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Factors Influencing Falls in High- and Low-Risk Patients in a Tertiary Hospital in Korea

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Objective: The purpose of this study was to explore the characteristics and predictors of falls in high- and low-risk inpatients in a tertiary hospital in Korea.

Methods: Fallers' data were extracted from quality improvement reports and electronic health records from June 1, 2014, to May 31, 2015. Data on nonfallers matched by the length of hospitalization and medical departments of fallers were extracted from electronic health records. Participants were classified into a high- or a low-risk group based on their Morse Fall Scale score, fall risk–related symptoms, and medications known to increase fall risk. Characteristics of falls and risk factors were analyzed using descriptive statistics and logistic regression analysis, respectively.

Results: In the high-risk group, education, surgery, department, impaired mobility, intravenous catheter placement, use of ambulatory aid, gait disturbance, and some medications were significantly different between the fallers and nonfallers. From these variables, education, operation, department, intravenous catheter placement, gait disturbance, and use of narcotics, vasodilators, antiarrhythmics, and hypnotics were statistically significant factors for falls. In the low-risk group, sex, age, length of hospitalization, surgery, department, diagnosis, and mental status were significantly different between the fallers and nonfallers. From these, sex, age, length of hospitalization, surgery, and liver-digestive diseases were statistically significant factors for falls.

Conclusions: Characteristics and risk factors for falls differed between the risk groups. Fall prevention strategies need to be tailored to the risk groups and fall risk assessment tools need to be revised accordingly.

Key Words: accidental falls, risk factors, inpatients, risk assessment

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Safety is a basic human need, and patients require a safe environment during their hospital stay. However, a hospital can be a dangerous place for falls, which can cause additional health problems.[1] Falls are the most common injuries occurring in medical institutions,[2] and falls incidence is used as a quality indicator of nursing care worldwide. In the United States, the incidence of falls among inpatients was 1.7 to 2.5 cases per 1000 patient days in 2008[3] and 3.3 to 11.5 cases per 1000 patient days in 2015.[4] In Korea, the incidence of falls among inpatients 15 years or older in a tertiary hospital was reported to be 1.9 cases per 1000 inpatients in 2010,[5] and the incidence of falls in 18 hospitals in 2015 was 3.87 cases per 1000 inpatients.[6] Although falls do not always lead to physical injuries, they are often associated with fractures that limit an individual's activity for a long period[7] and serious consequences including trauma, death, mental disorder, and financial loss.[8]

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Although falls are a multifaceted problem caused by various risk factors, including behavioral, physiological, and environmental factors, they are, to some extent, possible to predict and prevent.[9–11] Recent studies have identified age, history of falling, visual impairment, pain, emotional instability, sleep disturbances, dysuria, incontinence, depression, communication status, medications, and chronic diseases as the risk factors of falls.[5,8] Moreover, research has identified the direct causes of falls, which include unstable gait, agitation and confusion, incontinence/frequent urination, history of falling, and use of sedatives and hypnotics.[12]

In a clinical setting, it is crucial to identify patients at high risk for falls as early as possible and provide them with tailored fall prevention interventions. Tools for assessing fall risk have been developed, including the Morse Fall Scale (MFS), the Hendrich II Fall Risk Model, the Schmid Fall Risk Assessment Tool, the Johns Hopkins Hospital Fall Risk Assessment Tool, and the St Thomas's Risk Assessment Tool (STRATIFY).[9] Though emphasizing risk assessment, the effects of these assessment tools cast doubt on their utility and pose an efficiency problem regarding the use of medical resources.[13] Most recently, ambient sensors and wearable devices have been used in fall detection and prediction.[14] Advances in the Internet of Things and mobile technologies have helped with the integration of environmental factors in detecting and predicting falls.[15] However, the use of these technologies is costly and time-consuming and may require expert knowledge.[16]

The predictive validity of the tools varies depending on study participants and methods. For example, the MFS showed the highest sensitivity in studies with hospitalized patients[9,17] and in a meta-analysis.[18] The STRATIFY showed the highest sensitivity in a study with neurological patients.[19] Therefore, it is important to use tools that reflect the characteristics of the medical institutions and target patients.[19] The MFS, which is relatively easy to use because of the small number of items, is the most widely used instrument in Korea. However, one study found that 51.9% of the patients who experienced falls had been classified as low-risk patients using the MFS.[20] Similarly, a study by Jang and Lee[21] found that many falls occurred in patients classified as low risk. This finding may have occurred because of poor predictability of the MFS; this also suggests that all patients are at risk for falls, and it is necessary to provide fall prevention interventions to all patients. To provide tailored fall prevention interventions for high- and low-risk patients, it is necessary to identify whether factors affecting falls differ between the risk groups. The present study aimed to investigate fall-related characteristics in high- and low-risk groups and identify the factors affecting the occurrence of falls in these groups.

METHODS

Study Design

The present study was a retrospective case-control study comparing the characteristics of falls and identifying fall predictors between high- and low-risk groups. The MFS scores, data recorded in electronic health records (EHRs), and fall reports were analyzed.

Participants

Fallers were defined as patients 19 years or older who experienced falls in one of 15 departments (oncology, gastroenterology, liver transplantation surgery, general surgery, hepatobiliary surgery, colorectal surgery, gastrointestinal surgery, hematology, cardiology, neurology, obstetrics and gynecology, pulmonology, rehabilitation, orthopedics, and urology) in a tertiary hospital in S city, Korea from June 1, 2014, to May 31, 2015. All falls were reported to the quality improvement department in the study hospital. In total, 447 cases were identified. Nonfallers were 3667 inpatients who stayed in one of the 15 departments in the hospital for an average of 22 days in the same period.

In the present study, the high-risk group was defined as patients with either an MFS score of 45 or higher,[22] taking more than four fall risk–increasing drugs (e.g., central nervous system and cardiovascular drugs), or with at least one fall risk–related symptom (e.g., visual impairment and dizziness) even if they had an MFS score of less than 45.

Data Collection

General Characteristics of Patients

Patients' length of hospitalization, history of surgery, sex, age, education, clinical department, body mass index, diagnosis, pain, paralysis, weakness, deformity, visual impairment, hearing impairment, consciousness state, emotional state, incontinence, sleep disorder, fever, nutritional imbalance, environmental factors (catheters, tubes, or medical devices), and medications were extracted from EHRs. Measures of cognitive state, dizziness, balance disorder, gait disturbance, postural hypotension, activity level, use of assistive devices, and fall history were extracted from the fall case reports.

Fall Risk Characteristics of Patients

The fall risk was assessed once a day if a patient's condition did not change and more than once a day if it changed. Patients' MFS score, fall risk–increasing drugs, and symptoms were assessed. The MFS developed to identify patients at risk of falling consists of the following six items: (*a*) history of falling (0 = no, 25 = yes); (*b*) secondary diagnosis (0 = no, 15 = yes); (*c*) ambulatory aid (0 = bed rest/nurse assist, 15 = crutches/cane/walker, 30 = furniture); (*d*) intravenous (IV) or heparin lock (0 = no, 20 = yes); (*e*) gait (0 = normal/bed rest/immobile, 10 = weak, 20 = impaired); and (*f*) mental status (0 = oriented to own ability, 15 = forgets limitations).[22] In the present study, patients with MFS score of 45 or higher were categorized as high risk for falls.

The present study used data stored in a database created for a previous study[20] and was approved by the institutional review board of the study hospital (IRB 2015-0742 Ver3.0). To ensure reliability in the data collection process, researchers developed criteria for reviewing data from the case reports. After Fleiss' κ rated by four researchers for five cases reached 0.83, data collection was initiated. The collected data were safeguarded so that only the researchers could access them.

Data Analysis

The data were analyzed using SPSS/WIN, Version 21.0 (IBM Corp, Armonk, NY). The general and fall-related characteristics of the patients and the predictability of the MFS were assessed using descriptive statistics, χ^2, analysis of variance, and *t* tests. To identify factors affecting falls in the high- and low-risk groups, a logistic regression analysis was performed using the variables found to be significant in the univariate analyses as independent variables. The significance level for this study was set at 0.05.

RESULTS

Predictability of Falls

The sensitivity of the fall assessment tool developed based on MFS, fall risk–related symptoms, and medications was found to be 69.1%, with specificity of 47.7%, positive predictability of 13.9%, and negative predictability of 92.7% (Table 1).

Risk Factors of Falls by Fall Risk Groups

To investigate the relationship between the fall risk groups (low- and high-risk) and the actual occurrence of falls, 4114 patients were divided into the following four groups, which were then compared: (*a*) high-risk and nonfall group (n = 1918), (*b*) high-risk and fall group (n = 309), (*c*) low-risk and nonfall group (n = 1749), and (*d*) low-risk and fall group (n = 138).

Falls in High-Risk Group

In the high-risk group, 309 of 2227 patients experienced falls. The mean ± SD ages of the fallers and nonfallers were 61 ± 15.04 and 62.1 ± 13.93 years, respectively. When the characteristics of the patients in the fall and nonfall groups were compared, there were significant differences in education, surgery, clinical department, impaired mobility, IV catheter placement, use of ambulatory aids, and gait disturbances. In terms of medications, there were significant differences in the use of narcotics, antiepileptics, vasodilators, antiarrhythmics, muscle relaxants, and hypnotics. The results are summarized in Table 2.

A logistic regression analysis was performed to determine the factors affecting falls in the high-risk group. There were statistically significant differences in education, surgery, clinical department, activity level, IV catheter placement, use of ambulatory aids, gait disturbance, and drugs (narcotic analgesics, antiepileptic drugs, vasodilators, antiarrhythmic drugs, muscle relaxants, and hypnotics) between fallers and nonfallers in the high-risk group ($\chi^2 = 250.34$, $P < 0.001$). Patients with college or higher education were less likely to experience falls than those with elementary school or lower education (odds ratio [OR] = 0.54; 95% confidence interval [CI], 0.37–0.80; $P < 0.002$). The patients who did not have surgery had a lower risk of falls than those who had surgery (OR = 0.34; 95% CI = 0.24–0.48; $P < 0.001$). The patients from the gastroenterology department had a lower risk of falls than those from the hematology and oncology department (OR = 0.53; 95% CI = 0.35–0.81; $P = 0.003$), and those from the general

TABLE 1. Sensitivity, Specificity, and Predictive Values of the Fall Assessment Tool (N = 4114)

	Fall		
	Yes, n	No, n	
High risk	309	1918	Positive predictive value = 309/(309 + 1918) = 13.9%
Low risk	138	1749	Negative predictive value = 1749/(1749 + 138) = 92.7%
	Sensitivity = 309/(309 + 138) = 69.1%	Specificity = 1749/(1918 + 1749) = 47.7%	

TABLE 2. Comparisons of Characteristics Between Fallers and Nonfallers in the High-Risk Group (n = 2227)

Variables	Categories		Nonfaller (n = 1918) n (%) or M ± SD	Faller (n = 309) n (%) or M ± SD	χ^2 or *t*	*P*
Sex	Male		1103 (57.5)	175 (56.6)	0.08	0.804
Age, y			61.19 ± 15.04	62.1 ± 13.93	−1.06	0.290
Length of hospitalization, d			40.60 ± 29.13	41.74 ± 53.10	−0.360	0.720
Education	≤Elementary		438 (22.9)	74 (24.2)	16.88	0.001
	Middle school		279 (14.6)	64 (20.9)		
	High school		621 (32.5)	107 (35.0)		
	≥ College		574 (30.0)	61 (19.9)		
Body mass index	Underweight		287 (15.4)	51 (16.6)	4.85	0.088
	Normal weight		1120 (60.0)	199 (64.6)		
	Overweight		459 (24.6)	51 (16.6)		
Surgery	Yes		778 (40.6)	86 (27.8)	18.17	<0.001
Department	Hematology/oncology		480 (25.0)	92 (29.8)	95.76	<0.001
	Gastrointestinal medicine		465 (24.2)	40 (12.9)		
	Internal medicine (other)		372 (19.4)	66 (21.4)		
	General surgery		263 (13.7)	61 (19.7)		
	Neuro/chest/orthopedics		267 (13.9)	24 (7.8)		
	Obstetrics gynecology/urology		71 (3.7)	16 (5.2)		
	Surgery (other)		0 (0)	10 (3.2)		
Diagnosis	Vascular, pulmonary		189 (9.9)	38 (12.3)	6.10	0.191
	Neoplasm		1014 (52.9)	172 (55.7)		
	Liver, digestive		233 (12.1)	37 (12.0)		
	Infectious		78 (4.1)	14 (4.5)		
	Others		404 (21.1)	4825 (15.5)		
Physical factors	Unconsciousness	Yes	83 (4.3)	11 (3.6)	0.39	0.648
	Emotional instability	Yes	35 (1.8)	7 (2.3)	0.28	0.650
	Visual impairment	Yes	69 (3.6)	17 (5.5)	2.60	0.112
	Hearing impairment	Yes	49 (2.6)	13 (4.2)	2.69	0.132
	Dizziness	Yes	67 (3.5)	14 (4.5)	0.82	0.411
	General weakness	Yes	1029 (53.6)	171 (55.3)	0.31	0.623
	Impaired mobility	Yes	483 (25.2)	61 (19.7)	4.27	0.039
	Urinary impairment	Yes	12 (0.6)	3 (1.0)	0.47	0.452
Morse Fall Scale items	History of falling	Yes	263 (13.7)	54 (17.5)	3.09	0.080
	Secondary diagnosis	Yes	1432 (74.7)	230 (74.4)	0.01	0.944
	IV or heparin lock	Yes	1572 (82.0)	276 (89.3)	10.21	0.001
	Ambulatory aid: none/bed rest/nurse assist	Yes	1539 (80.2)	214 (69.3)	19.17	<0.001
	Ambulatory aid: crutches/cane/walker	Yes	304 (15.8)	76 (24.6)		
	Ambulatory aid: furniture	Yes	75 (3.9)	19 (6.1)		
	Gait normal/bed rest/immobile	Yes	900 (46.9)	102 (33.0)	21.14	<0.001
	Gait: weak	Yes	813 (42.4)	162 (52.4)		
	Gait: impaired	Yes	205 (10.7)	45 (14.6)		
	Mental status: oriented to own ability	Yes	1580 (82.4)	256 (82.8)	0.04	0.872
	Mental status: forgets limitations	Yes	33.8 (17.6)	53 (917.2)		
Medication	Antihypertensives	Yes	691 (36.0)	110 (35.6)	0.02	0.899
	Narcotics	Yes	444 (23.1)	132 (42.7)	53.15	<0.001
	Antiepileptics	Yes	421 (21.9)	45 (14.6)	8.78	0.003
	Diuretics	Yes	431 (22.5)	69 (22.3)	0.00	1.00
	Antidepressants	Yes	242 (12.6)	42 (13.6)	0.23	0.646
	Benzodiazepines	Yes	177 (9.2)	29 (9.4)	0.01	0.916
	Antipsychotics	Yes	171 (8.9)	32 (10.4)	0.67	0.396
	Vasodilators	Yes	25 (1.3)	15 (5.6)	19.02	<0.001
	Antihistamines	Yes	242 (12.6)	29 (9.4)	2.60	0.112
	Antiarrhythmics	Yes	72 (3.8)	23 (7.4)	8.87	0.006
	Muscle relaxants	Yes	20 (1.0)	10 (3.2)	9.64	0.005
	Chemotherapeutics	Yes	69 (3.6)	17 (5.5)	2.60	0.112
	Bowel softeners	Yes	511 (26.6)	73 (23.6)	1.25	0.296
	Hypnotics	Yes	165 (8.6)	53 (17.2)	22.03	<0.001

TABLE 3. Logistic Regression Analysis of Fall in the High-Risk Group (n = 2227)

Variables	Reference	*B*	*P*	OR	Lower Limit 95% CI	Upper Limit 95% CI
Constant		−2.811	<0.001	0.06	—	—
Education: college	≤Elementary	−0.61	0.002	0.54	0.37	0.80
Surgery	No	−1.09	<0.001	0.34	0.24	0.48
Department: GI	Hematology/oncology	−0.63	0.003	0.53	0.35	0.81
Department: GS	Hematology/oncology	0.78	<0.001	2.18	1.41	3.36
IV catheter placement	No	0.64	0.010	1.90	1.17	3.07
Gait: weak	Normal	0.43	0.008	1.53	1.20	2.10
Gait: impaired	Normal	0.57	0.013	1.77	1.13	2.78
Ambulatory aid: crutches, cane, walker	No	0.48	0.008	1.62	1.14	2.31
Medication: narcotics	No	0.97	<0.001	2.64	1.98	3.51
Medication: vasodilators	No	1.34	<0.001	3.82	1.88	7.78
Medication: antiarrhythmics	No	0.76	0.006	2.14	1.24	3.70
Medication: hypnotics	No	0.50	0.011	1.64	1.12	2.40
Medication: antiepileptics	No	−0.38	0.045	0.68	0.47	0.99
		Cox and Snell $R^2 = 0.107$, Nagelkerke $R^2 = 0.193$				

Abbreviations: GI, gastrointestinal; GS, general surgery.

surgery department had a higher risk of falls than those from the hematology and oncology department (OR = 2.18; 95% CI = 1.41–3.36; $P < 0.001$). In addition, IV catheter placement (OR = 1.90; 95% CI, 1.17–3.07; $P = 0.010$), weak gait (OR = 1.53; 95% CI = 1.20–2.10; $P = 0.008$), impaired gait (OR = 1.17; 95% CI = 1.13–2.78; $P = 0.013$), and the need to use ambulatory aids (OR = 1.62; 95% CI = 1.14–2.31; $P = 0.008$) significantly affected falls. Patients who were taking narcotics (OR = 2.64; 95% CI = 1.98–3.51; $P < 0.001$), vasodilators (OR = 3.82; 95% CI = 1.88–7.78; $P < 0.001$), antiarrhythmics (OR = 2.14; 95% CI = 1.24–3.70; $P = 0.006$), and hypnotics (OR = 1.64; 95% CI = 1.12–2.40; $P = 0.011$) were more likely to experience falls than those who were not, whereas those taking antiepileptic drugs were less likely to fall (OR = 0.68; 95% CI = 0.47–0.99; $P = 0.045$). The results are summarized in Table 3.

Falls in Low-Risk Group

In the low-risk group, 138 of 1887 patients experienced falls. The mean ± SD ages of the fallers and nonfallers were 59.73 ± 14.80 and 54.99 ± 13.49 years, respectively. When the characteristics of the patients in the fall and nonfall groups were compared, significant differences were found in sex, age, length of hospitalization, surgery, clinical department, diagnosis, and mental status. The results are displayed in Table 4.

A logistic regression analysis was performed to determine the factors affecting falls in the low-risk group. There were statistically significant differences in sex, age, length of hospitalization, surgery, clinical department, and diagnosis between fallers and nonfallers in the low-risk group ($\chi^2 = 168.72$, $P < 0.001$). Women were more likely to experience falls than men (OR = 1.53; 95% CI = 1.03–2.28; $P = 0.035$). As age increased (OR = 1.04; 95% CI = 1.02–1.06; $P < 0.001$), the risk of falls increased. Moreover, length of hospitalization affected the risk of falls (OR = 0.97; 95% CI = 0.95–0.98; $P < 0.001$). The patients who had surgery were less likely to experience falls than those who did not have it (OR = 0.28; 95% CI = 0.27–0.24; $P < 0.001$). Regarding the clinical departments, those from the gastroenterology department were less likely to experience falls than those from the hematology and oncology department (OR = 0.47; 95% CI = 0.24–1.00; $P = 0.048$). The results are shown in Table 5.

DISCUSSION

The present study investigated the predictive validity of a fall risk assessment tool developed based on MFS, fall risk–related drugs and symptoms in a tertiary hospital. The predictive power of the fall risk assessment tool was examined using sensitivity and specificity as measures of validity[23] and positive and negative predictability as measures of predictive validity.[24] The sensitivity and specificity of the fall risk assessment tool were lower than those previously reported for the STRATIFY.[25] They were also lower than the results reported in a systematic review by Matarese et al.[13] The positive and negative predictive values were similar to those reported in a study[17] where an MFS cutoff score of 50 was used for neurological patients. The sensitivity, specificity, and predictability of the tool were low overall, which suggests the need to develop a tool reflecting the characteristics of the clinical setting to accurately predict falls.

This study identified risk factors for falls by comparing inpatients who had experienced falls with those who had not according to fall risk. In the high-risk group, there were statistically significant differences in education, surgery, department, IV catheter placement, ambulatory aids, gait disturbance, impaired mobility, and use of certain medications between the fallers and nonfallers according to univariate analyses. A logistic regression analysis using these significant variables showed that education, surgery, department, IV catheter placement, impaired mobility, gait disturbance, and use of narcotics, vasodilators, antiarrhythmics, and hypnotics were associated with falls in the high-risk group. Patients with a college education or higher were 0.54 times less likely to experience falls than those with elementary school or lower. Thus, it is necessary to vary the content and delivery method of interventions according to patients' educational level. The risk of falls among patients underwent surgery was found to be 0.34 times lower than who did not. As healthcare professionals and caregivers tend to view surgical patients as more critically ill, they spend more time caring surgical patients. Patients with surgery stay in bed and move around less. Patients with an IV catheter

TABLE 4. Comparisons of Characteristics Between Fallers and Nonfallers in the Low-Risk Group (n = 1887)

Variables	Categories		Nonfaller (n = 1749) n (%) or M ± SD	Faller (n = 138) n (%) or M ± SD	χ^2/t	*P*
Sex	Male		1152 (65.7)	73 (52.9)	9.44	0.003
Age, y			54.99 ± 13.49	59.73 ± 14.80	3.95	<0.001
Length of hospitalization, d			36.25 ± 22.10	26.63 ± 53.35	2.07	0.040
Education	≤Elementary		259 (14.8)	28 (20.7)	3.42	0.331
	Middle school		242 (13.9)	18 (13.3)		
	High school		689 (39.5)	50 (37.0)		
	≥College		556 (31.8)	39 (28.9)		
Body mass index	Underweight		144 (8.3)	19 (13.8)	4.83	0.089
	Normal weight		1070 (61.7)	81 (58.7)		
	Overweight		520 (30.0)	38 (27.5)		
Surgery	Yes		1003 (57.3)	57 (41.3)	13.37	<0.001
Department	Hematology/oncology		361 (20.6)	28 (20.3)	150.68	<0.001
	Gastrointestinal medicine		532 (30.4)	25 (18.1)		
	Internal medicine (other)		61 (3.5)	12 (8.7)		
	General surgery		596 (34.1)	37 (26.8)		
	Neuro/chest/orthopedics		81 (4.6)	12 (8.7)		
	Obstetrics gynecology/urology		118 (6.7)	14 (10.1)		
	Surgery (other)		0 (0)	10 (7.2)		
Diagnosis	Vascular, pulmonary		52 (3.0)	6 (4.3)	25.15	<0.001
	Neoplasm		1169 (66.8)	86 (62.3)		
	Liver, digestive		322 (18.4)	12 (.6)		
	Infectious		64 (3.7)	9 (6.5)		
	Others		142 (8.1)	25 (18.1)		
Morse Fall Scale items	History of falling	Yes	8 (0.5)	2 (1.4)	2.39	0.163
	Secondary diagnosis	Yes	926 (52.9)	85 (61.6)	3.85	0.051
	IV or heparin lock	Yes	1526 (87.2)	113 (81.9)	3.23	0.088
	Ambulatory aid: none/bed rest/nurse assist	Yes	1730 (98.9)	136 (98.6)	0.15	0.663
	Ambulatory aid: crutches/cane/walker	Yes	19 (1.1)	2 (1.4)		
	Gait normal/bed rest/immobile	Yes	1652 (94.5)	126 (91.3)	3.47	0.177
	Gait: weak	Yes	91 (5.2)	12 (8.7)		
	Gait: impaired	Yes	6 (0.3)	0 (0)		
	Mental status: oriented to own ability	Yes	1748 (99.9)	136 (98.6)	15.62	0.015
	Mental status: forgets limitations	Yes	1 (0.1)	2 (1.4)		

were 1.90 times more likely to experience falls than those without, which is similar to the results of a systematic review by Evans et al.[26] Kong et al.[27] also found that IV catheter placement was a risk factor for falls. Thus, patients with an IV catheter may require special attention to prevent falls. Gait disturbance regardless of the use of ambulatory aids showed a significant influence on the occurrence of falls, which is similar to the findings of previous studies.[2,20] Even if an institution has an effective fall prevention program, patients need to be aware of their walking ability and seek help from those around them including medical staff if they want to walk safely with a cane or walker. The risk of falls in the patients taking narcotic analgesics, vasodilators, antiarrhythmics, and hypnotics was 2.64, 3.82, 2.14, and 1.64 times higher, respectively, than those who did not take such drugs. Similar findings

TABLE 5. Logistic Regression Analysis of Fall in the Low-Risk Group (N = 1887)

Variables	Reference	*B*	*P*	OR	Lower Limit 95% CI	Upper Limit 95% CI
Constant		−3.50	<0.001	0.03	—	—
Sex	Male	0.43	0.035	1.53	1.03	2.28
Age		0.04	<0.001	1.04	1.02	1.06
Length of hospitalization		−0.04	<0.001	0.97	0.95	0.98
Surgery	No	−1.28	<0.001	0.28	0.17	0.47
Diagnosis: liver, digestive disease	Neoplasm	−0.72	0.048	0.47	0.24	1.00
			Cox and Snell R^2 = 0.086, Nagelkerke R^2 = 0.213			

were found in a Cochran review result by Gillespie et al.[28] and a study by Sohng et al.[29] Thus, it is necessary to identify the types of medication taken by patients, especially drugs affecting central nervous or cardiovascular systems, which showed significant influence on falls in the present study.

In the low-risk group, there were statistically significant differences in sex, age, length of hospitalization, surgery, department, diagnosis, and mental status between the fallers and nonfallers. A logistic regression analysis showed that sex, age, length of hospitalization, surgery, and liver-gastrointestinal diseases affected falls in the low-risk group. The risk of falls was 1.53 times higher in women than it was in men. The risk of falls by sex has been found to vary in previous studies.[30,31] Thus, further research is needed before including sex as a predictor of falls to the fall risk assessment tool. The fallers were older than the nonfallers, which is consistent with the findings of a study by Yang and Chun.[32] This finding is also consistent with that of Yeom's study[33] in which older age was associated with increased mortality from falls. Yeom[33] proposed old age (>65 y) as a risk factor for falls. Thus, it is important to include age in the fall risk assessment of low-risk patients. In this study, the risk of falls increased by only 1.04 as age increased by 1 year, which was statistically significant but not clinically significant. Moreover, it was found that as the length of hospitalization increased, falls decreased. This could be because of patients having adjusted well to the hospital environment and due to more exposure to the fall prevention culture as they were constantly reminded of the possibility of falling. There were differences in fall occurrence by department, which is similar to the findings of a study by Jang and Lee.[21] The risk of falls was found to be 0.47 times lower among gastroenterology patients than hemato-oncology patients. Hemato-oncology patients tend to fall more frequently because of general weakness from chemotherapy, whereas gastroenterology patients fall less because of short hospital stays.

In this study, 7.3% of patients classified as low risk for falls had experienced falls. In the clinical setting, fall prevention activities are mainly focused on high-risk patients based on the fall risk assessment. Fall prevention activities such as exercises, medication control, and management of urinary incontinence, psychological interventions, environment/assistive technology, and education[34] have been offered by various healthcare professionals. However, a meta-analysis found no evidence that hospital fall prevention programs, including multifactorial interventions, reduced the number of falls. This finding may be caused by difficulties associated with a randomized control trial for fall prevention.[34,35] Considering the incidence of falls in the low-risk group, it is necessary to identify factors affecting falls not only in high-risk group but also in low-risk one. It is common to place a patient classified as low-risk in the blind spot of the fall prevention intervention. Therefore, patients classified as low-risk should be reassessed to identify risk factors and offer them fall prevention interventions.

According to the Institute for Clinical Systems Improvement[31] and the National Institute for Health and Care Excellence guidelines,[36] nurses need to objectively assess risk factors of falls. However, fall risk is often assessed based on narratives provided by patients or their caregivers. To make objective assessments, it is important to have an instrument that is simple and easy to use. Because patients can experience a fall at any time during their hospital stay regardless of their fall risk score, it is important for healthcare providers to remain alert to patients' falls.[37]

This study is limited by its retrospective design, which may result in possibly missing or misclassified falls. Furthermore, this study used secondary data obtained from EHRs, making it liable to shortcomings associated with any secondary data use. However, the authors are familiar with the study setting and the data used, which adds validity to the conclusions. Pediatric and psychiatric departments where the patients' acuity and medical conditions are very different from those included in this study, and emergency department and outpatient clinics where fall risk was not assessed were excluded from this study. This might have affected the interpretations of the findings, which limits the generalizability.

CONCLUSIONS

The fall risk assessment tool used in the study hospital did not show adequate sensitivity, specificity, or predictability. A good fall risk assessment tool should be able to differentiate between high- and low-risk individuals in a given population. In general, patients were classified into either high risk or low risk for falls, and interventions were provided to only the high-risk patients. However, all hospitalized patients are at risk, and stratifying patients in this way may leave some patients at risk of falls. We found that there were differences in the factors affecting falls in the low- and high-risk groups classified using a fall risk assessment tool. These findings suggest the need to use different fall prevention strategies for low- and high-risk patients. Thus, it is important to set preventive strategies considering risk factors, especially in low-risk patients. Furthermore, it is worthwhile to examine the relationship between the adequacy of the fall risk assessment tool itself and assessment skill with the actual occurrence of falls.

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