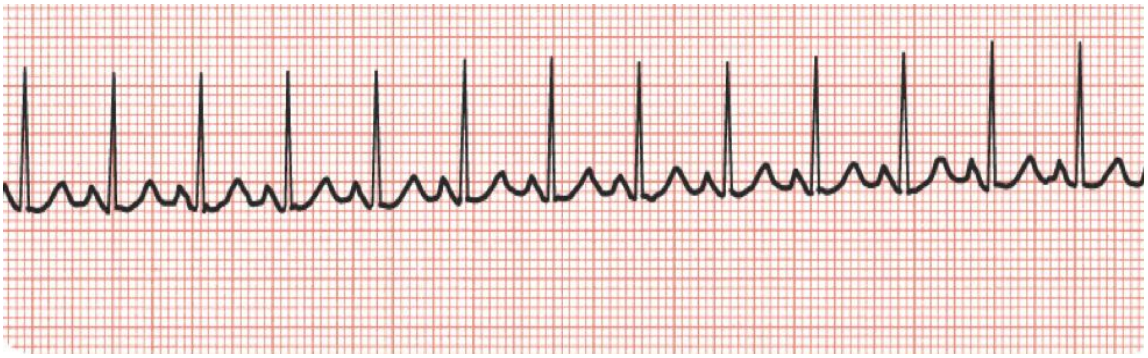
- Important finding:
  Flutter wave “saw tooth appearance”.

- Diagnosis:
  Atrial flutter.



Interpretation:

- Important finding:
  Ventricular fibrillation.

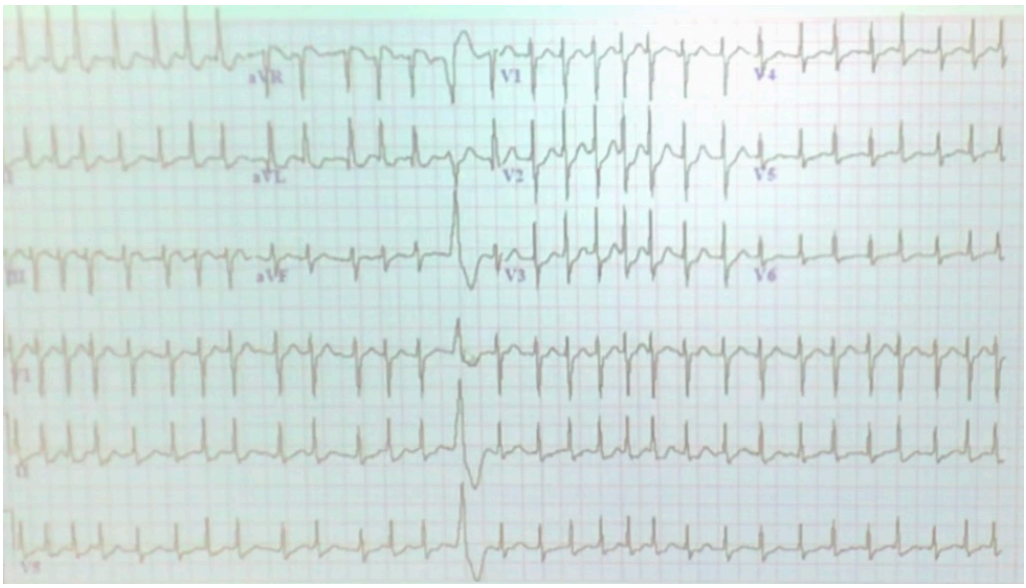


Interpretation:

- Important finding:
  Regular rhythm.
  Sinus rhythm (present P-wave).
  Tachycardia.
  Normal QRS complex.

- Diagnosis:
  Sinus tachycardia.

❖ **if there is no P wave in this ECG the diagnosis will be SVT.**



Interpretation:

ST depression on V2.

- Diagnosis:
  Atrial fibrillation with rapid ventricular response.
  PVC (Premature Ventricular Contraction)

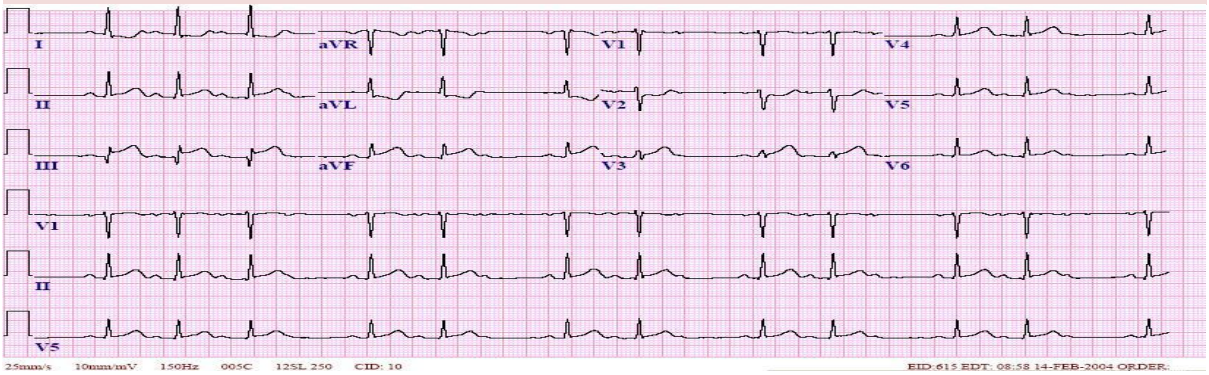
Interpretation:

Regular rhythm, tachycardia, absent P wave.

- Diagnosis:
  Ventricular Tachycardia.

Case Scenarios

55 Years old with heavy retrosternal chest pain radiating to his left arm for 3 hours



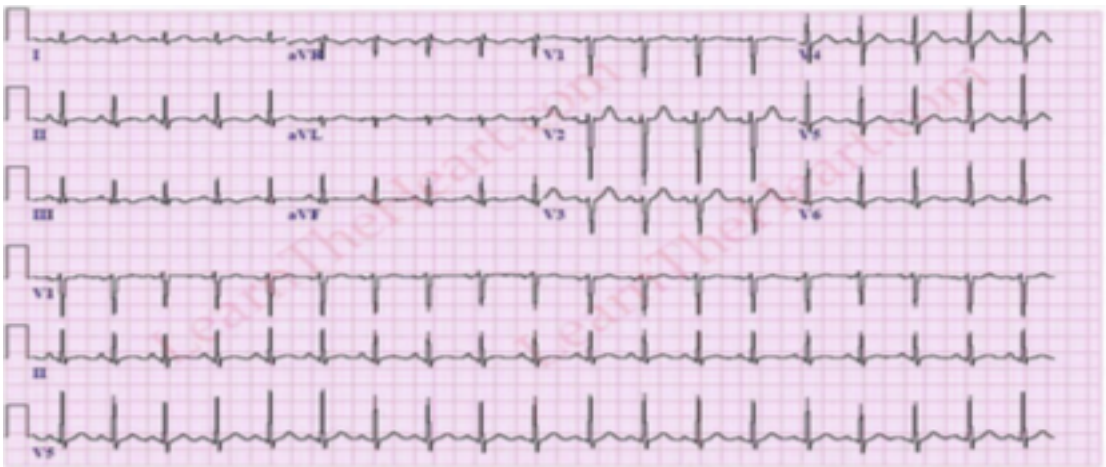
Interpretation:

Irregular rhythm.

- Findings:
  progressive prolongation of PR interval with a drop of QRS complex. Inferior ST segment elevation MI (leads II, III, and aVF) with reciprocal ST depression (leads I, 2 and aVL) (reciprocal change in the high lateral wall).

- Diagnosis:
  Acute inferior STEMI with 2nd degree type 1 heart block.

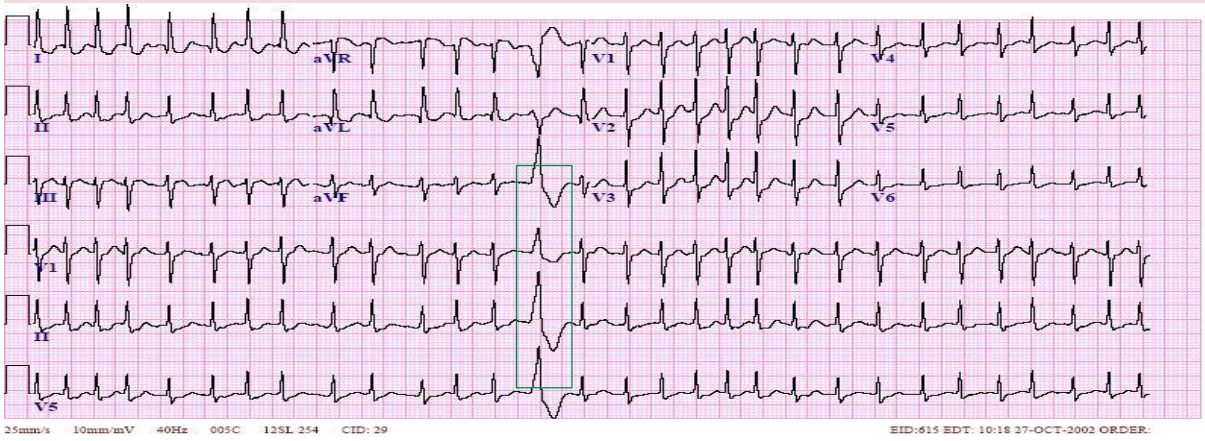
61-year-old with Hx of SOB for 2 days



Interpretation:

- Diagnosis:
  Sinus Tachycardia.

82-year-old male with a history of HTN presents to the clinic with a complaint of generalized weakness for 3 days.



Interpretation:

- Findings:
  Irregular rhythm.
  Absent P wave.

- Diagnosis:
  Atrial fibrillation.
  PVC.

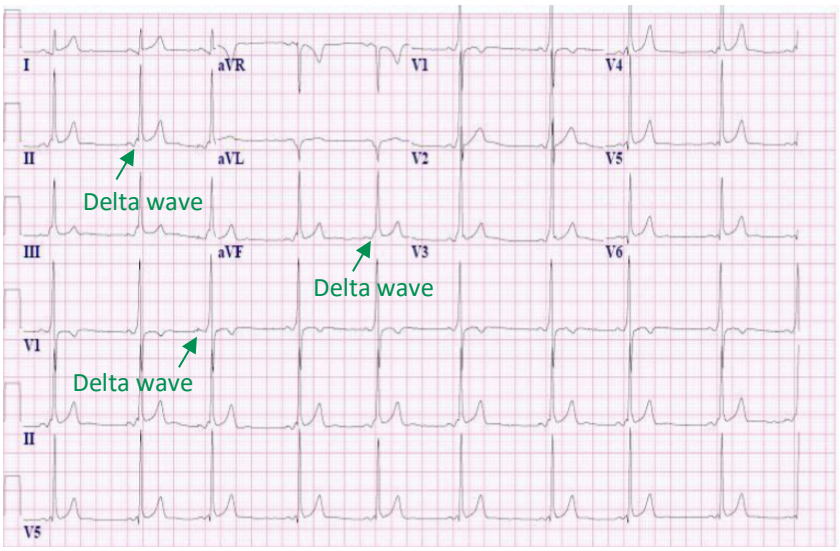
32-year-old male with Hx of SOB & Palpitations for 1 hour

Interpretation:

- Findings:
  Irregular rhythm.
  Present P wave before each QRS complex.
  Normal PR interval.

- Diagnosis:
  Sinus arrhythmia.

24 y old lady presented with Hx of syncope



Interpretation:

- Diagnosis:
  Short PR interval and delta waves consistent with Wolff-Parkinson-White (WPW) syndrome.

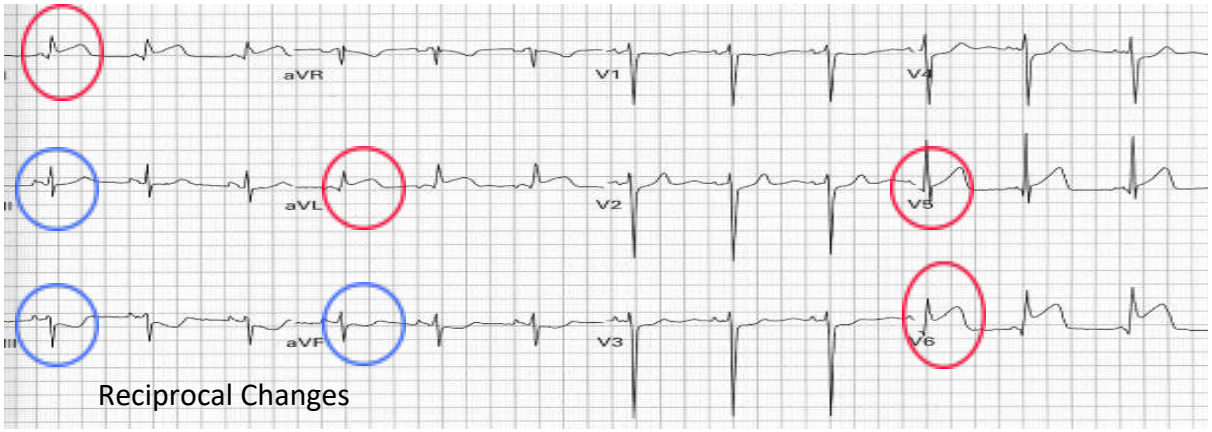
49 y old lady newly diagnosed HTN.

Interpretation:

Regular rhythm with a pause at the beginning. So, we don't say irregular only because of it. Borderline bradycardia. Fixed prolonged PR interval. ST segment depression among V4,5 and 6. Inverted T wave.

- Diagnosis:

63 y old male with chest pain for 8 h.

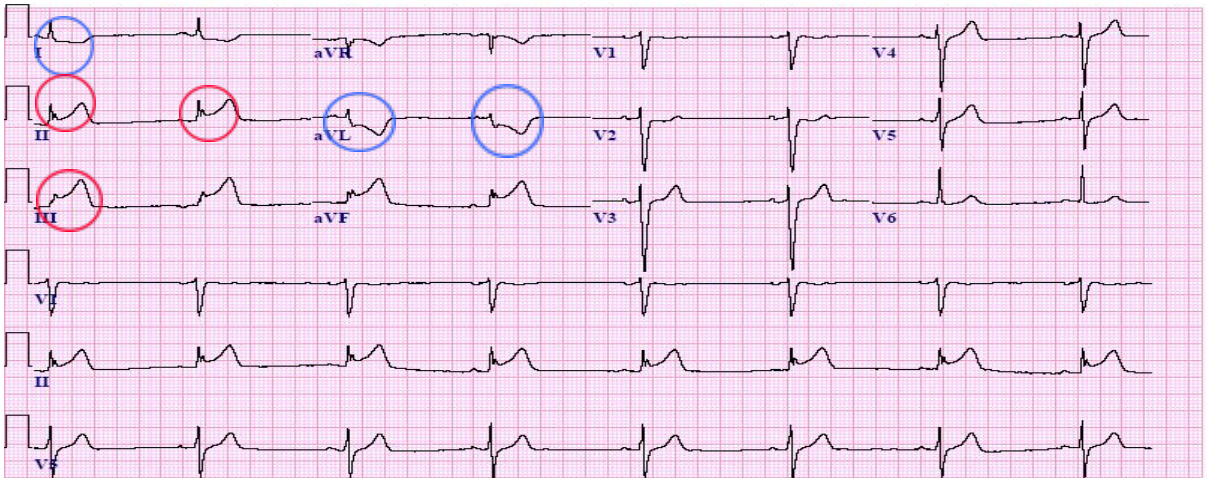


Interpretation:

Regular rhythm and everything are normal except ST segments. ST elevation (Lateral wall) with ST depression (Inferior wall). If we have reciprocal changes, it is definitely not pericarditis.

- Diagnosis:
  Lateral MI. LVH.

- 66 y old lady, diabetic presented with Hx of SOB for 3 h.
- HR 57, BP 90/60, other VS are stable

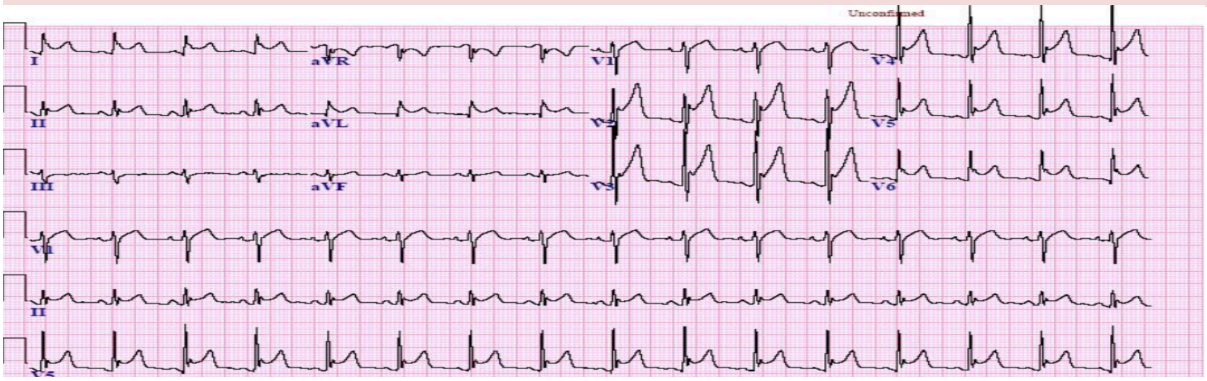


Interpretation:

Regular rhythm, Bradycardia, P wave is present.

- Diagnosis:
  Inferior MI with reciprocal changes

54-year-old male with no significant past medical history presents to his Family physician with 2 days of chest pain.

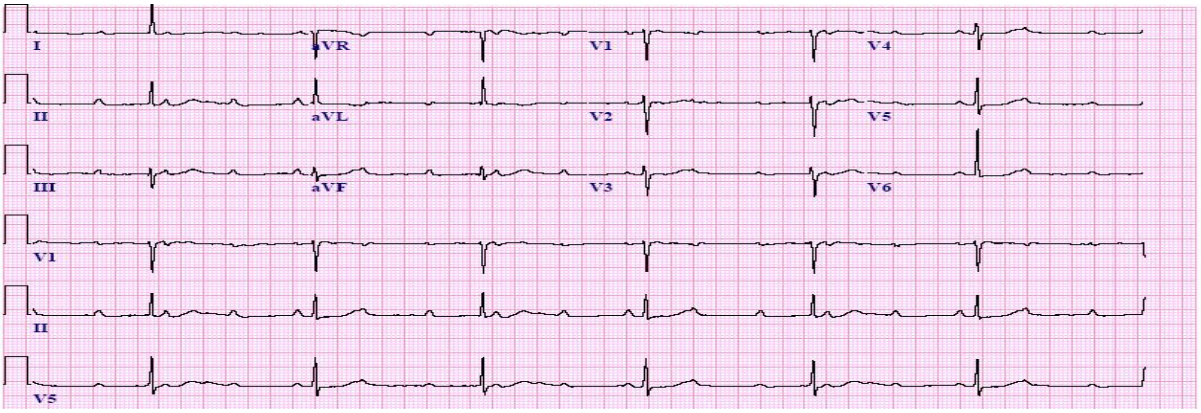


Interpretation:

- Important finding:
  Widespread ST elevation with PR segment depression.
  In AVR lead there is reciprocal changes (ST depression + PR segment elevation). Knuckle sign (aVR).

- Diagnosis:
  Acute pericarditis.

7-year-old with Hx of syncope

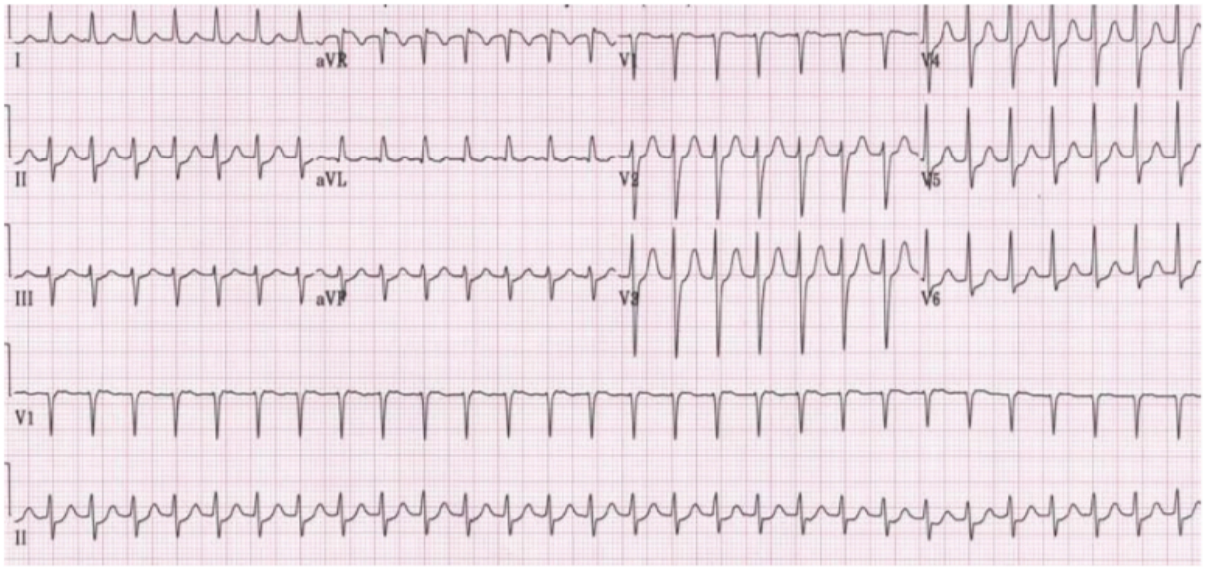


Interpretation:

- Important finding:
  Regular rhythm.
  Bradycardia.
  The P wave with a regular P-to-P interval.
  The QRS complex with a regular R-to-R interval.
  The PR interval will Be variable.
  As the hallmark of complete heart block is lack of any apparent relationship between P waves and QRS complex. AV dissociation.

- Diagnosis:
  3rd degree heart block (complete heart block).

32-year-old male with Hx of SOB + Palpitation for 1 hour

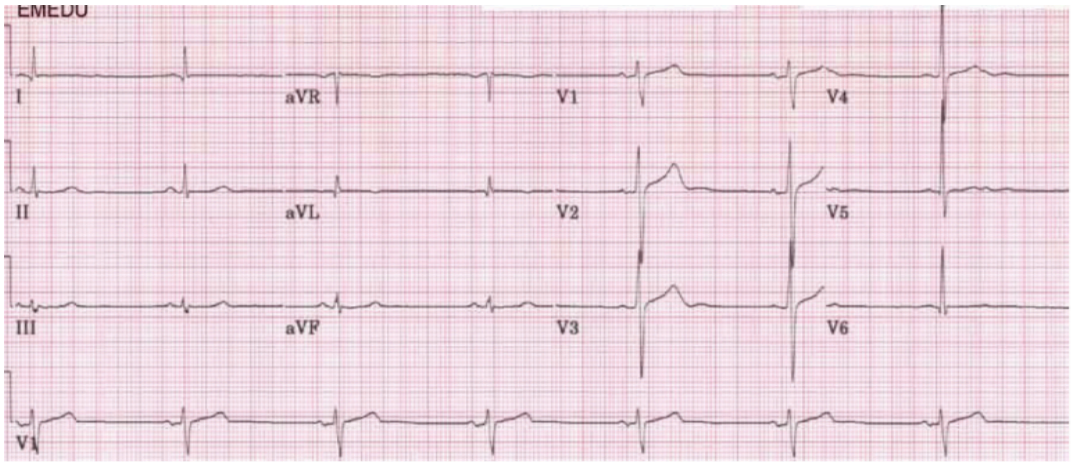


Interpretation:

- Findings:
  Regular tachycardia.
  Absent P wave.
  Normal QRS complex.

- Diagnosis:
  SVT.

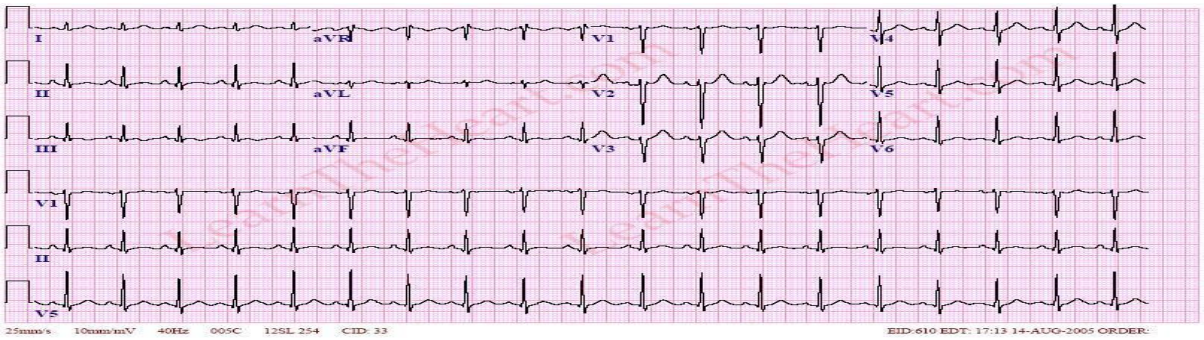
64 years old with Hx of dizziness for 6 hours



Interpretation:

- Diagnosis:
  Sinus bradycardia.

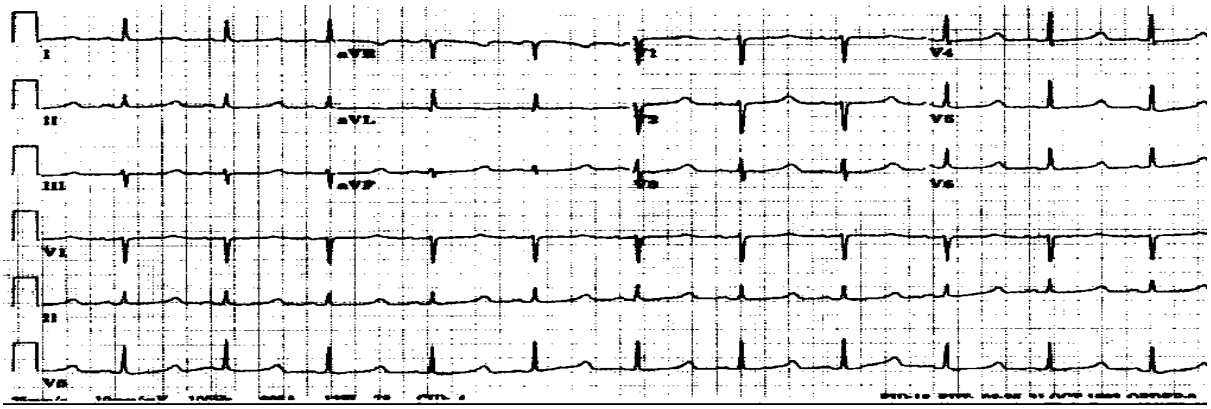
63 years old lady with Hx of SOB for 3 weeks Skipped



Interpretation:

- Diagnosis:
  Sinus tachycardia.

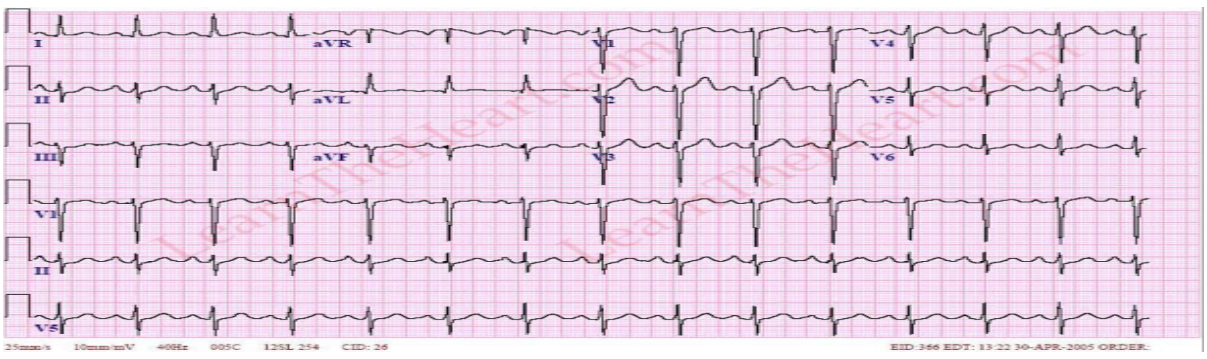
29 y old male with Hx of syncope 4 days ago Skipped



Interpretation:

- Findings:
  Long QT interval.

52 y old male pre-op ECG. Skipped



Interpretation:

- Findings:
  Normal sinus rhythm with a first-degree AV block