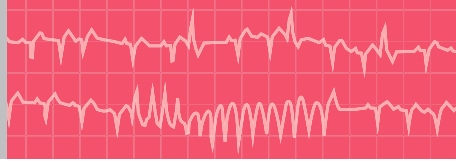


The ECG made very easy indeed

1

This guide has been written for those who are just starting to use ECGs in their clinical practice. It aims to reduce the facts to the bare minimum. If you have no previous knowledge of the ECG, this chapter is for you. Once you have understood it, the rest of the book will amplify your knowledge, but this is the place to start when using the ECG for patient care.

WHAT IS AN ECG?

'ECG' stands for electrocardiogram, or electrocardiograph. In some countries, the abbreviation used is 'EKG'.

The heart is a pump driven by intrinsic electrical impulses which make the heart beat. An ECG is a paper recording of that electrical activity. The ECG records where electrical impulses start and how they flow through the heart. It does not measure how well the heart is pumping.

The electrical activity of the heart starts in the 'internal pacemaker', which is called the sinoatrial node. This is in the right atrium. The normal rhythm is called 'sinus rhythm' (properly it should be called sinoatrial rhythm, but it isn't). The way electrical impulses flow through the heart is called conduction.

Abnormalities in the electrical activity of the heart can result in abnormal conduction or rhythms where the heart may go too quickly, too slowly, or beat irregularly.

Changes to the normal flow of electricity through the heart can be shown on an ECG and may indicate damaged heart muscle. Heart muscle can be damaged by many disease processes such as infarction, hypertension and pulmonary embolism.

WHEN DO YOU NEED AN ECG?

An ECG should be recorded whenever a patient has chest pain, palpitations, breathlessness or dizziness, or if the patient has had an episode of syncope (blackout) or an unexplained fall. In addition, a patient with a stroke or

a transient ischaemic attack (TIA) must have an ECG as these may be due to an irregular heart rhythm.

Remember that the patient's symptoms and physical signs will guide interpretation of the ECG.

HOW TO RECORD AN ECG?

Electrodes are placed on the chest and limbs of the patient to record different views of the heart's electrical activity.

Each view of the heart is described as a 'lead'. The word 'lead' does **not** refer to the electrodes.

The rhythm of the heart can be determined from only one view, i.e. one lead (this requires two electrodes).

For a full picture of the heart's electrical activity, a 12-lead view is conventional.

One electrode is attached to each limb. These four electrodes provide six 'limb leads' or six different views of the heart in a vertical plane. These are called leads I, II, III, VL, VF and VR. VL, VF and VR used to be called AVL, AVF and AVR, respectively, but the A is essentially meaningless and is redundant.

Six electrodes are attached to the chest, recording leads V_1 to V_6. Accurate placement of these electrodes is essential for comparing later ECGs. These leads 'look at' the heart from the front in a horizontal plane (Fig. 1.1).

■ Top tips for recording an ECG

1. To record a '3-lead ECG' using only limb electrodes, remember the mnemonic: "Ride Your Green Bike". R for red and right arm. Y for yellow, G for green and B for black. Apply the first red electrode to the right arm and work clockwise to left arm, left leg and finally right leg (the black electrode is the earth electrode).
2. Placement of the limb electrodes is easy: there is no specific position to remember.
   Try to find the least hairy area: anywhere from the shoulder or outer clavicle down to the wrist is fine for the upper limb; anywhere from the lower abdomen to the foot on right and left side is fine for the lower limb electrodes.
3. Placement of the chest electrodes MUST be accurate and standardized for every recording (see Figs 1.1 and 2.24).
4. Make sure the patient is warm and relaxed.
5. Check machine settings: standard is paper speed of 25 mm/second; the voltage calibration should be set so that 1 mV causes 1 cm of upwards deflection (for more details, see Chapter 2).
6. Make sure the date and time are recorded and always ensure the patient's name is on the ECG.
7. Write the patient's symptoms and BP on the ECG.

For more details, see Chapter 2, pages 28–38.

HOW TO INTERPRET AN ECG: THE BASICS

■ **Top tip: the more ECGs you read, the better you will become.**

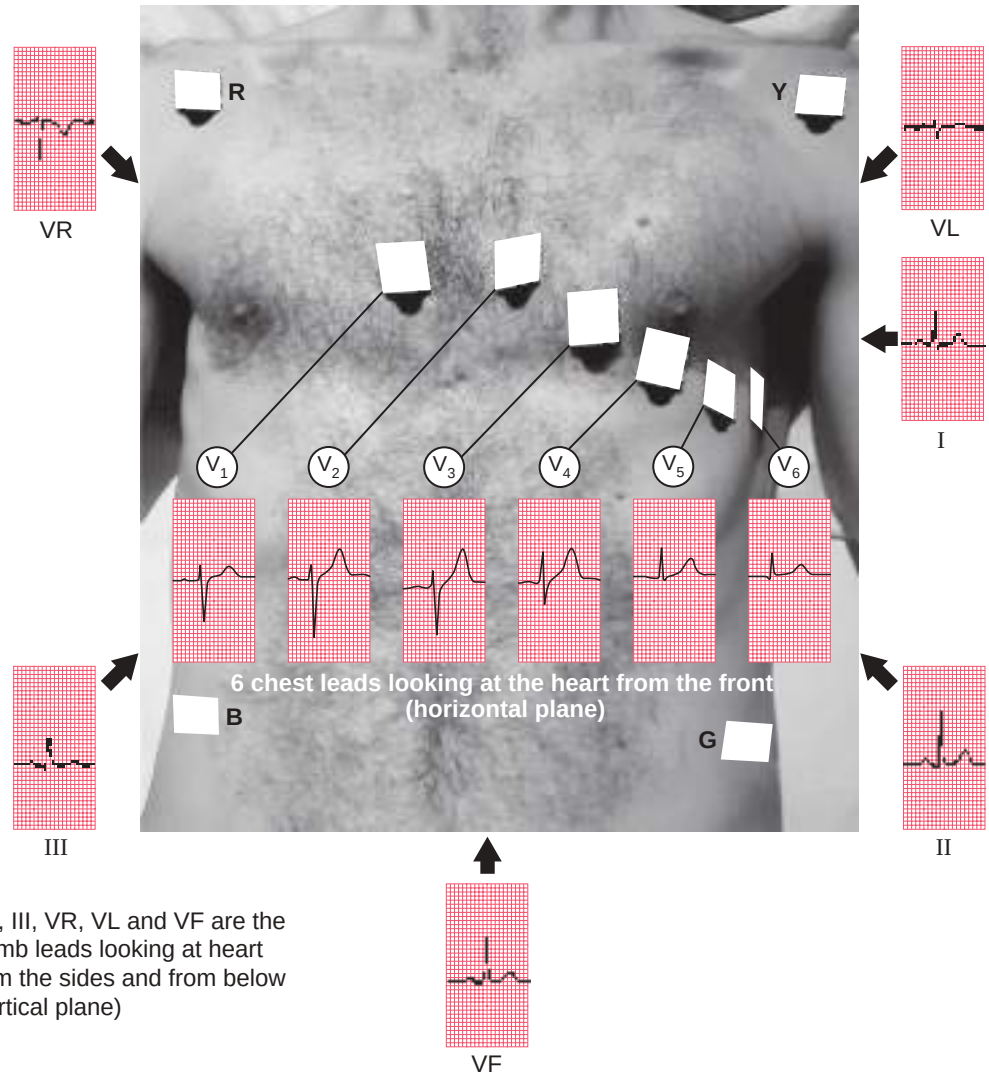
What follows is the bare minimum of ECG physiology for ECG interpretation.

The ECG waves and what they mean

- Think of the heart as having internal wiring. The internal pacemaker is the sinoatrial node situated in the right atrium (Fig. 1.2)
- In a normal heart, the sinoatrial node fires regularly and the electrical impulse spreads through an anatomical path to the ventricles resulting in ventricular contraction. The ventricular contraction is felt as the pulse or the heartbeat.
- Each heartbeat is represented by one ECG complex.
- An ECG complex is composed of five parts (Fig. 1.3).
- The P wave represents electrical activation, called depolarization, of the atrial muscle.

Fig. 1.1

Lead positions for a 12-lead ECG with 12 views of the heart



I, II, III, VR, VL and VF are the 6 limb leads looking at heart from the sides and from below (vertical plane)

Fig. 1.2

Internal wiring of the heart

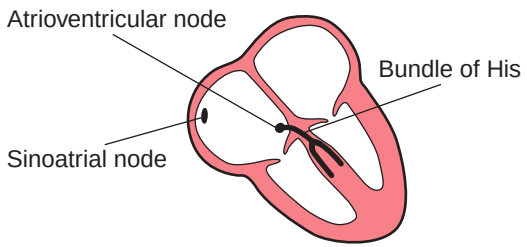
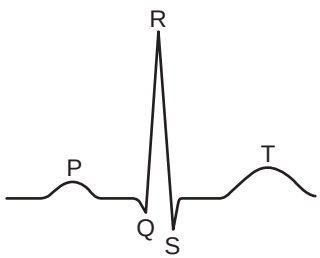


Fig. 1.3

ECG complex – one heartbeat



- The PR interval is the time taken for the electrical impulse to spread from the atria to the ventricles through the atrioventricular node and the high-speed conducting pathway called the bundle of His.
- The QRS complex records the impulse spreading throughout the ventricles resulting in ventricular contraction. In the normal heart, this does not take more than 3 small squares on an ECG.
- The ST segment is the period when the ventricles are completely activated.
- The T wave is the return (repolarization) of the ventricular muscle to its resting electrical state.
- A normal beat is represented by one P wave followed by one QRS complex and then one T wave.

Interpretation starts here!

Start by looking at the patient. Take basic observations of pulse and blood pressure before recording the ECG.

First, is the patient unwell? Are you expecting there to be an abnormality?

■ **Top tip: if the ECG does not fit your clinical expectation, check settings and electrode placement and repeat your recording. Make sure the ECG is recorded from the correct patient!**

If you are satisfied with your recording, think: Is there anything really obviously wrong, e.g. a very slow or fast heart rate? Complexes that do not look like anything you have seen before? If the patient is unwell, seek help immediately.

If the patient is stable, you have more time to try to assess the ECG yourself.

■ **Top tip: always approach the ECG the same way. Go through the following questions in the same order every time:**

Say **'R R P W Q S T'** – it rhymes, and might help you to remember the questions you need to answer!

R	Rate	What is the rate (measured in beats per minute [bpm])?
R	Rhythm	What is the rhythm?
P	P wave	Is there one P wave before every QRS complex?
W	Width	Is the width of the QRS complex normal (< 3 small squares)?
Q	Q wave	Are there any deep Q waves present?
S	ST segment	Is there ST segment depression or elevation?
T	T wave	Are there any abnormal inverted (upside down) T waves?

Let's now look at these questions in more detail. (Remember '**R R P W Q S T**'.)

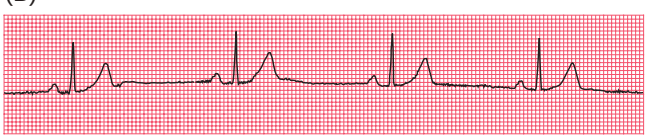
R **Rate: What is the rate?**
The closer together the QRS complexes are, the faster the heart is beating. As a rough guide, less than 3 large squares between each QRS complex indicates a rate of over 100 bpm (tachycardia) (Fig. 1.4A) and more than 6 large squares indicates a rate of less than 50 bpm (bradycardia) (Fig. 1.4B).

R **Rhythm: What is the rhythm?**
Is it regular or irregular? A regular rhythm means there is the same number of squares between each QRS complex (see Fig. 1.4A and B), and note that, whatever the rate, the rhythm is regular.
In Fig. 1.5, there is a variable number of squares between each QRS complex, which means it is an irregular rhythm.

Fig. 1.4

(A)

(B)



(A) Sinus tachycardia (B) Sinus bradycardia

Fig. 1.5

Irregular rhythm

Variable number of squares between each QRS complex

P **P waves: Is it sinus rhythm?**

This is the normal regular heart rhythm and means the electrical impulse starts in the sinoatrial node and is transmitted normally from the atria to the ventricles. This is represented by one P wave before every QRS complex.

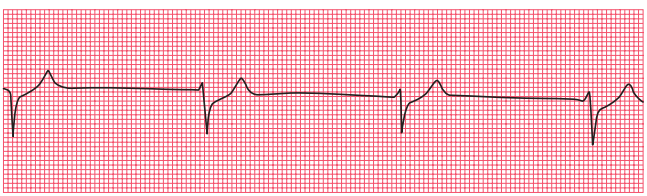
The P wave is the key to rhythm identification. First, can you identify the P waves? Look at all leads – the P wave may be more visible in some leads than others.

If you cannot see a P wave, the atria are not activated normally and there must be an abnormal rhythm (Fig. 1.6).

If there is more than one P wave before each QRS complex, then conduction to the ventricles is abnormal. This is called heart block (Fig. 1.7).

Fig. 1.6

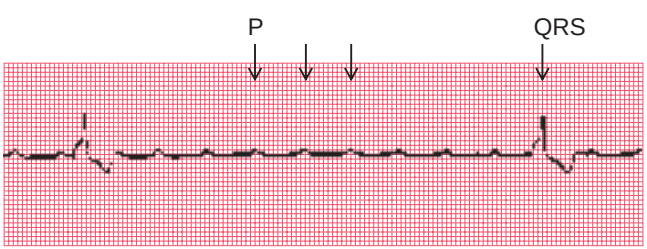
Abnormal rhythm (not sinus)



No P waves

Fig. 1.7

Heart block



Multiple P waves per QRS complex

W **Width: Is the QRS greater than 3 small squares?**
If so, this means there is abnormal conduction through the ventricles.
If the QRS complex is wider than 3 small squares, the spread of electrical activation through the ventricles must be slow. This could be because conduction through the ventricles is abnormal, or it could be because the electrical impulse erroneously began in the ventricular tissue rather than coming through the bundle of His (Fig. 1.8).

Q **Q wave: Are deep Q waves present?**
If the QRS complex starts with a deep downward deflection this may be a Q wave due to an old myocardial infarction (Fig. 1.9; see Ch. 6).

S **ST segment: Are there abnormalities in the ST segment?**
The ST segment should be level with the baseline, but can be elevated (Fig. 1.10) (myocardial infarction) or depressed (Fig. 1.11) (commonly due to ischaemia).

T **T wave: Is the T wave right-way up or upside down?**
It is normally upside down in VR and V_1. If it is upside down in any other lead, then the likely causes are ischaemia or ventricular hypertrophy (Fig. 1.12).

Fig. 1.8
Abnormal ventricular conduction

QRS ≥3 small squares

Fig. 1.9
Deep Q waves

Fig. 1.10
ST segment elevation

Fig. 1.11
ST segment depression

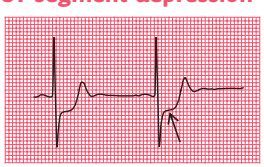
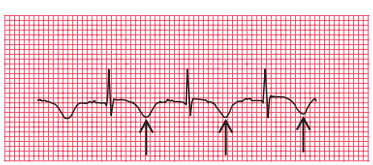


Fig. 1.12
T wave inversion



RHYTHMS YOU MUST BE ABLE TO RECOGNIZE

TABLE 1.1 Common Regular Rhythms

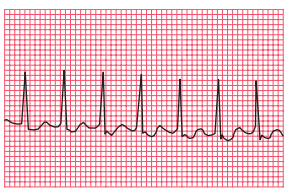
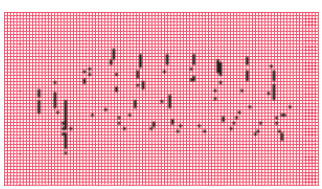
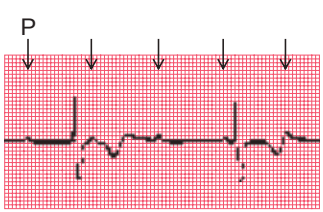
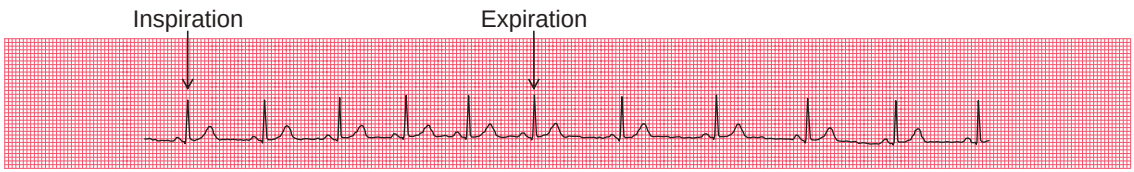
Type of rhythm	Physiological explanation	ECG changes	
Sinus rhythm (Fig. 1.13)	Atria and ventricle working normally (i.e. contracting sequentially)	One P wave for each QRS complex	Fig. 1.13 
Narrow complex tachycardia (Fig. 1.14)	Electrical activation starts in either sinoatrial node, atrial muscle or AV node	P waves may or may not be visible; QRS complex is narrow; rate usually above 120 bpm	Fig. 1.14 
Broad complex tachycardia (Fig. 1.15)	Electrical activity starts from the ventricles at a rate faster than the sinoatrial node	P waves not visible; QRS wide; rate usually above 120 bpm	Fig. 1.15 
Complete heart block (Fig. 1.16)	Atria and ventricles are no longer synchronized and are working independently, but both atria and ventricles are beating regularly due to intrinsic activity	P waves visible (arrows) but do not relate to QRS complexes. QRS complexes are usually wide but may be narrow; rate is slow but still regular	Fig. 1.16 

TABLE 1.2 Common Irregular Rhythms

Type of rhythm	Physiological explanation	ECG changes
Sinus arrhythmia	Atria and ventricle working normally (i.e. contracting sequentially) but affected by respiration; this is normal (Fig. 1.17)	One P wave for each QRS complex but distance between each QRS complex is shorter during inspiration

Fig. 1.17



Extrasystoles (sometimes called ectopic beats)	Extra beats, which may originate from above the ventricle (called supraventricular), meaning they originate from the atria or AV node (narrow QRS, Fig. 1.18), or from within the ventricle (wide QRS, Fig. 1.19)	Rhythm is usually sinus rhythm with occasional early beats resulting in an irregular rhythm

Fig. 1.18

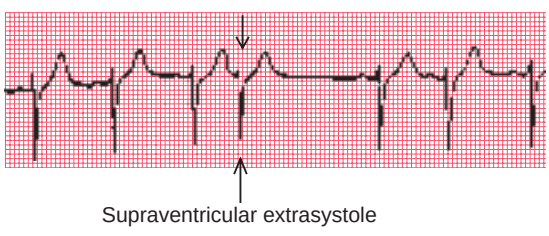
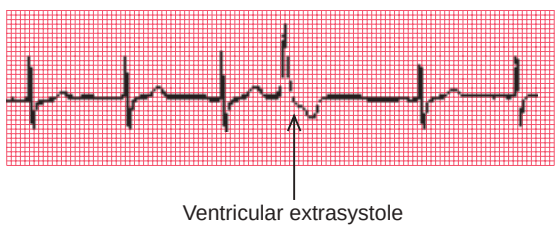
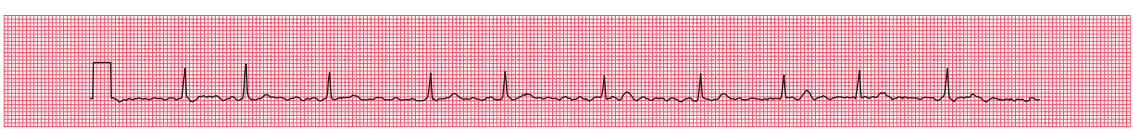


Fig. 1.19



Atrial fibrillation	Totally disorganized electrical activation of the atrial cells and irregular conduction to the ventricles (Fig. 1.20)	No P wave; QRS complex is usually narrow

Fig. 1.20

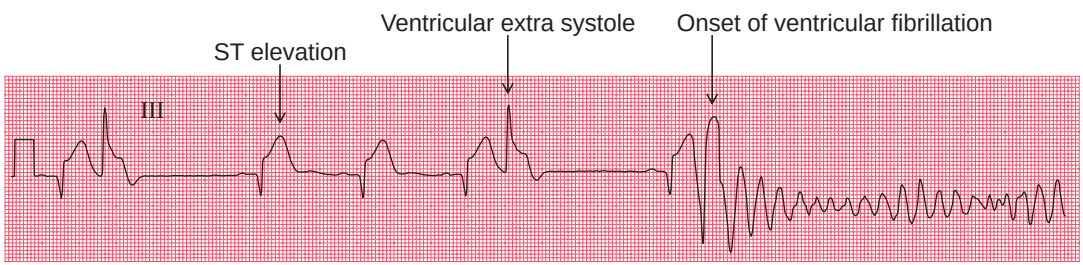


Continued

TABLE 1.2 Common Irregular Rhythms—cont'd

Type of rhythm	Physiological explanation	ECG changes
Ventricular fibrillation	Totally chaotic electrical activity in the ventricles without any pumping activity causes death, unless there is prompt resuscitation (Fig. 1.21)	No visible P waves or QRS complex. Wave form is chaotic and irregular

Fig. 1.21

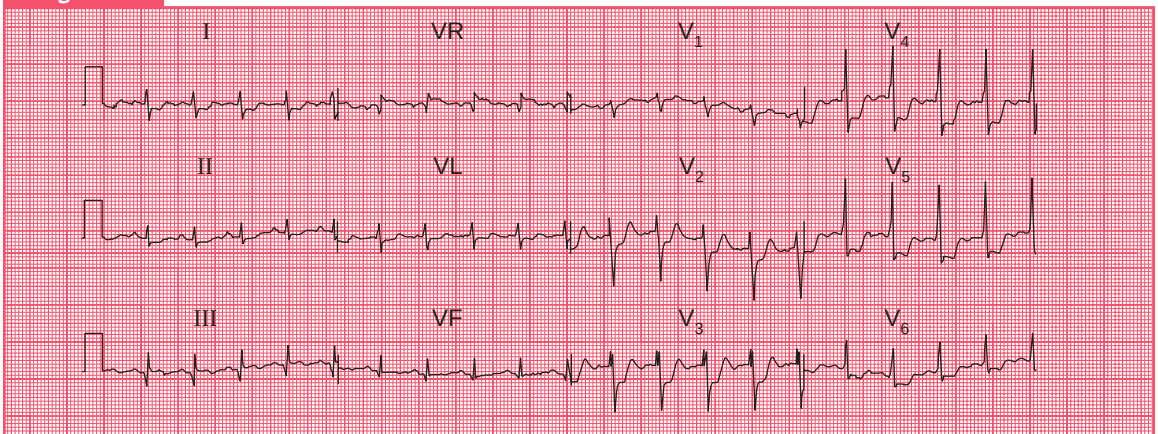


PATTERNS YOU MUST BE ABLE TO RECOGNIZE

The patterns you must be able to recognize, other than rhythm disturbance, are ischaemia, infarction and normal variants. These patterns concern the Q waves, the ST segments and the T waves.

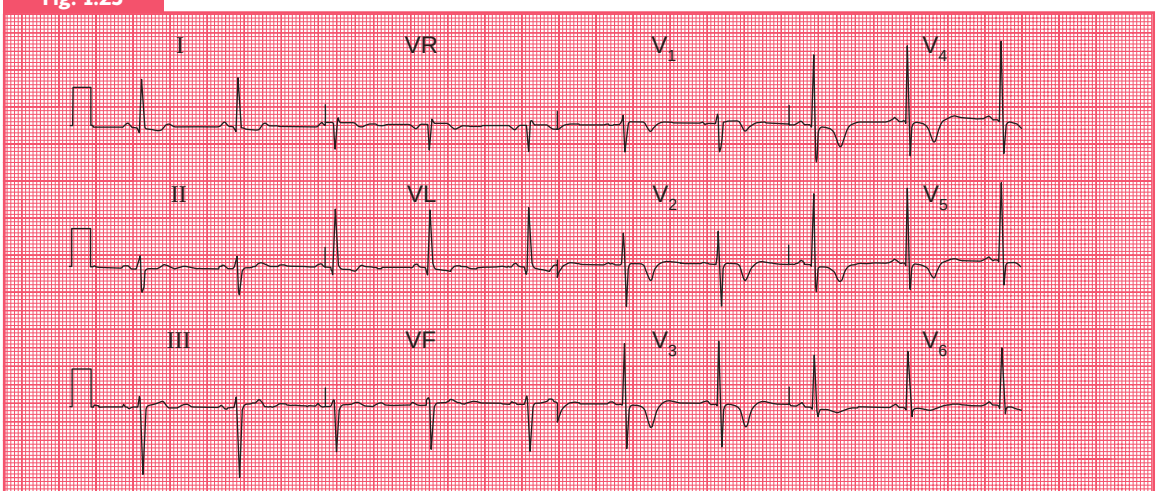
Fig. 1.22 shows sinus rhythm with ST depression in leads V_2–V_6. This change is characteristic of myocardial ischaemia and may be seen in someone having an anginal attack. Fig. 1.23 shows sinus rhythm with T wave inversion across all the chest leads (V_1–V_6). This pattern is also typical of acute myocardial ischaemia and may be seen in myocardial infarction.

Fig. 1.22



Acute myocardial ischaemia with ST depression
Sinus rhythm with ST depression in leads V_2–V_6

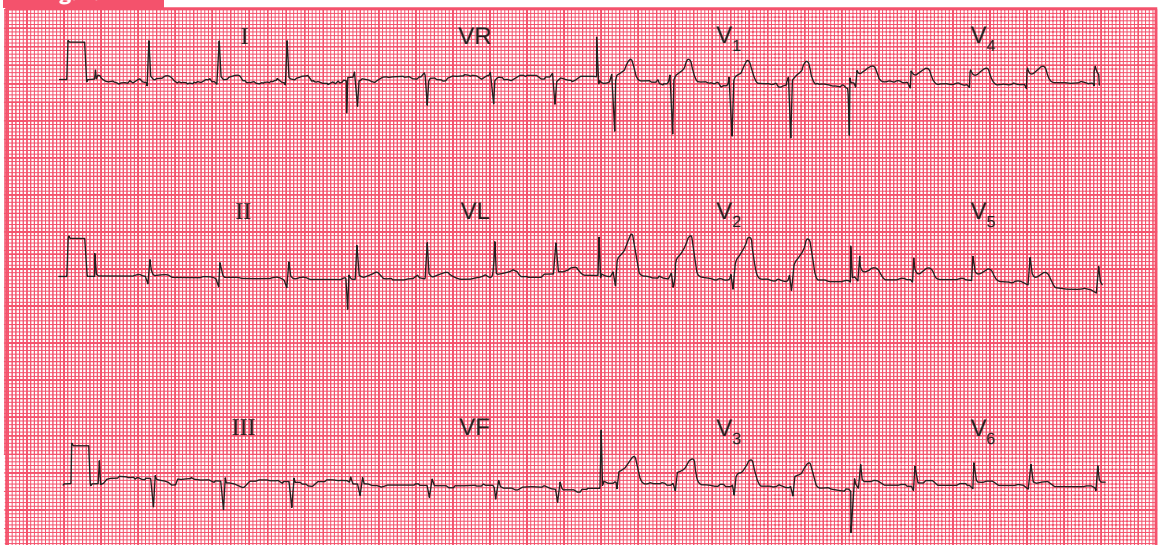
Fig. 1.23



Acute ischaemia with T wave inversion
Sinus rhythm with T wave inversion throughout all chest leads, V_1–V_6

Fig. 1.24 shows sinus rhythm with marked ST segment elevation in leads V_2–V_6. This is typical of acute myocardial infarction. Myocardial infarction with ST segment elevation is known as 'STEMI' (ST segment elevation myocardial infarction). Myocardial infarction without ST segment elevation is known as 'NSTEMI' (non-ST segment elevation myocardial infarction), e.g. Fig. 1.23 which could be either acute ischaemia or infarction.

Fig. 1.24



Acute myocardial infarction with ST elevation
Sinus rhythm with ST elevation in leads V_2–V_6

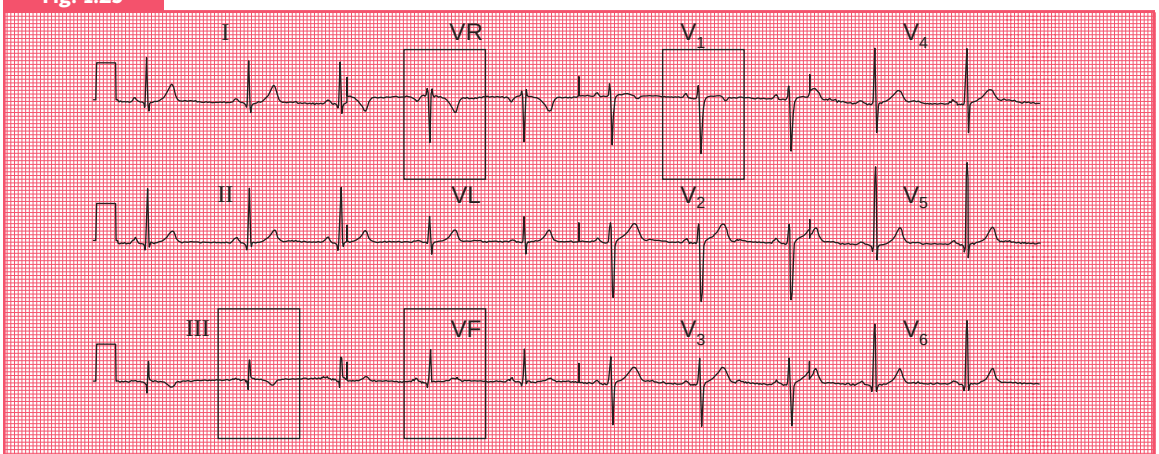
THE NORMAL ECG AND ITS VARIANTS

A big problem with ECG interpretation is the number of normal variants. ECGs from normal healthy people vary, just as normal healthy people vary!

When you start looking at ECGs, try and spot the major abnormalities first.

In Fig. 1.25, the T waves are normally inverted in VR and V_1, but inversion in lead III is normal provided that the T wave is upright in VF. Other examples of normal variants are discussed in Chapter 6, The ECG in healthy subjects.

Fig. 1.25



Normal ECG
T wave inversion in III but normal T wave in lead VF

ECG RED FLAGS

The following ECG abnormalities could be clinically important, but always consider the patients' clinical state first. Any of these changes could present as chest pain, breathlessness, palpitations or collapse.

- Ventricular rate above 120 bpm or below 45 bpm
- Atrial fibrillation
- Complete heart block
- ST segment elevation or depression
- Abnormal T wave inversion
- Wide QRS width

There are 12-lead examples of all these 'red flag' ECGs in Chapter 9.

Table 1.3 ECG Red Flags in an Unwell Patient – What to Look Out For

ECG abnormality	Consider
Ventricular rate above 120 bpm or below 45 bpm	Ischaemia, hypotension, sepsis
Atrial fibrillation	Valve disease, alcoholism, ischaemia, infection
Complete heart block	Any heart disease
ST segment elevation or depression	Infarction, ischaemia
Abnormal T wave inversion	Infarction, ischaemia, pulmonary embolism
Wide QRS width	Any heart disease

■ TOP TIP: DON'T PANIC – THE ECG REALLY IS VERY EASY!

Now you are ready to read the remainder of the book.