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ACC/AHA Guidelines for Ambulatory Electrocardiography: Executive Summary and Recommendations : A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the Guidelines for Ambulatory Electrocardiography) *Developed in Collaboration With the North American Society for Pacing and Electrophysiology*

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I. Introduction

Improvements in solid-state digital technology have enhanced transtelephonic transmission of electrocardiography (ECG) data and increased the accuracy of software-based analysis systems. These advances, in addition to better signal quality and greater computer arrhythmia interpretation capabilities, have opened new potential uses for ambulatory electrocardiography (AECG).

Traditional uses of AECG for arrhythmia detection have expanded as the result of increased use of multichannel and telemetered signals. The clinical application of arrhythmia monitoring to assess drug and device efficacy has been further defined by new studies. The analysis of transient ST-segment deviation remains controversial, but considerably more data are now available, especially about the prognostic value of detecting asymptomatic ischemia. Heart rate variability (HRV) analysis has shown promise for predicting mortality rates in cardiac patients at high risk. Despite these advances, a true automated analysis system has not been perfected and technician/physician participation is still essential.

II. AECG Equipment

The widespread availability and low cost of personal computers and workstations has allowed for the development of extremely sophisticated and automated signal processing algorithms. Current AECG equipment provides for the detection and analysis of arrhythmias and ST-segment deviation as well as more sophisticated analyses of R-R intervals, QRS-T morphology including late potentials, Q-T dispersion, and T-wave alternans.

There are 2 categories of AECG recorders: continuous recorders, typically used for 24 to 48 hours to investigate symptoms and ECG events that are likely to occur within that time frame, and intermittent recorders, which may be used for long periods of time (weeks to months) to provide briefer, intermittent recordings for investigating events that occur infrequently.

A. Continuous Recorders

Rapidly evolving technologies now allow for direct recording of the ECG signal in a digital format using solid-state recording devices. The direct digital recording avoids all of the biases introduced by the mechanical features of tape recording

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devices and the problems associated with recording data in an analog format, which requires analog-to-digital conversion before analysis. ECG signals can be recorded at up to 1000 samples per second, which allows for extremely accurate reproduction of the ECG signal necessary to perform signal averaging and other sophisticated ECG analyses. These solid-state recordings can be analyzed immediately and rapidly, and some recorders are now equipped with microprocessors that can provide “on-line analysis” of the QRS-T complex as it is acquired. Limitations of this technology include its expense, the limited storage capacity of digital data, and, in the case of on-line analysis, reliance on a computer algorithm to identify abnormalities accurately.

B. Variability of Arrhythmias and Ischemia and Optimal Duration of Recording

The day-to-day variability in the frequency of arrhythmias is substantial. Most arrhythmia studies use a 24-hour recording period, although the yield may be increased slightly with longer recordings or repeated recordings. Major reductions in arrhythmia frequency are necessary to prove treatment effect. To ensure that a change is due to the treatment effect and not to spontaneous variability, a 65% to 95% reduction in arrhythmia frequency after an intervention is necessary.

The variability of the frequency, duration, and depth of ischemic ST-segment depression is also marked. Because most ischemic episodes during routine daily activities are related to increases in heart rate, the variability of ischemia between recording sessions may be due to day-to-day variability of physical or emotional activities. It is therefore essential to encourage similar daily activities at the time of AECG recording. The optimal and most feasible duration of recording to detect and quantify ischemia episodes is probably 48 hours.

C. Intermittent Recorders

The 2 basic types of intermittent recorders have slightly different utility. Event recorders store only a brief period of ECG activity when activated by the patient in response to symptoms; loop recorders record the ECG in a continuous manner but store only a brief period of ECG recording (eg, 5 to 3000 seconds) in memory when the event marker is activated by the patient at the time of a symptom. These devices often use solid-state memory and can transfer data readily over conventional telephone lines. These recorders can be used for prolonged periods of time (many weeks) to identify infrequently occurring arrhythmias or symptoms that would not be detected with the use of a conventional 24-hour AECG recording. Newer recorders can even be implanted for longer-term monitoring.

D. Playback Systems and Method of Analysis

Most current playback systems use generic computer hardware platforms running proprietary software protocols for data analysis and report generation. Facsimile, modem, network, and Internet integration allow for rapid distribution of AECG data and analyses throughout a healthcare system.

It is critical that each classification of arrhythmia morphology and each ischemic episode be reviewed by an experienced technician or physician to ensure accurate diagnosis because AECG recordings during routine daily activities frequently have periods of motion artifact or baseline wander that may distort the ST-segment morphology. Although the identification of ischemia made by the computer algorithm alone may be helpful, the interpretations are frequently found to be incorrect when assessed by an experienced observer. Overreading is essential.

III. Heart Rate Variability

Analysis of R-R variability has been available for several years and is generally referred to as HRV. The balance between the cardiac sympathetic and vagal efferent activity is evidenced in the beat-to-beat changes of the cardiac cycle. Determination of this HRV is often performed to assess patients with cardiovascular disease. Several systems are commercially available to analyze spectral and temporal parameters of HRV.

IV. Assessment of Symptoms That May Be Related to Disturbances of Heart Rhythm

One of the primary and most widely accepted uses of AECG is the determination of the relation of a patient's transient symptoms to cardiac arrhythmias. Some symptoms are commonly caused by transient arrhythmias: syncope, near syncope, dizziness, and palpitation. However, other transient symptoms are less commonly related to rhythm abnormalities: shortness of breath, chest discomfort, weakness, diaphoresis, or neurological symptoms such as a transient ischemic attack. Vertigo, which is usually not caused by an arrhythmia, must be distinguished from dizziness. More permanent symptoms such as those seen with a cerebrovascular accident are less commonly associated with an arrhythmia. A careful history is essential to determine if AECG is indicated.

If arrhythmias are thought to be causative in patients with transient symptoms, the crucial information needed is the recording of an ECG during the precise time that the symptom

is occurring. With such a recording, one can determine if the symptom is related to an arrhythmia. Four outcomes are possible with AECG recordings. First, typical symptoms may occur with the simultaneous documentation of a cardiac arrhythmia capable of producing such symptoms. Such a finding is most useful and may help to direct therapy. Second, symptoms may occur even though an AECG recording shows no arrhythmias. This finding is also useful because it demonstrates that the symptoms are not related to rhythm disturbances. Third, a patient may remain asymptomatic during cardiac arrhythmias documented on the recording. This finding has equivocal value. The recorded arrhythmia may or may not be relevant to the symptoms. Fourth, the patient may remain asymptomatic during the AECG recording and no arrhythmias are documented. This finding is not useful.

A. Selection of Recording Technique

The characteristics of the patient's symptoms will often determine the choice of recording techniques. Continuous AECG recording may be particularly useful in patients who have complete loss of consciousness and would not be able to attach or activate an event recorder. Continuous AECG recording is particularly useful if symptoms occur daily or almost daily, although most patients do not have episodic symptoms this frequently.

Many patients have symptoms occurring weekly or monthly, in which case a single continuous AECG recording probably will not be useful. An intermittent recorder (which is often capable of transtelephonic downloading) is more useful for infrequent symptoms. A loop recorder, which is worn continuously, may be particularly useful if symptoms are quite brief or if symptoms include only very brief incapacitation such that the patient can still activate the recorder immediately afterward and record the stored ECG. However, even a loop recorder with a long memory may not be useful if loss of consciousness includes prolonged disorientation on awakening that would prohibit the patient from activating the device. Newer loop recorders can be implanted under the skin for long-term recordings, which may be particularly useful for patients with infrequent symptoms. Another type of intermittent recorder is the event recorder, which is attached by the patient and activated after the onset of symptoms. It is not useful for arrhythmias that cause serious symptoms, such as loss of consciousness or near loss of consciousness, because these devices take time to find, apply, and activate. They are more useful for infrequent, less serious, but sustained symptoms that are not incapacitating.

B. Specific Symptoms

The diagnostic evaluation of syncope is determined by many clinical factors. Unfortunately, the yield of AECG monitoring is relatively low. The majority of such patients have no symptoms during ambulatory recording, and further evaluation is necessary. However, because of the severity of the symptoms, such testing is usually warranted. The yield of ambulatory monitoring that captures an episode of palpitation is higher than the yield for patients with syncope, probably because the frequency of occurrence of palpitation is higher than the occurrence of syncopal episodes.

Other cardiac symptoms such as intermittent shortness of breath, unexplained chest pain, episodic fatigue, or diaphoresis might be related to cardiac arrhythmias. AECG monitoring may be indicated for these symptoms. Other conditions less likely to be associated with cardiac arrhythmias on AECG such as stroke or transient ischemic attack may prompt AECG if arrhythmias are suspected.

Indications for AECG to Assess Symptoms Possibly Related to Rhythm Disturbances

Class I

1. **Patients with unexplained syncope, near syncope, or episodic dizziness in whom the cause is not obvious**
2. **Patients with unexplained recurrent palpitation**

Class IIb

1. **Patients with episodic shortness of breath, chest pain, or fatigue that is not otherwise explained**
2. **Patients with neurological events when transient atrial fibrillation or flutter is suspected**
3. **Patients with symptoms such as syncope, near syncope, episodic dizziness, or palpitation in whom a probable cause other than an arrhythmia has been identified but in whom symptoms persist despite treatment of this other cause**

Class III

1. **Patients with symptoms such as syncope, near syncope, episodic dizziness, or palpitation in whom other causes have been identified by history, physical examination, or laboratory tests**
2. **Patients with cerebrovascular accidents, without other evidence of arrhythmia**

V. Assessment of Risk in Patients Without Symptoms of Arrhythmias

AECG monitoring has been increasingly used to identify patients, both with and without symptoms, at risk for arrhythmias.

A. After Myocardial Infarction

Myocardial infarction (MI) survivors are at an increased risk of sudden death, with the incidence highest in the first year after infarction. The major causes of sudden death are ventricular tachycardia and ventricular fibrillation. Currently, the 1-year risk of malignant arrhythmia developing in an MI survivor after hospital discharge is 5% or less. The goal of risk-stratifying patients is to identify a population of patients at high risk of development of an arrhythmic event and to reduce such events with an intervention. Ideally, these patients would be identified by a test or combination of tests with a high sensitivity and a very high positive predictive accuracy, so that as few patients as possible are unnecessarily exposed to treatment.

AECG monitoring usually is performed over a 24-hour period before hospital discharge. Frequent premature ventricular contractions (eg, >10 per hour) and high-grade ventricular ectopy (eg, repetitive premature ventricular contractions, multiform premature ventricular contractions, ventricular tachycardia) after MI have been associated with a higher mortality rate among MI survivors. The positive predictive value (PPV) of ventricular ectopy in most of these studies for an arrhythmic event has been low, ranging from 5% to 15%. The sensitivity of ventricular ectopy can be increased by combining it with decreased left ventricular (LV) function. The PPV increases to 15% to 34% for an arrhythmic event if one combines AECG monitoring with an assessment of LV function. AECG is not needed in asymptomatic post-MI patients who have an ejection fraction of ≥40% because malignant arrhythmias occur infrequently in such patients.

Low values for high-frequency measures of HRV and baroreflex sensitivity (BRS) indicate decreased vagal modulation of R-R intervals. Decreased HRV and BRS are independent predictors of increased mortality rates, including sudden death, in patients after MI. However, the predictive value of both HRV and BRS after MI, although statistically significant, is poor when used alone.

B. Congestive Heart Failure

Patients with congestive heart failure (CHF), whether caused by ischemic cardiomyopathy or idiopathic dilated cardiomyopathy, often have complex ventricular ectopy and a high mortality rate. Several recent studies with larger populations have found that ventricular arrhythmias (eg, ventricular tachycardia, nonsustained ventricular tachycardia)

are sensitive but not specific markers of death and sudden death. Despite identifying a population with an increased relative risk of an adverse event, these tests are either not sensitive or have low PPVs.

HRV is decreased in patients with CHF. However, there are divergent results with respect to the association between HRV and arrhythmic events. Thus, there is not sufficient evidence to support the routine use of AECG or HRV in patients with CHF or dilated cardiomyopathy.

C. Hypertrophic Cardiomyopathy

Sudden death and syncope are common among patients with hypertrophic cardiomyopathy. The exact relation between ventricular arrhythmias or HRV and outcomes for patients with hypertrophic cardiomyopathy remains open to question. Although AECG monitoring may add to the prognostic information provided by known risk factors for patients with hypertrophic cardiomyopathy, treatment of these ventricular arrhythmias has not consistently been shown to increase life expectancy. Hence, the specific role of AECG in the day-to-day treatment of these patients remains unclear.

D. Summary

Although arrhythmia detection and HRV analyses each provide some incremental information that may be useful in identifying patients without symptoms of arrhythmias at increased risk of future cardiac events, their overall value is quite limited at the present time because of their relatively low sensitivity and PPV. Combining AECG, HRV, signal-averaged ECG, and LV function improves the quality of the information provided, but the best way to combine data from these different tests remains elusive. Three groups may benefit from either AECG or HRV monitoring: patients with idiopathic hypertrophic cardiomyopathy, patients with CHF, and post-MI survivors with reduced ejection fraction. However, these tests cannot be recommended for routine use in any other population at the present time.

Indications for AECG Arrhythmia Detection to Assess Risk for Future Cardiac Events in Patients Without Symptoms From Arrhythmia

Class I

None

Class IIb

1. **Post-MI patients with LV dysfunction (ejection fraction ≤40%)**
2. **Patients with CHF**
3. **Patients with idiopathic hypertrophic cardiomyopathy**

Class III

1. **Patients who have sustained myocardial contusion**
2. **Systemic hypertensive patients with LV hypertrophy**
3. **Post-MI patients with normal LV function**
4. **Preoperative arrhythmia evaluation of patients for noncardiac surgery**
5. **Patients with sleep apnea**
6. **Patients with valvular heart disease**

Indications for Measurement of HRV to Assess Risk for Future Cardiac Events in Patients Without Symptoms From Arrhythmia

Class I

None

Class IIb

1. **Post-MI patients with LV dysfunction**
2. **Patients with CHF**
3. **Patients with idiopathic hypertrophic cardiomyopathy**

Class III

1. **Post-MI patients with normal LV function**
2. **Diabetic subjects to evaluate for diabetic neuropathy**
3. **Patients with rhythm disturbances that preclude HRV analysis (ie, atrial fibrillation)**

VI. Efficacy of Antiarrhythmic Therapy

AECG has been widely used to assess the effects of antiarrhythmic therapy. The technique is noninvasive, provides quantitative data, and permits correlation of symptoms with ECG phenomena. However, limitations of AECG as a therapeutic guide affect its usefulness. These limitations include significant day-to-day variability in the frequency and type of arrhythmias in many patients, a lack of correlation between arrhythmia suppression after an intervention and subsequent outcome, uncertain guidelines for the degree of suppression required to demonstrate an effect, either statistical or clinical, and an absence of quantifiable spontaneous asymptomatic arrhythmias between episodes in many patients with a documented history of life-threatening arrhythmias.

The basis for the use of AECG has been the hypothesis that a reduction from baseline levels in arrhythmia frequency or type during serial monitoring after institution of therapy will correlate with an improved long-term clinical response. The majority of placebo-controlled, randomized trial data

concerning this hypothesis have been generated in patients with asymptomatic ventricular ectopy. Uncontrolled data and data comparing AECG with electrophysiological studies are available in patients with prior sustained ventricular tachycardia or ventricular fibrillation. Because of the limited day-to-day occurrence of supraventricular arrhythmias and the uncertain significance of asymptomatic nonsustained atrial ectopy, quantitative analysis of long-term AECG recordings has not been widely used to guide therapy of supraventricular arrhythmias. However, intermittent monitoring to confirm the presence of an arrhythmia during symptoms and to document arrhythmia-free intervals has become a standard approach for evaluating the effects of antiarrhythmic therapy in patients with supraventricular arrhythmias. The AECG also may be used to monitor the effects of atrioventricular (AV) nodal–blocking drugs on heart rate in patients with atrial arrhythmias.

Very few patients with sustained supraventricular arrhythmias have episodes on a daily basis. Guidelines for assessing therapy for supraventricular arrhythmias based on a quantitative analysis of the frequency and pattern of asymptomatic atrial ectopic beats are not available. However, protocols for rigorous assessment of antiarrhythmic drug efficacy with intermittent monitoring have been developed and validated. In these protocols, patients are asked to record and transmit ECG data from intermittent recording monitors to document the presence of arrhythmias during symptoms. Once a baseline frequency has been established, therapy is begun and the “arrhythmia-free” interval is used as a measure of drug effect. This type of protocol is now accepted as the standard for an antiarrhythmic drug development program for supraventricular arrhythmias because it provides a statistically valid measure of drug effect or symptomatic arrhythmias in a given population. Asymptomatic arrhythmias, also commonly present, would not be detected unless long-term recordings of periodic surveillance transmissions were also obtained. Use of a similar protocol in routine practice is not common, but the use of intermittent recordings in a nonquantitative manner may be clinically useful in patients with recurrent symptoms. AECG recordings are also of value for documenting control of the ventricular rate in patients with continuous atrial arrhythmias because they provide data on the heart rate during the patient’s typical daily activities.

The concept of proarrhythmia includes both provocation of new arrhythmia and exacerbation of preexisting arrhythmia as a result of antiarrhythmic drug therapy. Proarrhythmia may occur early or late during the course of therapy. In previously asymptomatic patients with ventricular ectopy, proarrhythmia usually is defined as an increase in frequency of ventricular

premature depolarizations or of runs of ventricular tachycardia. The increase needed to differentiate proarrhythmia from day-to-day variability may be estimated statistically on the basis of baseline arrhythmia frequency. Prolonged QT intervals, sinus node dysfunction, and new or worsened AV conduction abnormalities are other types of asymptomatic but still clinically relevant proarrhythmia that may be detected by AECG in patients receiving antiarrhythmic drug therapy.

Indications for AECG to Assess Antiarrhythmic Therapy

Class I

To assess antiarrhythmic drug response in individuals in whom baseline frequency of arrhythmia has been characterized as reproducible and of sufficient frequency to permit analysis

Class IIa

1. **To detect proarrhythmic responses to antiarrhythmic therapy in patients at high risk**

Class IIb

1. **To assess rate control during atrial fibrillation**
2. **To document recurrent or asymptomatic nonsustained arrhythmias during therapy in the outpatient setting**

Class III

None

VII. Assessment of Pacemaker and ICD Function

Over the last 10 years, the function and diagnostic capabilities of pacemakers and implantable cardioverter-defibrillators (ICDs) have become more complex. As a result, trouble-shooting device function and determining optimal device programming have become more challenging.

AECG is useful in assessing postoperative device function as well as in guiding appropriate programming of enhanced features such as rate responsivity and automatic mode switching. AECG can sometimes be a useful adjunct to continuous telemetric observation after pacemaker implantation in assessing device function and thereby can aid in determining the need for either device reprogramming or operative intervention. Present-generation pacemakers are capable of limited AECG monitoring function, which at the present time is not capable of entirely supplanting conventional AECG. They accomplish this through various algorithms by which complexes are classified according to whether or not

they are preceded by atrial sensed or paced events. Tabular data then can be obtained from pacemaker memory at the time of follow-up interrogation, which quantifies how many or what percentage of atrial and ventricular events were either sensed or paced, including a separate quantification of sensed ventricular events without preceding atrial activity. Although these algorithms were primarily designed to profile pacemaker activity to optimize device programming including AV delay, rate responsivity, and upper and lower rate limits, these data can be used to broadly determine the frequency of ventricular ectopy. The resolution of the data, however, usually does not allow for minute-to-minute counts or detailed characterization of repetitive ectopy (ie, rate, duration, or morphology of ventricular tachycardia). Because devices in current use do not provide electrogram confirmation of these counts, the accuracy of the tabulated data provided by these devices depends on accurate sensing and pacing function. Undersensing or oversensing of cardiac events or events occurring during blanking refractory periods will result in inaccurate counts.

When compared with pacemakers, present-generation ICDs are capable of more detailed electrogram recording events precipitating device activation. These recordings, however, are made over a significantly more limited time duration (usually on the order of 5 to 30 seconds per event, up to approximately 5 to 10 minutes of total recording duration). Although these recordings provide more complete disclosure and allow for direct physician review, the limited recording duration and absence of a surface ECG with which to provide data regarding QRS morphology are substantial limitations.

During outpatient follow-up of patients undergoing device implantation, AECG is useful in correlating intermittent symptoms with device activity. Pacing thresholds in the atrium evolve after lead implantation, and abnormalities of sensing and capture can be documented during long-term follow-up. Device longevity can be maximized with appropriate programming of output parameters, and AECG can be useful in assessing device function after such reprogramming.

Patients having undergone ICD implantation for the management of ventricular arrhythmia often have ICD shock therapy during follow-up. AECG can be a useful adjunct in establishing the appropriateness of such therapy. The efficacy of adjunctive pharmacological therapy in suppressing spontaneous arrhythmias in an attempt to minimize the frequency of device activation also can be assessed by this technique. Although present-generation ICDs are capable of storing electrograms of the spontaneous rhythm resulting in device activation, differentiating supraventricular from

ventricular arrhythmias solely on the basis of these recordings can be difficult. At the present time, AECG remains a useful adjunct in fine-tuning device function, including ensuring that there is no overlap in programmed tachycardia detection rate and the maximum heart rate achieved during daily activity.

Technology remains a moving target. Devices capable of more robust telemetry capabilities are already under development, and although it is conceivable that future devices implanted for the management of tachyarrhythmias and bradyarrhythmias may be totally self-sufficient in their diagnostic function, at the present time AECG remains a useful adjunct in the evaluation of pacemaker and ICD function.

Indications for AECG to Assess Pacemaker and ICD Function

Class I

1. **Evaluation of frequent symptoms of palpitation, syncope, or near syncope to assess device function to exclude myopotential inhibition and pacemaker-mediated tachycardia and to assist in the programming of enhanced features such as rate responsivity and automatic mode switching**
2. **Evaluation of suspected component failure or malfunction when device interrogation is not definitive in establishing a diagnosis**
3. **To assess the response to adjunctive pharmacological therapy in patients receiving frequent ICD therapy**

Class IIb

1. **Evaluation of immediate postoperative pacemaker function after pacemaker or ICD implantation as an alternative or adjunct to continuous telemetric monitoring**
2. **Evaluation of the rate of supraventricular arrhythmias in patients with implanted defibrillators**

Class III

1. **Assessment of ICD/pacemaker malfunction when device interrogation, ECG, or other available data (chest radiograph and so forth) are sufficient to establish an underlying cause/diagnosis**
2. **Routine follow-up in asymptomatic patients**

VIII. Monitoring for Myocardial Ischemia

During the past decade, AECG monitoring has been extensively used for detection of myocardial ischemia. Although in the past there were a number of technical limitations that led to

inadequate and unreliable evaluation of ST-segment changes, with the recent advent of technological advancements it is now widely accepted that AECG monitoring provides accurate and clinically meaningful information about myocardial ischemia in patients with coronary disease.

However, there is a relative paucity of data regarding the role of AECG monitoring in asymptomatic subjects without known coronary artery disease (CAD) or peripheral vascular disease. There is presently no evidence that AECG monitoring provides reliable information concerning ischemia in asymptomatic subjects without known CAD. Most of the studies that have evaluated the relation between the findings obtained during exercise ECG testing and AECG monitoring have demonstrated that ST-segment changes indicative of myocardial ischemia during AECG monitoring are relatively infrequent in patients with no evidence of ischemia during exercise testing. However, in those with an ischemic response during exercise testing, between 25% and 30% of patients demonstrate ischemia during AECG monitoring. There is a significant correlation between the magnitude of ischemia during the exercise ECG and the frequency and duration of ischemia during AECG monitoring. However, the strength of the correlation is limited, indicating that the 2 tests are not redundant to characterize coronary patients.

AECG monitoring also has been used for preoperative evaluation of patients with peripheral vascular disease with no clinical evidence of CAD. Between 10% and 40% of patients referred for major vascular surgery have evidence of ischemia detected by AECG monitoring. Although the independent prognostic value of ischemia detected by AECG monitoring for postoperative cardiac complications has been reported, more recent and larger studies have emphasized that the presence of ischemia detected by AECG monitoring in these patients also predicts a poor long-term prognosis. However, on the basis of the available data, when feasible, exercise testing alone or with an imaging study remains the preferred test of choice for risk stratification of patients with CAD or for preoperative evaluation. For patients who cannot perform exercise, AECG can be used for further evaluation.

Although ST-segment depression is the most frequently encountered ECG sign of ischemia during AECG monitoring, it should be noted that occasionally one can encounter a period of ST-segment elevation (especially in patients with variant angina or high-grade proximal stenoses) indicative of transmural ischemia. Thus, ischemia monitoring by AECG can also be helpful for the evaluation of patients with anginal syndromes and a negative exercise tolerance test if variant angina is suspected.

It is important to note that ST-segment changes and other repolarization abnormalities can occur for reasons other than myocardial ischemia. These include hyperventilation, hypertension, LV hypertrophy, LV dysfunction, conduction abnormalities, postural changes, tachyarrhythmias, preexcitation, sympathetic nervous system influences, psychotropic drugs, antiarrhythmic drugs, digitalis, alterations in drug levels, and electrolyte abnormalities. Although the possibility of these false-positive changes should not preclude the use of AECG monitoring for detection of myocardial ischemia, it is critical to be aware of these conditions while evaluating the predictive value of ST-segment changes in a given patient.

Indications for AECG for Ischemia Monitoring

Class I

None

Class IIa

1. **Patients with suspected variant angina**

Class IIb

1. **Evaluation of patients with chest pain who cannot exercise**
2. **Preoperative evaluation for vascular surgery of patients who cannot exercise**
3. **Patients with known CAD and atypical chest pain syndrome**

Class III

1. **Initial evaluation of patients with chest pain who are able to exercise**
2. **Routine screening of asymptomatic subjects**

IX. Pediatric Patients

The purposes of AECG monitoring in pediatric patients include (1) the evaluation of symptoms that may be arrhythmia related; (2) risk assessment in patients with cardiovascular disease, with or without symptoms of an arrhythmia; and (3) the evaluation of cardiac rhythm after an intervention such as drug therapy or device implantation. As in adult patients, selection of the method of monitoring (ie, continuous recording versus patient-activated) is predicated on the frequency and symptoms of the arrhythmia.

An arrhythmia, usually supraventricular tachycardia, has been reported to correlate with palpitation in 10% to 15% of young patients, whereas ventricular ectopy or bradycardia are

demonstrated in another 2% to 5%. By comparison, sinus tachycardia is identified in nearly 50% of young patients with symptoms of palpitation during ambulatory monitoring, whereas 30% to 40% of patients have no symptoms during monitoring. Therefore, one of the primary uses of AECG monitoring in pediatric patients is to exclude arrhythmia as the cause of palpitation.

The role of AECG monitoring in young patients with transient neurological symptoms (syncope, near syncope, or dizziness) in the absence of structural or functional heart disease is limited. The intermittent nature of symptoms results in a low efficacy of 24- to 48-hour continuous ECG monitoring; conversely, temporary patient incapacitation usually precludes patient-activated recording. Continuous ECG monitoring is primarily indicated in pediatric patients with exertional symptoms or those with known heart disease, in whom the presence and significance of an arrhythmia may be increased.

AECG monitoring is commonly used in the periodic evaluation of pediatric patients with heart disease, with or without symptoms of arrhythmia. The rationale for this testing is the evolution of disease processes (such as long QT syndrome or hypertrophic cardiomyopathy), growth of patients and the need to adjust medication dosages, and the progressive onset of late arrhythmias after surgery for congenital heart defects.

Periodic AECG monitoring for young patients with hypertrophic or dilated cardiomyopathy or the long QT syndrome is recommended because of the progression of these diseases and the need to adjust medication doses with growth. The risk of sudden death with these diseases is much greater in pediatric patients than adults, with sudden death a first symptom in 9% to 15% of patients. One primary role of AECG monitoring is to identify occult arrhythmias, which may indicate the need for reevaluation of therapy in an asymptomatic patient. However, the absence of arrhythmia during monitoring does not necessarily indicate a low risk of sudden death.

AECG monitoring has a limited role for establishing a diagnosis of long QT syndrome in patients with borderline QT prolongation. This is because of differences in sampling, signal filtering, and recording methods compared with conventional ECG.

AECG monitoring may be used to identify asymptomatic patients with congenital complete AV block at increased risk for sudden arrhythmic events who may benefit from prophylactic pacemaker implantation. Conversely, routine AECG evaluation of asymptomatic patients with preexcitation syndromes (Wolff-Parkinson-White) has not been

demonstrated to define patients at risk for sudden arrhythmic death.

Unexplained syncope or cardiovascular collapse in patients with cardiovascular disease generally requires in-hospital continuous ECG monitoring, with an invasive evaluation when the underlying cause of the event is uncertain. However, if a cause cannot be established by invasive methods, AECG monitoring may be used for subsequent evaluation to evaluate for both transient bradyarrhythmias and tachyarrhythmias.

Indications for AECG Monitoring in Pediatric Patients

Class I

1. **Syncope, near syncope, or dizziness in patients with recognized cardiac disease, previously documented arrhythmia, or pacemaker dependency**
2. **Syncope or near syncope associated with exertion when the cause is not established by other methods**
3. **Evaluation of patients with hypertrophic or dilated cardiomyopathies**
4. **Evaluation of possible or documented long QT syndromes**
5. **Palpitation in the patient with prior surgery for congenital heart disease and significant residual hemodynamic abnormalities**
6. **Evaluation of antiarrhythmic drug efficacy during rapid somatic growth**
7. **Asymptomatic congenital complete AV block, nonpaced**

Class IIa

1. **Syncope, near syncope, or sustained palpitation in the absence of a reasonable explanation and where there is no overt clinical evidence of heart disease**
2. **Evaluation of cardiac rhythm after initiation of an antiarrhythmic therapy, particularly when associated with a significant proarrhythmic potential**
3. **Evaluation of cardiac rhythm after transient AV block associated with heart surgery or catheter ablation**
4. **Evaluation of rate-responsive or physiological pacing function in symptomatic patients**

Class IIb

1. **Evaluation of asymptomatic patients with prior surgery for congenital heart disease, particularly when there are either significant or residual hemodynamic abnormalities, or a significant incidence of late postoperative arrhythmias**
2. **Evaluation of the young patient (<3 years old) with a prior tachyarrhythmia to determine if unrecognized episodes of the arrhythmia recur**
3. **Evaluation of the patient with a suspected incessant**

atrial tachycardia

4. **Complex ventricular ectopy on ECG or exercise test**

Class III

1. **Syncope, near syncope, or dizziness when a noncardiac cause is present**
2. **Chest pain without clinical evidence of heart disease**
3. **Routine evaluation of asymptomatic individuals for athletic clearance**
4. **Brief palpitation in the absence of heart disease**
5. **Asymptomatic Wolff-Parkinson-White syndrome**

Footnotes

"ACC/AHA Guidelines for Ambulatory Electrocardiography: Executive Summary and Recommendations: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the Guidelines for Ambulatory Electrocardiography)" was approved by the American College of Cardiology Board of Trustees in June 1999 and by the American Heart Association Science Advisory and Coordinating Committee in June 1999.

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