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ACP/ACC/AHA TASK FORCE STATEMENT

Clinical Competence in Exercise Testing

A Statement for Physicians From the ACP/ACC/AHA Task Force on Clinical Privileges in Cardiology

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The granting of clinical staff privileges to physicians is one of the primary mechanisms used by institutions to uphold the quality of care. The Joint Commission on Accreditation of Healthcare Organizations requires that the granting of initial or continuing medical staff privileges be based on assessments of applicants against professional criteria specified in medical staff bylaws. Physicians themselves are thus charged with identifying the criteria that constitute professional competence and with evaluating their peers accordingly. But the process of evaluating a physician's knowledge and competence is often constrained by the evaluator's own knowledge and ability to elicit the appropriate information, a problem that is compounded by the growing number of highly specialized procedures for which privileges are requested.

This guideline is one of a series developed by the American College of Physicians, the American College of Cardiology and the American Heart Association to assist in the assessment of physician competence on a cardiovascular procedure-specific basis. The minimum education, training, experience and cognitive and technical skills necessary for the competent performance of exercise testing are specified. These are based, when possible, on published data linking these factors with competence in certain procedures or, in the absence of such data, on consensus of expert opinion. They are applicable to most practice settings and can accommodate a variety of ways physicians might substantiate competence in the performance of specific cardiovascular procedures (see also "Guide for the Use of American College of Physicians Statements on Clinical Competence," *Ann Intern Med* 1987;107:588–9).

Clinical Competence in Exercise Testing was approved by the American College of Physicians Board of Regents, the American College of Cardiology Board of Trustees and the American Heart Association Steering Committee.

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Overview of the Procedure

Exercise testing has been used in clinical practice for many years and its use has contributed significantly to the management of many patients. In its current form clinical exercise testing consists of the continuous monitoring of an electrocardiogram (generally a 12-lead system) with frequent 3-lead or 12-lead recordings taken according to clinical circumstances, frequent blood pressure determinations and continuous patient observation before, during and after exercise of progressively increasing intensity (usually with a treadmill or cycle ergometer) to any of a number of test end points. Arm exercise is occasionally used in selected patients, although it is seldom as satisfactory. Ventilatory gas

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exchange measurements, such as oxygen consumption or respiratory exchange ratio, may also be measured. The patient is also observed and monitored for 5 to 10 min after exercise ends.

In many instances exercise testing may be combined with other procedures, such as myocardial perfusion imaging, radionuclide ventriculography, echocardiography or other imaging procedures. If a physician is responsible for both exercise testing and imaging, clinical competence in both areas is required. In other cases one physician may be responsible for the exercise test and another for imaging. In such cases staff privileges are granted accordingly. The guidelines in this document pertain only to exercise testing.

Since the procedure entails a very small but definite risk, it should only be performed under the following conditions: with appropriate indications and careful consideration of contraindications, under the supervision of a properly trained physician and with appropriate technique and safety measures. The supervising physician should know that specificity, sensitivity and diagnostic accuracy of the test can vary considerably according to the prevalence of the condition in the population being tested (Bayes theorem) and according to the criteria used to determine a "positive," "negative" or "indeterminate" result. The physician must understand the many factors that can result in false positive, false negative or indeterminate results.

The clinical indications for exercise testing are broad and varied. In general, the procedure is used to answer a specific question and should not be performed if the information gained may be obtained with other techniques that have been or will be performed. Exercise testing should be conducted when it is anticipated that the results will affect patient management. It is important that the physician performing an exercise test know the indications for and diagnostic accuracy of other tests used in the evaluation of patients with known or suspected cardiovascular disease. Such tests include radionuclide ventriculography, nuclear magnetic resonance imaging, other imaging methods, ambulatory electrocardiography, cardiac catheterization and exercise testing combined with myocardial perfusion imaging, first pass or equilibrium radionuclide angiography or echocardiography.

For the purpose of this statement, performance of exercise testing includes knowing indications for and contraindications to the test, recognizing normal end points and abnormal responses or complications that may require that the test be discontinued, managing complications of the test and interpreting the test results. In selected patients exercise testing can be safely performed by properly trained nurses, exercise physiologists, physical therapists or medical technicians working directly under the supervision of the physician who should be in the immediate vicinity and available for emergencies. However, the physician should be present to observe the patient continuously when the test is performed on a patient with severe angina pectoris, possible unstable angina pectoris or exertional left ventricular dysfunction or arrhythmia. In all instances, the patient should be screened for contraindications immediately before the test.

Competent performance of exercise testing requires significant cognitive knowledge including clinical evaluation of the patient, knowledge of the pathophysiology of the disease or condition for which the test is performed and knowledge of electrocardiography, cardiac arrhythmias and exercise physiology including normal and abnormal responses to different types and levels of exercise.

Justification for Recommendations

The number of procedures that must be performed under supervision and the duration of training vary depending on the individual's aptitude and other training. The following recommendations for minimum criteria for competence are based on the American College of Cardiology's 17th Bethesda Conference on Cardiology Training (1) and the expert opinion of cardiovascular consultants, as well as the expert opinion of the Subcommittee on Cardiology of the American College of Physicians Committee on Clinical Privileges.

Indications, Contraindications and Complications

Individuals who perform or supervise exercise testing must understand the indications for and contraindications to the test.

General indications for exercise testing in cardiology patients are listed in Table 1 and categorized as class I, which comprises conditions for which there is general agreement that exercise testing is justified, and class II, which comprises conditions for which exercise testing is frequently used but in which there is a divergence of opinion about its value and appropriateness (2).

It is important to note that approximately 90% of men with a history consistent with typical angina pectoris have significant coronary artery disease when studied by coronary arteriography (3). In such patients an exercise test adds only slightly to the diagnostic accuracy of the clinical impression, although it may provide other important information. In contrast, the prevalence of significant coronary artery disease, as measured by angiography in women with a history of typical angina pectoris, may be as low as 60% to 70%. Since a false positive exercise ST segment response is much more frequent in women than in men, an abnormal ST segment response in this group of women does not greatly enhance the predictive accuracy of the clinical diagnosis

Table 1. General Indications for Exercise Testing

Class I: Conditions for which there is general agreement that exercise testing is justified
- To assist in the diagnosis of coronary artery disease (CAD) in male patients with symptoms that are atypical for myocardial ischemia
- To assess functional capacity and to aid in assessing the prognosis of patients with known CAD
- To evaluate the prognosis and functional capacity of patients with CAD soon after an uncomplicated myocardial infarction (before discharge or early after discharge)
- To evaluate patients after coronary artery revascularization by surgery or coronary angioplasty
- To evaluate patients with symptoms consistent with recurrent, exercise-induced cardiac arrhythmias
- To evaluate functional capacity of selected patients with congenital heart disease
- To evaluate patients with rate-responsive pacemakers

Class II: Conditions for which exercise testing is frequently performed but in which there is a divergence of opinion with respect to its value and appropriateness
- To evaluate asymptomatic male patients over the age of 40 with special occupations (pilots, air traffic controllers, fire fighters, police officers, critical process operators, bus or truck drivers and railroad engineers)
- To evaluate asymptomatic males over the age of 40 with two or more risk factors for CAD
- To evaluate sedentary male patients >40 years who plan to enter a vigorous exercise program
- To assist in the diagnosis of CAD in women with a history of typical or atypical angina pectoris
- To assist in the diagnosis of CAD in patients who are taking digitalis or who have complete right bundle branch block
- To evaluate the functional capacity and response to therapy with cardiovascular drugs in patients with CAD or heart failure
- To evaluate patients with variant angina
- To follow up serially (at 1-year intervals or longer) patients with known CAD
- To evaluate patients with a class I indication who have baseline electrocardiographic changes or coexisting medical problems that limit the value of the test (in some of these patients exercise testing may still yield clinically useful information, such as duration of exercise, blood pressure response and production of chest discomfort)
- To evaluate patients who have sustained a complicated myocardial infarction but who have subsequently "stabilized" (before discharge or early after discharge)
- To evaluate on a routine, yearly basis patients who remain asymptomatic after a revascularization procedure
- To evaluate the functional capacity of selected patients with valvular heart disease
- To evaluate the blood pressure response of patients being treated for systemic arterial hypertension who wish to engage in vigorous dynamic or static exercise
- To evaluate selected children and adolescents with valvular or congenital heart disease

From Subcommittee on Exercise Testing (2). Adapted with permission.

based only on clinical history. As a result, exercise testing alone without radionuclide imaging in women with atypical chest pain is of limited value when performed for diagnostic purposes.

General contraindications to exercise testing are listed in Table 2 and together with indications for exercise testing are representative of the cognitive material that the individual performing or supervising the test should know. The common causes of electrocardiographic false positive (or, in some instances, indeterminate) exercise tests are listed in Table 3. The major complications of exercise testing are listed in Table 4. More detailed discussions of indications, contraindications and complications of exercise testing are available elsewhere (2,4–13).

Minimum Training Necessary for Competence

The role of the credentials committee is critical because of the varied training backgrounds of physicians performing

Table 2. General Contraindications to Exercise Testing to Evaluate Myocardial Ischemia*
- Very recent acute myocardial infarction (generally <6 days)
- Angina pectoris at rest
- Severe symptomatic left ventricular dysfunction
- Potentially life-threatening cardiac dysrhythmias
- Acute pericarditis, myocarditis, or endocarditis
- Severe aortic stenosis
- Severe arterial hypertension (generally >200 mm Hg systolic or 120 mm Hg diastolic)
- Acute pulmonary embolus or infarction
- Acute thrombophlebitis or deep vein thrombosis
- Acute or serious general illness
- Neuromuscular, musculoskeletal or arthritic condition that precludes exercise
- Uncontrolled metabolic disease, such as diabetes, thyrotoxicosis, or myxedema
- Inability or lack of desire or motivation to perform the test

*Some of these are relative contraindications. In selected cases testing may be performed by a skilled cardiologist, generally in a referral center. All of the above are contraindications to testing in the office.

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Table 3. Possible Causes of False Positive or Indeterminate Electrocardiographic Exercise Test for Coronary Artery Disease

- Female gender
- Hyperventilation
- Nonfasting state
- Mitral valve prolapse syndrome
- Vasoregulatory abnormality
- Systemic arterial hypertension
- Left ventricular hypertrophy
- Drug administration (digitalis and others)
- Anemia
- Hypoxemia
- Electrolyte abnormalities, such as hypokalemia
- Sudden excessive exercise
- Excessive double product
- Cardiomyopathy
- Congenital heart disease
- Valvular heart disease
- Pericardial disorders
- Bundle branch block, especially left bundle branch block
- Ventricular pre-excitation (Wolff-Parkinson-White syndrome, pre-excitation variants)
- Ventricular pacemaker
- Advanced age
- Improper lead system
- Inadequate recording equipment
- Incorrect criteria
- Improper interpretation

exercise testing, and individual consideration is important. Many physicians acquire the skills necessary for exercise testing during a fellowship in cardiovascular disease. Some internal medicine residency programs provide training in exercise testing, often as an elective. A minimum of 4 weeks should be devoted to this training to achieve competence.

Because of the variable backgrounds of physicians and the diversity of their training experiences, multiple pathways to acquire competence are possible. The clinical and institutional setting in which the training occurs, the case mix, backup and collaboration available to trainees performing the procedures and the number of procedures performed under supervision must all be considered when granting privileges.

The number of procedures necessary to ensure competence has not been established by objective criteria. The majority opinion of this committee and its consultants is that the trainee should participate in at least 50 exercise procedures during training. However, it is recognized that not all training or practice environments are the same and a greater or smaller number of procedures may be deemed appropriate by a local credentials committee. Since survey data (14,15) indicate that some programs do not currently provide adequate training to fulfill the requirements of these guidelines, internal medicine program directors will need to plan with individual trainees to obtain appropriate experience.

Physicians who did not receive formal training during a residency or fellowship but who are currently performing exercise testing should have gained appropriate experience under the supervision of a physician qualified in exercise testing. Such postgraduate training may have included didactic courses and workshops, personal tutorials and, importantly, exercise testing performed under the supervision of a qualified physician. For physicians who finish training before 1992 without the opportunity for such formal training

Table 4. Complications of Exercise Testing

- Hypotension
- Congestive heart failure
- Severe cardiac dysrhythmia
- Cardiac arrest
- Acute myocardial infarction
- Acute central nervous system events such as syncope, stroke
- Accidental physical trauma (falls, etc.)
- Death

Table 5. Cognitive Skills Needed to Perform Exercise Tests Competently

- Knowledge of appropriate indications for exercise testing
- Knowledge of appropriate contraindications and risks of testing
- Knowledge to promptly recognize and treat complications of exercise testing
- Competence in cardiopulmonary resuscitation and successful completion of an AHA-sponsored course in advanced cardiac life support
- Knowledge of specificity, sensitivity and diagnostic accuracy of exercise testing in different patient populations
- Knowledge of how to apply Bayes' theorem to interpret test results
- Knowledge of various exercise protocols (Bruce, Naughton, Balke-Ware, USAFSAM and others) and indications for each
- Knowledge of basic cardiovascular and exercise physiology including blood pressure and heart rate response to exercise
- Knowledge of electrocardiography and changes in the electrocardiogram that may result from exercise, hyperventilation, ischemia, hypertrophy, conduction disorders, electrolyte disturbances and drugs
- Knowledge of cardiac arrhythmias and treatment of serious arrhythmias
- Knowledge of cardiovascular drugs and how they can affect exercise performance, hemodynamics and the electrocardiogram
- Knowledge of conditions and circumstances that can cause false-positive, indeterminate or false-negative test results
- Knowledge of the effects of age and disease on hemodynamic and electrocardiographic responses to exercise
- Knowledge of principles and details of exercise testing including proper lead placement and skin preparation
- Knowledge of prognostic value of exercise testing
- Knowledge of alternative diagnostic procedures to exercise testing
- Knowledge of end point of exercise testing and indications to terminate exercise testing
- Knowledge of the concept of metabolic equivalent (MET) and estimation of exercise intensity in different modes of exercise
- Ability and commitment to communicate diagnostic accuracy, risks, and results of the test to the patient, the medical record, and other physicians so that appropriately informed patient consent can be obtained

Abbreviations as in Table 1.

but who have performed exercise testing on a regular and substantial basis for more than 3 years, experience may be individually considered in lieu of formal training. Training in any setting must result in the acquisition of the cognitive skills outlined in Table 5.

While acquiring the knowledge and skills of exercise testing as part of a formal training program or subsequently, the physician should be supervised by an effective teacher who is expert in the clinical use of the procedure and performs testing on a regular basis. The trainee's experience should be documented in writing and confirmed by the supervisor. The following information should be documented in a training log book for each test performed during training: Date of test, patient identification number, patient age, indications for test, duration and results of the test (both electrocardiographic and hemodynamic), reason for terminating the test, complications and signature of the supervisor.

The completion of a short course or workshop that offers a limited cognitive background in cardiology or inadequate hands-on experience with the procedure will not, by itself, result in competence.

Maintenance of Competence

Continuing competence in exercise testing requires regular, continued performance of exercise testing. Performance of only a rare test can lead to missed or inappropriate diagnoses and may lead to a higher rate of complications. Twenty-five tests per year are suggested as the minimum number the physician should perform to maintain competence. Successful completion of a course in advanced cardiac life support and renewal on a regular basis is necessary.

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