Clinical Guidelines by Consensus

Recording a Standard 12-Lead Electrocardiogram

An approved method by the The Professional Body for Cardiac Scientists (SCST)

Issue Date: September 2024
Review Date: September 2028

Clinical Guidelines by Consensus
Recording a standard 12-lead electrocardiogram
An approved method by the SCST

Document ID	CS3
Lead Author(s)	SCST Standards Committee
Lead Authors' job titles	-
Additional Author(s)	See acknowledgements
Document version number	CS3 version 4.1
Ratifying committee	SCST Board
Ratification date	September 2024
Review date	September 2028
Body responsible for review	SCST Board
Committee for review	Standards Committee
Contact for document	standards@scst.uk.org
Referencing Included	Yes
Key Words (for searching)	ECG, Electrocardiogram, 12-lead
Intended users	All recording 12-lead ECG
Equality Impact Assessment	No

Please cite as:
Campbell B, Richley D, Ross C, Eggett CJ. Clinical Guidelines by Consensus: Recording a standard 12-lead electrocardiogram. An approved method by The Professional Body for Cardiac Scientists (SCST) 2024.
Available at: (quote link & date accessed)

Acknowledgements

Lead authors:

Brian Campbell
Catherine Ross
Christopher Eggett
Dave Richley

With many thanks to the following people for help in the document **development and review process**:

Vitor Morgado
Alice Marchant
Heather Herbert
Helen Twenlow
Joanne Ashton
Katie Sanders
Pooja Raithatha
Suzanne Ramsay
Tracy Simpson

Contents

1. Change history

Version	Date	Author	Reason	Ratification Required
1	Feb 2010	Consensus	Standardisation of practice	SCST Council
2	Jun 2014	Consensus	Standardisation of practice – review	SCST Council
2.1	Nov 2015	Consensus	Citation added, contributor details updated	Not required
3	September 2017	Consensus	Standardisation of practice – review	SCST Council
4	September 2024	Consensus	Standardisation of practice – review	SCST Board
4.1	October 2024	Consensus	Minor correction in figure 2	Not required

2. Introduction

The 12-lead electrocardiogram (ECG) is a graphical display of the electrical activity of the heart. It is usually recorded by means of a small, portable machine.

The ECG has many important uses, primarily in the diagnosis and assessment of a range of cardiac and non-cardiac conditions but also in helping to determine prognosis and guide therapy. Although the test is simple to perform, it is often done incorrectly, and this may lead to misdiagnosis and inappropriate therapeutic decisions[1-7].

The portability, low cost and ease of use of modern ECG machines has enabled ECGs to be recorded in a variety of settings - including hospital wards and departments, general practitioners' surgeries, ambulances, sports facilities and patients' homes - and by a variety of staff, many of whom have not been formally trained and assessed in correct recording technique[8]. Such personnel may consider themselves competent[9-10], and yet lack the knowledge of how to record ECGs correctly[11-14]. There is evidence that appropriate training leads to fewer ECG recording errors[15]. SCST recommends that all personnel who record ECGs be appropriately trained, assessed and qualified.

This document aims to provide guidance for practitioners on how to record ECGs that are of high quality and technically correct whilst observing principles of good clinical governance and patient privacy and dignity. The guidance is based on existing national and international standards, evidence from research and, where evidence is lacking, expert consensus. Although the guidelines apply particularly to the hospital environment, where most ECGs are recorded, recommendations regarding the technical aspects of ECG recording have wide applicability.

3. Purpose & Scope of Practice

These guidelines are not intended to disrupt existing high-quality ECG services. This document is intended as a template for developing best practice and as a recommendation for developing new services. This document is not intended to replace Trust policies and other legislation e.g. data protection and codes of conduct that should be adhered to in addition to the recommendations of these guidelines.

In promoting excellence in the recording of 12-lead ECGs, these guidelines address the following areas:

- Patient experience, privacy and dignity
    - Patient identification
    - Communication & informed consent
    - Chaperone
    - Level of undress
- Patient preparation
    - Patient position
    - Skin preparation
- Electrode placement:
    - Limb electrode positions
    - Chest electrode positions
    - Technique for locating chest electrode positions
- Obtaining a good quality recording
    - Paper speed
    - Use of the filter
    - Variation from standard
        - Amplitude gain
- Qualification requirements for practitioners
- Equipment and clinical room specification
    - Equipment
    - Environment
    - Infection control
- Documentation, processing, storage and confidentiality of 12-lead ECG recordings
- Special situations

These guidelines outline the optimum conditions for recording an accurate 12-lead ECG. The majority of ECGs are recorded in a hospital/clinical environment; however, these guidelines should be applied as far as possible in any setting where ECGs are undertaken. This may include ambulances, sports facilities, and patients' homes. Some locations may require adaptation to ensure safety and dignity is maintained or because of the lack of availability of equipment. For example, equipment to position the patient at a 45-degree angle may not be available in a patients' home.

The practitioner should make every effort to follow these guidelines, regardless of location. Where adaptations have been necessary due to the local environment, this should be clearly documented on the ECG if they may affect the recording, for example, change in patient position or lead position. Preservation of patient privacy and dignity should remain paramount in any location where ECGs are recorded.

4. Patient experience, privacy and dignity

It is vital that patient experience is placed at the centre of the process and to ensure that the patient's perception of the process is positive.

4.1 Patient Identification

It is essential that the patient undergoing the procedure is correctly identified, with at least two unique patient identifiers which can include name and date of birth. Additional identifiers may be confirmed if deemed necessary, as per employer policies.

For patients unable to provide their own identifying details confirmation of identity must be sought from carers or by using hospital wristbands.

The printed ECG recording must always be checked to ensure it bears the correct patient details. Practitioners must be aware of potential sources of error if details are not entered digitally for every patient e.g. some machines retain the information from the last patient, and these may be incorrectly printed on the ECG if they have not been altered. Local policy and practice should be developed to ensure that errors do not occur in busy clinical environments. It is recommended that at least two unique patient identifiers are confirmed e.g. date of birth and address.

4.2 Communication and informed consent

The patient should be given clear, precise information in a format that is consistent with their needs and level of understanding. Information can be in the form of a booklet, information letter or oral explanation or a combination. You may direct your patients to reliable sources, such as The British Heart Foundation (BHF), who have several booklets available for patients and healthcare professionals. You can find an ECG booklet here: https://www.bhf.org.uk/informationsupport/publications/tests-for-heart-conditions/electrocardiogram---your-quick-guide

As a minimum, SCST recommends the person performing the procedure should introduce themselves, explain their role and provide a brief overview of the procedure. If possible, this should include the level of undress involved and the use of adhesive electrodes and wires, with a reassurance that the procedure

is brief and painless. Informed consent is required in accordance with Good Clinical Practice (GCP), and in line with local policy before proceeding. For ECG recording, it is acceptable to obtain verbal consent.

4.3 Chaperone

In accordance with GCP, patients undergoing examinations that have the potential to be embarrassing or distressing should have the option of having a chaperone present[16].
A formal clinical chaperone is recommended, non-clinical staff who carry out chaperone duties may need a DBS checks. A relative or carer present can pose a difficulty and possibly influence or interfere with the test, and their attendance is not recommended. If English is not the patients first language a chaperone may be a hospital organised interpreter, a same sex interpreter may be most appropriate when requesting such bespoke services.
If the patient does not want a chaperone, record that the offer was made and declined in the patient's notes. If the practitioner or the patient declines an examination without a chaperone present, or if either is uncomfortable with the choice of chaperone, an offer may be made to defer the examination to a later date when a suitable chaperone would be available, if the delay would not adversely affect the patient's health[16].

4.4 Level of undress

Practitioners should respect the cultural sensitivities of the patient and minimise embarrassment[17]. Patients may feel uncomfortable being touched on their upper torso; practitioners must act in a sympathetic, caring and compassionate manner.

Patients should be asked to remove all clothing impeding access to the correct chest electrode positions. Normally this will involve undressing above the waist. Patients should be allowed to undress in a private environment with minimal risk of interruption. Once the cables have been attached to the electrodes the patient should be covered to preserve his/her modesty. The practitioner should make every effort to ensure the patient is comfortable and relaxed to minimise artefact on the ECG recording. Clinical discussions with the patient should only take place after re-dressing.

5. Patient preparation

Whilst it is recognised that 12-lead ECGs are performed in a variety of contexts, environments and states of urgency, attempts to achieve best practice and standard electrode positioning should always be made.

5.1 Patient position

Many patients are uncomfortable lying flat, so for consistency and practicality, a semi-recumbent position of approximately 45 degrees is recommended. Any significant variation from this position should be documented on the ECG recording. The limbs should be supported by the bed/couch to minimise artefact due to muscle tension.

The ECG appearance can be affected by the angle of incline of the torso at the time of recording. An ECG recorded from a patient in a supine position may vary significantly from one recorded with the patient in an upright position[18, 19] or inclined at 60 degrees or greater to the horizontal[20]. There is no evidence that variation of the inclination of the patient between horizontal and 45 degrees to the horizontal has any significant effect on the ECG.

Time should be taken to ensure that the patient is relaxed and comfortable. If these conditions are not satisfied the ECG may record somatic muscle potentials as well as cardiac activity and will make the ECG more difficult to interpret and potentially limit clinical value. Some patients cannot relax fully because of painful conditions such as arthritis, or they may have a condition such as Parkinson's disease which causes a tremor. You may request your patient to gently tuck both their hands behind their legs. These patients should be made as comfortable as possible and the ECG trace annotated with an appropriate explanation if it is suboptimal quality. Before recording the ECG, checks should be made to ensure the patient's limbs are still and appear relaxed. If the patient has clenched fists or stiff arms or is moving his/her fingers, it will not be possible to obtain a high-quality ECG.

5.2 Skin preparation

Skin preparation is often required to help produce an artefact-free ECG. Care must be taken with patients who have sensitive or broken skin. There are various ways to minimise the skin-to-electrode impedance, for example:

- The skin may require cleansing. There are a variety of methods, including washing with mild soap and water, or alcohol-based skin wipe.

- Exfoliation may be required and should be undertaken with very light abrasion using a paper towel, gauze swab or proprietary abrasive tape designed for this purpose.

- Chest hair may need to be removed to ensure adequate contact with the skin. Verbal consent should be obtained from the patient and a battery-operated razor with a single use blade or a single use razor should be employed and disposed of in a sharps bin immediately afterwards as per local infection control (IC) policies.

6. Electrode placement

Electrodes must be positioned in accordance with AHA recommendations[21-22].

If any of the electrodes are to be sited in non-standard positions the recording must be labelled with this information to avoid misinterpretation of altered ECG waveforms[22-26].

ECG cable connections are usually colour coded to aid identification. However, colour may vary depending on manufacturer. The colours detailed in this document comply with European (IEC) recommendations.

Note on electrode care: disposable electrodes should be checked to ensure they are not outside the 'use by' date specified by the manufacturer and that they are in good condition. It should be verified 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.

6.1 Limb electrode positions

Limb electrodes should be placed proximal to the wrists and ankles whenever possible (see table 1). Moving the electrodes up the limbs may alter the appearance of the ECG and should be avoided unless there is a significant tremor or a limb has been amputated.

Note: Limb electrodes must not be placed on the torso since this causes significant alteration to wave amplitudes. This can invalidate the use of the recording for many diagnostic purposes[23, 27].

Limb electrode positions:
Right arm limb lead (RA, red) – right forearm, proximal to wrist
Left arm limb lead (LA, yellow) – left forearm, proximal to wrist
Left leg limb lead (LL, green) – left lower leg, proximal to ankle
Right leg limb lead (RL, black) – right lower leg, proximal to ankle

Table 1 – Recommended limb electrode positions

6.2 Precordial (chest) electrode positions

The correct anatomical positions for the chest electrodes have been defined[21] (see table 2) and must always be used unless access is not possible. The

centre of the active area of the electrode should be aligned with the relevant anatomical landmark.

Precordial (chest) electrode positions:
V1, red (C1) – Fourth intercostal space at the right sternal edge
V2, yellow (C2) – Fourth intercostal space at the left sternal edge
V3, green (C3) – Midway between V2 and V4
V4, brown (C4) – Fifth intercostal space in the mid-clavicular line
V5, black (C5) – Left anterior axillary line at the same horizontal level as V4
V6, purple (C6) – Left mid-axillary line at the same horizontal level as V4 & V5

Table 2 – Recommended precordial electrode positions

Studies have demonstrated that the V1 and V2 electrodes are frequently placed too high and the V4, V5 and V6 electrodes too low[13, 28, 29, 30]. These errors can result in diagnostically misleading alterations to the ECG waveform[31].

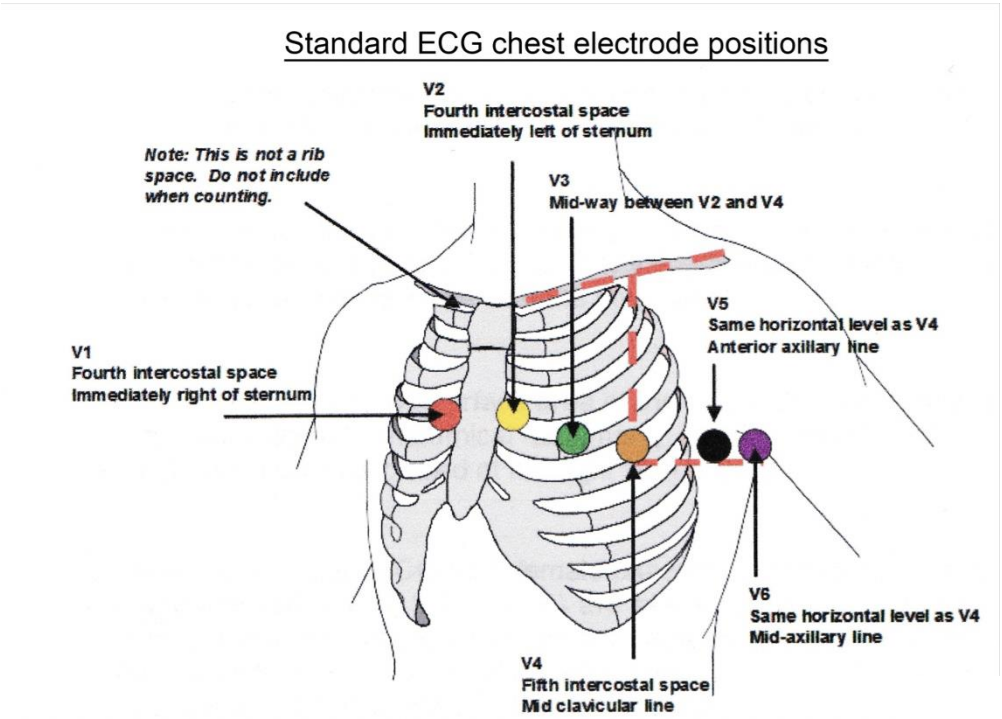


Figure 1 – Standard ECG precordial electrode positions

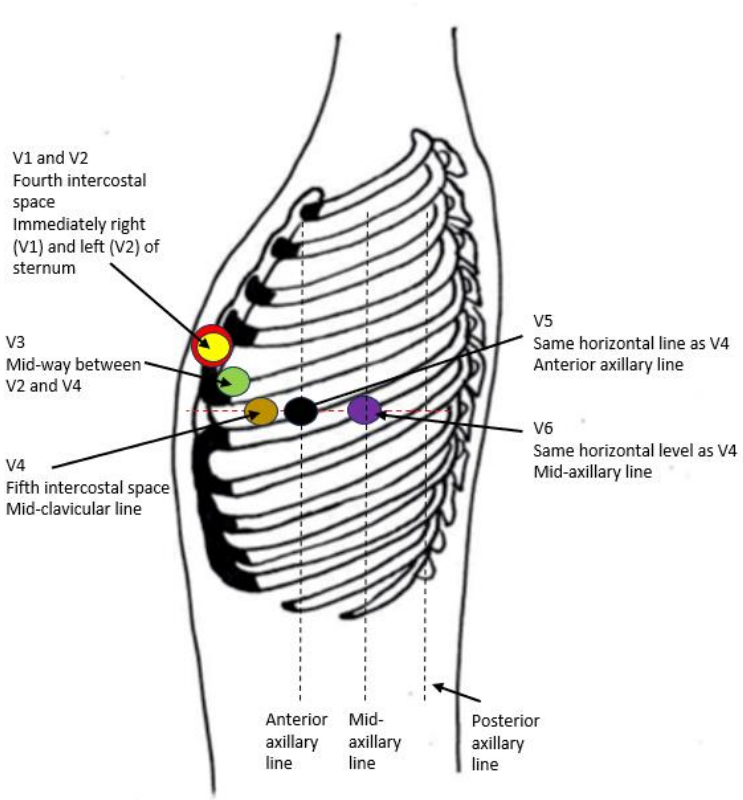


Figure 2 – Lateral view for precordial electrode positions (V4-6)

6.3 Technique for locating chest electrode positions

Accurate identification of the appropriate intercostal spaces should begin with location of the manubriosternal joint, also known as the angle of *Louis*.

- To locate the angle of *Louis* a finger should be run down the sternum from the top until a bony horizontal ridge is met. Sliding the finger down and to the patient's right side will locate the second intercostal space. From here it is possible to count down to the third and fourth intercostal spaces. In the fourth space, the finger should be slid towards the sternum until the edge is felt. This is where the centre of the V1 electrode should be placed.

- This procedure should be repeated on the patient's left side to correctly position the V2 electrode. (Note that the left and right sided rib spaces may be offset, so practitioners should avoid placing V2 adjacent to V1 without counting the rib spaces).

- Next, the V4 electrode should be placed in the 5th intercostal space in line with the mid-point of the clavicle.

- The V3 electrode should then be placed mid-way between the V2 and V4 electrodes.

- The V5 and V6 electrodes should then be positioned in horizontal alignment with the V4 electrode. The V5 electrode should be placed on the anterior axillary line; the V6 electrode should be placed on the mid-axillary line.

When recording an ECG from female patients it is convention to place the V4, V5 and V6 electrodes beneath the left breast when breast tissue overlies the correct anatomical positions. There is some evidence to suggest that the positioning of these electrodes over the breast may not significantly attenuate the signal[31, 32] but further supporting evidence is needed to warrant a change in this recommendation.

When lifting the breast to place electrodes, care and sensitivity is required. Using the back of the hand to lift the breast can be helpful in minimising contact.

To achieve accurate ECG electrode positioning, it is usually necessary for all upper torso clothing to be absent.

Note: If positioning varies from the recommended positions it is essential that this is documented on the ECG recording, including electronically stored ECGs.

ECGs in patients with breast implants (BI)[33]

There isn't a significant amount of literature regarding displacement of ECG electrodes in patients with breast implants. However, a small study by Bun et al. (2019) found that 42-46% of ECGs of women with structurally normal hearts, were considered abnormal by expert electrophysiologists, comparing to a control group. Careful attention should be paid to women presenting with chest pain or acute coronary syndromes (ACS). Two possible explanations for the ECG changes have been suggested by Bun et al:

- Incorrect placement due to increased volume of breast implant, makes positioning of the electrodes challenging in practice.

- Electrical vector deviations due to non-excitable material of the breast implant (speculative).

It may be reasonable that women considering BI surgery have an ECG prior to undergoing surgery, so it can be used as comparison if ever needed.

7. Obtaining a good quality recording

A 12-lead ECG and simultaneous rhythm strip is most commonly recorded at 25mm/s with a gain setting of 10mm/mV. The appropriate button should be pressed to initiate a recording; this is usually labelled as 'start' or 'auto'.

Standard ECG recording settings:
Paper speed – 25mm/sec
Voltage gain – 10mm/mV

Table 3 – Standard ECG recording settings

All filters should be 'off' for the initial attempt to record an ECG. The low-pass filter will reduce interference, but it also distorts the ECG[34], so should only be used when necessary and only after all attempts to eliminate the interference have failed.

If, despite efforts to relax the patient and make them comfortable, there is somatic muscle interference on the ECG, the filter may be switched on and the recording repeated. Use of the filter should be clearly identified on the final ECG.

Use of the filter (in auto mode):
Initial recording – filter off – recording made at 0.67 - 150Hz
Evidence of somatic muscle interference:
Repeat recording – filter on – recording made at 0.67 - 40Hz
The filter reduces interference but also distorts the ECG

Table 4 – Recommended use of ECG filters

Any features on the ECG that might indicate the need for urgent medical attention should be brought to the attention of appropriate staff. If the patient has any symptoms of possible cardiac origin, such as chest pain, palpitations or dizziness, at the time of recording, then this should be noted on the ECG.

Confirmation that an ECG of good quality has been recorded should be made by the practitioner. The recording should be assessed to ensure that all waveforms (such as P waves, QRS complexes and T waves) are clearly visible. The isoelectric line (the baseline between ECG deflections) should be stable, not wandering, and free of interference

At the end of the procedure, all the electrodes should be removed from the patient and disposed of as clinical waste.

Note: Incorrectly pressing 'copy' or 'reprint' may on some models of ECG machine initiate a printout of an ECG from a previous patient[36]. If patient details

are not entered into the machine it may not be clear that this ECG relates to a previous patient. Practitioners must fully understand the equipment they are using and the potential consequences of mistakes. Local practice guidance must minimise the chance of an identity or recording error occurring in this way.

7.1 Variation from standard

If ECG complexes are of such high amplitude that they overlap, then the gain may be adjusted to 5mm/mV to enable clearer visualisation of the complexes and more accurate measurements to be made. Any alteration to the gain settings should be clearly marked on the ECG.

On occasions, it may be necessary to adapt the recommended ECG recording techniques. For example, patients in wheelchairs may need to remain in their wheelchair during the recording process. Any variations to standard recording techniques should be described clearly on the recording for hard copy and electronically stored ECGs.

8. Qualification and training of staff recording 12-lead ECGs

The practitioner must be competent in the use of the electrocardiograph and in the recording of an ECG[10]. This should be demonstrated by the possession of a recognised qualification, such as one of those awarded by the SCST, including:

- Certificate in Electrocardiography (SCST);
- SCST Award in Practical Electrocardiography; or similar

In addition to those qualifications, some Trusts offer ECG lead placement training for the staff members required to perform an ECG. Please check local policies and mandatory training requirements.

It is essential that competence in the recording of an electrocardiogram be maintained and this should be demonstrated by periodic review.

9. Equipment and clinical room specification

The room and equipment should be clean and orderly with all waste from previous investigations disposed of in line with local policy and guidance.

Equipment should be safe and ready to use with correct date and time settings. A visual inspection should be performed prior to use to ensure that mains leads, cables and connectors are intact with no evidence of fractures, faults or insulation damage.

For battery-operated machines, the battery will need to have sufficient charge. It may be useful for a mains-powered ECG machine to have an easily

distinguishable plug if it is to be used in environments where several items of vital equipment are plugged into wall sockets e.g. intensive care units.

9.1 Equipment specification

The electrocardiograph must meet or exceed the requirements of International Electrotechnical Commission standards IEC 60601-2-25:2015 which establishes requirements for safety, including essential performance of recording and analysing single channel and multichannel electrocardiographs.

The device should be pre-programmed in accordance with the American Heart Association (AHA) specifications[21] as follows:

- To avoid distortion of the ST segment the low-frequency cut-off should be no higher than 0.67Hz in 'auto' mode or 0.05Hz in 'manual' mode.

Note: Digital filter design allows for a low-frequency filter level of 0.67Hz when recording in 'auto' mode. However, this may cause ST segment distortion when this setting is used in 'manual' mode. Fixing the low frequency setting at 0.05Hz in the pre-set should prevent this error occurring.

- To prevent the loss of high frequency information the high frequency cut-off should be no lower than 150Hz in adults and adolescents and no lower than 250Hz in children

- Disposable tab electrodes must meet or exceed the requirements of the American National Standards Institute/Association for the Advancement of Medical Instrumentation (ANSI/AAMI) EC12:2000(R)2015, which establishes minimum labelling, safety and performance requirements for disposable electrodes used for diagnostic electrocardiography

Recommended recording bandwidths pre-stored in ECG device setup:	
'Auto' mode	0.67 – 150Hz
'Manual' mode	0.05 – 150Hz
Mains filter	Off

Table 5 – Recommended recording bandwidths for ECG recording

9.2 Environmental considerations

The environment in which a 12-lead ECG is recorded may contribute considerably to the quality of the patient experience and output. As far as possible the environment should be:

- Safe
- Private: walled, curtained or screened
- Quiet
- Comfortable
- Accessible for disabled and able-bodied patients and staff
- Furnished with a height adjustable couch accessible from both sides
- Stocked appropriately, with battery operated razor with a single use blade (or a single use razor), electrodes, ECG paper, etc.
- Clean, with appropriate hand-cleaning and clinical waste facilities

9.3 Infection control

Appropriate measures to minimise the risk of infection transmission must be undertaken in accordance with local policy.

Hands should be washed[36] with soap and water or cleansed with alcohol gel, as per local policy, before and after any contact with a patient. It may be reassuring to patients if this is done in their presence.

For patients requiring high levels of infection control precautions, personal protective equipment such as gowns and gloves must be worn in accordance with local policies.

Appropriate clinical waste disposal facilities should be available including sharps bins for the disposal of the single-use blade for a battery-operated razor or a single use razor.

10. Documentation, processing, storage and confidentiality of ECG recordings

The ECG should be correctly labelled with the patient's identification, relevant clinical details and any variations to the normal recording conditions. ECG recordings that are digitally stored should be accompanied by the following identifiers to ensure accurate retrieval of clinical data and allow audit:

- Patient's first name and surname (formatted and spelled correctly);
- Patient's date of birth;
- A unique identifying number if available;
- The name and position of the referrer
- Identity of the person making the recording of the ECG
- Date and time of the recording
- The name of the institution
- Alterations from standard lead positions must be noted (section 8.1)

Typically, the electronic storage of ECG recordings is made by compressing data. This can speed up the transmission and retrieval of records that are stored in central databases and minimise the memory required for storage.

Data compression affects high frequency (short duration) signals more than the smoother low frequency (longer duration) signals. Therefore, compression has greater potential to alter measurements within the QRS complex, such as pacemaker 'spikes', Q-wave duration and R-wave amplitude, than to alter other signals such as the ST segment and the T-wave. A non-compressed ECG may differ from its compressed version. This has the potential to affect the comparison of serial ECGs when retrieving ECGs from storage media.

For the electronic storage of ECGs, it is recommended that compression algorithms should perform in a manner that allows retrieved data to adhere to the fidelity standards established in the 1990 AHA statement with reference to the original signal[37].

All information pertaining to the patient should be treated in a confidential manner in accordance with local policies and national guidelines on data protection[38]. Where possible, digital storage of ECGs should be considered.

11. Quality assurance (QA) and audit

Audit is a recognised way of assessing and improving practice. There is no single, comprehensive QA scheme that can be prescribed for ECG recording, but it is recommended that any scheme used addresses qualifications in ECG interpretation and the audit of reports.

The appendix[39] contains a useful checklist intended for use and an audit tool. This checklist can be used to assess how well the guideline is being followed. It may also be used to ensure that any local guidelines developed from this consensus document meet the requirements for competent service delivery.

12. Special situations

12.1 Dextrocardia

Dextrocardia is the most common form of cardiac malposition and refers to any situation where the heart is located within the right side of the chest rather than the left. It may be associated with the condition situs inversus where other organs are in a mirror image relation to the usual position.

Dextrocardia may be suspected if a resting 12-lead ECG reveals negative P waves and QRS complexes in lead I in the absence of any technical error such as reversal of the right and left arm connections. Poor R-wave progression observed in leads V1 through V6 supports this interpretation.

A second ECG should be recorded with the chest electrodes (V3 to V6) positioned on the right side of the chest using the same intercostal spacing and anatomic landmarks as previously described but on the right side. V1 and V2 should remain in the usual position.

This approach should provide a 'true' ECG representation. The limb lead complexes will continue to appear inverted, demonstrating the abnormal location of the heart. However, the repositioned chest leads (V3R to V6R) will now show appropriate R-wave progression.

There should be clear annotation on the recording to describe the repositioned electrodes, for example "V3R", "V4R" etc.

An alternative approach is to swap the right and left arm connections. This will 'normalise' the appearance of the limb leads. If this approach is preferred it is imperative that the ECG be very clearly annotated to prevent the possibility of dextrocardia being overlooked.

In dextrocardia:
Initial recording – standard positioning
Repeat recording – right-sided chest leads V3R to V6R
Annotate ECG clearly

Table 6 – Electrodes in dextrocardia

12.2 Posterior electrode positions

For some clinical situations recordings should be made from posteriorly positioned electrodes.

Posterior electrodes are placed in the same transverse plane as V4.

Posterior electrode positions:
V7 (C7) – Left posterior axillary line at the same horizontal level as V4
V8 (C8) – Left mid-scapular line at the same horizontal level as V4
V9 (C9) – Left spinal border at the same horizontal level as V4
Annotate ECG clearly

Table 7 – Posterior electrodes positioning

In the absence of an ECG machine/device with the ability to record a 15-lead ECG, it is recommended that a standard 12-lead ECG be recorded first. Subsequently V4, V5, and V6 should be repositioned as V7, V8 and V9 and a second recording made showing these posterior leads. The second recording must be clearly annotated with the new lead positions.

Right-sided posterior electrode positions are in the same anatomical positions but on the right side and are annotated V7R, V8R and V9R.

12.3 Electrocardiography on children

A patient and gentle approach is recommended to obtain an artefact-free ECG from children. The standard recording method is identical to that described for adults. If possible, the recording should be made with the child semi-recumbent, but the sitting position may be used if this will prevent restlessness or distress.

The four limb electrodes are attached as previously described in section 6.1.

The chest electrodes are normally positioned as previously described (section 6.2) but additional leads, such as V4R, V5R and V7, may be recorded at the request of a clinician or according to local policy. V4R and V3R are right-sided leads recorded from electrodes placed in a mirror image position to the V3 and V4 positions. V7 is a posterior lead with the electrode placed in the posterior axillary line in the same horizontal plane as the V4 electrode.

The routine use of right-sided chest leads when recording ECGs from children is variable but it is common for V4R to be used and V3 to be omitted in infants (up to 1-year old). Practice is determined largely by the indications for the ECG and clinician preference.

13. Conclusion

Consideration of the patient undergoing any diagnostic investigation must be at the centre of all clinical pathways and meticulous patient preparation, precise electrode placement, and the other factors described in this document are essential in the provision of accurate diagnostic information. It has been estimated that 300 million ECGs are performed each year in Europe[41] in a wide range of environments. Hence, it is of paramount importance that the recording of an ECG is undertaken by appropriately trained and qualified practitioners to ensure that high-quality consistent care and patient safety are upheld irrespective of where and by whom the procedure is performed.

14. References

1. Hill NE, Goodman JS. Importance of accurate placement of precordial leads in the 12-lead electrocardiogram. *Heart & Lung* 1987;16 (5):561-566.

2. Batchvarov VN, Malik, M, Camm AJ. Incorrect electrode cable connection during electrocardiographic recording. *Europace* 2007; 9:1081-1090. https://doi.org/10.1093/europace/eum198

3. Knight BP, Pelosi F, Michaud GF, Strickberger SA, Morady F. Clinical consequences of electrocardiographic artifact mimicking ventricular tachycardia. *N Engl J Med* 1999; 341:1270–1274. https:///doi.org/10.1056/NEJM199910213411704

4. Harrigan RA, Chan TC, Brady WJ. Electrocardiographic electrode misplacement, misconnection and artefact. *J Emerg Med* 2012; 43:1038-1044. https://doi.org/10.1016/j.jemermed.2012.02.024

5. Garcia-Niebla J, Llontob-Garcia P, Valle-Racero JI, Serra-Autonell G, Batchvarov, VN, Bayes de Luna A. Technical mistakes during the acquisition of the electrocardiogram. *Ann Noninvasive Electrocardiol* 2009;14 (4):389-403. https://doi.org/10.1111/j.1542-474X.2009.00328.x

6. Garcia-Niebla J, Serra-Autonell G, Bayes de Luna A. Brugada syndrome electrocardiographic pattern as a result of improper application of a high pass filter. *Am J Cardiol* 2012; 110(2):318-320. https://doi.org/10.1016/j.amjcard.2012.04.038

7. Castellanos A, Pastor JA, Zambrano JP, Myerburg RJ. Left bundle-branch block with technical right-axis deviation. *Circulation* 2002; 106:2288-2289. https://doi.org/10.1161/01.CIR.0000037661.44674.22

8. Wolff AR, Long S, McComb J, Richley D, Mercer P. The gap between training and provision: a primary care-based ECG survey in north-east England. *Br J Cardiol* 2012; 19:38-40. https://doi.org/10.5837/bjc.2012.008

9. Barnsley L, Lyon PL, Hibbert EJ, Cunningham I, Gordon FC, Field MJ. Clinical skills in junior medical officers: a comparison of self-reported confidence and observed competence. *Medical Education* 2004; 38:358-367. https://doi.org/10.1046/j.1365-2923.2004.01773.x

10. Richley D, Wolff A, Eggett C, Ashton J, Corrigan J. ECG Recording in primary care: is it done correctly? *Prim Care Cardiovasc J*. 2013; 6:25-27 https://doi.org/10.12968/pnur.2016.27.2.60

11. Rudiger A, Hellerman JP, Mukherjee R, Follath F, Turina J. Electrocardiographic artifacts due to electrode misplacement and their frequency in different clinical settings. *Am J Emerg Med* 2007; 25:174-178. https://doi.org/10.1016/j.ajem.2006.06.018

12. Bupp JE, Dinger M, Lawrence C, Wigate S. Placement of cardiac electrodes: written, simulated and actual accuracy. *Am J Crit Care* 1997;6 (6):457-62. https://pubmed.ncbi.nlm.nih.gov/9354224/

13. Rajaganeshan R, Ludlam CL, Francis DP, Parasramka SV, Sutton R. Accuracy in ECG lead placement among technicians, nurses, general physicians and cardiologists. *Int J Clin Pract.* 2007; 62:65-70 https://doi.org/10.1111/j.1742-1241.2007.01390..x

14. McCann K, Holdgate A, Mahammad R, Waddington A. Accuracy of ECG electrode placement by emergency department clinicians. *Emergency Medicine Australasia* 2007;19 (5):442–448. https://doi.org/10.1111/j.1742-6723.2007.01004.x

15. Thaler T, Tempelman V, Maggiorini M, Rudiger A. The frequency of electrocardiographic errors due to electrode cable switches: a before and after study. *J Electrocardiol* 2010; 43:676-681.

16. General Medical Council. Intimate examinations and chaperones.2013: http://www.gmc-uk.org/Maintaining_boundaries_Intimate_examinations_and_chaperones.pdf_58835231.pdf (accessed September 2017)

17. Keogh B. Review into the quality of care and treatment provided by 14 hospital trusts in England: overview report. NHS England. 2013: http://www.nhs.uk/NHSEngland/bruce-keogh-review/Documents/outcomes/keogh-review-final-report.pdf (accessed September 2017)

18. Baevsky RH, Haber MD, Blank FS, Smithline H. Supine vs semirecumbent and upright 12-lead electrocardiogram: does change in body position alter the electrocardiographic interpretation for ischaemia? *Am J Emerg Med* 2007; 25:753-756. https://doi.org/10.1016/j.ajem.2006.12.005

19. Khare S, Chawala A. Effect of change in body position on resting electrocardiogram in young healthy adults. *Nig J Cardiol* 2016; 13: 125-9 https://journals.lww.com/nijc/fulltext/2016/13020/effect_of_change_in_body_position_on_resting.7.aspx

20. Bergman KS, Stevenson WG, Tillisch JH, Stevenson LW. Effect of body position on the diagnostic accuracy of the electrocardiogram. *Am Heart J* 1989;117(1):204-206. https://doi.org/10.1016/0002-8703(89)90683-2

21. Kligfield P, Gettes LS, Bailey JJ, Childers R, Deal B, Hancock W, van Herpen G, Kors JA, Macfarlane P, Mirvis DM, Pahlm O, Rautaharju P, Wagner GS. Recommendations for the Standardization and Interpretation of the Electrocardiogram: Part I: The Electrocardiogram and Its Technology A Scientific Statement From the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society Endorsed by the International Society for Computerized Electrocardiology. *J Am Coll Cardiol*. 2007; 49(10):1109-1127. https://doi.org/10.1161/CIRCULATIONAHA.106.180200

22. Kossman CE, Brody DA, Burch GE, Hecht H, Johnston FD, Kay C, Lepeschkin E, Pipberger HV, Baule G, Berson AS, Briller SA, Geselowitz DB, Horan LG, Schmitt OH. Recommendations for standardization of leads and of specifications for instruments in electrocardiography and vectorcardiography. *Circulation* 1967; 35:583-601. https://doi.org/10.1161/01.CIR.35.3.583

23. Pahlm O, Haisty WK, Edenbrandt L, Wagner NB, Sevilla DC, Selvester RH, Wagner GS. Evaluation of changes in standard electrocardiographic QRS waveforms recorded from activity-compatible proximal limb lead positions. *Am J Cardiol*. 1992; 35:583-601 https://doi.org/10.1016/0002-9149(92)91315-U

24. Kania M, Rix H, Fereniec M, et al. The effect of precordial lead displacement on ECG morphology. *Medical & Biological Engineering & Computing* 2014; 52(2): 109-119. https://doi.org/10.1007/s11517-013-1115-9

25. Jowett N, Turner A, Cole A, Jones P. Modified electrode placement must be recorded when performing 12-lead electrocardiograms. *Postgraduate Medical Journal* 2005; 81 (952): 122-125 https://doi.org/10.1136/pgmj.2004.021204

26. Longo D, Poliserpi C, Toscano Quilon F, Díaz Uberti P, López C, García-Niebla J, Ramella I. Diagnostical mistakes in ablation procedures associated with a high placement of the leads V1-V3. *J Electrocardiol*. 2017 Feb 20. pii: S0022-0736 (17) 30058-4. https://doi.org/10.1016/j.jelectrocard.2017.02.011

27. Sevilla DC, Dohrmann ML, Somelofski CA, Wawrzynski RP, Wagner NB, Wagner GS. Invalidation of the resting electrocardiogram obtained via exercise electrode sites as a standard 12-lead recording. *Am J Cardiol*. 1989; 63:35-39. https://doi.org/10.1016/0002-9149(89)91072-2

28. Wenger W, Kligfield P. Variability of precordial electrode placement during routine electrocardiography. *J Electrocardiol*. 1996; 29:179-184. https://doi.org/10.1016/S0022-0736(96)80080-X

29. Zema MJ, Luminais SK, Chiaramida S, Goldman M, Kligfield P. Electrocardiographic poor R wave progression III: the normal variant. J Electrocardiol. 1980; 13:135-142 https://doi.org/10.1016/S0022-0736(80)80044-6

30. August T, Mazzeleni A, Wolff L. Positional and respiratory changes in precordial lead patterns simulating acute myocardial infarction. *Am Heart J*. 1958; 55:706-714. https://doi.org/10.1016/0002-8703(58)90008-5

31. Colaco R, Reay P, Beckett C, Aitchison TC, Macfarlane PW. False positive ECG reports of anterior myocardial infarction in women. *J Electrocardiol*. 2000; 33:239-244 https://doi.org/10.1054/jelc.2000.20359

32. Macfarlane PW, Colaco R, Stevens K, Reay P, Beckett C, Aitchison T. Precordial electrode placement in women. *Neth Heart J.* 2003; 11:118-122 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2499893/

33. Bun, S-S, Taghji, P, Errahmouni, A, et al. Electrocardiographic modifications induced by breast implants. Clin Cardiol. 2019; 42: 542–545. https://doi.org/10.1002/clc.23174

34. Nakagawa M, Tsunemitsu C, Katoh S, Kamiyama Y, Sano N, Ezaki K, Miyazaki H, Teshima Y, Yufu K, Takahashi N, Saikawa T. Effect of ECG filter settings on J-waves. *J Electrocardiol*. 2014 Jan-Feb;47(1):7-11 https://doi.org/10.1016/j.jelectrocard.2013.10.001

35. Medical and Healthcare Products Regulatory Agency (MHRA) medical device alert reference number MDA/2010/056 https://applications.health-ni.gov.uk/NICAS/Public/AlertInfo.aspx

36. Guidelines on Hand Hygiene in Healthcare published by the World Health Organisation 2009: https://www.who.int/publications/i/item/9789241597906 (accessed August 2023)

37. Bailey JJ, Berson AS, Garson A Jr, Horan LG, Macfarlane PW, Mortara DW, Zywietz C. Recommendations for standardization and specifications in automated electrocardiography: Bandwidth and digital signal processing. *Circulation* 1990; 81:730-739. https://doi.org/10.1161/01.CIR.81.2.730

38. Data protection act 1998: http://www.legislation.gov.uk/ukpga/1998/29/contents

39. Eldridge MJ, Richley D, Ross C, Cox C, Breen C, Baxter S, Blackman S, Brown C, Campbell B, Hutchinson J, Rees E. Clinical Guidelines by Consensus: Recording a standard 12-lead electrocardiogram. An

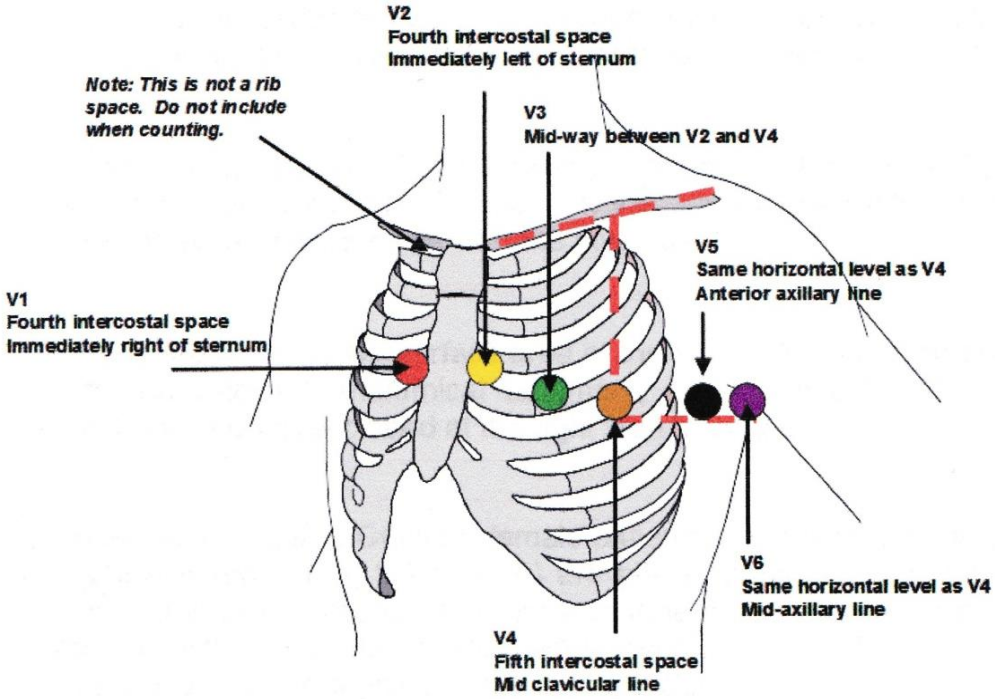
approved methodology by the Society for Cardiological Science and Technology 2014 (accessed August 2023)

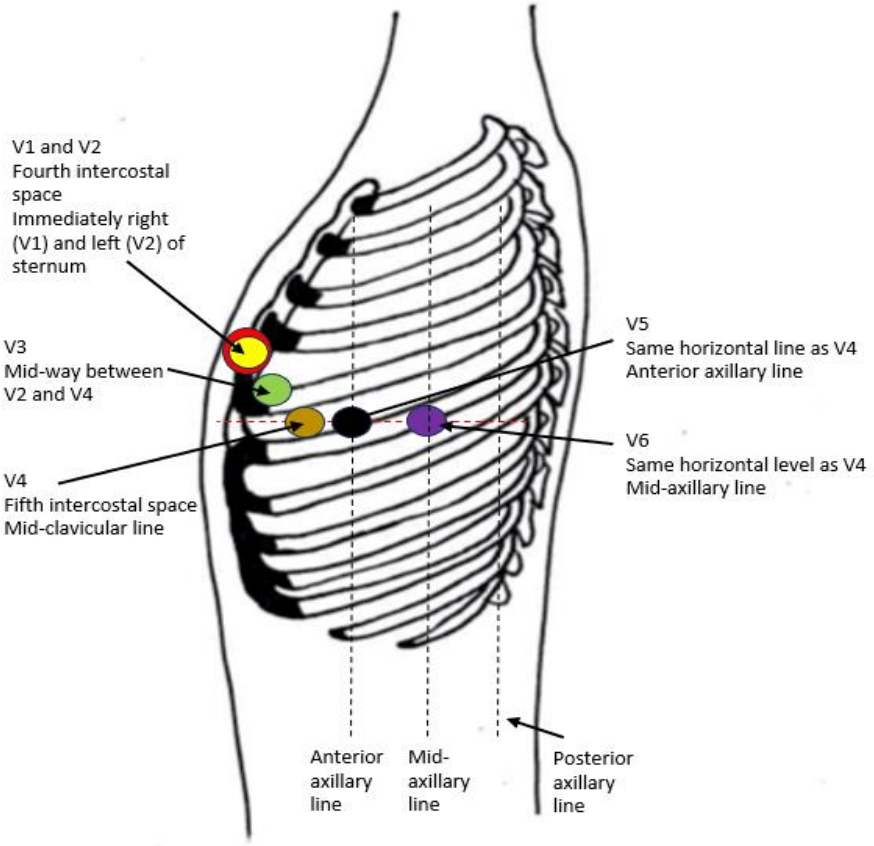
40. World Health Organisation Regional Office for Europe. Uses of the Electrocardiogram. Report on a WHO study; Copenhagen EURO Reports and Studies 37 (project ICP/ATH 003). WHO, Geneva 1981.

15. Appendix 1: 12-lead ECG Service Audit Tool[40]

Quality indicator	Yes ✓	No ✗	N/A
(1) Qualification & Training			
Did the operator have a recognised ECG qualification?			
Was the operator trained on the specific ECG equipment being used?			
(2) Identification of patient			
Were 3 identifiers used?			
Was wristband checked (unconscious / inpatients)?			
(3) Consent			
Was the procedure explained before proceeding?			
Was consent (verbal or written) properly obtained?			
(4) Patient experience, privacy and dignity			
Did the operator communicate with clarity and accuracy?			
Was information appropriate to patient's needs?			
Was level of undress appropriate?			
Was the patient treated with dignity and respect?			
Were cultural sensitivities observed?			
Was the patient aware / asked if they wanted a chaperone?			
(5) Environmental considerations			
Was the environment private (curtained, walled, screened)?			
Was the procedure conducted with no interruptions?			
Was the environment comfortable and warm?			
Was the area accessible for all users including disabled?			
Did the area have hand-cleaning facilities?			
Did the area have clinical waste disposal facilities?			
Was a height-adjustable couch available, wide enough for arms to rest on?			
Was the room stocked appropriately?			
(6) Equipment specification			
Was there an electrocardiograph meeting IEC 6061-2-25:2011 available?			
Were the default settings as specified below? Auto record 0.67-150Hz Manual record 0.05-150Hz ECG filter Off			
(7) Infection control			
Did the operator wash or use alcohol gel to clean hands?			
Was clinical waste disposed of appropriately?			
(8) Patient preparation			
Was the patient in the semi-recumbent position?			
Was appropriate skin preparation performed if required?			
(9) Electrode Placement			
Were limb leads placed on wrists and ankles?			
Were the precordial (chest) leads in the correct anatomical positions in accordance with SCST guidelines?			
Was an appropriate technique used to locate the correct anatomical positions for the precordial (chest) leads?			
Were the leads connected correctly to the electrocardiograph?			
(10) Recording Quality			
Was an artefact-free recording obtained?			
Was the initial recording at appropriate settings for paper speed (25mm/sec) and gain (10mm/mV)?			
Was the initial recording made with the filter off?			
Were appropriate modifications made and a second ECG recording produced if required (including changes to paper speed, gain, rhythm strip, right sided chest leads etc.)?			
(11) Documentation, processing and storage			
Did 3 identifiers appear on the printout / stored recording?			
Was the ECG annotated correctly with any modifications made (such as 'in wheelchair' or right-sided leads)?			
Was the ECG recording forwarded appropriately according to local policy (e.g. for medical review, electronic storage, copy in notes etc.)?			
Has the patient's information been treated in a confidential and secure way?			

16. ECG Standard Electrode Positions Reminder Chart





Precordial (chest) electrode positions:

V1 (C1) - Fourth intercostal space at the right sternal edge

V2 (C2) - Fourth intercostal space at the left sternal edge

V3 (C3) - Midway between V2 and V4

V4 (C4) - Fifth intercostal space in the mid-clavicular line

V5 (C5) - Left anterior axillary line at the same horizontal level as V4

V6 (C6) - Left mid-axillary line at the same horizontal level as V4 & V5

Limb electrode positions:

Right arm limb lead (RA, red)	-	right forearm, proximal to wrist
Left arm limb lead (LA, yellow)	-	left forearm, proximal to wrist
Left leg limb lead (LL, green)	-	left lower leg, proximal to ankle
Right leg limb lead (RL, black)	-	right lower leg, proximal to ankle

17. ECG Settings Reminder Chart

Standard ECG recording:

Paper speed - 25mm/sec

Voltage gain - 10mm/mV

Use of the filter:

Initial recording - filter off - recording made at 0.67-150Hz

Evidence of somatic muscle interference:

Repeat recording - filter on - recording made at 0.67- 40Hz

The filter reduces interference but also distorts the ECG

In dextrocardia:

Initial recording - standard positioning

Repeat recording - right-sided chest leads V3R to V6R

Annotate ECG clearly