

# Cardiovascular assessment of falls in older people

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**Abstract:** Falls in older people can be caused by underlying cardiovascular disorders, either because of balance instability in persons with background gait and balance disorders, or because of amnesia for loss of consciousness during unwitnessed syncope. Pertinent investigations include a detailed history, 12-lead electrocardiography, lying and standing blood pressure, carotid sinus massage (CSM), head-up tilt, cardiac electrophysiological tests, and ambulatory blood pressure and heart rate monitoring, which includes external and internal cardiac monitoring. The presence of structural heart disease predicts an underlying cardiac cause. Conversely, the absence of either indicates that neurally mediated etiology is likely. CSM and tilt-table testing should be considered in patients with unexplained and recurrent falls. Holter monitoring over 24 hours has a low diagnostic yield. Early use of an implantable loop recorder may be more cost-effective. A dedicated investigation unit increases the likelihood of achieving positive diagnoses and significantly reduces hospital stay and health expenditure.

**Keywords:** falls, elderly, arrhythmia, tilt-table test, carotid sinus hypersensitivity, orthostatic hypotension

## Introduction

Thirty-two percent of all community-dwelling older persons fall every year; half have recurrent falls (Tinetti et al 1988). Unintentional falls in the population over the age of 60 years cost the UK government nearly £1 billion per year, of which 50% are hospitalization costs and 41% institutionalization costs (Scuffham et al 2003). Thirty-nine percent of accident and emergency department attendances in patients over the age of 50 years are due to falls or syncope. Forty-one percent of falls were accidental, 22% were explained by medical diagnoses, 19% were due to cognitive impairment, and 15% were unexplained (Richardson et al 1997).

There is a significant overlap between falls and syncope in older persons. Patients with syncope often present with unexplained or recurrent falls (Dey et al 1997). Witnessed accounts for syncopal events are available in only 40%–60% of patients presenting for investigations at a syncope clinic (McIntosh et al 1993). Thirty percent of patients with witnessed loss of consciousness have amnesia for loss of consciousness (Kenny and Traynor 1991). Nearly two-thirds of older patients with orthostatic hypotension presenting with falls deny loss of consciousness (Ward and Kenny 1996). The insertion of dual-chamber pacemakers in nonaccidental fallers with cardioinhibitory carotid sinus syndrome significantly reduces falls, and many more episodes of falls than syncope were reported in both paced and non-paced patients (Kenny et al 2001). Falls and syncope in elderly patients are therefore often indistinguishable and could result from identical underlying pathophysiological processes.

One in 10 falls results in serious injury and up to 1 in 5 in a fracture (Tinetti 2003). Unintentional injuries are the fifth leading cause of death in older persons,

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and falls are responsible for two-thirds of the deaths resulting from unintentional injuries (AGS/BGS/AAOS 2001). Hip fractures are major consequences of falls and result in a 25% reduction in life expectancy and institutionalization rates of 8%–34% for patients initially admitted from the community (Braithwaite et al 2003). Recurrent falls are a common reason for admission to long-term care institutions (Donald and Bulpitt 1999). Falls are also known to have significant psychological consequences due to the fear of falling (Tinetti et al 1994).

This review outlines the various instruments for detecting cardiovascular causes of falls in older people and assesses the usefulness of each tool according to the current evidence base.

## Cardiovascular causes of falls

The prevalence of falls due to cardiovascular disorders remains largely unknown. Studies into nonaccidental falls, or falls with no evident explanation, are mainly limited to carotid sinus hypersensitivity (CSH). A longitudinal prospective study at an inner-city accident and emergency department involving more than 10 000 patients over the age of 50 years found a 15% prevalence of unexplained or recurrent falls, 23% of which were in individuals with cardioinhibitory CSH (Richardson et al 1997). In a separate case-control study, almost half of patients with nonaccidental falls had cardioinhibitory CSH compared with 13% of controls (Davies et al 2001).

The causes of syncope in the elderly have been better characterized, but the statistics do not include patients with falls and amnesia for loss of consciousness. Twenty to thirty percent of syncope cases are due to orthostatic hypotension (Allcock 2000). Cardioinhibitory CSH is thought to be present in 20%, but this is likely to be an underestimate. Vasovagal syncope causes a further 15%, and cardiac arrhythmias have been found in up to 20% (Kurbaan et al 2003).

The possible cardiovascular causes of unexplained falls extrapolated from causes of syncope are listed in Table 1. Over one-third of older people have more than one attributable cause (Kurbaan et al 2003). There is also an established association between orthostatic hypotension, vasovagal syncope, and carotid sinus syndrome (McIntosh et al 1993).

There is no increase in cardiovascular morbidity or mortality from neurally mediated syncope (Kapoor 1994). Conversely, Framingham data reported a more than twofold

**Table 1** Cardiovascular causes of falls in older people

Orthostatic hypotension
Neurally mediated syncope
Carotid sinus syndrome
Vasovagal syncope
Situational syncope, eg, cough, postprandial, micturition
Cardiac syncope
Arrhythmias
Bradycardias
Supraventricular tachycardia
Ventricular tachycardia
Structural disease
Aortic stenosis
Atrial myxoma
Left ventricular outflow tract obstruction
Subclavian steal syndrome

increase in risk of cardiovascular morbidity and an increase in risk of mortality with cardiac syncope by a hazard ratio of 2.66 (Soteriades et al 2002). A study comparing cases with similar degrees of heart disease, with and without cardiac syncope, suggested that structural heart disease was the most important predictor of mortality (Kapoor and Hanusa 1996). Priority should be given to investigations for cardiac arrhythmias and structural abnormalities in patients with features suggesting a cardiac etiology, the presence of heart disease, and an abnormal 12-lead electrocardiogram (ECG), unless the history strongly suggests neurally mediated syncope.

## Investigations

### History

A detailed history and physical examination will achieve a diagnosis in 45% of older patients with syncope (Kapoor 1994). This may not apply to unexplained falls in older people. A witness account is not available for more than one-third of falls in the elderly (McIntosh et al 1993). Fifty-one percent of fallers with cardioinhibitory carotid sinus syndrome have amnesia from loss of consciousness (Davies et al 2001). The absence of a history of loss of consciousness may also be accounted for by a loss of postural tone due to transient cerebral hypoperfusion that is not severe enough to cause loss of consciousness (Kenny 2002).

Patients may report symptoms such as lightheadedness, sweatiness, nausea, cold, clamminess, dizziness, and blurred vision prior to the fall. Symptoms associated with palpitations and exercise suggest cardiac syncope. Falls immediately after a change in posture (lying to sitting or sitting to standing) suggest orthostatic hypotension. Neurally mediated syncope may present with a history of sudden neck

movements or pressure on the carotid sinus from tight collars (which points to CSH) or prolonged standing in crowded, warm places, with vasovagal syncope. Falls related to specific circumstances, such as micturition, coughing, or defecation, may suggest situational syncope.

The absence of any preceding symptoms may not necessarily rule out a cardiovascular etiology. The typical history is that of an unexplained fall, where the patient could not give an account of how they had fallen (Dey et al 1997), or recurrent falls, two or more in a year. However, patients often attempt to rationalize their fall to a trip or a slip, and good history-taking skills are required to establish whether it was a true accidental fall.

A past medical history of heart disease is an independent predictor of cardiac syncope with a sensitivity of 95% and specificity of 47%. The absence of heart disease excludes a cardiac cause in 97% (Alboni et al 2001). Other medical diagnoses such as Parkinson's disease, multisystem atrophy, and diabetes mellitus are associated with orthostatic hypotension.

An accurate drug history is paramount. Older people tend to be taking multiple medications. Antihypertensives, antianginals, antihistamines, antipsychotics, tricyclic antidepressants, and diuretics, to name but a few, have been known to cause bradycardia, QT prolongation, orthostatic hypotension, and vasovagal syncope. They may also exacerbate preexisting tendencies. A temporal relationship between commencement of certain medications and the onset of symptoms may be helpful, but age increases the susceptibility to adverse effects, and long-standing medications may also be the culprit.

## Physical examination

The purposes of a physical examination are to detect signs of structural heart disease, to identify medical diagnoses that are associated with orthostatic hypotension, and to seek out neurological or musculoskeletal problems that would suggest other causes of falls. The presence of a slow rising pulse, ventricular heave, and an ejection systolic murmur strongly suggests aortic stenosis as the cause and immediately guides the course of further investigations to an echocardiogram and possible surgical intervention. Signs of raised jugular venous pressure, displaced apex beat, pulmonary edema, and peripheral edema indicate the presence of a low left ventricular ejection fraction and high probability of conduction defects, ventricular arrhythmia, and sudden cardiac death. Features of parkinsonism,

suggesting the possibility of orthostatic hypotension and autonomic failure, should lead to a more vigorous pursuit of postural blood pressure measurements and autonomic function tests.

## Lying and standing blood pressure

Orthostatic hypotension is defined as a reduction in systolic blood pressure of at least 20 mmHg or diastolic blood pressure of 10 mmHg or greater within 3 minutes of standing (Consensus Committee AAS/AAN 1996). Measurements should be carried out after the patient has been lying supine for at least 10 minutes. For frailer patients, an acceptable alternative is to perform the measurements using a tilt-table supine and at least 60 degrees of head-up tilt. Orthostatic hypotension can be asymptomatic or associated with symptoms of lightheadedness, dizziness, pallor, blurred vision, shakiness, weakness, coat-hanger distribution of pain, instability, falls, and loss of consciousness that appear shortly after rising. If features strongly suggesting orthostatic hypotension are present, repeated measurements performed as early in the morning as clinically feasible should be performed (Ward and Kenny 1996). Measurements using phasic beat-to-beat monitors, described below, are more sensitive than sphygmomanometer measurements. Attributable diagnosis of orthostatic hypotension should depend on reproduction of symptoms or dramatic falls in orthostatic blood pressure.

## 12-lead electrocardiogram

An abnormal ECG is a predictor of cardiac syncope and increased mortality. Conversely, a normal ECG suggests low risk of cardiac syncope; hence, a neurally mediated cause is more likely. ECG abnormalities suggesting the presence of an arrhythmia are listed in Table 2.

**Table 2** ECG abnormalities suggesting the presence of arrhythmias

Bifascicular block
Left bundle branch block (LBBB), or
Right bundle branch block (RBBB) and left anterior or posterior hemiblock
Atrioventricular block
Sinus bradycardia, sinus pauses
Pre-excitation (shortened PR interval)
Prolonged QT interval
Myocardial ischemia or infarction
Others
Brugada syndrome (RBBB with ST elevation in leads V1–V3)
Arrhythmogenic right ventricular dysplasia

## External and internal electrocardiographic monitoring

Electrocardiographic monitoring should be considered if features of a suggestive history, heart disease, or abnormal baseline ECG are present. A definitive diagnosis can be made only if there is symptom correlation with the ECG abnormality. The presence of ventricular pauses longer than 3 seconds or Mobitz II heart block or third degree block during waking hours or self-terminating ventricular tachycardia should lead to additional investigations. The presence of symptoms with no rhythm variation excludes the diagnosis of an arrhythmia (ESC 2004).

### In-patient monitoring

In-patient monitoring, with bedside monitors or telemetry, may be warranted when there is a high probability of life-threatening arrhythmias. In cases where monitoring is applied immediately after episodes of syncope, a diagnostic yield of 16% has been reported (Crocì et al 2002). This approach has not been measured specifically in cases of unexplained falls, but may be justified in terms of clinical risk in cases of abrupt-onset, extremely frequent falls, with features of heart disease.

### Holter monitoring

The detection rate with ambulatory ECG recording using a Holter monitor over 24 hours is low in cases of relatively infrequent falls or syncope. This approach is often favored owing to the view that Holter monitoring is non-invasive and has a low initial cost. However, in terms of cost-per-diagnosis, it is actually relatively expensive (Kessler et al 1995). The diagnostic rate in an unselected population is 1%–2% (Gibson and Heitzman 1984; Bass et al 1990; DiMarco and Philbrik 1990). Preselection of subjects with abnormal 12-lead ECG significantly increases the diagnostic yield of Holter monitoring (Manchanda and Ehsanullah 2001).

The diagnosis is often made by inference, with the detection of arrhythmia on Holter monitoring with no symptoms. This can lead to the initiation of unnecessary treatment with antiarrhythmics or pacemaker insertion in patients who actually have neurally mediated syncope. Conversely, the physician may be lulled into a false sense of security in the presence of a normal 24-hour ECG recording. The absence of an arrhythmia on Holter monitoring in patients with suspected cardiac syncope should lead to further investigations.

### External loop recorders

A study of patients with more than two episodes of syncope in 6 months indicated that external loop recorders were not useful in the absence of overt heart disease with negative tilt-tests (Schuchert et al 2003). External retrospective loop recorders, however, had a relatively high diagnostic yield of 25% in selected patients with frequent syncopal symptoms (Linzer et al 1990).

A recent study comparing external loop recorders with conventional Holter monitoring reported a symptom–rhythm correlation of 56% (44/78) for loop recorders versus 22% for Holter monitors (Sivakumaran et al 2003). Twenty-three percent of symptomatic patients fail to activate their loop recorder. Patients who are unfamiliar with technology, live alone, or have low motivation to reach a diagnosis have a lower diagnostic yield from external loop recorders (Gula et al 2004), which limits their usefulness in the elderly.

Cardiac event recorders with a continuous automatic arrhythmia detection function (Balmelli et al 2003) may be more appropriate for older people with unexplained falls, but symptom correlation may not be possible. Prospective recorders should not be used to investigate unexplained falls and syncope, as the patient is unlikely to be able to apply the recorder to the chest during the event.

### Implantable loop recorders

The implantable monitoring device is inserted subcutaneously under local anesthesia. It has a battery life of up to 18 months and memory for 40 minutes of continuous ECG recording retrospectively and a further 2 minutes after activation. An activation device is placed over the implanted loop recorder by the patient, family member, or carer after a typical symptomatic episode (Kenny and Krahn 1999). A diagnostic yield of nearly 50% was obtained in a small series of older people with unexplained falls and syncope (Armstrong et al 2003). This was comparable to larger series involving younger subjects with syncope (Krahn et al 1999).

A randomized, crossover study of patients with unexplained syncope comparing early implantation of a loop recorder and a “conventional” strategy of external loop recording, tilt-table tests, and electrophysiological testing demonstrated a much higher diagnostic yield (52% vs 20%) with an implantable loop recorder (Krahn et al 2001). This study excluded patients with left ventricular ejection fractions of less than 35%. A later study demonstrated an arrhythmia detection rate with symptom correlation of 80% in patients with structural heart disease compared with 50% in patients without structural heart disease (Mason et al

2003). The strategy of implanting an internal loop recorder immediately after the initial evaluation appears to be cost-effective (Benditt et al 2003; Krahn et al 2003).

Apart from prolonged ECG monitoring, the internal loop recorder also removes the logistics issue with adhesive external electrodes causing local irritation or not remaining adherent at the time of the event. It can be regarded as the diagnostic “gold standard” through its ability to establish the rhythm at the time of the fall or syncope (Brignole et al 2001).

An automatically activated version of the implantable loop recorder is now available. Auto-activation enhances diagnostic effectiveness (Ermis et al 2003) and allows the detection of significant asymptomatic arrhythmias (Krahn et al 2004), but its value is limited by the large number of stored inappropriate auto-activation events (Ng et al 2004).

## Echocardiography

Echocardiography has a low diagnostic yield in the absence of clinical, physical, or electrocardiographic findings (Sarasin et al 2002). This test is likely to be diagnostic only in the presence of severe aortic stenosis (Omran et al 1996) or atrial myxoma (Peters et al 1974). The role of echocardiography is as a risk stratification tool for patients with a positive cardiac history or an abnormal ECG, by detecting structural defects that are associated with arrhythmias or a reduction in cardiac ability to meet circulatory demands. Cardiac arrhythmias were diagnosed in 50% of subjects with a left ventricular ejection fraction of less than 40% (Sarasin et al 2002). Mild structural disease on echocardiogram is unlikely to be significant, guiding the investigating physician to a noncardiac route of investigations.

## Ambulatory blood pressure monitoring

Twenty-four-hour blood pressure measurements may have a role in the evaluation of hypotensive disorders, especially if drug-induced hypotensive symptoms or postprandial hypotension are suspected. A reversal in the diurnal blood pressure pattern is often observed in patients with orthostatic hypotension (Senard et al 1992). Alteration in blood pressure after changes in medication and postprandial dips in blood pressure are useful aids to diagnosis and treatment.

## Electrophysiological testing

Electrophysiological testing is indicated in the investigation of syncope in younger adults with an abnormal ECG and

preexisting heart disease, indicating a cardiac cause (ESC 2004). Transesophageal electrophysiological study is limited to the evaluation of supraventricular tachycardias in patients with a normal resting ECG (Santini et al 1990). An electrophysiological study (EPS) is otherwise an invasive test. A more pragmatic approach is often required in the frail elderly, who are more susceptible to both accidental and nonaccidental falls. In older people with little or no functional impairment, EPS is indicated for unexplained falls and syncope when a cardiac arrhythmia is suspected, according to the same diagnostic strategies as in younger adults with syncope.

The diagnostic yield of EPS has not been adequately evaluated. In studies comparing EPS with ECG monitoring and symptom correlation, the correct diagnosis was obtained in 15% (Fujimura et al 1989) to 86% (Brignole et al 1995). Unrelated atrial and ventricular tachyarrhythmias were, however, induced in 24% and 20% of patients, respectively. Diagnosis with EPS is, by inference, based on the confirmation of the initial clinical suspicion through the demonstration of an inducible arrhythmia or conduction disturbance (Lu and Bergfeldt 2003). Therefore, unrelated arrhythmias may easily be mistaken for the diagnosis. The usefulness of EPS is, as a result, highly dependent on the pretest probability, which is indicated by the presence of organic heart disease or an abnormal ECG (Linzer et al 1997). A negative EPS cannot completely exclude an arrhythmia (Krahn et al 2001).

EPS, however, does have the distinct advantage of potentially identifying the diagnosis and delivering a cure, through transcatheter ablation, during the same session. Its value is greatest in the:

- identification of sinus node dysfunction in the presence of significant sinus bradycardia (<50 beats per minute) (Gann et al 1979);
- prediction of impending high-degree atrioventricular block (trifascicular block – alternating right and left bundle branch block or alternating right bundle branch block with left anterior or posterior block) in subjects with bifascicular block (right bundle branch block with left anterior or posterior hemiblock) (Bergfeldt et al 1994);
- presence of inducible monomorphic ventricular tachycardia in patients with previous myocardial infarction (Olshansky et al 1999);
- presence of inducible supraventricular tachycardia with hypotension in patients with palpitations (Goldreyer et al 1976).

The insertion of a pacemaker significantly reduces syncopal episodes in subjects with high-degree AV block induced with EPS, but not sudden or total deaths (Dhingra et al 1979). The increased mortality seems to be related to underlying structural heart disease and ventricular tachyarrhythmia, but inducibility by ventricular stimulation does not appear to be able to predict sudden death (Englund et al 1995).

## Carotid sinus massage

Carotid sinus hypersensitivity is a disease of the elderly. It is rare before the age of 40 years and increases with age (Strasberg et al 1989). It is characterized by an asystolic pause of 3 seconds or more (cardioinhibitory CSH), a reduction in systolic blood pressure by 50 mmHg or more (vasodepressor CSH), or both (mixed CSH).

Carotid sinus hypersensitivity is diagnosed by 5–10 seconds of longitudinal massage over the carotid sinus, at the point of maximal impulse two fingerbreadths below the angle of the mandible at the level of the cricoid cartilage. Carotid sinus massage should be first performed on the right, as 70% of positive responses occur with right-sided massage (McIntosh et al 1993). If a negative response is obtained on the right, then left-sided carotid sinus massage should be performed after 1–2 minutes. Carotid sinus massage should be performed in supine and upright positions on a standard tilt-table. The diagnosis is missed in one-third of patients if only supine carotid sinus massage is performed (Parry et al 2000).

Continuous ECG monitoring is vital. Non-invasive beat-to-beat blood pressure monitoring, such as with digital photoplethysmography (Finapres, Ohmeda, Wisconsin, or Portapres, TNO Biomedical, Amsterdam), should also be used, as the blood pressure response is rapid and cannot be detected adequately with conventional manual or automated devices (Kenny et al 2000). As CSH is common in the asymptomatic elderly, a diagnosis of carotid sinus syndrome (CSS) can be made only in the presence of symptom reproduction (Thomas 1969) with a positive response to carotid sinus massage or in the absence of any competing diagnosis. Patients with CSS usually report few or no preceding symptoms (Davies and Kenny 1999). Symptoms of falls, drop attacks, presyncope, or syncope are usually brought on by mechanical stimulation of the carotid sinus, such as head turning, tight collars, shaving, and by vagal stimuli.

Complications of transient or persistent neurological deficits have been reported in 0.17%–0.45% of patients undergoing carotid sinus massage (Munro et al 1994; Davies

and Kenny 1998; Puggioni et al 2002). For this reason, carotid sinus massage should be avoided in patients with strokes or transient ischemic attacks in the last 3 months and in the presence of carotid bruits.

Carotid sinus hypersensitivity was present in 60% of elderly patients investigated in a syncope unit (Brignole et al 1991). Cardioinhibitory CSS has been demonstrated in up to 50% of older patients with unexplained falls (Davies et al 2001). Treatment of cardioinhibitory CSS by the insertion of a dual-chamber pacemaker has been shown to significantly reduce unexplained falls (Kenny et al 2001) and syncope (Brignole et al 1992), suggesting a causal relationship between cardioinhibitory CSS with syncope and unexplained falls in the elderly. Carotid sinus massage should therefore be performed in patients with unexplained falls if no diagnosis is apparent after the initial evaluation.

## Tilt-table testing

Vasovagal syncope is the result of a paradoxical response to orthostasis. The mechanism is unclear, but is believed to be due to a rapid reduction in venous return to the heart and a virtual collapse of the ventricles due to vigorous contraction, stimulating the Bezold-Jarish reflex, which causes peripheral vasodilatation and bradycardia (Samoil and Grubb 1992). In the elderly, vasovagal syncope is more likely to be due to a dysautonomic response whereby there is an inability of the baroreflex mechanism to adapt, leading to a progressive fall in heart rate and/or blood pressure before the onset of symptoms, than to a hypersensitivity response usually seen in young adults (Grubb and Karas 1992).

History can be diagnostic. Precipitating factors such as emotional stress, pain, fear, warm environment, and prolonged standing are often identifiable. Specific situations including coughing, defecation, and micturition precipitate symptoms in some patients. Patients usually report the prodromal symptoms of sweating, blurred vision, nausea, dizziness, fatigue, weakness, abdominal discomfort, or headache. Recovery after the event is usually rapid, but protracted symptoms can occur.

Head-up tilt has been used increasingly widely to diagnose vasovagal syncope since it was first reported in 1986 (Kenny et al 1986). Tilt-table tests (Figure 1) should be performed in a quiet, dimly lit room after at least 5 minutes of supine rest, or 20 minutes after cannulation. The tilt-table must have footboard support and should be able to return to the supine position in less than 10 seconds. There should be continuous beat-to-beat blood pressure as well as continuous ECG monitoring. The angle of tilt used is 60–70



Figure 1 Tilt-table test.

degrees. Passive tilt is assumed for at least 20 minutes and up to 45 minutes. After 20 minutes, a provocative agent, either intravenous isoproterenol (isoprenaline) (Almqvist et al 1989) or sublingual nitroglycerin (glyceryl trinitrate) (Raviele et al 1995), can be administered with a further 15–20 minutes of tilting. Isoproterenol is contraindicated in ischemic heart disease and sick sinus syndrome and is less well tolerated in the elderly than sublingual nitroglycerin (Graham et al 2001).

A test is deemed positive when there is symptom reproduction. The positive responses to head-up tilt have been classified into three main types: mixed, cardioinhibitory, and vasodepressor (Brignole et al 2000). The heart rate falls to less than 40 beats per minute for more than 10 seconds in type 2, cardioinhibitory response, which is subdivided into 2A and 2B. Types 2A and 2B, respectively, represent cardioinhibition with and without asystole of more than 3 seconds. The heart rate does not fall by more than 10% from baseline in pure vasodepressor response. The exceptions to the classification are chronotropic incompetence, where there is no rise in heart rate on tilting, and postural orthostatic tachycardia syndrome (POTS).

The positive response rate for head-up tilt with nitroglycerin administration following 20 minutes of passive phase has been reported as 69% with a specificity of 94% (Natale et al 1998). Older people do have more exaggerated responses to head-up tilt than younger adults (Del Rosso et al 2002). The exaggerated responses can be misinterpreted as false positives (Kumar et al 2000). Tilt-table tests are

therefore of diagnostic value only in patients with recurrent and unexplained falls or syncope.

The initial treatment of this relatively benign condition surrounds removal of triggers including culprit medications and abortive maneuvers. If the diagnosis is clear from the history, further testing is not always necessary. In some cases, however, there may be clinical indications to demonstrate vasovagal tendencies to the patient by performing tilt-table tests.

## Diagnostic strategy

Falls in the elderly are multifactorial (Fleming and Pendegast 1993). All older people who present with recurrent falls should receive a fall evaluation, which includes assessments of vision, gait and balance, and mental status as well as a thorough history and physical examination (AGS/BGS/AAOS 2001). A cardiovascular assessment should be considered in older people presenting with falls if there is a history of loss of consciousness suggesting syncopal events. It should also be performed when there is no plausible explanation for the mechanism of the fall, particularly if such falls are recurrent or result in serious injury.

The diagnostic strategy of unexplained falls and syncope in older people should be guided by the initial evaluation, which should include a detailed history including a collateral history whenever possible, physical examination, 12-lead ECG, and lying and standing blood pressure. A firm diagnosis can sometimes be made based on the initial evaluation, in which case no further investigation may be needed and a definite treatment can be planned. This definite treatment may range from reassurance to the immediate need for cardiac pacing or treatment for an acute myocardial infarct or pulmonary embolus, which may sometimes masquerade as falls in the elderly.

A past medical history of heart disease predicts a cardiac cause with 95% sensitivity and 48% specificity (Alboni et al 2001). An abnormal baseline ECG also increases the positive predictive value for cardiac investigations. Unless the history is strongly suggestive of an alternative diagnosis, heart disease and abnormal ECGs should guide the physician towards cardiac investigations. An echocardiogram is useful for risk stratification in cases with features of heart disease and abnormal ECGs and can occasionally be diagnostic (aortic stenosis and atrial myxoma). Twenty-four-hour ECG (Holter) monitoring has a low yield and is useful only for patients with daily symptoms. External loop recorders can be used for patients with frequent symptoms, but an

implantable loop recorder is most likely to produce a positive diagnosis of an arrhythmia. Early implantation of an internal loop recorder after the initial evaluation may be more cost-effective. Electrophysiological testing is indicated for patients with organic heart disease and suspicions of a cardiac cause.

The absence of any diagnosis after the initial evaluation increases the likelihood of a neurally mediated syncope. Tilt-table tests and carotid sinus massage should be considered. Tests for neurally mediated syncope may not be necessary if there has been only one episode of unexplained fall, or the episodes are extremely infrequent (one in a year or less), with no negative consequences.

If the primary strategy fails to establish a cause for the falls, a reappraisal of the work-up is required, and an alternative strategy must be planned. One-third of older people have more than one possible attributable cause to their symptoms (Kurbaan et al 2003). Further evaluation, therefore, is required if more than one cause is suspected or if symptoms are persistent.

## Dedicated investigation facilities

Uncoordinated efforts to investigate unexplained falls and syncope often lead to unnecessary investigations, low diagnostic yields, and mounting costs. Multifactorial interventions incorporating cardiovascular assessments have been shown in randomized, controlled trials to significantly reduce falls (Close et al 1999; Davidson et al 2005). One model of good practice is that in Newcastle, UK, where a dedicated day-case facility for falls and syncope in older people was set up in 1991. It offers rapid access service for inpatients and outpatients, multidisciplinary assessment, and one-stop cardiovascular investigations. The average length of stay for the relevant diagnostic codes for the hospital trust was far lower than those of its peer hospitals (2.4 vs 8.6 days). This translated to an estimated cost saving of over £2 million per year for the acute hospital in 1999 (Kenny et al 2002). A similar model for syncope in the United States has shown equally impressive cost savings (Shen et al 2004).

A dedicated investigation unit for falls and syncope in older people should have among its complement of staff physicians with a specialist interest in this area, specialist-trained nurses, receptionist, occupational therapist, and physiotherapist. It should have direct access to psychotherapists and psychiatrists and should work closely with social services. The equipment in the unit should include continuous ECG monitoring, beat-to-beat blood pressure

monitoring, tilt-tables, Holter monitors, external and internal loop recorders, 24-hour ambulatory blood pressure monitors, and autonomic function tests. There should also be easy access to echocardiography and electrophysiological studies. Other modes of investigations for noncardiovascular causes such as computed tomography, magnetic resonance imaging, and electroencephalography should be readily available.

## Conclusion

Falls are a common problem in older people, often leading to serious consequences. Orthostatic hypotension, neurally mediated syncope, cardiac arrhythmias, and structural heart disease may present as unexplained falls as well as syncope in older people. The investigative approach to unexplained falls and syncope in older people should be coordinated to minimize unnecessary investigations and maximize diagnostic rates.

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