Electrocardiography

Background

An electrocardiogram, commonly abbreviated as EKG or ECG, is a noninvasive procedure that records electrical changes in the heart. According to the American Heart Association (AHA), an ECG sends an electrical impulse (or wave) that travels through the heart. The wave causes the heart muscle to squeeze and pump blood. An electrocardiograph then records the information as line tracings on paper. Standard ECGs are commonly referred to as 12-lead ECGs.

A normal heartbeat on an ECG will show the timing of the top and lower chambers of the heart. The right and left atria make up the first wave, called a P wave, which is followed by a flat line when the electrical impulse reaches the bottom chambers. The right and left bottom chambers, or ventricles, make up the next wave, which is called a QRS complex. The final wave, or T wave, shows the electrical recovery, or return to a resting state, for the ventricles.

Physicians use ECGs to determine the duration of an electrical wave traveling to and from different areas of the heart. This helps determine whether the electrical activity is normal, slow, fast, or irregular. The procedure is also used to measure the amount of electrical activity passing through the heart, which helps determine whether parts of the heart are too large or overworked. ECGs are often used in conducting physical examinations, monitoring a patient’s condition during and after surgery, and in the ICU. An ECG can help determine causes of symptoms such as chest pain, shortness of breath, and palpitations, and is typically used by physicians as a starting point for diagnosing cardiac problems.

An ambulatory ECG (AECG) requires a patient to wear a small recorder, called a Holter monitor, as he or she goes about everyday activities, according to the AHA. The machine produces a graphic record of the heart’s electrical currents. There are two types of recorders. The more common of the two are continuous recorders, which are used for 24–48 continuous hours. Intermittent recorders are used for weeks, or even months, to provide brief, intermittent recordings.
In its updated 2007 policy paper, *Electrocardiograms, Family Physician Interpretation of*, the AAFP states that competency and interpretation of ECGs is an essential skill for family physicians.

According to the academy, clinical privileges should be based on the individual physician’s documented training and/or experience, demonstrated abilities, and current competence.

The academy states that electrocardiography should be used on patients who present with chest pain, dizziness, or syncope (i.e., fainting), or those with symptoms that may indicate risk of sudden death or myocardial infarction. According to the academy, an ECG may be necessary for:

- The diagnosis of overt or suspected cardiovascular disease
- The assessment of therapy results
- Subjects at risk of heart disease, usually those over age 40 without evidence of cardiovascular disease but with two or more of the following risk factors: hypercholesterolemia, diabetes, obesity, smoking, hypertension, or family history of heart disease
- Patients who are at lower risk but whose occupations magnify the consequences of a heart attack or arrhythmia
- The diagnosis and management of surgical preoperative conditions or subsequent postoperative complications
- The assessment of cardiac effects of systemic diseases or conditions such as renal failure, diabetic acidosis and hypothermia, electrolyte abnormalities, and potential cardiotoxic effects of drugs
The AAFP states that electrocardiography is not indicated for screening of healthy subjects without symptoms of heart disease, hypertension, or other risk factors associated with heart disease. According to the academy, training for ECG interpretation begins in medical school and continues in the family medicine residency program curriculum. The Accreditation Council for Graduate Medical Education (ACGME) requires that training include a separate, defined critical care experience and a structured clinical experience in cardiology that includes the interpretation of ECGs.

The depth of experience for each resident depends on the expected practice needs of the resident, especially in terms of practice location, available facilities, and accessibility of consultants. At times, the family medicine resident may find it appropriate to seek consultation from a cardiologist to manage or comanage a patient.

The AAFP’s *Policy on Training for Clinical Procedures* states that training in individual procedures includes clinical indications, diagnostic problem solving and mechanical skills acquired under direct supervision, prevention, and management of complications. Testing and demonstrated proficiency in ECG interpretation may be done by monitoring a physician’s interpretations or by administration of a test. The academy believes that local tests to ensure competence are appropriate as long as they apply equally to all physicians.

The academy states that the process for credentialing varies among organizations. Before applying for ECG privileges, the academy recommends that the documentation of training, experience, and current competence should be in order. The academy has the following guidelines in place to help with the credentialing process:

- Collect letters of recommendation from instructors and preceptors who have monitored the applicant’s clinical performance and from colleagues who have worked with the applicant
- Assemble case reports that include the number and types of cases and treatment outcomes
- Assemble documentation records maintained during family practice residency

Complete documentation, case reports, and letters of recommendation should be in order at the time of application for medical staff privileges. It is important that a copy of each document be
submitted in the event that the original documents are lost or misplaced. Ongoing documentation of clinical experiences should be maintained.

According to the academy, privileges for family physicians often overlap those in other clinical departments, resulting in confusion regarding which department is responsible for recommending privileges. The academy states that the chair of the department of family medicine determines the criteria for recommending privileges in the family medicine department and is responsible for reviewing the cardiology privileges of the members of the department.

In 2001, the American College of Physicians (ACP), American College of Cardiology (ACC), and AHA formed a task force that subsequently produced the Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography. The mission statement of the task force is to “assist in the assessment of physicians’ competence on a procedure-specific basis.” The assessment includes the minimum education, training, experiences, and cognitive and technical skills necessary for the competent reading and interpretation of ECGs and AECGs.

The task force states that ECGs have numerous clinical uses, such as reflecting changes associated with primary or secondary myocardial processes. ECGs also serve as the standard for noninvasive diagnosis of arrhythmias and conduction disturbances, and it occasionally is the only marker for the presence of heart disease.

The main categories of electrocardiographic diagnoses are:

- Normal tracing
- ECG technical problems
- Sinus node rhythms and arrhythmias
- Other supraventricular rhythms
- Ventricular arrhythmias
- Atrialventricular conduction
- Intraventricular conduction
- QRS axis and voltage
- Chamber hypertrophy or enlargement
- Repolarization abnormalities
- Myocardial infarction
- Clinical disorders
- Pacemaker-related issues

Positions of other interested parties
ACP, ACC, and AHA

In 2001, the American College of Physicians (ACP), American College of Cardiology (ACC), and AHA formed a task force that subsequently produced the Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography. The mission statement of the task force is to “assist in the assessment of physicians’ competence on a procedure-specific basis.” The assessment includes the minimum education, training, experiences, and cognitive and technical skills necessary for the competent reading and interpretation of ECGs and AECGs.

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Additional clinical disorder diagnoses by electrocardiography include:

- Diseases of the central nervous system
- Dextrocardia
- Digitalis toxicity
- End-stage renal disease
- Endocardial cushion defect
- Hypertrophic cardiomyopathy
- Hypothermia
- Hypothyroidism
- Long QT syndrome
- Mitral stenosis
- Orthotopic heart transplant
- Parkinsonian tremor
- Pericardial effusion
- Primary pulmonary hypertension or pulmonary stenosis
- Pulmonary embolism
- Secundum atrial septal defect
- Sick sinus syndrome
- Torsades de pointes
- Tricyclic antidepressant (overdose)
- Wolff-Parkinson-White syndrome
- Right ventricular displasia
- Brugada syndrome

The statement reads that ECGs are interpreted by physicians in many specialties, including cardiology, internal medicine, family practice, and emergency medicine. A physician in any specialty whose interpretations of ECGs contribute to clinical decision-making should have adequate knowledge to make accurate diagnoses.

The task force defines adequate knowledge as the ability to define, recognize, and understand the basic pathophysiology of certain electrocardiographic abnormalities. A competent ECG reader should also be able to recognize potential clinical diagnoses based on ECGs. Although clinical syndromes do not always produce a diagnostic ECG pattern, ECG interpreters should recognize the characteristic patterns.

ECG readers should also understand the importance of comparing a current tracing to previous tracings in order to make correct diagnoses.

All abnormal tracings should be compared with available previ-
ous tracings. The accuracy of some diagnoses may be considerably enhanced by reviewing previous tracings.

The task force states that training in electrocardiography varies greatly among medical specialties and that the ECG knowledge required for board certification also varies. ECG interpretation requires a basic knowledge of ECG technology and cardiac anatomy and physiology, as well as the ability to recognize diagnostic patterns.

Training in ECG technology includes:
- Basic electricity
- Lead placement: skin preparation and lead location
- Signal filtration and its effect on waveforms
- Technical artifacts
- Basics of computer diagnosis algorithms
- Safety

Training in cardiac anatomy and physiology includes:
- Basic electrocardiographic theory
- Ionic currents generating the action potential
- Action potential relationship to ECG waveforms
- Potential gradients related to ECG waveforms
- Anatomy of the cardiac chambers
- Activation and repolarization characteristics of cardiac tissues

Because pattern recognition is such an essential component of ECG interpretation, the committee estimates that most physicians can obtain competence only after reading at least 500 tracings under the supervision of an expert electrocardiographer. Because the completion of a residency or fellowship doesn’t guarantee adequate training in electrocardiography, the committee recommends documentation of the number of ECGs interpreted under supervision.

According to the task force, training in the use of ECGs, including supervised reading, is a requirement of a cardiology fellowship program. Board certification in cardiology requires passing a separate portion of the board certification examination in cardiology for ECG interpretation. Therefore, physicians who are certified in cardiology have demonstrated their competence in a standard examination.

Some physicians who are not board-certified in cardiology are experienced electrocardiographers and are appropriately credentialed to
read ECGs. Documentation of interpreting 500 ECGs during or after training under the supervision of an expert electrocardiographer may be an alternative way to demonstrate competence.

The task force states that maintaining competence requires ongoing practice. The task force recommends a minimum of 100 interpretations per year to maintain competence. It also suggests that periodic self-assessment and retraining in electrocardiography is necessary. Retraining may include ACC electrocardiography self-assessment programs, electrocardiography workshops, sessions provided by other national and international organizations, and other seminars and case conferences approved for continuing medical education credit. Clinicians credentialed to interpret ECGs should routinely participate in quality improvement activities, such as ECG readings with colleagues and periodic discussions of systemic issues involving ECG acquisition and interpretation.

Because certain abnormalities may occur only during sleep or with mental, emotional, or exercise-induced changes in cardiac oxygenation or function, an ECG may need to be recorded over long periods of time. As a result, according to the task force, ambulatory electrocardiography is used in clinical practices to detect, document, and characterize occurrences of abnormal electrical behavior of the heart during ordinary daily activities.

AECGs are frequently performed and interpreted in physicians’ offices. Current continuous AECG equipment can provide analysis of the multiple parameters of cardiac electrical activity, including arrhythmia assessment, analysis of ST-segment shifts, and assessment of heart rate variability.

Ambulatory electrocardiography is a subdivision of clinical electrocardiography. Criteria for competence are very similar. However, the task force states that interpretation of AECGs requires additional knowledge of the following:

- The appropriate indications for ambulatory electrocardiography
- The wide variability in arrhythmia occurrence in the ambulatory patient during a diurnal cycle and the influence of the autonomic nervous system on the rhythm of the heart
- Changes in the ECG that may result from exercise, hyperventilation, conduction disorders, electrolyte shifts, drugs, meals, temperature, Valsalva maneuvers, ischemia, and
transient repolarization phenomena related to a variety of cardiac diseases

- Cardiac drugs and how they may affect conduction and repolarization on the ECG
- Cardiac arrhythmias
- The sensitivity, specificity, and accuracy of ambulatory electrocardiography in various age groups and populations
- The most widely accepted criteria for ischemic ST-segment changes
- Ambulatory electrocardiographic evidence of failure to capture, sense, or pace for cardiac pacemakers and implantable cardiac defibrillators (ICD)
- Ambulatory electrocardiographic evidence of appropriate and inappropriate antitachycardia pacing or defibrillation in the ICD patient
- The advantages and disadvantages of the instrumentation used in continuous and intermittent ambulatory electrocardiography from recordings, and the possible causes for false-positive or false-negative test results that are due to inherent instrumentation or signal processing limitations
- The particular characteristics of the AECG instrumentation used to process the recordings for which the electrocardiographer is responsible
- The skills to interact with the AECG instrumentation in editing the computer output

Interpreting the standard ECG is a prerequisite to displaying minimum competence in ambulatory electrocardiography, according to the task force. Many physicians acquire the knowledge required for AECG interpretation in a training program during a residency or fellowship, and supervised interpretation of 150 AECGs is the norm. Therefore, the task force recommends that supervised interpretation of a minimum of 150 AECGs is mandatory for minimum competence. At the discretion of the program director, this experience may be gained, in part, from a teaching set of AECGs. Training should include typical and atypical AECG records that exemplify common and uncommon problems. The experience in AECG interpretation under the guidance of an authoritative faculty reviewer should be documented in the institution’s training program logbook.

A physician may become competent in interpreting AECGs by attending well-designed courses conducted by an expert in ambulatory electrocardiography, along with studies of teaching sets comprising representative recordings and subsequent inter-
Electrocardiography

pretation of these recordings, the task force states. Maintaining competence in ambulatory electrocardiography requires a continual updating of technological knowledge and an ongoing accrual of experience in the interpretation of AECGs. The task force recommends a minimum of 25 interpretations per year to maintain competence.

AOA

In its Specific Requirements for Osteopathic Subspecialty Training in Cardiology, part of its Basic Standards for Fellowship Training in Internal Medicine Subspecialties, the American Osteopathic Association (AOA) states that rotational requirements include a minimum of four months in ECG studies.

In regards to knowledge of noninvasive testing, which includes exercise stress testing, electrocardiography, and nuclear cardiology, the association states that the trainee must spend at least two months in an exercise testing facility. As an alternative, this may be incorporated into other rotations, such as heart station or noninvasive rotations. This is to expose the trainee to all types of exercise testing. By completion of the fellowship, the trainee must be capable of performing and interpreting the electrocardiographic portion of the treadmill and pharmacological testing.

The trainee must also be competent in the test protocols and the appropriateness of ordering tests. A minimum interpretation of 150 exercise tests should be performed. Interpretation of standard 12-lead ECGs should be incorporated in the entire 36-month training period. In order for the trainee to become proficient in interpretation and gain exposure to a wide variety of ECG abnormalities, it is recommended that a minimum of 3,500 studies be reviewed.

CRC draft criteria

The following draft criteria are intended to serve solely as a starting point for the development of an institution’s policy regarding this practice area.

Basic education: MD or DO

Minimum formal training: Successful completion of an ACGME- or AOA-accredited postgraduate training program in internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine, or demonstration of ECG interpretation skills by successful completion of ECG exams.
**References**

Required previous experience: Demonstrated current competence and evidence of accurate interpretation of at least 500 ECGs during the previous 36 months (an average of 167 per year).

A letter of reference should come from the director of the applicant’s training program in internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine. Alternatively, a letter of reference may come from the head of internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine at the facility where the applicant most recently practiced.

**Reappointment**

Reappointment should be based on unbiased, objective results of care according to the organization’s quality assurance mechanisms.

The successful applicant should be able to demonstrate current competence and evidence of accurate interpretation of at least 200 ECGs in the previous 24 months based on results of ongoing professional practice evaluation and outcomes.

In addition, continuing education related to ECG examinations should be required.

**For more information**

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Privilege request form
Electrocardiography

To be eligible to request clinical privileges to perform electrocardiography (including interpretation), an applicant must meet the following minimum threshold criteria:

➤ Basic education: MD or DO

➤ Minimum formal training: Successful completion of an ACGME- or AOA-accredited postgraduate training program in internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine, or demonstration of ECG interpretation skills by successful completion of ECG exams.

➤ Required previous experience: Demonstrated current competence and evidence of accurate interpretation of at least 500 ECGs during the previous 36 months (an average of 167 per year).

➤ References: A letter of reference should come from the director of the applicant’s training program in internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine. Alternatively, a letter of reference may come from the head of internal medicine, cardiology, family medicine, anesthesiology, electrophysiology, surgery, or emergency medicine at the facility where the applicant most recently practiced.

➤ Reappointment: Reappointment should be based on unbiased, objective results of care according to the organization’s quality assurance mechanisms.

The successful applicant should be able to demonstrate current competence and evidence of accurate interpretation of at least 200 ECGs in the previous 24 months based on results of ongoing professional practice evaluation and outcomes.

In addition, continuing education related to ECG examinations should be required.

I understand that by making this request, I am bound by the applicable bylaws or policies of the hospital and hereby stipulate that I meet the minimum threshold criteria for this request.

Practitioner’s signature: ____________________________________________________

Typed or printed name: __________________________________________________________________

Date: ___________________________________________________________________