Recording a 12-lead electrocardiogram (ECG) is a common part of clinical assessment in both primary and secondary care. In a hospital setting, an ECG may be part of pre-assessment for surgery or part of the admission procedure. In an emergency, an ECG may be used to assess the electrical functioning of the heart and to detect damage to the myocardium (heart muscle). In primary care, an ECG may be performed as part of an overall health assessment, or to monitor ongoing clinical conditions.

An ECG is a painless procedure that involves placing electrodes on specific parts of the chest and limbs to record the heart's electrical activity. The subsequent tracing is recorded on graph paper and consists of 12 specific waveforms, referred to as 'leads', each showing cardiac electrical activity from a different anatomical perspective. The data obtained allow an overall assessment of the rate and rhythm of the heart; the traces will also reflect any specific damage or changes to the structure of the heart.

A 12-lead ECG can help to diagnose a variety of conditions, such as myocardial infarction (the death of heart muscle due to a blocked coronary artery), myocardial ischaemia (inadequate blood supply to the heart), enlargement of the ventricles, and a range of other abnormalities including cardiac arrhythmias (abnormal and potentially dangerous heart rhythms). The 12-lead ECG is frequently used as part of a wider assessment, and is therefore a valuable tool in assessing the overall health status of the patient.

This guide demonstrates how to record a high-quality 12-lead ECG, a skill that requires regular practice. The guidance of an experienced practitioner is key. It is vital to position the electrodes correctly to ensure that you obtain an accurate ECG recording (Carvalho et al., 2020).

The 12-lead ECG records 12 different electrical views of the heart, but only 10 electrodes are placed on the skin. There are six chest electrodes and four limb electrodes. The four limb electrodes, placed on the wrists and ankles, provide the electrical information that produces six limb leads on the ECG. These leads are called I, II, III, aVR, aVL and aVF. (See also the three-part clinicalskills.net series on “Interpretation of a 12-lead electrocardiogram”.)

What does the ECG record?

The muscle of the heart needs electrical stimulation in order to contract and pump blood around the body. This electrical stimulus, or impulse, is created by the heart itself, and spreads through the heart’s specialised conduction system that consists of the sinoatrial (SA) node, atrioventricular (AV) node, Bundle of His, right and left bundle branches, and Purkinje fibres (Hampton & Hampton, 2019). As the electrical impulse spreads through the heart, a number of waveforms are recorded by the ECG. The spread of electricity through the atria (upper chambers) of the heart creates the P wave (a and b), while the passage of the impulse through the ventricles (lower chambers) creates the QRS complex (c). The T wave reflects the return of normal, resting electrical conditions within the ventricles (d). The pattern of P waves, QRS complexes and T waves recorded is used to diagnose heart problems in clinical practice. It is vital that an accurate recording is made as ECGs performed to an inappropriate standard can result in incorrect diagnoses and inappropriate treatments.
Gather all of the equipment you will need to record the 12-lead ECG. These items are usually kept together with the recording machine for convenience and in case it is necessary to carry out a 12-lead ECG urgently. Check the machine before use. Check the electrodes to ensure that they are in good condition and that their expiry dates have not passed. Check that the core of 'wet-gel' electrodes has not dried out. Electrodes should be kept inside the foil packaging to prevent dehydration of the gel. The thermal graph paper needs to be stored in a cool dry place when not in use.

Do not undertake or attempt any procedure unless you are, or have supervision from, a properly trained, experienced and competent person. Always first explain the procedure to the patient and obtain their consent, in line with the policies of your employer or educational institution.

Explain to the patient what you are going to do, and obtain consent. Even though the patient may have had an ECG before, explain that it is painless and why you need to take the recording. Explain the degree of undress required to perform the ECG and offer a chaperone. Provide reassurance. Ask the patient to remove their jewellery, or watch, if worn (store these safely).

Decontaminate your hands with alcohol-based hand sanitiser or with soap and water. Ensure that your hands are dry before starting the procedure. (Follow local infection prevention and control policy.)

Prepare the patient’s skin in line with your hospital or practice area’s policy, to ensure good contact between the skin and the electrodes, which will help produce an artefact-free ECG. You may need to cleanse the skin with soap and water, or a non-alcohol wipe. If the skin is dry, exfoliate very lightly using a paper towel, gauze swab or proprietary abrasive tape (Campbell et al., 2017).
Place the first chest electrode (V1) in the fourth intercostal space, at the right sternal margin (Campbell et al., 2017). To find this position, first locate the angle of Louis (manubriosternal joint). Run your finger down the sternum from the top until you encounter a bony ridge – this is the angle of Louis (inset). From here, run your finger horizontally to the right until you find the gap between the ribs at the edge of the sternum. This is the second intercostal space. Count down two rib spaces to the fourth intercostal space and place the V1 electrode there at the edge of the sternum (Campbell et al., 2017).

For a patient with a hairy chest, you may need to shave the area where the electrodes are to be attached, using clippers or a disposable razor. Try to avoid shaving if possible, because of the risk of infection if the skin is grazed (Carvalho et al., 2020). You must obtain the patient’s consent for shaving. It is not necessary to shave the whole chest. Prepare the skin after shaving if it is oily or dry (see page 2).

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This illustration shows an overview of where the chest electrodes should lie.

**Lead V2**
Repeat this procedure on the patient’s left side to correctly place the V2 electrode in the fourth intercostal space, at the left sternal margin (Campbell et al., 2017).

**Lead V3**
Place the V3 electrode midway between V2 and V4 (Campbell et al., 2017).

**Lead V4**
Place the V4 electrode next. Move down to the fifth intercostal space, and place the electrode in the midclavicular line (Campbell et al., 2017). For patients where breast tissue overlies the correct anatomical electrode position, place the V4, V5 and V6 electrodes beneath the left breast tissue. Do not use the nipple as a reference point for electrode placement.

**Lead V5**
Place the V5 electrode at the same horizontal level as V4, but in the left anterior axillary line, as shown here (Campbell et al., 2017).

**Lead V6**
Place the V6 electrode at the same horizontal level as V4 and V5, but in the left midaxillary line (Campbell et al., 2017).

**Position of chest electrodes**
This illustration shows an overview of where the chest electrodes should lie.
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Always first explain the procedure to the patient and obtain their consent, in line with the policies of your employer or educational institution.

### Lead box

The leads from the ECG machine usually converge in a plastic box. Place the box on the patient’s lower chest, to make it easier to join the correct leads to the electrodes. The leads are labelled and colour coded to indicate which electrode they should be connected to (refer to local instructions).

### Attach the limb leads

Untangle the leads and lay them out against the corresponding electrodes, using the labels on the leads as a guide. Use the crocodile clips to attach each of the limb leads to the electrodes. Check the labels and colour coding on the leads to ensure that they are connected to the correct electrodes.

### Attach the chest leads

Attach each of the six chest leads, labelled V1–V6, to the corresponding electrode.

### Check the position of the leads

When you are sure that all the electrodes are correctly connected, you are ready to generate the recording of the electrical activity of the heart.

### Enter the patient’s details

Before printing the trace, enter the patient’s name and identification number into the machine. This is essential as many departments store the ECG electronically and there is a significant risk of incorrect patient management if an ECG result is linked to the wrong patient record.

### Print the ECG trace

When you are confident that everything is ready, print the ECG. Some machines allow you to view the ECG on a screen before printing, so that you know the trace is of a good quality.
Check the paper speed and voltage gain

A standard ECG is recorded using a paper speed of 25 mm/s and a voltage gain of 10 mm/mV. The machine should default to these settings, but you should check the recording to ensure that these settings have been used. Changes in paper speed or voltage gain will affect the appearance of the waveforms, and therefore the interpretation of the result. The settings are usually printed in the bottom corner of the recording; if they are incorrect, adjust the machine settings and reprint the ECG. Ask for help if you are unfamiliar with the machine.

Check the patient’s name and details

Check that the patient’s name and identification number are correctly printed on the ECG, along with the time and date of the recording. Then proceed to assess the quality of the recording.

Assess the appearance of QRS complexes

On a normal 12-lead ECG, the QRS complexes are upright in leads I and II (a) and inverted in lead aVR (b). The QRS in lead V1 is mostly negative (below the baseline) (c) and becomes more positive (above the baseline) as you move across the precordium towards lead V6 (d). This normal pattern can be disrupted by a variety of disease processes, or by incorrect recording of the ECG. Check again that each wire is attached to the correct electrode if the pattern looks abnormal.
**Artefacts: (a) Electrical interference**

Electrical activity in the environment can produce a thickened line on the ECG. Move electrical appliances, such as syringe drivers, further from the patient. Try changing electrodes to improve skin contact. Use the machine’s manual filter button (if present) to reduce extraneous electrical activity, but activate this only when absolutely necessary because it can distort the recording (Campbell et al., 2017). Write on the recording that the filter has been applied.

**Artefacts: (b) Muscle tremor**

Muscle tremor occurs if the patient is not lying still, or is moving because of involuntary movements or shivering. Reassure the patient and ask them to lie as still as possible. Try to avoid moving the leads up the limbs, as this may affect the recording (Campbell et al., 2017), but you may have to do this with an amputee. Use the filter button, but only if absolutely necessary. Always add a comment to the ECG when a change from the ‘standard’ recording is made.

**Artefacts: (c) Wandering baseline**

A wandering baseline appears as a trace that does not align with the horizontal lines of the graph paper. It is important to correct this as it will make it difficult to detect ECG abnormalities. Causes include patient movement and poor contact between the electrodes and the skin. Check skin preparation (see page 2), and replace the electrodes if necessary. A flat line on the ECG tracing for a specific lead usually means a disconnection of that lead (Carvalho et al., 2020).

**Documentation**

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<td>RN</td>
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Record in the notes that a 12-lead ECG has been taken. Document any changes to the standard electrode placement (e.g., for a patient with an amputation) and any clinical signs or symptoms such as chest pain. Ask an member of staff to review the ECG (record their identity in the notes).

**Check the equipment**

Clean the machine and wires (follow local policy). Put the ECG machine away carefully without tangling the wires. Ensure that the ECG machine is plugged in to charge while not in use. If necessary, top up the supplies, such as ECG paper or electrodes.