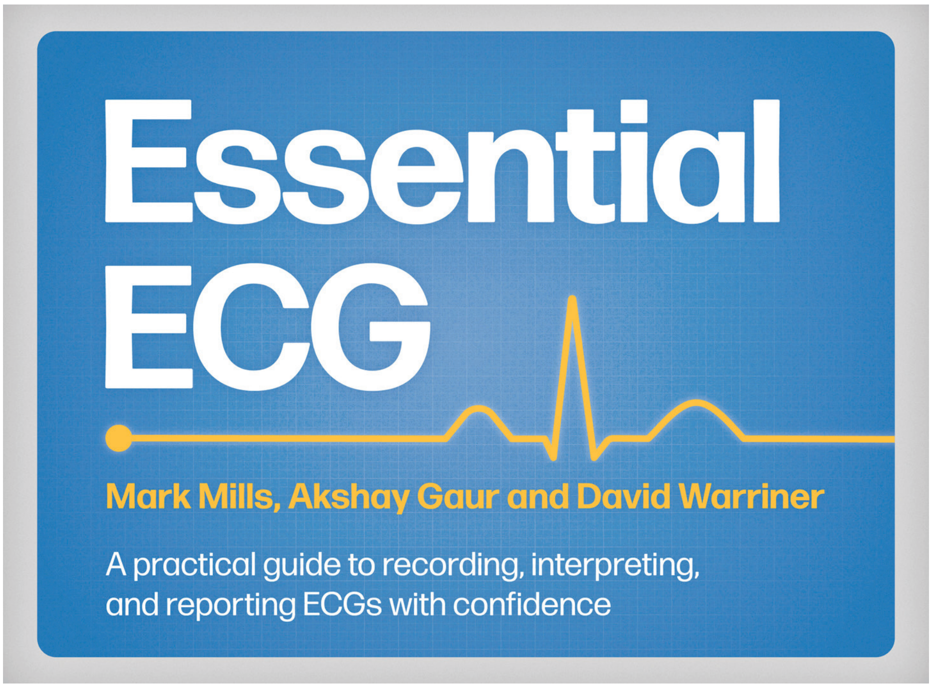


Part II
Test yourself

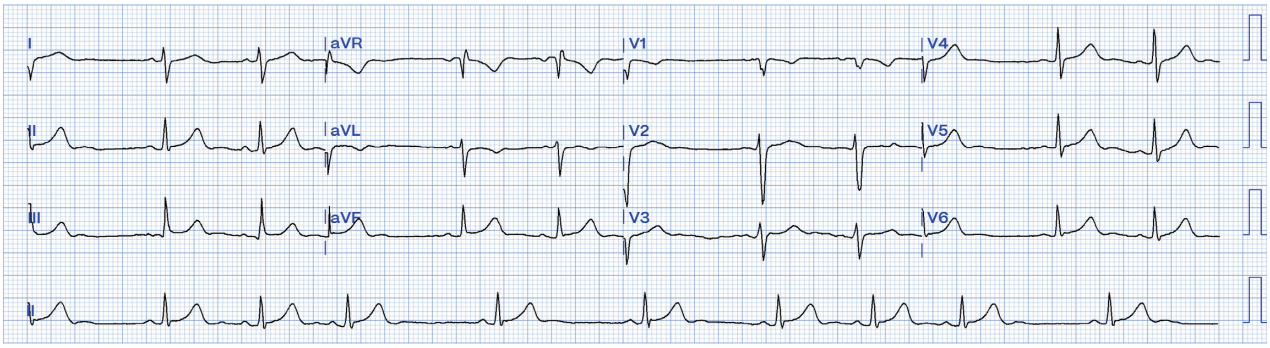
Case scenarios 20.31 to 20.50 of the test yourself ECGs are available here

Essential ECG (Mills, Gaur and Warriner)

ISBN: 9781914961656;
published March 2026;

Scion

20.31 A 17-year-old male referred with palpitations



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.31 Assessment: sinus arrhythmia

Features of this ECG:

- **Rate:** 60 bpm.
- **Rhythm:** irregular (sinus rhythm – a P wave precedes each QRS, although RR interval is variable).
- **Axis:** right axis deviation +120° (isoelectric QRS in lead I and + QRS in leads II and III).
- **P waves:** normal.
- **PR interval:** normal (120 ms).
- **QRS:** normal and narrow (80 ms).
- **ST segment:** isoelectric.
- **QTc:** normal (400 ms).
- **T waves:** normal.

Interpretation of the ECG:

- This is sinus arrhythmia, which is a normal variant.
- The heart rate increases with inspiration (RR interval shortens) and decreases with expiration (RR interval lengthens) (see *Fig. 20.31.1*).

Clinical notes:

- No further investigation or management required.

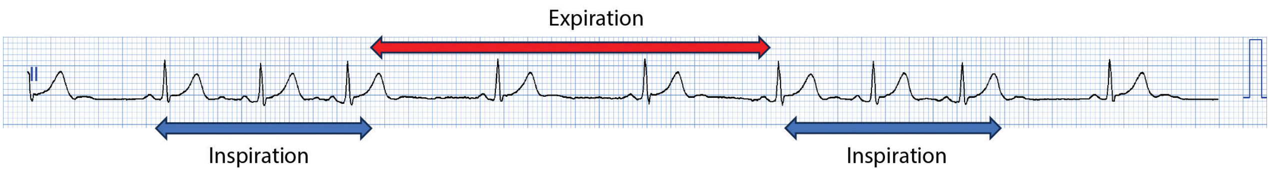
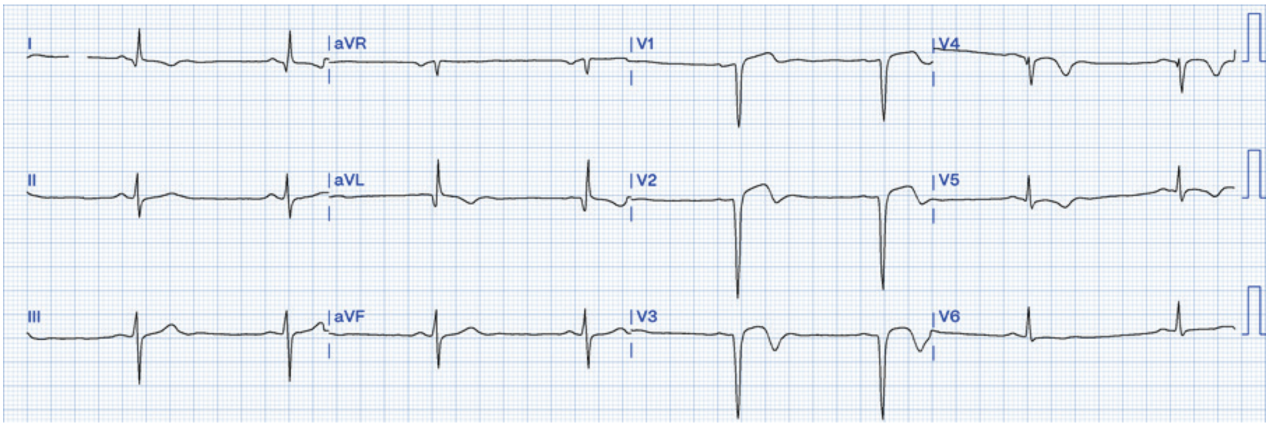


Fig. 20.31.1: As the patient inspires, the heart rate increases; as the patient expires, the heart rate decreases.

NOTES

20.32 An asymptomatic 49-year-old male attending an outpatient cardiology clinic



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.32 Assessment: sinus bradycardia

Features of this ECG:

- **Rate:** 50 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** normal.
- **P wave:** regular.
- **PR interval:** normal (160 ms).
- **QRS complexes:** normal width. Pathological Q waves in leads I, aVL, V2, V3 and V4. Loss of R wave progression across precordial leads.
- **ST segment:** mild (<1 mm) ST elevation in leads V1–V3.
- **QTc interval:** prolonged (430 ms).
- **T waves:** T wave inversion in leads I, aVL, V2, V3, V4 and V5. T wave flattening in V6.

NOTES

Interpretation of the ECG:

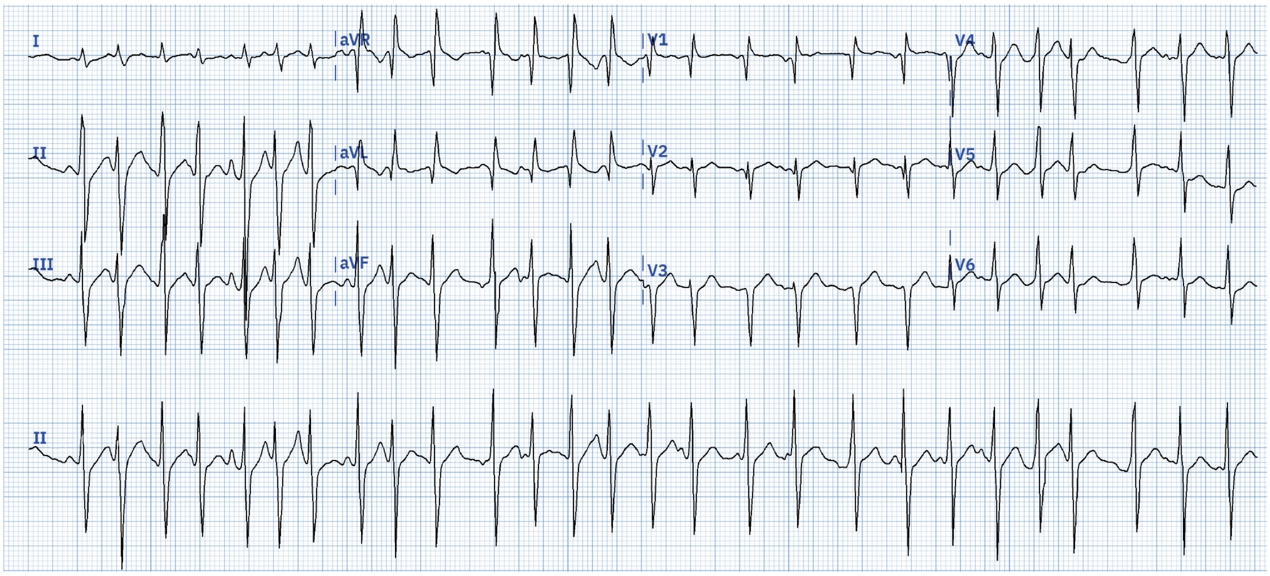
- Bradycardia with a consistent association between P waves and QRS complexes, and a normal PR interval, in keeping with sinus bradycardia.
- Pathological Q waves and T wave inversion in a pattern suggestive of prior anterolateral myocardial infarction (*Fig. 20.32.1*).

Clinical notes:

- Sinus bradycardia can be considered either physiological (e.g. in an athletic individual) or pathological (see *Section 8.2.1*).
- In this case, the ECG is suggestive of a prior myocardial infarction (see *Section 13.7*).
- The patient was asymptomatic, and the bradycardia was a result of beta-blocker usage.

Fig. 20.32.1: Pathological Q waves (blue arrows).

20.33 An 80-year-old male presenting with shortness of breath



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

Part II: Test yourself

20.33 Assessment: multifocal atrial tachycardia

Features of this ECG:

- **Rate:** 162 bpm (as the rhythm is irregular, multiply the number of QRS complexes during the 10-second rhythm strip (27) by 6 = 162).
- **Rhythm:** irregularly irregular.
- **Axis:** left axis deviation.
- **P waves:** multiple different morphologies, at least 3 different P waves (peaked, normal and inverted) seen.
- **PR interval:** variable.
- **QRS complexes:** normal (80 ms).
- **ST segment:** normal.
- **QTc:** prolonged (569 ms).
- **T waves:** normal.

NOTES

Interpretation of the ECG:

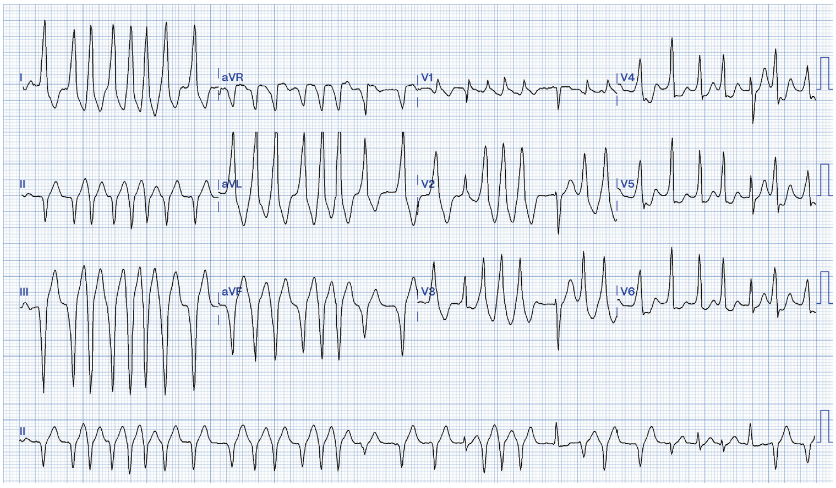
- By definition, MAT has a rate of >100 bpm.
- More than 3 distinct P wave morphologies (see *Fig. 20.33.1* with red arrows).
- P waves seen include upright, peaked and inverted.
- P waves are clearly seen prior to each QRS complex, which excludes atrial fibrillation.
- Varying PR intervals.
- Alternating RR intervals.

Clinical notes:

- MAT is a type of supraventricular tachycardia (see *Chapter 9.5.2*).
- MATs are commonly associated with chronic lung diseases such as COPD or pulmonary hypertension.
- Patient symptoms may range from asymptomatic to dyspnoea, palpitations and syncope.
- Management:
  - treat the underlying cause
  - rate-controlling agents such as beta-blockers.

Fig. 20.33.1: Rhythm strip demonstrating 3 different P waves (peaked, normal and inverted) seen in red.

20.34 A 42-year-old male with sudden-onset palpitations



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.34 Assessment: atrial fibrillation with pre-excitation

Features of this ECG:

- **Rate:** 186 bpm.
- **Rhythm:** irregularly irregular.
- **Axis:** left axis deviation.
- **P wave:** not seen.
- **PR interval:** unable to comment.
- **QRS complexes:** mainly wide QRS complexes (but also some narrow complexes), with beat-to-beat variation in QRS morphology.
- **ST segment:** difficult to assess, but suggestion of ST depression in lateral leads.
- **QTc interval:** unable to comment.
- **T waves:** unable to comment.

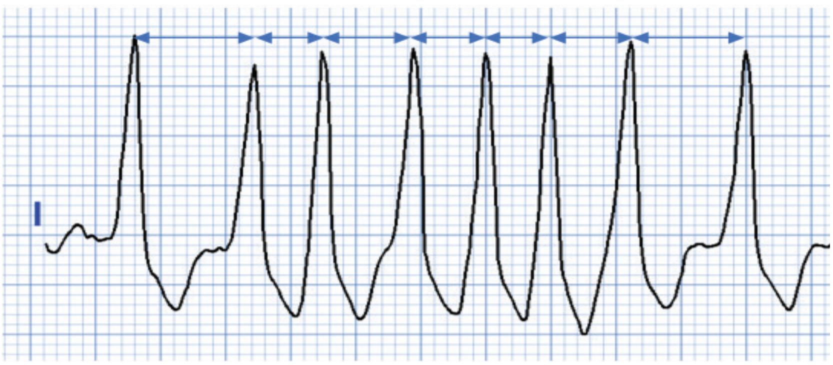


Fig. 20.34.1: Pre-excited AF: irregularly irregular and broad QRS complexes (as demonstrated by varying RR interval; blue arrows).

NOTES

Interpretation of the ECG:

- The findings of a rapid, irregularly irregular tachycardia, combined with varying morphology broad QRS complexes, are suggestive of atrial fibrillation (AF) with pre-excitation (also called 'pre-excited AF') (*Fig. 20.34.1*).
- AF can occur in patients with an accessory pathway (Wolff–Parkinson–White syndrome), allowing for rapid conduction directly from the atrium to the ventricle (bypassing the AV node) (see *Section 10.7*).
- This can be mistaken for polymorphic ventricular tachycardia, but in pre-excited AF the cardiac axis remains stable.

Clinical notes:

- AF occurs in around 20% of patients with an accessory pathway.
- Pre-excited AF should be treated as a medical emergency, as the rapid ventricular rates can degenerate into ventricular tachycardia or ventricular fibrillation.
- As a general rule, AV nodal blocking drugs should be avoided in this setting, as this preferences conduction via the accessory pathway, which can precipitate ventricular arrhythmias and cardiac arrest.
- Urgent DC cardioversion is the preferred treatment in the acute setting.
- Definitive treatment consists of catheter ablation of the accessory pathway.

20.35 An 88-year-old female with syncope

Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.35 Assessment: sino-atrial exit block

Features of this ECG:

- **Rate:** 42 bpm.
- **Rhythm:** irregular (sinus beats are noted, but a sinus beat (P waves + associated QRS complexes) is missing at the location of the red arrows – see *Fig. 20.35.1*).
- **Axis:** normal.
- **P waves:** normal morphology.
- **PR interval:** normal (160 ms).
- **QRS complexes:** narrow (90 ms).
- **ST segment:** normal.
- **QTc:** prolonged (520 ms).
- **T waves:** normal.

NOTES

Interpretation of the ECG:

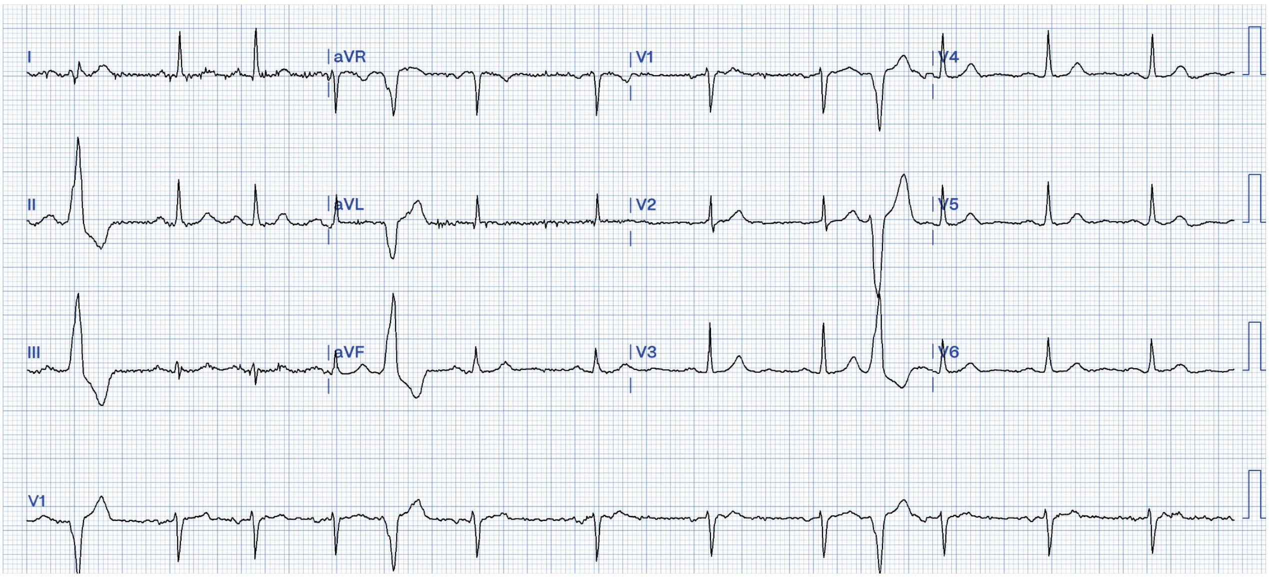
- A P wave (and its associated QRS complex / T wave) is missing where it would normally be expected (red arrows on *Fig. 20.35.1*), but the subsequent P waves arrive on time.
- The pause around the dropped P wave is exactly twice that of the preceding P–P interval (*Fig. 20.35.1*).
- This is consistent with sino-atrial exit block and is due to intermittent block of sinus node impulses into the surrounding atrium (see *Section 8.2.3*).

Clinical notes:

- Sinus node disease encompasses several conditions including sinus bradycardia and sino-atrial exit block (see *Section 8.2*).
- Sinus arrest refers to sino-atrial block resulting in a pause of ≥3 seconds.
- The most common symptoms of sino-atrial exit block relate to bradycardia (syncope, presyncope and fatigue).
- Permanent pacemaker implantation is the mainstay of treatment for sino-atrial exit block associated with symptoms and/or prolonged pauses.

Fig. 20.35.1: Rhythm strip illustrating missing P wave (red arrow).

20.36 A 42-year-old female with irregular palpitations



Features of this ECG:
- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.36 Assessment: premature ventricular complexes

Features of this ECG:
- **Rate:** 78 bpm (as the rhythm is irregular, multiply the number of QRS complexes during the 10-second rhythm strip (13) by 6 = 78).
- **Rhythm:** sinus rhythm for the majority of beats, although the 1st, 5th and 10th beats arrive abnormally early.
- **Axis:** normal.
- **P wave:** normal (difficult to assess in leads V1, V2, aVR and aVL, but seen clearly in the other leads).
- **PR interval:** normal (180 ms).
- **QRS complexes:** the sinus rhythm beats have normal QRS width and morphology. The extra beats are broad (>120 ms) with a left bundle branch block (LBBB) morphology.
- **ST segment:** normal.
- **QTc interval:** normal (420 ms).
- **T waves:** normal.

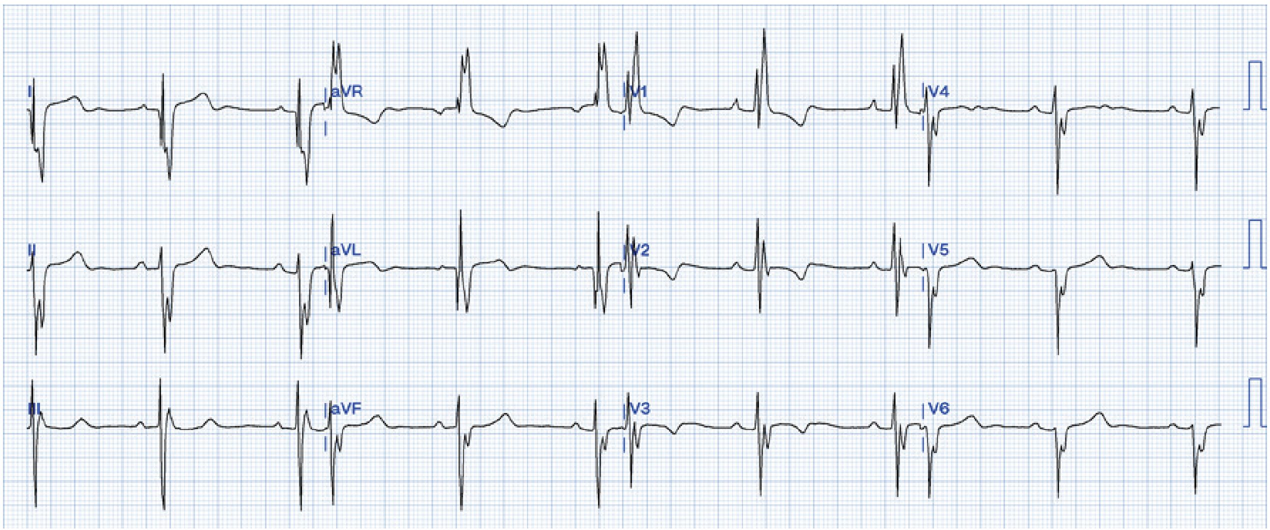
Fig. 20.36.1: The PVCs are of LBBB morphology ('W' pattern in V1).

Fig. 20.36.2: The PVCs are positive in leads II, III and aVF, in keeping with an inferior axis.

Interpretation of the ECG:
- The 1st, 5th and 10th beats are premature ventricular complexes (PVCs, also referred to as 'ectopics') (see *Section 11.3*).
- These are characterised by an abnormally early and broad QRS complex.
- PVCs arise from within the ventricles.
- The QRS morphology and axis can be used to pinpoint the origin.
- The LBBB morphology suggests that the PVC most likely originates from the right ventricle (*Fig. 20.36.1*).
- The inferior axis of the PVC suggests that it originates from the base of the heart and travels down towards the apex (*Fig. 20.36.2*).
- The combination of inferior axis and LBBB is suggestive of an origin in the right ventricular outflow tract.

Clinical notes:
- PVCs can occur in otherwise healthy individuals with structurally normal hearts and are usually benign.
- PVCs are often asymptomatic but can result in palpitations where the heart 'skips a beat' or an irregularly irregular pulse on examination.
- Other causes of PVCs include:
  - left ventricular dysfunction
  - electrolyte abnormalities
  - drug toxicity (e.g. digoxin toxicity).
- If a patient experiences frequent PVCs, or is highly symptomatic, management options include medications (e.g. beta-blockers) and catheter ablation.

20.37 A 24-year-old female admitted with chest pain



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.37 Assessment: right bundle branch block and right axis deviation

Features of this ECG:

- **Rate:** 50 bpm.
- **Rhythm:** sinus with P waves before every QRS complex.
- **Axis:** right axis deviation (RAD) (QRS – in leads I, II and III).
- **P waves:** normal.
- **PR interval:** normal (160 ms).
- **QRS complexes:** broad, e.g. 160 ms with a right bundle branch pattern (RSR′).
- **ST segment:** isoelectric.
- **QTc interval:** normal.
- **T waves:** inverted in V1–V3.

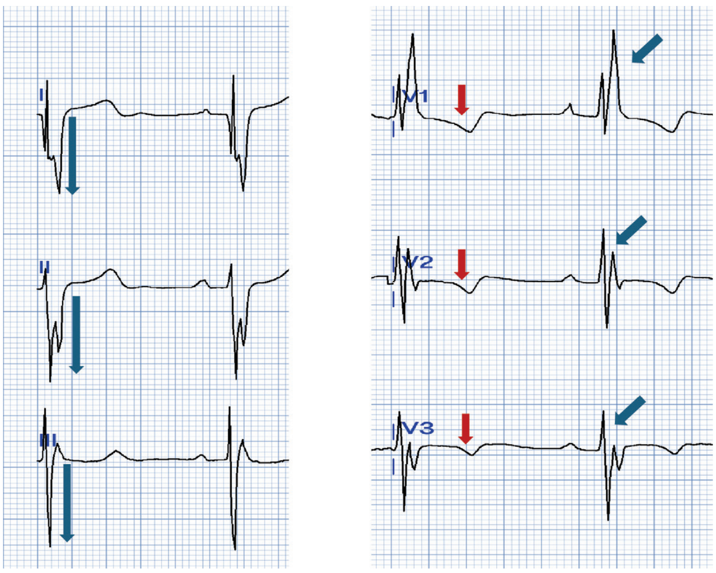


Fig. 20.37.1: Demonstrating RAD (negative QRS complexes in I, II and III) with long arrows, M-shaped broad QRS with RSR′ pattern (blue arrows) and T wave inversion (red arrows) in V1–V3.

Interpretation of the ECG:

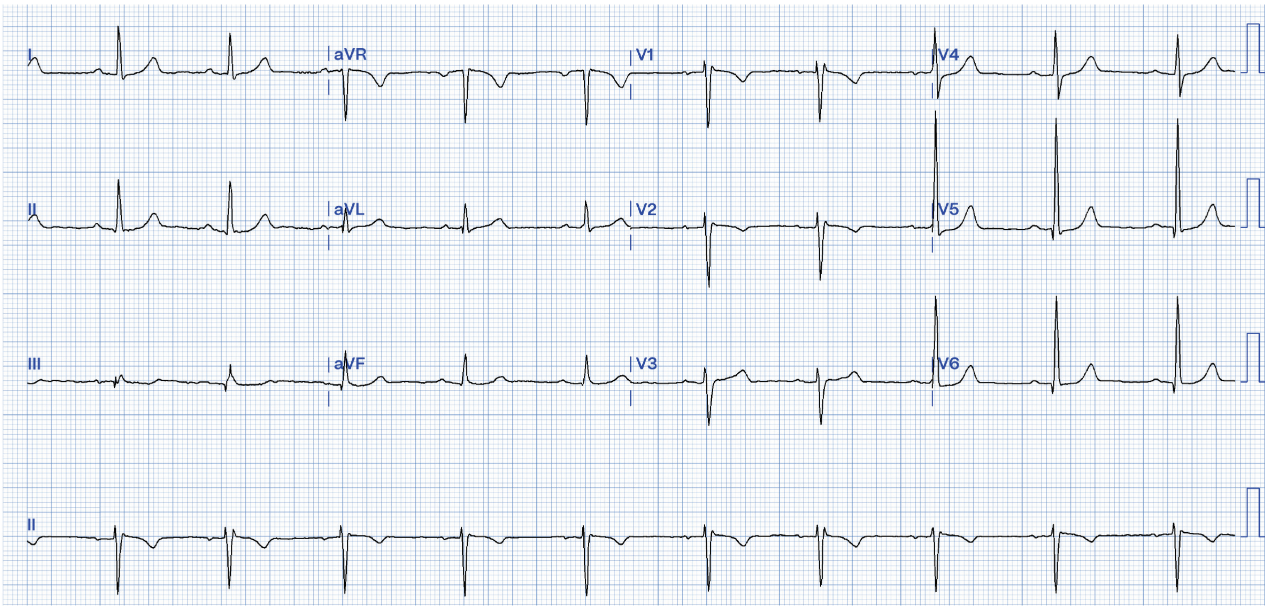
- Chest pain in a young fit patient in context of sinus rhythm with RBBB and RAD suggests possible pulmonary embolism (PE).
- RBBB and RAD (*Fig. 20.37.1*) pattern together can also be a normal variant or can indicate the presence of structural heart disease such as an atrial septal defect.
- Abnormal depolarisation begets abnormal repolarisation, hence T wave inversion in anterior (RV) leads.

Clinical notes:

- A CT pulmonary angiogram will be indicated if the clinical probability of PE is high.
- If this is normal, then an echocardiogram looking for an atrial septal defect, typically secundum.

NOTES

20.38 An 18-year-old male with anxiety



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.38 Assessment: incomplete right bundle branch block

Features of this ECG:

- **Rate:** 60 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** normal.
- **P waves:** normal.
- **PR interval:** normal (160 ms).
- **QRS:** RSR' pattern in V1 and V2, with normal QRS duration (80 ms).
- **ST segment:** isoelectric.
- **QTc:** normal (400 ms).
- **T waves:** normal.

NOTES

Interpretation of the ECG:

- An RSR' pattern in leads V1 and V2 (*Fig. 20.38.1*) with a normal QRS duration is consistent with an incomplete right bundle branch block (RBBB) pattern.

Clinical notes:

- Incomplete RBBB is a normal variant which is commonly seen in children and young adults.
- It requires simple reassurance.

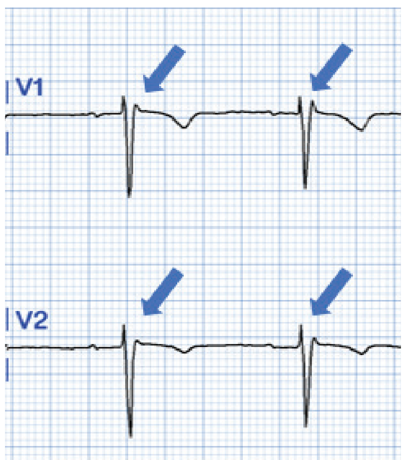


Fig. 20.38.1: Demonstrating M-shaped RSR' QRS pattern in V1 and V2 (arrows).

20.39 A 59-year-old female attending pre-operative assessment

Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.39 Assessment: bifascicular block

Features of this ECG:

- **Rate:** 60 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** left axis deviation +30° (positive QRS in lead I but negative QRS complexes in leads II and III).
- **P waves:** normal.
- **PR interval:** normal (160 ms).
- **QRS complexes:** broad (120 ms) with right bundle branch block (RBBB) morphology ('M' shape appearance in V1, 'W' shape in V6).
- **ST segment:** ST depression (<1 mm) in anterolateral leads (normal in the context of RBBB).
- **QTc:** normal (440 ms).
- **T waves:** T wave inversion in anterior leads (normal in the context of RBBB).

Interpretation of the ECG:

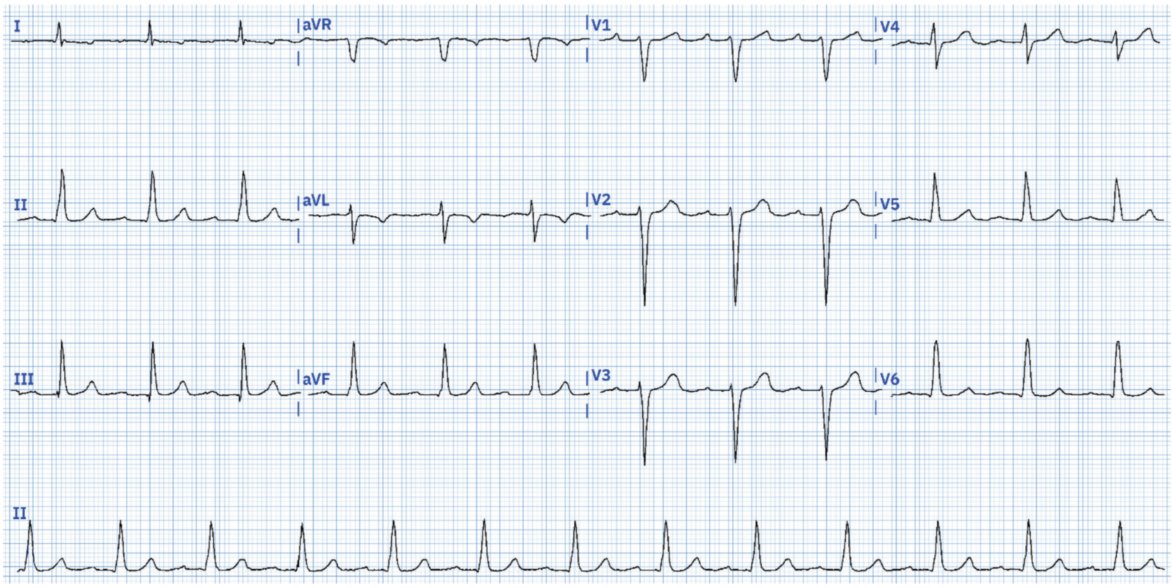
- The combination of left anterior fascicular block (see *Section 12.3.1*) and RBBB (see *Section 12.2*) is diagnostic of bifascicular block (see *Section 12.4*).

Clinical notes:

- Bifascicular block is often associated with underlying heart disease and can be a precursor to higher-degree atrioventricular block (see *Section 8.3*).
- No specific treatment is required for asymptomatic bifascicular block.
- Permanent pacemaker implantation may be indicated if the patient is symptomatic or has evidence of higher degree AV block.

NOTES

20.40 A 55-year-old male presenting with a lower respiratory tract infection



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.40 Assessment: first-degree AV block

Features of this ECG:

- Rate: 77 bpm.
- Rhythm: regular (sinus rhythm).
- Axis: normal axis.
- P waves: normal.
- PR interval: prolonged (240 ms).
- QRS: normal (90 ms).
- ST segment: isoelectric.
- QTc: normal (400 ms).
- T waves: normal.

Interpretation of the ECG:

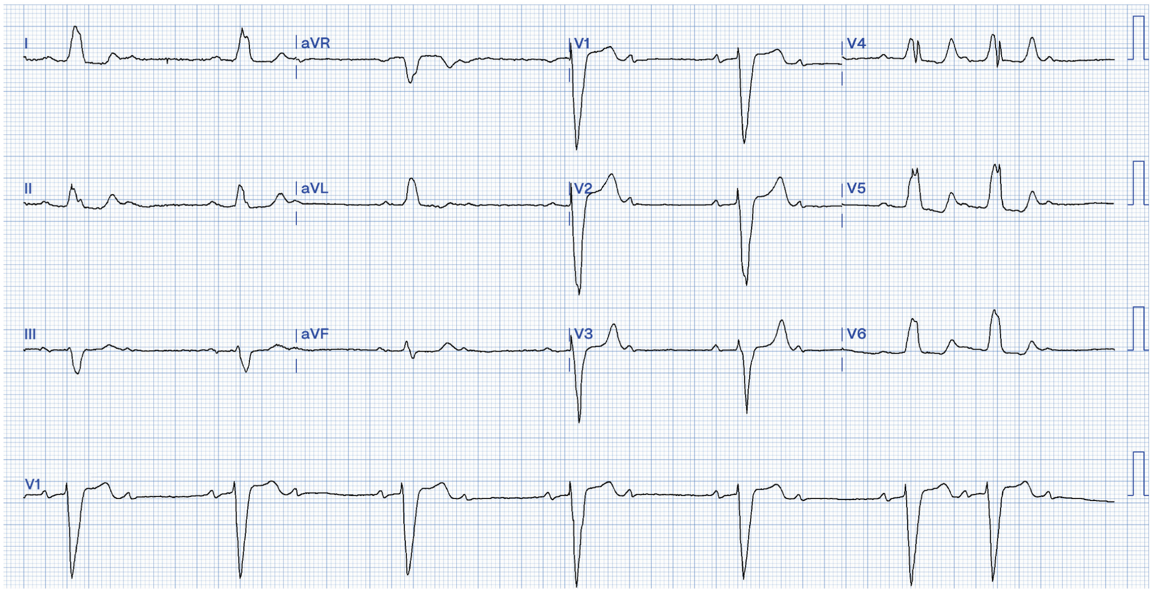
- This ECG shows evidence of first-degree AV block with a prolonged PR interval that is constant (see *Section 8.3.1*).
- Unlike higher degree AV blocks (see *Sections 8.3.2–8.3.4*), every P wave is followed by a QRS complex.

Clinical notes:

- First-degree AV block is usually asymptomatic and benign, and rarely requires intervention.
- It is important to elicit if the patient reports any symptoms of heart block (e.g. syncope or palpitations).
- In this case, treat the underlying infection and ensure the patient is not on any rate-limiting drugs that may exacerbate the heart block.
- If the PR interval is markedly prolonged (>300 ms), associated with other conduction disease (e.g. bundle branch block) or the patient is symptomatic, a permanent pacemaker may be indicated (see *Section 12.6*).

NOTES

20.41 A 70-year-old female with syncope



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.41 Assessment: second-degree AV block, Mobitz II (2:1 AV block)

Features of this ECG:

- Rate: 43 bpm.
- Rhythm: regular (sinus rhythm).
- Axis: normal.
- P wave: two P waves seen for every QRS complex.
- PR interval: when QRS complexes are present after a P wave, the PR interval is consistently prolonged at 240 ms.
- QRS complexes: broad QRS complexes (180 ms) with a dominant S wave in V1 ('W-shaped') and notched R wave ('M-shaped') in V6, in keeping with left bundle branch block (LBBB).
- ST segment: mild (<1 mm) ST elevation in V2.
- QTc interval: normal (380 ms).
- T waves: biphasic T waves in V5 and V6.

NOTES

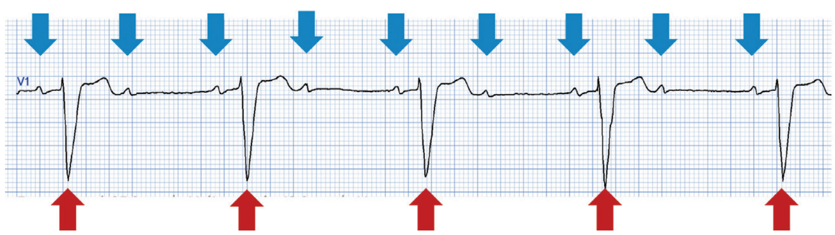


Fig. 20.41.1: Mobitz II AV block: the blue arrows highlight the two P waves for each QRS complex (highlighted with red arrows).

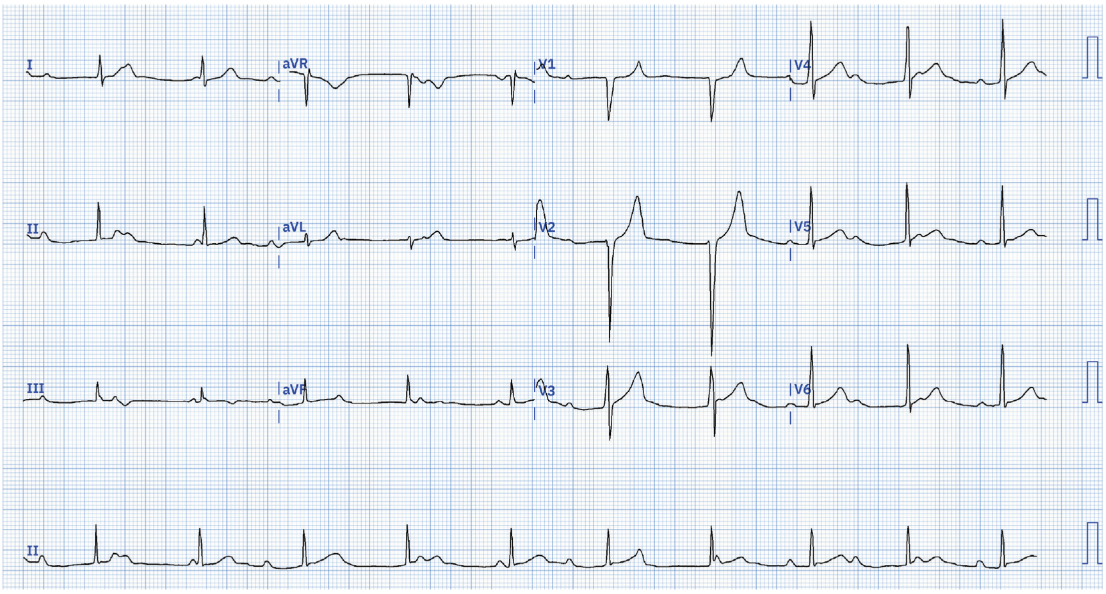
Interpretation of the ECG:

- P waves are seen 'marching through' at a normal and regular rate, but every other P wave is not associated with a QRS complex (*Fig. 20.41.1*).
- This is consistent with Mobitz II second-degree AV block, with a fixed 2:1 AV block pattern.
- Mobitz II AV block refers to intermittent block of atrial impulses into the ventricles, without progressive prolongation in the PR interval (see *Section 8.3.3*).
- Mobitz II AV block is usually due to conduction disease below the bundle of His, within the proximal bundle branches. As a result, QRS complexes are usually broad (in this case, with a LBBB morphology; see *Section 12.3*).

Clinical notes:

- Mobitz II is often associated with symptomatic bradycardia and haemodynamic compromise.
- If left untreated, approximately 1 in 3 patients will experience asystole at 1 year and, therefore, permanent pacemaker implantation is required in most cases.

20.42 An 88-year-old male with collapse



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.42 Assessment: complete heart block with junctional escape rhythm

Features of this ECG:

- Rate: 60 bpm.
- Rhythm: regular (junctional escape rhythm).
- Axis: normal.
- P waves: regular P waves which are not associated with QRS complexes.
- PR interval: unable to comment as no association between P waves and QRS complexes.
- QRS: narrow (80 ms).
- ST segment: normal.
- QTc: normal (417 ms).
- T waves: normal.

NOTES

Interpretation of the ECG:

- AV dissociation (no association between P waves and QRS complexes) consistent with third-degree heart block (see *Section 8.3.4*).
- The atria and ventricles are regularly firing at their own pace, without any communication between the two (AV dissociation; *Fig. 20.42.1*).
- In this case, the ventricular escape rhythm originates high up in the His–Purkinje system, resulting in a junctional (narrow) QRS.

Clinical notes:

- Symptomatic complete heart block warrants urgent treatment (e.g. atropine and/or temporary pacing).
- A permanent pacemaker implantation is the definitive management.

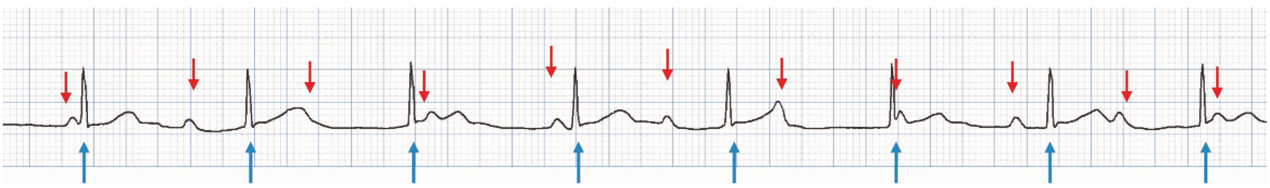
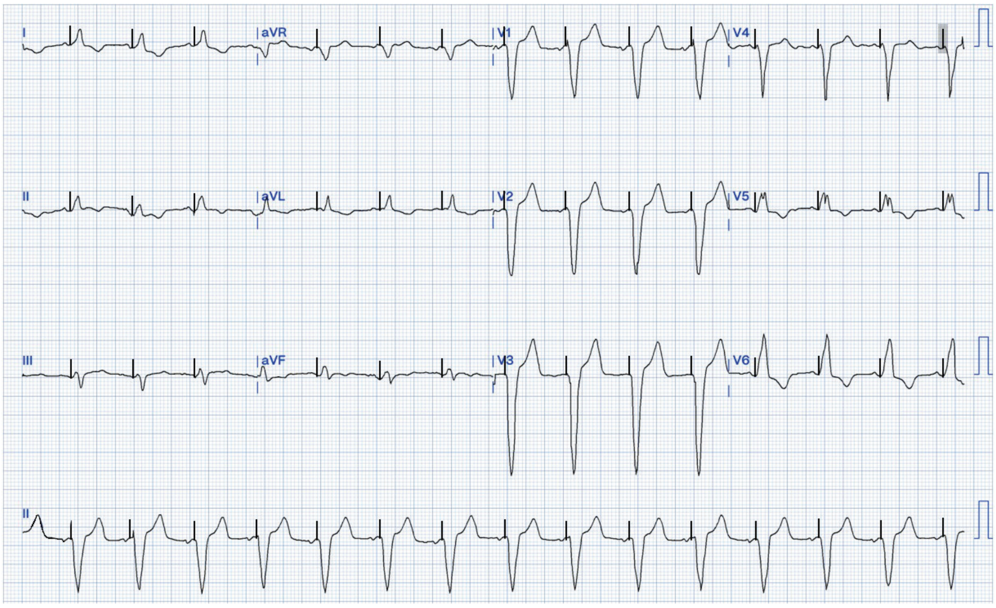


Fig. 20.42.1: Demonstrating no association between the P waves and QRS complexes. The atria / P waves (red) are firing regularly, independent of the ventricles / QRS complexes (blue), which are firing at their own intrinsic rate. This is consistent with complete heart block.

20.43 An 85-year-old male in the outpatient clinic



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.43 Assessment: dual chamber paced rhythm

Features of this ECG:

- Rate: 72 bpm.
- Rhythm: dual chamber (atrial and ventricular) paced rhythm, with pacing spikes visible before each P wave (atrial) and QRS complex (ventricular).
- Axis: left axis deviation.
- P waves: inverted.
- PR interval: normal (120 ms).
- QRS: broad (160 ms) with left bundle branch block (LBBB) morphology; the penultimate QRS complex on the rhythm strip is early and of different morphology.
- ST segment: normal.
- QTc interval: normal (460 ms).
- T waves: normal.

Interpretation of the ECG:

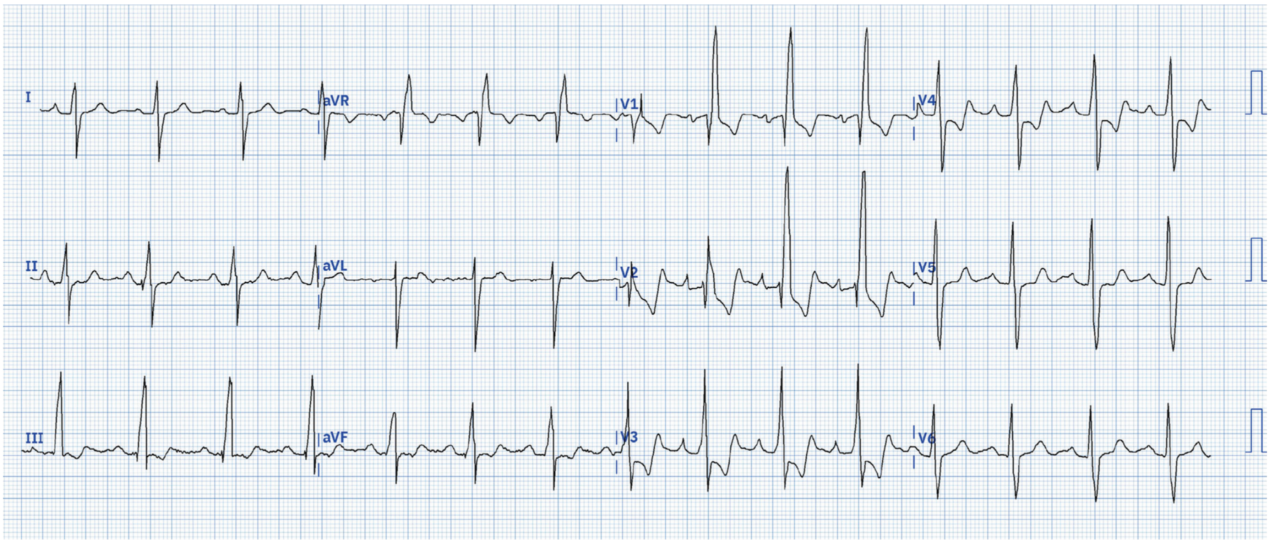
- Atrial pacing: a small vertical spike before each P wave (see *Section 17.2.1*):
  - the P wave is negative (inverted) in leads II, III and aVF because the electrical activation spreads upward and to the left from the right atrial pacing site (opposite to the normal sinus node activation).
- Ventricular pacing: a small vertical spike before each QRS complex (see *Section 17.2.2*):
  - the QRS complex is broad and of LBBB morphology
  - this occurs because the ventricle is activated from the right ventricular apex, causing the electrical impulse to spread slowly through the myocardium rather than via the His–Purkinje system, resulting in LBBB pattern.
- The penultimate beat is a premature ventricular complex (see *Section 11.3*).

Clinical notes:

- Pacing spikes followed by a P wave and/or QRS complex confirm that the pacemaker is delivering electrical impulses to the heart as intended.
- Close inspection of the relationship between pacing spikes and the following complexes is important, as abnormalities may be due to pacemaker malfunction (see *Section 17.3*).

NOTES

20.44 A 38-year-old female with progressive shortness of breath



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.44 Assessment: right ventricular hypertrophy

Features of this ECG:

- **Rate:** 85 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** right axis deviation.
- **P waves:** normal.
- **PR interval:** normal (160 ms).
- **QRS complexes:** broad (120 ms) with dominant R wave in V1 (R/S ratio >1) and dominant S wave in V5 (15 mm).
- **ST segment:** ST segment depression in precordial leads V1–V4.
- **QTc interval:** prolonged (480 ms).
- **T waves:** inverted in V1–4 and biphasic in aVF and III.

Interpretation of the ECG:

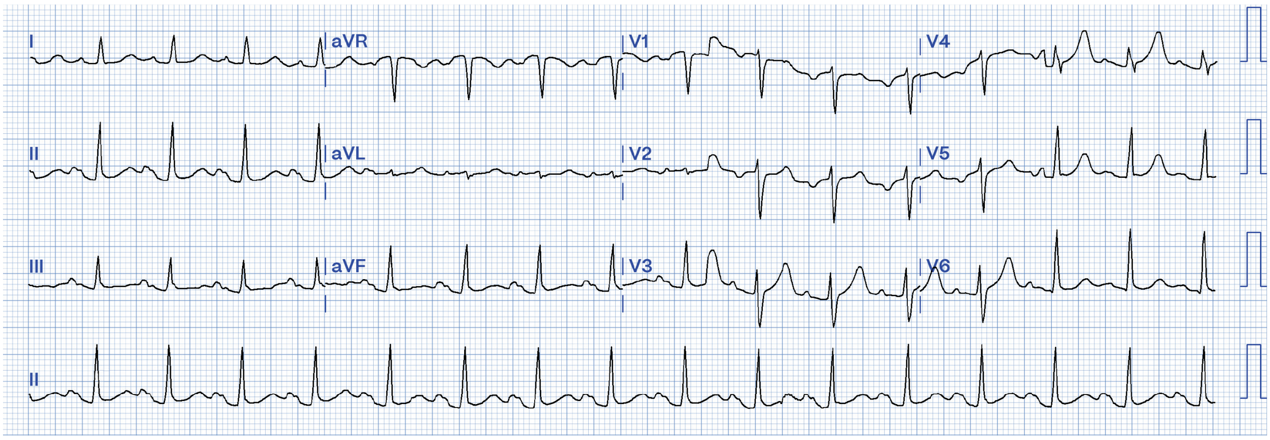
- The combination of right axis deviation (see *Section 5.5*), dominant R wave in V1 and dominant S wave in V5/6 is consistent with right ventricular hypertrophy (RVH; see *Section 6.3.2*).
- The ST segment depression and T wave inversion in the precordial leads is normal in the setting of RVH (right ventricular 'strain' pattern).

Clinical notes:

- RVH is typically due to COPD, pulmonary hypertension or congenital heart disease (e.g. pulmonary valve stenosis).
- These conditions can lead to chronic pressure overload in the right ventricle, resulting in hypertrophy.
- In this case, the patient had a known diagnosis of primary pulmonary hypertension.

NOTES

20.45 A 45-year-old female with a diastolic murmur



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.45 Assessment: left atrial enlargement

Features of this ECG:

- **Rate:** 115 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** normal.
- **P wave:** broad, bifid P wave (best seen in lead II); negative P wave in V1 and V2.
- **PR interval:** normal (200 ms).
- **QRS complexes:** normal width (80 ms).
- **ST segment:** normal.
- **QTc interval:** prolonged (480 ms).
- **T waves:** normal.

Interpretation of the ECG:

- The presence of broad (>120 ms), bifid ('notched', with >40 ms between peaks) P waves in lead II, and negative P waves in V1 and V2 is suggestive of left atrial enlargement (see *Section 6.2.1*).
- The notching occurs due to delay in left atrial activation (i.e. the first notch represents right atrial activation, the second left atrial activation).
- These features are highlighted in *Fig. 20.45.1*.
- This abnormality is often referred to as 'P mitrale', although it is technically incorrect as does not always reflect mitral valve disease.

Clinical notes:

- Left atrial enlargement occurs due to pressure or volume overload of the left atrium.
- Causes of left atrial enlargement include atrial fibrillation, mitral valve disease, heart failure and systemic hypertension.
- In this case, in the context of a diastolic murmur, the ECG is suggestive of mitral valve stenosis.
- Left atrial enlargement cannot be confirmed through ECG alone and warrants further imaging (e.g. echocardiography) if the clinical picture is in keeping with structural heart disease.
- It is also known as 'inter-atrial block'.

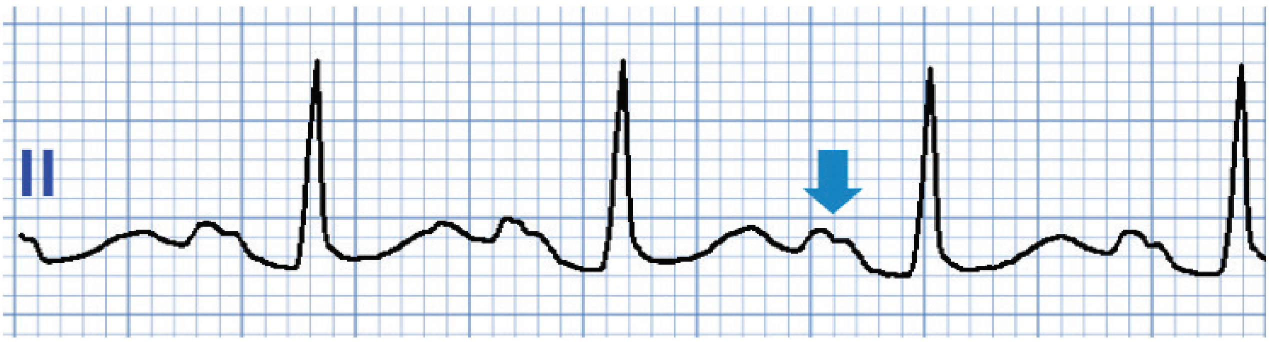
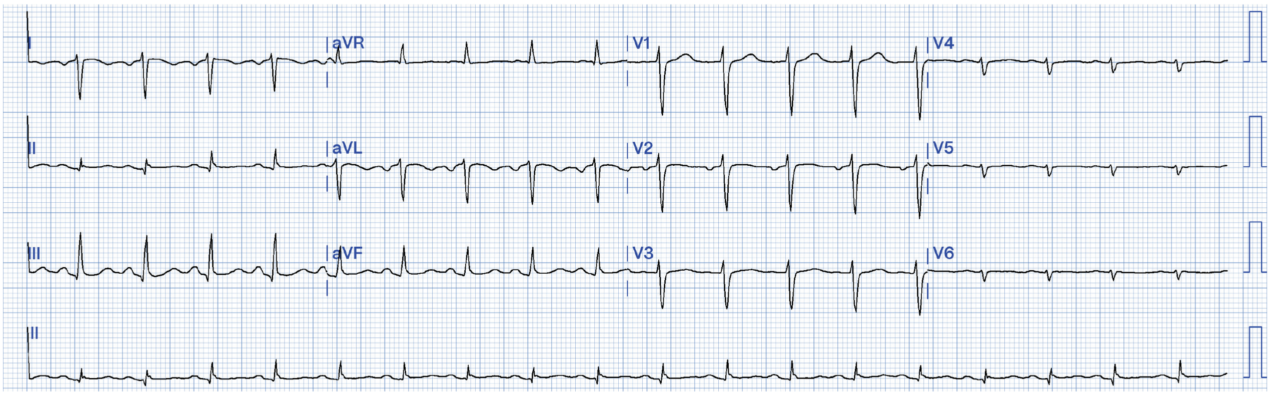


Fig. 20.45.1: Left atrial enlargement: broad, bifid P wave (blue arrow).

20.46: An 18-year-old male in the adult congenital heart disease clinic



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.46 Assessment: dextrocardia

Features of this ECG:

- **Rate:** 100 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** right axis deviation +120° (negative in leads I and II and positive in lead III).
- **P waves:** inverted in lead I but otherwise normal.
- **PR interval:** normal (160 ms).
- **QRS complexes:** normal in duration (80 ms) but no R wave progression and negative in lead I.
- **ST segment:** normal.
- **QTc interval:** normal (400 ms).
- **T waves:** inverted in leads I and aVL, and flat in V5–V6.

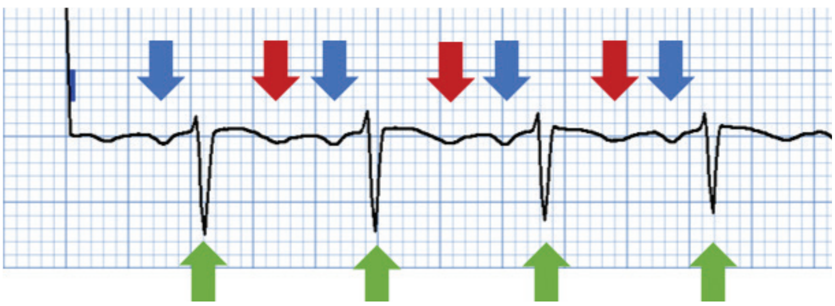


Figure 20.46.1: Global negativity in lead I with P waves (blue arrows), QRS complexes (green arrows) and T waves (red arrows) all negative.

NOTES

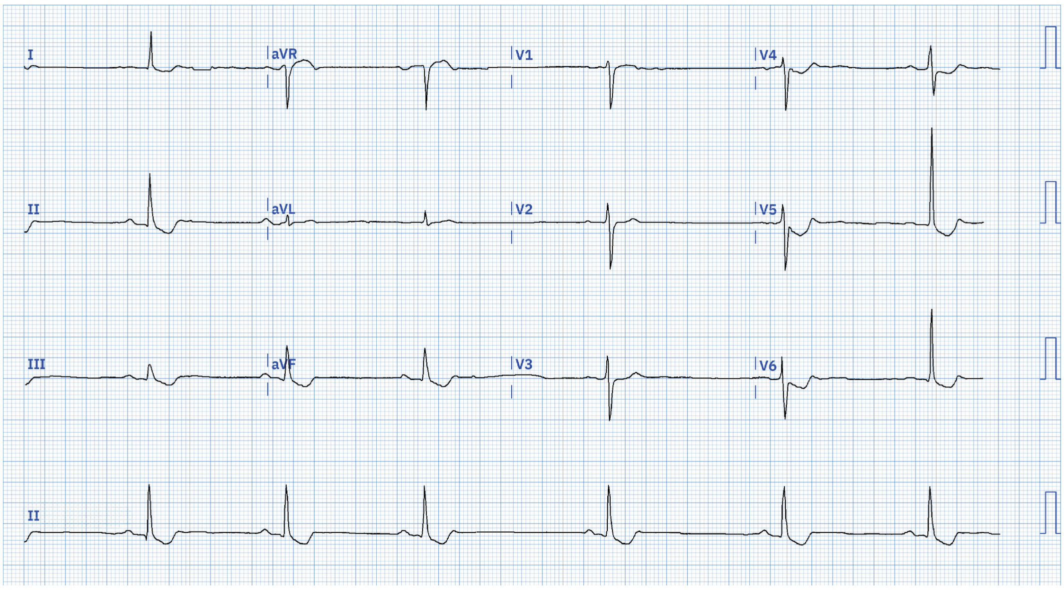
Interpretation of the ECG

- The combination of right axis deviation, inversion of all complexes (aka 'global negativity', with inverted P wave, negative QRS, inverted T wave) in lead I (*Figure 20.46.1*), and lack of R wave progression in the chest leads, with dominant S waves throughout is consistent with dextrocardia (see *Section 19.6*).

Clinical notes

- Dextrocardia is a rare congenital condition where the apex of the heart is located on the right-hand side of the body.
- There are no particular consequences of dextrocardia in isolation, but it is often associated with cardiac, bowel and lung disorders.
- Patients with dextrocardia need all the usual ECG limb and chest electrodes but they must be placed in a mirror image, e.g. on the right not left.

20.47 An 80-year-old male with dyspnoea and fatigue



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

Part II: Test yourself

20.47 Assessment: digoxin effect

Features of this ECG:

- **Rate:** 45 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** normal.
- **P waves:** normal.
- **PR interval:** borderline normal (200 ms).
- **QRS complexes:** narrow (80 ms), with poor R wave progression (see *Section 4.4*).
- **ST segment:** down-sloping ST segments.
- **QT interval:** normal (360 ms).
- **T waves:** normal.

Interpretation of the ECG:

- The bradycardia and down-sloping ST segments are consistent with digoxin effect (see *Section 15.4.1*).
- In this context, the down-sloping ST segment is often referred to as the 'reverse tick' sign, most prominent here in the infero-lateral leads (*Fig. 20.47.1*).
- The borderline PR interval suggests there is slowed conduction via the AV node (see *Section 8.3.1*).

Clinical notes:

- Digoxin is a positive inotrope (i.e. it increases the force of the heartbeat) and negative chronotrope (i.e. it slows the heart rate and AV conduction), making it useful in both heart failure and atrial fibrillation.
- The 'reverse tick' sign is not a pathological finding but indicates that the patient is taking digoxin.
- Digoxin toxicity (i.e. high serum levels) can result in arrhythmias (e.g. ventricular tachycardia, premature ventricular contractions, AV block). If suspected, this should be confirmed through blood testing.

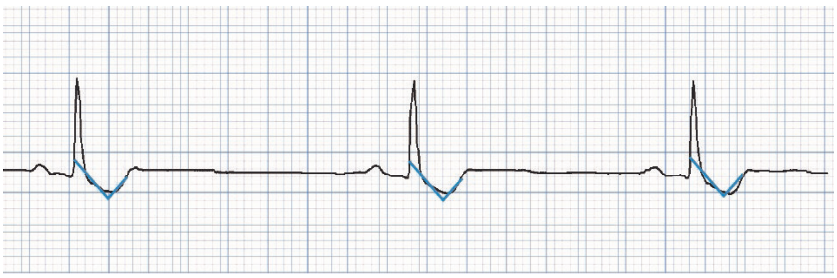
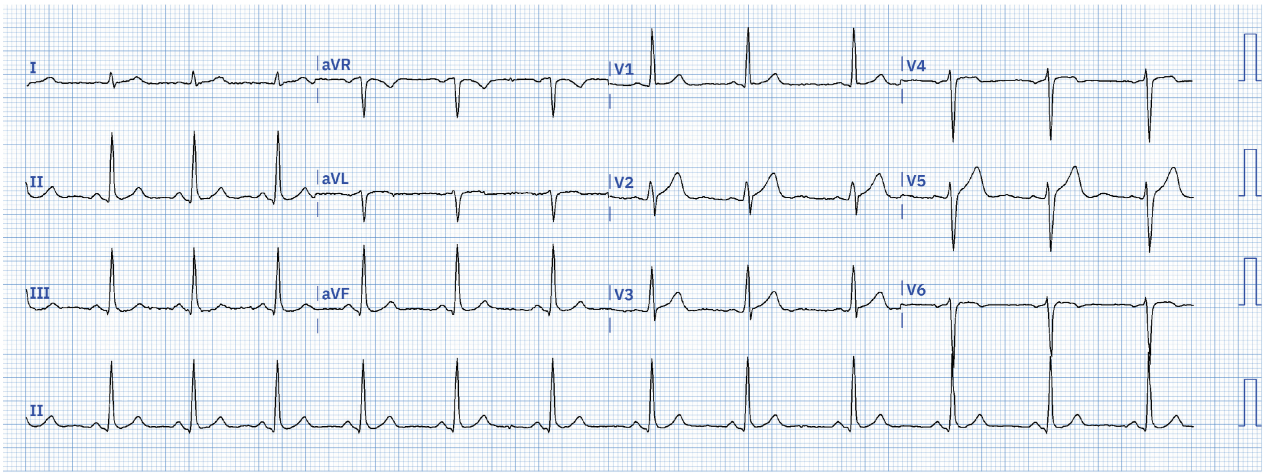


Fig. 20.47.1: 'Reverse tick' sign seen in digoxin effect.

NOTES

20.48 A 29-year-old male with shortness of breath



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.48 Assessment: precordial lead reversal

Features of this ECG:

- **Rate:** 72 bpm.
- **Rhythm:** regular (sinus rhythm).
- **Axis:** normal.
- **P waves:** normal.
- **PR interval:** normal (160 ms).
- **QRS complexes:** narrow (80 ms), with atypical R wave progression (for example, the R wave in V1 is taller than the R wave in V2, yet the R wave in V2 is smaller than the R wave in V3).
- **ST segment:** normal.
- **QTc interval:** normal (366 ms).
- **T waves:** normal.

Interpretation of the ECG:

- At first glance, this ECG appears to be relatively normal. However, on closer inspection, the R wave progression in the precordial leads does not appear to be normal (see *Section 4.4*). In this case, this is due to lead reversal.
- The first hint of chest lead reversal on this ECG is that V1 is positive and V6 is negative (this would usually be the opposite). This suggests V1 and V6 lead reversal.
- There is also evidence of atypical R wave progression, which suggests possible misplacement of other chest electrodes. In this ECG, the following errors in electrode placement have been made:
  - the positions of V1 and V6 have been swapped
  - the positions of V2 and V4 have been swapped
  - the positions of V3 and V5 have been swapped.

Clinical notes:

- Swapping the position of the chest electrodes can completely distort the ECG, making it uninterpretable.
- Interchanging two or more precordial electrodes can affect the transition of QRS complexes across the anterior leads.
- It is important to consider the clinical context of the patient before jumping to a conclusion based on the ECG.
- Once this patient's chest leads were readjusted and placed into the correct position, a completely different, albeit normal, ECG is produced (*Fig. 20.48.1*).

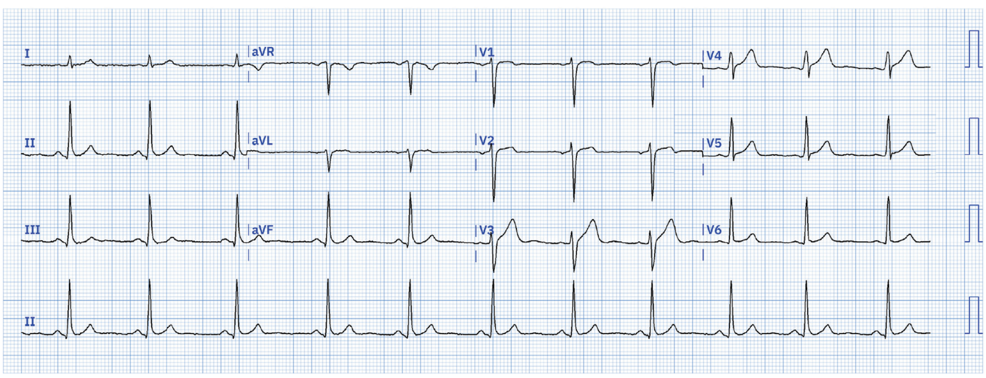
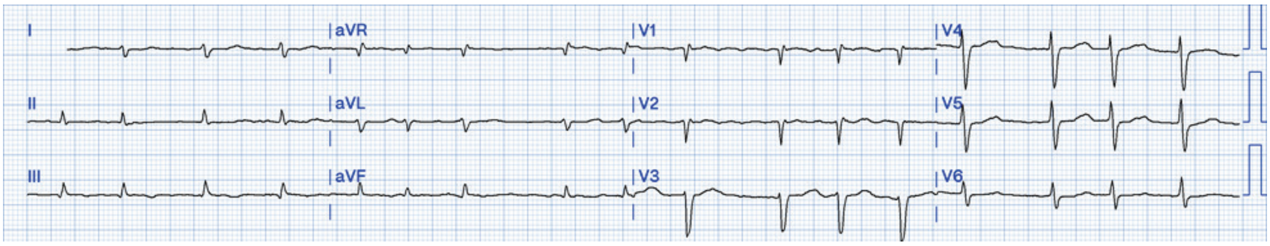


Fig. 20.48.1: 12-lead ECG following correct lead placement.

NOTES

20.49 A 76-year-old male with ongoing breathlessness for months



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

20.49 Assessment: small voltage QRS complexes with atrial fibrillation

Features of this ECG:

- **Rate:** 102 bpm.
- **Rhythm:** irregularly irregular.
- **Axis:** right axis deviation (QRS positive in leads II, III and aVF and QRS negative in lead I).
- **P wave:** no organised atrial activity (e.g. P waves being seen).
- **PR interval:** no P waves are seen, therefore no PR interval can be calculated.
- **QRS complexes:** low voltage (<10 mm in pre-cordial leads or <5 mm in limb leads).
- **ST segment:** isoelectric.
- **QTc interval:** prolonged (486 ms).
- **T waves:** normal.

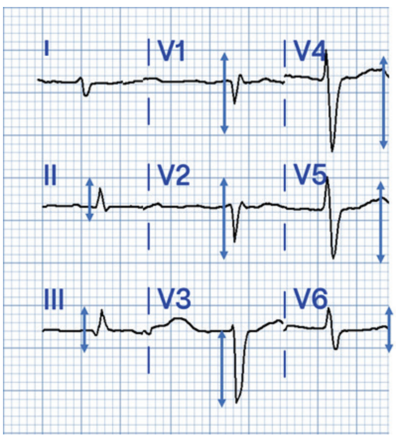


Fig. 20.49.1: Demonstrating small complexes in limb leads (<5 mm, one large square, small arrows) and small complexes in precordial leads (<10 mm, 2 large squares, large arrows).

Interpretation of the ECG:

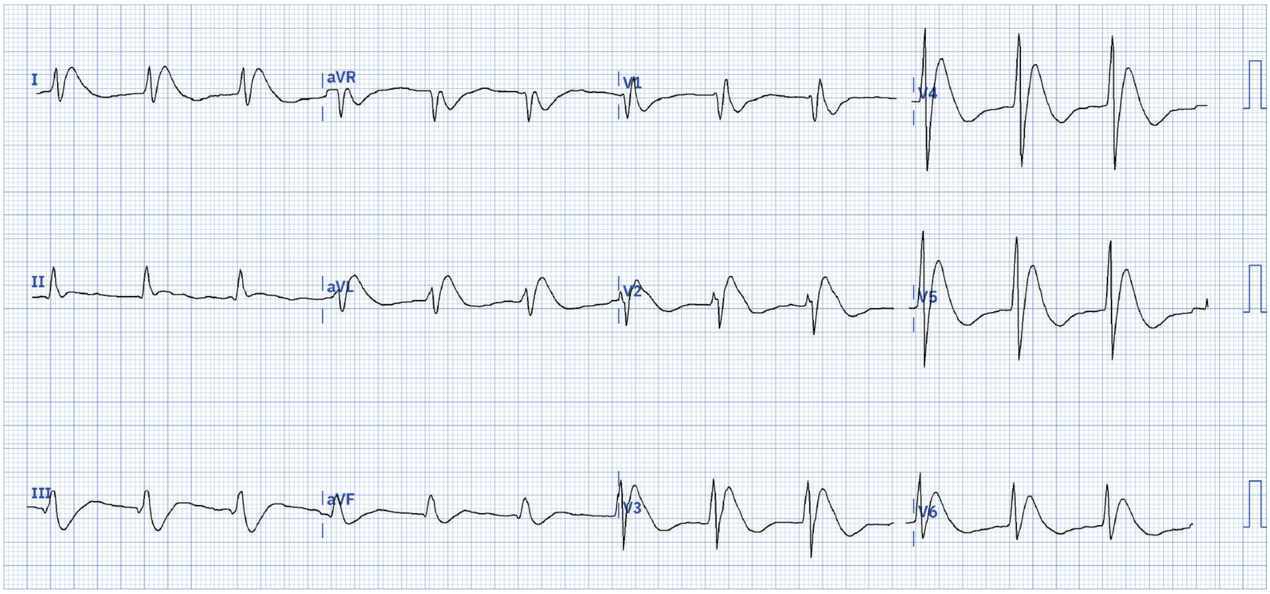
- The rhythm is irregularly irregular without organised atrial activity, i.e. atrial fibrillation.
- Low voltage QRS complexes (*Fig. 20.49.1*) suggest fat, fluid or air are between the heart and electrodes.
- Common causes of right axis deviation include lung disease, myocardial infarction and RV dilatation.

Clinical notes:

- One-third of patients with AF will present without symptoms of palpitations.
- Given the onset is >48 hours ago, it would be unsafe to attempt chemical or electrical cardioversion.
- Rate control and oral anticoagulant would be the mainstay of acute management.
- Echocardiography will be important to assess cardiac structure, function and presence of any pericardial fluid.

NOTES

20.50 A 20-year-old male with fever



Features of this ECG:

- Rate:
- Rhythm:
- Axis:
- P waves:
- PR interval:
- QRS:
- ST segment:
- QT interval:
- T waves:

Interpretation of the ECG:

Clinical notes:

Part II: Test yourself

20.50 Assessment: Brugada syndrome

Features of this ECG:

- **Rate:** 75 bpm.
- **Rhythm:** junctional (no P waves, regular and narrow QRS).
- **Axis:** normal +90° (QRS complexes positive in leads I, II and III).
- **P waves:** not seen.
- **PR interval:** not able to comment.
- **QRS:** normal duration (100 ms).
- **ST segment:** elevation (2 mm in V1, 5 mm in V2, 7 mm in V3, 9 mm in V4–V5 and 5 mm in V6).
- **QTc:** normal (340 ms).
- **T waves:** T wave inversion in leads V1–V6.

Interpretation of the ECG:

- Coved ST elevation along with T wave inversion is seen in the anterior chest leads (*Fig. 20.50.1*).
- This is a type 1 pattern (1 of 3) which is diagnostic of Brugada syndrome (see *Section 19.2*).

Clinical notes

- Aggressive treatment of the fever, addressing the cause of the fever and prompt referral to a specialist.

NOTES

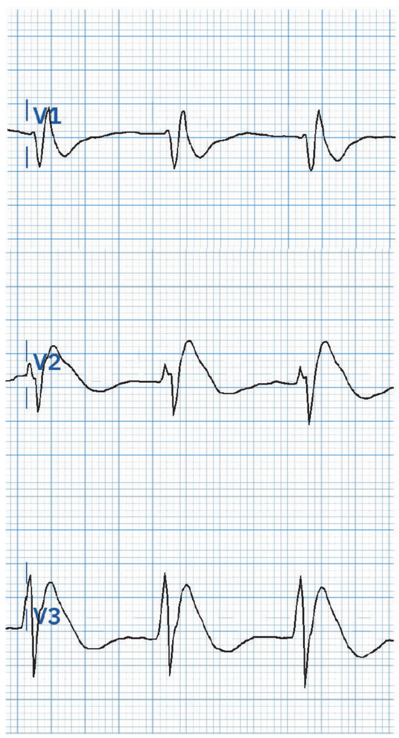


Fig. 20.50.1: Brugada syndrome: coved ST elevation and S wave inversion in V1-V3.