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The QBIC incorporates an XScale processor (Intel PXA263B1C400) using 32 MByte internal flash memory, 256 MByte external SDRAM, a VGA connector, a low-power RF transceiver, RS-232/USB serial ports, a Bluetooth module, as well as a slot for an external miniSD card. All external connectors as well as the single rechargeable battery cell are located in the belt, where also more battery units could be placed (Figure 3).

QBIC consists of two microvia boards. In order to provide high modularity for other not yet known applications, the large basic components such as processor and memory are grouped on the main board (24 cm<sup>2</sup>, eight layers) and mounted as chip scale packages. Application-specific interfaces reside in the rigid-flex extension board

(15 cm<sup>2</sup>, four layers), which connects via the flex cables to the main board (see Figure 3). Comparable systems require an area of 56–80 cm<sup>2</sup>, which corresponds to a size reduction of 30–50%.

**Acknowledgements:** We thank our colleagues from the AMON consortium and the QBIC team of the Wearable Computing Lab, ETH Zurich, for their contributions.

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# ► Cardiac event recording yields more diagnoses than 24-hour Holter monitoring in patients with palpitations

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## Summary

Palpitation is a common symptom that sometimes results from a substantial cardiac arrhythmia. We compared the diagnostic yield of trans-telephonic event monitors with those of Holter monitoring in patients with intermittent palpitations. In all, 310 patients were randomly assigned to receive an event recorder or 24-hour Holter monitoring. Event recorders were used for seven days or until two recordings were obtained while symptoms occurred. The main end-point was an electrocardiogram (ECG) recorded during symptoms. The patients with palpitation recorded the one-lead ECG trace and sent it to a telemedicine call centre, where a nurse responded. There were 119 symptomatic patients in the event recorder group and 74 in the Holter group. The total costs were €6019 for event recording and €9605 for Holter monitoring. The average costs were €51 per symptomatic patient detected by event recorder monitoring and €130 per symptomatic patient detected by Holter monitoring. More patients therefore received a clear diagnosis, and more quickly, when using event recording than with Holter monitoring. For this reason, event recorders are preferable to Holter monitors for patients with palpitations.

## Introduction

Palpitation is a common symptom that sometimes results from a substantial cardiac arrhythmia.<sup>1</sup> Establishing the cause of palpitations may be difficult because historical

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or ECG electrodes, stores them in an extractable memory card or transmits the processed data wirelessly. Thus, patients can be monitored constantly without needing to be connected by wires to their beds or any fixed positions. Adding a receiver station with a connection to the telephone network makes QBIC suitable for home-care applications.

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## Summary

Palpitation is a common symptom that sometimes results from a substantial cardiac arrhythmia. We compared the diagnostic yield of trans-telephonic event monitors with those of Holter monitoring in patients with intermittent palpitations. In all, 310 patients were randomly assigned to receive an event recorder or 24-hour Holter monitoring. Event recorders were used for seven days or until two recordings were obtained while symptoms occurred. The main end-point was an electrocardiogram (ECG) recorded during symptoms. The patients with palpitation recorded the one-lead ECG trace and sent it to a telemedicine call centre, where a nurse responded. There were 119 symptomatic patients in the event recorder group and 74 in the Holter group. The total costs were €6019 for event recording and €9605 for Holter monitoring. The average costs were €51 per symptomatic patient detected by event recorder monitoring and €130 per symptomatic patient detected by Holter monitoring. More patients therefore received a clear diagnosis, and more quickly, when using event recording than with Holter monitoring. For this reason, event recorders are preferable to Holter monitors for patients with palpitations.

## Introduction

Palpitation is a common symptom that sometimes results from a substantial cardiac arrhythmia.<sup>1</sup> Establishing the cause of palpitations may be difficult because historical

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clues are not always accurate.<sup>2</sup> Twenty-four-hour Holter monitoring is usually used, but the yield of this test is low in patients whose symptoms occur infrequently.<sup>3-6</sup> Another method of studying palpitations is trans-telephonic event recording;<sup>7</sup> the recordings can be transferred to a receiving station for diagnosis and management.<sup>8</sup> The strengths of Holter monitoring include its simplicity and the lack of need for patient activation. The continuous monitoring allows capture of asymptomatic arrhythmias or arrhythmias associated with loss of consciousness, as well as documentation of circadian variation in arrhythmia occurrence. However, the period of monitoring may be limited and is often inadequate to diagnose the cause of symptoms; it may also limit the ability of patients to perform many normal activities and require the patient to keep a diary to correlate symptoms and arrhythmia. An event recorder requires manual patient activation to record data, but it can be left with the patient for a long period of time until symptoms occur, and allows the patient to have a normal daily life.

The aim of the present study was to compare the diagnostic yield of trans-telephonic monitoring using an event recorder with Holter monitoring in patients with intermittent palpitations.

## Methods

In all, 310 patients were randomly assigned to receive event recorder monitoring or 24-hour Holter monitoring. Event monitoring was used for seven days, or until two recordings were obtained while symptoms occurred. The main end-point was an electrocardiogram (ECG) recorded during symptoms. The patients with palpitation recorded the one-lead ECG trace and sent it to a telemedicine call centre, where a nurse compared the trace with a baseline one, checked the patient's symptoms and decided to end the telephone call, or in presence of major arrhythmia to request the cardiologist's intervention.

The system information flow is the following: a telephone call arrives (e.g. from general practitioners, patients, health centres) and the user is automatically identified through the stored telephone number or identity code. The telephone call is answered by an operator who recalls the patient's data stored in the enrolment phase and activates the 'new call procedure', inserting new data relating to the present call (a control one or a call made in the presence of symptoms). At this point, the trace can be received and the user is connected to the cardiologist or the nurse on duty, who may be at home but will be connected to the central database through the Internet. The specialist or the nurse examines the stored information and compares the trace with the baseline one; they collect information about the patient's history and clinical symptoms, and provide a teleconsultation and/or nursing triage. At the end of the call, the reported ECG trace is sent to the user by email or fax, and the data are transferred to the Web server, from where they are made available via the Internet to approved users. The teleworking model used by the staff involved depends on a PC connected to the central system through the Internet via a secure pathway (a virtual private network).

## Results

Most of the patients were women (Table 1). The mean age of the patients was similar in both groups. There were 119 symptomatic patients in the event recorder group and 74 in the Holter group. There were 81 documented arrhythmias (68% of symptomatic patients) in the event recorder group and 53 (72% of symptomatic patients) in the Holter group.

During Holter monitoring, only two patients suffered from palpitation. There was no difference between the two methods in detecting supraventricular and ventricular tachycardia, or in excluding arrhythmic events. Event recorder monitoring recorded 13 episodes of

**Table 1** Patient characteristics

	Event recorder monitoring	Holter monitoring	P
<i>Demographics</i>			
Patients	155	155	
Sex (M/F)	44/111	31/124	NS
Age (years)	52 (SD 18)	53 (SD 16)	NS
Cardiac disease	64	63	NS
<i>Diagnoses</i>			
Tachyarrhythmia	13 (11%)	5 (7%)	NS
Supraventricular or ventricular beats	25 (21%)	16 (22%)	NS
Arrhythmias	81 (68%)	53 (72%)	NS
Total symptomatic patients	119 (77%)	74 (48%)	<0.01
<i>Costs (€)</i>			
Total costs	6019	9605	<0.01
Average cost per patient monitored	38.83	61.97	<0.01
Average cost per symptomatic patient	50.57	129.80	<0.01

NS= $P \geq 0.05$

tachyarrhythmia compared with five with Holter monitoring, but the difference was not significant.

The total costs with event recorder monitoring were €6019 and were €9605 with Holter monitoring. The average costs were €39 per patient for event recorder monitoring and €62 per patient for Holter monitoring. The average costs were €51 per symptomatic patient detected by event recorder monitoring and €130 per symptomatic patient detected by Holter monitoring.

## Discussion

The present study confirmed the advantage of the near realtime diagnosis that was possible using event recorder monitoring. Diagnoses were produced more quickly than by Holter monitoring. Furthermore, the costs were lower with event recorder monitoring. For this reason, event recorders are preferable to Holter monitors for patients with palpitations.

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# ► Effect of home-based telecardiology on chronic heart failure: costs and outcomes

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## Summary

Chronic heart failure (CHF) remains a common cause of disability. We have investigated the use of home-based telecardiology (HBT) in CHF patients. Four hundred and twenty-six patients were enrolled in the study: 230 in the HBT group and 196 in the usual-care group. HBT consisted of trans-telephonic follow-up and electrocardiogram (ECG) monitoring, followed by visits from the paramedical and medical team. A one-lead ECG recording was transmitted to a receiving station, where a nurse was available for reporting and interactive teleconsultation. The patient could call the centre when assistance was required (tele-assistance), while the team could call the patient for scheduled appointments (telemonitoring). The one-year clinical outcomes showed that there was a significant reduction in rehospitalizations in the HBT group compared with the usual-care group (24% versus 34%, respectively). There was an increase in quality of life in the HBT group (mean Minnesota Living Questionnaire scores 29 and 23.5, respectively). The total costs were lower in the HBT group (€107,494 and €140,874, respectively). The results suggest that a telecardiology service can detect and prevent clinical instability, reduce rehospitalization and lower the cost of managing CHF patients.

## Introduction

The number of patients with chronic heart failure (CHF) is increasing, mainly because of the growing number of elderly persons in heart failure. These patients are often

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