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

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The selective 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 the Accreditation of Healthcare Organizations requires that the granting of initial or continuing medical staff privileges be based on assessments of applicants against professional criteria that are specified in the medical staff bylaws. Physicians themselves are thus charged with identifying the criteria that constitute professional competence and with evaluating their peers on the basis of such criteria. Yet the process of evaluating a physician's knowledge and competence is often constrained by the evaluator's own knowledge base 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 recommendation is one in a series developed to assist in the assessment of physician competence on a procedure-specific basis. The minimal education, training, experience and cognitive skills necessary for proper interpretation of electrocardiography are specified; whenever possible, these are based on published data linking these factors with competence in certain procedures and, in the absence of such data, on consensus of expert opinion. They are applicable to any practice setting and can accomodate a variety of pathways that physicians might take to competence in the performance of specific procedures (see also Guide to the use of ACP statements on clinical competence. Ann Intern Med 1987;107:588–9).

Overview of the Procedure

Introduced in 1903 by Einthoven, electrocardiography is the most commonly used laboratory procedure for the diagnosis of heart disease. As a record of electrical activity of the heart, it is a unique technology that provides information not readily obtained by other methods.

The procedure is safe, there being essentially no risk to the patient; it is simple and reproducible; the record lends itself to serial studies; and the relative cost is minimal. The electrocardiogram (ECG) has the following utilities: It may serve as an independent marker of myocardial disease; it may reflect anatomic, electrophysiologic, metabolic and hemodynamic alterations; it provides information that is often essential for the proper diagnosis of and therapy for a variety of cardiac disorders; and it is without equal as a method for the diagnosis of arrhythmias. Electrocardiography is the procedure of first choice in patients presenting with chest pain, dizziness or syncope, symptoms that may be predictive of one or both of the two leading and potentially catastrophic cardiovascular disorders—sudden death or myocardial infarction. Electrocardiographic abnormalities also may be the first indicators of life-threatening side effects of drugs and of severe metabolic or electrolyte disturbance and occasionally the only sign of myocardial disease, such as "asymptomatic" myocardial infarction in the aged (1).

Appropriate and accurate use of the ECG requires that its sensitivity and specificity be understood and considered in the interpretation of the recording. This is somewhat more complex for the ECG than for many other laboratory tests because the ECG is composed of a number of waveforms each with its own sensitivity and specificity and each influenced differently by a variety of pathologic and pathophysiologic factors.

When considering the sensitivity and specificity of the ECG it is important to recognize that the ECG is a record of electrical activity. Consequently, diagnoses of structural (i.e., myocardial infarction, hypertrophy) or pathophysiologic (i.e., electrolyte disturbance, effect of drugs) changes are made by inference and are, therefore, subject to error. The data that allow for a diagnosis by inference were derived from extensive studies correlating the ECG with a variety of clinical pathologic and experimental states.

It is also important to recognize that the same ECG pattern may be recorded with different structural and pathophysiologic states. This explains the frequent low specificity for etiology and anatomy. For example, although ST segment and T wave changes are the most common and most sensitive ECG abnormalities, these changes are at the same time the least specific (2,3). Similarly, different etiologic factors and structural abnormalities may result in an identical form of bundle branch block.

It is obvious from the foregoing that the sensitivity and specificity of the ECG depends to a large extent on the clinical question asked. Although the sensitivity and specificity of the ECG for myocardial disorders vary considerably depending on the cause, size and location of the pathologic process, the sensitivity and specificity for arrhythmias are consistently high. The ECG is the only practical method for recording and analyzing abnormalities of cardiac rhythm and conduction.

Justification for Recommendations

The indications, contraindications and recommendations for the minimal education, training, experience and skills necessary to perform the procedure are derived principally from the 17th Bethesda Conference on adult cardiology training (4)* and the 10th Bethesda Conference on optimal electrocardiography (5), data extracted from published reports and the opinion of the ACP/ACC/AHA Task Force on Cardiology of the American College of Physicians' Clinical Privileges Project.

[*The 17th Bethesda Conference was recently updated and published as the first Core Cardiology Training Symposium, which includes Task Force 2: Electrocardiography, Ambulatory Electrocardiography and Exercise Testing (J Am Coll Cardiol 1994;25:1–34)].

Recommendations on maintenance of competence are based on the expert opinion of the ACP/ACC/AHA Task Force on Cardiology of the American College of Physicians' Clinical Privileges Project.

Indications, Contraindications and Complications

Although there may be a difference of opinion as to indications for an ECG study in a given clinical setting, largely because of lack of definitive data, some of the settings in which an ECG is indicated include the following:

1. For the diagnosis of overt or suspected cardiovascular disease. Follow-up recordings are indicated when there is a change in clinical status.

2. For assessing the results of therapy.

3. In subjects at risk of heart disease, usually >40 years old without evidence of cardiovascular disease but with two or more of the following risk factors: hypercholesterolemia, diabetes, obesity, smoking or positive family history. In this group, frequent follow-up recordings are usually not indicated unless signs or symptoms of heart disease appear.

4. In selected subjects with fewer risk factors whose occupations magnify the consequences of a heart attack or arrhythmia, for example, commercial airline pilots or bus drivers.

5. Before surgical intervention as an aid in the diagnosis and management of preoperative conditions or subsequent postoperative complications. However, it should be emphasized that definitive data regarding the utility of electrocardiography as a routine baseline preoperative procedure are not available (6).

6. For assessing cardiac effects of systemic diseases or conditions, such as renal failure, diabetic acidosis and hypothermia, electrolyte abnormalities and potential cardiotoxic effects of drugs.

Electrocardiography is not cost-effective as a screening procedure for cardiovascular disease or as a baseline study in asymptomatic healthy subjects without symptoms or signs of heart disease, hypertension or other risk factors for development of heart disease (7–10). A statement of the indications for electrocardiography was published by the American College of Cardiology and the American Heart Association (11) in March 1992.

Although there are no complications resulting from the technique itself, inappropriate interpretation; lack of appreciation of the importance of sensitivity, specificity and predictive value; and failure to correlate the ECG findings with the overall clinical picture may result in serious iatrogenic heart disease. For example, an abnormal T wave is often equated with "ischemia," when in fact the specificity of an abnormal T wave for any one cause (i.e., ischemia) is low (2,3). Furthermore, moderate T wave inversion predicts an annual mortality rate of 21% when associated with a history of heart disease compared with only 3% in the absence of heart disease (12). Thus, a T wave abnormality is of clinical value only when interpreted in light of the total clinical picture and other laboratory results.

Computer Interpretation of the ECG

Because of frequent and often significant errors of interpretation and lack of reproducibility of the interpretation, it is mandatory in the clinical setting that all computer-interpreted ECGs be verified and appropriately corrected by an experienced electrocardiographer.

Minimal Training Necessary for Competence

There are a number of different routes by which a physician can acquire the necessary interpretive skills to recognize the clinically important features of an ECG test (see Appendix). The cornerstone of training is interpretation of a large number of ECGs and review of the interpretations with an experienced faculty. In addition to rotations on an ECG service, training can be obtained in a wide variety of settings, which may include intensive care unit assignments, classroom work and didactic sessions. The ECG interpretations, clinical correlations and clinical integration essential for proper ECG training must be under the supervision of physicians qualified to teach electrocardiography.

There are no studies that define the minimal number of ECGs that must be read during the training program to attain competence; however, some survey data are available. The American College of Physicians (ACP) surveys of internal medicine residency program directors, general internists and cardiologists asked respondents to estimate the number of procedures needed to attain competence. The median number recommended by both program directors and general internists was 100; the median number recommended by cardiologists was 750 (13). The recommendation of the Seventeenth Bethesda Conference is that cardiology fellows read 3,500 ECGs (4). This Task Force recommends the interpretation and review of 800 procedures within a 3-year training period under the supervision of an experienced faculty. The ECGs should reflect a wide variety of clinical situations and ECG abnormalities (see Appendix).

Although many physicians acquire the cognitive skills needed for proper interpretation of the ECG during a fellowship or a residency program, completion of a fellowship or residency does not guarantee competence. Some training programs do not include structured teaching of electrocardiography. The requirement by the American Board of Internal Medicine Subspeciality Board on Cardiovascular Disease that the candidate successfully pass the ECG component of the examination before being certified implies that those who successfully pass the examination are competent in ECG interpretation.

On occasion, a physician may become competent in the interpretation of ECGs by attending well designed courses coupled with studies of unknown recordings available in standard texts and by interpreting large numbers of recordings under the supervision of a physician knowledgeable in electrocardiography. Simply attending courses that offer little opportunity for testing individual interpretation of the ECG will not result in competence.

It is evident that although formal teaching of electrocardiography as a part of a fellowship in cardiology or an internal medicine residency is the best approach to becoming competent in reading ECGs, competence can occasionally be attained by routes other than those followed during a residency or fellowship. For this reason, applicants for privileges to read ECGs may have to be evaluated on the basis of their actual cognitive knowledge rather than on the basis of the structure of the training. When the competence of a physician requesting privileges is not clear, monitoring the candidate's interpretations or administration of a test may be appropriate.

Maintenance of Competence

Although continuing competence of ECG interpretation requires regular reading, this alone may not ensure competence. Furthermore, there are no data that document a correlation between the frequency of unsupervised ECG interpretations and the desired skill. Therefore, as a part of quality assurance programs, a random sample of ECG interpretations by the physician requesting continuing privileges should be reviewed periodically by independent experts to confirm continued competence. The recordings in question should be reviewed by physicians experienced in ECG interpretation. If no one within the hospital is qualified to investigate a candidate's experience, then an outside qualified expert should be consulted.

The American College of Cardiology has developed and field-tested a self-assessment program in electrocardiography that is available through the College's office in Bethesda, Maryland.

Appendix

Electrocardiographic Items

- Technique
  - Proper electrode placement
  - Correct standardization
  - Proper frequency response
  - Proper paper speed
  - Effect of age, weight and body build
  - Muscle tremor and other artifacts
- Normal electrocardiogram (ECG)
- QRS axis, rotation, position
  - Left-axis deviation (<-30°)
  - Right-axis deviation (>+100°)
  - Electrical alternans
  - Clockwise, counterclockwise rotation
  - Vertical, horizontal, intermediate position
- Sinus node rhythm
  - Normal
  - Sinus arrhythmia
  - Sinus bradycardia
  - Sinus tachycardia
  - Sinus pause or arrest
  - Sinoatrial exit block
- Atrial rhythm
  - Atrial premature complexes
    - Blocked
  - Chaotic atrial rhythm
  - Atrial tachycardia
  - Atrial tachycardia with atrioventricular (AV) block
  - Atrial flutter
  - Atrial fibrillation
  - Any of the above with aberration
- Junctional rhythm
  - Junctional rhythm (passive)
  - AV junctional premature complex
  - AV junctional escape complex or rhythms
  - Junctional parasystole
  - AV nonparoxysmal junctional tachycardia
  - AV node reciprocating tachycardia (reentrant)
  - Junctional tachycardia with block
  - AV reciprocating tachycardia (Wolff-Parkinson-White syndrome)
  - Any of the above with aberration
- Supraventricular tachycardia (not otherwise identified)
- Wide QRS tachycardia
  - Supraventricular with aberration

  - Ventricular
- Ventricular rhythm
  - Ventricular premature complexes
    - Uniform, with fixed coupling, single or couplets
    - Multifocal, multiform
    - R or T wave phenomenon
    - Interpolated
  - Ventricular bigeminy
  - Ventricular parasystole
  - Ventricular tachycardia
    - Bidirectional
  - Accelerated idioventricular rhythm
  - Ventricular escape complex or rhythm
  - Ventricular flutter
  - Ventricular fibrillation
  - Torsade de pointes
  - Reciprocal (echo) complexes
  - Fusion complexes
  - Capture complexes
- AV conduction
  - AV block
    - First degree
    - Second degree
    - Type I (Wenckebach)
    - Type II (Mobitz)
    - High degree
    - Complete
    - Paroxysmal
  - Ventriculoatrial conduction
  - AV dissociation
- Hypertrophy, enlargement
  - Right atrial enlargement
  - Left atrial enlargement
  - Biatrial enlargement
  - Left ventricular hypertrophy
    - Voltage only
    - Voltage and ST-T wave changes
  - Right ventricular hypertrophy
  - Combined ventricular hypertrophy (biventricular)
- Intraventricular conduction disturbances
  - Right bundle branch block
    - Incomplete
    - Complete
    - Rate related
  - Left anterior fascicular block
  - Left posterior fascicular block
  - Left bundle branch block
    - Incomplete
    - Complete
    - Rate related
  - Nonspecific interventricular block
  - Peri-infarction block
  - Pre-excitation (Wolff-Parkinson-White syndrome)
- Myocardial infarction

- Septal
- Anteroseptal
- Anterior
- Lateral
- High lateral
- Extensive anterior
- Inferior
- Posterior
- Right ventricular
- Non-Q wave infarction
- Acute injury and/or infarction
- Old
- Age undetermined
- Probable ventricular aneurysm
- Atrial infarction

ST, T, QT, U wave changes
- Normal variant
  - Early repolarization
  - Juvenile T waves
- Nonspecific ST and/or T wave changes
- ST and/or T wave changes
  - Suggestive of myocardial ischemia
  - Suggestive of acute pericarditis
  - Suggestive of an acute process
- Prolonged QT interval
- Short QT wave
- Prominent U waves
- Negative U waves

Pacemaker
- Normal function
- Abnormal function

ECG patterns suggestive of clinical diagnosis
- Hypertrophic cardiomyopathy
- Dextrocardia
- Long QT syndrome
- Mitral stenosis
- Cerebrovascular accident
- Chronic lung disease
- Pericarditis, acute
- Pericardial tamponade
- Pulmonary embolus
- Hyperthermia
- Hypothermia
- Hypercalcemia
- Hypocalcemia
- Hyperkalemia
- Hypokalemia
- Antiarrhythmic drugs
- Digitalis effect

Clinical Competence in Electrocardiography has been 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. This statement is being published simultaneously in Journal of the American College of Cardiology and Circulation.

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