First experience of monitoring with cardiac event recorder electrocardiography Omron system in childhood population for sporadic, potentially arrhythmia-related symptoms

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Received 17 February 2011; accepted after revision 26 April 2011; online publish-ahead-of-print 26 May 2011

Aims
To document symptomatic episodes of palpitations with traditional methods such as 24 h Holter monitoring (HM) or loop recorders remains a big challenge in clinical practice. Clinical trials with patient-activated electrocardiography (ECG) recorders show increased diagnostic yield in such patients. However, studies in the paediatric population are limited. We want to present a first experience with an event-recording system Omron HeartScan in children with symptomatic palpitations.

Methods and results
Thirty paediatric patients (age 4–16 years) were followed with the Omron at our centre. All patients had a normal echocardiogram, a normal baseline 12-lead ECG and a normal 24 h HM. Indications with regard to monitoring were palpitations (n = 30). Two of them also had episodes of pre-syncope. The average of palpitation episodes in the past 3 months was 13.2 ± 8.3. The mean age of the study population was 9.7 ± 2.3 years [17 males (56.7 %)].

In all patients (n = 30) a diagnostic event could be recorded with the studied system. Four patients were diagnosed with supraventricular tachycardia (SVT) and underwent catheter ablation. The remaining patients (n = 26; 87%) were diagnosed with sinus tachycardia. Two patients with SVT additionally had episodes of pre-syncope. None of the patients could be diagnosed with previous 24 h HM.

Conclusion
This event recorder has a high diagnostic yield in the childhood population. The children enjoyed the ease of using the system under daily-life conditions. In this study the system was able to record a diagnostic event in all patients with palpitations.

Keywords
Palpitations • HeartScan • Patient-activated event recorder • ECG

Introduction
Since Holter monitoring (HM) was introduced in the early 1960s, this ambulatory electrocardiography (ECG) device has been established as one of the most effective non-invasive diagnostic tools in cardiology.1

It has been widely used in the diagnosis and assessment of many cardiac diseases and remains a highly refined tool for detecting cardiac arrhythmias and risk prediction.2 However, the short duration of conventional HM, which is limited to a 24 h period of recording, can be inadequate if cardiac symptoms are infrequent. Although newer Holter monitors are available with recording capability of up to 2 weeks, limitations of these systems and conventional HM are still frequent non-compliance with keeping a diary of symptoms, and using event markers, which significantly decreases the diagnostic value.3

The low diagnostic yield of this instrument among paediatric patients with transient palpitations, chest pain, and syncope,
which are common indications for HM, has been confirmed by Hegazy et al. in a large study population. In the adult population, a low diagnostic yield in patients with palpitations has also been reported. Many studies with so-called patient-activated ‘event recorders’ show increased diagnostic yield and are even more cost effective than conventional 24 h or 48 h Holter ECG monitoring. However, there are limited data about the experience with such event recorders in the paediatric population. In this paper, we would like to present a first experience with event-recording system Omron HeartScan in children aged 4–14 with symptomatic transient palpitations.

**Methods**

**Population**

Thirty patients (age < 18 years) with palpitations referred to the Heart Rhythm Management Centre, division of paediatric arrhythmology (UZ Brussel VUB, Brussels, Belgium) between March 2010 and December 2010 were included. Exclusion criteria were age > 18 years, the presence of a pacemaker or implantable defibrillator, syncope, and congenital heart disease. Children who were not capable of using the device adequately due to their age and children with mental or physical illness were also excluded from the study. After a detailed description of the study to parents or guardian, written informed consent was obtained from all.

All patients referred with palpitation routinely underwent a ‘palpitation protocol’ that included a history, physical examination, 12-lead ECG, routine laboratory investigation, echocardiography, and 24 h HM. After completing the ‘palpitation protocol’, we still found no sign of palpitations diagnosed for all patients. We then proceeded to employ the ambulatory monitoring with the patient-activated ECG recorder.

We documented age, gender, number of episodes in the last 3 months, and clinical findings from the ‘palpitation protocol’ assessment. All children were instructed on how to use the Omron HeartScan and recorded a first ECG registration with the physician. In addition, the children were invited to make at least one ECG recording each day, with or without symptoms, to improve their skills in using the device and to increase the possibility to record an asymptomatic episode. Eight unsuccessful ECG registrations were recorded in five patients during the first 3 days of the study. These registrations were not related to the symptoms of the patients. Each child was regularly followed at our centre. If patients experienced any symptoms, they were seen prior to their scheduled follow-up visit. All data on the Omron HeartScan were evaluated during the follow-up visit. The device remained with the patients until a diagnostic event was recorded.

**Statistical analysis**

Statistics were calculated using the SPSS package. All values are expressed as percentages of total or mean ± standard deviation.

**The patient-activated electrocardiography recording system**

The Omron HeartScan 801® (Omron Corporation, Shikoku Horikawa, Shimogoy-ku, Kyoto, Japan), as originally described by Kaleschke et al., is a portable ECG recording device with liquid crystal display (LCD) and allows offline analysis of collected data on the storage card for (Figure 1). After the device is turned on for a few seconds, it is ready to record 30 s of a single-channel ECG. The device has two stainless-steel electrodes integrated into the surface of the device.

To start the ECG recording, the patient attaches one of the electrodes to the chest (Figure 2). The right index finger of the patient holds the device and is in contact with the second electrode. By pressing the start button, the device will record 30 s of a single-channel ECG. An acoustic signal indicates the end of the recording. Once the recording is done, the result can be viewed on the LCD and be uploaded to a computer by extracting the data from the storage card for further off-line analysis. The storage card itself is a standard secure digital card with a storing capacity of ≥5000 ECG recordings (30 s). Once the files are uploaded to a computer, it can be easily forwarded by email due to their small data size (6 kB/30 s ECG).

**Results**

Thirty-one children were screened for our study. Only one patient was excluded due to incapability of using the Omron HeartScan correctly. Thirty children (n = 30) with paroxysmal palpitations were included in our study. All data sets were analysable for arrhythmias. All participants underwent the ‘palpitation protocol’ but none of them received a diagnosis for the palpitations. Unlike the Omron HeartScan, the 24 h ambulatory ECG recording was unable to detect any cardiac arrhythmias.
The average of palpitation episodes experienced in the past 3 months was 13.2 ± 8.3. The mean age of the study population was 9.7 ± 2.3 years, 17 males (56.7%; Table 1). In two children (6.7%), palpitations occurred concomitantly with one episode of pre-syncope. One (3.3%) of them presented with positive family history for sudden death and underwent pharmacological test with Ajmaline in which Brugada syndrome was excluded.

The monitoring was performed until the symptom recurred (mean days 22.8 ± 16.5; range: 5–65 days). The average duration of one palpitation episode was 11.2 ± 6.7 min.

Of the 30 patients, 87% (n = 26; mean age: 9.7 ± 2.2 years; 54% male; Table 1) had sinus tachycardia (ST) (mean frequency per minute 108.11 ± 1.92; range: 105–112). The low heart rate of tachycardia, which was related to stress situation, suggests that the tachycardia are more likely to be sinus node origin than ectopic focus.

Four patients (13%) were diagnosed with supraventricular tachycardia (SVT) and were successfully ablated in our centre. Two of them (7%; male and female, aged 9 and 14 years resp.) had atrial-ventricular (AV) nodal re-entrant tachycardia. One patient (3%; male, age 7 years) had AV re-entrant tachycardia or an accessory pathway and another one (3%; male, age 7 years) had atrial tachycardia. The majority of the patients (n = 22; 73%) had recurrence of palpitations in the first 4 weeks.

### Discussion

#### Main findings

Our Heart Rhythm Management Centre, division of paediatric arrhythmology, has ~2500 consultations a year per paediatric cardiologist. About 1300 of them are new patients. Palpitations are one of the most common causes for consultation. The age of the children with palpitation varies between 6 and 18 years. Younger children are sometimes seen because their parents claim to ‘feel’ the palpitation on their chest.\(^3\) Annually, a paediatric cardiologist would see an average of 110 patients undergoing the ‘palpitation protocol’, in our paediatric division of cardiology. The present work reviewed cardiac event monitoring with the Omron HeartScan of 30 healthy paediatric patients with
palpitations from our centre. All patients underwent the ‘palpitation protocol’ first; none of them had a diagnosis of the palpitations. The 24 h ambulatory ECG recording was unable to detect any cardiac arrhythmias. Our data indicate that the Omron HeartScan provides useful diagnoses for all children with suspected arrhythmia. The system was able to detect SVT in 13% of the patients. A recent study with transtelephonic electrocardiographic monitoring reported a comparable result. In our trial, 87% patients were diagnosed as suffering from ST. Although ST is typically benign, it can be associated with underlying conditions such as hypoxia, anaemia, hypovelema, shock, myocardial ischaemia, pulmonary oedema, hyperthyroidism, medication, hypocalcaemia, and illicit drug use. However, our laboratory investigations as part of the ‘palpitation protocol’ excluded these causes in these patients.

Documentation of sinus rhythm during symptoms can help to avoid further investigations with costly and invasive diagnostic procedures. If we compare the Omron HeartScan to conventional 24 h Holter ECG, we observed that a more prolonged and patient-activated monitor can provide more helpful information. The low diagnostic yield of HM in our study correlates with data from another large paediatric study. The major advantage of this device compared with other event recorders, including loop event recorders, is that it can provide useful ECG registration during a symptomatic event, such as palpitations, combined with high patient comfort due to the size, mobility, and the lack of external electrodes that have to be attached to the patient’s chest. Furthermore, signal artefact or dropout is common during ambulatory monitoring with any type of device. This can be related to skin preparation during electrode placement for event recorders that are worn externally. However, in our study all data sets from the Omron HeartScan were analysable for arrhythmias.

The children have really enjoyed the ease of handling of the Omron HeartScan system. Our youngest patient was only 4 years old and had no problems in using the system. Although our paediatric patients when using the device were not under observation of healthcare personnel, the quality of ECG recordings was still high and could be properly analysed. This observation correlates with data from previous studies in a larger adult population.

**Limitations of the study**

Our small study population was a highly selected group of patients. Most of the patients suffered from frequent palpitations. Our study design allowed patients to use the Omron HeartScan until a diagnostic event was recorded. Hence, the diagnostic yield of the system may be lower when the event recorder is used by a less selective group of patients or patients with infrequent episodes of palpitations. Furthermore, if patients are only allowed to use the device during a limited period of time, for instance, due to the cost-related issues, it may also lower the diagnostic yield of the system. Our report invites further study on the reproducibility and cost-effectiveness of time-limited patient-operated ECG systems in a larger and more general paediatric population.

Our study included only paediatric patients with episodes of palpitation. Although this symptom has been described to be the commonest indication for ambulatory event monitoring, other cardiac symptoms such as chest pain are also frequently referred for ambulatory investigations. Thus, further studies are also needed in patients with cardiac symptoms other than palpitation.

**Conclusion**

The studied patient-operated single-channel ECG device is a well-tolerated cardiac event recorder in our paediatric population for sporadic, potentially arrhythmia-related symptoms. All children were able to use the device adequately and enjoyed the ease of handling it under daily-life conditions. Unlike the 24 h HM, this device could provide useful diagnoses in all our included patients. A diagnostic event could be recorded with the Omron in all patients. It is noteworthy that a majority of our patients had ST. This is an essential negative finding and coupled with symptoms can lead to reassurance of the child, parents, and the treating physician.

We recommend further larger studies in a more general paediatric population with cost-effectiveness analysis to confirm the value of this system in the cardiac assessment of paediatric patients.

**Acknowledgements**

The author thanks Moens A.L. from Cardiovascular Research Institute Maastricht, Maastricht University Medical Centre, the Netherlands.

**Conflict of interest:** none declared.

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**Group beating related T-wave alternans in a patient with atrioventricular nodal reentrant tachycardia**

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We report two electrocardiogram (ECG) tracings recorded in a 40-year-old woman with atrioventricular nodal reentrant tachycardia. The ECGs were recorded in the emergency room at admission (Panel A) and after the administration of adenosine intravenously (Panel B). The tachycardia slowed down showing a ‘group beating’ behaviour (consisting of two beats in each group) before termination. Noteworthy was the presence of T-waves alternans associated with the group beating phenomenon.

The main explanation of this ECG finding is the change in the heart geometry and filling consequent to the changing in coupling intervals during the group beating phenomenon.

**Conflict of interest:** none declared.