ACP/ACC/AHA TASK FORCE STATEMENT

Clinical Competence in Ambulatory 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 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 and technical skills necessary for competent ambulatory electrocardiographic interpretation 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 accommodate a variety of pathways physicians might take to competence in the performance of specific procedures (see also “Guide for the Use of American College of Physicians Statements on Clinical Competence,” *Ann Intern Med* 1987;107:588–9).

Overview of the Procedure

Ambulatory electrocardiography is used in clinical practice to detect, document and characterize occurrences of abnormal cardiac electrical behavior of the heart during ordinary daily activities. Because such abnormalities may occur only rarely or only during sleep or with mental, emotional or exercise-induced changes in cardiac oxygenation or function, or both, the electrocardiogram (ECG) may need to be recorded over long periods of time.

Ambulatory electrocardiography is a subdivision of clinical electrocardiography and for this reason the criteria for competence are frequently the same as those for classic electrocardiography. There are,

however, technical and cognitive aspects peculiar to ambulatory electrocardiography that require additional knowledge. Some of these are referred to in the overview discussion that follows.

Since the introduction in 1961 of ambulatory electrocardiography, systems have been developed with a broad range of recording fidelity, equipment size and weight, analysis capabilities and reporting formats (1–4). Because of the many differences in recording, analysis and reporting systems, this document can only address ambulatory electrocardiography in the generic sense, that is, by general description of system types rather than the specific characteristics of any particular system.

There are three basic types of recorders: continuous recorders, intermittent (event) recorders and real-time analytic recorders. The last type examines the ECG in a continuous manner and analyzes each beat as it occurs (3). Continuous recorders have two or more amplifiers and an analog tape recorder for capturing the ECG continuously. The amplifiers are similar to those used in the conventional electrocardiograph although the frequency response may vary from the standard 12-lead ECG recorder and among various ambulatory ECG systems. In real-time systems, the incoming ECG signals, rather than being stored on analog tape, are digitized, encoded and stored in solid state memory (2). Such systems provide for on-line analysis.

Intermittent recorders record only a limited number of short segments of data; their purpose is to capture abnormal electrical behavior when the patient has the symptoms for which the study was undertaken. The recorder is patient activated in most cases, although some recorders may also be set to record at specific time intervals. The intermittent recordings may be transmitted by telephone to a strip-chart recorder at the time of occurrence of the event or, if this feature is provided for in the recorder, the data may be stored and transmitted at a later time. Virtually all current continuous tape systems utilize rapid playback and computer-assisted analysis, whose goals are to recognize and characterize episodes of arrhythmias, primarily ventricular and atrial premature complexes, couplets, bigeminy, supraventricular and ventricular tachycardias, periods of bradycardia and transient ST-T wave changes.

Some systems provide for “full disclosure” of all complexes detected during the recording period. These are plotted on compressed time and voltage scales and permit visual scanning of the entire record by the physician.

Ambulatory electrocardiography has the potential for producing a substantial amount of invalid data because of technical problems inherent in the recording and analytic processes. Many of the potential sources of error in the computer analysis systems are quite complex, and expertise in the *technical* aspects of ambulatory electrocardiography requires an understanding of computer algorithms for the detection of QRS complexes and their classification as well as the problems associated with editing the computer analysis. It is not reasonable to expect that clinicians who have not been involved in computer applications in electrocardiography should have the knowledge base to assess all potential technical failings. For this reason, systems with full disclosure capabilities are preferred by many clinicians because they can “read” the tracing much as they do a 12-lead ECG. Although the details of the QRS pattern may be obscured in these miniaturized records, basic rhythms can be detected, verified and correlated with the patient's symptoms. Although this method of final review by the physician provides only a *qualitative* interpretation, it does assure that significant arrhythmias have not been missed by the computer because of errors of QRS recognition or classification, or both, that went unrecognized during the editing process. *Quantitation* of abnormal rhythms requires computer analysis in most cases of tapes with a high proportion of arrhythmias; however, errors may be introduced during the data collection and processing steps that invalidate the quantitative statements (5–7).

Because of the variabilities in equipment types and the positive and negative attributes of each, physicians cannot be expected to be familiar with all systems in detail; however, the physician credentialed to interpret the ambulatory ECG must be familiar with the systems used in his or her own laboratory.

Computer interpretation of the ambulatory ECG, even when restricted to arrhythmia and ST segment shift recognition, is in certain respects more demanding than that for analysis of the 12-lead ECG. The latter is recorded while the patient is resting quietly, artifacts can be recognized and controlled, the analysis can be done in real time, changing QRS configuration due to patient movement is not a problem and the patient's metabolic and hemodynamic state is stable during the short period of time required for the recording. The ambulatory state is not so stable in most cases. Noise interference from numerous sources that may occur over a 24-h recording period is the major problem that results in computer inaccuracies in both arrhythmia and ST segment shift recognition and analysis. Most systems incorporate some form of signal processing in one or more components to adjust for recording artifacts and, because this most often involves the filtering out of low frequency events, ST segment shifts may be artifactually altered (8–10). In addition, the criteria for the diagnosis of ischemic ST segments in the ambulatory ECG are in evolution.

Physicians are rarely involved in the data collection and processing phases of the ambulatory ECG. In fact, many physicians and hospitals use commercial reading services. However, regardless of the processing method, the physician who interprets the recording's content and signs the report bears the responsibility for the validity of the report. It is therefore necessary that he or she be aware of the potential for false positive or false negative findings in arrhythmia detection and classification (Table 1) and in the diagnosis of myocardial ischemia (Table 2) This physician will usually be one who is providing interpretations of ambulatory ECGs for other physicians, that is, one who directs the ambulatory ECG service for the hospital. The physician who *orders* the ambulatory ECG is responsible for ensuring that the study has been ordered for the proper indications and that the findings are placed in proper perspective for decision making for the individual patient. If the hospital utilizes a commercial service to process 24-h ambulatory ECGs, there will be no credentialing requirement unless the service only processes the recording, leaving the interpretation to a designated physician in the hospital. In such a case a full disclosure printout should be provided by the commercial service.

Justification for Recommendations

The indications, contraindications and recommendations for the minimal education, training, experience and skills necessary to interpret the ambulatory ECG are derived primarily from “Guidelines for Ambulatory Electrocardiography: A Report of the American College of Cardiology/American Heart Association Task Force on Assessment of Cardiovascular Procedures” (2), the American College of Cardiology's 17th Bethesda Conference on Adult Cardiology Training (11), the opinion of cardiovascular consultants and the expert opinion of the ACP/ACC/AHA Task Force on Cardiology of the American College of Physicians' Clinical Privileges Project.

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

Indications, Contraindications and Complications

General indications for ambulatory electrocardiography are discussed in References 2 and 12. These statements outline the range of indications for the procedure and may be modified by clinical judgment in individual patients and by advances in medical practice.

With prolonged monitoring, nearly all patients manifest arrhythmias on the ambulatory ECG. These increase with patient age, severity of cardiovascular disease and the duration of the recording period (13–24). It is important, therefore, when reporting the significance of the findings, to appreciate the wide range of normal to avoid unnecessary anxiety on the part of the patient or the physician who requested the

study. Conversely, arrhythmias that have prognostic importance for future cardiac events need to be recognized and reported promptly to the patient's physician if that physician is other than the one who is interpreting the recording. As with arrhythmias, it is important to appreciate that the predictive accuracy of ST segment changes of “ischemic type,” in the absence of concomitant angina, even if all possible sources of false positive ST responses are absent, may vary with the patients being studied and in accordance with the clinical setting (25,26).

There is general consensus that the greatest utility of ambulatory electrocardiography is in the area of arrhythmia assessment and, in particular, correlation of an arrhythmia with symptoms (2). Indeed, there is no feasible alternative for that application. The electrocardiographer in charge of ambulatory ECG interpretation for a hospital must have a knowledge base that varies somewhat from that of physicians who restrict themselves to the interpretation of 12-lead ECGs. The knowledge base differences are not in arrhythmia recognition, as such, but in the recognition of artifacts, the interpretation of the significance of the frequency of arrhythmia occurrence and the contribution of associated cardiac conditions.

Complications resulting from the test are primarily those of skin irritation, particularly when application of the electrodes is prolonged, as with event recorders.

Although there are few complications from ambulatory electrocardiography, inappropriate interpretation and failure to correlate the findings with the clinical assessment may result in severe iatrogenic heart disease. For example, the interpretation of type I second-degree heart block as abnormal might result in pacemaker implantation when, in the majority of cases, this is a normal finding during sleep and in young, athletic persons with high vagal tone. The appropriate use of the information derived from the ambulatory ECG is, as with the 12-lead ECG, a joint responsibility of the physician who interprets the tracing and the physician who uses the results of the test to guide patient management.

Minimal Training Necessary for Competence

Prerequisite to minimal competence in ambulatory electrocardiography is competence in interpreting the standard 12-lead ECG. These recommendations do not address the special problems involved in monitoring the function of cardiac pacemakers and are not to be used to assess competence in that procedure. In addition, training should result in acquisition of the cognitive skills outlined in Table 3 There may be several pathways to achievement of these skills; the essential factors are interpretation of a sufficient number of recordings to have encountered most of the situations that might confound the interpretation and review of these interpretations with experienced faculty. Many physicians acquire the knowledge required for ambulatory ECG interpretation in a training program during a residency or fellowship or after entering practice. The Task Force recommends that supervised interpretation of a minimum of 75 ambulatory ECGs be considered necessary for minimal competence. At the discretion of the program director, one half of this experience may be gained from a teaching set of ambulatory ECGs. This teaching set should include a wide range of typical and atypical records that exemplify common and some uncommon problems likely to be encountered. The experience in interpretation of ambulatory ECGs should be documented by entries in a permanent logbook certified by the program director.

A physician may become competent in interpretation of the ambulatory ECG by attending well designed courses coupled with studies of teaching sets comprising representative recordings and subsequent interpretation of these tracings with an expert in ambulatory electrocardiography. These courses should meet all the requirements for attainment of minimal competence as noted above.

In light of variations in training options, applicants for clinical privileges should be evaluated on the basis of the actual skills they possess rather than on the basis of the type of training program completed. The cognitive and technical skills of candidates should be attested to by a supervisor in all cases. When

the competence of a physician requesting privileges is not clear, assessment of the candidate's performance in interpreting ambulatory ECGs, by an outside expert if necessary, may be appropriate.

Maintenance of Competence

Maintaining competence in ambulatory electrocardiography requires continued involvement. Performance of only an occasional interpretation may result in missed or inappropriate arrhythmia diagnoses, particularly when recording or analysis systems or technical personnel are changed in the laboratory for which the physician is responsible. The Task Force recommends a minimum of 20 interpretations a year to maintain competence. One half of this experience may be gained from a teaching set of ambulatory ECGs.

Currently there are no formal data to document a correlation between the frequency of performing the procedure and practitioner competence. Continuing competence as a part of quality assurance programs may be assessed by a random sample of ambulatory ECG interpretations performed by the physician requesting continuing privileges. The samples should be examined by a physician experienced with the procedure or one who is currently training physicians in interpretation of the ambulatory ECG. If no one within the hospital is qualified to review a candidate's experience and cognitive skills, a qualified outside expert should be consulted.

References

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Table 1. Some Causes for False Positive or False Negative Findings in Arrhythmia Detection and Classification

1. Inadequate computer QRS detection and classification algorithms
2. Low voltage recording
3. Physiologic variations in QRS form and voltage
4. Noise interference
5. Incorrect technician interpretation or lack of attention to detail in the editing phase
6. Tape drive malfunction
7. Incomplete degaussing of previously used tapes
8. Marked sinus arrhythmia causing sudden rate changes
9. Atrial fibrillation
10. Ventricular pre-excitation
11. Rate-dependent intraventricular block

Table 2. Some Causes for False Positive or False Negative Findings in Detection and Interpretation of Myocardial Ischemia From the Ambulatory Electrocardiogram

1. Positional effects on ST segment
2. Lack of calibration
3. Hyperventilation
4. Tachycardias
5. Electrolyte changes
6. Drugs
7. Left ventricular hypertrophy
8. Sudden excessive exercise
9. Vasoregulatory changes
10. Intraventricular conduction disorders
11. Inadequate lead system
12. Incorrect criteria for ischemia
13. Inadequate recording fidelity
14. Signal processing including the effects of filtering and noise rejection algorithms on low frequency electrocardiographic components

Table 3. Some Cognitive Skills Needed to Interpret Ambulatory Electrocardiograms Competently

1. Knowledge of cardiac arrhythmias, their diagnosis and significance in normal subjects and in patients with heart disease
2. Knowledge of pacemaker types and their sensing and pacing characteristics
3. Appreciation of the wide range of variability in arrhythmia occurrence in the ambulatory patient and the influence of the autonomic nervous system on the rhythm of the heart
4. Knowledge of electrocardiography and changes in the electrocardiogram (ECG) that may result from exercise, heart rate, hyperventilation, conduction disorders, electrolyte shifts, drugs, meals, temperature, left ventricular hypertrophy, ischemia, noncardiovascular events and other causes for repolarization changes
5. Knowledge of the most widely accepted criteria for ischemic ST segment interpretation
6. Knowledge of cardiac drugs and how they may affect the ECG, in particular conduction and repolarization
7. A basic understanding of the instrumentation involved in continuous and intermittent ambulatory electrocardiography from recorder through the analytic steps and the possible causes for false positive or false negative test results that are due to inherent instrumentation design and signal processing
8. Knowledge of the particular characteristics of the equipment used to process the recordings for which the electrocardiographer is responsible
9. Appreciation of the skills required by the technologist involved in editing the computer output and the need to be assured of the competence of the technologist
10. Knowledge of the advantages and disadvantages of generic ambulatory ECG systems and the system most appropriate for the clinical question that is being asked
11. Knowledge of the sensitivity and specificity and diagnostic accuracy of ambulatory electrocardiography in various age groups and in different patient groups, particularly with respect to ST segment evaluation and the application of Bayes' theorem
12. Knowledge of the appropriate indications for ambulatory electrocardiography