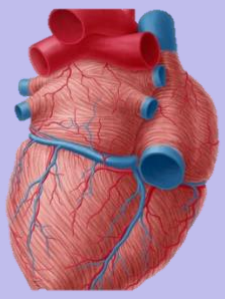
ESSEX MEDICAL SOCIETY



A GENERAL PRACTITIONER'S GUIDE TO INTERPRETING ECGS

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Introduction

This is a brief and simple guide on how to interpret ECGs.

The key to interpreting an ECG is to use a system when looking at each image. This will ensure that no important details are missed.

This guide will briefly go through a basic system that can be used to interpret any ECG,
and this will be followed by a variety of common ECGs.
Each image will be followed by a diagnosis and description of the underlying condition.

The basics of interpreting an ECG

The interpretation of any ECG should start by confirming the patient's identity, time and date of the ECG, and whether the patient experienced any chest pain when the ECG was taken.

This should be followed by checking the calibration of the ECG. The standard speed setting is 25mm/second. This means that 5 large squares (25 small squares) are equal to one second. Every small square is equal to 40 milliseconds, and the rhythm strip at the bottom of the ECG is taken over a period of 10 seconds. The voltage should be set to 1mV = 10mm (1mV = 2 large squares). Knowing these values is important when interpreting the characteristics of the ECG.

Rhythm and Rate

- Firstly, look at the ECG and decide whether there is an equal distance between each of the QRS complexes.
    - If so then the rate is regular, if not the rate is described as irregular.
    - If the rate is regular and a P wave precedes every QRS complex then the rhythm can be described as sinus rhythm.
- If the rhythm is regular then the rate can be calculated by the following equation:
    - Rate = 300/Number of large squares between each QRS complex
- If the rhythm is irregular then the rate can be calculated by the following equation:
    - Rate = 6 x Number of QRS complexes found in the rhythm strip.
- If the rate is < 60 bpm the patient is bradycardic. If the rate is > 100 bpm the patient is tachycardic.

Cardiac Axis

- Cardiac axis gives us an idea of the direction of the electrical flow through the heart muscle.

- The easiest way to evaluate this is by looking at leads I and aVF.
    - If the QRS complexes are positive in both then there is no axis deviation.
    - If the QRS complex in lead I is negative and aVF is positive, then there is right axis deviation.
    - If the QRS complex in lead I is positive and aVF is negative then there is left axis deviation.

- Left axis deviation can be normal up to -30º.

- If a patient is found to have left axis deviation also look at lead II.
    - If lead II is positive then the axis deviation is within normal limits.

- if lead II is negative then the left axis deviation is pathological.

P wave

- The P wave is created by depolarisation of the atria. Look for the presence of a P wave, and its characteristics.

- If P waves are not present the atria are not contacting normally

    - The most likely cause is atrial fibrillation (this would also have an irregularly irregular rhythm).

- If the P waves are peaked (p-pulmonale), this is a sign of right atrial hypertrophy, and if they are bifid (p-mitale), this is a sign of left atrial hypertrophy.

P-R interval

- This is measured from the start of the P-wave to the start of the QRS complex.

- The P-R interval should be between 120-200ms (3-5 small squares).
    - If it is < 120ms then there may be an accessory pathway present such as in Wolf-Parkinson-White syndrome.
    - If it is > 200ms then the patient has a degree of heart block.

Q wave

- A Q wave is any negative deflection that precedes the R wave.

- Pathological Q waves are classed as being > 2mm deep and > 1mm wide.
    - The most common cause is an old full thickness myocardial infarction.

QRS complex

- The QRS complex is created by depolarisation of the ventricle.
    - Normally it should be narrow (< 120ms or < 3 small squares).
    - If the QRS complex is wide, this could be due to a beat originating from the ventricles, or due to bundle branch block.
    - If the QRS complex is large (deepest S wave in V1 + tallest R wave in V5 or V6 > 35mm), this indicates left ventricular hypertrophy.
    - If the QRS complexes are small (<10mm in all chest leads), it could indicate a pericardial effusion.

ST segment

- This is from the end of the QRS complex to the end of the T wave, and is used to identify ischaemia.

- In an acute myocardial infarction the first sign of ischaemia is tall hyper-acute T waves.
  - This is followed by T wave inversion and ST depression or ST elevation.

- The diagnostic criteria for an STEMI is ST elevation of > 2mm in two consecutive chest leads (V1-V6) or > 1mm in two or more of the inferior leads (leads I, II and aVF).
  - In a STEMI reciprocal ST depression is often seen.

- The main abnormalities seen in a non- ST elevation myocardial infarction (NSTEMI) are;
  - ST segment depression or T wave inversion/flattening.

- The table below summaries how the ECG leads correspond to the vascular territories of the heart.

Type of myocardial infarction	Leads affected	Most common vessel affected
Anterior	V1-V4	Left anterior descending
Lateral	V5,V6,I,aVL	Circumflex
Anterio-lateral	V1-V6, I, aVL	Left main coronary artery
Inferior	II, III, aVF	Right coronary artery

QT interval

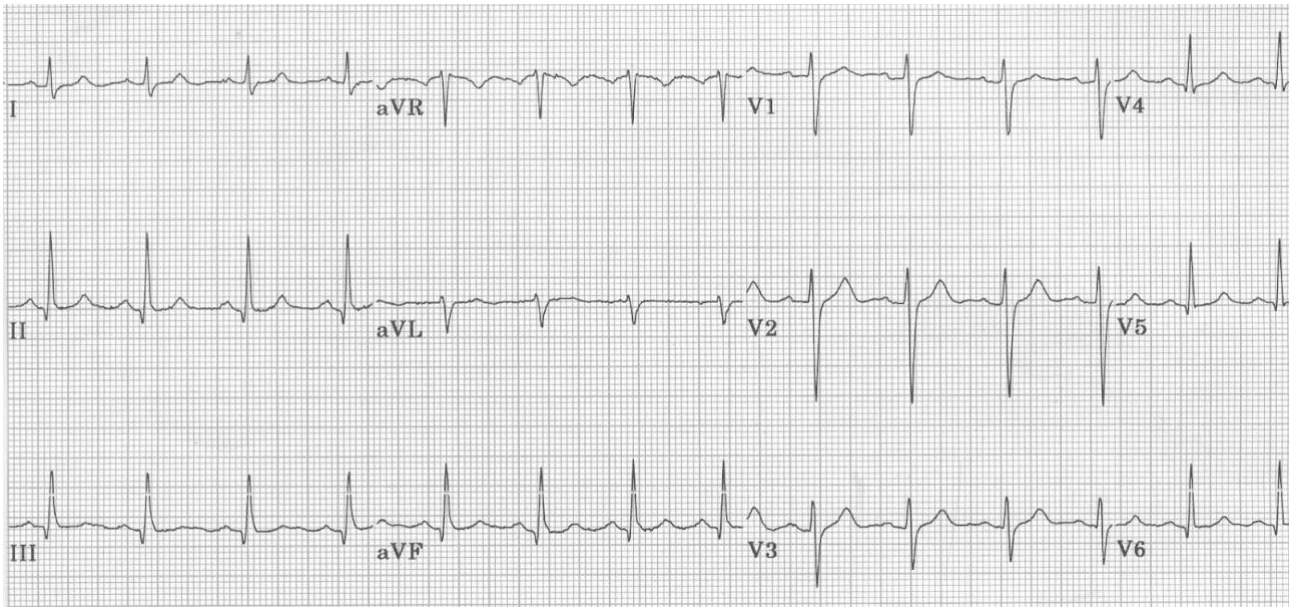
- The QT interval is measured from the Q wave to the end of the T wave.

- The QTc calibrates the QT interval by accounting for the patient's heart rate.

  - If the QTc > 440ms in males, or QTc > 460ms in females it is seen as prolonged.

  - If the QTc > 500ms, patients are at a high risk of torsades de pointes (a dangerous polymorphic ventricular tachycardia).

ECG 1



Diagnosis: Normal ECG

This ECG shows:

. Normal calibration

. Sinus rhythm

. Rate of 72 bpm

. Normal cardiac axis

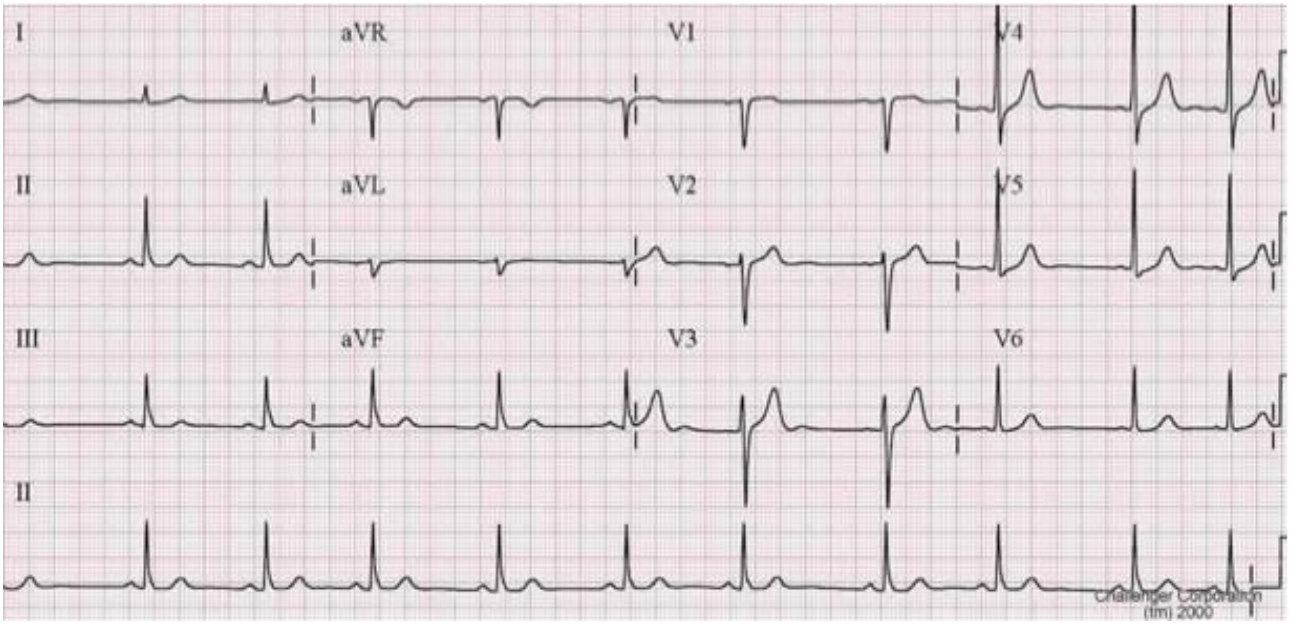
. P waves are present and of normal morphology

. P-R interval is ≈160ms (< 200ms)

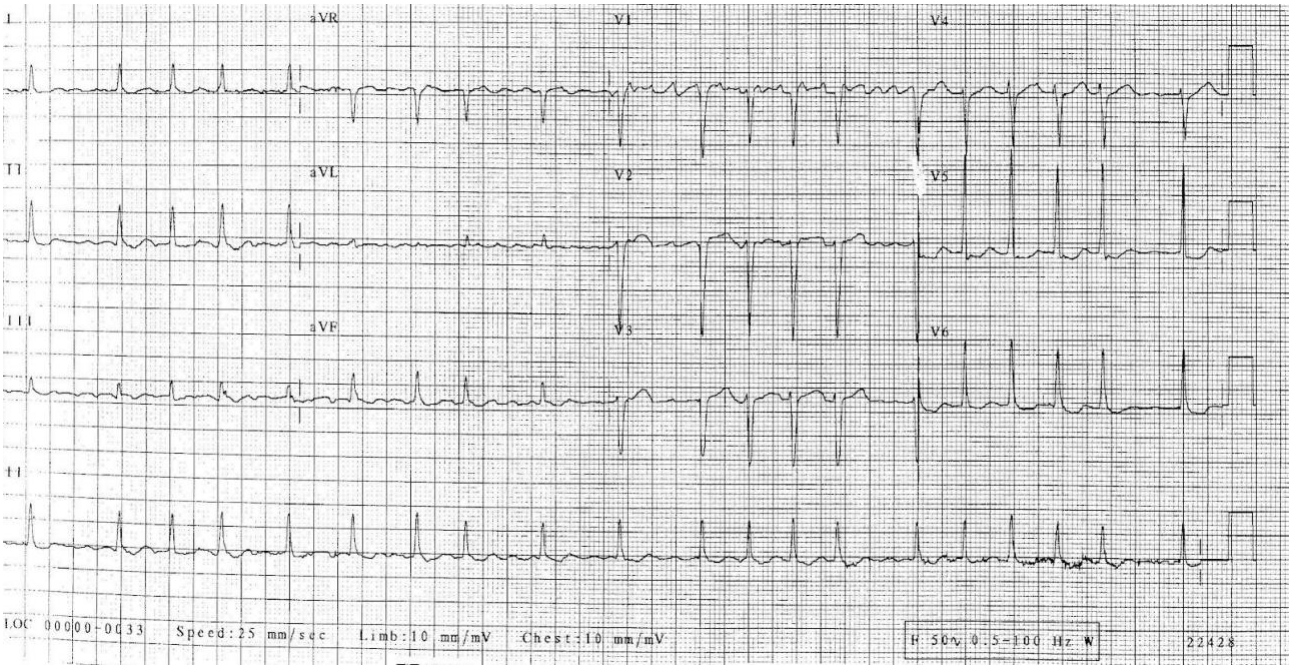
. QRS complex is narrow < 120ms

. There are no ST segment changes.

- Sometimes there may be slight variations in the distance between the QRS complexes.
    - This is due to changes in heart rate that are caused by inspiration and expiration.
    - It is a normal variant and known as sinus arrhythmia. An example is shown below:


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

ECG 2


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00000-0033
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
22428

Diagnosis: Atrial fibrillation

This ECG shows:

. Normal calibration

. Rhythm is irregularly irregular

. Rate is 120bpm

. P waves are absent

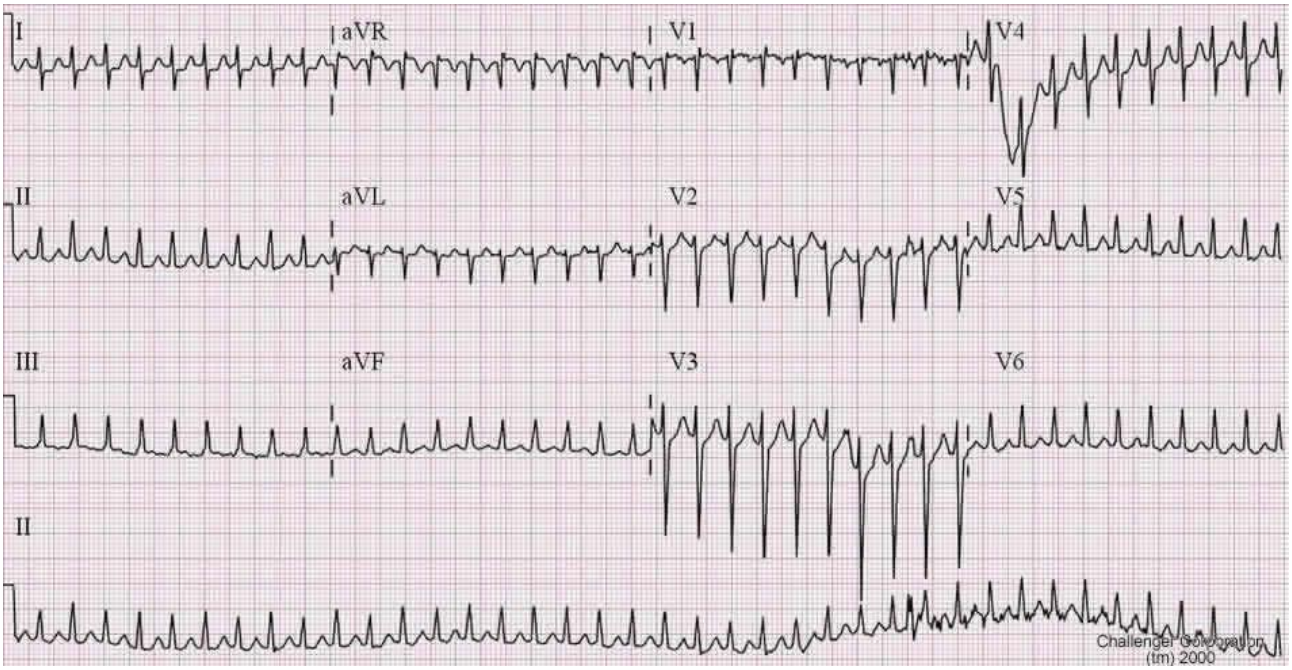
. QRS complex is narrow (<120ms)

. There are no ST segment changes

- The combination of an irregularly irregular rhythm and absence of P waves makes this atrial fibrillation (AF).

- This patient is tachycardic and therefore this should be described as having fast AF or AF with a rapid ventricular response.

ECG 3



Diagnosis: Supraventricular tachycardia (SVT)

This ECG shows:

. Normal calibration

. Rhythm is regular

. Rate is 234bpm

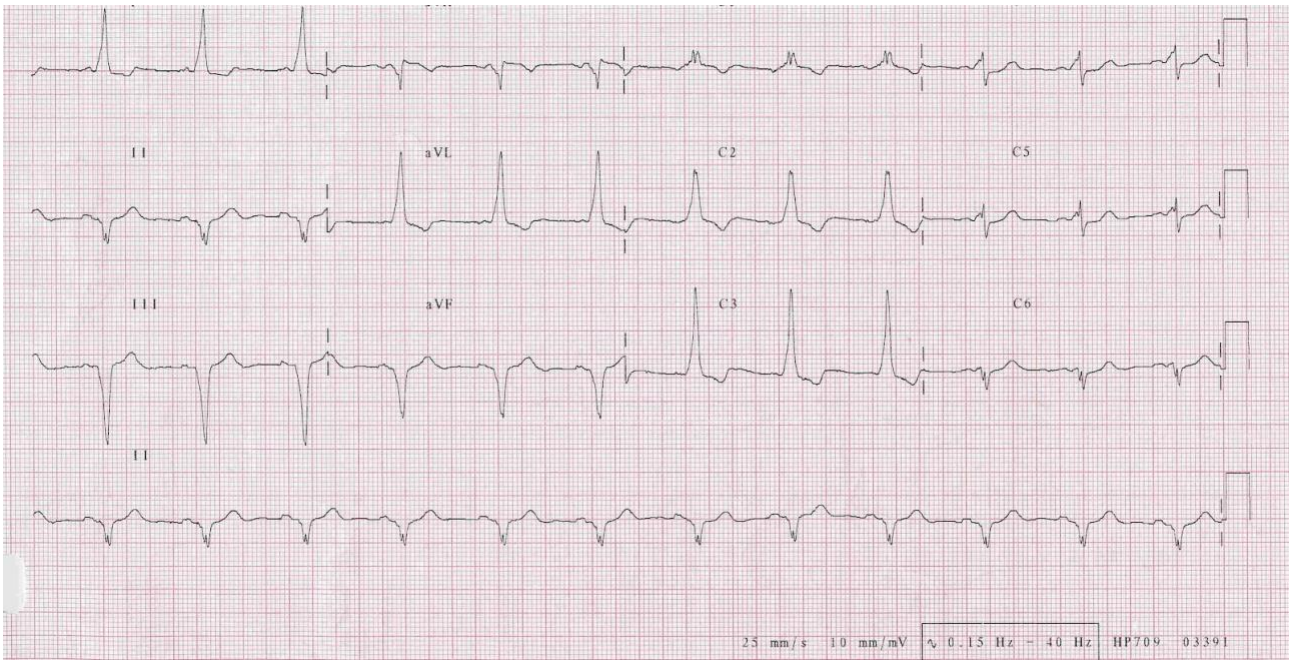
. P waves are absent

. QRS complex is narrow

. There are no ST segment changes

- This is a regular narrow complex tachyacardia, with no P waves.
    - Therefore this is a junctional or AV-node re-entry tachycardia.

ECG 4


I
aVL
C2
C5
III
aVF
C3
C6
II
25 mm/s 10 mm/mV 0.15 Hz - 40 Hz HP709 03391

Diagnosis: Wolf-Parkinson-White (WPW)

This ECG shows:

. Normal calibration

. Rhythm is regular

. Rate is 72 bpm

. Left axis deviation

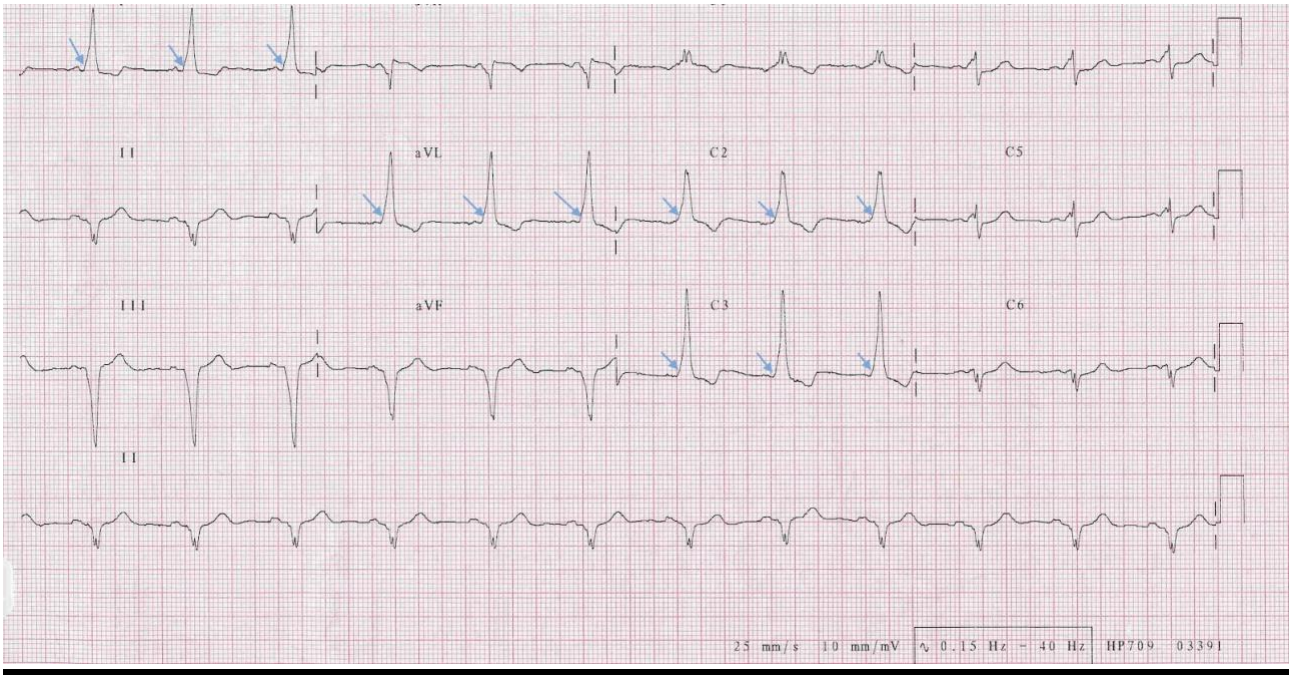
. Short P-R interval of 100ms (<120ms)

. Slurred upstroke towards the QRS known as a Delta wave

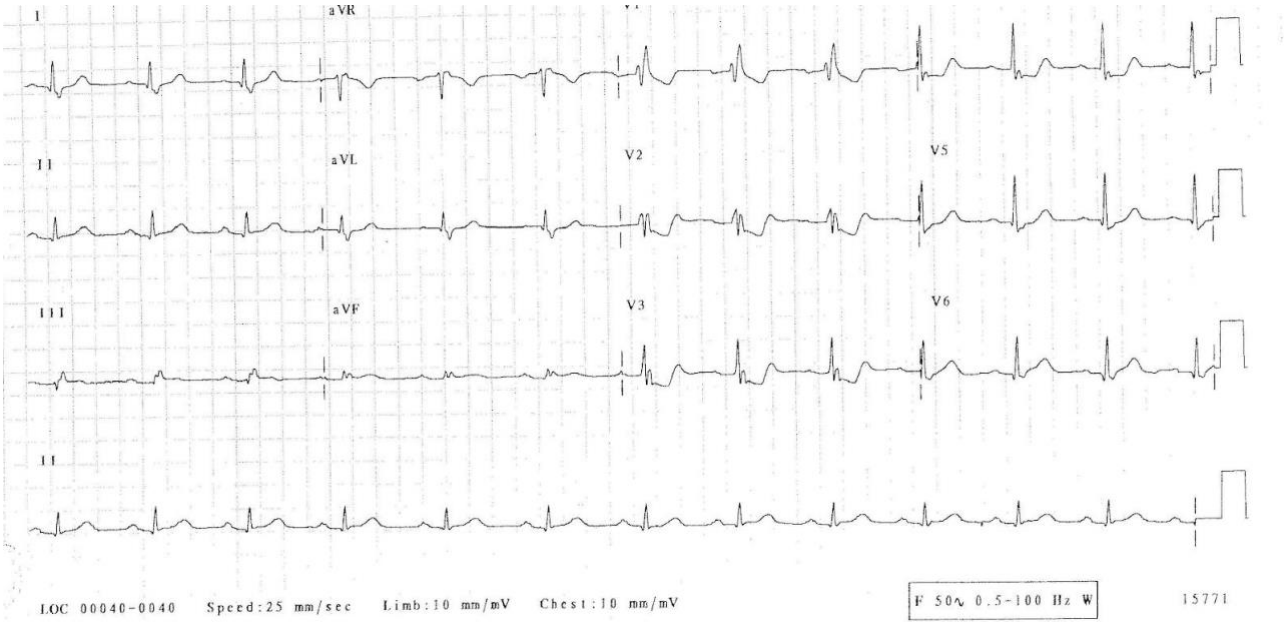
. Widened QRS complex (occurs as a result of the delta waves)

. ST depression in leads I, aVL, V1-V3

- The presence of a short P-R interval and delta waves make this WPW.
- In the ECG below, arrows point towards the delta waves.


I
aVL
C2
C5
III
aVF
C3
C6
II
25 mm/s 10 mm/mV 0.15 Hz - 40 Hz HP709 03391

ECG 5


I
aVR
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
15771

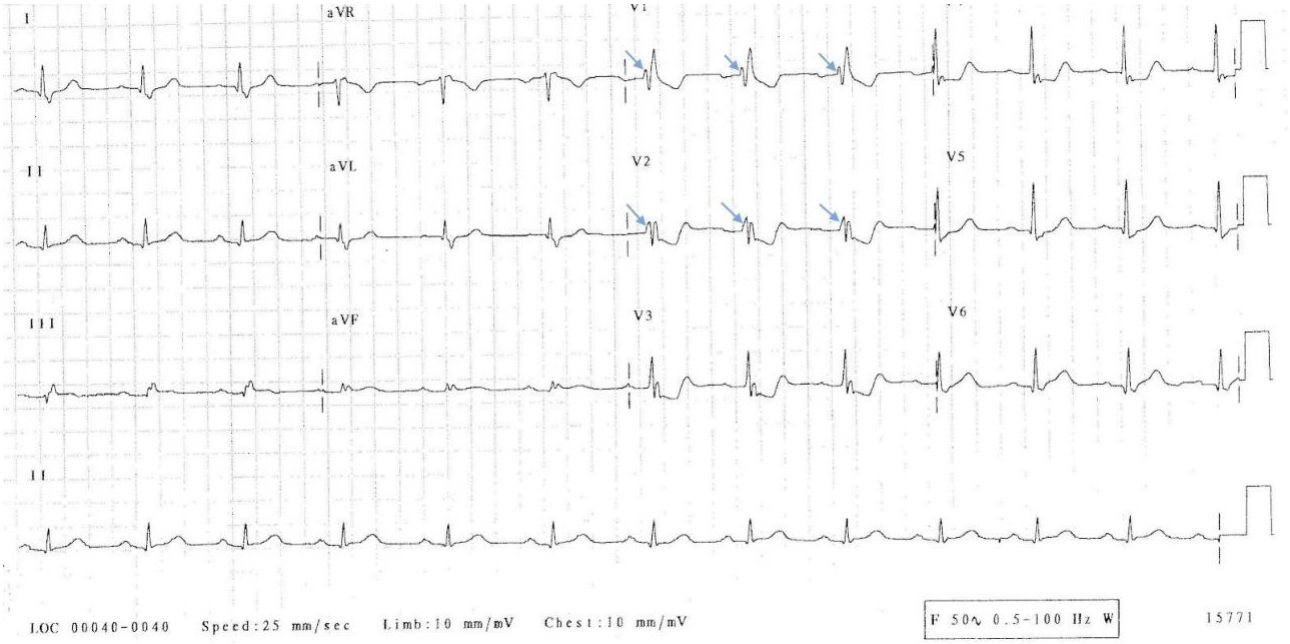
Diagnosis: Right bundle branch block (RBBB)

This ECG shows:

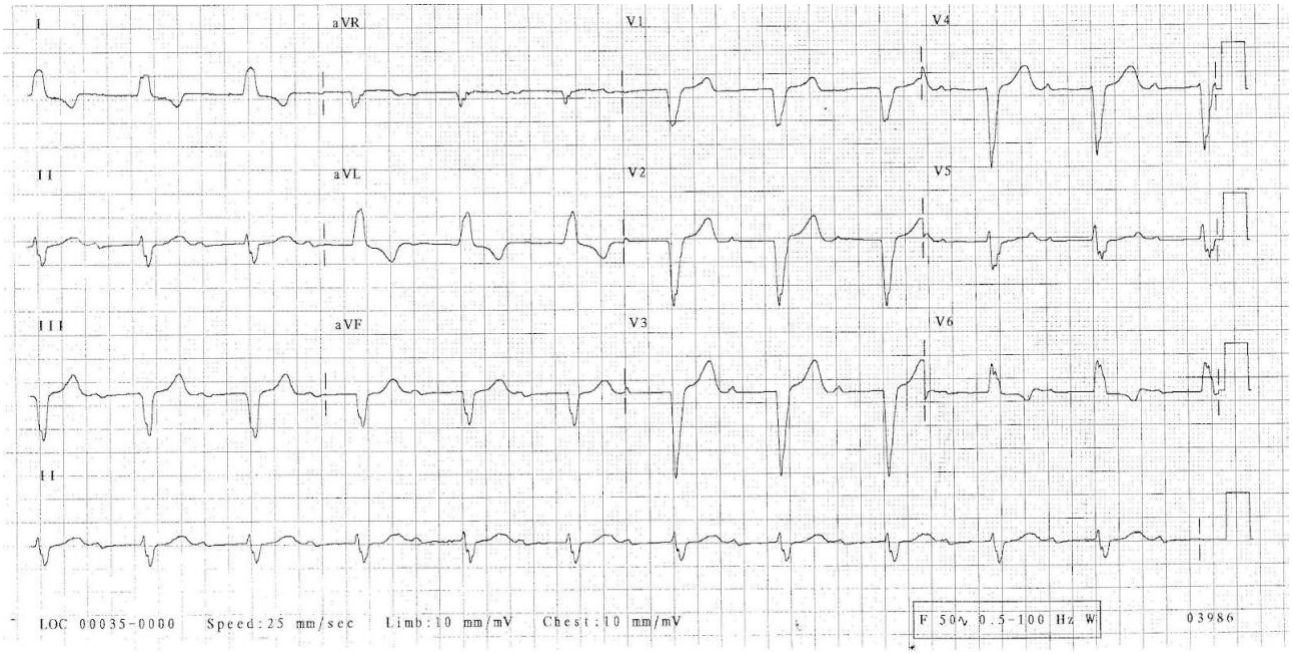
- Normal calibration
- Rhythm is regular
- Rate is 72bpm
- QRS complex is widened (>120ms)
- QRS complex has an ‘M’ shaped morphology is V1 and V2, and a ‘W’ shaped morphology in V5 and V6

- A widened QRS complex with an RSR pattern (M shaped morphology) in V1 and V2, along with a wide, slurred S wave in V5 and V6 (W shaped morphology) means this is RBBB.

- In the ECG below arrows point to the RSR pattern.


I
aVR
V1
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
15771

ECG 6


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00035-0000 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
03986

Diagnosis: Left bundle branch block (LBBB)

This ECG shows:

. Normal calibration

. Rhythm is regular

. Rate is 66bpm

. Left axis deviation

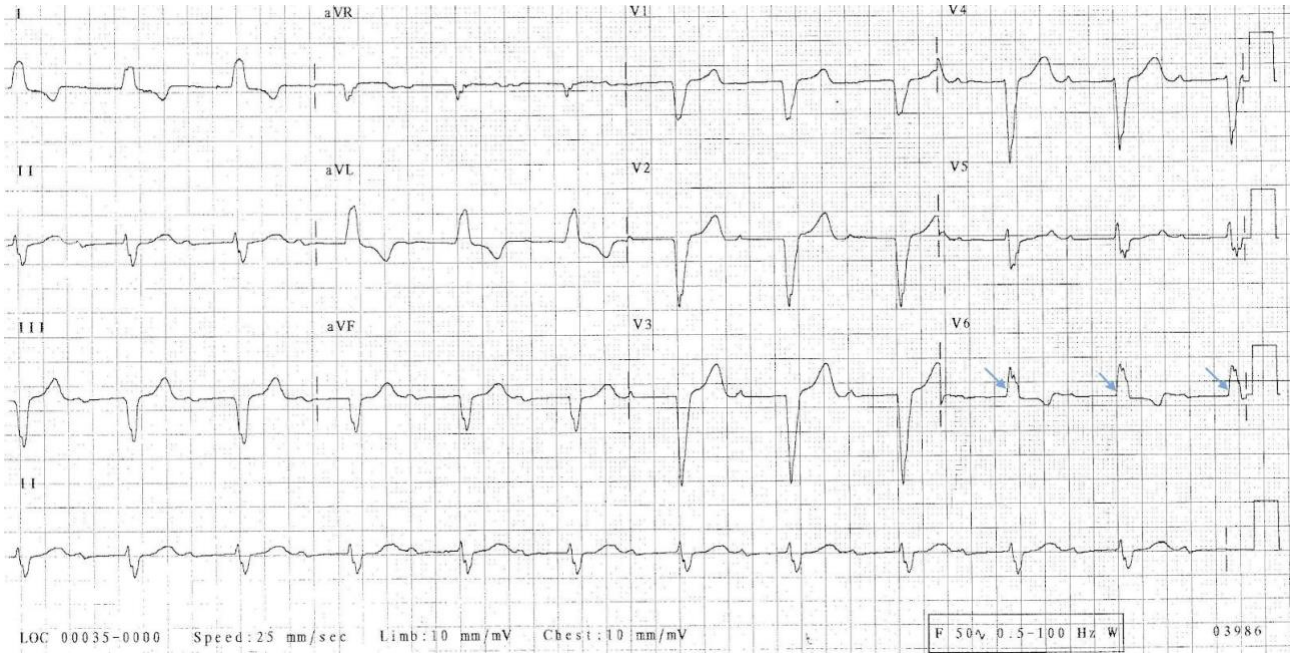
. QRS complex is widened (>120ms)

. QRS complex has an ‘W’ shaped morphology is V1 and V2, and a ‘M’ shaped morphology in V5 and V6

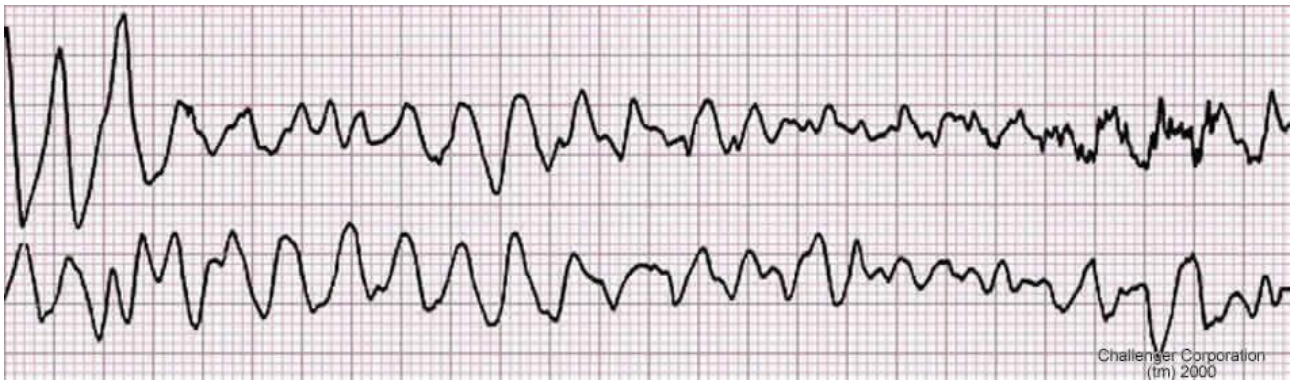
. T wave inversion in V6, lead I and aVL

- A widened QRS complex with an W shaped morphology in V1 and V2, along with a wide QRS with an M shaped morphology in V5 and V6 means this is LBBB.

- In the ECG below arrows point to the M shaped QRS complexes.


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00035-0000
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
F 50Hz 0.5-100 Hz W
03986

ECG 7



Diagnosis: Ventricular fibrillation (VF)

This ECG shows:

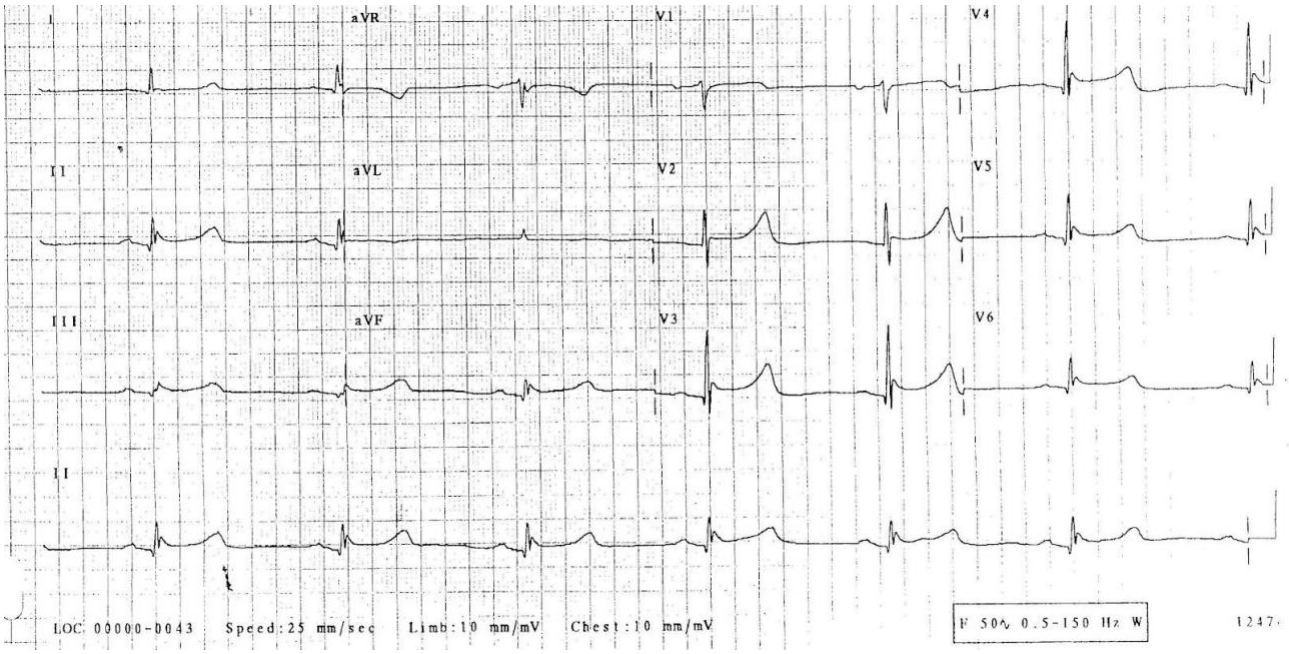
. Rhythm is irregular

. Rate is 200-400bpm

. No identifiable P waves, QRS complexes or T waves

- This ECG shows chaotic electrical activity of varying amplitude and is know as VF.

ECG 8


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00000-0043
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
F 50∿ 0.5-150 Hz W

Diagnosis: hypothermia

This ECG shows:

. Normal calibration

. Rhythm is regular

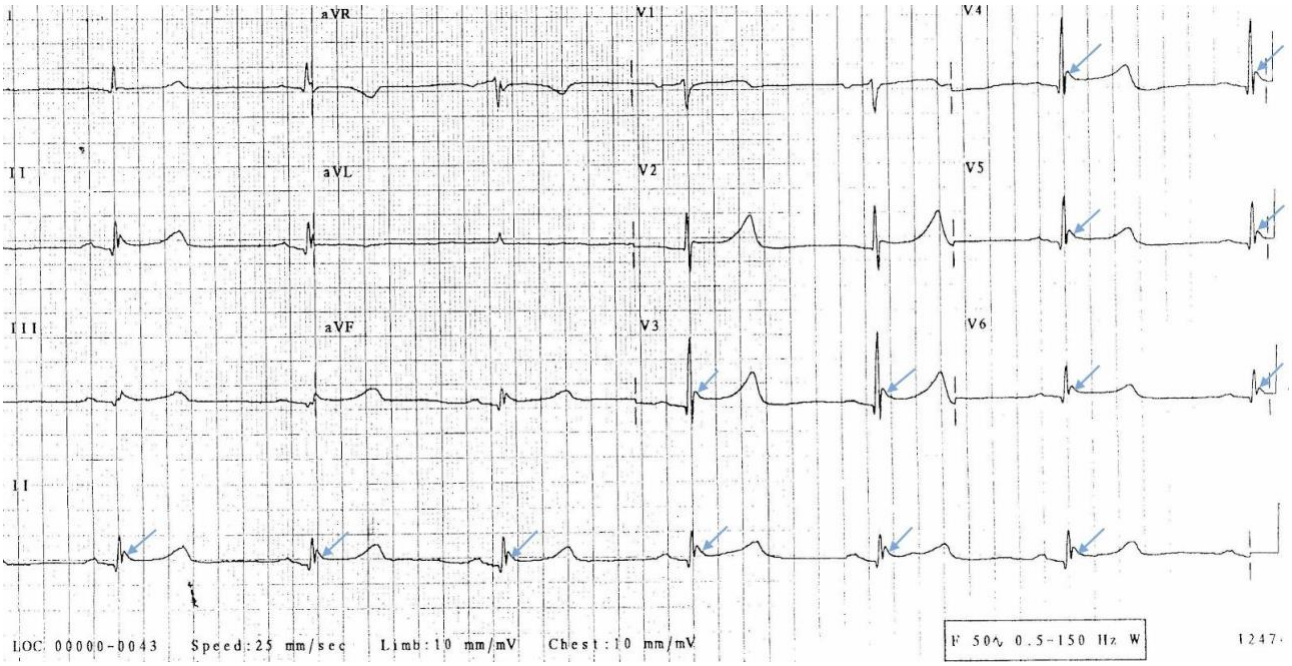
. Rate is 36bpm

. Prolonged P-R interval (>200ms)

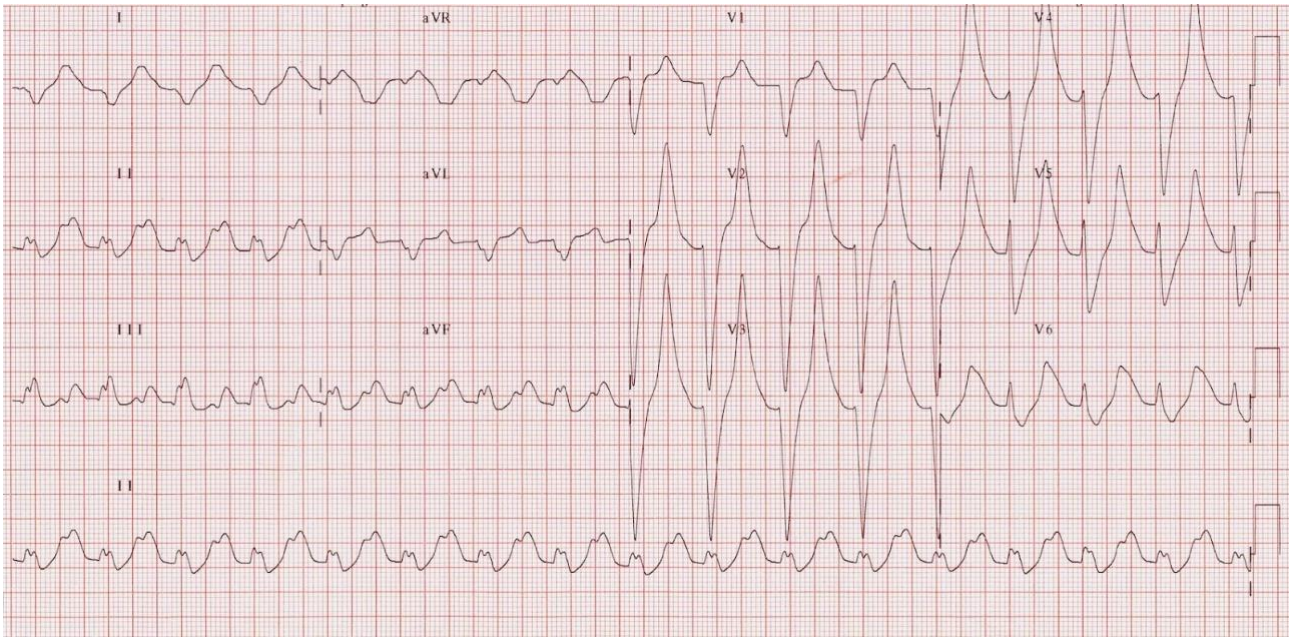
. QRS complex is narrow, but followed by a J wave

. Prolonged QTc

- ECG findings in hypothermia include bradycardia, prolonged P-R interval, J waves and a prolonged QTc. J waves (also known as Osborn waves) are upward deflections seen after the QRS complex.
    - In the ECG below arrows point to the J waves.


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00000-0043
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
F 50∿ 0.5-150 Hz W

ECG 9



Diagnosis: Hyperkalaemia

This ECG shows:

. Normal calibration

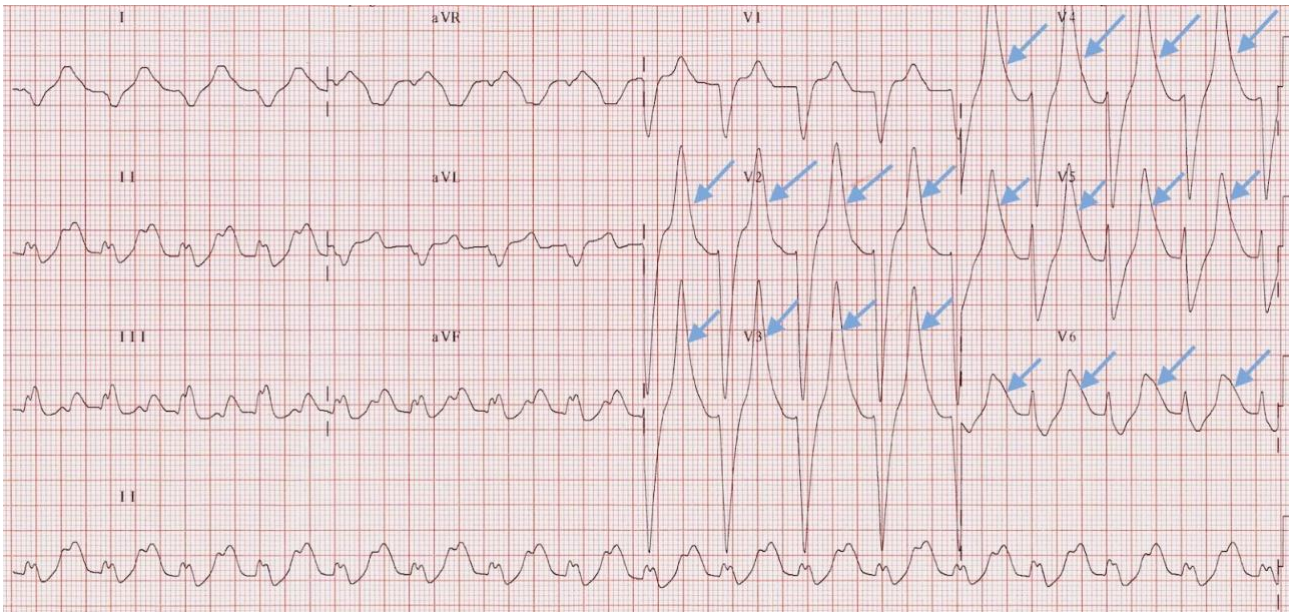
. Rhythm is regular

. Rate is 100 bpm

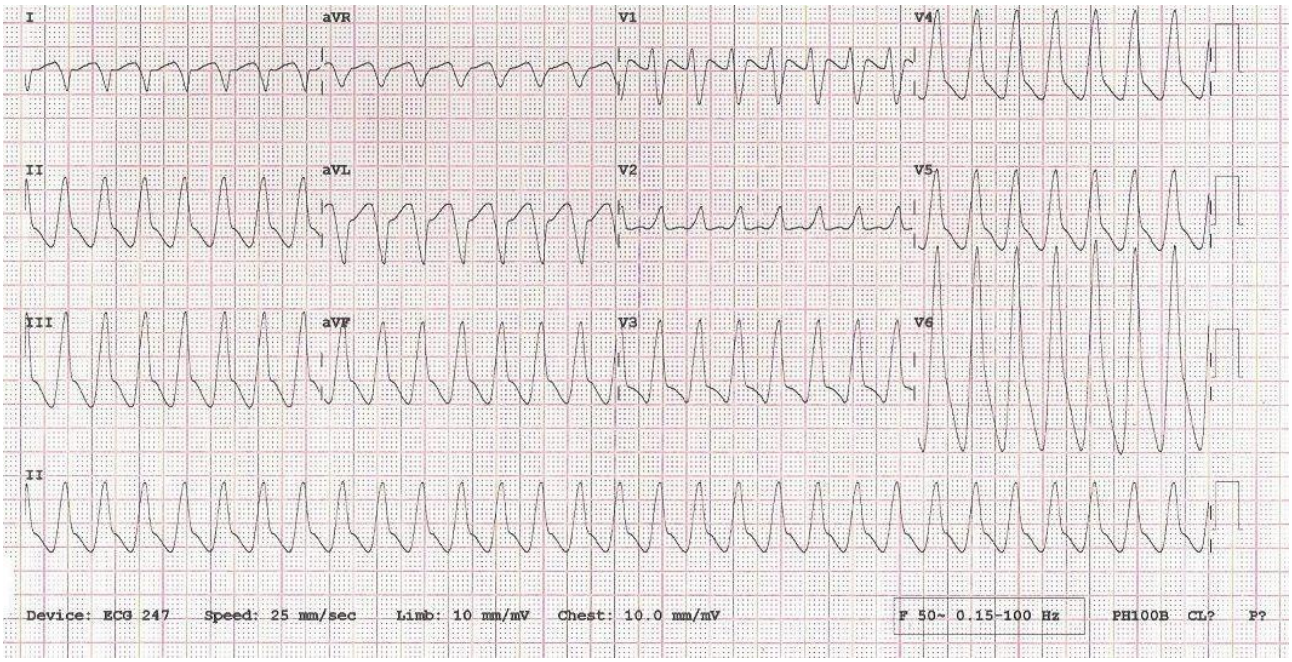
. QRS complex is wide (>120ms)

. Tall tented T waves

- Hyperkalaemia causes tall tented T waves, small P waves and a wide QRS complex, which eventually becomes sinusoidal.
    - In the ECG below arrows point towards the tall tented T waves.


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

ECG 10


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
Device: ECG 247
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10.0 mm/mV
F 50~ 0.15-100 Hz
PH100B CL? F?

Diagnosis: Ventricular tachycardia (VT)

This ECG shows:

. Normal calibration

. Rhythm is regular

. Rate is 180bpm

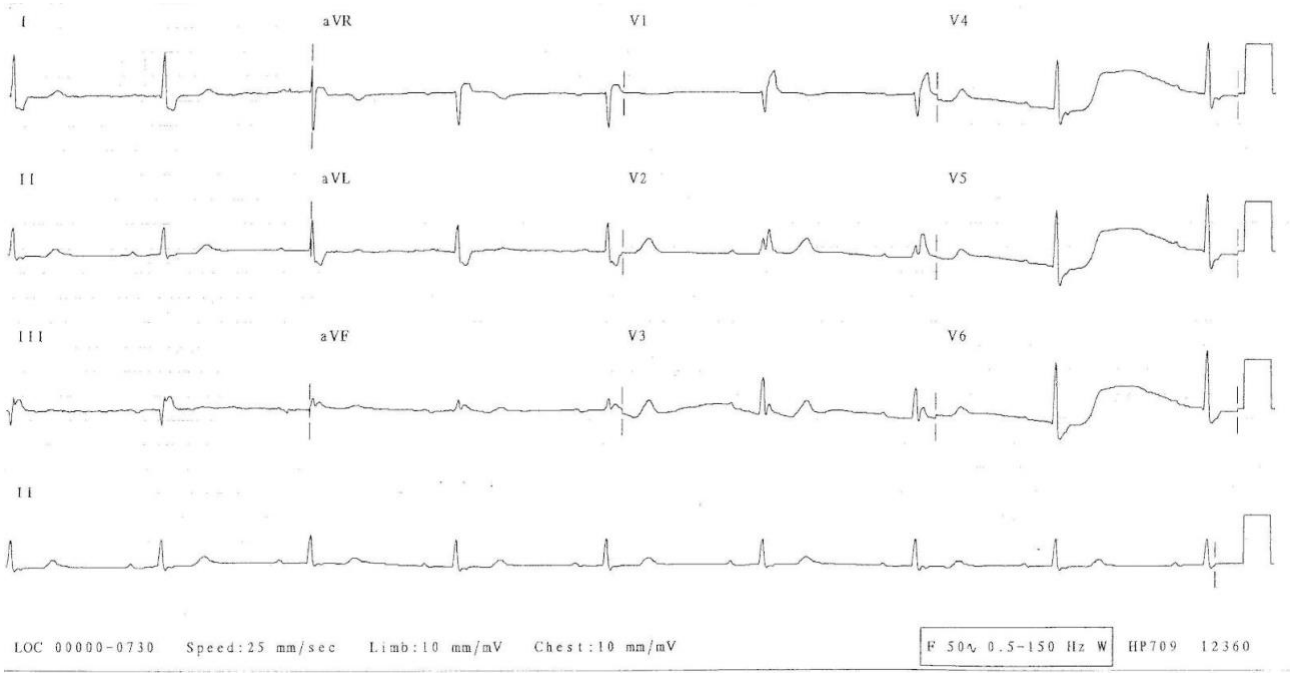
. Left axis deviation

. No P waves present

. Wide QRS complex (>120ms)

- This is a broad complex tachycardia, and therefore treated as VT until proven otherwise.

ECG 11


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00000-0730 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-150 Hz W HP709 12360

Diagnosis: First degree heart block

This ECG shows:

. Normal calibration

. Rhythm is regular

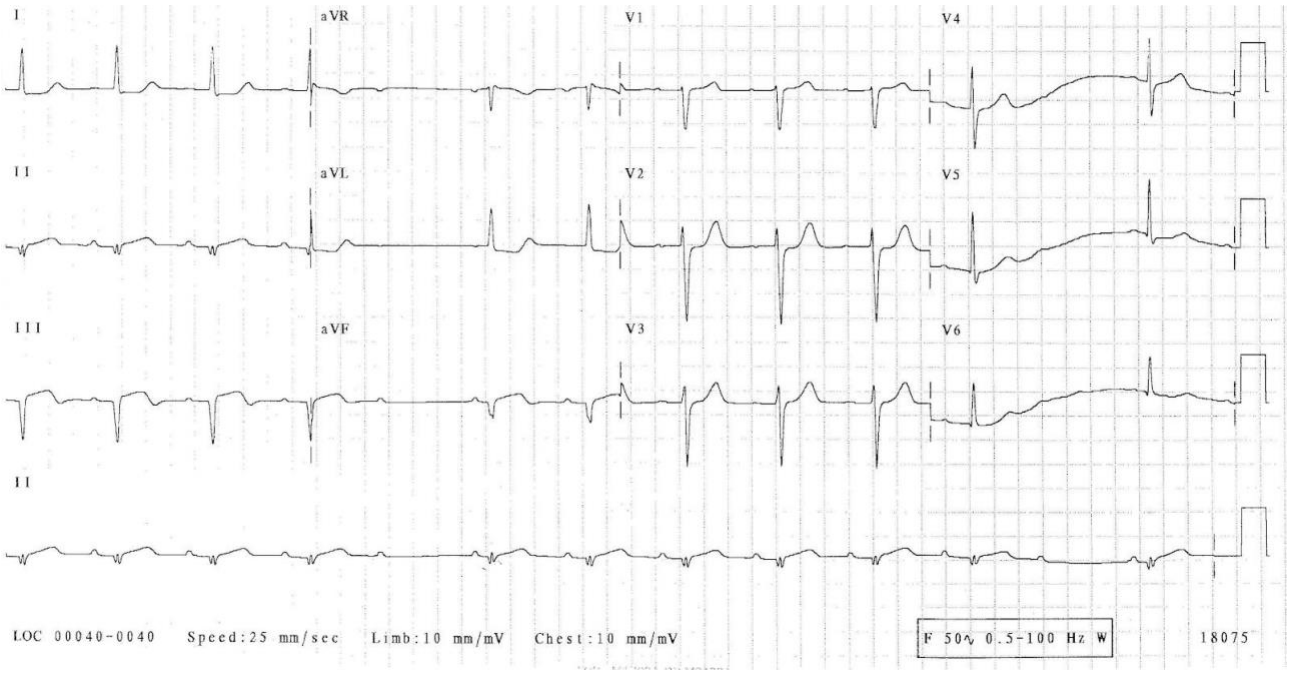
. Rate is 49bpm

. Prolonged P-R interval (>200ms)

. Narrow QRS complexes

- First degree heart block is where the P-R interval is >200ms and is constant throughout the ECG.

ECG 12


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
18075

Diagnosis: Second degree heart block Mobitz type 1

This ECG shows:

. Normal calibration

. Rhythm is irregular

. Rate is 66bpm

. Left axis deviation

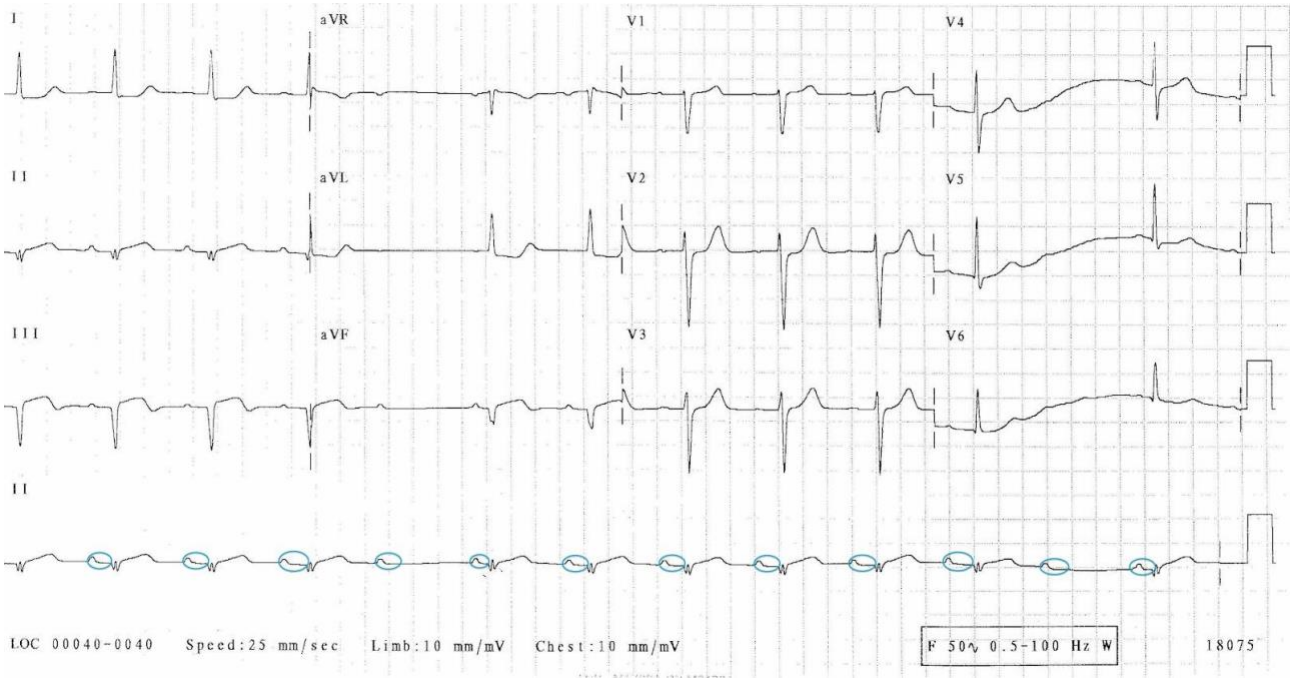
. Prolonged P-R interval (>200ms)

. Narrow QRS complexes

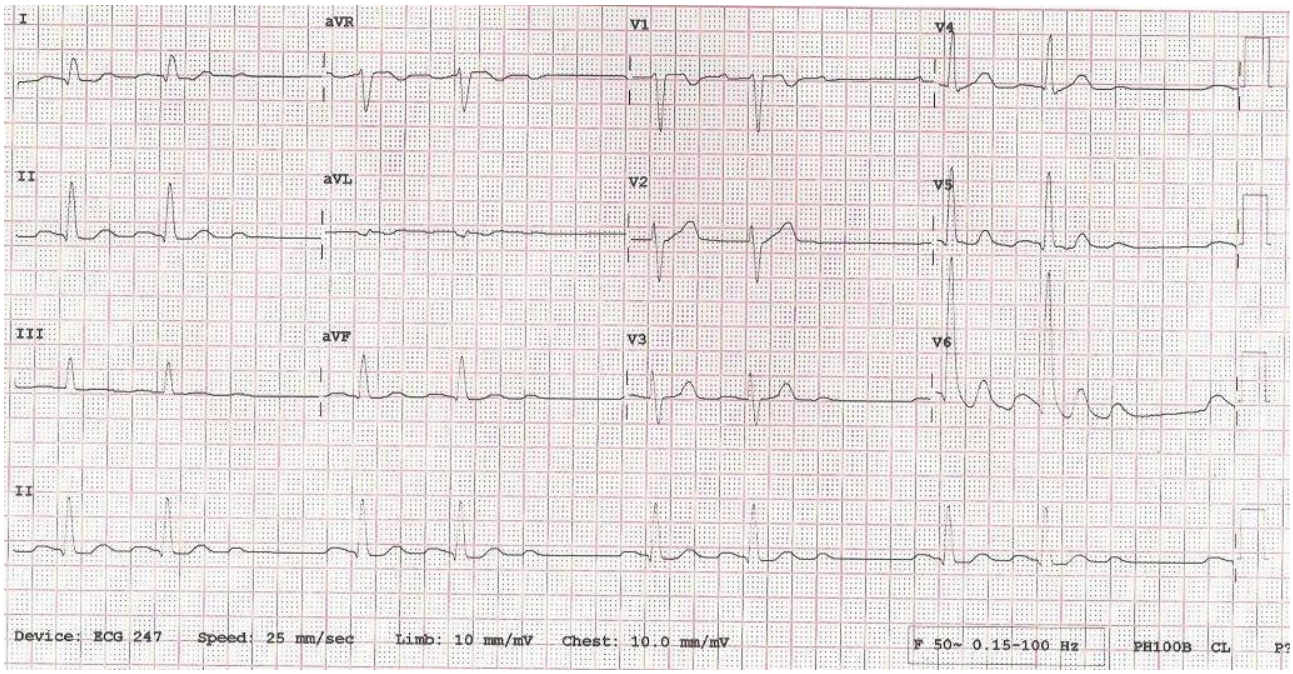
- This is second degree heart block Mobitz type 1 (also known as Wenckebach phenomenon).

- After each beat the subsequent P-R interval becomes prolonged until a QRS complex is dropped.

- In the ECG below the changes in the P-R interval and subsequent dropped QRS complex are circled.


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50∿ 0.5-100 Hz W
18075

ECG 13


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
Device: ECG 247
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10.0 mm/mV
F 50~ 0.15-100 Hz
PH100B CL

Diagnosis: Second degree heart block Mobitz type 2

This ECG shows:

. Normal calibration

. Rhythm is irregular

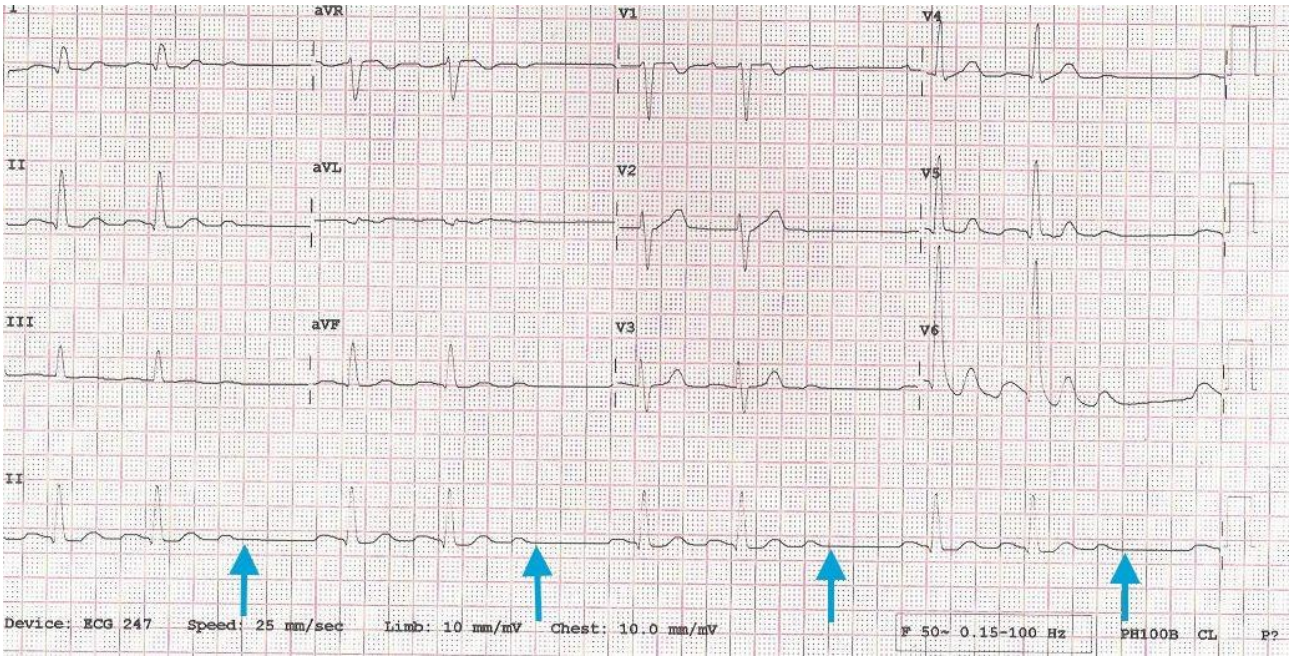
. Rate is 60bpm

. Prolonged P-R interval (>200ms)

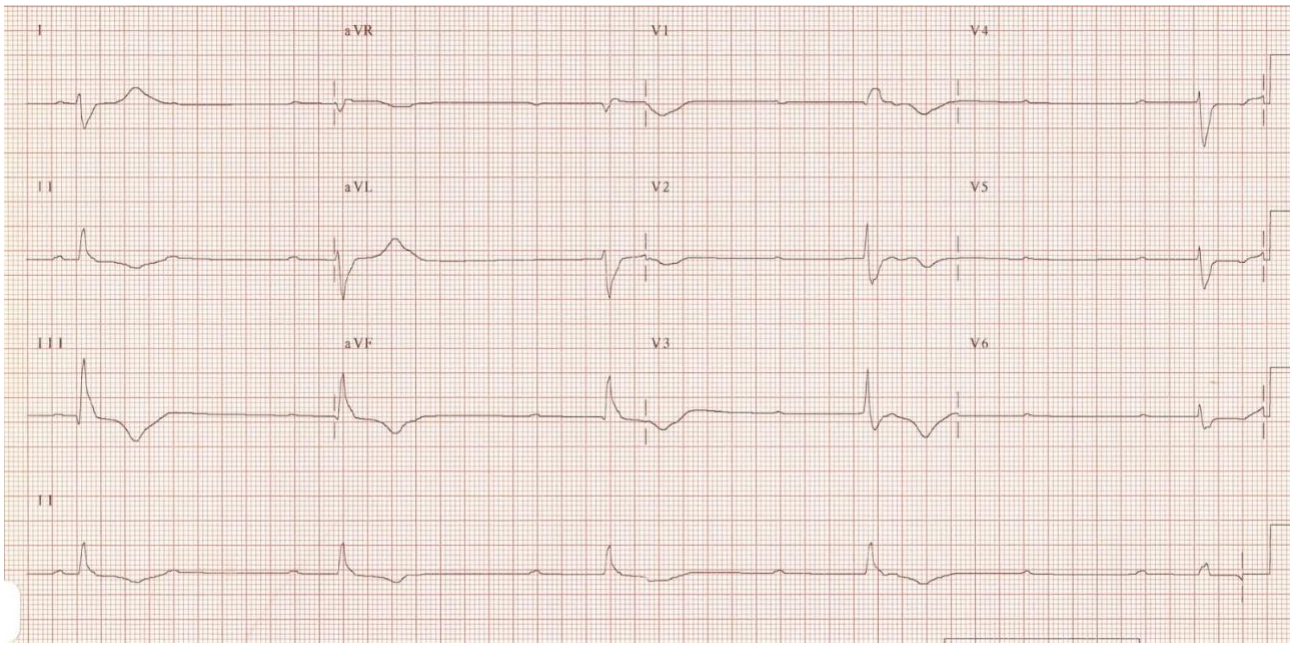
. Narrow QRS complexes

- Second degree heart block Mobitz type 2 the P waves occur at a constant rate and P-R interval remains constant.
    - There is a consistent dropping of the QRS complex.

- In the ECG below, arrows show the dropped QRS complexes.


aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
Device: ECG 247
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10.0 mm/mV
F 50~ 0.15-100 Hz
PH100B CL
P?

ECG 14



Diagnosis: Third degree heart block

This ECG shows:

. Normal calibration

. Rhythm is regular

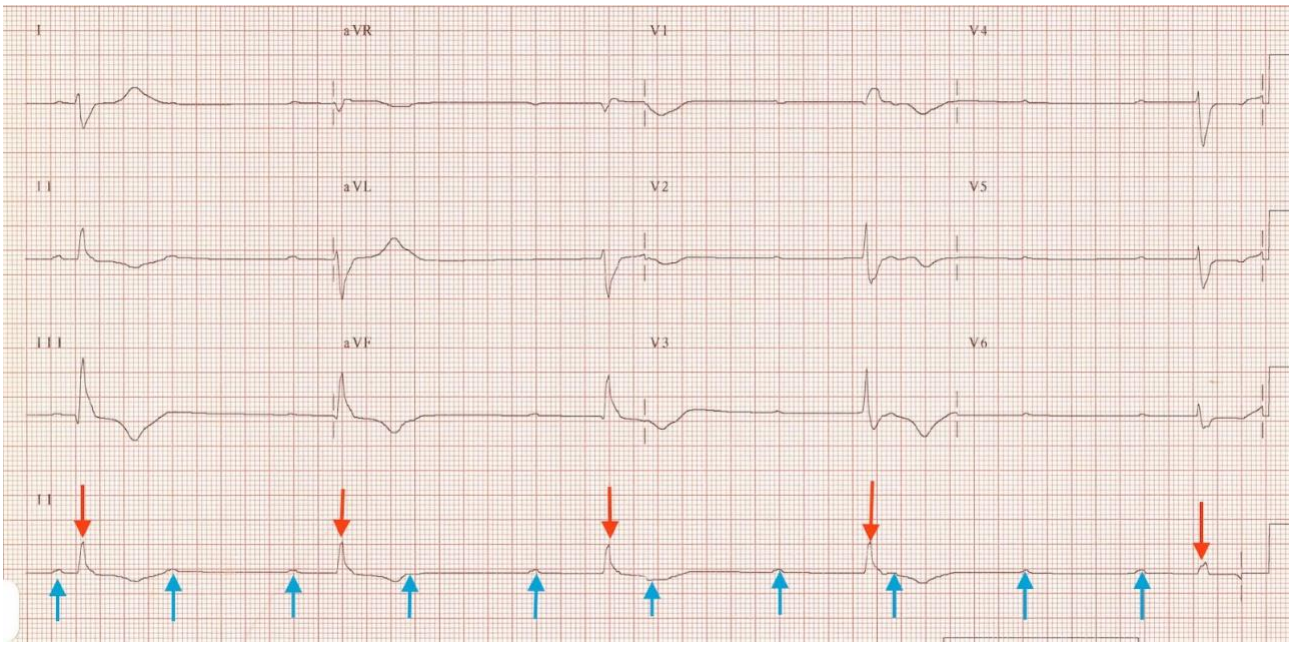
. Rate is 30bpm

. Complete dissociation of the P waves and QRS complexes

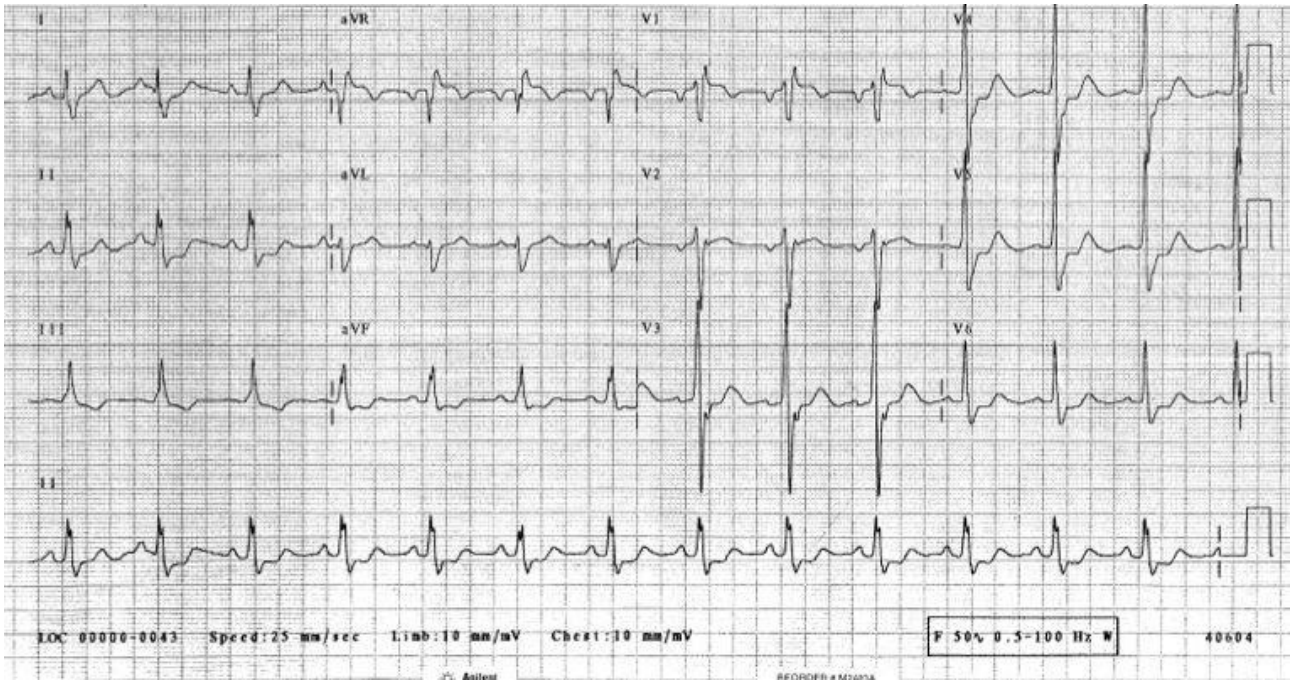
. P waves occur regularly at a rate of 60bpm, and QRS complexes regularly at 30bpm

- Third degree heart block (also known as complete heart block) is characterised by complete dissociation of the P waves and QRS complexes.

- In the ECG below the P waves are marked by a blue arrow and QRS complex by an orange arrow.


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

ECG 15


I
aVR
V1
II
aVL
V2
III
aVF
V3
II
LOC 00000-0043 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50% 0.5-100 Hz N
40604

Diagnosis: Bifascicular block

This ECG shows:

. Normal calibration

. Rhythm is regular

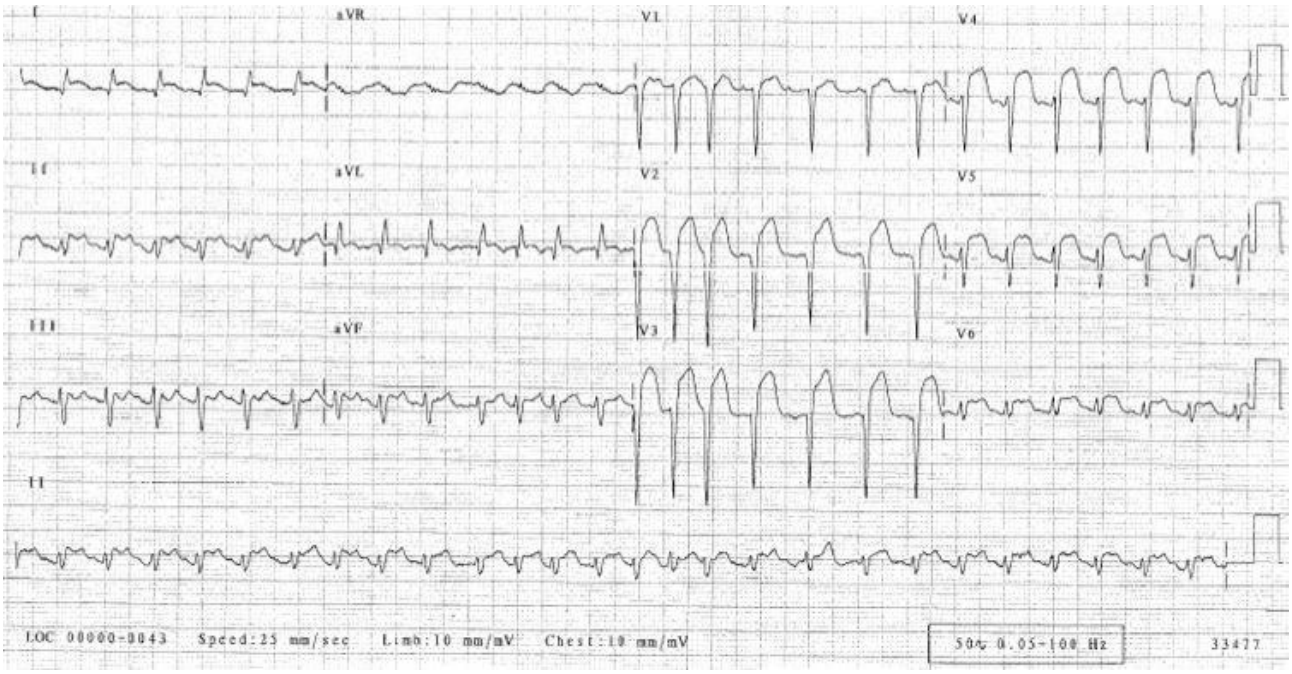
. Rate is 78bpm

. Right axis deviation

. Widened QRS (>120ms) with an M shaped morphology in V1 and V2 (RBBB)

- Bifascicular block is RBBB and either right or left axis deviation.

ECG 16


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00000-0043 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
50~ 0.05-100 Hz
33477

Diagnosis: Anterio-lateral ST elevation myocardial infarction (STEMI) and atrial fibrillation (AF)

This ECG shows:

. Normal calibration

. Rhythm is irregularly irregular

. Rate is 162bpm

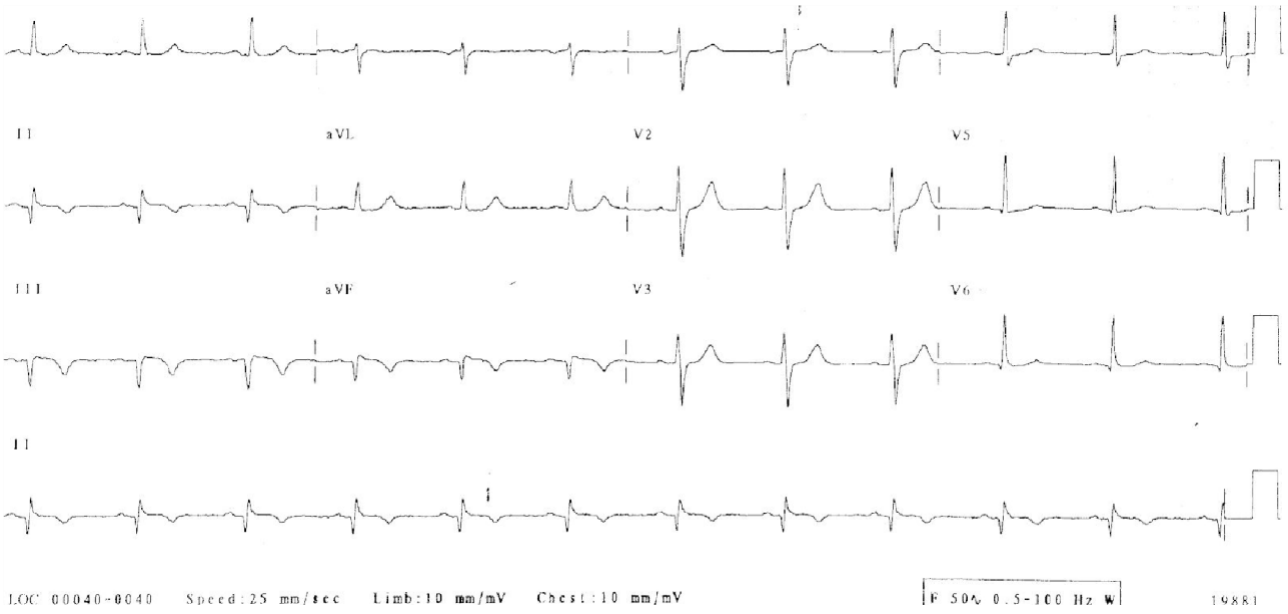
. Left axis deviation

. ST elevation in V1-V6 and lead I

. T wave inversion in aVL

- An anteriolateral ST elevation is characterised by ST elevation in the anterior leads (V1-V4) and in the lateral leads (V5,V6,lead I and aVL)

ECG 17


I
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040 Speed:25 mm/sec Limb:10 mm/mV Chest:10 mm/mV
F 50Hz 0.5-100 Hz W
19881

Diagnosis: Old inferior ST elevation infarction

This ECG shows:

. Normal calibration

. Rhythm is regular

. Rate is 72bpm

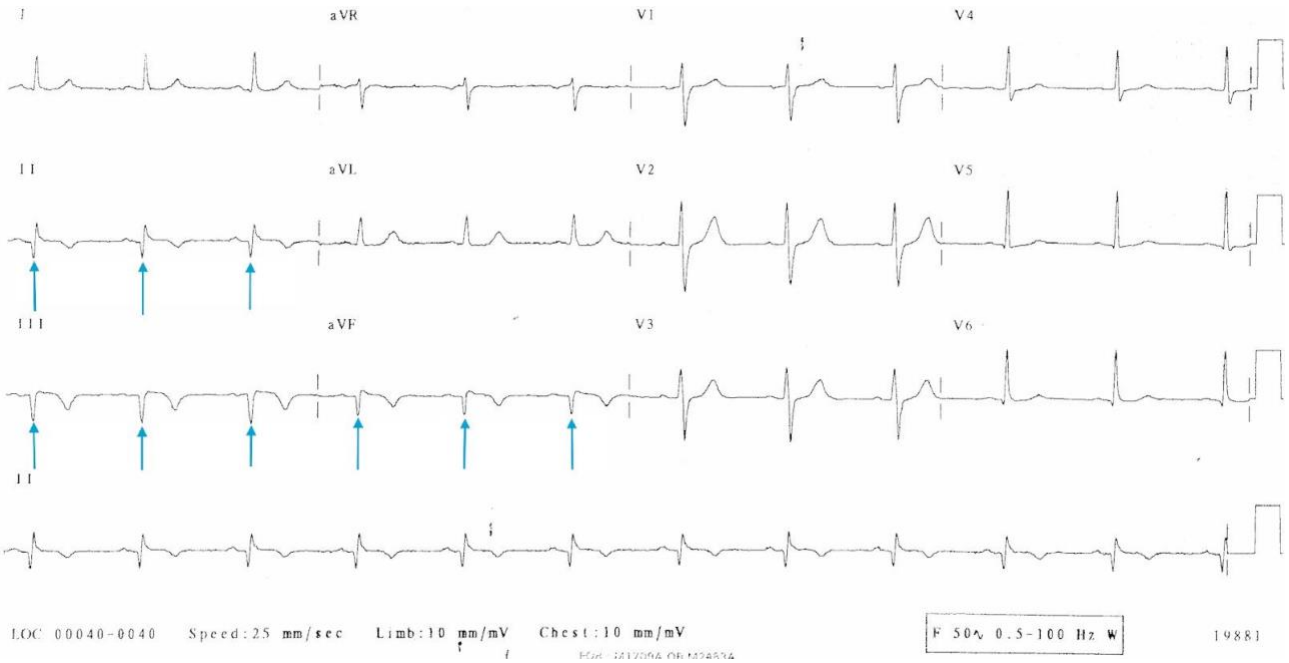
. Left axis deviation

. Q waves in lead II, III and aVF

. T wave inversion in II, III, and aVF

- Q waves develop as a result of an old STEMI. It is an inferior STEMI because leads II, III, and aVF are affected.

- In the ECG below the Q waves are marked by blue arrows.


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
F 50Hz 0.5-100 Hz W
1988

ECG 18


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
LOC 00040-0040
Speed:25 mm/sec
Limb:10 mm/mV
Chest:10 mm/mV
50∿ 0.15-150 Hz
07295

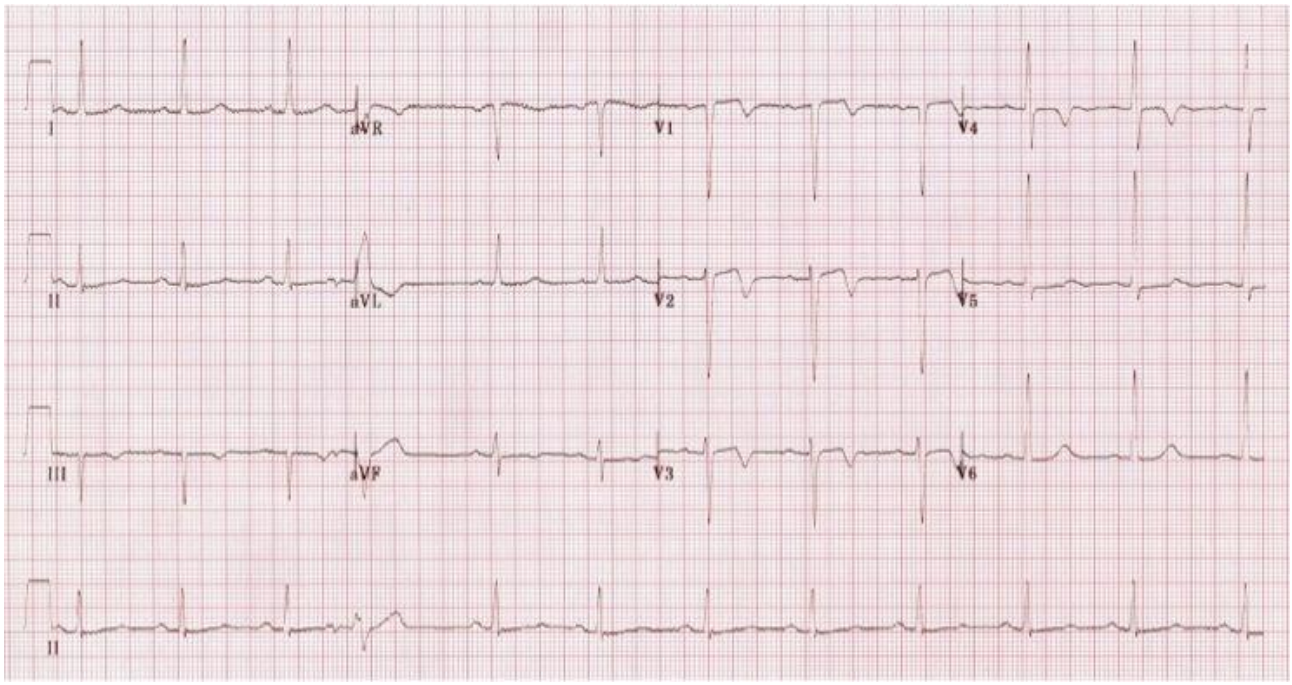
Diagnosis: Anterior ST elevation myocardial infarction (STEMI)

This ECG shows:

- Normal calibration
- Rhythm is regular (one atrial ectopic beat)
- Rate is 72bpm
- ST elevation in V1-V5
- T wave inversion in V6

- Anterior STEMIs present with ST elevation in leads V1-V4.

ECG 19



Diagnosis: Anterior NSTEMI

This ECG shows:

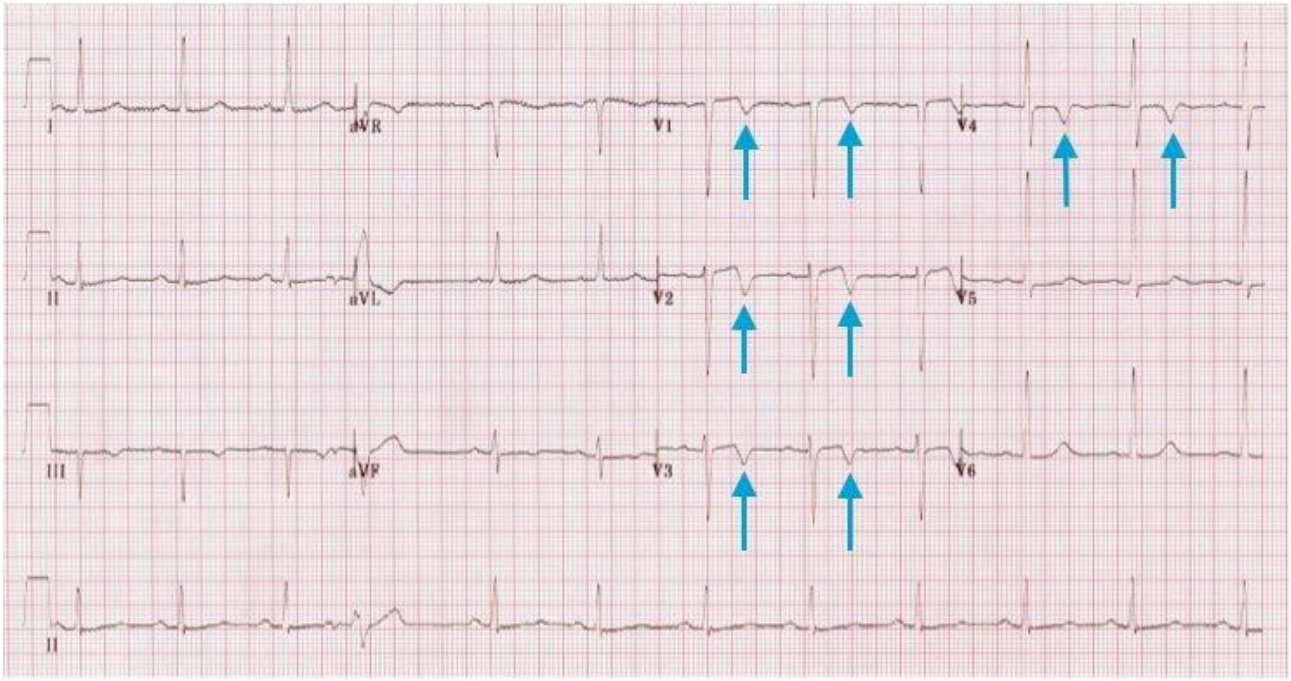
. Normal calibration

. Rhythm is regular (one ventricular ectopic beat)

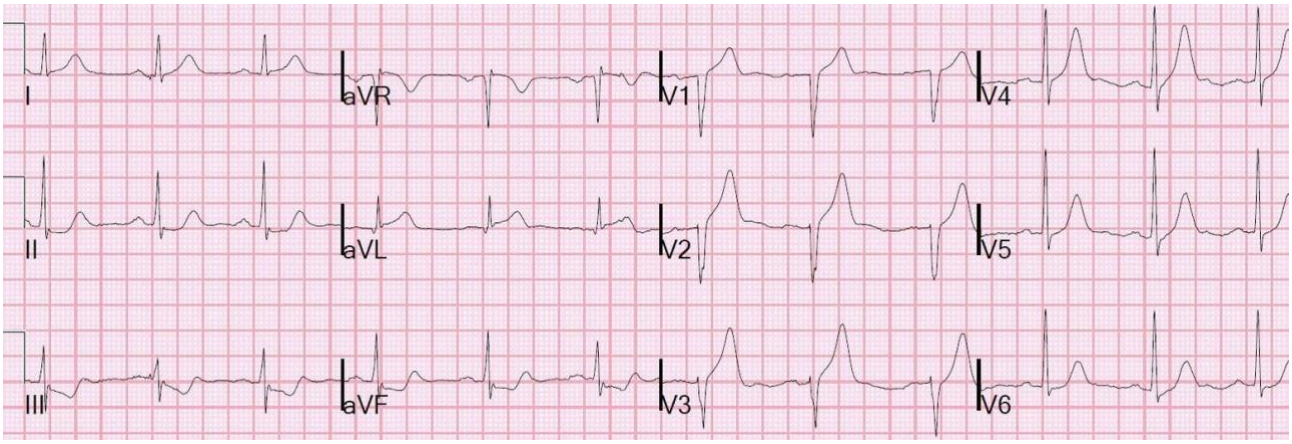
. Rate is 72bpm

. T wave inversion in V1-V4

- Anterior NSTEMIs present with T wave inversion or ST depression in leads V1-V4.
- In the ECG below the T wave inversion is marked by blue arrows.


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

ECG 20



Diagnosis: Anterior ST elevation myocardial infarction (STEMI)

This ECG shows:

. Normal calibration

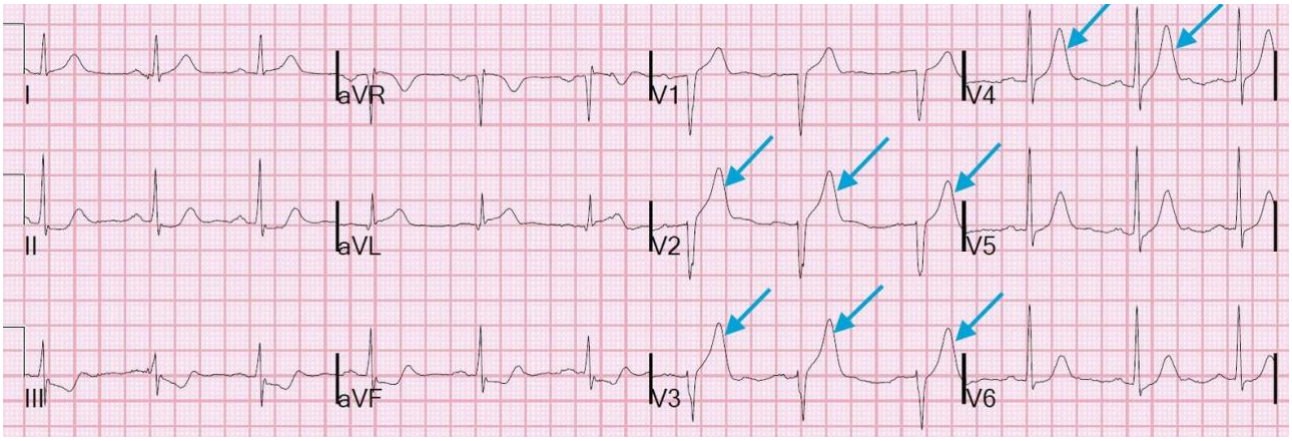
. Rhythm is regular

. Rate is 72bpm

. Hyperacute T waves in V2-V4

. Reciprocal ST depression in leads II, III and aVF

- Hyperacute T waves are the first ECG changes seen in a STEMI.
- In the ECG below the hyperacute T waves are marked by blue arrows.


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