Guidelines for Ambulatory Electrocardiography

A Report of the American College of Cardiology/American Heart Association Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Subcommittee on Ambulatory Electrocardiography)

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Preamble

It is becoming more apparent each day that despite a strong national commitment to excellence in health care, the resources and personnel are finite. It is, therefore, appropriate that the medical profession examine the impact of developing technology on the practice and cost of medical care. Such analyses, carefully conducted, could potentially impact on the cost of medical care without diminishing the effectiveness of that care.

To this end, the American College of Cardiology and the American Heart Association in 1980 established a Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures with the following charge:

The Task Force of the American College of Cardiology and the American Heart Association shall define the role of specific noninvasive and invasive procedures in the diagnosis and management of cardiovascular disease.

The Task Force shall address, when appropriate, the contribution, uniqueness, sensitivity, specificity, indications, contraindications and cost-effectiveness of such specific procedures.

The Task Force shall include a Chairman and four members, two representatives from the American Heart Association and two representatives from the American College of Cardiology. The Task Force may select ad hoc members as needed upon the approval of the Presidents of both organizations. Recommendations of the Task Force are forwarded to the President of each organization.

The members of the Task Force are: Roman W. DeSanctis, MD, Harold T. Dodge, MD, T. Joseph Reeves, MD, Sylvan Lee Weinberg, MD, and Charles Fisch, MD, Chairman.

This document was reviewed by the officers and other responsible individuals of the two organizations and received final approval in October 1988. It is being published simultaneously in Circulation and the Journal of the American College of Cardiology.

Both the potential impact of this document on the practice of cardiology and some of its unavoidable shortcomings are clearly set out in the introduction.

Charles Fisch, MD, FACC

Introduction

Defining the Role of Ambulatory Electrocardiographic Systems in Clinical Decision Making

With the introduction in 1961 of a method for recording the electrocardiogram (ECG) from an ambulatory subject over extended time periods, a new electrocardiology was initiated. Instrumentation considerations dominated the development of the technology over the subsequent years. A broad
range of advances and improvements were made in recording fidelity, equipment size and weight, and data acquisition and analysis systems. The periods of time over which the signal can be recorded lengthened progressively. The capability for non-continuous recording, triggered by either the subject or arrhythmia occurrence, became available. Automated off-line and real-time analysis systems were developed to decrease technician time or to provide more prompt reporting, or both, and, purportedly, to increase accuracy. Ambulatory ECG recording and review systems continue to evolve, and improvements in the analysis and editing capabilities of commercial systems are being introduced with some frequency.

With maturing of the ambulatory ECG instrumentation, clinical applications expanded. In addition to the use of ambulatory ECG recordings for the confirmation of arrhythmias as the cause of symptoms occurring during daily activities, the technology is being applied to the prediction of future cardiac events, detection of myocardial ischemia, and documentation of the therapeutic efficacy of antiarrhythmic and anti-ischemic agents. With this increased utilization has come the need to define the role of ambulatory electrocardiography more precisely. As the applications broaden and encompass elements of the ECG signal other than rhythm, the quantitative aspects of system performance become more critical. When a test is being used for diagnosis, as a guide to therapeutic management, or for prognostic purposes, knowledge of its predictive value is essential. The predictive value, in turn, depends on the sensitivity and specificity of the test and the prevalence of the disease in the population group to which the person being tested belongs. For accuracy in these more diverse applications, more complete information about possible technical errors, physiologic or artifactual influences on the test, and the distribution of normal and abnormal results is critical to the effective use of the test to solve clinical problems.

Ambulatory electrocardiography as an aid to clinical decision-making was the focus of the Subcommittee deliberations. Therefore, this report is based on the most frequently stated clinical reasons for ordering an ambulatory ECG. Under each broad clinical indication, further subgrouping is accomplished and each subgroup is assigned to one of the following classes:

Class I: Conditions for which (or patients for whom) there is general agreement that an ambulatory ECG is a useful and reliable test.

Class II: Conditions for which (or patients for whom) an ambulatory ECG is frequently used but there is a divergence of opinion with respect to its utility.

Class III: Conditions for which (or patients for whom) there is general agreement that an ambulatory ECG is not a useful test.

When appropriate, specific types of systems may be stated to be the most appropriate for a particular clinical indication.

Assumptions Underlying the Subcommittee Report

Because of the numerous differences in the recording and analysis systems and the absence of a method for intersystem comparisons, the Subcommittee developed the indication assessments on the assumptions that for each system 1) electrical signals are being reliably recorded, retrieved, and displayed; 2) the accuracy of the system being employed is known relative to the purposes for which it is being employed; and 3) verification of the accuracy of system functioning is available as required. Recommendations for technologically accurate and repeatable studies and quality control in the analysis of ambulatory ECGs have been put forth previously.

The generic term ambulatory electrocardiogram (or ambulatory ECG) is used to indicate all forms of continuous or intermittent recording as well as transtelephonic data transfer.

The Subcommittee has not made any recommendations regarding resources required for the provision of adequate ambulatory ECG services or for the training of the individuals, physicians, and technical personnel responsible for acquiring and interpreting the data. In general, however, the Subcommittee supports the training requirements for cardiovascular fellows as outlined in the American College of Cardiology Bethesda Conference on Optimal Electrocardiography. The Subcommittee considers the most critical concerns to be those surrounding knowledge of the characteristics of the system or systems being utilized by any provider of ambulatory ECG services. It needs to be recognized that all systems are dependent, to variable degrees, on the skills and compulsion of the technical personnel as well as the physicians making the final report. Totally automated systems have not yet achieved a documented accuracy sufficient to eliminate the need for human overview.

In virtually all of the situations in which the role of ambulatory electrocardiography is discussed, it is assumed that the patients to receive the test have undergone a complete history and physical examination and that the usefulness and likely yield of the test have been carefully considered. The decision to perform an ambulatory ECG and the interpretation of its results are rarely done in isolation without consideration of other factors relevant to the individual patient. When appropriate, other invasive and noninvasive tests should be performed before use of an ambulatory ECG is considered. Given the diversity of uses of ambulatory electrocardiography, it is impossible to provide a "cookbook" listing of the precise usefulness of ambulatory recordings in all circumstances. There may be situations that have been given a Class I categorization for
which an ambulatory ECG is not necessary or appropriate and other circumstances with a Class III rating for which the test is both clinically appropriate and useful.

Finally, as with any test, the role of ambulatory electrocardiography is undergoing evaluation and the recommendations made here may undergo continuous and at times striking changes so that the guidelines given at this time may not be applicable as additional information becomes available. The American College of Cardiology and the American Heart Association recognize the fact that the ultimate judgment regarding the propriety of any specific procedure is the responsibility of the physician caring for the patient. The guidelines should not be considered all inclusive or exclusive of other methods that may be available for the care of the individual patient.

Instrumentation and Systems

The purpose of this section is to describe the capabilities and characteristics of systems used for ambulatory electrocardiography. Instrumentation includes devices for acquisition, analysis, and display of long-term ECG recordings. Emphasis is placed on a general description of system types and their characteristics rather than on specific performance standards. These have been reviewed in a previous report.¹

Recording Systems

The primary goal of ambulatory electrocardiography is to document and characterize occurrences of random, spontaneous, sleep-related, emotion- or stress-induced abnormal cardiac electrical behavior in the ambulatory subject. To capture these often rare and occasionally life-threatening events and to correlate symptoms with rhythm disturbances or ST segment shifts during activity, it is necessary to record or observe cardiac electrical behavior in a continuous manner for long periods of time and during the course of the normal daily activities of the patient. Numerous recording devices have evolved to meet the needs for ambulatory electrocardiography and include two basic families: continuous recorders and intermittent recorders.

Continuous recorders. These are small devices that typically include two ECG amplifiers and an analog tape recorder for permanently storing the continuous records. Amplifier characteristics are similar to those used in conventional ECG recording systems (high input impedance, high noise immunity, linear response, for example), although the frequency response of ambulatory devices is narrower. This fact limits fidelity of the recordings to the extent that high frequency notching and ST segment displacement may not be recorded or interpreted reliably in all systems. Most recorders use ½ in. (0.32 cm) tape cassettes or ¼ in. (0.64 cm) tape reels and record at very slow speeds (typically 0.0625 in. [0.16 cm/sec) to achieve continuous recording over 24 hours. Timing accuracy is based on precision of the tape drive motor and gearing and, in some cases, recording of timing signals along with the data. Event markers, provided on most units, consist of a button that is activated by the patient to document the occurrence of a symptom. The button introduces a recognizable artifact in the recording that, during playback, can be correlated with the patient’s symptoms. The recorders are compact, battery operable, and wearable, thus permitting continuous data recording for 24 hours and, importantly, during the normal daily activities of the patient. Recording and ground leads are placed to minimize noise and patient discomfort and to maximize signal information.

All-Digital Recording Systems. The advent of very high density semiconductor memory has led to the potential for all-digital recording systems. In these devices, the incoming amplified signals are digitized, encoded, and stored in the solid state memory. In the presence of efficient and accurate coding algorithms, it is thus potentially possible to reproduce full disclosure records in addition to summaries of arrhythmia content. Primary advantages to be gained by such devices are reduction in size, elimination of mechanical parts (electrical tape drive motor and gears), reduction in energy requirements (battery size), and improvement of signal to noise ratios (elimination of tape noise, both during recording and playback). These devices also provide the potential for adding on-board intelligence to analyze and process incoming data in real time, for example, to characterize or classify complex arrhythmia configurations, track heart rate, count premature ventricular complexes, and other applications. These systems are referred to as real-time analysis ambulatory systems.

Interruption recorders. The design philosophy of these recorders differs from that of continuous recorders. Although the hardware implementation of the two systems is similar, intermittent recorders are capable of recording only a limited number of short segments of data. Their purpose is to capture critical cardiac electrical behavior when the patient first detects the onset of symptoms (palpitation, dizziness, fast heart rate, or other symptoms).

Transfacilephonic Capability. Some recorders can provide transtelephonic transmission of signals directly to a centralized analysis or interpretation facility. In this mode, the patient may dial the facility, hold a transducer on the recorder to the phone mouthpiece, and play back selected segments for interpretation.

Review Systems

Rapid playback and analysis capability. A variety of systems are available for analysis of 24-hour continuous recordings. These offer a wide range of data display and statistical summary options. Virtually all conventional tape systems utilize rapid playback (60× or 120× real time) resulting in the
potential for complete analysis of a tape in 15–30 minutes. The objectives of the analysis include
determination of QRS complex configuration and
frequency, reporting of data on heart rate, and
detection and characterization of episodes of arrhythmias. The information is typically presented in
tabular form as well as in graphic forms such as
displays of frequency distributions of arrhythmias
and histograms of cycle length. In addition, during
playback and analysis, segments of data containing
arrhythmic events (isolated premature ventricular
complexes, couplets, bigeminal episodes, or bursts
of ventricular tachycardia) or potential ischemic
events (ST segment depression or elevation), or
both, may be printed as standard ECG strips.

Full disclosure capability. Some systems provide
a “full disclosure” capability in which a complete
record of “every complex occurring for 24 hours” is
plotted on compressed time and voltage scales.
Though the resolution of the full disclosure display is
insufficient to detect subtle morphologic changes on
a beat-to-beat basis, isolated premature complexes,
sequences of premature ventricular complexes, and
ventricular tachycardia are clearly evident. Because
time of day is either recorded or computed, episodes
of abnormal cardiac activity can be correlated with
patients’ observations of symptoms. In general, sys-
tems that provide for full disclosure are preferred
because the physician in charge of the patient can
visually scan the record as indicated.

Interactive capability. In addition to a wide range
of analysis and display formats, systems have a
spectrum of capabilities for automatic or manual
interaction during processing. This is a necessity
because no machine provides perfect discrimination
between “unusual” but physiologic signals and
noise or artifact. Even when precautions are
observed for skin preparation and electrode place-
ment, noise introduced by muscle potentials, patient
or lead motion, or electrical interference precludes
the possibility of perfect, low noise recordings for
24 hours. The better systems of analysis can detect
“difficult” signal segments and provide an operator
with the raw signals, which can be ignored, classi-
fied, or simply displayed in hard copy form. Other
systems permit interactive modification of detection
and classification parameters in order to tailor the
processing to specific requirements.

Clinical Indications for Ambulatory
Electrocardiography

Assessment of Symptoms That May Be Related to
Rhythm Disturbances of the Heart

General Considerations

One of the primary and most widely accepted
uses of ambulatory electrocardiography is in deter-
miming whether patients’ symptoms of palpitation,
dizziness, shortness of breath, syncope, or other
manifestations of cardiovascular dysfunction are
related to cardiac arrhythmias. Although ECG
recordings made in such patients during asympto-
matic periods may occasionally yield important
cues to the possible cause of symptoms, in most
cases such determination requires documentation
of the spontaneous occurrence of symptoms
in relation to arrhythmias. An ambulatory ECG show-
ing no arrhythmia is of little value if the patient does
not experience symptoms during the period of
recording and if the recording, therefore, cannot
exclude an arrhythmia as the cause of the symp-
toms. An ambulatory ECG demonstrating asympto-
matic arrhythmias may give a clue to the cause of
the patient’s symptoms but, because asymptomatic
arrhythmias frequently occur in the general popula-
tion, it is possible that these arrhythmias have little
relevance to the patient’s symptoms. An ambula-
tory ECG that excludes arrhythmia as the cause of
a patient’s symptoms by showing no arrhythmia at
the time of occurrence of a typical symptomatic
episode may be as valuable as a recording clearly
demonstrating a relation between the patient’s symp-
toms and a cardiac rhythm disturbance. Although
the 24-hour ambulatory ECG is not likely to be
clinically useful when symptoms are not expected
to occur during the recording period, it remains an
acceptable adjunctive procedure in certain situa-
tions such as syncope, where the low diagnostic
yield is offset by the severe nature of the symptoms.

Selection of patients for different recording
devices. The need to record the ECG until symp-
toms occur causes the yield of useful information
from ambulatory studies to be heavily dependent on
patient selection (especially the frequency of occur-
rence of symptoms) and the type of system utilized.
There are relatively few data from which to derive
the sensitivity, specificity and cost-effectiveness
of ambulatory recordings in symptomatic patients.
For patients who experience symptoms daily, a con-
tinuous 24-hour ambulatory ECG generally provides
useful information about the relation between the
symptoms and arrhythmias. However, most patients
seeking medical attention do not have typical symp-
toms on a daily basis. In the early days of ambula-
tory electrocardiography it was often necessary to
record the tracings for several or more consecutive
days, and several studies have demonstrated a
need to record over a period of days to weeks or
longer. The introduction of patient-activated inter-
mittent recorders and transtelephonic ECG capabil-
ity have greatly aided the evaluation of such patients
and have made multiple day 24-hour ambulatory
ECGs a cost-ineffective procedure unless the
patient’s symptoms include abrupt loss of conscious-
ness. For patients whose typical symptoms do not
occur daily and are not incapacitating, transtele-
phonic devices would appear to be superior to a
single 24-hour recording. These devices are also
more cost-effective than multiple 24-hour record-
ings once the patient’s baseline arrhythmias have
been characterized by a single conventional 24-hour
recording. When a patient’s symptoms are tran-
sent, devices with both continuously applied electrodes and a memory loop may be necessary. When transtelephonic ECG strips show no relation between a patient's symptoms and an underlying arrhythmia, no further monitoring is required. When the strips show a definite correlation between symptoms and an arrhythmia, an additional routine 24-hour ambulatory ECG may be valuable even if no symptoms are anticipated during the recording period. In such patients the 24-hour recording helps to assess the frequency of occurrence of asymptomatic episodes of arrhythmias similar to those recorded at the time of symptoms. These recordings frequently help to determine whether the arrhythmia causing symptoms is the only arrhythmia present or whether the patient has frequent episodes of similar arrhythmias that are asymptomatic.

In considering the appropriateness of ambulatory electrocardiography in an individual patient, the likelihood that the patient's symptoms are due to a cardiac arrhythmia must be considered. Symptoms such as palpitation have a high likelihood of being due to an arrhythmia; therefore, ambulatory electrocardiography should be considered early in the evaluation of patients with this symptom. In contrast, episodic shortness of breath is much less likely to be caused by an arrhythmia. Ambulatory electrocardiography should be utilized in patients with this symptom only when other causes have been considered and excluded, and only when the symptom is paroxysmal and has some probability of being related to a cardiac rhythm disturbance.

**Classification of Indications for Ambulatory Electrocardiography to Assess Symptoms Possibly Related to Rhythm Disturbances**

**Class I:** Palpitation, syncope, dizziness.

**Class II:** Shortness of breath, chest pain, or fatigue (not otherwise explained, episodic and strongly suggestive of an arrhythmia as the cause because of a relation of the symptom with palpitation).

**Class III:** Symptoms not reasonably expected to be due to arrhythmia.

**Assessment of RR Interval Characteristics**

**General Considerations**

Although not widely appreciated, beat-to-beat changes in heart rate or cycle length (RR intervals) may contain useful information for the diagnosis of certain conditions. The ambulatory ECG is ideally suited to assess RR intervals over long periods of time. During sinus rhythm, beat-to-beat differences in cardiac cycle length occur because of changes in autonomic tone. In situations of complete cardiac denervation such as cardiac transplantation, a mild sinus tachycardia at rest is present with no beat-to-beat difference in cardiac cycle length. In these patients, changes in cardiac cycle length occur over periods of several minutes or longer, probably in response to circulating catecholamines. A similar situation occurs with neuropathies commonly seen with advanced diabetes mellitus. Patients with sleep apnea syndrome develop a marked sudden increase in vagal tone at the time of their apnea, probably related to performing a Mueller maneuver. Such patients experience marked bradycardia during episodes of apnea and show a characteristic cyclical RR interval pattern on properly analyzed ECG recordings. The ambulatory ECG, when evaluated for RR interval information, is extremely useful for diagnosing obstructive sleep apnea.

Although the systems providing for the assessment of RR interval characteristics are not widely available at this time, they are in production and will soon be available for general clinical use.

Prognostic information for patients with coronary artery disease recently has been observed to be available from the study of RR variability on the ambulatory ECG. Prospective studies of patients after myocardial infarction have shown that heart rate variability may be a predictor of prognosis, independent of ventricular arrhythmias or left ventricular function.

**Classification of Indications for Ambulatory Electrocardiography to Assess RR Interval Characteristics**

**Class I:** Sleep apnea and visceral diabetic neuropathy (only when RR interval evaluation is performed).

**Class II:** RR interval variability as a prognostic sign in coronary artery disease.

**Class III:** None.

**Assessment of Risk in Patients With or Without Symptoms of Arrhythmia**

**General Considerations**

These individuals fall into two categories: those whose activities might endanger themselves or others if an arrhythmia occurred and those whose medical condition is associated with a higher than usual frequency of life-threatening arrhythmias.

**Specific Considerations**

The asymptomatic individual whose sudden incapacitation could threaten the lives of others. The prototypic individual in this category is the airline pilot. Despite the potential adverse consequences of a sudden incapacitating arrhythmia, the frequency of events that could be predicted by ambulatory ECG recording is too low to justify testing.

The asymptomatic patient about to embark on an exercise program. Premature ventricular complexes and even ventricular tachycardia, if detected by ambulatory electrocardiography in asymptomatic patients without organic heart disease, have virtually no predictive value for future cardiac events. In the absence of additional data, there is little justification for ambulatory electrocardiography in this patient group.

The patient with known stable coronary artery disease and no prior myocardial infarction. In
patients with coronary artery disease and no prior myocardial infarction, both frequent and complex forms of premature ventricular complexes indicate a higher risk for subsequent cardiac events.\textsuperscript{11} This increment in risk is almost entirely in the subgroup of patients with evidence of significant myocardial dysfunction. The use of ambulatory electrocardiography in such patients, therefore, usually requires as an indication the presence of frequent and complex ventricular ectopic beats and evidence for impaired myocardial functioning.

The postinfarction patient. Postinfarction patients with premature ventricular complexes have been stated to be at higher risk for cardiac events, even after correction for ejection fraction.\textsuperscript{12} Although routine performance of ambulatory ECGs after myocardial infarction may be questioned on the basis of cost-effectiveness, there may be a reasonable medical justification for the study in this group of patients.

The patient after bypass surgery or angioplasty. Limited information exists in regard to ambulatory ECG studies of patients after angioplasty or revascularization surgery. In general, such groups of patients probably have the same set of indications as those with known stable coronary disease without prior myocardial infarction.

The postinfarction patient entering an exercise program. For the typical postinfarction patient entering an exercise program, 24-hour electrocardiography appears to offer no information of value for clinical decision-making.

Cardiomyopathies. Runs of ventricular tachycardia in patients with hypertrophic cardiomyopathy, whether or not associated with symptoms, constitute a higher risk for sudden death.\textsuperscript{13} With therapy, the frequency of these tachycardias often can be reduced and survival improved.\textsuperscript{14} The diagnosis of hypertrophic cardiomyopathy is, therefore, an indication for an ambulatory ECG.

Mitral valve prolapse. Patients who are symptomatic and who have documented mitral valve prolapse should be considered under the guidelines for the symptomatic patient. Neither asymptomatic premature ventricular complexes nor other asymptomatic arrhythmias in patients with mitral valve prolapse indicate a more grave prognosis in comparison with that of patients without arrhythmias.\textsuperscript{15} In the absence of additional information, therefore, the presence of the diagnosis of mitral valve prolapse alone does not establish the need for ambulatory ECG recordings.

\section*{Classification of Indications for Ambulatory Electrocardiography to Assess Risk of Future Cardiac Events in Patients With or Without Symptoms From Arrhythmia}

\section*{Class I}

\begin{itemize}
  \item In the patient with idiopathic hypertrophic cardiomyopathy, with or without symptoms.
  \item In the postmyocardial infarction patient with left ventricular dysfunction.
\end{itemize}

\section*{Class II}

\begin{itemize}
  \item In the patient who has known stable coronary artery disease or who has undergone coronary bypass surgery or angioplasty and has evidence for myocardial dysfunction or arrhythmia.
  \item In the patient with Wolff-Parkinson-White syndrome.
  \item In the patient with long QT intervals.
  \item In the patient with documented significant aortic valve disease and symptoms suggestive of arrhythmia.
  \item In the patient with dilated cardiomyopathy and symptoms suggestive of arrhythmia.
\end{itemize}

\section*{Class III}

\begin{itemize}
  \item In the patient with known stable coronary artery disease without evidence for myocardial dysfunction or arrhythmia.
  \item In the person with asymptomatic mitral valve prolapse.
  \item In the asymptomatic person without known heart disease about to embark on an exercise program.
  \item In the asymptomatic person who requires assessment of risk for potentially disabling arrhythmias because his or her occupation might place others in jeopardy if an arrhythmia were to occur.
\end{itemize}

\section*{Assessment of Efficacy of Antiarrhythmic Therapy}

\section*{General Considerations}

The use of ambulatory electrocardiography to assess antiarrhythmic drug therapy is based on the assumption that a decrease in the frequency of arrhythmias is associated with either a decrease in symptomatic events or improved survival. There has not been agreement as to the specific magnitude of reduction in the frequency of arrhythmia that predicts a decrease in cardiac events. Hence, ambulatory ECG criteria for assessment of the efficacy of antiarrhythmic therapy are arbitrary.\textsuperscript{16–21} Because there are wide variations in the frequency of arrhythmias without therapy, a change in frequency must be of major magnitude before efficacy can be inferred. To permit appropriate assessment of therapeutic efficacy and detection of proarrhythmic effect, both the pretreatment frequency and the complexity of ectopic activity must be recorded before and during therapy and the patient needs to serve as his or her own control.\textsuperscript{18–22} Furthermore, the time intervals between recordings may be critical.\textsuperscript{23,24}

\section*{Specific Considerations}

\subsubsection*{Premature ventricular complexes.} Analysis of premature ventricular complexes must incorporate consideration of the substantial amount of spontaneous variation in frequency that occurs without therapy.\textsuperscript{25,26} Hence, drug efficacy has been defined as a minimum of 50, 80, or 90% reduction in ventricular premature complex frequency when comparing the pre- and post-treatment 24-hour ambulatory recording periods.\textsuperscript{17,19} The degree of reduction required depends on the number of recordings obtained to establish spontaneous variability, the
population examined, and the malignancy of the arrhythmias. The arbitrary definition of “reduced” ectopic activity has to be viewed within the contexts of the clinical and baseline frequency. At one end of the spectrum is absence of symptoms, no history of heart disease, and uniform and relatively infrequent premature ventricular complexes for which no ambulatory assessment is required. As each of these factors increases in severity or frequency, the risk of a cardiac event increases. There are as yet no universally accepted algorithms for integrating this multivariate information into a reliable statement of risk for an individual patient. For this reason, although ambulatory electrocardiography is frequently used to assess pharmacologic efficacy in the suppression of premature ventricular complexes, there is no agreement on this practice with respect to indications or utility. When the arrhythmias are of high frequency and are reproducible, however, ambulatory electrocardiography may be useful in such assessment.

Ventricular tachycardia. Patients with episodic ventricular tachycardias are candidates for ambulatory electrocardiography if drugs are to be used for arrhythmia control. Current data suggest that among patients experiencing “malignant ventricular arrhythmia” (sustained symptomatic ventricular tachycardia, for example, or ventricular fibrillation unrelated to acute myocardial infarction), there are subgroups in whom improved outcome is predicted when there is either a marked reduction in premature ventricular complexes or ventricular couplets or ablation of nonsustained salvos of ventricular tachycardia, or both. Conversely, withdrawal of antiarrhythmic drugs from patients with a malignant ventricular arrhythmia has been reported to be associated with recurrence of the arrhythmia.

Supraventricular arrhythmias. There are few reports analogous to those concerning ventricular arrhythmias that assess the relation between percent reduction in supraventricular arrhythmias and subsequent clinical outcome. Because permanently disabling events are not commonly associated with the supraventricular tachycardias, amelioration of symptoms usually is considered to be a sufficient criterion for therapeutic efficacy. In light of the high risk for systemic emboli, atrial fibrillation may be an atrial arrhythmia that even during asymptomatic periods requires assessment of therapeutic efficacy. Among such patients, particularly if they are not receiving anticoagulant agents, documentation of the suppression of atrial fibrillation paroxysms by antiarrhythmic drugs is an indication for ambulatory electrocardiography. A second condition for which some believe supraventricular arrhythmia suppression should be assessed is the Wolff-Parkinson-White syndrome.

Classification of Indications for Ambulatory Electrocardiography to Assess Efficacy of Therapy
Class I
In patients with baseline high frequency, reproducible, sustained, symptomatic premature ventricular complexes, supraventricular arrhythmias, or ventricular tachycardia.

Class II
• In patients with known episodic or reverted atrial fibrillation to determine efficacy of arrhythmia control.
• In patients with premature ventricular complexes of variable frequency and complexity or relatively infrequent brief salvos of ventricular or supraventricular arrhythmias.
• In patients with the Wolff-Parkinson-White syndrome.
• For the assessment of proarrhythmia effects.
• For the assessment of tachycardias, bradycardias and conduction defects related to drug administration.

Class III
None.

Assessment of Pacemaker Function

General Considerations
The assessment of pacemaker function during a patient’s normal daily activities often is essential for proper management. Because of the limited time of examination provided by the traditional pacemaker follow-up clinic visit and transtelephonic monitoring systems, the use of ambulatory electrocardiography for pacemaker evaluation over 24 hours or more during daily activities has increased the diagnostic yield in the detection of pacemaker dysfunction. Enhanced detection of pacemaker dysfunction by ambulatory electrocardiography also has proven valuable in the early postimplantation period when compared with in-hospital telemetry monitoring. This increased diagnostic yield is not related simply to more prolonged time of examination. It has been facilitated by ambulatory ECG technology that permits detection and recognition of the pacing stimulus artifact through its amplification and recording on a separate dedicated channel. Current technology can automatically provide information concerning failure to capture, failure to sense, failure to generate an impulse, number of pacing stimuli, and percent of beats paced. Although currently reliable for single chamber pacemakers, the technology needs additional refinement for the automatic evaluation of dual-chamber pacemakers. Ambulatory electrocardiography is of value, however, in the presence of dual-chamber pacemakers by making possible the visual interpretation of the ECG during daily activities.

Classification of Indications for Ambulatory Electrocardiography to Assess Pacemaker Function

Class I
• Evaluation of paroxysmal symptoms in patients with pacemakers.
• Detection of myopotential inhibition.
• Detection of pacemaker mediated tachycardia.
• Evaluation of antitachycardia pacing device functioning.
• Evaluation of rate-responsive physiologic pacing function.

Class II
• Routine pacemaker follow-up evaluation.
• Evaluation of atrial and/or ventricular sensing and pacing immediately after implantation of either dual- or single-chamber pacing devices.
• Evaluation of percent of time pacemaker is functioning and utilized in a 24-hour day.
• Evaluation of rate and supraventricular arrhythmias in patients with implanted defibrillators.

Class III
Evaluation of pacemaker failure identified by standard ECG or pacing surveillance instrumentation, or both.

Detection of Myocardial Ischemia

General Considerations
The application of ambulatory electrocardiography for the detection of myocardial ischemia is more recent than its use in arrhythmia detection and classification. The development was slowed by technical considerations that increased the complexity of the instrumentation required for accurate measurement of ST segment deviation. There is now convincing evidence that ST segment shifts of the ischemic type can be detected by ambulatory electrocardiography and assessed, provided that 1) the total system instrumentation from recorder through the analysis and playback components is adequate, and 2) developments in instrumentation are progressing rapidly in response to the growing clinical interest in ischemia not associated with angina (asymptomatic ischemia). 33–40 Instrumentation is evolving that is capable of examining two or more channels of data for changes in magnitude, integral area, and shape of the ST segment.

Predictive value. The predictive value of the ambulatory ECG for the detection of ischemia depends on the sensitivity and specificity of the test as well as the prevalence of the disease in the population being tested. The predictive value is low in asymptomatic patients without documented coronary artery disease primarily because many physiologic and technical factors that can alter the ST segment are unrelated to ischemia and, therefore, result in false-positive tests. In the presence of coronary artery disease, the predictive value for ischemia may be high in patients with typical angina, because, as is the case with the exercise ECG, the concomitant occurrence of ST segment changes and typical angina increases the specificity of the test.

Analysis and interpretation of ST segment deviation. Repolarization and, thus, ST segment configuration, may be altered by physiologic events other than ischemia, and these may occur with some frequency and to a changing degree in the ambulatory patient with coronary artery disease (postural changes, tachycardia, hypertension, sympathetic nervous system discharge, hyperventilation, left ventricular dimension and pressure changes, alterations in intraventricular conduction, and drug level fluctuations). Therefore, the criteria for ischemic ST segment changes on the ambulatory ECG must be interpreted with great care to preclude false-negative test results. ST segment evaluation, when used for research purposes where the instrumentation is accurate, the findings compulsively validated and the clinical variables recognized or controlled, is providing useful information. The significance of ischemic-type ST change, whether caused by ischemia or other factors altering repolarization as an independent risk factor, is under investigation, 38–40 as is the use of the ST segment as a method to assess the efficacy of antischemic therapy. The data relative to the technical and clinical criteria that must be met to assure appropriate clinical application of the findings from such studies are in rapid evolution and will facilitate utilization of ambulatory electrocardiography for the detection of ischemia, evaluation of therapy, and risk prediction.

The Subcommittee consensus at the present time is that further data relative to the utility of ST segment analyses for the evaluation of myocardial ischemia are required to prevent misuse of this important technology. Although there is increasing evidence that the information derived from ambulatory electrocardiography will be important in the management of ischemic heart disease, the Subcommittee has chosen a conservative approach until such time as the studies are more widely confirmed.

Classification of Indications for Ambulatory Electrocardiography for the Detection of Ischemia in Patients With Chest Pain

Class I
Patients with chest pain suggestive of Prinzmetal’s angina. In this group, ambulatory electrocardiography may demonstrate characteristic ST segment elevation at the time of chest pain and thus establish the diagnosis.

Class II
Symptomatic patients who are unable to be tested by treadmill or bicycle. Ambulatory electrocardiography can document ST segment shifts accompanying episodes of chest pain provoked by everyday stresses.

Class III
• Patients whose description of chest pain is classic for angina pectoris and who have one or more risk factors for coronary artery disease. The diagnosis of angina pectoris is almost certain in such patients, and its probability is unlikely to be improved further by ambulatory electrocardiography.

• Patients with atypical chest pain and one or more risk factors. In this group the diagnosis of angina pectoris is highly uncertain, and ambulatory electrocardiography is not the diagnostic procedure of choice.

• Patients with chest pain atypical for myocardial ischemia in the absence of coronary artery disease.
risk factors. Ischemia as a basis for chest pain is very unlikely in these patients, and ambulatory electrocardiography is not the diagnostic procedure of choice.

Classification of Indications for Ambulatory Electrocardiography for the Detection of Ischemia in the Asymptomatic Individual

Class I
None.

Class II
None.

Class III
- Primary detection of ischemia in the asymptomatic individual with known risk factors for coronary artery disease. There is increased probability of ischemia, but ambulatory electrocardiography is not the diagnostic procedure of choice.
- Detection of ischemia in the asymptomatic individual without identifiable coronary artery disease risk factors. Ischemia is very unlikely and ambulatory electrocardiography is not the procedure of choice.

Classification of Indications for Ambulatory Electrocardiography for the Primary Detection of Asymptomatic Ischemia in the Patient With Known Coronary Artery Disease

Class I
None.

Class II
- Postmyocardial infarction patients who have been known to have premature ventricular complexes. Some clinicians are employing ambulatory electrocardiography to determine whether ST segment changes and ventricular arrhythmias occur simultaneously, because this combination is thought to confer increased risk of death.
- Patients with chronic stable angina to assess efficacy of antiischemic therapy. Some clinicians are employing ambulatory electrocardiography to determine whether a patient’s therapeutic regimen is satisfactorily suppressing asymptomatic ischemia.

Class III
- For routine use after myocardial infarction.
- For routine use in the post revascularization patient, either after percutaneous transluminal coronary angioplasty or after coronary artery bypass grafting.
- For patients entering a cardiovascular rehabilitation program.

Classification of Indications for Ambulatory Electrocardiography to Assess Risk of Future Cardiac Events

Class I
None.

Class II
For risk prediction in patients with known coronary artery disease, anterior myocardial infarction, and stable or unstable angina when combined with confirmatory stress testing.

Class III
For risk prediction when used as a sole test.

References


38. Sweet RL, Sheffield LT: Myocardial infarction after exercise-induced electrocardiographic changes in a patient with variant angina pectoris. Am J Cardiol 1974;33:813-817


Guidelines for ambulatory electrocardiography. A report of the American College of Cardiology/American Heart Association Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Subcommittee on Ambulatory Electrocardiography).
S B Knoebel, M H Crawford, M I Dunn, C Fisch, J S Forrester, A M Hutter, Jr, H L Kennedy, R L Lux, L T Sheffield and C Fisch

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