# 24-hour ambulatory electrocardiographic monitoring is unhelpful in the investigation of older persons with recurrent falls

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## Abstract

**Background:** although frequently used in the assessment of patients with falls, it is unclear whether 24-hour ambulatory electrocardiography contributes to their assessment in older persons.
**Objective:** to identify electrocardiographic abnormalities in patients with recurrent falls and case controls, and determine whether 24-hour ambulatory electrocardiography identifies causal arrhythmias for falls.
**Design:** prospective case–control study.
**Methods:** 24-hour ambulatory electrocardiography recordings were compared for the type and prevalence of arrhythmias and symptom correlation in consecutive older subjects with recurrent falls attending the accident and emergency department and in case controls (no previous falls or syncope). ECG abnormalities were categorised as major (ventricular arrhythmia, pauses, <30 b.p.m., Mobitz II, complete heart block) and minor (multiple ectopics, paroxysmal atrial arrhythmia and other bradyarrhythmias).
**Results:** 128 fallers (76 ± 6 years) and 100 case controls (75 ± 5 years) were recruited. Co-medication and co-morbidity were similar in both groups. 49% (63) of recordings in fallers and 41% (41) of recordings in controls were abnormal. There was no difference between groups in the prevalence of major or minor abnormalities or of symptoms during recording (breathlessness, fatigue, chest pain and dizziness). Palpitations occurred in 10% of fallers and 13% of controls. One patient fell during monitoring with no associated rhythm abnormality.
**Conclusion:** multiple abnormalities are present on 24-hour ambulatory electrocardiography in older people whether or not they have experienced falls. 24-hour electrocardiography does not discriminate between fallers and non-fallers and is not helpful in the investigation of recurrent falls.

**Keywords:** *ambulatory electrocardiography, older persons, falls, investigations, elderly*

## Introduction

Falls are a major health care issue in older people. Thirty per cent of those aged over 65 years and 45% over 75 years will have at least one fall per year [1]. Recurrent falls are associated with higher mortality and morbidity, in particular loss of confidence and independence, a reduction in physical function and earlier admission to long-term institutional care [2–4]. The cause of falls is usually multifactorial. Recognised risk factors include environmental hazards, multiple and culprit medications, gait and balance abnormalities, visual impairment and a variety of cardiovascular disorders including cardiac arrhythmias, carotid sinus hypersensitivity, orthostatic hypotension and vasovagal hypersensitivity [5].

The symptoms of falls and syncope overlap in older adults [6]. One explanation for this is amnesia for loss of consciousness. As up to 40% of events are unwitnessed, patients may describe falls rather than syncope. Given this overlap, 24-hour ambulatory electrocardiography may be used in the investigation of falls, and assessment of cardiovascular status including heart rate and rhythm is recommended in falls prevention guidelines [7]. Ambulatory

monitoring is not specifically recommended, but our study was prompted by a 3-month audit at an inner city teaching hospital, which found that 30% of requests for 24–48-hour ambulatory electrocardiography were for the indication of 'falls' [8]. However, there is little evidence to support the use of prolonged rate monitoring. Even in recurrent syncope, the evidence for diagnostic benefit is sparse; only 5% of patients had correlation of symptoms with arrhythmia in an overview of eight studies of ambulatory electrocardiography in syncope [9]. Our objectives were to determine whether there were differences in 24-hour ambulatory electrocardiography recordings in patients with falls compared with case controls, and whether identified electrocardiographic abnormalities were associated with falls.

## Subjects and methods

We recruited patients aged 65 years or over who presented to the accident and emergency department with a fall or fall-related injury, and had sustained an additional fall in the preceding 12 months. Patients were excluded if they were cognitively impaired (MMSE < 24) [10], had more than one previous syncopal episode, or had a medical explanation for their fall i.e. acute myocardial infarction, stroke, epilepsy, hypoglycaemia.

Case controls were matched for age and sex, but had no history of a fall in the preceding 3 years or any previous syncope. They were recruited from general practice populations in the same catchment as cases in response to advertisements for study volunteers.

The study was approved by the local regional ethics committee.

### Clinical evaluation

After informed consent, all subjects received a detailed evaluation of medical and drug history and full cardiovascular examination. Co-morbidities such as hypertension and diabetes were defined by standardised diagnostic criteria, and their presence determined from medical history corroborated by general practice records. Ischaemic heart disease was recorded if the subject had a history of previous myocardial infarction, current or previous angina. Atrial fibrillation was confirmed with 12-lead electrocardiogram. The fallers group underwent additional assessments as part of a separately reported falls prevention study [11].

Both groups were fitted with a dual-channel, 24-hour ambulatory electrocardiogram recorder (Del Mar 456A) and instructed in using a diary sheet to record symptoms and activities during the recording period. Subjects detailed the time, circumstances and symptoms associated with any falls during the recording period. Tapes were analysed using an electrocardiogram scanner (Del Mar Accuplus 363). Electrocardiographic abnormalities detected by the scanner were printed and examined by a technician blinded to subject group. The type and duration of arrhythmia was assessed and recorded as detailed below.

### Electrocardiographic abnormalities

Electrocardiographic abnormalities identified were categorised using published criteria [12].

Major abnormalities were defined as (i) ventricular tachycardia of three or more consecutive premature ventricular beats, (ii) sinus or ventricular pauses of two or more seconds, (iii) bradycardia with a heart rate of less than 30 beats per minute, (iv) Mobitz Type II atrioventricular block, (v) complete heart block.

Minor abnormalities were defined as (i) multiple ventricular ectopic beats at a rate of 30 or more premature beats per hour, (ii) paroxysmal supraventricular tachycardia for 10 or more beats at a rate of 150 beats per minute or more, (iii) bradycardia with a heart rate of 30–39 beats per minute, (iv) Mobitz Type I heart block, (v) paroxysmal atrial fibrillation or flutter.

For any identified electrocardiographic abnormalities, association with symptoms was determined by correlating symptom diary reports with timing of identified rhythm disturbance and by questioning patients. If the subject experienced symptoms during the ambulatory monitoring period, the corresponding electrocardiographic trace was additionally examined.

### Statistical analysis

Differences between the baseline characteristics of the fallers and controls were analysed using independent samples $t$-test for continuous variables and Fisher's exact test for categorical variables. Abnormalities identified were categorised as discrete variables and $P$ values calculated using Fisher's exact test. Ninety-five per cent confidence intervals (CI) were calculated for relative risks when applicable. Analysis was performed using Statistical Package for the Social Sciences (SPSS) version 10.

## Results

24-hour ambulatory electrocardiographic recordings were obtained from 128 cases and 100 age- and sex-matched controls; 112 subjects volunteered to be controls. Twelve were excluded as they were either under the age of 65 years, or had a previous history of falls or syncope.

Table 1 details the baseline clinical characteristics of the two groups. The mean age of subjects with recurrent falls was

**Table 1.** Baseline characteristics of fallers and control subjects

| | Fallers ($n=128$) | Controls ($n=100$) | $P$ value |
|---|---|---|---|
| Mean (SD) age | 76.8 (6.2) | 75.3 (5.5) | 0.065 |
| No. (%) male | 42 (33) | 41 (41) | 0.215 |
| Co-morbidity | | | |
| No. (%) with ischaemic heart disease | 35 (27) | 19 (19) | 0.160 |
| No. (%) with atrial fibrillation | 9 (7) | 4 (4) | 0.398 |
| No. (%) with hypertension | 47 (37) | 23 (23) | 0.030 |
| No. (%) with diabetes | 18 (14) | 5 (5) | 0.027 |
| Medications | | | |
| No. (%) taking beta-blockers | 26 (20) | 14 (14) | 0.225 |
| No. (%) taking calcium antagonists | 26 (20) | 12 (12) | 0.109 |
| No. (%) taking atrioventricular-conduction slowing agents | 4 (3) | 2 (2) | 0.698 |

Independent $t$-test used for continuous variables, Fisher's exact test for categorical variables.

76.8 years (±6.2) compared with 75.3 years (±5.5) in the case controls (P=0.065). Fallers were more likely to have hypertension (47 subjects (37%) versus 23 (23%), odds ratio (OR) 1.6 (95% CI 1.0–2.4)) and diabetes (18 (14%) versus 5 (5%), OR 2.8 (95% CI 1.1–7.3)). Otherwise, the clinical characteristics of groups were similar. The median number of falls in the previous year in the recurrent fallers was three (range 2–50).

### Symptoms

Mild symptoms occurred in 13 (10%) fallers and 13 (13%) controls, OR 0.8 (95% CI 0.4–1.6). These symptoms included breathlessness in 4 (3%) fallers and 7 (7%) controls, fatigue in 1 faller (1%) and 3 (3%) controls, chest pain 3 (2%) versus 2 (2%), dizziness in 6 fallers and palpitations in 5 controls. In one control patient, palpitations correlated with a short run of supraventricular tachycardia (maximally 14 beats). In one faller, an episode of dizziness was associated with multiple ventricular ectopic beats. No other symptoms correlated with electrocardiographic abnormalities.

### Abnormalities identified

There was no difference between the mean heart rates: 70.2 (±9.6) in the fallers and 71.8 (±8.8) in controls, P=0.198.

At least one electrocardiographic abnormality was identified in 63 (49%) of recordings in fallers and 41 (41%) of controls, OR 1.2 (0.9–1.6).

The prevalence of different abnormalities did not differ between fallers and controls as detailed in Table 2. No patients had bradycardia of less than 30 beats per minute or complete heart block.

One case subject fell during monitoring. No electrocardiographic abnormalities were detected at the time of the fall. None of the control group fell during recording.

## Discussion

24-hour ambulatory electrocardiography is frequently used in the investigation of falls in our hospital [8], yet even in

**Table 2.** Abnormalities identified on 24-hour ambulatory electrocardiography

| | Fallers (n=128) | Controls (n=100) | Relative risk (95% CI) |
|---|---|---|---|
| Any abnormality | 63 (49%) | 41 (41%) | 1.2 (0.9–1.6) |
| Major abnormalities | | | |
| Pauses ≥ 2 seconds | 8 (6%) | 8 (8%) | 0.8 (0.3–2.0) |
| Ventricular tachycardia ≥ 3 beats | 5 (4%) | 3 (3%) | 1.3 (0.3–5.3) |
| Mobitz II heart block | 1 (1%) | 0 (0%) | 1.00[a] |
| Bradycardia < 30 b.p.m. | 0 (0%) | 1 (1%) | 0.44[a] |
| Complete heart block | 0 (0%) | 0 (0%) | |
| Minor abnormalities | | | |
| Bradycardia 30–39 b.p.m. | 11 (9%) | 5 (5%) | 1.7 (0.6–4.8) |
| Paroxysmal supraventricular tachycardia ≥ 10 beats at a rate ≥ 150 b.p.m. | 13 (10%) | 13 (13%) | 0.8 (0.4–1.6) |
| Ventricular ectopy ≥ 30 beats/h | 43 (34%) | 24 (24%) | 1.4 (0.9–2.1) |
| Paroxysmal atrial fibrillation | 6 (5%) | 4 (4%) | 1.2 (0.3–4.0) |
| Mobitz I heart block | 0 (0%) | 0 (0%) | |

[a]For comparisons where relative risks cannot be calculated, probabilities have been determined using Fisher's exact test.

subjects with a history of recurrent falls, no causative arrhythmias were identified by traditional ambulatory recording in our study.

We identified a high frequency of cardiac rhythm abnormalities in both fallers and case controls. This concurs with previous studies in healthy asymptomatic older persons, and in those with evidence of cardiac disease [13–24]. Previous studies have examined heterogeneous populations including independent community-dwelling older subjects with evidence of cardiovascular disease, hypertension, diabetes and taking cardioactive medication [13, 14, 16]. Our sample was similar in the heterogeneity of co-morbidity. Others have excluded patients with co-morbidities, and may therefore have examined a less representative sample of the community, but have still shown a high prevalence of arrhythmia [22, 25]. The commonest abnormalities identified in healthy older people are frequent premature ventricular and supraventricular ectopic beats, with sinus pauses and AV block occurring rarely [14, 18, 19, 22, 25]. The prevalence of these and other rhythm abnormalities was similar in our study to previous reports [14, 18, 22].

As our control subjects were recruited as volunteers from a community sample, there may have been selection biases, which could have led to over- or under-representation of co-morbidities. There was a trend to greater co-morbidity, significantly so for diabetes and hypertension, and higher cardioactive medication use in the fallers. The fallers may therefore have been a frailer group, but this did not translate to a higher prevalence of identified rhythm abnormalities. The study was not powered for the small difference in abnormalities observed; with 128 cases and 100 controls there was 80% power to detect a difference in abnormality rates of 20% assuming a significance level of 5%. 24-hour ambulatory electrocardiography monitoring is frequently included in the investigation of syncope, particularly in those with evidence of heart disease [9]. The diagnostic yield of ambulatory monitoring in subjects with syncope or dizziness varies widely, with arrhythmias detected in between 4 and 64% of recordings [26, 27]. However, a rhythm symptom correlation is made in only 4% of subjects [9]. Thus, the majority of arrhythmias detected do not correlate with symptoms.

There are no previous prospective case–control studies examining the utility of 24-hour ECG specifically in community-dwelling fallers. In institutionalised older persons, there were no differences in ambulatory monitoring findings between 51 fallers and 27 non-fallers, where the prevalence of cardiovascular disease was nearly 80%, much higher than our group [28]. In a series of 28 subjects presenting with a history of episodic, diffuse cerebral symptoms or unexpected falls, eight had arrhythmias known to be capable of causing symptoms [24]. However, only one subject had symptoms during 24-hour ambulatory electrocardiography monitoring. When 17 of the symptomatic subjects were compared with 17 asymptomatic age- and sex-matched controls, no differences were evident in the prevalence of identified arrhythmias. Gordon et al. [29] examined 59 patients living in a geriatric residential setting presenting with falls, dizziness or syncope. In 12 patients who had fallen, cardiac arrhythmias were reported to have been contributory, but in only two of these

cases was the ECG diagnostic. More recently, a review of older patients with atrial fibrillation and falls did not recommend ambulatory ECG monitoring due to lack of symptom–rhythm correlation, and suggested long-term ambulatory monitoring with external or internal event recorders [30]. Thus, the evidence for the diagnostic benefit of 24-hour ambulatory electrocardiography in fallers is sparse.

Our study has demonstrated that electrocardiographic abnormalities are very common in older persons, and there are no differences between abnormalities identified in fallers and non-fallers. Ambulatory electrocardiography did not identify causal arrhythmias for falls. Thus, the routine use of 24-hour ECG monitoring in older persons presenting with falls is unlikely to be helpful.

## Key points

- The cause of recurrent falls is multifactorial and includes cardiac arrhythmias.
- 24-hour ambulatory electrocardiography identifies multiple electrocardiographic abnormalities in older persons, in both fallers and non-fallers.
- Symptom–rhythm correlation is crucial in determining whether an arrhythmia is causative in older persons.
- 24-hour ambulatory electrocardiography is not helpful in identifying the cause of falls in older persons.

## Acknowledgements

## Conflicts of interest declaration

None of the authors has any conflict of interest to declare with respect to this article.

## Provenance of equipment

Del Mar 456A ambulatory electrocardiographic recorder (Holter Monitor) and Del Mar Accuplus 363 electrocardiogram scanner manufactured by Del Mar Reynolds Inc., 13 Whatney, Irvine, CA 92618-2837, USA.

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