Falls and Fall-Related Injuries in Older Dialysis Patients

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Dialysis patients are increasingly older and more disabled. In community-dwelling seniors without kidney disease, falls commonly predict hospitalization, the onset of frailty, and the need for institutional care. Effective fall prevention strategies are available. On the basis of retrospective data, it was hypothesized that the fall rates of older (≥65 yr) chronic outpatient hemodialysis (HD) patients would be higher than published rates for community-dwelling seniors (0.6 to 0.8 falls/patient-year). It also was hypothesized that risk factors for falls in dialysis outpatients would include polypharmacy, dialysis-related hypotension, cognitive impairment, and decreased functional status. Using a prospective cohort study design, HD patients who were ≥65 yr of age at a large academic dialysis unit were recruited. All study participants underwent baseline screening for fall risk factors. Patients were followed prospectively for a minimum of 1 yr. Falls were identified through biweekly patient interviews in the HD unit. A total of 162 patients (mean age 74.7 yr) were recruited; 57% were male. A total of 305 falls occurred in 76 (47%) patients over 190.5 person-years of follow-up (fall-incidence 1.60 falls/person-year). Injuries occurred in 19% of falls; 41 patients had multiple falls. Associated risk factors included age, comorbidity, mean predialysis systolic BP, and a history of falls. In the HD population, the fall risk is higher than in the general community, and fall-related morbidity is high. Better identification of HD patients who are at risk for falls and targeted fall intervention strategies are required.

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During the past decade there have been dramatic changes in the demographics of dialysis units worldwide. Patients are older and have complex comorbidity and more disability (1). Within Canada, one in four of all incident dialysis patients are older than 75 yr (2). Consequently, dialysis staff must face the challenge of providing comprehensive care for patient issues that more traditionally are addressed by geriatric services.

Falls are a major problem in older people. More than 30% of community dwellers who are older than 65 yr fall at least once during a 1-yr period, with a higher incidence of falls being common in frail individuals or those with disabilities (3–6). Falls are the most common cause of trauma in the elderly, with unintentional injuries being the ninth most common cause of death in this age group (7). A fall can be the first manifestation of serious or acute physical decline (8). Falls predict hospitalization, functional decline, and the need for long-term institutional care (9–11). Even in the absence of physical injury, falls can lead to the individual becoming fearful of experiencing subsequent falls (12). In turn, this *fear of falling* syndrome often causes a voluntary limitation of mobility, a gradual decrease in functional independence, and ultimately an increased need for residential care (13). Therefore, the health implications of falls are enormous, with costs for fall-related fractures alone being estimated at well over US$10 billion (14).

Falls among dialysis patients have received little attention. Previous reports of falls in the dialysis population are limited to a few retrospective or short-term prospective studies (15–17). These suggest that the prevalence of falls in the elderly hemodialysis (HD) population is at least as high as in individuals without uremia in the community (16,17) and that the incidence of fall events may be higher (15). No long-term prospective studies have been reported in this population to determine accurately the annual incidence of falls or to examine the risk factors for falls.

Numerous risk factors for falls in older people have been identified, many of which are amenable to intervention (3). Problems that are associated with increased fall risk include arthritis, depressive symptoms, and orthostasis, as well as impairment in cognition, vision, balance, strength, and gait (3,18). The use of more than four prescription medications of any type increases fall risk (18). Specific culprit medications include sedatives, tricyclic antidepressants, anticonvulsants, or class 1A anti-arrhythmics and drugs that predispose to hypotension (19,20). Patients with a past history of falls are at an increased risk for recurrent nonsyncopal falls (21).

Older dialysis patients tend to have numerous risk factors for falls. They often have multiple comorbidities at the time of starting dialysis, including a high prevalence of diabetes, car-

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diovascular disease, depression, sleep disorders, restless leg syndrome, and peripheral and autonomic neuropathies (22,23). Polypharmacy is ubiquitous in dialysis patients. Furthermore, HD is associated with rapid fluid and electrolyte shifts that predispose patients to dialysis-related hypotension and self-limiting arrhythmias (24). Combined, these risk factors could place older dialysis patients at a very high risk for falling. The objectives of this prospective cohort study were to determine the incidence of falls and the proportion of fallers among dialysis patients who are aged ≥65 yr during at least a 1-yr period, to document the resulting morbidity and mortality, and to identify fall risk factors in this population.

Materials and Methods

This study was a single-center, prospective cohort study.

Study Participants

The inclusion criteria were (*1*) age ≥65 yr and (*2*) undergoing chronic HD at the University Health Network, Toronto, Canada, during the period April 9, 2002, to April 9, 2003 (both incident and prevalent patients). Patients were excluded when they were unable or unwilling to provide informed consent. Patients who were living in a long-term institutional setting were excluded. Ethics approval was granted by the local Research Ethics Board.

Baseline Assessment

Baseline assessments were conducted by a research nurse using standardized protocols. The medical history was abstracted from clinical and electronic charts. The Charlson Comorbidity Index was used to summarize medical comorbidity (25). A full medication, dialysis, and laboratory history was recorded for each patient. BP and dialysis details of the last six consecutive dialysis sessions were recorded. These included predialysis, postdialysis, and nadir BP during dialysis. The need for saline bolus(es) to maintain BP during dialysis and the mean volume of ultrafiltration also were noted. Medications that are known to predispose to falls, termed fall-provoking medications, were defined as those that potentially result in low BP (β blockers, calcium-channel blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, any nitrate administered on a regular basis, diuretics, adrenergic and serotoninergic modulators, and vasodilators) and those that potentially cause sedation or impaired cognition (benzodiazepines, antidepressants, antiseizure medications, antihistamines, opiates, and miscellaneous sedative agents). Basic and instrumental activities of daily living were measured using the Barthel (26) and the Lawton-Brody Instrumental Activities of Daily Living Scale (27). Patients were questioned regarding their use of a walking aid.

All patients were asked to participate in a full clinical evaluation that included the following: Assessment of depressive symptoms using the Mental Health Inventory (28); cognitive assessment using the Folstein Mini-Mental Status Examination (29) and clock drawing task (30); assessment of falls, including events recalled from the previous 12 mo, fear of falling (31), and falls efficacy (32); assessment of vision (expressed as the functional acuity score [33]); assessment of hearing (whisper test) (34); assessment for foot abnormalities (examination for ulcers, amputation, or minor deformities, *e.g.*, bunion or toe deformities); and assessment of orthostatic BP and heart rate immediately before dialysis. All patients also were asked to participate in an evaluation of functional mobility as measured by the timed up-and-go (TUG) test (31,35).

Follow-Up

Patients were visited by the research nurse every two weeks to ascertain whether they had fallen. Additional verbal reports of falls from patients or dialysis nursing staff or reports of falls that resulted in admissions were followed up by the research nurse. Details of falls were obtained using a standardized form based on the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) studies, which included timing, circumstances, injuries sustained, and any health care attention sought (31). Timing of falls was categorized into "before dialysis on a dialysis day," "after dialysis on a dialysis day," and "on a nondialysis day." Patients were followed until April 9, 2004; death; transfer to another HD unit; or kidney transplantation.

Definition of a Fall

A fall was defined as an event that resulted in a person's coming to rest inadvertently on the ground or other lower level (31). Injurious falls were defined as those that caused minor (*e.g.*, cuts, bruises) or major injuries (*e.g.*, fractures, loss of consciousness, hospitalization, death). For simple comparisons of fallers and nonfallers, patients were considered to be fallers when they sustained one or more falls during the follow-up period.

Statistical Analyses

Demographic data were analyzed using descriptive statistics (mean ± SD, or median and quartiles for continuous data and percentages for categorical data, respectively).

The fall incidence was determined from the number of falls that occurred during the study divided by person-years of follow-up. The average number of falls per individual during the study was determined with the mean cumulative function (MCF; SAS version 9.1; SAS Institute, Cary, NC) (36). The timing of falls with respect to dialysis treatment days was examined by comparison of the average number of falls per person on dialysis days *versus* nondialysis days using the MCF. Univariate comparisons between fallers and nonfallers were made using the χ^2 test, t test, or Mantel-Haenszel tests, as appropriate.

The "fall rate" was calculated for each patient by dividing the number of observed falls by the total follow-up time in years. Each patient was classified into one of four ordered categories of numbers of falls per year: (*1*) zero, (*2*) more than zero and up to 1, (*3*) more than 1 and up to 2, and (*4*) more than 2. A proportional odds regression model was used to relate this ordinal outcome to variables that were hypothesized *a priori* to predict fall incidence. These predictor variables were history of falls (dichotomous variable); age (per decade); the total number of fall-provoking medications; gender; and comorbidity score, mean predialysis systolic BP (SBP), vision and Mini-Mental Status Examination adjusted for age, education, and gender (37). Interpretation of the odds ratio in the proportional odds model differs from that in standard binary logistic regression models as it indicates how the predictor changes the odds of a patient's being in one of the higher fall rate groups as compared with the lower fall rate groups. The overall model fit was assessed through a likelihood ratio test that compared this model with the multinomial model. A significance level of 0.05 was used. Regression and demographic analyses were performed using R-statistical software (version 2,01; R-Core Development Group, R Foundation of Vienna, Vienna, Austria).

Results

Population Studied

A total of 232 patients who were 65 yr or older received at least one chronic outpatient HD treatment between the study dates. Thirty-nine patients died, and eight were transferred to

another dialysis facility before being approached for participation. Three were excluded because of a language barrier. Of 182 potential participants, 168 (92%) agreed to participate. The baseline assessment was not completed in six patients because of death ($n = 4$), withdrawn consent ($n = 1$), and prolonged hospitalization ($n = 1$). These six patients were excluded from further analysis. Patients who were not recruited were of similar age and gender to those who were recruited.

Baseline characteristics of those studied are presented in Tables 1 through 3. Fallers were more likely to be older (75.8 *versus* 73.9 yr; $P = 0.04$), to have required dialysis for a shorter period of time (2.4 *versus* 3.4 yr; NS), to have a higher number of comorbid conditions at baseline (11.0 *versus* 9.8; $P = 0.03$), and to recall having had one or more falls in the 12 mo before the study.

Physical Performance Measures

A total of 151 (93%) patients attempted the TUG test. Fifty-eight (77%) of the 75 patients who were able to perform the TUG appropriately had a score that was considered to be low risk for falls (<15 s). Of the remaining 76 patients who were unable to complete the test, 43 required a cane, 12 required a walker, and an additional 21 required personal assistance to walk. On univariate analysis, physical performance (categorized into three groups: TUG time <15 s unaided, unaided TUG time ≥15s, and those who needed aid/assistance) did not predict falls.

Fall Incidence

Patients were followed for a median of 468 d (quartiles 365 to 506 d). Thirty-eight patients did not complete at least 12 mo of follow-up because of death ($n = 27$; 71%), transfer to another facility ($n = 7$; 18%), kidney transplantation ($n = 3$; 8%), or renal recovery ($n = 1$). Of those with <12 mo of follow-up, the median period of follow-up was 241 d (quartiles 147 to 304 d). A total of 305 falls occurred among 76 patients during 190.5 person-years of follow-up for a fall incidence rate of 1.60 falls/person-year (Figure 1). Of the 76 patients who fell, 45 (57%) had multiple (two or more) falls (range 2 to 48). After exclusion of one individual with 48 falls, the fall rate was 1.36 falls/person-year. Using the MCF method, the average number of falls *per person per year* was 2.78 (95% confidence interval [CI] 1.75 to 3.80).

Fall Characteristics

The most common activity at the time of the fall was walking ($n = 91$ indoors, $n = 41$ outdoors). There also was a high frequency of falls when standing from the seated position ($n = 72$) or when trying to rise from a lying position ($n = 28$). Falls occurred with similar frequency on dialysis and nondialysis days ($P < 0.05$). After adjustment for dialysis frequency during the week, the calculated average number of falls per person was 1.45 (95% CI 0.89 to 2.01) and 1.35 (95% CI 0.82 to 1.89) on dialysis days and nondialysis days, respectively. On dialysis days, falls were more common after dialysis (73%) than before (27%).

Fall-Related Injuries

Injurious falls were common (167 [55%] of 305); however, emergency department visits occurred in only 12.5% of all falls and 24% of all injurious falls. Some patients chose not to visit the emergency department but sought medical attention in the dialysis unit ($n = 19$), bringing the total proportion of falls that required medical attention to 19%. Most (136 [81%] of 305) injuries were minor (bruises, lacerations, and sprains), but 12 (7%) individuals sustained head injuries with loss of consciousness and eight (4%) sustained fractures of their upper limb ($n = 3$), hip/pelvis ($n = 4$), or lower limb ($n = 1$). Twenty-six (16%) patients were hospitalized as a direct result of the fall. A total of six (4%) patients died within 7 d of their fall as a direct result of the fall-related injury.

Table 1. Patient demographics[a]

Parameter	Final Study Participants ($n = 162$)	Fallers (≥1 Fall during Follow-Up) ($n = 76$)	Nonfallers ($n = 86$)
Age at time of study start (yr; mean ± SD)[b]	74.7 ± 6.1	75.8 + 6.3	73.9 ± 5.4
Duration on RRT at study start (yr; median [range])[c]	2.3 (0 to 26)	2.4 (0 to 26)	3.4 (0 to 24)
Incident patients (n [%])	20 (11.9)	4 (5.1)	2 (2.4)
Male (%)[b]	57	66	48
Primary renal disease (%)			
diabetes	27	34	20
renovascular or hypertensive renal disease	28	29	27
glomerulonephritis	12	8	16
other	28	26	30
unknown	5	3	7

[a]RRT, renal replacement therapy.
[b]$P < 0.05$.
[c]Includes time on RRT with a functioning transplant (if relevant).

Table 2. Baseline medical characteristics of fallers and nonfallers[a]

Characteristic	Final Study Participants (n = 162)	Fallers (≥1 Fall during Follow-Up) (n = 76)	Nonfallers (n = 86)
Duration of study follow up (d; median [quartiles])	468 (365 to 506)	454 (346 to 565)	426 (380 to 505)
Medical history			
total no. of comorbid conditions (mean ± SD)[b]	10.5 ± 3.5	11.0 ± 3.8	9.8 ± 3.2
diabetes (%)	45	53	38
CCI score (mean ± SD)[b]	8.7 ± 1.8	9.6 ± 1.7	8.4 ± 1.4
major foot abnormalities (%)	8.6	7.9	9.3
minor foot abnormalities (%)	35	46	24
hearing difficulty (patient reported; %)	12	14.5	10.5
reduced vision (%)[c]	49.4	52.1	47.2
Medications			
mean no. of medications	9.0 ± 3.6	9.4 ± 3.8	8.8 ± 3.4
taking ≥1 BP medication (%)	86	86	86
taking ≥1 CNS medication (%)[d]	49	51	47
Laboratory values			
hemoglobin (g/L)	117 ± 12	115 ± 13	118 ± 11
creatinine (μmol/L)	723 ± 188	704 ± 165	743 ± 203
albumin (g/L)	37 ± 3	37 ± 3	38 ± 3
calcium (mmol/L)	2.4 ± 0.2	2.4 ± 0.2	2.4 ± 0.2
phosphate (mmol/L)	1.5 ± 0.4	1.5 ± 0.5	1.5 ± 0.4
iPTH pmol/L (median [quartiles])	18 (6 to 36)	16 (7 to 29)	19 (6 to 47)
BP and dialysis parameters			
mean SBP pre-HD[b]	144 ± 20	140 ± 21	147 ± 18
mean DBP pre-HD	73 ± 10	72 ± 9	74 ± 10
mean SBP post-HD	139 ± 20	137 ± 21	141 ± 20
mean DBP post-HD	71 ± 10	70 ± 10	71 ± 10
mean nadir SBP (mmHg)	118 ± 18	117 ± 17	118 ± 19
mean ultrafiltration volume (L)	2.3 ± 1.0	2.3 ± 1.0	2.2 ± 1.0
median change in SBP on standing (mmHg; quartiles)	−4.0 (−8.2 to 2.3)	−3.0 (−8.8 to 2.0)	−4.5 (−8.3 to 3.0)
median change in DBP on standing (mmHg; quartiles)	−1.0 (−4.0 to 2.0)	−1.0 (−5.0 to 0.0)	0 (−2.3 to 5.3)

[a]CCI, Charlson Comorbidity Index; CNS, central nervous system; DBP, diastolic BP; HD, hemodialysis; iPTH, intact parathyroid hormone; SBP, systolic BP.
[b]$P < 0.05$, fallers *versus* nonfallers.
[c]Defined as reduced visual acuity, stereoscopic vision, or contrast sensitivity.
[d]Medications that cause sedation or impaired cognition (see text).

Factors That Are Predictive of Falls

The ordinal regression results showed that male gender, a history of falls, low mean predialysis SBP, and higher comorbidity were statistically significant and clinically important risk factors for falls. The relationship between mean predialysis SBP and fall risk is shown in Figure 2. Age increased the odds for having more falls but was not statistically significantly. Vision, cognitive impairment, and the number of medications were not predictive of falls (Table 4). Model fit was good (likelihood ratio $\chi^2 = 11.7$ on 11 df, $P = 0.76$).

Discussion

This is the first longitudinal study to examine the burden of falls in older patients who receive chronic outpatient HD. Our results show that 47% of patients had at least one fall during follow-up, with a fall rate of 1.60 falls/person-year of follow-up and an average of 2.78 falls per person (95% CI 1.75 to 3.80). It is likely that these are conservative estimates, because many patients who died during the study reported having previously had falls, thus leading to a censoring bias. Of those who did have a fall, the majority (57%) experienced a second fall during the study period. The mortality rate that was associated directly with falls was 4%, well above that reported in the literature for community-dwelling seniors (8,9,38–40). Fall-related injury rates were similar to that reported among the general population, with most injuries being relatively minor bruises, abrasions, and soft tissue injuries (10).

Table 3. Baseline functional characteristics of fallers and nonfallers[a]

Characteristic	Final Study Participants (n = 162)	Fallers (≥1 Fall during Follow-Up) (n = 76)	Nonfallers (n = 86)
Functional status			
≥1 fall in past year (%)[b]	47	50	19
experience some fear of falling	61%	68%	55%
Falls Efficacy Scale score (/50)	38 ± 14.1	38 ± 13.8	36 ± 14
dependent[c] in ≥1 BADL[d]	55%	58%	53%
dependent[c] in ≥1 IADL[e]	92%	94%	91%
need walking aid (%)	48.2	47.7	48.7
Barthel index BADL score (/100)	93 ± 10	93 ± 10	94 ± 9
Lawton Brody IADL score (/24)	19 ± 3	19 ± 3	19 ± 3
Mental health			
MMSE score (/30)	24.5 ± 4.0	24.5 ± 3.9	24.4 ± 4.1
clock score (/20)	9.2 ± 6.3	10.6 ± 6.5	8.0 ± 5.9
depressive symptoms (%)[f]	30	34	23

[a]BADL, basic activities of daily living; IADL, instrumental activities of daily living; MMSE, Mini-Mental Status Examination.
[b]$P < 0.05$, fallers *versus* nonfallers.
[c]Able to complete the activity of daily living only with help from another person.
[d]*E.g.*, bathing, dressing, feeding.
[e]*E.g.*, shopping, meal preparation.
[f]Score of ≥3 of 6 on the Mental Health Questionnaire.

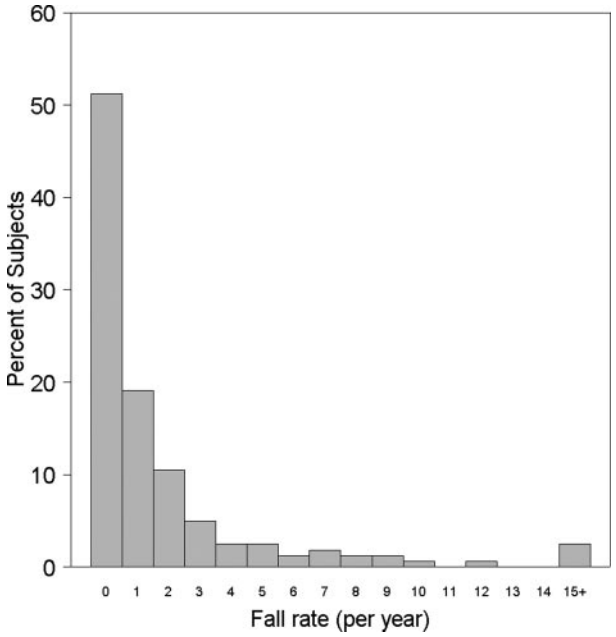

Figure 1. Fall rate per year (see text for definition of fall rate).

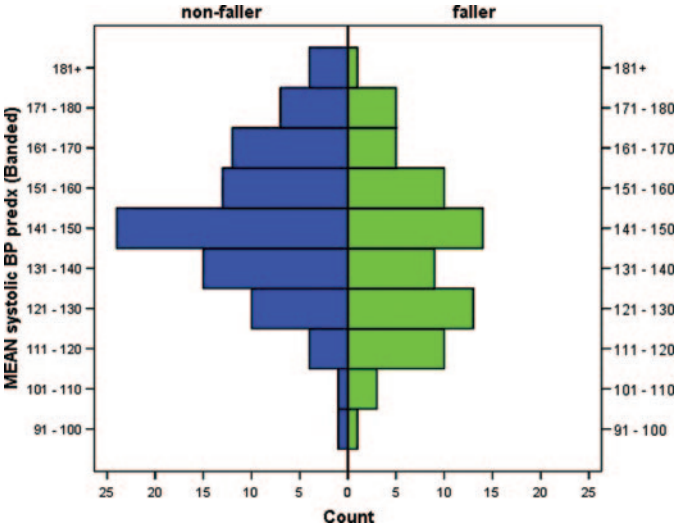

Figure 2. Mean predialysis systolic BP, drawn in bands of 10 mmHg, for both fallers (lighter shading) and nonfallers (darker shading).

At initial glance, the burden of falls reported in this article seems much higher than in previous reports on dialysis populations; in older, frail populations (0.6 to 0.84 falls/patient-year [6,18]) and in those who reside in nursing facilities (1.0 to 1.4 falls/resident-year [41]). A retrospective study in our own dialysis unit found that only 27% of seniors who were on chronic HD recalled having had a fall within the previous 12 mo (17). In an 8-wk prospective study, Desmet *et al.* (15) found that only 12.7% of their dialysis population (of all ages) had a fall, and they noted a fall rate of 1.18 falls/person-year. It is very likely that both studies underestimated the fall risk in seniors who were on HD because of study design limitations. Retrospective studies are prone to recall and survivorship biases (42), whereas studies with a short follow-up period have increased measurement error because of the unpredictable timing of falls. Our study likely is more representative of the actual fall risk for older dialysis patients.

Table 4. Results of regression model to examine factors that are predictive of falls[a]

Factor	OR (95% CI)	*P*
Reports previous falls	2.33 (1.22 to 4.45)	0.01
Male	1.98 (1.02 to 3.81)	0.04
CCI score	1.24 (1.04 to 1.47)	0.01
Mean predialysis SBP (per 10-mmHg change in pressure)	0.85 (0.72 to 1.00)	0.05
Age (per decade)	1.57 (0.93 to 2.65)	0.09
No. of fall-provoking medications	1.08 (0.88 to 1.31)	0.46
Cognition (per 5% change in MMSE)	1.09 (0.71 to 1.67)	0.69
Vision (per 10 points)	1.01 (0.80 to 1.27)	0.94

[a]CI, confidence interval; OR, odds ratio.

Our data are limited by the fact that we recruited dialysis patients from a single in-center HD unit. As with most units within Canada, our unit conforms to Canadian HD practice guidelines (43). We perform regular quality assurance surveys that are based on dialysis adequacy, achieved hemoglobin levels, and bone metabolism parameters (calcium, phosphate, and parathormone levels). By restricting our study population to a singe center, we increased the homogeneity of care provided at the expense of possibly decreasing the generalizability of the results to other units across the world. The second limitation of our study is incomplete physical performance data. Physical performance measures and fall risk have been correlated closely in many studies of falls (5,44). Unfortunately, we found that many of our patients were either unwilling or unable to participate in the TUG test without the use of assistance or an aid, suggesting that dialysis patients have a higher level of disability than previously recognized.

We used biweekly patient interviews to identify falls. Thus, we depended on patients' remembering whether they did or did not have a fall and when that fall occurred. Most fall studies track falls prospectively using a fall calendar that is mailed either weekly or monthly in an effort to reduce recall bias. Unlike community-dwelling seniors, HD patients interact with health care staff on average three times per week. In a pilot study within the HD unit, we found that patient participation with fall calendars was poor, with patients preferring to report falls verbally. We reduced errors that were the result of underreporting or misclassification of falls by ensuring that the study nurse formally interviewed each participant biweekly to identify and obtain detailed information about each fall (45). It still is possible that we did not capture some falls and that our data are limited by recall bias, especially given the relatively high prevalence of cognitive impairment in our patient population. If present, then recall bias would result in an underestimation of the fall rate and our high reported fall rate would be a conservative estimate of the true fall rate.

One of our study objectives was to identify risk factors for older dialysis patients who were most likely to fall repeatedly. We found that low predialysis SBP, male gender, increased comorbidity, and a history of falls were predictive of recurrent falls. The relationship between predialysis SBP and falls is not surprising and has been reported in both the geriatric and nephrology literature (16,19). Of importance, BP is the only potentially modifiable risk factor identified, and our data argue in favor of raising predialysis BP targets in older HD patients who report previous falls. The general geriatric literature reports an increased prevalence of falls in individuals who use four or more medications (3,18). We were surprised to find no association between medications and falls in either univariate or multivariate analyses. We believe that this may be related to the high number of medications taken by all HD patients. Only four of 162 patients were taking fewer than four medications, and most were taking seven to 12 medications. This result is in contrast to that of Desmet *et al.* (15), who, in a younger, relatively healthy dialysis population, found that age, diabetes, medications (especially antidepressants), and ambulatory aid requirement were predictive of falls.

For the clinical nephrologist who is caring for older patients treated with chronic outpatient dialysis, fall risk should be considered as important as other concurrent issues, such as anemia management and bone mineral metabolism. Falls are well recognized as precursors to fractures, increased functional disability, and the need for long-term institutional care (5,9,10,13). Falling is a marker of frailty, and fall prevention is a key to reducing poor outcomes. Therefore, nephrologists can play an instrumental role in identifying those who are at high risk for falls and referring these individuals to multidisciplinary falls assessment clinics (grade A recommendation [46]) and fall prevention programs. Recognition of patients who recall having fallen in the past year could be used to trigger evaluation of fall risk. This could help to minimize the morbidity and possibly the mortality that are associated with recurrent falls and in turn improve the quality of life of the patients, reduce the burden on family and health care caregivers, and potentially reduce institutionalization. Although there are many effective interventions for falls (14,47–51) none has been studied in dialysis populations.

Conclusion

We have shown that dialysis patients are at high risk for falls. Multifaceted fall prevention programs have been shown to be

effective in the general population, and trials of such programs are warranted in the dialysis population.

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