Falling: should one blame the heart?
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Citation for published version (APA):
Jansen, S. (2015). Falling: should one blame the heart?
EIGHT

EFFECTIVENESS OF A CARDIOVASCULAR EVALUATION AND INTERVENTION IN OLDER FALLERS: A PILOT STUDY
ABSTRACT

BACKGROUND
Cardiovascular abnormalities are increasingly recognized as important fall-risk factors in older persons. Effectiveness of treating these abnormalities on fall incidence is still uncertain. We therefore studied the efficacy and feasibility of a comprehensive cardiovascular evaluation and intervention in older fallers.

METHODS
Design: Prospective pilot study. Setting: Tertiary university teaching hospital in the Netherlands. Participants: Consecutive referrals to falls clinic with ≥ 1 fall in the past year, aged 65 years or older. Intervention: In addition to a routine multidisciplinary falls assessment, echocardiography, ECG and tilt-table testing followed by a multidisciplinary treatment advice was performed. The intervention aimed at improvement of falls-prevention care by optimizing cardiovascular function (drug interventions, specific advice or invasive diagnostics and/or treatment). Measurements: Primary outcome measure was occurrence of one or more additional cardiovascular diagnoses that contributed to the fall incident and subsequent treatment (advice). Secondary outcome measures included feasibility of the multidisciplinary intervention, fall incidents during six-month follow-up, fall-related injuries and quality of life.

RESULTS
Fifteen patients were included. In ten patients (66%), a diagnosis was made upon comprehensive cardiovascular examination, which was considered a cause or contributing factor to the fall incident in seven patients (47%). Initial orthostatic hypotension and carotid sinus syndrome were most frequently diagnosed. This evaluation and intervention appears to be feasible in current clinical practice.

CONCLUSION
An additional cardiovascular evaluation, in particular continuous non-invasive blood pressure recording, identifies cardiovascular causes of falls in almost half of the cases. This may be of additional value to the current baseline assessment of older fallers under certain conditions. A randomized controlled trial is warranted to assess effectiveness of the intervention on fall incidence and fall-related injury.
INTRODUCTION

Falls in older people and their related injuries form a major and growing health care burden. It is therefore important to improve current falls assessment with respect to modifiable risk factors. Although several studies have investigated the efficacy of multifactorial interventions, evidence regarding specific individual interventions is still incomplete.

Syncope in older persons is often mistaken for falls. Cardiovascular abnormalities are therefore increasingly recognized as potentially modifiable risk factors for falls. Major groups of cardiovascular fall risk factors include orthostatic hypotension, carotid sinus syndrome, arrhythmia and structural cardiac abnormalities causing significant left ventricular dysfunction. Despite recommendations of falls guidelines, cardiovascular work-ups are still not routinely performed in the evaluation of older fallers, in particular non-invasive blood pressure recording. This is potentially due to a lack of evidence and the specific content of the work-up, requiring additional equipment and trained staff.

We therefore performed a pilot-study to investigate the efficacy and feasibility of adding a comprehensive structural cardiovascular evaluation to the routine falls-clinic work-up, followed by multidisciplinary treatment advice. This study was performed in preparation for an intended randomized clinical trial to study the effect of this intervention on the incidence of recurrent falls.

METHODS

Design and setting

This study was designed as a prospective pilot study in which patients visiting a falls clinic underwent additional cardiovascular evaluation and intervention in a tertiary university hospital in the Netherlands. The study protocol was approved by the Medical Ethics Committee of the Academic Medical Center. Written informed consent was obtained from all participants.

Participants

Participants were subsequent patients that had finished fall-clinic assessment. All patients that presented to the emergency department (ED) with a fall or fracture due to a fall were screened for invitation to the falls clinic assessment if there was a presence of two or more modifiable risk factors for their fall, as revealed by a standardized falls questionnaire that was sent to all fallers in the ED. Inclusion criterion was one or more falls in the past year. A fall was defined as coming to rest unintentionally to the ground or to another lower level with or without losing consciousness, excluding falls caused by acute medical conditions or exogenous factors.

Exclusion criteria were: age <65 years and a Mini-Mental State Examination score (MMSE) of 21 points or lower (range 0-30), indicating global cognitive impairment. Participants were recruited between February and October 2012.

Cardiovascular evaluation and intervention

The intervention consisted of a cardiovascular evaluation with subsequent multidisciplinary consultation and treatment advice by a cardiologist and geriatrician. The primary cardiovascular evaluation consisted of additional detailed history taking, which was possible in all fifteen patients. Besides history taking, a standard 12-lead ECG, trans-thoracic Doppler-echo cardiogram, and Head-Up-Tilt test (HUT) and active stand protocol with continuous blood pressure (BP) recording to assess neurocardiovascular syndromes (orthostatic hypotension, vasovagal collapse and carotid sinus syndrome) were performed. It was recorded whether a cardiovascular cause or contribution to the fall incident was suspected, based on the history.

Echocardiography

Standard echo/Doppler transthoracic examination was performed according to local protocol. Echocardiograms were performed by echocardiographers, supervised by a cardiologist. Left and right ventricular systolic function was scored as good, fair, moderate or poor. Ventricles were assessed for hypertrophy and dilatation. Valvular stenosis and regurgitation were assessed for all valves. Valvular regurgitation was categorized as mild, moderate or severe, based on the jet extension. Systolic pulmonary arterial pressure was estimated when tricuspid regurgitation was detected, using the peak regurgitant velocity. Pulmonary hypertension was defined as a systolic pulmonary artery pressure (PAP) of 35 mmHg or higher. Mild pulmonary hypertension was defined as a systolic pulmonary artery pressure of 35–50 mmHg, and severe pulmonary hypertension as a pressure of 50 mmHg or over.
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**Active stand**

All measurements were performed using a Nexfin non-invasive, beat-to-beat finger-blood-pressure measurement device (ccNexfin, technology, Edwards Lifesciences, California, USA). To measure active orthostatic changes, patients were asked to stand up for five minutes after five minutes of supine rest. Initial orthostatic hypotension (IOH) was defined as a ≥40 mmHg fall in systolic BP (SBP) or a ≥20 mmHg fall in diastolic BP (DBP) within 15 seconds after standing, with a spontaneous and rapid return of BP. Classic OH was defined as a ≥20-mmHg fall in SBP or a ≥10-mmHg fall in DBP within five minutes after active stand, but not within the first 15 seconds. BP changes had to be accompanied by symptoms of cerebral hypoperfusion to diagnose OH.

**Head-up tilt (HUT)**

A manually operated tilt-table was used. Carotid sinus massage (CSM) was performed in the supine position, proceeding to a HUT angle of 70° if negative. Carotid sinus syndrome (CSS) was defined as a ≥50 mmHg fall in BP (vasodepressor subtype), asystole of ≥3 seconds (cardioinhibitory subtype) or both (mixed subtype), accompanied by symptoms of cerebral hypoperfusion. For provocation of vasovagal syncope (VVS), HUT was continued for 30 minutes or until collapse occurred. VVS was defined as a ≥20-mmHg fall in BP or asystole of ≥3 seconds. Delayed OH was defined as a symptomatic ≥20-mmHg fall in SBP or a ≥10-mmHg fall in DBP beyond five minutes after HUT.

**ECG’s and additional cardiovascular testing**

Standard 12-lead ECGs were performed. ECG’s were evaluated for rhythm, frequency, conduction intervals, electrical axis, QRS- and ST morphology. Additional cardiac-function testing included 24-hour ECG-monitoring, electrophysiological studies, ECG-stress-testing or internal/external loop recorder studies.

**Multidisciplinary treatment advice**

Multidisciplinary consultation and treatment advice was given by a geriatrician and cardiologist. The intervention aimed at improving falls-prevention care by optimizing cardiovascular function (drug interventions, specific advice or invasive treatment).

For neurocardiovascular syndromes, treatment comprised education about the syndrome and its precipitating factors. In patients who were able to perform physical counter-maneuvers, leg crossing and squatting were encouraged. Medications known to cause (orthostatic) hypotension were reduced or eliminated when safely possible. Physical exercise was encouraged to improve calf-muscle function. For OH specifically, increased fluid intake, elevation of the head of the bed at night (≥20°), pressure-stockings and sufficient salt intake (<10g/day) in the absence of hypertension were advised. Patients with CSS were advised to avoid accidental mechanical manipulation of the carotid sinuses. In case of cardioinhibitory subtype CSS, insertion of a biventricular pacemaker was considered. For VVS, patients were advised to increase fluid and salt intake and lie down or squat in case of prodromal symptoms.

In case of severe cardiac valve abnormalities, patients were referred to a specialized team of cardiologists to assess potential valve replacement. For all structural cardiac abnormalities (mild valve abnormalities, impaired LVEF, LVH and pulmonary hypertension), drug treatment was optimized. Treatment advice for cardiac arrhythmias, such as pacemaker treatment or catheter ablation, depended on the type of the arrhythmia, according to current syncope guidelines.

**Outcome measures**

Primary outcome measure was the identification of a new cardiovascular diagnosis that caused or contributed to the fall-incident with subsequent treatment advice. Secondary outcome measures were fall incidents during follow-up, fall-related injuries and (change in) quality of life. Participants were asked to report their falls and related injury weekly on a falls calendar and to send in the information every three months. Participants who failed to send their falls calendar were contacted by SJ to check compliance. At baseline and at end of follow-up, participants filled out questionnaire in which quality of life was measured through EQ5D. At baseline and at end of follow-up, participants filled out questionnaire in which quality of life was measured through EQ5D. Follow-up duration was six months. To assess feasibility, we registered whether patients objected to the extra visit to the hospital, whether we encountered logistical problems in the referral of patients to the syncope clinic and whether it was possible to plan the multidisciplinary treatment meeting within the standard pathway of care.

**Baseline characteristics and assessment of falls**

Medication use and co-morbidity were obtained in an interview with study participants at baseline. This was croschecked with the patient’s medical records. The following drugs were considered potential fall-risk-increasing drugs (FRID): psychotropic drugs, cardiovascular drugs, analgesics (mainly opioids), anti-cholinergic drugs, antihistamines, anti-
Baseline characteristics of the population are shown in table 1, including (modifiable) fall risk factors identified in the falls clinic. Mean age of patients was 75 (±7) years, 67% was female. Nearly half of participants had a history of hypertension, one patient had a history of myocardial infarction and one patient had atrial fibrillation. Three patients had a history of heart valve abnormalities. A quarter of participants used diuretics, a third of participants used ace-inhibitors and nearly half of participants used a beta-blocker. Most frequently recognized risk factors for falls were: mobility problems, use of fall risk increasing drugs, multifocal glasses and visual impairment. Eight patients had orthostatic intolerance, of whom only two were diagnosed with OH in the falls clinic using the conventional method by sphygmomanometer (BP recording at every minute, from 1 to 5 minutes upon active stand).
TABLE 2. FINDINGS OF A COMPREHENSIVE CARDIOVASCULAR EVALUATION IN OLDER FALLERS, N = 15

<table>
<thead>
<tr>
<th>Finding</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSS</td>
<td>4 (27)</td>
</tr>
<tr>
<td>Vasodepressor type</td>
<td>4</td>
</tr>
<tr>
<td>Cardionotihorbidity type</td>
<td>0</td>
</tr>
<tr>
<td>OH</td>
<td>5 (33)</td>
</tr>
<tr>
<td>Initial</td>
<td>4</td>
</tr>
<tr>
<td>Delayed</td>
<td>1</td>
</tr>
<tr>
<td>Vasoergic collapse</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Drug-induced hypotension</td>
<td>3 (7)</td>
</tr>
<tr>
<td>Electrocardiographic abnormality</td>
<td>6 (40)</td>
</tr>
<tr>
<td>Sinus bradycardia/pseudo 1st degree AV-block/horizontal axis</td>
<td>1</td>
</tr>
<tr>
<td>First-degree AV block/ left bundle branch block</td>
<td>1</td>
</tr>
<tr>
<td>AF/LAFB/left axis deviation</td>
<td>1</td>
</tr>
<tr>
<td>LAFB/pathological Q -wave/ lateral axis deviation</td>
<td>1</td>
</tr>
<tr>
<td>Left axis deviation</td>
<td>1</td>
</tr>
<tr>
<td>Premature ventricular contractions</td>
<td>1</td>
</tr>
<tr>
<td>Echocardiographic abnormality</td>
<td>8 (33)</td>
</tr>
<tr>
<td>Grade 1 MV and Grade 1 TV insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Grade 2 MV and Grade 1 TV insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Grade 1 MV and Grade 2 TV insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Grade 1 TV insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Moderate LV dysfunction + Grade 1 TVand TV insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Moderate LV + RV dysfunction</td>
<td>1</td>
</tr>
<tr>
<td>Moderate RV dysfunction</td>
<td>1</td>
</tr>
</tbody>
</table>

CSS = carotid sinus syndrome; OH = orthostatic hypotension; AV = atrioventricular; LAFB = left anterior fascicular block; MV = mitral valve; PV = pulmonary valve; TV = tricuspid valve; LV = left ventricular; RV = right ventricular.

New cause or contributing factor for the fall incident
In seven patients, additional history taking suggested a cardiovascular diagnosis. Upon cardiovascular examination, a diagnosis was made in ten patients (66%) (table 3). In seven patients (47%), this diagnosis was considered a new or contributing factor to the fall incident: initial OH in four participants, delayed OH in one, CSS in one, and drug induced hypotension in one participant (see case selection). In the majority of these patients (6/7) the history suggested a cardiovascular cause or contribution to the fall incident. In one patient, a cardiovascular cause of the fall was suspected, but no abnormalities were found during the assessment. Eight patients (53%) received non-pharmacological treatment advice for CSS or OH. Tapering of anti-hypertensive medication was initiated in the patient with drug-induced hypotension. One patient was referred for additional cardiovascular analysis with internal loop recorder, but during follow-up no cardiac arrhythmias were documented.

Five patients experienced another fall during follow-up, one was injurious. Quality of life increased slightly during follow-up in seven (47%) patients, but this was not significantly different from baseline values. No patients objected to the extra visit to the hospital. Occasionally, patients had to wait longer than three weeks to be evaluated due to the waiting list. Planning of the multidisciplinary meeting was logistically challenging (because it had no regular place within the standard pathway of care), but gradually improved throughout the study.

Case selection
Case A
A 71-year old female presented with two recent falls. One was on an escalator without LOC or amnesia, the second occurred at home after getting up from the bed. The latter fall was accompanied by retrograde amnesia. She also complained of orthostatic intolerance and dizziness upon head turning, but OH was not objectified during routine falls assessment. Additional history taking suggested positional vertigo as major cause for the fall. During active stand, she was found to have initial orthostatic...
hypotension. Echocardiography and ECG were unremarkable. During examination, all movements of the tilt-table caused severe dizziness. Patient received treatment advice for OH and was also referred to a physiotherapist for positional vertigo exercises. During follow-up, she had had no new fall incidents.

Case B
A 78-year old male patient presented with recurrent falls and blackouts, light-headedness and orthostatic intolerance. He had a medical history of mitral valve insufficiency and was therefore treated with thiazide-diuretics and mononitrates to optimize his mitral valve insufficiency through afterload reduction. During evaluation, he was found to have low resting BP (105/65 mmHg), which was intermittently lower during HUT (90/50 mmHg). Additional history taking suggested severe afterload reduction as a result of medical overtreatment. He developed bradycardia to 30 beats-per-minute during CSM, with symptom reproduction. However, diagnostic criteria for CSS were not met. His ECG showed AF with slow ventricular response (55/min). Echocardiography showed no valve insufficiencies. Anti-hypertensive medications were tapered to reduce hypotension. During follow-up, he reported an improvement of his light-headedness and blackouts. Follow-up echocardiography showed no increase of his mitral valve insufficiency and he developed no symptoms of congestive heart failure.

Case C
A 72-year old female had fallen in her home, after she had just got up from the bed as she had an unpleasant abdominal sensation. During walking to the kitchen she experienced a floating feeling with light-headedness and seeing black spots. After that she fell on the floor, but could not remember whether she lost consciousness. Further history taking during syncope assessment revealed that she had frequent episodes of light-headedness and feeling bloated during walking, but she was usually able to prevent herself from losing consciousness by leaning against a wall or sitting down. Cardiovascular evaluation revealed initial OH without symptom reproduction, and CSS with symptom reproduction. Patient received treatment advice for CSS and OH. During follow-up, there were no further fall or syncope events, as she was able to prevent herself from fainting during prodromal episodes by performing physical counter manoeuvres.

DISCUSSION
The results of our study show that nearly half of patients seen in a falls clinic were found to have cardiovascular abnormalities that were considered a new or contributing factor to their fall incident upon comprehensive cardiovascular evaluation. Moreover, we found that in the majority of cases, additional history taking was discriminatory for finding a cardiovascular cause of the fall. Most important contributing factors were initial OH, delayed OH, CSS and drug-induced hypotension, all of which were diagnosed through continuous non-invasive BP measurement. Echocardiographic abnormalities and ECG abnormalities were frequently found, but in none of cases considered a cause or contributing factor to the fall incident.

Carotid sinus syndrome and OH have been reported as frequent causes of falls in older adults. In our sample, initial OH was considered a contributing factor to the fall incident in 27% of patients. CSS was frequently diagnosed (27%) but only considered a contributing factor to the fall in one patient, as CSS symptoms did not correlate with symptoms at the time of the fall incident. Alcock et al. reported a prevalence of 37% for CSS, and 30% for OH in patients presenting with falls, syncope or dizziness. Kenny et al. found a prevalence of 50% of CSS in patients presenting with unexplained falls, syncope or dizziness. Davies et al. frequently found CSS (73%), OH (19%) and VVS (15%) in patients seen in the emergency department after a fall. These results are in line with our findings, but reported percentages of CSS are higher than in our sample. This is potentially due to the fact that our sample included all patients presenting with falls, rather than unexplained falls, syncope and dizziness only. These results have clinical implications, as for diagnosis of initial OH, CSS and VVS, continuous non-invasive BP measurement is required. In most fall clinics, this is not yet routinely performed. Therefore, two important modifiable risk factors (CSS and IOH) may be overlooked in current fall care.

Forty percent of patients showed abnormal ECG findings, none of which were considered a contribution to the fall. In one case, ECG findings led to additional cardiovascular examination through ILR insertion, although no arrhythmias were recorded during follow-up. However, rhythm-and-conduction abnormalities have been cited as an important cause of syncope. Cardiac arrhythmia and atrial fibrillation have recently been associated with falls and syncope in older adults and several ECG abnormalities
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Clinic is located in the medical ward. Patients with a suspected cardiovascular cause of their fall are therefore referred to the syncope clinic for further assessment by a cardiologist specialized in syncope. Better integration of the falls- and syncope clinic would lead to enhanced streamlining of care. This would however require additional trained staff. Overall, we found that the set-up of the evaluation was feasible. Continuous non-invasive BP measurement could be a valuable first addition to routine falls-work up, as initial OH and CSS could otherwise be overlooked.

The strengths of our study include the detailed cardiovascular evaluation and clinical approach, including very limited exclusion criteria. As we included all patients that experienced one or more falls without selecting those in whom cardiovascular pathology was suspected, we were able to fully explore the benefits of a cardiovascular evaluation (including additional history taking) and intervention for all types of falls-clinic patients. The limitations of our study comprise the small number of patients and the lack of a control group. However, this pilot study was set up to assess the efficacy and feasibility of adding a structural cardiovascular evaluation with additional structured history taking to the current standard falls clinic assessment, in preparation of a randomized clinical trial.

After a cardiovascular evaluation with structured additional history taking and subsequent intervention, a new or contributing cardiac cause of a fall was identified in nearly half of patients who attended a falls clinic. The evaluation and intervention appeared to be feasible in current clinical practice. This shows that a structured additional history taking and subsequent cardiovascular analysis could be of additional value to the current assessment of older fallers, in which standard continuous BP measurement during routine falls-work up could be an important first step. Effectiveness of treatment of these cardiovascular abnormalities in reduction of falls needs to be further studied through randomized clinical trials.

ACKNOWLEDGMENTS

We thank Mrs. Kammenga, Mrs. Scheffer, Mrs. de Bruin and Mrs. Samson for their help in data acquisition.

Cardiovascular conditions can lead to near-syncope and falls in those who already have unstable gait, use sedative medications, suffer from poor vision or have other risk factors for falls, whereas these conditions do not lead to syncope per se in younger and healthier individuals. The results of our study show that even in patients in whom falls were explained after multifactorial falls clinic assessment, we found cardiovascular abnormalities that were likely to have contributed to their fall incidents.

This confirms the multifactorial nature of fall incidents, and underpins the need for a broad assessment of fallers, including cardiovascular risk factors. This is however in slight contrast with current syncope guidelines, in which detailed history taking, which is considered the cornerstone of syncope assessment, precedes cardiovascular work-up that is targeted at finding a clearly defined cause for the syncope event. In the majority of patients with whom a cardiovascular cause or contribution of their fall was found, the detailed history was suggestive of this finding. However, in one patient with a cardiovascular explanation for the fall, the history did not provide any clues for an associated cardiovascular condition. It is known that amnesia for loss of consciousness occurs frequently in syncope, and fall events are often unwitnessed. Furthermore, history taking can be complicated due to cognitive problems, making history taking for falls due to syncope in older adults challenging compared to younger adults. Therefore, the role of additionally structured history taking in the identification of fallers who require cardiovascular evaluation and treatment deserves further study.

Another aim of our study was to assess the feasibility of adding a cardiovascular examination to the current falls assessment. In our hospital, the syncope unit is located in the cardiology department, whereas the falls clinic is located in the medical ward. Patients with a suspected cardiovascular cause of their fall are therefore referred to the syncope clinic for further assessment by a cardiologist specialized in syncope. Better integration of the falls- and syncope clinic would lead to enhanced streamlining of care. This would however require additional trained staff. Overall, we found that the set-up of the evaluation was feasible. Continuous non-invasive BP measurement could be a valuable first addition to routine falls-work up, as initial OH and CSS could otherwise be overlooked.

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