Home Recording of Arrhythmias by Patients using a Portable Electrocardiograph

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Twenty-four hour ambulatory electrocardiographic monitoring will detect frequently recurring abnormal rhythms, but when the interval between arrhythmias is several days or longer it becomes increasingly impractical and expensive to use this technique[1,2]. We describe the development and clinical use of a simple, cheap machine that can be used by patients to record their rhythms as they occur. It is based on an inexpensive domestic tape-recorder that is familiar to most patients.

The Portable Short Electrocardiogram (PSE)

The recording system comprised a domestic portable cassette recorder modified internally to record an ECG signal, plus a separate replay demodulator. The cassette recorder was the Sony model TCM-757. The circuitry required to convert the ECG signal to one suitable for recording was contained on a purpose-built printed circuit board located in the space normally occupied by the loudspeaker. The input was derived in the conventional way from three colour-coded chest electrodes and was then fed into the purpose-built circuit where it was converted into a frequency-modulated signal suitable for recording. There was a simple on/off switching mechanism, also colour-coded, and two small lights were provided; one showed the condition of the battery, the other was to inform the patient if the recording was satisfactory. The light was triggered to flash on each ‘R’ wave, a continuous glow indicating the need to reapply the electrodes.

A simple booklet, with the method set out in numbered steps, together with a diagram of the chest with the coloured lead placem ents, was also provided. Since elderly patients had difficulty in reading small print, the booklet was produced in large type. The recorder, booklet, electrodes, and a supply of isopropyl alcohol-impregnated swabs and dry gauze swabs were supplied in a small case for convenience.

When an ECG had been recorded, the PSE was returned by the patient for replay at a later date. To do this, the recorder was connected via the earphone socket to the demodulator unit containing the circuits required to convert the frequency-modulated signal produced by the recorder back to the original signals produced by the patient. The gain of the system was set so that the demodulated signal was of the same amplitude as the original. A Cambridge VS4B, or similar electrocardiograph, was connected to the output terminals of the demodulator. The tape was then replayed in the normal manner into the demodulator, and the resulting output signal recorded by the electrocardiograph after monitoring on a Life Trace oscilloscope.

The estimated cost of the PSE recorder is under £300 and the demodulator is £150. Any number of recorders can be used with a single demodulator, and an appropriate package of recorders and demodulator will be supplied by the manufacturers under the provisional name of the ‘Cardiolan’.

Use of the PSE

During the development stages 66 volunteers, age range 13-76 years (mean 46.7 years), used the recorders. Twenty-seven recordings in 24 subjects were made with the electrodes applied by medical staff. The frequency response of the PSE was checked and modified during the period in which these observations were made, in comparison with ECGs taken from these electrodes direct to a Cambridge VS4B electrocardiograph.

A further 42 subjects were shown how to use the PSE, using the instruction booklet. They were then requested to apply the electrodes to themselves and record their own ECGs. They were asked for comments on the design of the recorder and booklet, and if they found it easy to use them. A standard lead II and chest lead V4 and V5 were recorded on a Cambridge VS4B for comparison. As a
result of these experiences, six prototype recorders were manufactured (Fig. 1).

Fig. 1. The modified Sony cassette recorder, disposable electrodes, isopropyl alcohol swabs, gauze swabs and instruction book which were taken home by the patient in a small carrying case. The demodulator unit is shown on the left.

These recorders were then used to investigate 21 patients complaining of intermittent palpitations. Each patient had a 24-hour ambulatory ECG recording and was then given the portable recorder and instructions on its use. The patients were allowed to keep the recorder for a period of up to three months. They were asked to make a record when they had symptoms and were encouraged to return the results to the hospital as soon as possible. If they did not have any symptoms they were requested to record a random ECG to demonstrate that it was still possible to use the recorder successfully after a lapse of three months. All the tracings were of good quality and no battery failures were observed even when four records were obtained at 17[2], 18, and 20 weeks. The results are summarised in Table 1. The patients used the PSE without difficulty, and the records were suitable for arrhythmia detection, the only artefacts being occasional AC interference or slight somatic tremor.

### Discussion

Conventional 24-hour ECG monitoring commonly fails to record infrequent, short-lasting arrhythmias. Repeated daily recordings are time-consuming and expensive and failure to capture significant arrhythmias is frustrating for the technician. To overcome these problems, cheaper systems have been devised in which the patient only records at the time of the symptoms. However, continuous use of electrodes for many days frequently causes skin irritation and when abnormalities occur only at long intervals such as a week or more, problems with electrode contact seem likely to make these systems inadequate. An alternative is to use telephone telemetry, which is proving

| Patient | Age | Sex | 24-Hour ECG Record Palpitations | No. | Result | PSE Record Palpitations | No. | Result | Time patient kept PSE recorder (weeks) |
|---------|-----|-----|---------------------------------|-----|--------|-------------------------|-----|--------|--------------------------------------|
| 1*      | 49  | F   | Atypical                        | 1   | SVE    | Typical                 | 4   | AF     | 4                                    |
| 2       | 43  | F   | —                               | 1   | SR     | Typical                 | 1   | SR     | 12                                    |
| 3       | 40  | F   | —                               | 1   | SR     | —                      | 1   | SR     | 7                                    |
| 4       | 45  | M   | —                               | 1   | SR     | —                      | 1   | SR     | 12                                    |
| 5       | 31  | F   | —                               | 1   | SR (WPW) | Typical                | 1   | SVT    | 11                                    |
| 6       | 33  | M   | —                               | 1   | SR     | —                      | 3   | SR     | 20                                    |
| 7(a)    | 29  | F   | —                               | 1   | SR     | —                      | 3   | SR     | 18                                    |
| (b)     |     |     |                                  |     |        |                         |     |        |                                       |
| 8(a)    | 23  | F   | —                               | 1   | SR     | Typical                | 1   | SVT    | 10                                    |
| 9(a)    | 34  | F   | —                               | 1   | SR     | Atypical               | 1   | ST     | 9                                    |
| (b)     |     |     |                                  |     |        |                         |     |        |                                       |
| 10(1)   | 79  | M   | —                               | 1   | VES    | Typical (Dizzy)        | 1   | AF     | 3                                    |
| 11      | 53  | M   | (a)                             | 2   | SVE & VES | Typical                | 2   | AF     | 3                                    |
| (b) Typical |     |     |                                  |     |        |                         |     |        |                                       |
| 12      | 63  | M   | —                               | 1   | VES    | (Chest Pain)           | 1   | SR     | 12                                    |
| 13      | 62  | F   | —                               | 2   | SR     | Typical                | 1   | ST     | 9                                    |
| 14      | 45  | M   | —                               | 1   | VES    | Typical                | 1   | VES    | 3                                    |
| 15      | 52  | M   | —                               | 1   | VES VT | Typical                | 2   | 16 × VT | 13                                   |
| 16      | 62  | M   | Atypical                        | 1   | SR     | —                      | 1   | SR     | 17                                    |
| 17      | 20  | M   | Atypical                        | 2   | SR (WPW) | Typical               | 1   | SR     | 15                                    |
| 18      | 77  | M   | Atypical                        | 1   | SVE. SVT | Typical                | 2   | AF     | 24 hr                                |
| 19      | 52  | M   | Atypical                        | 1   | VES    | Typical                | 2   | SVT    | 13                                    |
| 20      | 49  | F   | Atypical                        | 1   | VES    | Atypical               | 6   | VES    | 2                                    |
| 21      | 70  | F   | Atypical                        | 1   | SR     | Typical                | 1   | SVT    | 5                                    |
of value in the follow-up of patients with implanted pacemakers[3], but has not been fully evaluated in the diagnosis of intermittent arrhythmias. The disadvantage of this system is that the ECG department needs to give a 24-hour service, and delay on the hospital switchboard can be a problem unless a special telephone line is provided. A further problem is the availability of a telephone for the patient to use.

There are several advantages to the system described in this article. Patients have no difficulty in making satisfactory ECGs at intervals for up to five months after initial instruction. Because the device is cheap, it may be left with the patient for weeks or months. We have suggested a three-month period on the basis that significant arrhythmias are likely to occur within this period and battery failure may become apparent if longer periods are used. There have been no battery failures in this series. The PSE is easily carried in the case supplied, and patients reported no problems with portability.

For successful use of this intermittent ECG recorder, arrhythmias must persist long enough for application of the electrodes and use of the machine. When arrhythmias persist for an hour or more, local patients may have time to visit the ECG department, but where longer distances are involved or symptoms are of shorter duration, the home ECG is particularly valuable.

Delay in recording during symptoms is a potential problem, particularly with transient, serious arrhythmias such as ventricular tachycardia. The commonest diagnoses in this series have been supraventricular tachycardias including atrial fibrillation. The single patient with ventricular tachycardia in this series recorded repeated bouts that were clearly associated with symptoms, unlike the episodes recorded during 24-hour ECG monitoring.

We emphasised that the PSE recordings should be taken during appropriate symptoms and only one patient failed to appreciate this, recording during a bout of chest pain. The patients are asked to state clearly that the symptoms were occurring during the recording.

We believe that the portable home ECG is valuable in assessing whether or not patients with possible cardiac symptoms have significant cardiac arrhythmias. Supraventricular arrhythmias are readily diagnosed and when characteristic symptoms coincide with normal rhythm, patients benefit from reassurance that no arrhythmia is present. The system is particularly valuable for patients who live at a distance from the hospital and is easy to use and cheap. It is mainly envisaged as an adjunct to routine Holter monitoring, but if this technique is not available the PSE will improve arrhythmia detection and hence patient management. Recordings from the PSE can be made without difficulty on the standard ECG machines available in District General Hospitals. The PSE cannot compete with 24-hour monitoring for the detection of transient arrhythmias and Stokes-Adams attacks, but we have shown that serious rhythm abnormalities requiring treatment can be detected when they had not been observed on a routine 24-hour ambulatory ECG recording.

References
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