

# Ambulatory ECG monitoring in primary care

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## Abstract

**Objective:** Investigating symptoms suggestive of cardiac arrhythmia in primary care requires a strategy beyond the resting 12-lead electrocardiogram (ECG), as the test is generally only of use while the patient is experiencing discomfort during the recording. This study assessed the use of automated ambulatory ECG monitors in diagnosing cardiac arrhythmias.

**Design:** A retrospective review of patients at one general practice.

**Participants:** 52 consecutive patients (73% female; age 52±18 years, range 22 to 93 years) with symptoms suggestive of cardiac arrhythmia.

**Method:** Automated ECG was recorded for 24 hours. Patients were also given a diary to record symptoms. The ECG reports were examined at the end of the test and correlated with symptoms, patient notes, and history before a decision to refer to secondary care was made.

**Results:** Episodes (> 30 s) of tachycardia (> 120 bpm) were present in 52% of patients and bradycardia (< 50 bpm) in 19%. The most common supraventricular arrhythmia was atrial ectopics, detected in 52% of patients. Three patients (6%) were found to have atrial fibrillation (AF) during the 24-hour test. Ventricular arrhythmia was detected in 71% of patients, with an average ectopic rate of 28±88 per hour (range < 1 to 397 per hour). Overall, 73% of patients were symptomatic during the 24-hour test, with 10% experiencing symptoms on at least 10 occasions.

**Conclusions:** Use of ambulatory ECG in patients with symptoms of cardiac arrhythmia proved feasible and useful in primary care. Results were used as the basis of referrals for 50% of patients tested, and to inform initiation or changes of medication in a further 24% of patients.

**Keywords:** cardiac arrhythmias, ambulatory, electrocardiography.

## Introduction

Cardiac arrhythmia affects more than 700,000 people in England and is consistently in the top ten reasons for hospital admission, consuming significant accident and emergency time and bed days.<sup>1</sup> In the general population, arrhythmias are normally quite minor, silent, and typically benign. Symptoms may affect the patient enough to be both disruptive and distressful. In extreme cases, some arrhythmias can cause life-threatening situations that may lead to stroke, cardiac arrest, or sudden death.

Symptoms that suggest arrhythmia include palpitation, dizziness, an irregular heartbeat, and dyspnoea. Chest pain, syncope, and presyncope may also be caused by arrhythmias. In many cases the patient will feel no symptoms at all.

The first-line test for the examination of patients experiencing these symptoms is the 12-lead resting ECG.<sup>1</sup> This test has the advantage that it can also detect other types of heart disease including hypertrophy, myocardial infarction, conduction abnormalities, and electrolyte imbalances.

The 12-lead ECG is less useful for paroxysmal arrhythmia as the chance of the patient having an event during the few minutes it takes to perform the test is often very low. It is also of limited use for detecting coronary artery disease as the patient is at rest and therefore unlikely to suffer an ischaemic episode.

Following a negative 12-lead ECG test, the advantages of a complementary ambulatory ECG test for 24 hours are well

documented.<sup>2,4</sup> This demonstrates that a short-term 12-lead ECG showing a negative result should not be used to rule out the presence of paroxysmal arrhythmias. Holter monitors have further been indicated as a routine investigation for the diagnosis of atrial fibrillation (AF) in primary care.<sup>5</sup> See Table 1 for a list of conditions where ambulatory ECG is, or may be useful and effective.

The use of ambulatory ECGs in primary care is uncommon, as many professionals are unable to accurately identify arrhythmia (especially AF) from rhythm strips.<sup>6</sup> For those who are competent at ECG interpretation, standard Holter monitors require lengthy interaction with complex analysis software. This is a time-consuming process that can be a barrier to adoption; however, the rewards are high as fewer than half of patients tested are found to have any indication of heart disease.<sup>7</sup> The timely use of an ambulatory ECG can reduce referral waiting times for patients needing further investigation, and may allow those with negative results to be quickly reassured or a differential diagnosis considered.

Automated ambulatory ECGs, which analyse the signal in real time, do not require additional software interaction, allowing for swift report generation and interpretation by a competent general practitioner (GP).

Birch Hill Medical Practice was involved in the development of such a monitor, the C.Net2000+,<sup>8</sup> its subsequent clinical trial,<sup>9</sup> and has been using the equipment since 1999. The C.Net5000 superseded the C.Net2000+ in October 2006.

### Key messages from this study

- Adopting state-of-the-art technology allows rapid assessment of symptoms indicative of arrhythmia in primary care
- Providing speedy diagnosis leads to earlier treatment or reassurance, reduced patient travelling, fewer referrals, and increased GP job satisfaction
- In isolation, symptoms are not adequate to diagnose arrhythmias and their severity, so knowledge of silent events allows the GP to provide appropriate treatment
- Automated ambulatory ECG tests as a Locally Enhanced Service make a significant contribution to the 18-week target for cardiac diagnostic services

**Table 1: When to use ambulatory electrocardiography\***

**Conditions where ambulatory electrocardiography is useful and effective:**

- Patients with unexplained syncope, presyncope, or episodic dizziness with no obvious cause.
- Patients with unexplained recurrent palpitation.
- To assess antiarrhythmic drug response in individuals in whom baseline frequency of arrhythmia has been well characterised as reproducible and of sufficient frequency to permit analysis.
- For the evaluation of frequent symptoms of palpitation, syncope, or presyncope to assess pacemaker and implantable cardiac defibrillator devices.

**Conditions where ambulatory electrocardiography may be useful and effective:**

- To detect proarrhythmic responses to antiarrhythmic therapy in high-risk patients.
- Patients with episodic shortness of breath, chest pain, or fatigue.
- Patients with neurological symptoms and suspected atrial fibrillation or atrial flutter.
- Patients with syncope, presyncope, dizziness, or palpitation, which persist despite treatment of another suspected cause.
- Evaluation of patients with chest pain who cannot exercise.
- To assess arrhythmia risk after myocardial infarction.
- To assess rate control during atrial fibrillation.

\* Adapted from the ACC/AHA guidelines for ambulatory electrocardiography (1999)<sup>20</sup>

range 22 to 93 years) with symptoms suggestive of cardiac arrhythmia underwent automated ambulatory ECG monitoring in a primary care setting with the C.Net2000+ or C.Net5000.

The main reasons for investigation were palpitation, irregular heartbeat, dizziness, and dyspnoea (see Figure 1). Concomitant symptoms experienced included syncope (with dizziness) and chest pain (with palpitation). Additional reasons for testing were to review current medication and to investigate episodes of tachycardia or bradycardia. Two patients had abnormal resting 12-lead ECGs requiring further investigation.

The ECG reports were examined at the end of the test and correlated with symptoms, patient notes, and history before a decision to refer to secondary care was made.

**Carrying out the test**

An automated ambulatory ECG test can be initiated in five minutes, either at the surgery or during a domiciliary visit. The procedure involves skin preparation, connecting the monitor, starting the test, and giving instructions to the patient. Preparation requires the removal of any chest hair from the electrode pad positions, abrading the locations to remove any dead skin, and ensuring that the area is dry before applying the pads.

Electrode pad placements are 'V4' (fifth intercostal space, left midclavicular line) and (thoracic equivalents of) right arm and left arm. These placements are optimised for artefact reduction, arrhythmia detection, ST segment analysis, patient comfort, simplicity of location, and conformity with traditional ECG nomenclature.

**Figure 1. Symptoms experienced by patients in primary care**



Note: Some patients experienced more than one symptom

This study reviews how the equipment was used, clinical findings, and outcomes for 52 consecutive patients, over a two-year period from June 2005 to May 2007.

**Methods**

Fifty-two consecutive patients (73% female; age 52±18 years,

**Figure 2. The C.Net5000 automated ambulatory ECG monitor**



The monitor measures 107 mm x 80 mm x 27 mm and weighs 200 g.

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The monitor (see Figure 2) is compact and lightweight and has a screen for guidance on starting the test and reviewing the final test report. It requires two disposable or rechargeable AA batteries for 24-hour ECG analysis and subsequent report storage.

Once the test has been started and the monitor has screened the signal for abnormalities, the display can be locked to remove the ECG trace from the patient's view. A diary sheet is given to the patient for them to record activities and symptoms during the period of the test. The sheet also contains instructions on how to use the monitor's symptom button. The monitor is placed inside a pouch and fitted on a belt, which the patient wears during the test.

The test is stopped automatically after 24 hours, but can also be manually terminated by the GP or nurse at any time. The C.Net report can then be reviewed on-screen, but is generally transferred to a computer for review and incorporation into patient notes. The download and interpretation of the report typically takes less than five minutes.

The C.Net report content is similar to a Holter report and consists of a summary page (including table of contents, quantitative statistics, rates, and duration), automated analysis pages (including 24-hour trends and 24-second

rhythm strips), and symptom button press pages (also as 24-second rhythm strips).

The 24-hour trend pages show heart rate correlated with ST segment deviation (always included), AF (when detected), and ventricular ectopic rates (when detected).

The automatic 24-second rhythm strip pages include (when detected) tachycardia, bradycardia, wide complex tachycardia, ST segment depression, atrial fibrillation and atria lflutter, low RR variability, asystole, atrial ectopics, ventricular ectopics, and multifocal ventricular ectopics. If no abnormalities were detected, a typical signal page is presented.

**Results**

The average test length was 23 hours 50 minutes, with a median of 97% of ECG data analysed (free from artefact and lead disconnection). In two tests, this percentage fell below 70% (the manufacturer's threshold at which a re-test is suggested). Diaries indicated that in one of these tests the patient deliberately disconnected the electrode lead, possibly due to a skin reaction with the electrode pads (26% analysed), and in the other test the electrode lead accidentally became detached during sleep (67% analysed).

The average length of the C.Net report was 10±4 pages (range 4 to 19 pages). This was broken down into a summary

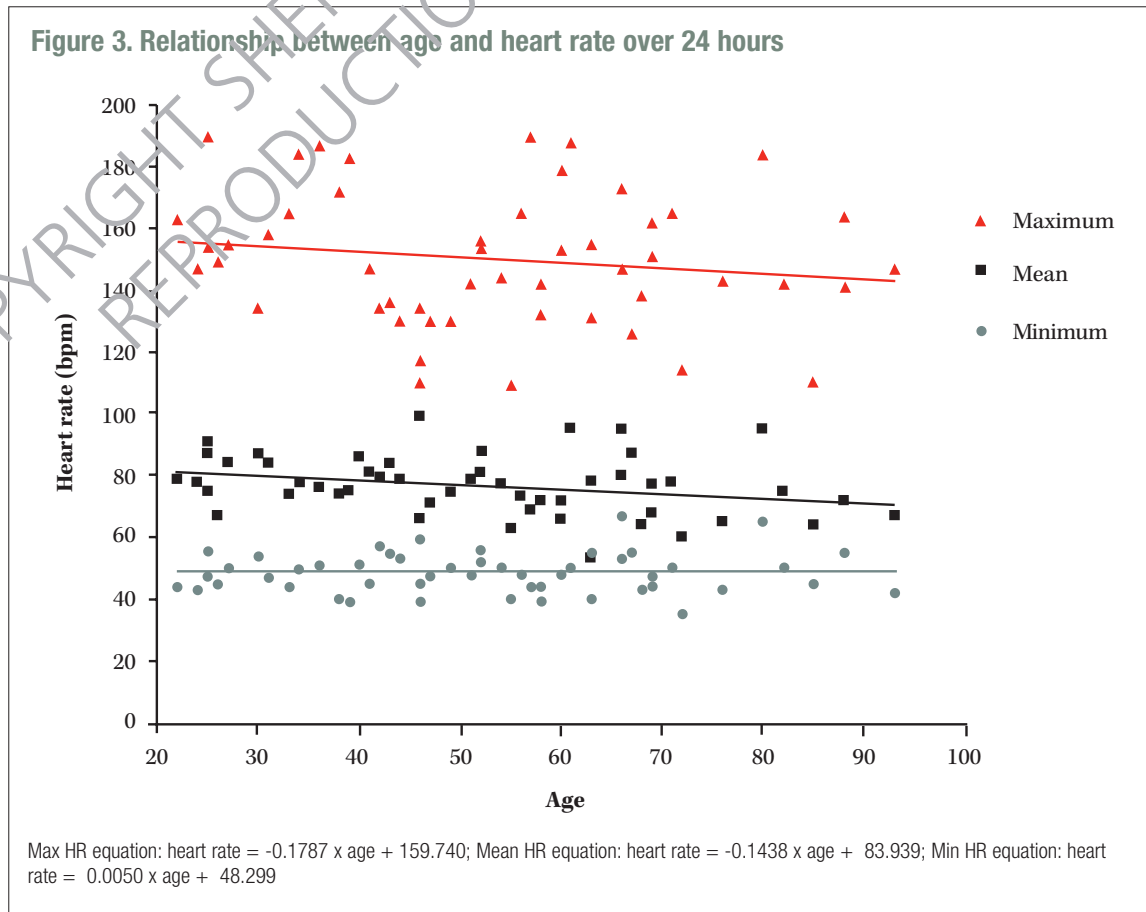


Figure 4. Sinus pause in a 72-year-old female

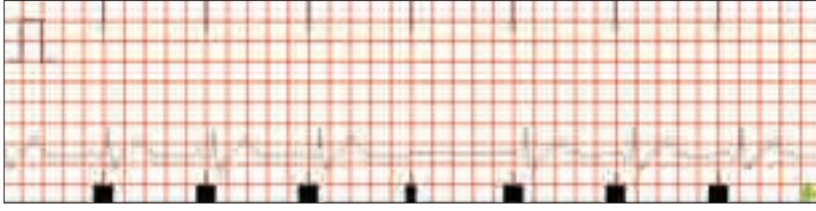


Figure 5. Multifocal ventricular ectopics in a 60-year-old male

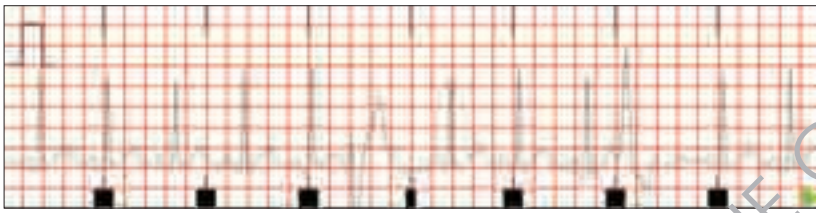
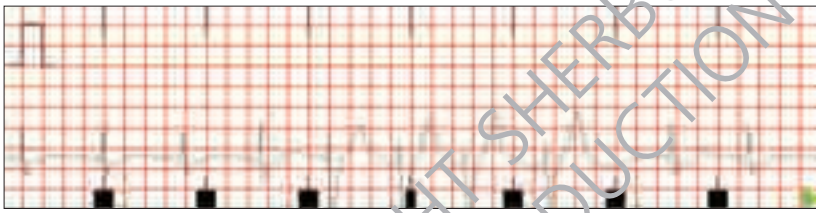


Figure 6. Ventricular run at 92 bpm in a 66-year-old female



page (all reports), up to three automatic trend pages ( $1.8 \pm 0.6$ ; range 1 to 3), up to 10 automatic rhythm strip pages ( $4.3 \pm 1.6$ ; range 1 to 7), and up to 10 symptom button press pages ( $2.8 \pm 3.3$ ; range 0 to 10).

Clinical findings are presented below and separated into heart rate, supraventricular arrhythmia, ventricular arrhythmia, and symptomatology sections. Additional observations from the reports included first-degree atrioventricular block, prominent U waves, and ST segment depression.

#### Heart rate

Over the monitoring period, the mean heart rate was  $76 \pm 10$  beats per minute (bpm) (range 53 to 99 bpm), the minimum  $49 \pm 7$  bpm (range 35 to 67 bpm), and the maximum  $150 \pm 22$  bpm (range 109 to 190 bpm). Episodes ( $> 30$  s) of tachycardia ( $> 120$  bpm) were present in 52% of patients and bradycardia ( $< 50$  bpm) in 19%.

The correlation between heart rate and age is presented in Figure 3.

Linear regression indicates that both average and maximum heart rates have a slight inverse correlation with age; minimum heart rate showed no age-dependent relationship.

Table 2. Summary of findings in patients with ventricular arrhythmia

Category	Classification	Percentage
Focus	Unifocal	46
	Multifocal	54
Pattern	Trigeminy	32
	Bigeminy	30
	Couplets	14
	Runs	8
Rate*	Infrequent	89
	Frequent	11
Symptomatology	No symptoms	38
	Symptoms only during sinus rhythm	38
	Symptoms linked to ventricular arrhythmia	24

\* Rate is determined by whether the average ventricular ectopics per hour is less than 30 (infrequent) or at least 30 (frequent)<sup>18,19</sup>

#### Supraventricular arrhythmia

The most common supraventricular arrhythmia was atrial ectopics, detected in 52% of patients. Three patients experienced coincidental symptoms.

The most serious supraventricular arrhythmia detected was AF. AF is a major risk factor for stroke<sup>10</sup> and the value of early detection and treatment is known to reduce both relative risk and mortality,<sup>11</sup> fulfilling many of the Wilson-Junger criteria for a screening programme.<sup>12</sup>

Fitzmaurice *et al.* conclude that active screening for AF detects additional cases over current practice.<sup>13</sup> The preferred method of screening in patients aged 65 or over in primary care is opportunistic pulse taking with follow-up electrocardiography. Pulse palpation in isolation has a high sensitivity (0.93 to 1.00) but a very low positive predictivity (0.08 to 0.23).<sup>14</sup>

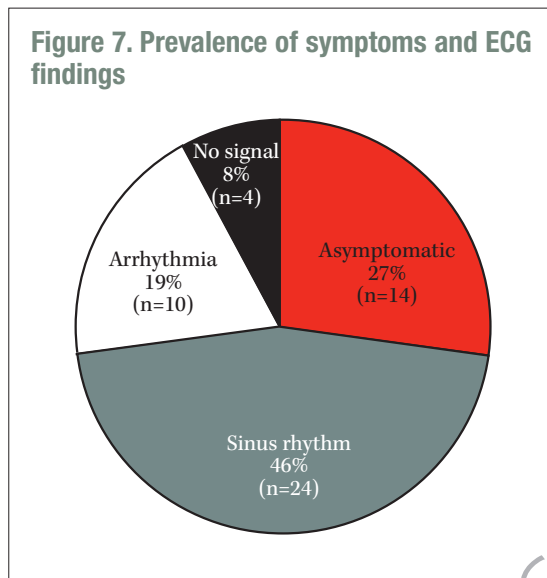
In this study three patients (6%) were found to have AF during the 24-hour test: one patient (aged 58 years) had short paroxysmal bursts during the night that corresponded with symptoms; one patient (aged 61 years) exhibited AF throughout the test yet was asymptomatic; one patient (aged 80 years) had sustained AF from 5 am to 8 am but symptoms occurred late evening and coincided only with normal sinus rhythm.

The poor correlation between patient-reported symptoms and AF has been noted before;<sup>15</sup> patients with paroxysmal AF are more likely to experience asymptomatic than symptomatic episodes.<sup>16</sup>

Four patients experienced tachycardia episodes in excess of

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**Figure 7. Prevalence of symptoms and ECG findings**



180 bpm. Three had supraventricular tachycardia (two of which were due to uncontrolled AF) and one sinus tachycardia corresponding to periods of exercise as recorded in the diary.

Reviewing long RR intervals identified two patients with sinus pauses (> 2.00 s) and one patient with second-degree atrioventricular block. The C.Net report does not distinguish between the two, and over-reading is required to separate the lack of atrial activity (see Figure 4) from intermittent atrioventricular conduction.

#### Ventricular arrhythmia

Ventricular arrhythmia was detected in 71% of patients, with an average ectopic rate of  $28 \pm 88$  per hour (range < 1 to 397 per hour). There was no sexual predisposition (27 of 38 female; 10 of 14 male); however, patients with ventricular arrhythmia ( $57 \pm 18$  years), were significantly older than those without ( $40 \pm 12$  years). A summary of the findings is presented in Table 2.

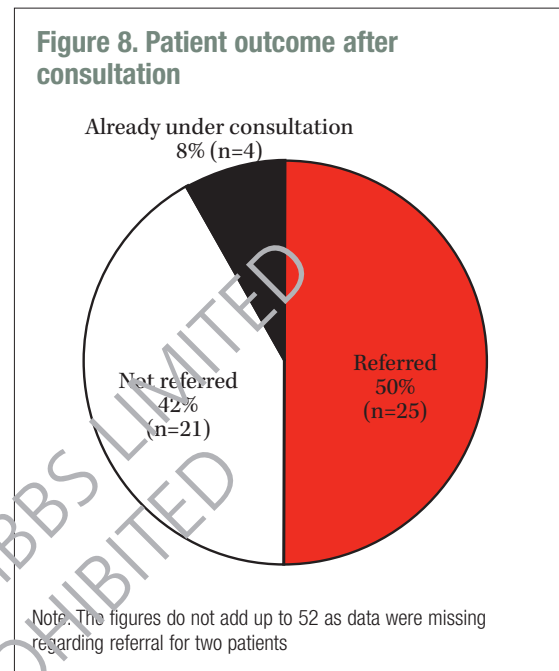
Of those patients with ventricular arrhythmia, 54% experienced ectopy with multifocal morphologies (see Figure 5); complex ectopic patterns included trigeminy (32%), bigeminy (30%), couplets (14%), and runs (8%).

The three patients who experienced runs exhibited with maximum run rates of 112 bpm (age 22), 77 bpm (age 80), and 92 bpm (age 66; see Figure 6). No runs were symptomatic. (Note that the minimum threshold employed for ventricular tachycardia was 120 bpm,<sup>17</sup> and none were detected in this study.)

Ectopic frequency was dichotomised at a rate of 30 per hour to separate 'infrequent' from 'frequent'.<sup>18,19</sup> Of those patients in whom ventricular arrhythmia was detected, 11% were classified as having frequent ectopy.

Symptoms were experienced during the test in 62% of those patients with ventricular arrhythmia, which correlated with

**Figure 8. Patient outcome after consultation**



either sinus rhythm (38%) or ventricular ectopy (24%). In the latter group there was no arrhythmia present on the event pages that was not automatically detected by the monitor.

#### Symptomatology

Overall, 73% of patients were symptomatic during the 24-hour test, with 10% experiencing symptoms on at least 10 occasions. Button presses corresponded to sinus rhythm in 46% of patients, and arrhythmia in 19%. In the remaining 8%, the ECG traces were uninterpretable (see Figure 7).

Of the 10 patients (19%) where arrhythmia and symptoms were coincidental, three had events showing both atrial and ventricular arrhythmia, one showed only atrial arrhythmia and six showed only ventricular arrhythmia.

Symptoms were more likely to correlate with arrhythmia in patients with dizziness (43%) than irregular heartbeat (30%) or palpitation (20%).

#### Referrals

Decisions to refer to secondary care were made during a consultation after reviewing patient notes and over-reading the C.Net report in correlation with the patient diary. The outcomes are presented in Figure 8.

Of the patients who were referred onwards, one test showed that no abnormalities were detected; referral for a 48-hour Holter test was made at the request of the patient. This test was also negative, ultimately reassuring the individual in question. The rest of the referral decisions were based on the presence of ST segment depression, sinus pauses, second-degree atrioventricular block, AF, supraventricular tachycardia, and/or frequent or complex ventricular arrhythmia in the C.Net report.

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Undertaking  
ambulatory ECG  
monitoring in  
primary care  
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patients  
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**Table 3. Summary of C.Net report findings**

Category	Percentage
Sinus bradycardia	19%
Sinus tachycardia	52%
Supraventricular tachycardia	6%
Atrial fibrillation	6%
Sinus pauses	4%
Second-degree atrioventricular block	2%
Atrial ectopics	52%
Ventricular arrhythmia	71%
Infrequent	63%
Frequent	8%
Multifocal	38%
Trigeminy	23%
Bigeminy	21%
Couplets	10%
Runs	6%
Asymptomatic	27%
Symptomatic	73%
Sinus rhythm	46%
Arrhythmia	19%
No signal	3%

Additional tests carried out in secondary care included an echocardiogram, a stress test, a Holter test, and a resting 12-lead ECG test. Diagnoses included mitral and tricuspid valve regurgitation, hypertensive heart disease, hormonal imbalance, AF, left ventricular dilation and reduced ejection fraction, and silent ischaemia.

The most likely outcome for the patient was an alteration or initiation of medication. Lifestyle changes were also suggested, including reducing caffeine intake, losing weight, and decreasing salt intake.

Four patients were already being treated in secondary care (two with a cardiologist, one with an oncologist, and one with a rheumatologist). In each case the reason for 24-hour ambulatory ECG monitoring was to review current medication. As a result of the tests, two of the patients had their dosage altered.

Of the patients who were not referred, 24% either started medication or had their current medication altered, 14% were advised to change their lifestyle (i.e. lose weight or reduce caffeine or alcohol intake), and 62% were reassured with no further action taken.

### Conclusions

Over the two-year period of this study, 52 patients were able to experience investigation of symptoms indicative of cardiac arrhythmia in primary care using an automated ambulatory

ECG monitor. A summary of findings from the C.Net reports is presented in Table 3.

Undertaking ambulatory ECG monitoring in primary care allows the GP to rapidly assess patients. Technological advances have reduced the interaction required to review 24 hours of ECG data, thus making it a practical complementary test to the resting 12-lead ECG. Whilst the resting 12-lead ECG may be considered the first-line test for detecting arrhythmias, it is not as useful for the detection of paroxysmal arrhythmias.

Assessment of symptomatic events in isolation does not identify all patients with arrhythmia (especially in AF, where early identification can lead to improved patient outcomes). This study has shown the benefit of automated analysis, which enables the detection of silent events.

Many patients were reassured or had appropriate changes to their medication without delay, thus reducing the burden on secondary care. Patient compliance and acceptance to monitoring in primary care was high, with only one patient seeking referral despite a negative test. Furthermore, providing a prompt and reliable service brings greater job satisfaction to the GP.

With some Primary Care Trusts now starting to offer reimbursement for 24-hour ambulatory ECG tests as a Locally Enhanced Service, GPs are better placed to help meet the 18-week target for cardiac diagnostic services.

### Acknowledgements

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### Declaration

GK declares no conflicts of interest. The study was funded by the practice as part of a continuing patient pathway improvement plan, and no payments have been received from the manufacturer or from any other source. GK has never received a payment or fee from the manufacturer of the device used in this study.

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