

The Spectrum of Ambulatory Electrocardiographic Monitoring

Harry G. Mond, OAM, MD, PhD, FRACP, FACC, FCSANZ^{a,b*}

^aDepartment of Cardiology, The Royal Melbourne Hospital, and University of Melbourne, Melbourne, Vic, Australia

^bCardioscan Pty Ltd, Melbourne, Vic, Australia

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Since its introduction as a clinical investigative tool, the 12-lead electrocardiograph (ECG) has been the gold standard for recognition of cardiac arrhythmias. The resting 12-lead ECG, however, gives only a rhythm snapshot in time, whereas arrhythmias may be short-lived, paroxysmal and even asymptomatic making documentation in many patients very difficult. To overcome this, ambulatory ECG monitoring has been developed as a means of recording the ECG in patients over a set period of time, whether it be short-, medium- or long-term. With the miniaturisation of recording devices and advances in solid state technology, there has been a recent revolution in hardware design, so that the boundaries between these time-dependent devices have become blurred. Not surprisingly, the indications for monitoring have broadened as the quality and range of monitoring devices have become available. In this review, the indications for ambulatory ECG monitoring with emphasis on non-arrhythmic indications such as ST segment analysis, heart rate variability, signal averaged ECGs, diurnal QT and QTc analysis, obstructive sleep apnoea and vectorcardiography will be discussed. Also, the types of electrode systems used, lead placement, monitoring hardware, data collection, analysis and presentation as well as cost effectiveness of the investigation will be covered.

Keywords

Electrocardiography • Electrocardiographic monitoring

Introduction

The resting 12-lead electrocardiogram is a surface record of the electrical activity of the heart plotted against time with the actual standardised recording of the non-invasive test being an electrocardiograph (ECG). Initially designed for clinical application by Einthoven in 1901, the test, since that time, has served as the gold standard for arrhythmia recognition. The resting 12-lead ECG, however, gives only a snapshot in time, whereas arrhythmias may be short-lived, paroxysmal and even asymptomatic making documentation difficult. In order to be able to monitor cardiac rhythms for longer periods, ambulatory ECG monitoring was initially suggested by Paul Dudley White, the eminent American pioneer in cardiology and the challenge was taken up by a Montana physicist and inventor, Norman “Jeff” Holter. His initial working model was a 39 kilogram portable battery

operated radio transmitter and receiver which was carried on the back of the subject. The tape recorder had a playback with the analysis time equal to the recording time. In 1962, commercial production commenced by Del Mar (Del Mar Avionics, Irvine, CA, USA) on a much smaller, lighter and quicker to analyse, two channel portable magnetic tape recorder which was marketed as the Holter monitor. Subsequent advances in electronic engineering, monitoring, storage and miniaturisation has led to the modern sophisticated units, we take for granted today.

Types of Ambulatory ECG Monitoring

There are three methods of ambulatory ECG monitoring; short-, medium- and long-term. With advances in data

*Corresponding author at: Department of Cardiology, The Royal Melbourne Hospital, 3050, Victoria, Australia. Tel: +613 9527 9243, Fax: +613 9527 9262., Email: hmond@bigpond.net.au

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collection and transmission, the indications for ambulatory ECG monitoring have broadened, so that these groups overlap, but for descriptive purposes, this remains the most appropriate way of grouping a diverse array of hardware. Another simple, but well recognised category of monitoring, continuous and intermittent recording, also suffers from technology overlap [1].

Short-term (12 Hours to One Week). Holter Monitor

The modern Holter monitor is very small, inexpensive and now can be performed for up to one week in the same subject. The digital recording devices use memory cards or can be solid state with rapid download times. For analysis, there are high-speed playback and sophisticated computerised software together with standardised summary reports. Although used predominantly for arrhythmia recognition, Holter monitoring can also be used for non-arrhythmic indications.

Medium-term (One Week to One Month). Event Monitor

There are many different designs of monitors in this group. The original and simplest design still available today, is the patient activated event recorder. This may be a small monitor either attached to the chest wall with electrodes or directly applied during symptoms using fixed electrodes on the back of the device. Unlike a 12-lead ECG recording, the event monitor is activated during patient symptoms and is most useful for infrequent arrhythmia documentation.

Loop recorders are medium-term event recorders, which continually monitor patients and document arrhythmias for a fixed period immediately prior to activation and for a set period after activation. In recent years, event recorders with arrhythmia recognition algorithms have become available, which automatically record on arrhythmia detection, thus not necessarily requiring patient activation. They may also be able to automatically transmit to a central station following a recording. Because these devices continually monitor the patient they are referred to as *ambulatory cardiac telemetry devices* and are frequently used for up to 30 days. In this group, much of the recent development centres on the identification of atrial fibrillation, particularly those asymptomatic patients with cryptogenic stroke or following pulmonary vein ablative therapy. They may use novel patch electrodes which only require weekly replacement and allow the patient to shower with the monitor attached. The technology for these devices is continually evolving and it is anticipated that they will play a larger role in the future.

Long-term (Two to Three Years). Implantable Loop Recorder

These have been available for many years, but recent advances particularly in miniaturisation, make this form of

monitoring much more desirable. They can now be implanted in the doctor's office or in an out-patient setting with minimal sedation or local anaesthesia. They too, can be designed to transmit data remotely to a central office, although this can be energy expensive and generally the patient needs to attend a centre where a programmer is used to retrieve the stored data.

Indications for Ambulatory ECG Monitoring

Just as the technology and range of devices for ambulatory ECG monitoring have expanded, so have the indications for these studies. Although the major goal is arrhythmia recognition, a much smaller non-arrhythmic group is now emerging. The list of indications in Table 1 presents considerable overlap and fails to clearly define the importance and even the relevance of each group. To some extent, this has been addressed in the 1999 American College of Cardiology/American Heart Association guidelines for ambulatory electrocardiography and reproduced in Table 2 [1]. Although almost 20 years old, these guidelines still provide perspective on the relevance of the more established indications. With time, as experience with each form of monitoring is obtained, the indications will become stratified into clearer indication groups.

Table 1 Indications for ambulatory ECG monitoring.

Arrhythmia indications:

Cardiac palpitations
Unexplained syncope and dizziness
Suspected slow heart rhythms
Hereditary "electrical" abnormalities
Evaluate the abnormal ECG; ectopy and heart block
Cryptogenic stroke evaluation "neuro-cardiology"
Evaluation of success of either antiarrhythmic or ablative therapy
Evaluation of ventricular tachycardia
Paediatric monitoring
Following acute myocardial infarction
Congestive and hypertrophic cardiomyopathy
Monitor cardiac implantable electronic device therapy
Chest pain or dyspnoea thought to be associated with arrhythmias

Non-arrhythmia indications:

ST segment analysis
Heart rate variability
Signal-averaged ECG
Monitoring changes in QT and QTc intervals
Obstructive sleep apnoea
Vectorcardiography

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