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ORIGINAL RESEARCH

Geriatric falls in the context of a hospital fall prevention program: delirium, low body mass index, and other risk factors

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Background: Inpatient geriatric falls are a frequent complication of hospital care that results in significant morbidity and mortality.

Objective: Evaluate factors associated with falls in geriatric inpatients after implementation of the fall prevention program.

Methods: Prospective observational study comprised of 788 consecutive patients aged 79.5±7.6 years ($\bar{\chi} \pm$ standard deviation) (66% women and 34% men) admitted to the subacute geriatric ward. Comprehensive geriatric assessment (including Mini-Mental State Examination, Barthel Index of Activities of Daily Living, and modified Get-up and Go Test) was performed. Confusion Assessment Method was used for diagnosis of delirium. Patients were categorized into low, moderate, or high fall risk groups after clinical and functional assessment.

Results: About 15.9%, 21.1%, and 63.1% of participants were classified into low, moderate, and high fall risk groups, respectively. Twenty-seven falls were recorded in 26 patients. Increased fall probability was associated with age ≥76 years ($P<0.001$), body mass index (BMI) <23.5 ($P=0.007$), Mini-Mental State Examination <20 ($P=0.004$), Barthel Index <65 ($P=0.002$), hemoglobin <7.69 mmol/L ($P=0.017$), serum protein <70 g/L ($P=0.008$), albumin <32 g/L ($P=0.001$), and calcium level <2.27 mmol/L. Four independent factors associated with fall risk were included in the multivariate logistic regression model: delirium (odds ratio [OR] =7.33; 95% confidence interval [95% CI] =2.76–19.49; $P<0.001$), history of falls (OR =2.55; 95% CI =1.05–6.19; $P=0.039$), age (OR =1.14; 95% CI =1.05–1.23; $P=0.001$), and BMI (OR =0.91; 95% CI =0.83–0.99; $P=0.034$).

Conclusion: Delirium, history of falls, and advanced age seem to be the primary risk factors for geriatric falls in the context of a hospital fall prevention program. Higher BMI appears to be associated with protection against inpatient geriatric falls.

Keywords: falls, geriatric inpatients, comprehensive geriatric assessment, delirium, body mass index

Introduction

Inpatient geriatric falls are a frequent complication of hospital care that results in significant morbidity and mortality, including serious injuries, prolonged hospitalization, increased hospital financial liability, decreased quality of life, and increased risk for placement in nursing homes.[1–6] Prevention strategies and interventions that have been implemented at the hospital and hospital ward level have been shown by others to reduce the number of fall incidents.[7,8] Multiple fall risk factors have been identified in community-dwelling elderly, among them specific medical conditions,[9–12] balance and gait disorders, history of falls, visual impairment, advanced age, female sex,

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Table 1 Components of the fall prevention program implemented in the Department of Geriatrics at University Hospital Number 7 SUM, Katowice, Poland

I) Components of the fall prevention program
   1) Comprehensive geriatric assessment with fall risk evaluation at admission and the documentation and analysis of all patient fall data irrespective of fall complications
   2) Patient and caregiver education (including ward layout and instruction on use of the nurse call button, safe footwear, orthopedic equipment as well as the necessity of requesting staff assistance during ambulation)
   3) Addressing vision and hearing impairment where possible
   4) Medication review and reduction where possible, especially minimization of psychoactive drugs or those with anticholinergic activity. In addition, adjustments are made to avoid overly aggressive antihypertensive, antiarrhythmic, and antihyperglycemic treatment
   5) Adequate hydration and feeding
   6) Treatment of chief complaint and comorbidities
   7) Pain relief
   8) Individualized rehabilitation, including physiotherapy, for maintenance of mobility
   9) Matching orthopedic devices with patients when necessary along with instruction on how to properly use the equipment
   10) Patient monitoring and surveillance adjusted to individual mental and physical status

II) Symptoms and signs indicating high fall risk (any of the following conditions)
Recurrent falls or syncope reported by the patient or their caregiver, recent fall or syncope as reason for hospitalization, substantial balance or gait disorders, fear of falling, severe weakness, serious mental disorders (disorientation and agitation), advanced uncorrected vision or hearing impairment, symptomatic orthostatic hypotension, positive Romberg or other neurological signs of impaired balance, modified Get-up and Go Test[24] score below 6 points, or Tinetti POMA[25] score below 19 points

III) Symptoms and signs indicating moderate fall risk (any of the following conditions)
Fall or syncope in the last 12 months reported by the patient or their caregiver, mild balance or gait disorders, moderate weakness, mild mental disorders, moderate vision or hearing impairment, asymptomatic orthostatic hypotension, minor neurological signs of potential balance impairment, modified Get-up and Go Test[24] score 6–7 points, or Tinetti POMA[25] score 19–23 points

Abbreviation: POMA, Performance-Oriented Mobility Assessment.

polypharmacy, pain, cognitive decline, and environmental factors.[13,14] Certain medications have also been shown to be associated with increased fall risk in community-based elderly, including antiarrhythmics, nonselective β-blockers, benzodiazepines, and antidepressants.[15] Specifically in hospitalized patients, alterations in consciousness, inattention,[16] confusion,[17] anemia, osteoporosis, and a history of falls[3] as well as specific medications, including benzodiazepines, haloperidol, tricyclic antidepressants,[17] zolpidem, and calcium channel antagonists,[18] were identified as fall risk factors. The STRATIFY scale was found to be the best tool for assessing the risk of falls for hospitalized acutely ill adults.[19] However, no screening tool has shown sufficient prognostic accuracy to be recommended for predicting falls among newly admitted acute care hospital patients aged 65 years or older.[20,21]

In 2013, a standard operational program for fall and delirium prevention was implemented in the Department of Geriatrics at University Hospital Number 7 SUM, Katowice, Poland, a subacute geriatric ward at a multiprofile university hospital. For the purposes of the program, fall was defined as a sudden, uncontrolled body transition caused by loss of body balance control or body support instability. In addition to inpatient geriatric fall prevention strategies described by others,[1] this program classifies patients at admission according to three levels of geriatric fall risk: low, moderate, and high (Table 1). The assessment includes clinical and functional evaluation made by the department team. Initial fall risk classification is modified if patient status changes significantly during hospitalization. On the basis of a comprehensive geriatric assessment, an individualized multifactorial approach to reduce patient fall risk is applied. Patient ambulation is restricted based on patient fall risk assessment: moderate-risk patients are instructed to request staff assistance before ambulating between dusk and dawn, while high fall risk patients are instructed to request staff assistance before ambulating at all times. These restrictions are accompanied by an individualized rehabilitation program for each patient, directed at early mobilization and maintenance of mobility. Patients with cognitive impairment are provided with increased nursing surveillance. The program requires the documentation and analysis of all patient fall data irrespective of fall complications. The study was designed to analyze geriatric falls in hospitalized patients after implementation of a fall prevention program.

Patients and methods

Participants

This prospective observational study comprised of 788 consecutive patients aged 79.5±7.6 years ($\bar{\chi}$ ± standard deviation) within a range of 60–100 years, among whom 66% were women and 34% were men. Participants were admitted to the

Department of Geriatrics at University Hospital Number 7 SUM Uppersilesian Medical Center in Katowice, Poland, a subacute geriatric ward at a multiprofile university hospital, between June 2013 and June 2014.

Measurements

Patients were evaluated by taking comprehensive general history (including fall history and balance disorders) and by performing a physical examination (postural balance and gait assessment), geriatric functional assessment, blood work (Table 2), electrocardiogram, abdominal ultrasound, and chest X-ray. BIS_cr equation[22] was used to estimate glomerular filtration rate. This method is recommended in very elderly persons if cystatin C is not available.[23] Modified Get-up and Go Test[24] (scored from 0 to 10 with lower values suggesting increased ambulatory disability) was used to evaluate patient fall risk. The test consists of five exercises: 1) rise from a hard chair with backrest, 2) stand for 5 seconds, 3) walk a distance of 3 m at normal speed, 4) execute a 180° turn and return to the chair, and 5) sit down in the chair. Each of the tasks is scored either 2 points (normal, confident, self-reliant performance), 1 point (mildly to moderately abnormal performance – use of orthopedic devices or any deviation from a confident, normal, but self-reliant, performance), or 0 points (severely abnormal – need for staff assistance or inability of self-reliant performance of the exercise). Tinetti Performance-Oriented Mobility Assessment[25] was also applied in a limited number of cases to assess risk of falls (scored from 0 to 28 with lower values indicating higher fall risk). Mini-Mental State Examination (MMSE)[26] was used to assess global cognitive performance. Geriatric Depression Scale–Short Form was used to screen for depression.[27] Barthel Index of Activities of Daily Living (Barthel Index)[28] and Lawton Instrumental Activities of Daily Living Scale (IADL)[29] were used to determine functional status. MMSE scores range from 0 to 30, Barthel Index from 0 to 100, and IADL from 9 to 27; higher scores indicate better functional status. Geriatric Depression Scale–Short Form scores range from 0 to 15, with higher scores indicating higher depression probability. Confusion Assessment Method for diagnosis of delirium[30] was applied. Dementia was diagnosed according to recommendations from the National Institute on Aging-Alzheimer's Association.[31] Pain intensity was assessed with the Visual Analog Scale[32,33] scored from 0 to 10, or with Doloplus-2 scale[34,35] based on the behavioral–observational method and scored from 0 to 30 points (with higher scores indicating more severe pain) in patients who were unable to report pain intensity because of cognitive impairment. To harmonize both pain scales, Doloplus-2 values were divided by a factor of 3 and pain intensity was scored from 0 to 10 in each patient. Body mass index (BMI) was calculated in all subjects. On the basis of clinical and functional assessment, patients were categorized into low, moderate, and high fall risk groups (Table 1).

Data collection

Data was collected by three research nurses and entered into predefined forms.

Statistical analysis

Data were analyzed using STATISTICA version 10 (StatSoft, Inc., Tulsa, OK, USA). Chi-square test, *V*-square test, and Fisher's exact test were used for categorical variables, and the nonparametric Mann–Whitney *U*-test for quantitative variables was used to compare patients who experienced a fall during hospitalization with those who did not. Probability density analysis was used to calculate fall probability with regard to hospitalization day and time. Multivariate binary logistic regression was performed to assess factors predictive of falls. Variables were adjusted for clinical, functional, and laboratory factors. Multivariate analysis with backward elimination included variables that yielded *P*-values of 0.1 or lower in the initial univariate analysis (Table 3). The Kaplan–Meier method was used to estimate probability of fall-free hospitalization in subgroups of patients with respect to select variables, while differences between these subgroups were assessed with the Wilcoxon–Gehan method. Variables were tested to define the value corresponding with the lowest *P* level. *P*-values <0.05 were considered statistically significant.

Ethics

The study protocol was registered with the Bioethical Committee of the Medical University of Silesia in Katowice, Poland. The committee determined that "the study is characterized by record review and in the context of law is not a medical experiment and does not require assessment by the bioethical committee" (Letter KNW/0022/KB/78/I/13). On the basis of this decision, study participant written informed consent was not required for our study nor was separate patient consent required for our statistical analysis or research since patient data are not disclosed outside internal hospital ward staff.

Results

On the basis of assessment at admission, 15.9%, 21.1%, and 63.1% of study participants were classified into low, moderate,

Table 2 Demographic, clinical, and functional differences between patients who experienced falls during hospitalization (group F) as compared with patients who did not (group C)

Variable	Group F (n=26)	Group C (n=762)	Group F vs group C
	Mean ± SD or percentage		*P*-value
Age, years	86.0±5.0	79.3±7.6	<0.001
Sex, percentage of females	66.5	53.8	0.179
Hypertension, %	73.1	76.1	0.721
Diabetes mellitus, %	34.6	29.7	0.587
Myocardial infarction in anamnesis, %	11.5	11.8	0.789
Congestive heart failure, %	34.6	23.9	0.210
Stroke in anamnesis, %	7.69	12.8	0.632
Peripheral artery disease, %	7.69	6.96	0.805
Parkinson's disease, %	0.00	7.34	0.296
Dementia in anamnesis, %	46.2	21.5	0.003
Delirium in anamnesis, %	7.69	2.63	0.350
Cancer in anamnesis, %	15.4	11.3	0.739
Falls in anamnesis, %	61.5	35.2	0.006
Fall-related injuries in anamnesis, %	23.1	8.27	0.009
Behavioral disorders in anamnesis, %	26.9	11.3	0.015
Pressure ulcers, %	0.00	3.15	0.735
Urinary incontinence, %	46.2	41.3	0.624
Bladder catheterization, %	3.85	8.01	0.686
Number of used medications	5.15±2.38	5.06±2.59	0.892
Neuroleptic treatment before admission, %	30.8	15.5	0.037
High fall risk, %	76.9	62.6	0.496
BMI, kg/m^2	24.3±3.7	27.5±5.8	0.003
Heart rate, beats per minute	72.1±10.0	71.8±12.4	0.529
Systolic blood pressure, mmHg	131.9±24.0	134.5±19.4	0.427
Diastolic blood pressure, mmHg	74.8±10.4	76.8±10.1	0.533
CAM, points	1.12±1.73	0.16±0.74	0.037
MMSE score	20.7±6.6	22.6±7.9	0.040
Barthel Index	57.9±26.3	70.2±29.2	0.011
Lawton IADL	16.0±6.0	18.5±6.4	0.038
Modified Get-up and Go Test	3.65±2.61	4.47±2.77	0.094
Hemoglobin, mmol/L	7.30±1.34	7.76±1.14	0.052
White blood cells, G/L	7.93±3.23	7.60±3.75	0.361
Total protein, g/L	66.2±6.2	70.4±7.4	0.003
Albumin, g/L	32.0±5.8	35.2±6.1	0.008
Glucose, mmol/L	5.84±2.04	6.27±2.11	0.108
Bilirubin, µmol/L	11.10±5.90	11.23±8.82	0.830
Alanine transaminase, nmol/L/s	604±1,438	332±317	0.286
Creatinine, µmol/L	90.0±27.0	92.3±56.3	0.398
Estimated GFR using BIS_creatinine equation, mL/min/1.73 m^2	53.6±18.4	62.1±24.8	0.041
Thyrotropin, mIU/L	1.91±1.39	2.57±6.38	0.817
Vitamin B_{12}, pmol/L	264.9±152.0	310.7±202.2	0.304
Total cholesterol, mmol/L	4.00±0.89	4.53±1.17	0.095
LDL-cholesterol, mmol/L	2.31±0.74	2.64±0.98	0.196
HDL-cholesterol, mmol/L	1.19±0.49	1.36±0.43	0.201
Triglycerides, mmol/L	1.26±0.56	1.16±0.47	0.475
C-reactive protein, mg/L	23.2±29.2	23.0±47.0	0.126
Sodium, mmol/L	137.8±5.0	139.2±4.1	0.189
Potassium, mmol/L	4.12±0.73	4.18±0.54	0.551
Calcium, mmol/L	2.26±0.12	2.33±0.17	0.009
Delirium incident during hospitalization, %	30.8	3.81	<0.001
Neuroleptic use during hospitalization, %	42.3	14.6	<0.001

Abbreviations: BMI, body mass index; BIS, Berlin Initiative Study; CAM, Confusion Assessment Method; GFR, glomerular filtration rate; HDL, high-density lipoprotein; IADL, Instrumental Activities of Daily Living Scale; LDL, low-density lipoprotein; MMSE, Mini-Mental State Examination; SD, standard deviation.

Table 3 Variables that yield *P*-values of 0.1 or lower in the initial univariate logistic regression analysis of factors predictive of falls

Variable	*P*-value	OR	95% CI
Quantitative variables			
Highest recorded CAM value, points	<0.001	1.85	1.45–2.36
Age	<0.001	1.15	1.08–1.23
Barthel index at admission, points	0.038	0.99	0.98–1.00
Estimated GFR using BIS_creatinine equation, mL/min/1.73 m^2	0.070	0.98	0.96–1.00
Lawton IADL at admission, points	0.058	0.94	0.89–1.00
Serum albumin level, g/L	0.013	0.93	0.88–0.99
Serum total protein level, g/L	0.005	0.93	0.89–0.98
BMI, kg/m^2	0.006	0.89	0.82–0.97
Serum total calcium level, mg/dL	0.052	0.58	0.33–1.01
Categorical variables			
Delirium occurrence at the ward	<0.001	9.82	3.98–24.22
Neuroleptic use during hospitalization	<0.001	4.30	1.93–9.61
History of fall-related trauma	0.013	3.33	1.29–8.59
Dementia	0.005	3.13	1.42–6.89
History of falls	0.008	2.95	1.32–6.59
Behavioral disorders in anamnesis	0.020	2.90	1.18–7.09
Neuroleptic use before admission	0.042	2.43	1.03–5.71

Abbreviations: BIS, Berlin Initiative Study; BMI, body mass index; CAM, Confusion Assessment Method; CI, confidence interval; GFR, glomerular filtration rate; IADL, Instrumental Activities of Daily Living Scale; OR, odds ratio.

and high fall risk groups, respectively. Twenty-seven falls were registered in 26 patients; three falls in the low-risk group of 125 patients (11.5% of patients who fell), three falls in the moderate-risk group of 166 patients (11.5%), and 20 falls in the high-risk group of 497 patients (76.9%). No fall was complicated by serious injury or decline in functional status. Increased hospital fall activity occurred on day 2 of hospitalization, with day 0 taken as day of admission (Figure 1). We observed a 24-hour biphasic pattern of increased falls with a minor spike between 04:00 and 05:00 and a major spike in the evening, about 21:00 (Figure 2). Among other demographics,

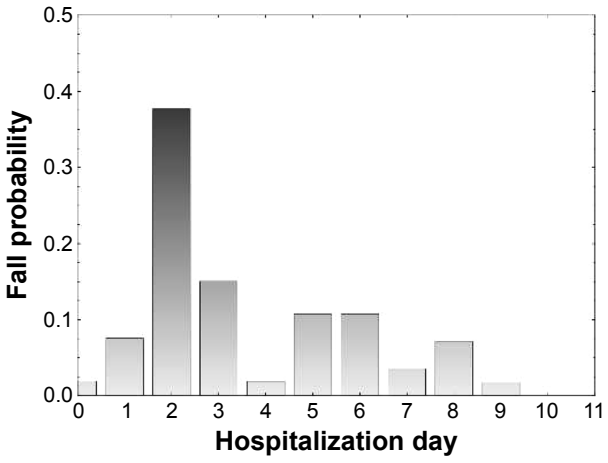

Figure 1 Fall probability of geriatric inpatients who experienced a fall incident during hospitalization in relation to hospitalization day.

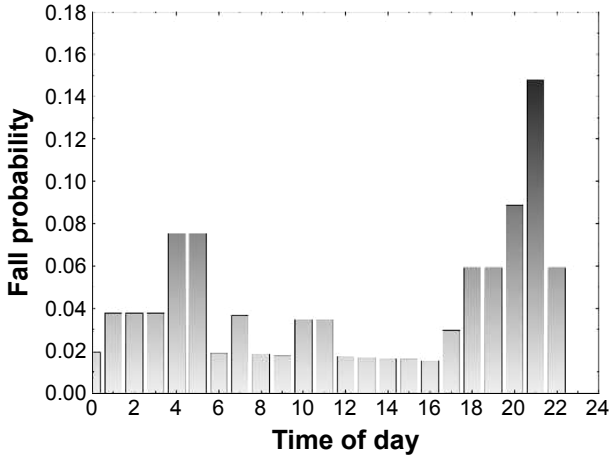

Figure 2 Fall probability of geriatric inpatients who experienced a fall incident during hospitalization in relation to the time of day.

laboratory, and clinical factors, patients with dementia, treated with neuroleptics before and during hospitalization, as well as patients with lower cognitive and functional status tended to be associated with increased falls (Table 2). Increased fall probability was associated with age ≥76 years ($P<0.001$), BMI <23.5 ($P=0.007$), MMSE <20 ($P=0.004$), and Barthel Index <65 ($P=0.002$; Figure 3A–D), as well as with hemoglobin level <7.69 mmol/L ($P=0.017$), serum protein level <70 g/L ($P=0.008$), albumin level <32 g/L ($P=0.001$), and calcium level <2.27 mmol/L ($P=0.001$) (Figure 4A–D). Four independent factors associated with risk of fall were included in the multivariate logistic regression model: delirium occurrence at the ward (odds ratio [OR] =7.33; 95% confidence interval [CI] =2.76–19.49; $P<0.001$), history of falls (OR =2.55; 95% CI =1.05–6.19; $P=0.039$), age (OR =1.14; 95% CI =1.05–1.23; $P=0.001$), and BMI (OR =0.91; 95% CI =0.83–0.99; $P=0.034$).

Discussion

As is the case for many geriatric syndromes, fall prevention in the hospital or health care facility setting requires multifactorial risk assessment and interventions tailored to specific patient needs.[36] Fall risk factors in the elderly may differ depending on local environmental conditions. Despite numerous studies, no well-defined and highly effective fall prevention program for the elder-care setting has been described. Therefore, it seems reasonable to compare results from different centers. We examined fall incidence and related risk factors in geriatric ward patients after implementation of a staff-developed fall prevention program in 2013. A significant proportion of our patients were identified during screening as being at moderate or high fall risk, which

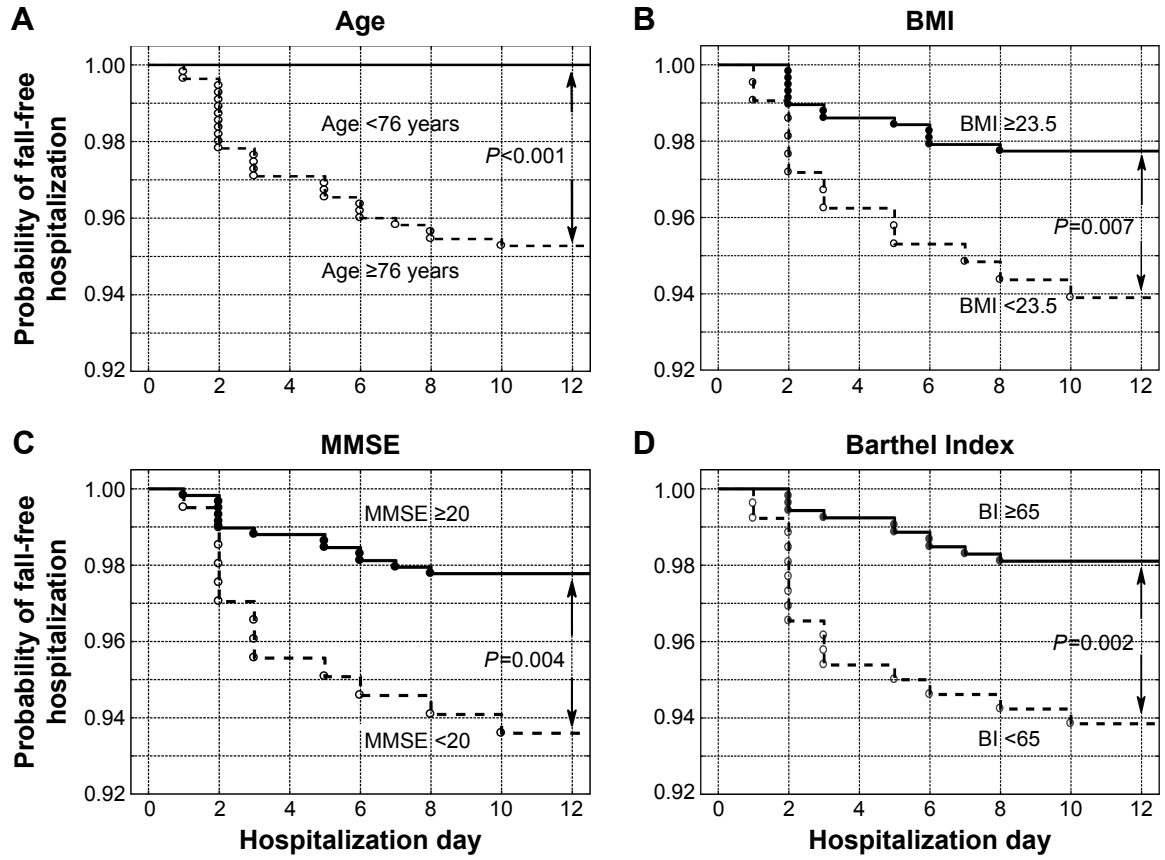

Figure 3 Probability of fall-free hospitalization according to (**A**) age <76 years compared to older age, (**B**) BMI ≥23.5 compared to lower values, (**C**) MMSE scores ≥20 compared to lower values, and (**D**) Barthel Index of Activities of Daily Living (BI) ≥65 compared to lower values.
Abbreviations: BMI, body mass index; MMSE, Mini-Mental State Examination.

is consistent with other similar studies.[20,21] This suggests high sensitivity but low specificity and obviates the need for better fall prediction tools for assessing geriatric patients admitted to the acute care hospital wards. Serious injury or decline in functional status was not observed as a consequence of the 27 recorded falls that 26 patients experienced during the study period. Notably, we observed an increased fall probability on the second day of patient hospitalization during evening hours. This observation, of particular practical significance, is most likely multifactorial and complex. Loss of visual perception during periods between dusk and dawn may have a magnified effect in persons with impaired senses, including geriatric patients. This explanation would seem to be supported by studies associating lighting and perceptual cues in older adults with risk of falls.[37] Evening or nocturnal psychomotor agitation (sundown syndrome) is a common phenomenon in patients with cognitive impairment, which may result in failure to adhere to ambulatory restrictions and result in increased tendency toward falls.[38] In the literature, data on 24-hour fall patterns in the hospital setting are inconsistent.[39] Among demographic and clinical characteristics of patients who experienced falls, advanced age, history of falls, dementia, and poor functional state were, as it would be expected from other studies,[36] factors predictive of falls. Lower BMI appeared to be another risk factor in our study group. Coutinho et al[40] showed that BMI ≤20, cognitive impairment, previous stroke, and lack of urine control were associated with increased incidence of severe fall-related fractures in 250 hospitalized patients matched with 250 community controls. O'Neil et al[17] found association between low BMI (≤18.5) and increased risk of hospital falls. Decreased body mass may be related to frailty, a syndrome prevalent in geriatric inpatients,[41] associated with increased fall risk.[42] Both low and very high BMI are associated with increased prevalence of frailty.[43] However, some observations indicate that obesity may be protective against falling in community-dwelling older adults.[44] Delirium appears to be the greatest risk factor for falls in our cohort of inpatients. Delirium-related cognitive deterioration combined with psychomotor agitation acutely impairs both patient compliance and secure mobility.[45,46] Other studies demonstrated that agitation was associated with falls in

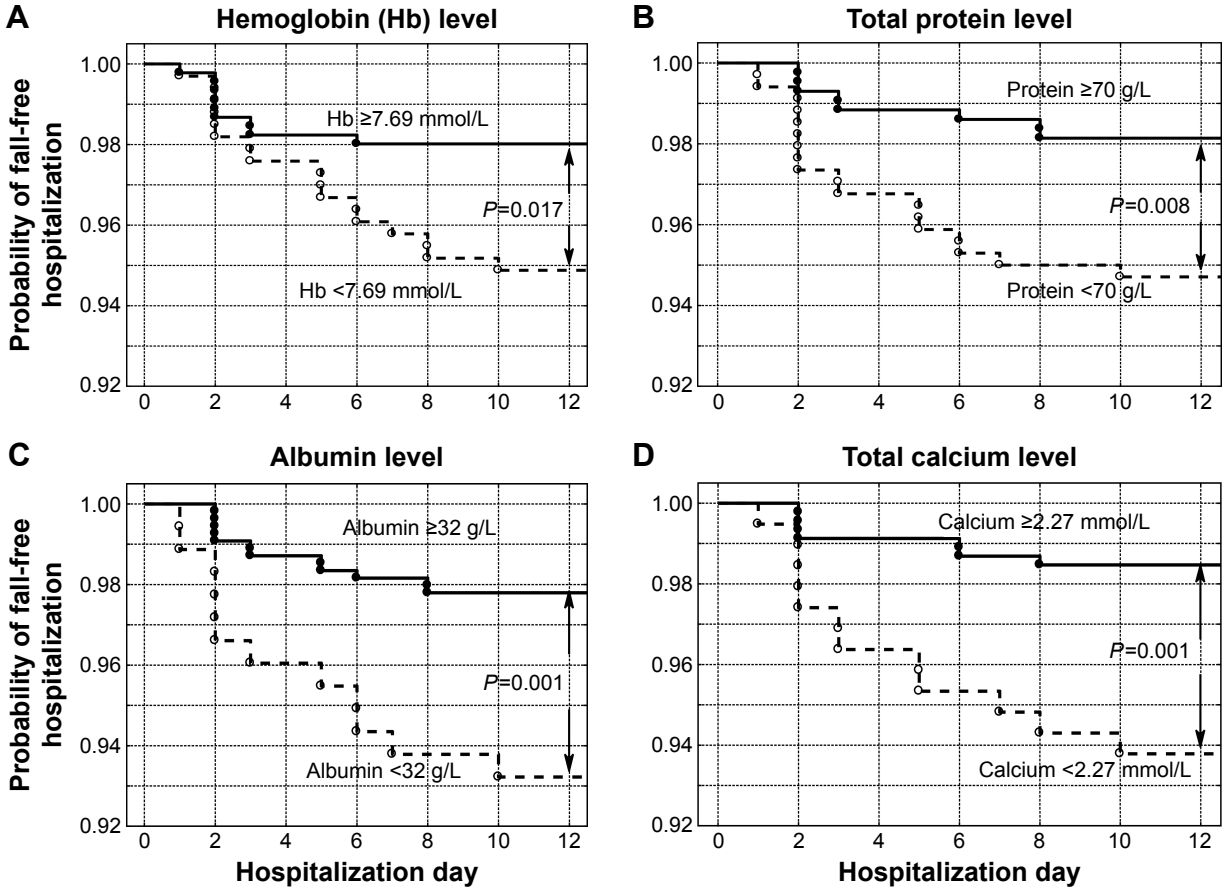

Figure 4 Probability of fall-free hospitalization according to (**A**) hemoglobin level ≥7.69 mmol/L compared to lower values, (**B**) serum total protein level ≥70 g/L compared to lower values, (**C**) serum albumin level ≥32 g/L compared to lower values, and (**D**) serum total calcium level ≥2.27 mmol/L compared to lower values.

patients residing in elder-care units.[47,48] Delirium has also been associated with previous falls both in acute general medicine patients[49] as well as in geriatric ward patients.[50] A history of falls has been recognized as predictive of future falls during hospitalization.[51]

Implementation of a geriatric fall prevention program in the hospital setting presents unique challenges for medical professionals. Particular care must be taken to address fall interventions that may also inadvertently complicate comorbid conditions. Specifically, restricting patient-independent ambulation during hospitalization in moderate- and high-risk patients may decrease overall ambulation during hospitalization in these patients and increase the probability of delirium. Additional concerns with restriction of independent ambulation include strain on limited staff time, eliciting or enhancing a fear of falling among a susceptible population,[52] or even the implication of loss of independence.[36] A critical compensatory intervention in this respect is a comprehensive individualized rehabilitation program directed toward early mobilization and maintenance of mobility for prevention of both falls and their risk factors, including delirium.[1,45] Given the morbidity and mortality associated with hospital falls, clinicians have been working toward the goal of decreasing hospital falls to the point of "never-events".[53] In this respect, temporary limits on patient-independent ambulation during hospitalization seem reasonable.

The main limitation of our study was the lack of fall risk comparison before and after program implementation. Our fall prevention program assessed all patients admitted to the ward and documented all patient falls irrespective of fall complications. Since fall data before program implementation were incomplete, we were unable to assess the effectiveness of the program interventions. Nevertheless, it appears that an effective fall prophylaxis program requires implementation of evidence-based as well as common-sense interventions and counseling strategies.

Conclusion

Delirium, history of falls, and advanced age seem to be the primary risk factors for geriatric falls in the context of a

hospital fall prevention program. Higher BMI appears to be associated with protection against inpatient geriatric falls.

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Disclosure

The authors report no conflicts of interests in this work.

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