



THE SOCIETY FOR  
**CARDIOLOGICAL SCIENCE & TECHNOLOGY**

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## **Clinical Guidance by Consensus**

**Recommendations for Clinical Exercise Tolerance Testing**



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# The Society for Cardiological Science and Technology

## Recommendations for Clinical Exercise Tolerance Testing

### Foreword

Since the concept of standardising the performance of clinical exercise tolerance testing (ETT) within the UK was first put forward in 1994,<sup>(1, 2)</sup> the Society for Cardiological Science and Technology (SCST), in association with the British Cardiovascular Society (BCS), have provided guidance to facilitate equity and quality of service throughout the United Kingdom (UK). The first publication of standards by the SCST during the 1990s provided the first national directive for ETT performance standards. In 2001, SCST and BCS jointly published an agreed guideline for physiologist managed ETT; these were re-designed and released as a protocol in 2003<sup>(3)</sup>. There are numerous standards and guidelines in the literature, this document aims to summarise and highlight best practice for the performance of ETT in the UK.

#### **Important Note:**

*Throughout this document the personnel performing the exercise tolerance test are referred to as “Cardiac Physiologist” as it is likely that this professional group will carry out the majority of exercise tolerance tests. However, the guidance set out in the text is best practice and should be followed by any professional performing clinical exercise testing.*

## 1 Introduction

This document aims to provide Health Care Professionals (HPC) performing and reporting on exercise tolerance tests (ETTs) with recommendations on how to conduct the ETT.

Clinical ETT is an established non-invasive procedure that provides diagnostic and prognostic information for the evaluation of several pathologies, the most common of which is coronary heart disease. The ETT does not provide detailed information on an individual's capacity for dynamic exercise; other techniques, such as cardio-pulmonary exercise testing (CPX), exist for this purpose. To ensure the maximum effectiveness from the ETT, it should be performed to national standards derived from current best practice.

Although ETT is considered a safe procedure, complications such as acute myocardium infarctions and ventricular arrhythmias may occur. Whilst the statistical possibility of an adverse event is low the severity of the event outcome further highlights the importance of following nationally approved standards.

The recommendations presented within this document are intended for use in any environment where an ETT is required and although not exhaustive such environments may include clinical laboratories, clinics, public or privately funded hospitals.

These recommendations are not intended to apply to paediatric exercise testing, cardio-pulmonary exercise testing, pharmacological studies, or radionuclide studies. These investigations require further standards beyond the scope of this document. However the guidance presented in this document could provide useful information for these investigations.

This document presents several key changes to previous editions including the clarification of low to high risk ETT (see section 4.1); continual professional development for Health Care Professionals performing ETT (see section 7); a description of the roles and responsibilities of the ‘assisting role’ (see section 7); and UK resuscitation council recommendations on out-of-hospital resuscitation facilities (see section 8).

## 2 Scope

- This guidance is aimed at clinical electrocardiography exercise tolerance testing for adult subjects
- The tests may be performed in any suitable establishment as outlined in this document

- The guidance is for all personnel involved including cardiac physiologists, nursing staff, and any others who lead or assist in the clinical electrocardiographic exercise tolerance testing
- It is envisaged that this consensus would be integrated into local or national patient care pathways where ETT is utilised

### 3 Indications

Numerous descriptions exist in the literature for ETT indications and the reader should refer to such publications. Presented in Table 1 are the most widely accepted indications for ETT.

Table 1 – generally accepted indications for ETT <sup>(4)</sup>

1.	Diagnosis of coronary artery disease (CAD) in patients with chest pain that is atypical for myocardial ischaemia
2.	Assessment of functional capacity and prognosis of patients with known CAD
3.	Assessment of prognosis and functional capacity of patients with CAD soon after uncomplicated myocardial infarction (before hospital discharge or early after discharge)
4.	Evaluation of patients with symptoms consistent with recurrent, exercise-induced cardiac arrhythmias
5.	Assessment of functional capacity of selected patients with congenital or valvular heart disease
6.	Evaluation of patients with rate-responsive pacemakers
7.	Evaluation of asymptomatic men >40 years with special occupations (airline pilots, bus drivers, etc)
8.	Evaluation of asymptomatic individuals >40 years with two or more risk factors for CAD
9.	Evaluation of sedentary individuals (men >45 years and women >55 years) with two or more risk factors who plan to enter a vigorous exercise program
10.	Assessment of functional capacity and response to therapy in patients with ischaemic heart disease or heart failure
11.	Monitoring progress and safety in conjunction with rehabilitation after a cardiac event or surgical procedure

### 4 Patient Referral

It is essential that only patients that are able to perform dynamic ETTs be referred to the laboratory. Referral of patients for the investigations has been widely discussed in various publications <sup>(5, 6)</sup>. Prior to low risk ETT (see 4.1 for clarification) a physical examination and clinical history should be performed by a clinician with emphasis on excluding specific contradictions to low risk ETT (see section 4.1). Confirmation of the suitability for the investigation must be documented by completing a suitable request form (Appendix A illustrates a suitable example). The request form must be signed by a physician indicating the following statement:

*'The physician has clinically examined the patient and the resting 12-lead ECG. The physician confirms that none of the contra-indications exist and that it is safe to proceed with a low risk assessment for an adverse cardiac event exercise tolerance stress test.'*<sup>(3)</sup>

If the indication for the ETT is not clear then the referring physician must be contacted for further information. It is important to note that the supervising Cardiac Physiologist has a duty of care, prior to starting the test, to ensure that the patient can perform the ETT safely. If the patient does not meet the criteria for the investigation, the supervisor should postpone the ETT until the reasons for postponement can be discussed with the referring physician.

#### 4.1 Clarification of low and high risk ETT

A low risk ETT is classified as an ETT that excludes the contra-indications listed in Table 2, i.e. 'low risk for an adverse cardiac event'. These listed conditions are not exhaustive and other conditions may be regarded as high risk. Such conditions are under the discretion of the supervisor and referring physician.

Referrals that contravene these contraindications are regarded as high risk. All high-risk cases must be performed with an appropriately trained physician present (patients with a history of increasing or unstable angina or heart failure should not be exercised as low or high risk until their condition has stabilised). The physician's role would be ultimately to provide immediate clinical assessment of the patient and the administration of pharmacological therapies if required.

The supervisor must remember that a patient scored as low risk may have undergone clinical changes since referral and the supervisor must always ascertain the current level of risk prior to exercise. If potential valvular or congenital pathologies are suspected, a physician must have performed an appropriate cardiac

examination to ascertain the current status, with a view to ascertain the risk and whether more intensive monitoring or exclusion from testing is warranted.

Table 2 – Contra-indications to low-risk exercise tolerance testing<sup>(3)</sup>

<ul style="list-style-type: none"> <li>▪ Severe angina or worsening rest angina</li> <li>▪ Angina which is &lt;1month post MI, post-PTCA/stent, post-CABG</li> <li>▪ Known left main stem stenosis</li> <li>▪ Uncontrolled raised BP (SBP &gt;180mmHg and/or DBP&gt;100mm Hg)</li> <li>▪ Hypotension (SBP&lt; 90mmHg)</li> <li>▪ History of sustained ventricular arrhythmias</li> <li>▪ Repolarisation abnormalities that prevent ST analysis, for example left bundle branch block</li> <li>▪ Tests for provocation of any arrhythmia</li> <li>▪ Significant aortic stenosis</li> <li>▪ Hypertrophic obstructive cardiomyopathy</li> <li>▪ Screening tests for pilots, LGV, PCV licensing when physiologist is unfamiliar with the requirements from the Licensing Authority</li> </ul>
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#### 4.2 Open access referrals

Referrals may be received from physicians located in out-of-hospital environments including primary care direct access. All referrals must follow the referral process outlined in this document.

## 5 Patient Interests

The patient's interests and respects must be upheld during the entire ETT process.

#### 5.1 Patient information leaflet

It is considered best practice to provide the patient with an information leaflet explaining the ETT prior to attendance. It is recommended that any patient information leaflet reflect the interests of the patient and include the key points outlined throughout Section 5 of this guidance. To achieve this aim it is recommended that relevant stakeholders are involved in the local design of the leaflet.

#### 5.2 Instruction to withhold medication

This instruction may prove to be of concern to the patient. It is recommended that the referring physician provide clear instruction confirming the specific name of the medication(s) to be withheld, the period during which the medication is to be withheld e.g. 48 hours prior to ETT, and when to re-commencement therapy.

The laboratory should provide contact details where the patient may seek advice regarding the ETT. The patient information leaflet should clearly indicate the contact details. The patient information letter should also specify when to stop administration, and when to recommence. If clarity of instruction cannot be obtained then the default must be to perform the investigation without ceasing the administration of any medication.

#### 5.3 Obtaining patient consent for the procedure

An explanation of the testing procedure must be provided to the patient. Written consent may be obtained in line with local consent policy.

#### 5.4 Pre-test instructions

In order for a patient to achieve their maximum exercise tolerance, the instructions listed in Table 3 should be adhered to.

Table 3 – Adjustable factors that may affect exercise tolerance

<p>Prior to attending the patient should:</p> <ul style="list-style-type: none"> <li>▪ Eat only a light meal</li> <li>▪ Wear comfortable shoes</li> <li>▪ Avoid strenuous exercise 4 hours prior</li> <li>▪ Avoid or minimise smoking 24hrs prior</li> <li>▪ Conform to any medication requests</li> </ul>
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The supervisor should ascertain if the patient's exertional effort could be affected by such factors. If the supervisor believes the result of the ETT could be compromised then the final written report must state the reasons.

#### 5.5 Test instruction during the procedure

The use of conversation during the procedure is two-fold. The supervisor needs to appropriately assess the patient's symptoms throughout the procedure, and also provide the patient with reassurance. The value of an appropriate 'bed side manner' cannot be overstated.

#### 5.6 Communication of results

The patient must receive an indication of how and when the results of the investigation would be released.

## 6 **Testing Laboratories**

An appropriately controlled environment is essential for the performance of the ETT.

#### 6.1 Environment

The room should be well lit, clean, well ventilated room and, if necessary, air-conditioned. The room must be large enough to comfortably accommodate all the necessary equipment, provide sufficient space for emergency and/or resuscitation procedures, and to allow free access to emergency personnel with a stretcher trolley. There must be some means of maintaining the privacy and dignity of the patient throughout the ETT.

#### 6.2 Location

The location of the laboratory should facilitate access to medical personnel that may be approached for medical advice in the event of an adverse incident. It is essential that medical staff be able to reach the room within one minute of a cardiac arrest alarm being announced. Appropriate location examples would be close to a cardiology ward or department.

#### 6.3 Staff training

It is essential that members of the exercise team are familiar with local practices for responding to adverse reactions, emergency and resuscitation. All staff must be familiar with all local procedures. The cardiac arrest drill should be rehearsed on at least an annual basis and involve those persons potentially likely to be involved in the arrest. Local procedures must be in line with current UK resuscitation council guidelines<sup>(7)</sup>.

#### 6.4 Assistance in an emergency

In order that assistance can be summoned immediately should an emergency occur, immediate access to a suitable alarm system and/or telephone facilities must be made available. The alarm must be tested on a regular basis at a frequency of at least once per week.

#### 6.5 Resuscitation equipment

Full resuscitation facilities for managing a cardiac or respiratory arrest must be kept within the laboratory during any testing; and be in line with current UK resuscitation guidelines<sup>(8, 9)</sup>. This must include a defibrillator. There must also be suction and oxygen available. All resuscitation equipment must be fully checked at the start of each exercise test session.

#### 6.6 The ECG recording system

A suitable ECG display and recording system, which must provide continuous monitoring with a minimum of three leads (preferably 12-lead) in order to detect arrhythmias during pre-test, exercise and recovery stages. It must also have the ability to acquire and display (screen and/or print copy) a minimum of a 12-lead ECG result at any point during the investigation.

The system must also provide a computerised analysis of the pre-test, exercise and recovery ST segments, and a hardcopy printout must be included in the final investigation report<sup>(3)</sup>. However there is a possibility that such systems may provide unreliable results due to phenomena such as movement artefact<sup>(4)</sup> and aberrant conducted ECG complex morphology. **It is essential that all monitoring and reporting staff compare computerised ST analysis with raw unaltered data to validate its accuracy.**

### 6.7 Equipment for dynamic exercise

There are currently two common types of equipment providing controlled dynamic exercise; the treadmill and ergometer (bike). For treadmill investigations, the treadmill should be electrically driven and be a minimum of 127cm in length with a moving belt that is at least 40 cm wide<sup>(3)</sup>. For safety reasons the treadmill should have side and front rails for the patient to steady himself or herself. It should have an emergency stop button readily accessible to performing staff. The treadmill should have variable speed and grade capability and must be accurately calibrated at regular intervals as per local policies on use of medical devices and manufacturer's recommendations.

### 6.8 Health and safety

Health and safety incidents may occur while the patient is undertaking dynamic exercise, such as a fall. The physical support of patients while undergoing dynamic exercise should be according to local health and safety policies. The use of mercury blood pressure devices is not recommended because of the potential risk of breakage and resulting leakage of mercury.

### 6.9 Blood pressure recording

It is essential that any blood pressure measuring device used for dynamic exercise testing provide accurate measurements. There are a variety of automated blood pressure units approved for use however it should be noted that they may be unreliable at high exercise intensities with motion/noise artefact or during specific arrhythmias.

## **7 Staffing**

Appropriately trained and competent personnel are essential for the safe supervision and management of the ETT. Table 4 demonstrates the currently recognised staff levels for performing ETT.

Table 4 – recognised levels for ETT



### 7.1 Management of the exercise laboratory

It is recommended that the managing Cardiac Physiologist hold an appropriate postgraduate qualification. It is also expected that the manager has advanced knowledge in ECG interpretation.

The manager must also be available to provide specialised advanced consultation when the need arises. Such knowledge required would include non-cardiac exercise patient risk, mobility disorders, indifferent diagnosis of the ECG, advanced 12-lead ECG reporting skills, knowledge of how the results of other investigations may affect the risk of the exercising patient; e.g. biochemistry, echocardiography, ambulatory ECG/BP monitoring, respiratory function, pacing.

It is recommended that the manager have auscultation skills so as to provide a limited aortic valve screen prior to ETT. However the supervisor must contact the referring physician in the events of a query.

Patients partaking in ETT with anti-bradycardia, implantable defibrillators, biventricular pacemaker or other such devices, would require a Cardiac Physiologist with specialist knowledge of exercise pacing physiology. If the managing or supervisor cannot provide this knowledge, a Cardiac Physiologist with pacing expertise must be present during the procedure.

### 7.2 Training

Exercise testing must be conducted by appropriately trained staff with advanced knowledge and skills in this speciality. With regard to adverse incidents all staff must be familiar with both normal and abnormal responses during exercise and must recognise and take appropriate actions to prevent untoward events. All personnel must be trained to provide cardiopulmonary resuscitation and must hold at least the 'immediate life support' (ILS) provider status<sup>(3, 8)</sup>.

### 7.3 Staffing requirements

A minimum of two suitably qualified healthcare practitioners must be present during the exercise and recovery stages of the investigation. The supervision of the ETT must be undertaken by an individual who meets the requirements of a supervisor as indicated in section 7.5 with extensive exercise test experience and be fully competent in the use of all equipment. The assisting role would require an in-house ETT training programme to meet the requirements set out in 7.6.

### 7.4 Role of supervisor

The supervisor is responsible for the safe conduct of the ETT. The specific roles of the supervisor are to:

- Supervise the investigation
- Deliver effective and timely life support
- Interpret data derived from the investigation
- Provide an accurate report on the investigation
- Ensure all facilities are acceptable for use
- Ensure protocols regarding clinical notes and request forms are followed.
- Ensure that all staff involved in the procedure are suitably qualified.
- All contra-indications to low risk ETT have been excluded.

If the supervisor believes the investigation cannot be conducted appropriately or safety then the supervisor should postpone the investigation. The supervisor will be required to use his/her advanced knowledge of exercise physiology to ensure the safe performance of the investigation.

Screening tests for pilots, LGV, PCV license applicants must only be supervised by staff that are familiar with the requirements from the Driver Licensing Vehicle Authority. For information on current requirements see [www.dvla.gov.uk](http://www.dvla.gov.uk) <sup>(10)</sup>.

### 7.5 Experience of supervisor

The supervising healthcare professional must be able to demonstrate the completion of the following training requirements and standards:

- Have attained the practical/academic knowledge, and skills of clinical exercise testing as part of a formal training programme. For example, BSc (Hons) Clinical Physiology (Cardiology) that incorporates the underpinning knowledge of the physiology, electrocardiography and pharmacology relating to exercise stress testing together with assessment of practical competence in performing exercise testing or completion of the relevant British Association for Nursing in Cardiac Care Competency Statements.
- Have successfully completed resuscitation training and hold current life support certification (minimum ILS).
- Have undertaken and documented a minimum of 50 exercise tests in the supervising role whilst being overseen by a competent trainer. At least five of these tests must have been formally assessed.

The managing Cardiac Physiologist with responsibility for ETT or a consultant cardiologist and head of department must certify these clinical training requirements have been met.

With regard to CPD the supervisor must be able to demonstrate:

- Annual updates of ILS or 3 yearly updates of ALS (timing and name of qualification as per UK Resuscitation Council Guidance).
- A record noting the appropriate demonstration of the ability to use all relevant equipment within the laboratory must be maintained as per device competency requirements.
- Undertake supervision of a minimum of 50 tests per year covering an appropriate range of clinical conditions and maintain a CPD record to support their work.

### 7.6 Assisting role

The assisting role includes preparing the patient for the investigation, preparation of the testing environment including a defibrillator trolley check, and providing assistance during the exercise and recovery stages under the direction of the supervisor. The role would include competency in the use of ETT equipment, understanding of the ECG and assisting the patient as deemed necessary by the supervisor.

### 7.7 High risk patients

These recommendations are designed for the safe conduct of the investigation in patients with a low risk of a cardiac adverse event. For patients deemed as high risk, as indicated by the contraindications outlined in section 8.4, there must be a physician present in the laboratory for immediate clinical consultation and administration of an appropriate range of pharmacological therapies.

## **8 The ETT procedure**

The care pathway and standard operating protocol (SOP) for the patient undergoing the ETT investigation must be clearly defined in each department performing the investigation.

### 8.1 Prior to patient admission

Prior to the admission of the patient into the laboratory it is good practice to ensure that the requirements listed in Table 5 are met.

Table 5 –Requirements for each ETT session

<ul style="list-style-type: none"><li>▪ The resuscitation trolley has been checked to ensure it is fully stocked and functional. A record of the check should be made.</li><li>▪ There is adequate functional supply of piped or non-piped cylinder oxygen available.</li><li>▪ The alarm has been successfully tested within a weekly period.</li><li>▪ Ensure the defibrillator is functioning correctly by testing the device at 100J or other appropriate methods.</li><li>▪ The named physician or covering medical team is informed of and the likely duration of the session (emergency contact arrangements must be agreed).</li><li>▪ Ensured a second appropriately qualified staff member is present.</li><li>▪ The patients' clinical case notes and request forms are present.</li></ul>
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The arrangements for immediate clinical consultation and assistance in a variety of clinical concerns and emergencies should be clearly defined and displayed in each department offering the ETT e.g. contact details for an in-house pager for medical consultation.

### 8.2 Patient information leaflet

It is recommended that the patient has received an investigation information leaflet explaining the procedure and detailing any specific instructions prior to attending for the investigation. See section 5.1 for further details.

### 8.3 On patient admission

The supervisor must ensure that an appropriately completed request form is present. A physician must have performed a clinical history and physical examination with emphasis on excluding specific contradictions and confirming suitability for the investigation. Any significant changes in clinical history or significant omissions from the request form and the supervisor should consult a physician, ideally the referring physician. The head of ETT service and lead cardiologist should agree the design of the request form locally.

The supervisor must assess the current risk of exercising the patient during the pre-test stage. It is important to question the patient regarding relevant clinical history, particularly in reference to the time period between referral date and date of test. To ensure the patient remains in the low risk category. Such questions should also establish the current condition of patient symptoms that may adversely affect the ETT (see appendix B for a suitable example of a pre-test questionnaire).

Every effort should be made to respect the sensitivities of patients and minimise their embarrassment. A gown should be used where necessary, with front fastening to allow for electrode adjustment if required. The patient should be prepared as indicated in section 5.4.

An explanation of the testing procedure should be provided to the patient in line with local consent policies.

Confirmation that the patient has followed any medication instructions must also be established. The patient must be told how to perform the test and the testing procedure may require demonstration.

### 8.4 Skin preparation

The most critical point of the electrode-amplifier-recording system is the interface between electrode and skin. Removal of the superficial layer of skin significantly lowers its resistance, thus decreasing the signal to noise ratio. In brief, the areas where electrodes are to be placed (see section 8.5) should be shaved if

necessary and rubbed with an alcohol-based substance designed for use on skin. When the skin is dried it should be lightly abraded using a paper towel, gauze swab or proprietary abrasive tape designed specifically for this purpose<sup>(11)</sup>.

### 8.5 Electrode position

Since a standard 12-lead ECG with electrodes placed on the limbs cannot be obtained during exercise, due to movement artefact, modification of the standard 12 lead ECG electrode positions is required<sup>(15)</sup>. This however places difficulties in analysing limb lead morphologies, such as axis and amplitudes. It is important to note that such changes may lead to a false ECG diagnosis of pathological ST segment deviation. Hence a resting standard 12 lead ECG and a modified Exercise 12 lead ECG should be obtained prior to the testing, and compared in order to note any changes attributable to modified positions.

In summary<sup>(15)</sup>:

- Chest electrodes – as per standard 12-lead ECG
- Right arm electrode – upper right side of torso (infraclavicular fossa), 2cm below clavicle
- Left arm electrode – upper left side of torso (infraclavicular fossa), 2cm below clavicle
- Right leg electrode – lower right side of torso, half-way between costal margin and iliac crest
- Left leg electrode – lower left side of torso, half-way between costal margin and iliac crest

### 8.6 Exertional stage of the test

A resting ECG and blood pressure measurement must be made both in supine and standing positions before exercise stage begins.

A good level of communication between the patient and staff supervising the test must be maintained throughout the investigation. Once the patient has commenced exercise, the supervisor must not leave the laboratory until the patient reaches an acceptable condition for discharge. The Bruce protocol should be the default test protocol for use. The modified Bruce protocol can be utilised in subjects under appropriate conditions such as limited mobility or post MI. There must be continuous monitoring of heart rate, blood pressure, ST segments, arrhythmias, QRS morphologies and the patient's physical condition throughout the test. It is recommended that the computerised ST analysis criteria use J+80ms or J+60ms. There is evidence to suggest that significant upsloping ST depression may be more readily detected at J+80ms.

### 8.7 Frequency of measurements

The minimum frequency of BP and 12-lead ECG measurements should be at supine and standing baseline, immediately before progression into the each stage, at peak exercise and at one minute interval throughout recovery or until return to an acceptable resting value<sup>(3)</sup>.

### 8.8 Indicators for Cessation of test

All tests must be symptom limited or maximal; whichever is the sooner (unless specifically requested otherwise).

In addition to the accepted reasons for the cessation of investigation<sup>(5)</sup> the following reasons must also be taken into consideration.

Table 6 – modified from Test end points<sup>(3)</sup>

<ul style="list-style-type: none"><li>▪ Technical difficulties monitoring the ECG or systolic blood pressure</li><li>▪ Central nervous system symptoms (e.g., ataxia, dizziness, or near syncope)</li><li>▪ Signs of poor perfusion (cyanosis or pallor)</li><li>▪ Exercise induced arrhythmias – AF, SVT, VT, frequent VPBs, multifocal VPBs, heart block with symptoms + BP drop</li><li>▪ Rapid ST elevation with or without pain</li><li>▪ SBP failing to increase &gt;20mmHg.</li><li>▪ &gt;3mm ST depression without symptoms</li><li>▪ &gt;2mm ST elevation with symptoms</li><li>▪ Severe chest pain or dyspnoea</li><li>▪ SBP rise &gt;230mm Hg.</li><li>▪ Heart rate falling &gt;20% of starting rate</li><li>▪ Unsteadiness of gait</li><li>▪ Predicted maximum heart rate maintained for one minute</li><li>▪ Development of bundle branch block</li><li>▪ Patient requests to stop</li></ul>
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### 8.9 Post-exercise (Recovery) Period

The purpose of the recovery period is to ensure that all patient physiological measurements have returned to near baseline conditions and to monitor for the possible development of symptoms and ECG changes. There is evidence to suggest that a cool-down walk may not be appropriate as it may delay or eliminate the appearance of ST segment depression<sup>(6)</sup>. Monitoring should continue for a minimum of six minutes after exercise termination or until electrophysiological or haemodynamic changes have stabilised. Ideally heart rate and ECG should return to near to baseline values.

During recovery if maximum test sensitivity is to be achieved, subjects should be encouraged to recover in the supine position; however the sitting position is permissible for subject comfort. It is widely accepted that abnormal responses occur during recovery even after a seemingly normal exercise response. It is thought that such abnormal ECG responses are related to mechanical dysfunction and electrophysiological abnormalities in the ischaemic ventricle. They may persist from minutes to hours and may not be false positive.

### 8.10 Discharging the patient

The supervisor has the responsibility of discharging the patient from the laboratory. Discharge should only be performed if the supervisor is satisfied that the patient is stable in regards to the results of the investigation and the patient's general symptoms. If there is any concern the designated physician or medical team must be contacted for further advice and/or clinical assessment of the patient. To safeguard against the late-onset development of post-exercise symptoms it is good practice to request that the patient waits within the department for a further 15-20 minutes before leaving.

If symptoms develop during the post-recovery period the supervisor must decide on an appropriate course of action. Any events post-recovery should be appropriately recorded, for example in the clinical case notes. In the interest of efficiency it is best practice to ensure the prompt return of the test result to the referring source, ideally within 24 hours.

### 8.11 Emergency procedures

Each laboratory must have in place local emergency procedures for dealing with adverse, emergency and resuscitation events<sup>(7, 9)</sup>. A mechanism must be in place to ensure that a medical team or physician is immediately contactable. It is the responsibility of the supervisor to manage any incident until more experienced assistance arrives. Emergency arrangements must be clearly defined within each department, including procedures for transfer to acute wards. All staff must have adequate training and be fully aware of their roll in the event of an emergency.

### 8.12 UK Resuscitation Council Recommendations

For exercise tests performed in an out of hospital environment, guidance from the UK Resuscitation Council states that 'measures in place for cardiac exercise testing in the community setting should ensure that patients receive an equivalent level of care as that of patients having the same procedure in a hospital setting'. It should be remembered that ETT is a planned procedure and all efforts should be made to minimise risk to the patient.

The UK Resuscitation council recommends:

- The avoidance of high-risk patients.
- Patients who deteriorate or have a cardiac arrest must receive immediate medical care and advanced life support.
- Ensure recorded arrangements are in place with the local ambulance service to transfer sick patients to the nearest acute hospital.
- In the absence of a hospital based cardiac arrest team, individuals involved in testing should have the necessary skills to treat common cardiac emergencies and cardiac arrest. This may necessitate the presence of a doctor competent in dealing with cardiac emergencies and advanced life support.
- The room and equipment available should match that available in the hospital setting.
- The need for regular arrest/emergency drills is essential, especially for those who rarely deal with real emergencies.
- A risk analysis must be undertaken by any setting where such testing takes place.

## 9 Interpretation and reporting

The supervisor must analyse and interpret the results and write a report on the ETT. The report must be written immediately after the test and should contain relevant information to assist the physician in making or confirming a clinical diagnosis. The report must include specific requirements as indicated in this section.

If the test results are highly abnormal, the referring physician should be notified as soon as possible.

When constructing the report it is important to note when a significant event developed, reached a peak, and resolves e.g. exertional chest tightness developed during stage 2, evolved into chest pain at peak exercise, and resolved by 4 minutes into recovery. A test result statement may be included that states whether the test is positive, negative or equivocal in relation to the ischaemia criteria outlined in section 9.3. However, it should be kept in mind that with the sensitivity and specificity of the investigation it is not possible to state with 100% accuracy whether the test is positive or negative.

### 9.1 Symptoms

During dynamic exercise there is a potential for the development of non-cardiac or cardiac related symptoms. It is important to describe the development and nature of such symptoms. Non-cardiac symptoms must not be under-reported.

It is known that ischaemic related chest pain is strongly predictive of CAD and hence it is important to obtain a careful description of the pain from the subject to ascertain as to whether it is typical angina or non-ischaemic chest pain.

### 9.2 Subject's appearance

The subject's general appearance is helpful in clinical assessment. A change in facial complexion (pallor) may be associated with a wide range of pathologies. For example with regards to inadequate cardiac output, a drop in skin temperature and peripheral cyanosis during exercise can indicate poor tissue perfusion with secondary vasoconstriction; or neurological manifestations such as light-headedness or vertigo.

### 9.3 Electrocardiographic changes

Electrocardiographic changes can broadly be divided into four categories; arrhythmias, ST segment shifts, T wave and QRS morphological changes. There is a potential for any arrhythmia to develop during exercise with potential rapid deterioration of the patient. QRS morphological changes can result from development of partial or complete bundle branch blocks. Hence it is important to establish changes in morphology due to the accepted changes in limb positions of electrodes prior to exercise. ST segment shifts can be described broadly as elevation or depression (horizontal, downsloping or upsloping). T wave changes due to myocardial ischaemia are well described in the literature however the supervisor must be aware that hyperventilation and postural changes can induce T wave shifts. **A standing 12-lead ECG is essential for comparison prior to exercise.** Typical ST deviation markers of myocardial ischaemia include  $-0.2\text{mV}$  ( $2\text{mm}$  at  $10\text{mm/mV}$ ) with anginal-like symptoms or  $-0.3\text{mV}$  ( $3\text{mm}$  at  $10\text{mm/mV}$ ) without.

### 9.4 METS

The use of metabolic equivalent estimation is widely described in the literature. Their use in the exercise test is limited and should be used with caution. At best the METS calculation would provide an estimation of cardiac function in the absence of any respiratory or mobility limitations<sup>(4)</sup>. For assessment of functional capacity more accurate investigations are available such as CPET/CPX.

### 9.5 Writing the report

The report is usually written by the supervisor in conjunction with the computerised ETT analysis system. Specifically the report must include the points outlined in Table 7<sup>(3)</sup>. In regard to the provision of an opinion, it is permitted to state whether the test result is positive, negative or inconclusive according to the criteria outlined in this document.

Table 7 – Minimal requirements for inclusion in an ETT report (modified from the BCS 2003 protocol <sup>(3)</sup>)

<ul style="list-style-type: none"> <li>▪ Indication for the investigation</li> <li>▪ The protocol used</li> <li>▪ The resting ECG appearances</li> <li>▪ Any deviation from the last clinical assessment by a physician</li> <li>▪ Any deviation from the pre-test instructions</li> <li>▪ Whether medication was terminated for the purpose of the investigation</li> <li>▪ Total exercise time and recovery times</li> <li>▪ % of predicted maximum heart rate achieved</li> <li>▪ Whether the test was maximal or submaximal relating to the maximum heart rate</li> <li>▪ Reason for termination</li> <li>▪ When a significant event developed, reached a peak, and resolved</li> <li>▪ If appropriate the maximum ST changes in which lead and when</li> <li>▪ Patient's cardiac symptoms – what, when, association with other abnormalities</li> <li>▪ Details regarding any arrhythmias</li> <li>▪ Patient's other symptoms, for example, claudication, dizziness, fatigue</li> <li>▪ A comment on patient's appearance before, during and after the exercise test</li> <li>▪ Whether computerised ST analysis was reliable or otherwise</li> </ul>
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## 10 Audit

Regular audit of the clinical exercise tolerance test service is essential. Each laboratory must develop and routinely apply audit to ensure the adequate operation of the service.

## 11 Authors and acknowledgements

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## Appendix B

### Pre-test patient questionnaire for Low risk Clinical exercise tolerance test

Incomplete forms are a contra-indication

**DO NOT proceed with the test unless this form is completed**

Hospital number	Date of request
Name	Date of test
Address	Ward/OPD
DOB	Consultant

#### SCST/BCS guidelines

Please indicate Yes or No. If answered NO to any question then consult a senior staff member before proceeding.

Is the resuscitation equipment correct and functional?	Yes or No
Medical team informed of exercise test session?	Yes or No
Is the request form completed and signed by a physician?	Yes or No
Does the request form comply with SCST/BCS guidelines?	Yes or No
Are the patient's notes present?	Yes or No
The patient has <b>not</b> seen a physician since the test request date?	Yes or No
Is the resting blood pressure >90mmHg or <180/100 mmHg?	Yes or No
There are <b>no</b> significant changes on the ECG since last recording?	Yes or No
There are <b>no</b> recent changes in medical history/treatment?	Yes or No

#### Risk assessment

These guidelines will aid in the risk management of the patient. If answered YES to any question then consult a senior member of staff before proceeding.

Has the patient had chest pain related to angina in the last 24 hours?	Yes or No
Has the patient had a MI/CABG/PTCA in the last 4 weeks?	Yes or No
Has the patient been informed they have a heart murmur?	Yes or No
Does the patient have diabetes? If so is hypoglycaemia possible?	Yes or No
Does the patient have any breathing disorders?	Yes or No
Does the patient suffer from any knee, leg or ankles problems?	Yes or No
Does the patient suffer from any spine or muscle problems?	Yes or No
Does the patient suffer from any palpitations or dizziness spells?	Yes or No

**If appropriate, indicate problem:**

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Signature of supervising CP	Signature of assisting CP	Date of test
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