Carotid sinus hypersensitivity is common in older patients presenting to an accident and emergency department with unexplained falls

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Abstract

Objective: to determine the prevalence of carotid sinus hypersensitivity and orthostatic hypotension in older patients with non-accidental falls attending an accident and emergency department.

Design: a prospective case–control non-randomized study. Data were collected from semi-structured interviews, physical examination and neurocardiovascular investigations.

Setting: we recruited cases and controls from an inner-city accident and emergency department.

Participants: 26 consecutive patients presenting to accident and emergency with non-accidental falls and 54 controls matched for age, sex and cognitive function presenting to the same department either because of an accidental fall or a reason other than falling.

Main variables measured: detailed history and clinical evaluation, including postural phasic blood pressure measurements, heart rate and blood pressure responses to supine and upright carotid sinus stimulation.

Results: orthostatic blood pressure responses did not differ between groups. The heart rate and blood pressure responses to carotid sinus massage were abnormal in patients with non-accidental falls compared with controls (P=0.002). Asystolic responses were present in 12 (46%) of 26 cases and seven (13%) of 54 controls. Loss of consciousness occurred during carotid sinus massage in seven (27%) of the cases, all of whom had asystole, and in none of the controls.

Conclusions: Almost half of the cognitively normal older patients attending accident and emergency with non-accidental falls have carotid sinus hypersensitivity, emphasizing that a post-fall intervention strategy should include carotid sinus studies.

Keywords: carotid sinus hypersensitivity, elderly, falls, orthostatic hypertension, syncope

Introduction

Falls are the most common cause of accidents in those aged over 65 years [1]. Strategies to target and evaluate falls and provide successful interventions are of key importance. Falls can result in serious morbidity. Repeated falls are associated with restriction in activities of daily living [2], changes in health status [3], hospitalization [4], reduced mobility and social isolation [5], and increased mortality [4, 6].

Falls are common: 25% of those aged over 65 fall at least once a year [7]. It is therefore important not to consider all falls as medical problems. Identifying those with modifiable risk factors for further falls will allow a more rational approach.

A multi-disciplinary intervention in the treatment of falls can reduce both further falls and subsequent injury [8, 9]. The role of cardiovascular instability as a mechanism for causing unexplained falls has only been partly explored in these intervention studies.

Older patients with modifiable cardiovascular causes for falling can present with non-accidental falls. This was so in up to 20% of patients with orthostatic hypotension and 30% of patients with baroreflex abnormalities.
manifesting as carotid sinus hypersensitivity attending a tertiary referral investigation centre for syncope [8]. A causal association between non-accidental falls and hypotension or bradycardia is attributed to possible amnesia for loss of consciousness.

Because falls are a common presentation to accident and emergency (A&E) departments, our objective was to study patients with non-accidental falls presenting to A&E to determine the prevalence of orthostatic hypotension and carotid sinus hypersensitivity.

Methods

Design
A prospective case–control non-randomized study, comparing a consecutive series of cases presenting to A&E with non-accidental falls and controls presenting with a single accidental fall or for any reason other than a fall.

Choice of subjects
Consecutive patients presenting to an inner-city A&E department with non-accidental falls over a 4-week period in August and September 1999 were eligible as cases.

We interviewed all patients over 65 presenting to A&E. First, we asked about the presenting complaint and any history of falls. All patients with falls had an abbreviated 10-point mental test [10] administered to screen for cognitive impairment or dementia. Those scoring < 10 underwent a mini-mental state examination [11].

A ‘non-accidental fall’ was defined as “inadvertently coming to rest on the ground or other lower level”, with no evident explanation for the event at presentation or within 7 days of presentation [12].

Patients with an ‘accidental fall’ gave a clear history of a simple slip or trip (slipping on wet leaves, falling off ladders etc). Those who presented for any reason other than falling (e.g. non-fall-related lacerations, burns) were classified as attending for ‘other reasons’.

We selected the control groups of people attending for ‘accidental falls’ and ‘other reasons’ by matching for age, sex and cognitive function with the cases.

Exclusion criteria were: refusal to consent to investigation, a mini-mental state examination score < 25 (which might result in an inaccurate history of the type of fall), co-morbidity precluding investigation (hospital admission, myocardial infarction within 6 months or stroke, fracture etc), contraindications to carotid sinus massage [13], residence outside a 15-mile radius of the hospital, and inability to speak English.

Cases and controls gave written informed consent. The study was approved by the Newcastle upon Tyne joint ethics committee.

All subjects had a detailed history including social history, details of previous falls and injuries, chronic medical conditions and the number and type of prescribed medications. We recorded symptoms of dizziness and precipitating factors for falls and dizziness such as head turning, prolonged standing and postural change. We also performed routine clinical examination.

Cardiovascular investigations included 12-lead electrocardiogram, carotid sinus massage [14] and postural blood pressure recordings [15].

Carotid sinus massage
We performed massage of the left and then the right carotid sinus for 5 s on each side [14]. The test was carried out both supine and upright (to 70° using an Akron foot-plate-assisted hydraulic tilt bed). We categorized abnormal responses as: (i) asystole for >3 s (cardioinhibitory carotid sinus hypersensitivity); (ii) a fall in systolic blood pressure of >50 mmHg in the absence of asystole of >1.5 s (vasodepressor carotid sinus hypersensitivity) or (iii) a combination of both (mixed carotid sinus hypersensitivity) [16].

Postural blood pressure
Patients were tested in the morning. After 20 min supine rest, we measured beat-to-beat blood pressure non-invasively with digital artery photoplethysmography (Finapres–Ohmeda) over a 2-min period. A sustained symptomatic fall in systolic blood pressure exceeding 20 mmHg over 2 min while standing unsupported was indicative of orthostatic hypotension [15].

Statistical analysis
We compared cases (patients with non-accidental falls) separately with each of the control groups. When data took the form of contingency tables, we used Fisher’s exact test to compare cases and controls. For data that were distributed approximately normally, we used an independent-sample t-test to compare cases with controls. For other data that were at least ordinal, we used a Wilcoxon Mann–Whitney U test to compare cases and controls.

Results
Thirty-six consecutive patients with non-accidental falls met inclusion criteria and were invited to attend for further investigation. Twenty-six agreed, two did not reply and eight refused investigation. Twenty-one of the 26 were women. All lived at home.
Carotid sinus hypersensitivity and non-accidental falls

Twenty-eight patients with accidental falls and 26 attendees for other reasons were recruited as control patients. All lived at home.

Five non-accidental fallers and five accidental fallers and six patients attending for other reasons had a history of falls or syncpe. The number of falls was higher among cases than either of the control groups (P<0.001; Table 1).

Social circumstances, co-morbidity (including ischaemic heart disease), culprit medication and smoking history did not differ between cases and controls. The presence of cardiac dysrhythmia (either previously documented or newly diagnosed in the study) did not differ between the groups (Table 1).

At 42% [95% confidence interval (CI) 24–61], postural dizziness was more common in the cases than in either control group—15% (95% CI 0.5–32) in non-fallers, 4% (95% CI 0.2–0.11) in accidental fallers. Dizziness during other manoeuvres, and in particular dizziness during head turning or prolonged standing, were not more common in cases.

Postural blood pressure changes were similar in cases and controls. Baseline blood pressure did not differ significantly between the groups (Table 2).

Carotid sinus hypersensitivity was more prevalent in cases than in either control group: 12 cases had cardio-inhibitory carotid sinus hypersensitivity compared with three of those attending for other reasons and four of the accidental fallers. Similarly, the number of cases with vasodepressor carotid sinus hypersensitivity was 18, compared with 11 of those attending for other reasons and five of the accidental fallers. The maximum fall in systolic blood pressure during carotid sinus stimulation was greater and the maximum prolongation in R–R interval was longer in cases than in either set of controls. For cases, the absolute maximum R–R interval was 1825 ms longer (95% CI 641–3008) than for non-fallers and 1875 ms longer (95% CI 725–3022) than for accidental fallers (P<0.003 and P<0.002 respectively). The maximum fall in systolic blood pressure was 17.1 mmHg greater for cases than for accidental fallers (95% CI 8.4–25.9) and 9.1 mmHg greater for cases than for those attending for other reasons (Table 3).

Seven patients who had presented with non-accidental falls had loss of consciousness witnessed during upright carotid sinus massage in the laboratory, but later denied loss of consciousness. These patients, all of whom had clinically significant asystolic responses to carotid sinus massage (>3 s), demonstrated amnesia for loss of consciousness, which is a proposed mechanism for cardiovascular syncope presenting as falls [17]. None of the controls who had cardioinhibitory carotid sinus hypersensitivity lost consciousness during carotid sinus stimulation.

Discussion

Almost half of patients with non-accidental falls had cardioinhibitory carotid sinus hypersensitivity, compared with 13% of controls. Orthostatic hypotension was not more prevalent in those with non-accidental falls. From our experience in a tertiary referral centre, non-accidental falls are often associated with cardiovascular disorders, particularly carotid sinus syndrome and orthostatic hypotension. Whether this association is apparent in fallers attending A&E departments is unclear.

Falls are a common presenting symptom at the A&E department—45% of attendances by adults aged >50 years are the result of a fall [18, 19]. In practice, it is important not to convert all falls into medical emergencies but to focus on falls associated with modifiable risk factors.

In this study we compare three groups of older patients attending an A&E department, matched for age, sex, cognitive function and co-morbid conditions that are confounding variables in studies of falls in elderly subjects. Use of culprit medications for cardiovascular syncope were also similar between the groups (Table 4).

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**Table 1.** Clinical characteristics of non-accidental fallers and controls

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non-accidental falls (n=26)</th>
<th>Controls</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, years (SD)</td>
<td>79 (7)</td>
<td>77 (8)</td>
<td>78 (7)</td>
<td>0.267</td>
</tr>
<tr>
<td>No. of women</td>
<td>21</td>
<td>20</td>
<td>23</td>
<td>0.734</td>
</tr>
<tr>
<td>Median mini-mental state examination score (range)</td>
<td>30 (26–30)</td>
<td>29 (25–30)</td>
<td>30 (26–30)</td>
<td>0.391</td>
</tr>
<tr>
<td>Median no. of co-morbid diagnoses (range)</td>
<td>2 (0–5)</td>
<td>1 (0–5)</td>
<td>1.5 (0–4)</td>
<td>0.216</td>
</tr>
<tr>
<td>No. of subjects with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Features of ischaemic heart disease</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1.0</td>
</tr>
<tr>
<td>History of cardiac dysrhythmia</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Postural dizziness</td>
<td>11</td>
<td>4</td>
<td>1</td>
<td>0.06</td>
</tr>
<tr>
<td>Median no. of subjects (range) with previous</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls</td>
<td>4 (1–20)</td>
<td>0 (0–2)</td>
<td>0 (0–2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Syncope episodes</td>
<td>0.5 (0–13)</td>
<td>0 (0–3)</td>
<td>0 (0–2)</td>
<td>0.02</td>
</tr>
<tr>
<td>Injuries</td>
<td>1 (0–3)</td>
<td>0 (0–1)</td>
<td>0 (0–2)</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Table 2. Postural blood pressure among non-accidental fallers and controls

<table>
<thead>
<tr>
<th></th>
<th>Non-accidental falls (n=26)</th>
<th>Controls No falls (n=26)</th>
<th>Accidental falls (n=28)</th>
<th>P-value (cases vs controls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline systolic blood pressure, mmHg (SD)</td>
<td>137 (22.14)</td>
<td>132 (20.34)</td>
<td>131 (22.33)</td>
<td>0.234 0.238</td>
</tr>
<tr>
<td>No. with postural hypotensiona</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>0.339 0.220</td>
</tr>
<tr>
<td>Mean fall in systolic blood pressure, mmHg (SD)</td>
<td>-4.0 (-46 to 40)</td>
<td>-6.5 (-5.2 to 61)</td>
<td>-7.0 (-35 to 24)</td>
<td>0.410 0.671</td>
</tr>
<tr>
<td>Mean vasodepressor responseb (SD)</td>
<td>-56.3 (20.5)</td>
<td>-47.2 (19.0)</td>
<td>-39.1 (10.1)</td>
<td>0.103 0.001</td>
</tr>
<tr>
<td>No. with &gt; 50 mmHg (R-R &lt; 3 s)</td>
<td>18</td>
<td>11</td>
<td>5</td>
<td>0.051 0.001</td>
</tr>
<tr>
<td>Mean maximum RR response, ms (SD)</td>
<td>3643 (2823)</td>
<td>1818 (1023)</td>
<td>1769 (1050)</td>
<td>0.003 0.002</td>
</tr>
<tr>
<td>No. with R-R interval &gt; 3000 ms</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>0.013 0.016</td>
</tr>
</tbody>
</table>

aBlood pressure fall ⩾ 20 mmHg.
bSystolic blood pressure vasodepressor response during carotid sinuses massage.

Table 3. Responses to carotid sinus massage among non-accidental fallers and controls

<table>
<thead>
<tr>
<th>Response to carotid sinus massage</th>
<th>Non-accidental falls (n=26)</th>
<th>Controls No falls (n=26)</th>
<th>Accidental falls (n=28)</th>
<th>P-value (cases vs controls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean blood pressure, mmHg (SD)</td>
<td>-56.3 (20.5)</td>
<td>-47.2 (19.0)</td>
<td>-39.1 (10.1)</td>
<td>0.103 &lt;0.001</td>
</tr>
<tr>
<td>Mean maximum R-R, ms (SD)</td>
<td>3643 (2823)</td>
<td>1818 (1023)</td>
<td>1769 (1050)</td>
<td>0.003 0.002</td>
</tr>
<tr>
<td>No. of subjects with R-R interval &gt; 3000 ms</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>0.013 0.016</td>
</tr>
</tbody>
</table>

The differences in response to carotid sinus massage were present for both absolute blood pressure and heart rate changes and for the presence of predetermined abnormal responses in blood pressure and heart rate during carotid sinus stimulation.

The mechanism of falling in those with exaggerated responses to carotid massage is unclear, but we propose that some patients experience cardiovascular syncope which they later recall only as a fall [13, 20, 21]. This is supported by the observation that seven subjects who had had non-accidental falls had loss of consciousness witnessed but later denied this, thus demonstrating amnesia for loss of consciousness [16]. There was no evidence of syncope in asymptomatic controls or those with accidental falls during testing. Cases had previously experienced more episodes of falls than controls, and higher injury rates.

It is important to establish carotid sinus syncope as an attributable cause of symptoms such as the bradycardia type is amenable to treatment with physiological cardiac pacemakers [22]. In addition, some patients with vasodepressor carotid sinus syndrome respond to treatment with fludrocortisone [23]. Medications known to enhance vagal activity were not responsible for the exaggerated responses in cases in this series.

Orthostatic hypotension was more frequent in cases, but this did not achieve statistical significance.

This is a single-centre explanatory study. Subjects with cognitive impairment were excluded and sample sizes are small. We did not investigate any effects of interventions, although a randomized controlled study has recently confirmed that pacing is of benefit in fallers with carotid sinus hypersensitivity [24].

The prevalence of abnormal responses to carotid sinus stimulation is high. In a healthy asymptomatic population of elderly people the reported prevalence is 0–12%. This increases with advancing years, cardiovascular morbidity and dementia. It is difficult to attribute a causal association between an abnormal response and falls. The significantly higher prevalence of abnormal responses in A&E attendees who are cognitively normal but have had non-accidental falls goes some way to assist in identification of clinical characteristics of patients who might benefit from further assessment and intervention. The 13% prevalence (i.e seven cases out of 54 subjects) of cardioinhibitory

Table 4. Use of medications known to cause carotid sinus hypersensitivity among non-accidental fallers and controls

<table>
<thead>
<tr>
<th>No. of subjects, by fall status</th>
<th>Non-accidental falls</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>No falls</td>
<td>Accidental falls</td>
<td></td>
</tr>
<tr>
<td>β-blockers</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Digoxin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Methyldopa</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Verapamil</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disopyramide</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Carotid sinus hypersensitivity and non-accidental falls

Carotid sinus hypersensitivity among accidental fallers and non-fallers mirrors previous community data. Whether or not an abnormal response in such patients reflects the existence of at-risk groups is not known.

Key points
- Postural dizziness is more common in older non-accidental fallers than in age- and sex-matched controls, while postural blood pressure changes are similar.
- Carotid sinus hypersensitivity is more prevalent in non-accidental falls.
- Heart rate and blood pressure responses are abnormal in older adults with non-accidental falls.
- Half of those with non-accidental falls and carotid sinus hypersensitivity demonstrate amnesia for loss of consciousness during induced asystole of > 3 s.

Acknowledgements
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References
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