Recording an ECG

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1. Introduction

The resting 12-lead electrocardiogram (ECG) is an important first line investigation that records the electrical activity of the heart. This investigation can aid the diagnosis and help define the appropriate patient treatment pathway in a range of cardiac conditions, many of which are life threatening and require immediate action.

Modern ECG machines are portable, low cost and easy to use and these features facilitates recordings in a wide variety of environments including hospitals, GP surgeries, ambulances, sports facilities and patients’ homes. The challenge is to ensure high-quality, consistent recording techniques are maintained irrespective of the clinical scenario. ECGs not performed to appropriate standards can result in incorrect diagnoses and inappropriate treatments. There are many personnel recording ECGs who have not been properly trained or assessed. Personnel may consider themselves competent, despite a lack of training, and yet lack essential knowledge in ECG recording technique that results in incorrect ECG recording.

Evidence indicates that appropriate training leads to fewer ECG recording errors. It is recommended that all personnel who record ECGs are appropriately trained, assessed and qualified.
2. Purpose

In promoting excellence in the recording of 12-lead ECGs, the following areas are addressed:

- 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

3. 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.

Patient Identification

It is essential that the patient undergoing the procedure is correctly identified.

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

The printed 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.
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. As a minimum 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, with a reassurance that the procedure is brief and painless. Informed consent is required in accordance with local policy before proceeding.

Chaperone

In accordance with good clinical practice, patients undergoing examinations that have the potential to be embarrassing or distressing should have the option of having a chaperone present. The chaperone should usually be a health professional and must have knowledge of the standard practice of recording a 12-lead ECG. Patients may also request a relative or carer to be present. 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.

Level of undress

Practitioners should respect the cultural sensitivities of the patient and minimise embarrassment. 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.

4. 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.

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 or inclined at 60 degrees or greater to the horizontal. 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. 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.

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 cleaning
- 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. Oral 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

5. Electrode placement

Electrodes must be positioned in accordance with AHA recommendations.

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.

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.

**Limb electrode positions**

Limb electrodes should be placed proximal the wrists and ankles whenever possible. 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.

<table>
<thead>
<tr>
<th>Limb electrode positions:</th>
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<tbody>
<tr>
<td>Right arm limb lead (RA, red) – right forearm, proximal to wrist</td>
</tr>
<tr>
<td>Left arm limb lead (LA, yellow) – left forearm, proximal to wrist</td>
</tr>
<tr>
<td>Left leg limb lead (LL, green) – left lower leg, proximal to ankle</td>
</tr>
<tr>
<td>Right leg limb lead (RL, black) – right lower leg, proximal to ankle</td>
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**Precordial (chest) electrode positions**

The correct anatomical positions for the chest electrodes have been defined (see figure below) 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.
Studies have demonstrated that the V1 and V2 electrodes are frequently placed too high and the V4, V5 and V6 electrodes too low. These errors can result in diagnostically misleading alterations to the ECG waveform.

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
**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 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 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 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.

**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

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

**Evidence of somatic muscle interference:**

The filter reduces interference but also distorts the ECG.

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.

8. **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.

**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

**Infection control**

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

Hands should be washed 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)

All information pertaining to the patient should be treated in a confidential manner in accordance with local policies and national guidelines on data protection.

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 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.