CHAPTER 21—FALLS

PREVALENCE AND MORBIDITY

Falls are one of the most common geriatric syndromes threatening the independence of older persons. A fall is considered to have occurred when a person comes to rest inadvertently on the ground or a lower level. Most discussions in the literature of falls by older persons do not include falls associated with loss of consciousness (eg, syncope, seizure) or associated with overwhelming trauma. The majority of falls are not associated with syncope.

The incidence of falls increases with age and varies according to living status. Between 30% and 40% of community-dwelling persons aged 65 years and older fall each year. Among those with a history of a fall in the previous year, the annual incidence of falls is close to 60%. In the long-term-care setting, about half of all persons fall each year.

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Complications resulting from falls are the leading cause of death from injury in men and women aged 65 and older. The death rate attributable to falls increases with age, with white men aged 85 years and older having the highest death rate (> 180 deaths per 100,000 population). Most falls result in an injury of some type, usually minor soft-tissue injuries, such as bruises and scrapes; however, 10% to 15% result in fracture or other serious injury. In general, falls are associated with subsequent declines in functional status, greater likelihood of nursing-home placement, increased use of medical services, and the development of a fear of falling. Of those elderly persons who fall, only half are able to get up without help, thus experiencing the "long lie." Long lies are associated with lasting declines in functional status.

The true cost of falls in health care dollars is difficult to ascertain. It has been estimated that in the United States the lifetime costs of fall-related injuries for persons aged 65 and older is $12.6 billion. Since many falls result in injury, there is a significant use of emergency department facilities among fallers. Studies from the early 1990s indicate that almost 8% of persons aged 70 and older go to emergency departments each year because of a fall-related injury, and close to a third of these people are admitted to the hospital for a median length of stay of 8 days. A population-based study conducted in Washington State identified 149,504 hospital stays for patients aged 65 years of age and older discharged from the state's hospitals in 1989. Of these, 7873 (5.3%) of the stays were for injuries from falls. Of the $995,499,233 in hospital charges in 1989 for persons in Washington aged 65 and older, $53,346,191 (5% to 6%) were attributable to hospitalizations of patients with fall-related trauma.

CAUSES

Falls, incontinence, delirium, and other geriatric syndromes result from the accumulated effect of impairments in multiple domains. The falls of older people are rarely due to a single cause. Rather, there is often a complex interaction among factors intrinsic to the individual (age-related declines, chronic disease, acute illness, medications), challenges to postural control (environment, changing positions, normal activities), and mediating factors (risk-taking behaviors, underlying mobility level).

At least five community-based prospective cohort studies of risk factors for falls have been published over the past decade. The risk factors for falls identified in three of the five studies reviewed were age and cognitive impairment; those identified in two studies were female gender, past history of a fall, lower-extremity weakness, balance problems, psychotropic drug use, and arthritis. These studies differed significantly in the types of risk factors evaluated, the types of population studied (eg, past fall history was sometimes an entry criterion), and the outcome (one fall, two or more falls, injurious falls). The fact that as

many as 25 different risk factors were found across five studies highlights the multifactorial nature of falls and suggests the existence of other circumstances surrounding falls that are not accounted for in studies of this type. In general, the risk of falling increases with the number of risk factors, although some persons with no risk factors experience falls.

Successful falls prevention begins with a knowledge of the age-related changes that increase the risk of falls. The ability to maintain upright posture depends on sensory input from the visual, proprioceptive, and vestibular systems. With aging, there are declines in all three systems. For example, the visual system demonstrates reductions in visual acuity, depth perception, contrast sensitivity, and dark adaptation. The proprioceptive system loses sensitivity in the lower extremities. The vestibular system demonstrates a loss of labyrinthine hair cells, vestibular ganglion cells, and nerve fibers.

Despite these age-related changes in sensory systems, it has been difficult to quantify the age-related changes in postural control that are independent of disease. In general, when postural stability is tested in young and old persons with no apparent musculoskeletal or neurologic impairment, age-related differences in measured sway are found to be most pronounced when moderately severe perturbations of stance are administered, such as changing the support surface, changing body position, altering the visual input, or moving the support surface horizontally or rotationally. This occurs because these perturbations stress the redundancy of the sensory systems in their ability to maintain postural stability. In addition, there may be other age-related changes in the central nervous system that affect postural control, including loss of neurons and dendrites, and depletion of neurotransmitters, such as dopamine, within the basal ganglia.

Since it is difficult to find elderly persons without at least subtle neurologic findings, studies have been unable to determine whether some of the young-old differences may be due to these factors. Some of the most striking postural control differences between young and old persons relate to the order or grouping of muscle activation patterns. Thus, in response to perturbations of the support surface, older persons tend to activate the proximal muscles, such as the quadriceps, before the more distal muscles, such as the tibialis anterior. This strategy may not be an efficient way to maintain postural stability. Similarly, in the elderly person there may be greater co-contraction of antagonistic muscles, and the onset of the muscle activation and associated joint torque may be delayed. Finally, the ability to recover balance upon a postural disturbance may be compromised by an age-related decline in the ability to rapidly develop joint torque by using muscles of the lower extremity. All of these strategies potentially undermine upright posture.

Another important physiologic contributor to the successful maintenance of upright posture is the regulation of systemic blood pressure. The failure to perfuse the brain, which accompanies hypotension, increases the risk of a fall, usually in association with syncope. In addition to the age-related declines in baroreflex sensitivity to hypotensive stimuli manifested as a failure to cardio-accelerate, everyday stresses such as changing posture, eating a meal, or suffering an acute illness may result in hypotension. Since many elderly persons have a resting cerebral perfusion that is compromised by vascular disease, even slight reductions in blood pressure may produce cerebral ischemic symptoms, such as falls. Finally, with aging, there is a reduction in total body water, which places older persons at increased risk of dehydration with acute illness, diuretic use, or hot weather. Since there is a progressive decrease in basal and stimulated renin levels, as well as a decrease in aldosterone production with aging, dehydrating stresses may lead to orthostatic hypotension and a fall.

A number of age-related chronic conditions deserve special mention because of their association with fall risk. Parkinson’s disease, in particular, increases the risk of falls through several mechanisms, including the rigidity of lower-extremity musculature, the inability to correct sway trajectory because of the slowness in initiating movement, hypotensive drug effects, and, in some cases, cognitive impairment. Another common disease contributing to falls is osteoarthritis. When present in the knee, osteoarthritis may affect mobility, the ability to step over objects and maneuver, and the tendency to avoid complete weight bearing on a painful joint.

One of the most easily modified risk factors for falls that has been repeatedly demonstrated in observational studies is medication use. Individual classes of medications, such as the benzodiazepines, antidepressants, and antipsychotic drugs, have been associated with an increased risk of hip fracture. An increased risk of falling has also been found to be associated with recent changes in the dose of a medication and the total number of prescriptions.

The relative importance of environmental factors to the risk of falling has not been well-quantified because they so frequently interact with risk factors intrinsic to the individual. Well-designed intervention studies have focused on improving the risk-factor profile of the person or have combined individual interventions with environmental manipulation, making it difficult to isolate the contributions of the environmental factors**.** Nevertheless, attention to safety hazards in the home environment would appear to be worthwhile, and one intervention study targeting environmental factors was successful in reducing falls.

DIAGNOSTIC APPROACH

History and Physical Examination

Many falls never come to clinical attention for a variety of reasons: The patient may never mention the event, there is no injury at the time of the fall, the clinician may fail to ask the patient about a history of falls, or the patient or the clinician may make the invalid assumption that falls are an inevitable part of the aging process. Treatment of injuries resulting from falls commonly fails to include an investigation of the cause of the fall.

In the clinical evaluation of the geriatric patient who is not specifically being seen for a problem with falling, it is still important that an assessment of fall risk be integrated into the history and physical examination. (See Figure 21.1 for an overview of falls assessment and management in all older persons.) The most important point in the history is the previous history of a fall, since this is a strong risk factor for future falls. For patients presenting with a fall, important components of the history include the activity of the faller at the time of the incident, the occurrence of prodromal symptoms (lightheadedness, imbalance, dizziness), the location of the fall, and the time of the fall. Loss of consciousness is associated with injurious falls and should raise important considerations, such as orthostatic hypotension or cardiac or neurologic disease. (See Syncope.) Information on previous falls should be collected to identify patterns that may help target strategies to reduce risk factors. A complete medication history should focus specifically on vasodilators, diuretics, and sedative hypnotic drug use because these agents have been associated with increased risk of falls. In addition to inquiring about the circumstances surrounding the fall, the clinician taking the history should attempt to identify environmental factors that may have contributed. Thus, information on lighting, floor covering, door thresholds, railings, and furniture may add important clues.

The physical examination of the person who has fallen should focus on risk factors. Much of the examination duplicates that of a gait assessment (see Gait Disturbances.) Footwear may also be an important factor to consider. In one small study to test the effect of various shoe types on balance in older men, shoes with thin, hard soles were found to produce the best results, even though they were perceived as less comfortable than thick, soft, mid-soled shoes, such as running shoes.

Probably the most important part of the physical examination is an assessment of integrated musculoskeletal function, which can be accomplished by performing one or more tests of postural stability. (See Gait Disturbances.)

A simple maneuver called the “functional reach” test is a practical way to test the integrated neuromuscular base of support and has predictive validity for falls in elderly men. This test is performed with a leveled yardstick secured to a wall at the height of the acromion. The person being tested assumes a comfortable stance without shoes or socks and stands so that his or her shoulders are perpendicular to the yardstick. He or she makes a fist and extends the arm forward as far as possible along the wall without taking a step or losing balance. The total reach is measured along the yardstick and recorded. Inability to reach 6 inches or more is cause for concern and merits further evaluation. In its initial description, the functional reach correlated with other physical performance measures, such as walking speed ($r = 0.71$), tandem walk using an ordinal scale ($r = 0.67$), and standing on one foot measured as number of seconds that a one-footed stance could be maintained ($r = 0.64$).

Laboratory and Diagnostic Tests

There is no standard diagnostic evaluation of a person with a history of falls or with a high risk of falls. Obviously, laboratory tests for hemoglobin, serum urea nitrogen, creatinine, or glucose levels can help to exclude such causes of falling as anemia, dehydration, or hyperglycemia with hyperosmolar dehydration. There is no proven value of routinely performing Holter monitoring of persons who have fallen. Because

data demonstrate that carotid sinus hypersensitivity contributes to falls and even hip fracture, some have advocated performing carotid sinus massage with continuous heart rate and phasic blood-pressure measurement in persons with unexplained falls. Similarly, the decision to perform echocardiography, brain imaging, or radiographic studies of the spine should be driven by the findings of the history and physical examination. Echocardiography should be reserved for those with heart murmurs believed to contribute to the maintenance of blood flow to the brain. Spine radiographs or magnetic resonance imaging may be useful in patients with gait disorders, abnormalities on neurologic examination, lower-extremity spasticity, or hyperreflexia to exclude cervical spondylosis or lumbar stenosis as a cause of falls.

TREATMENT AND PREVENTION

Multiple studies of preventive interventions have been conducted over the past decade, including programs to improve strength or balance, educational programs, optimization of medications, and environmental modifications in homes or institutions. Some interventions have targeted single risk factors; others have attempted to address multiple factors.

A Cochrane Collaboration systematic review of interventions to reduce the incidence of falling in elderly persons was performed. This review considered only studies that included elderly persons randomized to an intervention versus control, or into one of two interventions. As of May 1997, 18 individual study reports meeting the inclusion criteria and one planned meta-analysis were identified. The meta-analysis came from the group of studies called the FICSIT trials (Frailty and Injuries: Cooperative Studies of Intervention Techniques) and was not included in the review. Three of the studies that were part of the FICSIT group, however, were individually included. Of the 18 studies, 14 reported the effect of interventions in persons living in the community, two were set in long-term-care institutions, and two were hospital-based, either in a rehabilitation hospital or an acute geriatric assessment and treatment unit. Five of the studies compared a physical exercise intervention with an attention control visit, education only, or no intervention. One also included a cognitive intervention, and another compared a more intense exercise program with a lower-intensity program. In nine of the studies the intervention was targeted to risk factors identified on an initial assessment, including intrinsic risk factors and environmental factors. The other studies employed a variety of interventions, including physician referrals with or without a formal recommendation; health visitor assessments of nutrition, medical conditions, environmental hazards, and physical fitness; multifactorial interventions based on geriatric assessment; targeted risk factor intervention; counseling; and even hormone replacement therapy. The hospital-based studies evaluated the effectiveness of a bed alarm system and the use of blue identification bracelets for the prevention of falls in high-risk elderly inpatients.

The results of this systematic review revealed that neither an untargeted exercise intervention alone, nor an untargeted exercise and health education or health education alone significantly reduced the risk of falls when compared with usual care. Behavioral interventions targeting risk factors might reduce the risk of falls. The most favorable results were observed in studies in which health screening was followed by targeted interventions. Pooling of the data from five studies suggested that a targeted intervention in which older people are assessed by a clinician trained to identify intrinsic and environmental risk factors is likely to reduce the fall rate (odds ratio = 0.79; 95% confidence interval 0.65–0.96). The costs of implementing such a program with a multidimensional health assessment followed by targeted interventions have been explored in one of the five studies to investigate such an approach. The results of that study indicate that targeted intervention is apparently cost-effective.

Since the release of this systematic review of interventions, several additional randomized, controlled trials have been published. In one of the FICSIT studies, the effect in older adults of strength and endurance training on gait, balance, physical health status, fall risk, and health services use was examined. This single-blinded, randomized, controlled trial enrolled 105 elderly persons with at least mild deficits in strength and balance. There were three exercise groups (strength training using weight machines, endurance training using bicycles, and strength and endurance training) and a control group. After 6 months of the intervention, with all exercise groups combined versus the control group, a significant beneficial effect of exercise on time to the first fall (relative hazard = 0.53, 95% confidence interval 0.30–0.91) was found, despite the fact that there was virtually no effect on intermediate outcomes such as gait and balance. The fall rate among those in the control group (0.81 falls per year) was significantly higher than the rate among those in the exercise groups (0.49 falls per year) (relative risk = 0.61, 95% confidence interval 0.39–0.93).

In contrast to the Cochrane review, which did not find exercise to be effective in reducing falls, these findings support the overall FICSIT meta-analysis results that found positive effects of strength and endurance training on fall risk. Of course, it is possible that only some endurance and strength training protocols are effective and possibly effective only in certain subgroups. All these studies highlight the need for clarification of the effect of exercise on groups of elderly persons with differing functional status.

The efficacy of an interdisciplinary approach to falls prevention was confirmed by a study of patients aged 65 and older who presented to an emergency department with a fall. Patients randomly assigned to an intervention group, who had a detailed medical and occupational therapy assessment with referral to relevant services, if needed, had fewer falls (183) than the control group assigned to usual care (510). The odds ratio of falling for the intervention group was 0.39. In another randomized study of 530 persons aged 65 and over who were recruited prior to discharge from hospitals, a home visit by an experienced occupational therapist to address specific home modifications was found to result in a 19% reduction in the risk of falling in the next 12 months over that of a control group not receiving the home visit. The intervention reduced falls by 36% among participants who had a history of a fall in the year prior to enrollment. The success of this intervention may have been due to a combination of home modification and changes in behavior, but it suggests that simple, cost-effective interventions are available to prevent falls among vulnerable elderly persons.

CLINICAL GUIDELINES

For elderly patients who have sustained a fall, a multifactorial approach that is based on data about risk factors and a multidimensional assessment of the patient and that targets interventions on the basis of these findings is appropriate. For elderly persons who have no history of falling, it is reasonable to use traditional multidimensional geriatric assessment with targeted interventions as risk factors are identified. For a summary of the recommendations of the expert panel on falls prevention assembled by the American Geriatrics Society, the British Geriatrics Society, and the American Academy of Orthopaedic Surgeons, see the Appendix.

ANNOTATED REFERENCES

- American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guidelines for the prevention of falls in older persons. *J Am Geriatr Soc.* 2001;49(5):664–672.

  The aim of this publication is to guide clinicians in assessing fall risk and managing older patients at risk of falling or who have fallen. A review of the literature was performed to allow recommendations to be evidence based, wherever possible. Grades, based on the quality of the evidence and potential effect of the intervention, are provided for each recommendation. The recommendations cover the following areas: Approach to assessing older persons as part of routine care, not presenting with a fall; approach to assessing older persons with one or more falls, or who report recurrent falls or abnormalities of gait or balance; multifactorial interventions for the management of falls by older persons in various settings; and single interventions for managing falls by older persons. See the Appendix, for a summary of specific recommendations of the panel.

- Close J, Ellis M, Hooper R, et al. Prevention of falls in the elderly trial (PROFET): a randomised controlled trial. *Lancet*. 1999:353(9147):93–97.

  This randomized, controlled trial in a group of patients aged 65 and older who presented to an emergency department with a fall confirmed the efficacy of an interdisciplinary approach to falls prevention. Patients randomly assigned to an intervention group, who had a detailed medical and occupational therapy assessment with referral to relevant services as necessary, were found to have fewer falls (183) than the control group assigned to usual care (510). The odds ratio of falling for the intervention group was 0.39. There was also a trend toward fewer hospitalizations in the treatment group. The importance of this study lies in its targeting fallers presenting to the emergency department, since a history of falls is one of the most potent risk factors for future falls.

- Cumming RG, Thomas M, Szonyi G, et al. Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomized trial of falls prevention. *J Am Geriatr Soc*. 1999;47(12):1397–1402.

  One of the time-honored interventions to prevent falls involves the assessment and modification of the environment. Despite the obvious contribution of environmental factors to the risk of falling, there have been few randomized, controlled trials supporting this approach. This randomized, controlled trial of a trained occupational therapist home visit to assess and modify the environment reduced the 12-month incidence rate of falls among those elderly persons recruited from acute hospitals prior to discharge. In addition to generating a list of the specific recommended home modifications for each participant's home, the study occupational therapist supervised the completion of recommended home modifications, including further home visits, if needed. The risk of falling was reduced by 19% in the intervention group and by 36% in the subgroup who had a history of previous falls. There were several important limitations of the study, including the recruitment of persons at relatively low risk of falls, the generalizability, and the possibility that the intervention effect was due to characteristics of the occupational therapist (control participants did not receive a visit) or to co-interventions. The fact that falls away from home were also reduced in the treatment group suggests that the intervention influenced not only the environment, but the individual as well.

- Gillespie LD, Gillespie WJ, Cumming R, et al. Interventions for preventing falls in the elderly. *Cochrane Database Syst Rev*. 2000;2:CD000340.

  The Cochrane Library of systematic review is a valuable resource for evaluating clinical trials of various therapeutic interventions. Since few such reviews specifically focus on older persons, it is particularly timely to have compiled the growing number of clinical trials in the area of falls prevention. The results of this systematic review revealed that neither an untargeted exercise intervention alone versus usual care, nor an untargeted exercise and health education or health education alone versus usual care significantly reduced the risk of falls. Behavioral interventions targeting risk factors apparently reduce the risk of falls. The most favorable results were observed in studies in which health screening was followed by targeted interventions. Pooling of the data from five studies suggested that an intervention in which older people are assessed by a clinician trained to identify intrinsic and environmental risk factors is likely to reduce the fall rate (odds ratio = 0.79; 95% confidence interval 0.65–0.96).

- Robertson MC, Devlin N, Gardner MM, et al. Effectiveness of economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: randomised controlled trial. ***BMJ.*** 2001;322(7288):697.

  The authors used a randomized, controlled trial to study the impact of a nurse-delivered home exercise program on 240 men and women aged 75 years and older. Outcome measures included number of falls, number of resultant injuries, program costs, and hospital costs associated with falls. Total falls, serious injuries, and hospitalizations due to falls were all reduced. Cost-effectiveness was demonstrated for participants 80 years and older.

- Robertson MC, Gardner MM, Devlin N, et al. Effectiveness of economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: controlled trial in multiple centres. ***BMJ.*** 2001;322(7288):701.

  Trained nurses from within general practices delivered home exercise programs to 330 men and women aged 80 and older. When the intervention group was compared with 120 control participants who received usual care, falls were found to have been reduced by 30% in both men and women. There were no differences in the number of participants who had serious injuries, and there was no difference in hospital costs resulting from falls in study versus control participants.

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