
*The Journal of*

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## CONTENTS




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The Journal of Society for Cardiological Science and Technology welcomes submissions likely to be of interest to professionals working in the field of clinical cardiac physiology. These may include original research, audits, educational articles, correspondence, opinions or information on professional matters, case studies and reviews of books or equipment.

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# A VIEW FROM THE PRESIDENT

I hope you have all had an enjoyable and restful Summer. SCST have been involved in a number of projects and it is with some sadness that I say those do not become suspended during the Summer. I for one was lying on a beach rewriting and discussing the level 4 apprenticeship syllabus for cardiac physiology, however hopefully now we are all refreshed and ready to hit the ground running. SCST are currently dedicating significant resources to a number of important projects.

The first is the provision of 7-day services within Echocardiography in NHS England. I represent SCST on the 7-day services sub group, which was established to consider viable options and make recommendations to achieve targets by March 2020. This piece of work specifically relates to Standard 5 of the 7-day services clinical standards that specifies that hospital inpatients should have scheduled seven-day access to diagnostic services, such as echocardiography, within 1 hour for critical patients and within 12 hours for urgent requests for patients admitted as an emergency. Through the consideration of the options the group will develop new and innovative proposals, and subsequently, an implementation plan. The subgroup will aim to ensure strategic alignment and coordination of the key national bodies involved in all aspects of the provision of echocardiography by the NHS in England. SCST have engaged with our stakeholder partners and have formed a working group with BSE to develop plans to address these action points. I will keep you updated on the progress of this work.

The second major piece of work which I am leading for SCST as part of the Chief Professions Officers Medicines Mechanisms project is for the provision of Patient Group Directions for Clinical Scientists, Biomedical Scientists and Operating Department Practitioners. The Chief Professions Officers' Scoping Project: Medicines Prescribing, Supply and Administration Mechanisms scoping project report, recommended that a number of healthcare professions be considered for supply and administration of medicines mechanisms, with prioritisation being given to those professions which would demonstrate benefits to a wide patient population and are aligned with the Five Year Forward View and NHS England's business priorities for 2017/18. While this project is being led by NHS England any outcome from the project will be a four-country accepted practice. The working group will gather evidence to produce a detailed case of need for each profession and progress the cases of need through to agreement of legislative change to permit the use of Patient Group Directions (PGDs). I am currently leading on writing the documentation for the case of need for all clinical scientists and again will update you over the upcoming months on the progress of this work.

You will note from this month's edition of the journal that the SCST Clinical Standards group have published an update to the ECG recording guidelines. This is a piece of work that involved extensive research into the latest scope of practise within ECG both in the mechanism of recording and the adaption of technological advances within this field. While we don't advocate the unnecessary printing of documents and the global warming implications may have in relation to reduced numbers of trees I think we could make an exception in this case and encourage you all to have a copy of this on file in your ECG departments as the go to document.

I hope to be able to meet many of you at the annual National Update meeting in November, details of which are included in this month's journal.This event will allow you to hear about our latest projects and offers an opportunity to discuss both formally and informally issues with members of council and also to network with colleagues from across the UK. It is our aim this year to allow colleagues the opportunity to discuss issues which are closer to home and as such aim to have a session which will have each of the Chief Scientific Officers from across the UK present to discuss issues such as workforce andaccreditation of services.

Catherine Ross FSCST MSc.
*Clinical Scientist*
*President of The Society for Cardiological Science and Technology*

# CLINICAL GUIDELINES BY CONSENSUS

## Recording a Standard 12-Lead Electrocardiogram

## An approved method by the Society for Cardiological Science & Technology (SCST)

**Issue Date: September 2017**
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## 1. CHANGE HISTORY

| VERSION | DATE | AUTHOR | REASON | RATIFICATION REQUIRED |
|---|---|---|---|---|
| 1 | Feb 2010 | Consensus | Standardisation of practice | Yes: SCST Council |
| 2 | June 2014 | Consensus | Standardisation of practice | Yes: SCST Council |
| 2.1 | Nov 2015 | Consensus | Citation added, contributor details updated | Not required |
| 3 | Sept 2017 | Consensus | Standardisation of practice | Yes: SCST Council |

## 2. 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[1-7]. There are many personnel recording ECGs who have not been properly trained or assessed[8]. Personnel may consider themselves competent[9, 10], despite a lack of training, and yet lack essential knowledge in ECG recording technique that results in incorrect ECG recording[11-14].

Evidence indicates that appropriate training leads to fewer ECG recording errors[15]. While these guidelines generally apply to the hospital/clinical environment, where most ECGs are performed, the training of personnel and technical aspects of the performance of a standard ECG apply to all situations. SCST recommends that all personnel who record ECGs are appropriately trained, assessed and qualified.

These guidelines provide essential information pertinent to the correct ECG recording technique in keeping with good scientific practice[16]. They are written by expert practitioners following critical evaluation of published evidence. Where evidence was limited a consensus decision was made.

## 3. PURPOSE

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

**Patient experience, privacy and dignity**
- o Patient identification
- o Communication & Informed consent
- o Chaperone
- o Level of undress

**Patient preparation**
- o Patient position
- o Skin preparation

**Electrode placement:**
- o Limb electrode positions
- o Chest electrode positions
- o Technique for locating chest electrode positions

**Obtaining a good quality recording**
- o Paper speed
- o Use of the filter
- o Variation from standard
  - • Amplitude gain

**Qualification requirements for practitioners**

**Equipment and clinical room specification**
- o Equipment
- o Environment
- o Infection control

**Documentation, processing, storage and confidentiality of 12-lead ECG recordings**

**Special situations**

## 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[16].

### 4.1. 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.

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

### 4.3. 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 present17. 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[17].

### 4.4. LEVEL OF UNDRESS

Practitioners should respect the cultural sensitivities of the patient and minimise embarrassment[18]. 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 position19, 20 or inclined at 60 degrees or greater to the horizontal21. 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.

### 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 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 batteryoperated razor with a single use blade or a single use razor should be employed and disposed of in a sharps bin immediately afterwards

## 6. ELECTRODE PLACEMENT

Electrodes must be positioned in accordance with AHA recommendations[22-24].

**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[24-28].**

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 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[25, 29].

**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

### 6.2. PRECORDIAL (CHEST) ELECTRODE POSITIONS

The correct anatomical positions for the chest electrodes have been defined22 (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.

**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

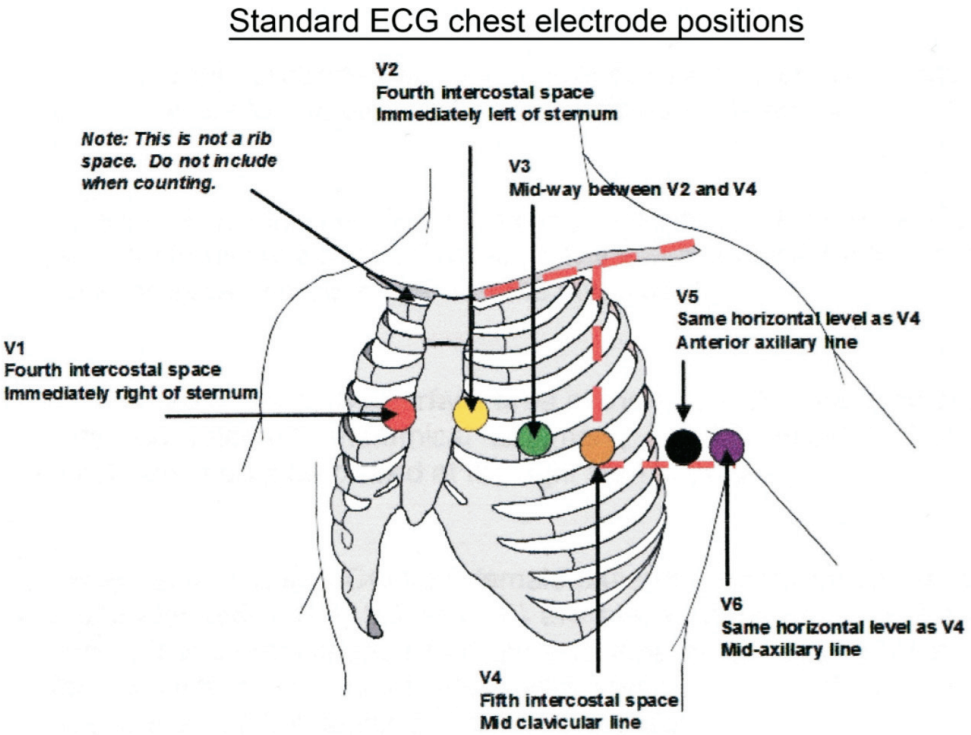
V3, green (C3) – Midway between V2 and V4

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

Studies have demonstrated that the V1 and V2 electrodes are frequently placed too high and the V4, V5 and V6 electrodes too low[13, 30, 31, 32]. These errors can result in diagnostically misleading alterations to the ECG waveform[33].




### 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 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 midaxillary 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[33, 34] 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 ECG35, 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

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 patient36. 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 ECG10. This should be demonstrated by the possession of a recognised qualification, such as one of those awarded by the Society for Cardiological Science and Technology, including:

- Award in Practical Electrocardiography
- Certificate in Electrocardiography

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) specifications22 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 cutoff 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

### 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 washed37 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[38].

All information pertaining to the patient should be treated in a confidential manner in accordance with local policies and national guidelines on data protection[39].

## 11. AUDIT

Audit is a recognised way of assessing and improving practice. The appendix 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

## 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

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 rightsided 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 Europe40 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.

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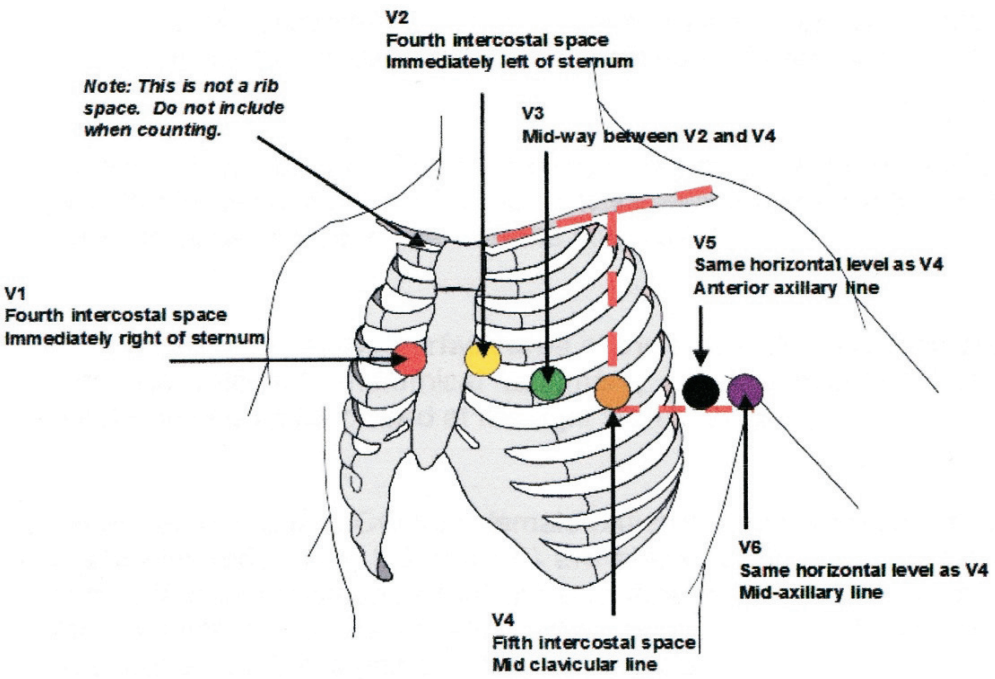
## 15. APPENDIX 1: 12-LEAD ECG SERVICE AUDIT TOOL

| Quality indicator | Yes ✓ | No ✗ |
|---|---|---|
| (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?<br>Auto record 0.67-150Hz<br>Manual record 0.05-150Hz<br>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:**

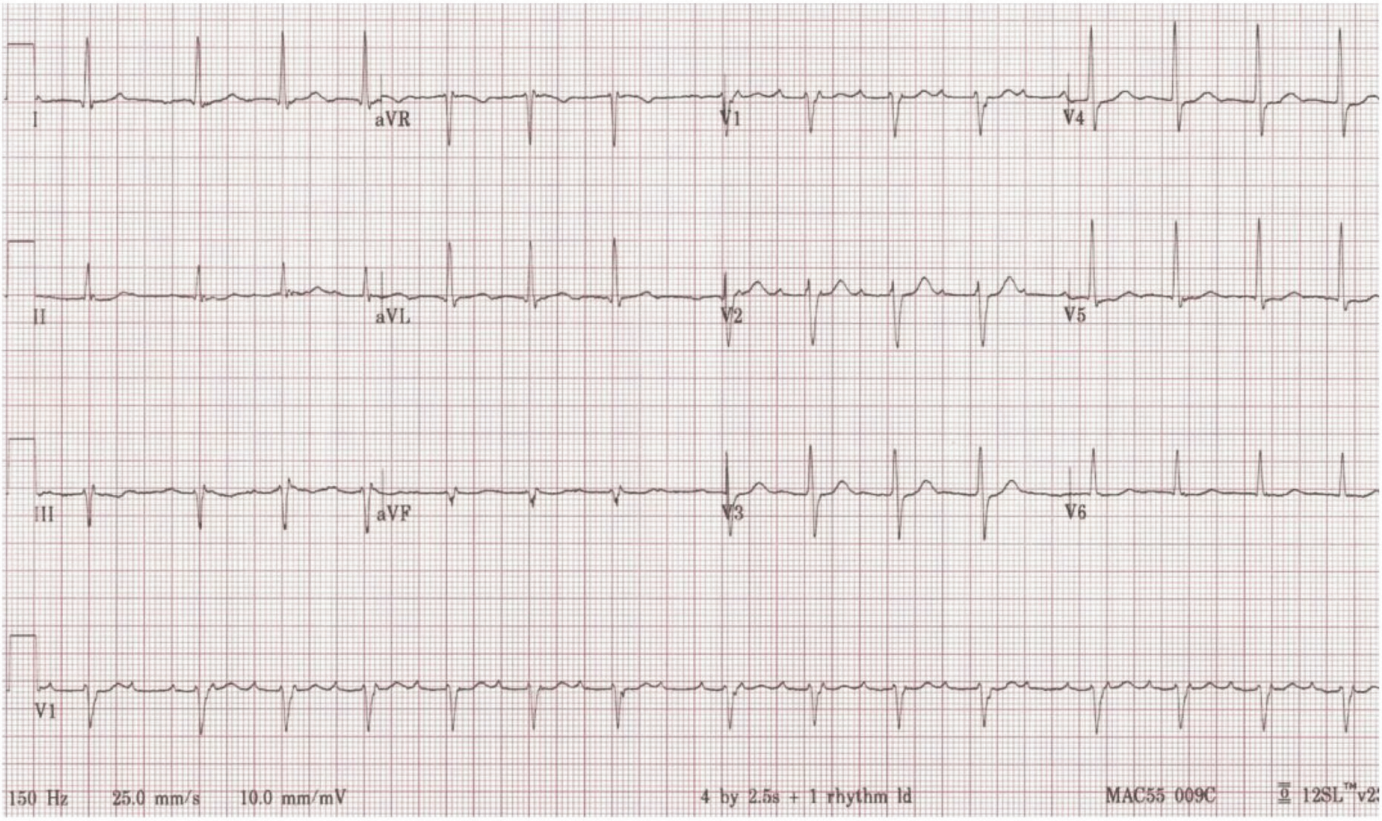
Initial recording - standard positioning

Repeat recording - right-sided chest leads V3R to V6R

Annotate ECG clearly

## ARRHYTHMIA CHALLENGE

What is the rhythm? Discussion on page 26.




# OVERCOMING THE POTENTIAL CHALLENGES IN ELECTROCARDIOGRAPHY ASSOCIATED WITH PARKINSON'S DISEASE

**Sarah Jane Elliott BSc, MSc**
**Cardiac Healthcare Science Practitioner**

### INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disease that affects movement control[1]. In PD neurons in a part of the brain known as the substantia nigra progressively degenerate, which leads to a reduction in the amount of the neurotransmitter dopamine in the brain. The reduction in dopamine levels leads to the lack of movement control characteristic of the disease[2]. Symptoms of PD include a resting tremor, rigidity, slowness of movements and postural instability[1].

Electrocardiography (ECG) is a widely used and essential diagnostic tool. ECG monitoring may be specifically requested for patients with PD as commonly prescribed medications for PD have been associated with prolongation of the corrected QT interval (QTc), which is a predictor of cardiovascular mortality[3, 4]. Research suggests that patients with PD may be more at risk of QTc prolongation[3, 5, 6]. Therefore it is important that a good quality ECG tracing is obtained in order to accurately measure the QTc.

The cardiographer may face additional challenges when recording an ECG from a patient with PD. Tremor (a symptom of PD) and deep brain stimulation (a treatment for PD) can both result in artefact on the ECG[1,11]. Not all patients with PD will present these challenges nor are they exclusive to these patients. It is vital that the cardiographer (as the individual recording the ECG in a clinical setting) can minimise artefact in order to produce an ECG of the best possible quality.

## TREMOR-INDUCED ARTEFACT

Tremor-induced artefact has the potential to be misinterpreted as atrial fibrillation, atrial flutter and ventricular tachycardia (VT) on the ECG. Although the clinician should identify artefact on the ECG having taken into account the condition of the patient, it is still possible for misinterpretation to occur. This could lead to unnecessary investigations and treatment, potentially causing harm to the patient[7].

Boos et al. reported that a patient was given an intravenous amiodarone infusion when their ECG mimicked VT, which was later identified as artefact related to their PD tremor[8]. In another case, Nam et al. reported that a patient was anticoagulated and admitted for an electrophysiology study when their PD tremor-induced artefact was misinterpreted as atrial flutter[9]. These cases demonstrate the potential for misinterpretation of artefact and the importance of the role of the cardiographer in minimising artefact on the ECG.

Current SCST guidelines state that where patients have a significant tremor it is acceptable to move the electrode higher up the limb(s). This simple action can considerably reduce the tremor-induced artefact on the ECG. It is important to note that the electrodes should not be placed on the torso as this causes significant alteration to wave amplitudes[10]. Tremor-induced artefact may also be minimised by changing the low-pass filter from 150Hz (as the recommended setting) to 40Hz. Changing this setting on the ECG machine requires little effort from the cardiographer and can substantially reduce the somatic muscle interference which can result from rigidity as well as tremor in PD. It is important to note that the 40Hz low-pass filter distorts the ECG and should therefore only be used when necessary[10].

It is essential that the ECG is annotated appropriately with any deviations from standard practice. This includes any changes in the positioning of electrodes and the use of the 40Hz low-pass filter. It is also beneficial to indicate if the patient has a significant tremor at the time of the ECG recording. These steps can further help to prevent misinterpretation occurring[10].

## DEEP BRAIN STIMULATION (DBS)-INDUCED ARTEFACT

DBS is now a well-recognised treatment option in PD and is increasingly used to treat a variety of neurological conditions[11]. DBS involves surgically implanting a lead into the brain, which extends subcutaneously down the neck, connecting to a pulse generator, which is generally located under the clavicle. Once implanted the device parameters are set to maximise the response for the individual - for instance either monopolar or bipolar stimulation can be used. The patient has the ability to turn the device on or off via a programmer[12].

The electrical impulses delivered by the stimulator can be recorded onto the ECG as electromagnetic interference[11, 12]. This artefact is visible as a thickened baseline caused by regular oscillation in the ECG trace[13]. The amplitude of the artefact is dependent on the programmed parameters of the individuals DBS[12]. DBS causes artefact when monopolar settings are used, but the level of artefact is reduced when bipolar stimulation settings are used[11]. Electromagnetic interference resulting from DBS can potentially mask the underlying rhythm and make the ECG uninterpretable[14].

There are two main recommendations for removing artefact caused by DBS (which are applicable to other types of extra-cardiac stimulators). Firstly, activating the 40Hz low-pass filter has the potential to remove all artefact from the ECG tracing. However, this is dependent on the configuration of the DBS - in some cases due to the device parameters using the low-pass filter may not reduce the artefact enough to allow accurate interpretation of the ECG[12].

The second recommendation to remove artefact from DBS is to temporarily turn off the device. For cases where the use of the low-pass filter is ineffective this may be the most viable way to record an accurate ECG. However, inactivation of the DBS or alteration of the settings may result in patient discomfort and worsening of symptoms including tremor. This could subsequently result in tremor-induced artefact appearing on the ECG, which can be minimised as described previously[12].

For patients with DBS for whom ambulatory Holter monitoring is required, artefact from the device may prevent an interpretable recording being obtained. It would be advisable to get a specialists opinion regarding inactivation of the DBS or changing the device parameters for the duration of the Holter recording for such individuals[12].

## CONCLUSIONS

The ECG is an essential tool in the diagnosis of various conditions. Whilst PD may create challenges for the cardiographer, simple techniques may be used to overcome them. These include; the appropriate repositioning of limb electrodes, setting the low-pass filter to 40Hz and annotating the ECG print out[10]. Such actions ensure that the best possible ECG trace is produced whilst reducing the risk of misinterpretation occurring. Where DBS-induced artefact cannot be removed using the low-pass filter, it may be possible to temporarily inactivate or change parameters of the device[12].

Improving clinical education and awareness amongst healthcare staff in the techniques to overcome ECG artefact can help ensure that patients with PD are not unnecessarily hindered in their cardiovascular care. For instance, if a healthcare team are unaware of the appropriate use of the low-pass filter, an individual with DBS may not receive accurate cardiac monitoring. This has the potential to lead to avoidable patient harm. It is important that patients with PD have their ECG monitored accurately in order to reduce the risk of QTc prolongation caused by medication, which is a major modifiable risk factor[3]. Having knowledge of the potential artefacts and methods to eliminate them is essential to ensure accurate ECG interpretation[11].

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# IQIPS AND THE ROUTE TO ACCREDITATION

**Georgina Martin**
**SCST Representative at IQIPS**

The mandate from the Government to NHS England sets out objectives to improve the nation's health and create the highest quality health care service. A significant number of organisations are already contributing to these objectives by providing high quality scientific and diagnostic services that are accredited under government recognised schemes.

Accreditation is an important part of quality assurance and provides confidence in services, management systems and people. It ensures technical competence and integrity against nationally and internationally recognised standards. NHS England fully supports a commissioning system focused on the prioritisation of accredited healthcare services across all scientific and diagnostic services.

Following this work, the United Kingdom Accreditation Service (UKAS) has agreed to manage and deliver our professional bodies accreditation. The Royal College of Physicians (RCP) are no longer involved.

A panel of Cardiac physiology experts will be brought together with UKAS to determine the scope of the application and re-look at the standards set to be used as the criteria for accreditation. It is felt that there has been a lot of duplication when collecting the evidence from the four domains. **1. Clinical, 2. Patient Experience, 3. Facilities, resources and workforce 4. Safety.**

In the coming months, expressions of interest will be sought from those wishing to be considered for selection to help to pull this work together.

- Is accreditation applicable to me?
- Where to start?
- Meeting the relevant requirements
- How to apply
- Pre-assessment visit
- The initial assessment visit
- Post assessment
- Maintaining your accreditation
- Making the most of your accreditation
- Extending your accreditation

(This can all be found on the above website).

## THE ROUTE TO ACCREDITATION

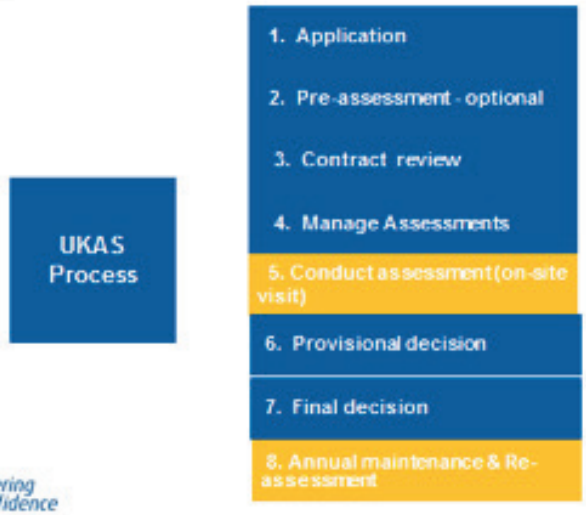
This section provides a step-by-step guide through the key steps of the accreditation process. You will be able to access the documents and supporting information you need at each stage of your application, as well as access information about potential costs and timescales. It also includes information on how to maintain your accreditation status, extend your scope, and advice on how to get the most value from your accreditation.

If you are still not sure what to do and want to talk to someone, please call **01784 429 000** or email **apps@ukas.com** or go on to: **www.ukas.com/about/about-accreditation**

Alternatively, you can submit a short enquiry form to register your interest.

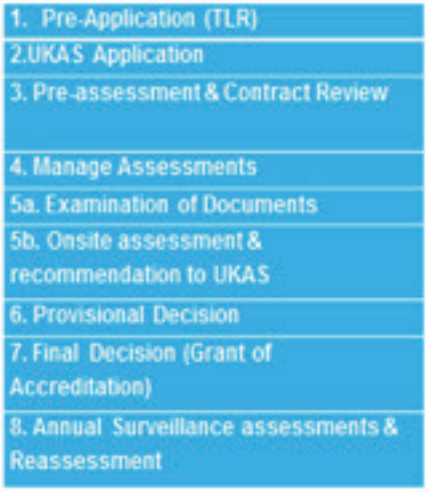
## An accreditation scheme


## Accreditation Process




*Delivering Confidence*

## IQIPS Process



## Maintenance of Accreditation

**4-year accreditation cycle**

Surveillance year 1, SU1 - WBA only

Surveillance year 2, SU2 - WBA plus mini on-site visit

Surveillance year 3 , SU2 – WBA only

Re-assessment year 4, RA – WBA plus on-site visit with a refreshed assessment team

## Responsibilities in accreditation

- The customer is responsible for providing convincing evidence to demonstrate conformity to the recognised Standard
- The accreditation body (UKAS supported by its trained assessors) is responsible for verifying the evidence provided by the customer
- Once accredited sanctions can be applied:
  - Suspension – partial, full
  - Withdrawal – partial, full
  - Financial

## Objectives of an accreditation Standard

- The service is well-led and supported to provide their duties impartially
- Desired objectives and outcomes are defined and routinely monitored
- Appropriate ways of working (processes/procedures/methods) are defined, documented and routinely implemented
- Risks are identified, assessed and mitigated
- Staff are trained and competent for their roles
- Necessary equipment, facilities and resources are adequate, well- maintained and fit for purpose
- The environment and working practices are safe
- Communication and feedback mechanism are adequate and timely
- Care is patient-focussed, accurate, effective, efficient, safe, responsive and accessible

Delivering Confidence

The cost is £500 to register on the "Traffic Light System". You get this back if you apply for registration within one year.

£1000 fee to apply / application fee. There will then be a cost for the 4 year cycle of re-accreditation and monitoring your systems.

This is not going to go away; NHS England, the United Kingdom Accreditation Service (UKAS) and the Institute of Physics and Engineering in Medicine, recently published a joint statement regarding their new accreditation scheme for the Clinical Engineering and Physical Science Services (CEPSS), which will be equivalent to our IQIPS accreditation. The key to making this work is to get the support of your Trust Board and working as a "Physiological Group" within your Trust. It really does raise your standards, profile and makes the service fit for the future.

# REPORT FROM COMMUNICATIONS & EVENTS COMMITTEE

**Tracy Simpson**
**Chair of Communications & Events Committee**

### SCST NATIONAL UPDATE MEETING

The National Update Meeting is on Friday 24th November 2017 at the Jurys Inn, Birmingham. We have a range of excellent speakers and this a fantastic opportunity to learn about changes to the profession, share learning and network. A finalised agenda will be available soon via e-circular, website, Facebook & Twitter and booking will open via Eventbrite. Topics include: where are we with RCCP & AHCS, Patient Group Directives and Cardiac Scientists, equivalence and IQIPS workshops, emerging roles for Healthcare Scientists.

Please remember this event is free to members of SCST. There is a charge for non-members of £50 if registering before 16th October and £80 after the 16th October. SCST membership costs £45 for a year.

### SCST PROMOTION

We continue to be active SCST Facebook & Twitter.

Facebook: SCST - The Society for Cardiological Science and Technology

Twitter: @SCSTcouncil Website: www.scst.org.uk

We are currently reviewing the website, out of date information will be removed and it will be updated regularly. We are also designing a timetable and information for a regular e-circular.

# ARRHYTHMIA CHALLENGE: DISCUSSION

**Dave Richley**
**Retired cardiac physiologist**

At first glance, because of the irregular ventricular rate and the absence of clear P waves in the limb leads, this may look like atrial fibrillation. However, this is not the case. As is usual when trying to elucidate an arrhythmia, the first task is to identify the atrial activity, before then going on to define its relationship, if there is one, to the ventricular activity. Not all of the atrial activity is clearly visible here but I have identified with arrows the first seven P waves in V1, the lead which atrial activity is frequently most obvious (fig 1). The 2nd P wave, which I have marked with a dotted arrow, is masked by the QRS, so its presence can only be inferred by the regularity of the other P waves. It can now be seen that there is fast, regular atrial rhythm with a rate of 200/minute. These P waves are not of sinus node origin: in the limb leads they are of very low amplitude and slightly negative in lead I. In V1 the P waves are completely positive, whereas sinus P waves typically have a small terminal negative deflection in V1. This then is an atrial tachycardia. Clearly the ventricular rate is slower than the atrial rate and it is irregular. The rhythm may therefore be described as atrial tachycardia with variable block but we can actually provide a more detailed explanation of exactly what seems to be happening.

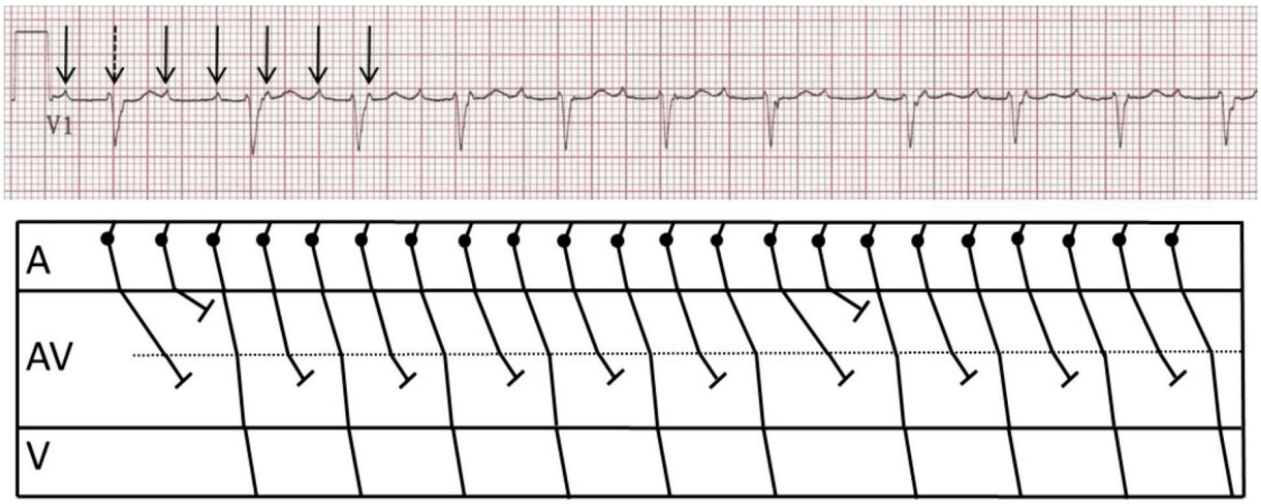



*Figure 1. Section of ECG in V1 with simultaneous laddergram*

Although the ventricular rate is irregular, there is a pattern to the irregularity. There are periods when the ventricular rate is almost regular with a rate of about 100 beats per minute and these periods are separated by pauses that are all of the same duration. Grouped beating is suggestive of Wenckebach block and indeed we can see very gradual prolongation of the PR interval in successive conducted beats before the pauses. However, this is not simple atrial tachycardia with Wenckebach block: if it were, the ventricular rate would mostly be about 200 bpm. In order to explain what is happening we need to invoke the long-established concept of dual-level AV nodal Wenckebach block, a mechanism that often accounts for the ventricular rate in atrial flutter with so-called variable block1. This concept requires that the AV node be regarded as consisting of an upper and lower region, each with different electrophysiological properties. I have tried to illustrate in the laddergram how this mechanism might apply to the ECG under discussion, with a dotted line showing the border between the upper and lower AV node. I propose that that there are long periods of Wenckebach AV block in the upper AV node such that occasional atrial impulses fail to reach the lower AV node. Of those impulses that do penetrate to the lower AV node, every other one is blocked from progressing to the ventricles; in other words there is 2:1 block of atrial impulses in the lower AV node. Pauses occur when an impulse that is blocked in the lower AV node is immediately followed by an impulse that is blocked in the upper AV node at the end of a Wenckebach sequence.

There may be alternative explanations for this arrhythmia but I think this one is plausible and illustrates a few useful tips to help in the elucidation of difficult arrhythmias:

- Inspect the ECG carefully to identify atrial activity and remember that atrial deflections may be masked by a QRS or T wave
- Look for repeated patterns when the ventricular rate appears at first glance to be irregular.
- Grouped beating suggests possible Wenckebach behaviour
- Dual-level AV nodal Wenckebach block is common in atrial flutter and tachycardia

**REFERENCE**

1. Besoain-Santander, Pick A, Langendorf R. A-V conduction in auricular flutter. Circulation 1950;2:604-616.

# BACK DUE TO POPULAR DEMAND

**Dave Richley**
**Education Committee member and SCST Vice-President**

SCST have decided to put on another Foundation Course in Essential ECG Interpretation in York and it will take place on 12th and 13th February 2018. The first course in June was attended by 38 people and the feedback was very good. Several people contacted us to request that we run another course because they had wanted to attend the June course but couldn't be released from work. As before, the venue is the National Railway Museum, which is just a few minutes' walk from York railway station and also has free parking. York is easy for most people to get to because of its excellent rail links, and for those with the opportunity and inclination to explore, there is a multitude of historic attractions in this beautiful city. Not only that – you can enjoy looking at classic steam locomotives in your coffee breaks!

This is the ideal course for people working in an acute setting who need or want to be able to recognise the clinically most important ECG patterns.

Full details of the course syllabus, teaching package and how to book are available at:
**https://ecgcourse.eventbrite.co.uk.**

Please book early to avoid disappointment!

# SAVE THE DATE!

## SOCIETY FOR CARDIOLOGICAL SCIENCE AND TECHNOLOGY
## SCOTTISH BRANCH SCIENTIFIC MEETING & AGM

**3rd NOVEMBER 2017**
**CORINTHIAN, GLASGOW**

Registration and Lunch - 12.15 - 13.00

13.00 HCS National Delivery Plan – Update
Adrian Carragher National Lead Clinical Physiology

13.30 Computation of Fluid Dynamic Modelling in stenotic arterial beds.
Presenter- Joe West, PhD student Glasgow University

13.45 MSc Research project- Monitoring of Phrenic Nerve in AF Ablation
Presenter –Tara Wylie- STP trainee Aberdeen Royal

14:00 Echo presentation Presenter: Stephen Glen, Consultant Cardiologist FVRH

14.30 ANNUAL GENERAL MEETING

15.00 MSc Research project- BNP assay for Heart Failure diagnosis in an In patient population
Presenter: Selas Jennings QUEH

15.15 QT Audit of mental Health patients on Cardiotoxic drugs
Presenter - Elaine Ferrie- University Hospital Crosshouse

15.30 Brugada Syndrome
Presenter- Kerrigan Cowan FVRH

15.45 MI or not MI? That is the question!
Presenter- Chris Llewellyn ARI

16.15 – 18.00 Wine and Canapés and catch up with friends old and new.

Cost: £40

REGISTRATION:

Name_____ Email Address:_____

Hospital:_____

Cheques payable to SCST Scottish Branch and send to: Catriona MacGregor, HCS Professional Lead, Eglinton House, Ailsa Hospital, Dalmellington Rd, AYR KA6 6AB. Or pay on the day.

Email: catmac50@btinternet.com

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# NATIONAL UPDATE MEETING 2017

**24TH NOVEMBER 2017**
**JURY'S INN, BROAD STREET, BIRMINGHAM**

This year's SCST National Update Meeting is looking to be a fantastic event!It is the ideal opportunity to learn about current national developments within Cardiac Science and also a great place to ask questions and network with colleagues from further afield.

The agenda includes:

- Workshops on equivalence
- Workshops on IQIPS accreditation
- Emerging roles for Healthcare Scientists
- Patient group directives and Cardiac Scientists
- Healthcare Science from a national perspective

The meeting is FREE to members of SCST but open to all.

Early bird registrationfor non-members is available. Booking via Eventbrite & is open now!
https://www.eventbrite.co.uk/e/scst-national-update-meeting-2017-tickets-36890602786

Please share this event with colleagues and students participating in Cardiac PTP or STP programmes.