

1

12-Lead ECG Interpretation

The 12-lead electrocardiogram (ECG) is one of the most widely used diagnostic tools in acute and critical care. It provides a rapid, non-invasive assessment of cardiac rhythm, conduction pathways, and evidence of ischaemia, electrolyte disturbances, and structural abnormalities. For advanced practitioners, systematic interpretation is crucial to prevent missed diagnoses and to inform timely management.

A structured approach ensures accuracy and reproducibility. The following framework is widely adopted in UK practice and aligns with the algorithms of the Resuscitation Council UK and guidance from the European Society of Cardiology (ESC).

Step 1: Confirm Patient and Technical Details

Before interpretation, always check that the ECG belongs to the correct patient and that recording standards are met.

- Patient details: full name, date of birth, hospital/NHS number, and date and time of recording.
- Technical settings: confirm paper speed at 25 mm/s and calibration of 10 mm/mV. Incorrect calibration may mimic voltage abnormalities (e.g. low voltage or hypertrophy).
- Artefact: movement, poor electrode contact, or electrical interference may obscure findings.

Step 2: Rate, Rhythm, and Axis

Heart rate: calculate using R–R intervals. At 25 mm/s, 300 divided by the number of large squares between R waves equals the rate in bpm. In irregular rhythms, use a 10 s strip and multiply by 6.

Rhythm

- Is it regular or irregular?
- Is there a P wave before every QRS, and a QRS after every P?
- Assess P-wave morphology (upright in I, II, and aVF; inverted in aVR).

Cardiac axis

- Normal axis: -30° to $+90^{\circ}$.
- Left axis deviation: lead I positive, aVF negative. Causes include left anterior fascicular block, LVH, and inferior MI.
- Right axis deviation: lead I negative, aVF positive. Causes include RVH, PE, and lateral MI.
- Extreme axis deviation: lead I negative, aVF negative ('northwest axis') → severe ventricular rhythms.

Step 3: Intervals and Conduction

- PR interval: 120–200 ms (3–5 small squares). Prolonged = first-degree AV block; short = pre-excitation (e.g. WPW).
- QRS duration: ≤ 120 ms. Wide QRS may indicate bundle branch block, ventricular rhythm, or hyperkalaemia.
- QTc interval: corrected QT < 440 ms (men) or < 460 ms (women). Prolonged QT intervals increase the risk of torsades de pointes; shortened QT intervals may occur in hypercalcaemia.

Step 4: Regional Lead Groups

Interpretation is improved by grouping leads by anatomical territory and associated coronary arteries.

Region	Leads	Coronary Artery
Inferior	II, III, aVF	Right coronary artery (RCA)
Lateral	I, aVL, V5–V6	Left circumflex (LCx)
Anterior	V1–V4	Left anterior descending (LAD)
Septal	V1–V2	LAD (proximal)

This mapping aids localisation of acute infarction and recognition of reciprocal changes.

Step 5: ST Segment and T-Wave Abnormalities

- ST elevation: hallmark of ST-elevation myocardial infarction (STEMI); must be ≥ 1 mm in ≥ 2 contiguous limb leads or ≥ 2 mm in ≥ 2 contiguous chest leads. Always correlate with reciprocal depression.
- ST depression: suggests ischaemia, non-ST-elevation myocardial infarction (NSTEMI), or reciprocal changes in STEMI; may also be drug-related (e.g. digoxin effect).

- T-wave inversion: ischaemia, previous MI, PE, or pericarditis.
- Tall, tented T waves: hyperkalaemia.
- Flattened T waves/U waves: hypokalaemia.

Step 6: Common ECG Diagnoses

Diagnosis	Key Features
Atrial fibrillation	Irregularly irregular, absent P waves
Atrial flutter	Sawtooth flutter waves, often 2:1 conduction
Supraventricular tachycardia	Narrow complex, regular, absent P waves
Ventricular tachycardia	Broad QRS, AV dissociation, capture/fusion beats
Heart block	1°, 2° (Mobitz I/II), and 3° complete AV dissociation
STEMI	Localised ST elevation, reciprocal changes
NSTEMI/unstable angina	ST depression, T inversion, raised troponin (NSTEMI)
Electrolyte disorders	Hyperkalaemia: tall T, sine wave; hypokalaemia: U waves

Interpretation Pearls for Advanced Practitioners

- Always compare with previous ECGs to differentiate acute from chronic changes.
- Remember lead aVR: ST elevation here with widespread depression may indicate left main coronary artery occlusion – a high-mortality finding.
- Bundle branch blocks: new left bundle branch block (LBBB) in the context of chest pain may represent STEMI equivalent.
- Be cautious of pacemaker rhythms: they can mask ischaemic changes.
- Artefact, hyperventilation, and hypothermia can mimic pathology.

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