Ambulatory cardiac rhythm monitoring

Cardiac arrhythmias may cause palpitations, dyspnoea, angina pectoris, dizziness or even syncope and sudden death. This article will review the indications for investigation, the novel devices that are available for investigating patients with suspected cardiac dysrhythmias and the new technology available for analysis and reporting.

Cardiac arrhythmias may cause palpitations, dyspnoea, angina pectoris, dizziness or even syncope and sudden death. A 12-lead electrocardiogram (ECG) may reveal the nature of the arrhythmia when symptoms are present and may show features which reflect a predisposition to arrhythmias such as a short PR interval/delta wave or QT prolongation. Although for those patients whose symptoms are intermittent, diagnosis can be more difficult, a variety of techniques are now available to identify the problem and guide appropriate treatment. Fortunately, the microchip era has given rise to technological innovations which may help in different clinical situations – based mainly on the frequency, nature and duration of a patient's symptoms. These may include continuous Holter analogue or digital ECG tape recorders, intermittent 'post-symptom' event recorders, external and implantable 'loop' recorders. This article will review the indications for investigation, the range of technology that is currently available for investigating patients with suspected cardiac dysrhythmias, how to choose the most appropriate device, as well as the technology available for analysis and reporting.

Indications for ECG monitoring

Patients with palpitations (frequent or intermittent), dizziness, syncope or even dyspnoea should be considered for ambulatory ECG (AECG) recordings if paroxysmal cardiac dysrhythmias are a possible cause and a 12-lead ECG is not diagnostic (Zimetbaum and Josephson, 1998; Brignole et al, 2004). Other indications for AECG monitoring are shown in *Table 1*. Guidelines for AECG have been published (Crawford et al, 1999).

Choosing the most appropriate device

If when symptoms occur, they are prolonged and last long enough to get to a hospital, patients should be advised to attend for a 12-lead ECG as this is likely to be diagnostically helpful. Patients should be given a letter to take with them indicating why the ECG is being requested and the patient should receive a copy of the ECG to take to his/her cardiologist (*Figure 1*). Alternatively, the type of diagnostic device should be tailored to each individual's symptom history. There are a wide range of AECG recorders currently available, which may be classified as 'continuous' or 'event' recorders (*Table 2*). For patients with symptoms, the number and quality of recordings during symptoms are important.

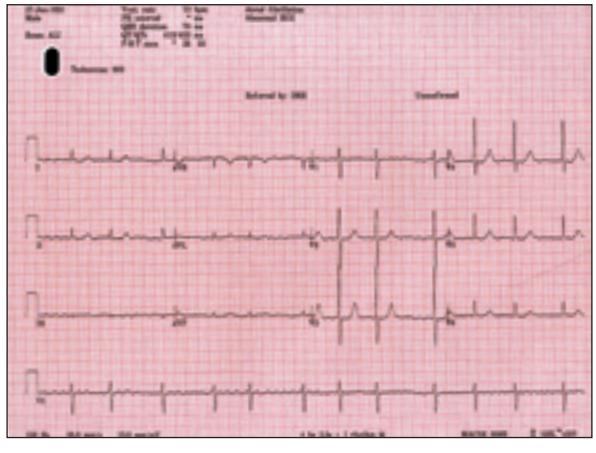
When symptoms are relatively frequent, e.g. daily or almost daily, continuous Holter monitoring is appropriate. This type of recording is also useful for patients who have complete loss of consciousness when they would be unable to attach or activate an event recorder. Devices are available that can record for 24, 48 and 72 hours when the device is then removed for analysis. The Vista Plus (Novacor, Cedex, France) can record a continuous ECG digitally for 8–11 days.

Simple event recorders or loop recorders are appropriate when intermittent symptoms are less frequent and

Table 1. Indications for ambulatory electrocardiogram recording

Detection of arrhythmia in patients with dizziness, syncope, near syncope, palpitations and less commonly dyspnoea, angina pectoris, weakness or neurological symptoms
Detection of arrhythmia to assess risk of future cardiac events
Measurement of heart rate variability to assess risk of future cardiac events
Assessment of antiarrhythmic therapy
Assessment of pacemaker and automatic implantable cardioverter/defibrillator function
ST segment monitoring for silent ischaemia

Figure 1. 12-lead electrocardiogram confirms atrial fibrillation in this patient with intermittent palpitations.



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short-lived but occur within a 2–6-week period and noticeable enough for the patient to record the 'event' by use of the event recorder button or the signal to save the relevant ECG loop on loop recorders. An event recorder is useful for infrequent, less serious but sustained symptoms that are not incapacitating, but are of little help in patients with serious symptoms such as syncope or near syncope, as it may take some time to find, apply and activate the device. Although a loop recorder is indicated if symptoms are too brief to allow attachment or activation of the simple event recorder, these too have limitations if loss of consciousness is associated with prolonged disorientation on awakening that would prevent the patient from activating the device. For external loop recorders, the electrodes will have to be changed every few days to avoid skin irritation and to optimize the quality of the recording. Three-lead ECG recordings are likely to be more helpful than single-lead ECGs, although rhythm analysis should be possible from the latter. Digital recordings may be more useful than analogue ones. Examples of AECG recordings are shown in *Figure 2*.

For patients with less specific symptoms, e.g. dyspnoea or dizziness, continuous ECG recording is likely to be most useful, and for those with unexplained, intermittent syncope or very infrequent symptoms suggestive of arrhythmia, an implantable loop recorder might be most appropriate – usually after attempts to record an ECG with an external loop recorder during symptoms have been unsuccessful.

Mobile outpatient cardiac telemetry using the CardioNet (CardioNet Inc, San Diego, USA) provides home-based, real-time cardiac rhythm surveillance and patients with certain pacemakers and automatic implantable cardioverter/defibrillators (AICD) may be fortunate enough to have a diagnostic Holter monitoring facility within the device which is helpful in detecting variations in heart rates, the frequency of abnormal rhythms and the therapies delivered.

Types of device

Continuous ECG Holter recorders

The patient goes about his/her usual daily activities while wearing a small, battery-operated, portable recorder that connects to bipolar electrodes on the patient's chest. The patient is required to keep a time diary of all activities and symptoms and when appropriate to activate an event marker to allow correlation between symptoms and ECG abnormalities. Over time, this test will hopefully show changes in rhythm that may not be detected during a resting or exercise ECG. Although asymptomatic arrhythmias and arrhythmias associated with loss of consciousness may be identified, this type of monitoring has low sensitivity (15–22%) in patients with syncope and/or palpitations of unknown origin.

Older devices magnetically record the ECG as an analogue signal on cassette tape (C60/C90) (*Figure 3*), while more modern, solid-state devices record the ECG digitally on memory cards within the recorder. Direct digital recordings avoid the artifacts that may be produced by mechanical recorders and the limitations of data recorded in analogue format. Currently available continuous Holter ECG recorders are shown in *Table 3*. Some can record continuous ECG from between 24 hours to 11 days.

The Vision 5L (Burdick, Bothell, WA, USA) weighs 112 g and can record high quality 3-channel ECG for up to 48 hours on a compact Flash card. Data can be downloaded and analysed rapidly using Vision Premier software on a Windows-based PC (*Figure 4*). The Q-Track I/II (Quinton, Bothell, WA, USA) can record 12-chan-

Table 2. Holter recorders

Continuous recorders (with event marker facility), e.g. Vision 5L		
Event recorders	External loop recorders	Post-symptom recorder (no memory loop), e.g. CorDigital MicroER
		Pre/during/post-symptom (memory loop) recorder, e.g. R Test Evolution 3
	Implantable loop recorders	Patient-activated, e.g. Reveal
		Automatic, event-activated, e.g. Reveal Plus

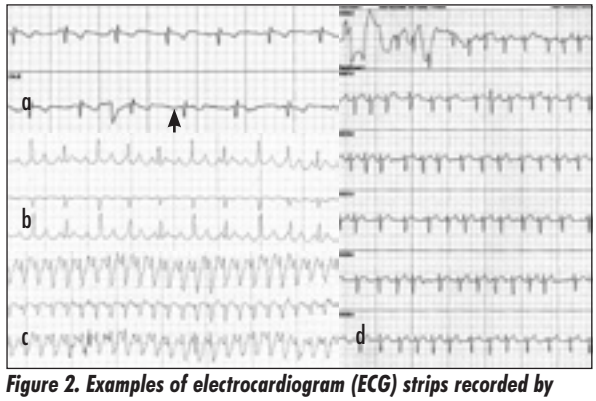


Figure 2. Examples of electrocardiogram (ECG) strips recorded by this 24-hour ambulatory ECG device in a single patient. ECGs show: a. Sinus rhythm (arrow = P wave). b. Atrial flutter with 3:1 block. c. Atrial flutter with 2:1 block and aberrant conduction. d. Atrial fibrillation.

Figure 3. Cassette tape recorders are still used in many electrocardiogram departments for the continuous 24-hour ambulatory electrocardiogram monitoring, but are being replaced by solid-state digital recorders.

Table 3. Continuous recorders
Aria Digital (Del Mar Reynolds Medical, Hertford, Herts, UK)
Cardio Card (Nasiff Associates, Brewerton, NY, USA)
C.Net2000+ (Cardionetics, Fleet, Hampshire, UK)
H3+ (Mortara, Milwaukee, WI, USA)
LifeCard CF (Del Mar Reynolds Medical, Hertford, Herts, UK)
Oxford Medilog AR4 (Cephalon, Nørresundby, Denmark)
AB-180R Digital Holter (Advanced Biosensor, Columbia, SC, USA)
Q-Track I /II (Quinton, Bothell, WA, USA)
Seer Light (Marquette/GE, Little Chalfont, Bucks, UK)
Spiderview (ELA/Sorin, Arvada, CO, USA)
Trillium 5000 (Forest Medical, East Syracuse, NY, USA)
Vision 5L (Burdick, Bothell, WA, USA)
Vista Access/Plus (Novacor, Cedex, France)

nel ECG digitally for 24 hours, can detect pacemaker function and atrial fibrillation and is capable of ST analysis. The data can be downloaded and scanned in <90 seconds. The Vista Plus device can record 1–3 channel ECG for 8–11 days. This credit card-size device can be worn around the neck attached to the patient by the special 5-lead cable. The Seer Light Extend (Marquette/General Electric Healthcare UK, Little Chalfont, Bucks, UK) compact digital recorder provides 2- or 3-channel ECG recording for up to 48 hours and has an easy-to-find patient event button. The PC-based MARS Holter (GE Healthcare UK, Little Chalfont, Bucks, UK) monitoring system is used for analysis. The C.Net2000 (Cardionetics, Fleet, Hampshire, UK) uses neural network computing to analyse the ECG in real time and has been shown to be useful in general practice (Standing et al, 2001). An easy-to-read report with classification of arrhythmias and sample ECG traces is available quickly after downloading the recorded data.

Figure 4. a. Monitor and PC loaded with specific software for ambulatory electrocardiogram analysis. b. Vision 5L recorder, memory card (single arrow) and card reader (double arrows). c. Vision 5L recorder with memory card in card reader.

Table 4. External event recorders	
Post-symptom without memory loop	CardioCall VS20 (Del Mar Reynolds Medical, Hertford, Herts, UK)
	CorDigital Micro ER (Instromedix, Rosemont, IL, USA)
	CG-5000 (CardGuard, Neuhausen am Rheinfall, Switzerland)
	HeartOne (Aerotel, Holon, Israel)
Pre-/post-symptom with memory loop	CardioCall VS20 (Del Mar Reynolds Medical, Hertford, Herts, UK)
	CorDigital Micro LR (Instromedix, Rosemont, IL, USA)
	CG - 6106 CardGuard, Neuhausen am Rheinfall, Switzerland)
	Genesis (Lechnologies, Sussex, WI, USA)*
	Heart 2005/2006A (Aerotel, Holon, Israel)
	LifeWatch Explorer (Instromedix, Rosemont, IL, USA)
	King of Hearts Express/+/AF (Instromedix, Rosemont, IL, USA)
	SpiderFlash (ELA/Sorin, Arvada, CO, USA)
	R Test Evolution 3 (Novacor, Cedex, France)†
	Recollect Mini Holter (CardioControl, Aston Abbotts, Bucks, USA)

*Currently available in USA; †Fully programmable, automatic cardiac event recorder

External 'post-symptom' event recorders

These small portable devices are kept in the continual possession of the patient during the prolonged monitoring period. During symptoms, the patient places the device on the chest and starts the recorder by pressing an activation button. After a 10-second or so sample of ECG (usually a single lead rhythm strip) has been recorded, this can be transmitted to the monitoring station as per instructions. The patient keeps the device until several recordings have been made or for an agreed period (maybe 2–6 weeks). These devices only allow capture of data once the activation button has been pressed and studies have shown that short-lived arrhythmias may frequently be missed by these 'post-symptom onset' recorders. Currently available event recorders are shown in *Table 4*.

The CorDigital Micro ER (Instromedix, Rosemont, IL, USA) recorder/transmitter weighs only 42 g and fits into a patient's pocket, purse or handbag (*Figure 5a*). At the onset of symptoms, the patient simply holds the device on the chest and presses the 'record' button, which records and stores 32 seconds of real-time ECG in solid-state memory. Six events can be stored before it is necessary to transmit the information to the receiving centre. The Cardiocall VS20 (Del Mar Reynolds Medical, Hertford, Herts, UK) device (*Figure 5b*) can be used as a simple event recorder. By connecting an electrode to the chest this device may be used as a loop recorder (*Figure 5c*). Using a credit-card like programmer, the direct contact/looping mode together with the number of recording channels and the pre- and post-activation times can be selected (*Figure 5d*). For 'post-symptom' event recorders, transmission of the ECG rhythm is usually done by dialing up the receiving centre, holding the recorder over the mouthpiece of the patient's own telephone handset and pressing a 'send' button on the recorder (*Figure 6*). The ECG recording is received and printed out at the receiving centre.

External 'pre-/post-symptom' event loop recorders

These devices are useful for intermittent symptoms which are short-lived, when other recorders have proved unsuc-

cessful in capturing an event. The patient wears the digital recorder and electrodes over a few days to several weeks (2–4 weeks), constantly recording a 1–3 lead ECG. When an arrhythmia is felt, he/she can activate a record feature that has been programmed for that particular individual, e.g. this might enable capture of the ECG for any set period up to and including the event and after the event as a loop of ECG. If no event is detected, the loop is continually renewed and erased. When a telephone is accessible, the patient can transmit the captured information from the memory to the monitoring station. These devices are useful for patients with syncope, since the record button can be pressed once consciousness has been regained, which will capture the ECG before, during and after the symptoms. Some devices can also be programmed to automatically record one or more specific arrhythmias. Currently available external loop recorders are shown in *Table 4*.

The Cordigital Micro LR (Instromedix, Rosemont, IL, USA) (*Figure 7b*) can store up to 6 events totaling 524 s and has a battery life of 62 days or 150 recordings. The King of Hearts Express (Instromedix, Rosemont, IL, USA) (*Figure 7c*) is a small and easy to use, programmable device and can be worn on the waist, in the shirt pocket or on a cord around the neck. To record an event, the patient presses the record button and to transmit the event, simply dials up the receiving centre by telephone and places the device over the telephone's mouthpiece to transmit the stored ECG for analysis. The King of Hearts Express + and AF recorders can be programmed to automatically detect bradycardia, tachycardia and atrial fibrillation. Genesis (Lechnologies, Sussex, WI, USA) (*Figure 7a*), allows either a 1 or 2-channel recording, programmable for up to eight events (from 1–8 minutes each, pre and post), a total memory of 8 minutes of 2-lead ECG data and can automatically transmit 30 seconds of direct data before the memory transmission is made. This is important for ongoing serious arrhythmias such as ventricular tachycardia. It is small and lightweight, can fit in a shirt pocket or clip on a belt and with a single coin cell has 30 days of battery life. There is also automatic detection of electrode or lead detachment. The R Test Evolution 3 (Novacor, Cedex, France) weighs 45 g and is fully programmable to automatically capture a variety of cardiac arrhythmias, ST shifts and pacemaker spikes with programmable pre- and post-event times (*Figure 8*).

Implantable loop recorders

The Reveal (patient-activated) and Reveal Plus (autoactivated) both allow 14 months monitoring, 42 minutes of memory, continuous recording and are available from Medtronic, Inc (Minneapolis, Minnesota, USA). The Reveal loop recorder (*Figure 9*) is an implantable, patient-activated monitoring device which continually records subcutaneous ECG and is indicated for patients who experience transient symptoms that may suggest an arrhythmia and for those with clinical syndromes or situations that put them at risk of cardiac arrhythmias.

The device is 6.1 x 1.9 x 0.8 cm, weighs 17 g and has two bipolar sensing leads 3.7 cm apart within the shell of the device. Under local anaesthesia, the device is placed

Figure 5. Non-looping, post-symptom, event recorders include (a) CorDigital MicroER and (b) Cardiocall VS20. This can be clipped onto a waistbelt. Its four metal feet are placed on the chest to record the electrocardiogram event. c. With electrodes attached to the chest, the device can be used as a loop recorder. d. The Cardiocall VS20 is set up using this credit card-like programmer.

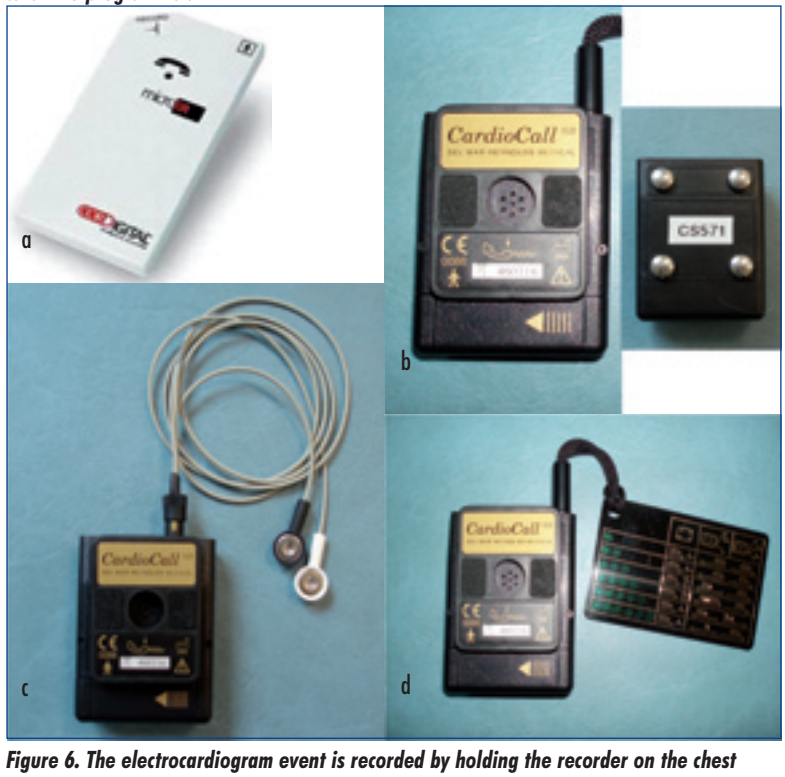


Figure 6. The electrocardiogram event is recorded by holding the recorder on the chest and pressing a 'record button'. The patient then transmits the electrocardiogram down a standard telephone line to a receiving centre.

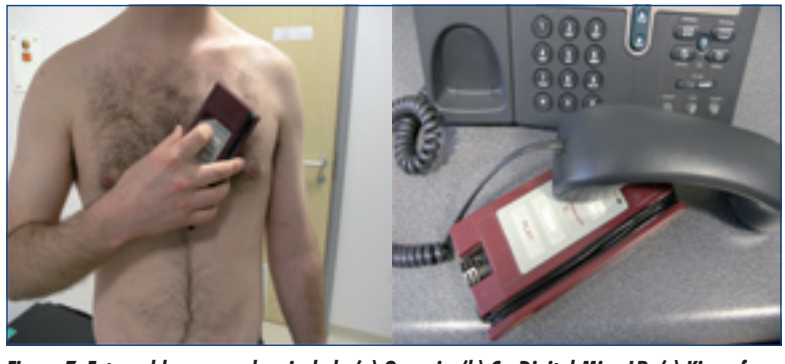
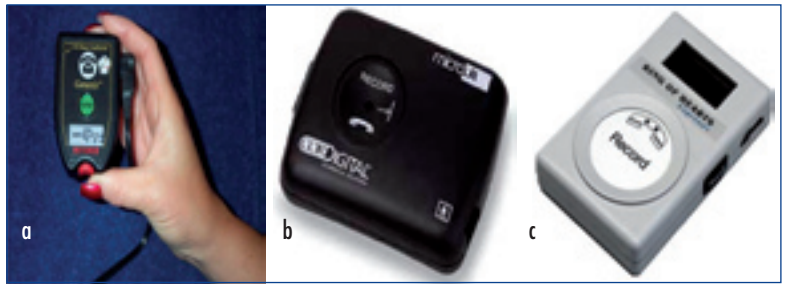


Figure 7. External loop recorders include (a) Genesis, (b) CorDigital MicroLR, (c) King of Hearts Express.



subcutaneously in the right or left pectoral region using non-absorbable sutures. When symptoms occur, the patient can place a hand-held activator over the device to activate storage of a memory loop of the cardiac rhythm. The pre-activation and post-activation periods are programmable. The Reveal Plus has an autoactivation component – rhythms are automatically recorded when the heart rate exceeds or falls below a certain preset limit. Both possess 42 minutes of memory for standard ECG and have a high (60–88%) diagnostic yield. The device can be programmed and data is retrieved using the portable Medtronic 9790 Programmer. Up to 14 months of monitoring is possible.

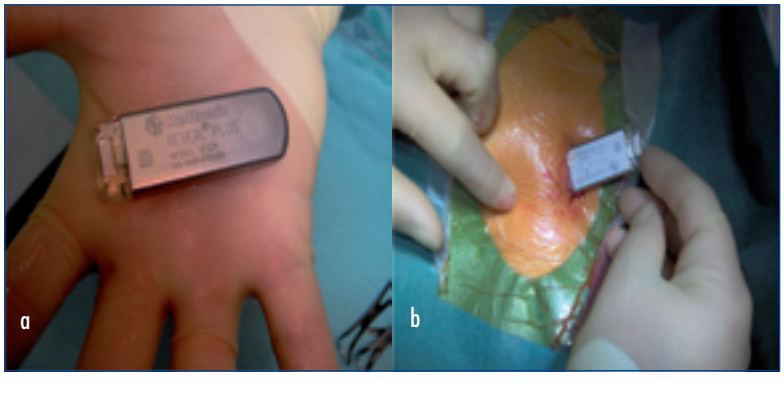
Patients should avoid sources of magnetic imaging, diathermy, high sources of radiation, electrosurgical cautery, defibrillation, lithotripsy and radiofrequency ablation to avoid damage to the device and/or inappropriate sensing. The device should be removed under local anaesthesia once the relevant diagnostic information has been revealed or when the battery is depleted. The cost is approximately £1450.

Combined ECG and ambulatory blood pressure recorder

For those patients with dizziness, syncope or presyncope, where it is difficult to know whether arrhythmia or hypotension may be responsible, a dual device which records ECG and ambulatory blood pressure might be useful (*Figure 10*). The Duolter and Triolter (Novacor, Cedex, France) are examples of such devices.

Figure 8. R Test Evolution 3 recorder is worn around the neck and has multiple programmable features.

Figure 9. a. Reveal Plus insertable loop recorder. b. Device being implanted subcutaneously in the left pectoral region.



Pacemakers and implantable automatic implantable cardioverter-defibrillators

Trans-telephonic monitoring of pacemakers has existed for many years. It requires the patient to apply a transmitter over the skin which transmits the ECG as an audio signal to a pacemaker clinic. Modern pacemakers and AICDs are equipped with 'diagnostic' monitoring capabilities. They are based on continuous rhythm monitoring, in which data are stored in the form of histograms that track variance and trends in heart rate. AICDs provide detailed information on the detection of abnormal rhythms and the therapies delivered. Interrogation will provide a log of events and allow direct visualization of ECGs. A newer generation of pacemakers and AICDs allows patients to send diagnostic information to their cardiologist as frequently as is necessary using cellular technology and standard telephones. This will reduce the need for hospital visits.

Mobile outpatient cardiac telemetry

The CardioNet (CardioNet Inc., San Diego, CA, USA) is an AECG arrhythmia detector with an alarm and extended memory that provides mobile, home-based, real-time cardiac rhythm surveillance. It includes a lightweight 3-lead sensor worn as a pendant or on a belt clip which records 2 channels of ECG. The sensor constantly communicates with the CardioNet monitor, a unit about the size of a Palm Pilot, which can be kept in a pocket or purse. Arrhythmias can be automatically detected and transmitted by cellular telephone so that abnormal ECG waveforms can be sent immediately to the remote monitoring centre. It is able to store up to 72 hours of ECG waveforms. The ECG recordings can also be transmitted over standard telephone lines to the centre at the end of each day or at any time if the patient notices symptoms. It is still being evaluated but should overcome some of the problems associated with continuous Holter recorders. The HEARTLink II Telemetry @ Home Service (Cardiac Telecom, Greensburg, PA, USA) is a similar automatic arrhythmia detection system.

Figure 10. The Duolter can record ambulatory electrocardiograms and ambulatory blood pressure.

Skin preparation and patient education

Before attaching ECG electrodes to the patient's chest, hair should be removed and the skin carefully prepared using a skin abrasive pad and skin cleanser. Where necessary, patients should be taught the technique when they are required to change and move the electrodes. The electrode position is shown in *Figure 10*. Patients should be carefully informed about the purpose of their monitoring device, how it functions, how to record an event and how to download recordings (where appropriate) to a receiving/diagnostic centre. They should be taught to use a diary card and given general advice about wearing the equipment, e.g. avoiding showering.

Rhythm analysis

Generally, once the ambulatory recording has been made, the data on the tape or memory card will need to be downloaded and then analysed on a specific, dedicated analyser available from the same company as the recorder or by using (usually Windows-based) software which enables analysis on a department's PC (*Figure 4*). The modern, compact low-profile recorders save their digital ECG recordings on removable memory Flash cards (*Figure 4*) which can then be downloaded rapidly onto the PC using a USB cable or Flash card reader. Solid-state recordings can be analysed immediately and rapidly and some devices have microprocessors that can present on-line analysis of the QRST complexes. The type of ECG analysis and report printouts can be custom-designed from software menus. Besides detailed arrhythmia analysis (including full disclosure and printouts), heart rate variability, QT interval duration and ST segment analysis may be available options. An example is shown in *Figure 11*. Fax, modems, networks and internet integration allow for rapid distribution of digitally-recorded data and analysis to the relevant, interested personnel.

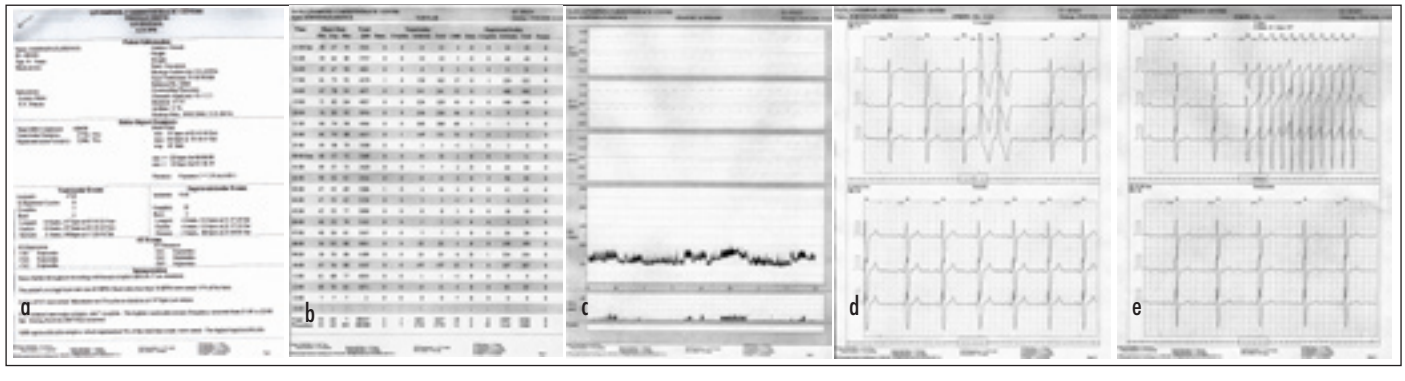
Discussion

For patients with paroxysmal cardiac arrhythmias, a 12-lead ECG during an episode is perhaps the most useful diagnostic investigation. However, for most patients who are unable to get to hospital for this to be done, there are now a range of devices designed to capture an ECG during symptoms and help clinch a diagnosis and guide treatment.

Although a 24-hour continuous ECG recorder might capture an episode, the sensitivity is low (15–22%) in patients with syncope and/or palpitations of unknown aetiology (Di Marco and Philbrich, 1990; Linzer et al, 1997). It may be helpful in demonstrating other conduction abnormalities. For example, in patients with sick sinus syndrome and palpitations, it may show features consistent with this diagnosis such as brief periods of sinus arrest, short runs of asymptomatic atrial tachycardia, atrial flutter or fibrillation. Longer periods of monitoring using modern solid-state recorders should improve the sensitivity and diagnostic yield. The role for mobile outpatient cardiac telemetry remains to be established but looks promising if the resources can be found (Kowey and Kocovic, 2003; Kowey et al, 2003).

For less frequent symptoms, event recorders are useful as long as the duration of the symptoms is long enough for the individual to record the ECG by pressing the 'record' button while holding the device on the chest. Unfortunately, these devices are unable to capture a diagnostic ECG during a sudden syncopal episode or the period directly before arrhythmia onset. For example, it may fail to demonstrate that the identified atrial fibrillation actually follows a period of severe bradycardia such as sinus arrest in sick sinus syndrome – which may have important prognostic and therapeutic implications. External loop recorders are able to overcome this shortcoming and the optimum duration of monitoring ranges from 2–4 weeks (Zimetbaum and Josephson, 1998). The technology to allow automatic activation of the device on the basis of predetermined rhythm specifications (such as minimum and maximum heart rate and heart rate irregularity) is rapidly evolving. A high degree of specificity is achieved by requiring the patient to activate the monitor at the time of symptoms. In a study of patients with palpitations, sensitivities of 66–83% have been reported (Kus et al, 1995; Zimetbaum and Josephson, 1998). For

Figure 11. Analyses and reports can be customized using the software purchased from the relevant manufacturer. This data from the R Test Evolution 3 shows: a) a summary report; b) arrhythmias in tabular format (by the hour); c) hourly heart rate/ventricular ectopic count graphs; d) sample electrocardiogram showing ventricular couplet and e) run of ventricular tachycardia.



dizziness, presyncope and syncope, loop recorders provide significantly higher diagnostic yields than continuous Holter recorders and their cost effectiveness has been demonstrated (Fogel et al, 1997; Krahn et al, 1999; Sivakumaran et al, 2003). However, reapplying ECG electrodes to the skin on a daily basis is inconvenient and sometimes uncomfortable. Patient-activated devices will not record asymptomatic arrhythmias or arrhythmias associated with loss of consciousness, although newer external loop recorders with programmable, automatic detection of bradyarrhythmias or tachyarrhythmias should overcome these limitations (Reiffel et al, 2005). The implantable loop recorder is a more recent addition to diagnostic strategies for patients with syncope (Krahn et al, 1999). It enables long-term cardiac monitoring to capture ECG during a spontaneous episode in patients with infrequent symptoms and produces a higher diagnostic yield than Holter monitoring (Kenny and Krahn, 1999; Sivakumaran et al, 2003; Krahn et al, 2004a). The auto-activation feature of the second generation implantable loop recorders is probably more effective in detecting arrhythmias compared with manual activation alone (Ermis et al, 2003; Farwell et al, 2004; Krahn et al, 2004b).

Current digitally-acquired ECG recordings can now be downloaded and analysed rapidly (<2 minutes) in contrast to the analogue tape recorders and older analysers of only a few years ago. This advance has significantly improved the usefulness and efficiency of arrhythmia detection services.

Conclusions

A variety of devices are now available for helping capture intermittent cardiac arrhythmias and help in diagnosis and treatment of patients with palpitations, dizziness or syncope. Research on the nature and frequency of arrhythmias in specific cardiac conditions and the effects of new devices and antiarrhythmic agents in clinical trials has been made much easier by today's advances in the technology. Current solid state, digital ECG recorders which store information on memory cards enable prolonged multilead, monitoring – either continuously or in an event or loop memory fashion, and recently, implantable loop recorders have been introduced for the more diagnostically-difficult cases. Software is now available which enables sophisticated analysis of the ECG recordings and is becoming more commonly PC-based rather than only being available on expensive, unit-specific analysers. **BJHM**

KEY POINTS

- Cardiac arrhythmias may cause palpitations, dyspnoea, angina pectoris, dizziness or even syncope.
- Ambulatory electrocardiogram (ECG) monitoring is indicated in the investigation of these patients if a resting 12-lead ECG is diagnostically unhelpful.
- Current monitoring devices include continuous 1–12-lead ECG recordings, post-symptom event recorders, external and implantable 'loop' recorders and 'dual' ECG/blood pressure ambulatory monitors.
- Some pacemakers and ambulatory implantable cardioverter/defibrillator units have internal Holter monitoring facilities.
- ECG data may be saved on cassette tape but is now more often saved digitally on memory cards.
- Unit-specific analysers or Windows-based software programs enable rapid downloading of the data using a USB cable or Flash card reader and comprehensive analysis including full arrhythmia and ST analysis, heart rate variability and QT analysis, pacemaker detection and comprehensive report printing.

Conflict of interest: none.

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