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Risk Factors and Characteristics of In-Hospital Falls After Spine Surgery

A Retrospective, Single-Center Cohort Study in the Republic of Korea

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Background: Falls after orthopaedic surgery can cause serious injuries, which lengthen hospital stays and increase medical expenses. This has prompted hospitals to implement various fall-prevention protocols. The aims of this study were to determine the incidence of in-hospital falls after spine surgery, to analyze the overall risk factors, to discern factors that have a major influence on falls, and to evaluate the effectiveness of the fall-prevention protocol that we implemented.

Methods: This was a retrospective, single-center study including patients who underwent spine surgery from January 2011 to November 2021 at the National Health Insurance Service Ilsan Hospital (NHISIH) in Goyang, Republic of Korea. Reported falls among these patients were examined. Patient demographics; surgery type, date, and diagnosis; and fall date and time were evaluated.

Results: Overall, 5,317 spine surgeries were performed, and 128 in-hospital falls were reported (overall incidence: 2.31%). From the multivariable analyses, older age and American Society of Anesthesiologists (ASA) score were identified as independent risk factors for in-hospital patient falls (multivariable adjusted hazard ratio [aHR] for age 70 to 79 years, 1.021 [95% confidence interval (CI), 1.01 to 1.031]; for age ≥80 years, 1.035 [1.01 to 1.06]; and for ASA score of 3, 1.02 [1.01 to 1.031]). Similar results were seen in the subgroup who underwent primary surgery. Within 2 weeks following surgery, the highest frequency of falls occurred at 3 to 7 days postoperatively. The lowest fall rate was observed in the evening (6 to 10 P.M.). Morbidities, including rib, spine, and extremity fractures, were recorded for 14 patients, but none of these patients underwent operative treatment related to the fall. The NHISIH implemented a comprehensive nursing care service in May 2015 and a fall protocol in May 2017, but the annual incidence rate did not improve. The fall rate was higher after thoracolumbar surgeries (2.47%) than after cervical surgeries (1.20%). Moreover, a higher fall rate was observed in thoracolumbar cases with a greater number of fusion levels and revision spine surgeries.

Conclusions: Patients with advanced age, more comorbidities, a greater number of fusion levels, and revision surgeries and who are female are more vulnerable to in-hospital falls after spine surgery. Novel strategies that target these risk factors are warranted.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

In-hospital patient falls are an important issue and have been receiving attention from many hospitals and national health systems[1,2]. Approximately 2% to 17% of patients have experienced a fall during their hospitalization[3-5]. Up to 50% of those patients experienced injuries secondary to in-hospital falls, with 1% to 10% having serious outcomes such as fractures, cerebral hematomas, and death[3]. In addition to physical injuries, falls can cause prolonged length of hospital

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stay, delayed rehabilitation, unnecessary costs, and potential legal liability[6,7].

Falls comprise the largest proportion of accidents that occur during hospitalization[8]. Thus, the prevention of in-hospital falls has become an important goal for national health-care systems, and various hospitals have implemented fall-prevention strategies[1,2,4,9]. Therefore, recognizing and evaluating potential risk factors and eliminating fall risk are important tasks to providing a safe medical environment.

Although falls have been defined and reported in various ways, a universally accepted definition has not been developed to date[10]. To properly present and consistently track and manage fall data, it is crucial for each medical institution to have a clear fall definition.

Previous studies regarding in-hospital patient falls have been based on hospital-wide falls, involving all patients from different departments, from internal medicine to the surgery department[11-15]. Risk factors, such as older age, use of sedative medications, history of delirium, and previous falls, have been identified for in-hospital falls[4,11,15,16]. However, only a few studies have been conducted to determine risk factors for specific patient units[2,4]. We have focused on patients undergoing orthopaedic surgery because of mobility limitation in the immediate postoperative period, which is a period during which patients are more prone to falls.

Most studies on in-hospital falls experienced by orthopaedic patients have focused on patients who had undergone total joint replacement, especially total knee replacement[4,17-19]. We were unable to find any studies specifically regarding in-hospital falls among patients who underwent spine surgery. As society ages, the number of patients with degenerative diseases is increasing, causing a gradual increase in the number of spine surgeries performed[20]. Most patients who undergo spine surgery cannot walk immediately after surgery and are bedridden for several days postoperatively. During this period, many in-hospital falls can occur, causing serious injuries to patients and substantially delaying recovery.

The aims of the current study were to determine the incidence of in-hospital falls following spine surgery, to analyze the overall risk factors for falls after spine surgery, and to discern which factors have a major influence on falls so that falls can be more effectively prevented in the future. In addition, we aimed to evaluate the effectiveness of the fall-prevention protocol of the institution where the study was conducted.

Materials and Methods

Data Collection

This single-center retrospective review was conducted with the approval of the institutional review board of the National Health Insurance Service Ilsan Hospital (NHISIH), Goyang, Republic of Korea. The requirement of informed consent was waived because of the study's retrospective nature. We reviewed the electronic medical records of all patients who underwent spine surgery at the NHISIH during the period of January 2011 to November 2021. We defined an "in-hospital fall" as a patient being found sitting or lying on the floor, regardless of whether the fall was witnessed. Both the designated doctor and nurse had to have agreed on the fall situation. We specifically selected patients who experienced a fall after undergoing spine surgery and for whom the fall was documented in an electronic medical records system. We included falls that occurred within the admission period for spine surgery, while falls during other admission periods were excluded. Additionally, falls that occurred outside the ward and that did not activate our protocol were also excluded. Demographic data, including age at the time of surgery, sex, body mass index (BMI) at the time of surgery, American Society of Anesthesiologists (ASA) score, surgery date, surgery type, and diagnosis, were obtained for every patient. For patients who experienced falls, the date and exact time of the accident and injury caused by the fall were collected by the researchers.

On the basis of the above criteria, we reviewed 5,317 spine surgeries performed in 4,892 patients, and 128 in-hospital falls reported postoperatively among 123 patients. We categorized the type of spine surgery in 3 ways: cervical and thoracolumbar; primary and revision surgery; and decompressive laminectomy and fusion (among thoracolumbar surgeries). In addition, the 3 categories of diagnosis were lumbar degenerative disease, a herniated lumbar disc, and miscellaneous (fracture, infection, and tumor).

The NHISIH piloted a comprehensive nursing care service in July 2013, and began its official operation in May 2015. The comprehensive nursing care service is a patient ward system consisting of professionally trained nurses and nursing assistants who provide 24-hour specialized nursing services. This setting does not allow the patients' family members or guardians to stay in the hospital. In addition, the NHISIH has an "in-hospital fall protocol," which was implemented in May 2017. When a patient fall is reported, the designated nurse can activate this protocol, and a direct message is sent to the assigned resident, on-duty resident, and staff member. In addition, every patient who experiences a fall must undergo a brain computed tomography (CT) scan and a series of radiographs, including of the ribs and chest, hips, and lumbar spine. On-duty orthopaedic or neurosurgery residents perform a physical examination to assess whether additional radiographs may be needed for other extremities. On-duty radiology residents review and interpret these images. One of the prime objectives of implementing the nursing care service and fall protocol was to provide care for patients systematically and prevent in-hospital accidents such as falls. We aimed to analyze the impact of this care system on in-hospital patient falls after spine surgery.

Statistical Analysis

To evaluate characteristics potentially associated with falls, patients who experienced multiple falls during the same hospitalization were counted only once. Therefore, although 128 falls occurred during the study period, 123 were statistically assessed. General demographic data of patients (age, sex, BMI, ASA score, surgery type, and fusion level) were collected, and each type of data was independently analyzed using the chi-square test. Univariable and multivariable analyses comparing

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TABLE I Incidence of In-Hospital Falls in Patients Undergoing Spine Surgery, According to Demographic Data, Type of Surgery, and Type of Diagnosis*

		In-Hospital Falls		
	Total No. of Procedures	No. of Patients	Incidence *(%)*	P Value
Overall	5,317	123	2.31	
Age in yr				<0.0001†
≤59	1,338	9	0.67	
60-69	1,606	24	1.49	
70-79	2,022	72	3.56	
≥80	351	18	5.13	
Sex				0.0273†
Male	2,052	36	1.75	
Female	3,265	87	2.66	
ASA score				<0.0001†
1	760	3	0.39	
2	2,372	42	1.77	
3	2,140	77	3.60	
4	45	1	2.22	
BMI in kg/m^2				0.707
<20	315	11	3.49	
≥20-<25	2,463	56	2.27	
≥25-<30	2,091	45	2.15	
≥30	448	11	2.46	
Surgery type				
(1)				0.0088†
Cervical	665	8	1.2	
Thoracolumbar	4,652	115	2.47	
(2)				0.0362†
Primary	4,744	101	2.13	
Revision	573	22	3.84	
(3)				0.0336†
Fusion: 1 level	1,814	31	1.71	
Fusion: 2 level	1,068	32	3	
Fusion: 3/4 level	563	20	3.55	
Decompressive laminectomy	582	10	1.72	
Diagnosis				
Lumbar degenerative disease				0.1236
No	1,797	34	1.89	
Yes	3,520	89	2.53	
HLD				0.2249
No	4,780	114	2.38	
Yes	537	9	1.68	
Miscellaneous				0.5007
No	5,088	116	2.28	
Yes	229	7	3.06	

*ASA = American Society of Anesthesiologists, BMI = body mass index, and HLD = herniated lumbar disc. †Significant difference between groups ($p < 0.05$).

the incidence of falls across patient demographics were performed using a generalized estimating equation. In all cases, a p value of <0.05 was considered significant. Analyses were performed using SAS version 9.4 (SAS Institute).

Results

The baseline characteristics were compared between all patients who underwent spine surgery and those who experienced in-hospital falls. We analyzed and compared fall incidences according

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to demographic characteristics, type of surgery, and type of diagnosis (Table I).

The overall in-hospital fall rate was 2.31 per 100 procedures. The fall rate was 0.67% for patients ≤59 years of age and 5.13% for those ≥80 years of age, representing a significant difference ($p < 0.0001$). The fall rate also differed significantly for male and female patients, at 1.75% for male patients and 2.66% for female patients ($p = 0.0273$). Moreover, significantly different fall rates of 0.39%, 1.77%, 3.60%, and 2.22% were observed for patients with an ASA score of 1, 2, 3, and 4, respectively ($p < 0.0001$).

In the univariable analysis, a higher fall rate was associated with older age, female sex, and higher ASA score. Moreover, lower rates were observed for patients with cervical spine surgery, primary surgery, and fewer fusion levels. No significant differences in fall rates according to BMI and diagnosis categories were observed (Fig. 1).

In the multivariable analyses of all patients and in the subgroup who underwent primary surgery, older age and ASA score of 3 were independent risk factors for in-hospital patient falls (Figs. 2 and 3).

Incidences of Fall and Injury

In total, 128 in-hospital falls were reported postoperatively in 123 patients during the study period. The postoperative day and time of in-hospital patient falls are presented in Appendix Supplementary Figure 1 and in Table II. The fall rate was high in the first postoperative week (67 cases, 52.3% of all falls) and decreased in the second postoperative week (33 cases, 25.8%).

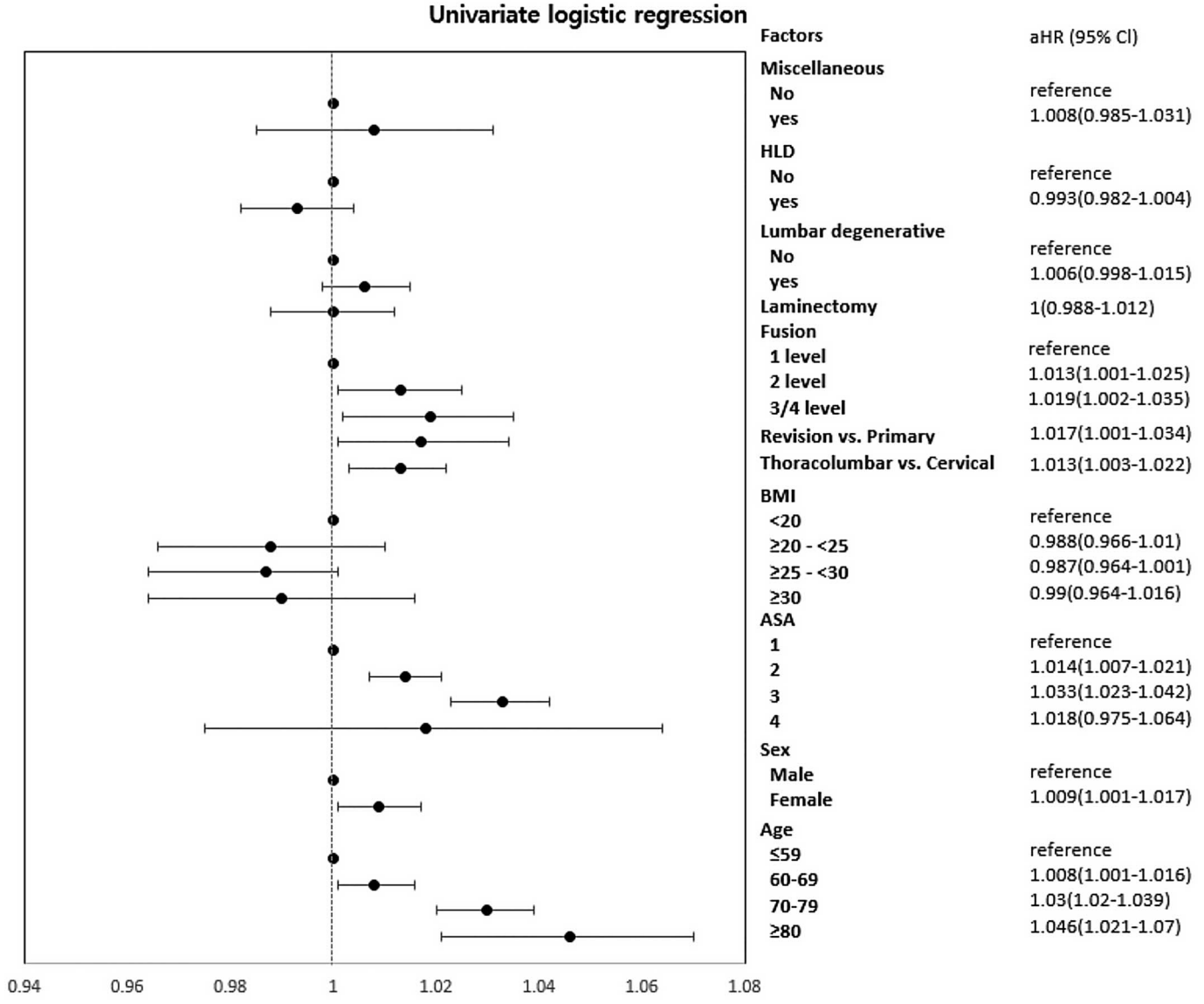

Fig. 1

Univariable logistic regression analysis of in-hospital patient falls. aHR = adjusted hazard ratio, CI = confidence interval, HLD = herniated lumbar disc, BMI = body mass index, and ASA = American Society of Anesthesiologists score.

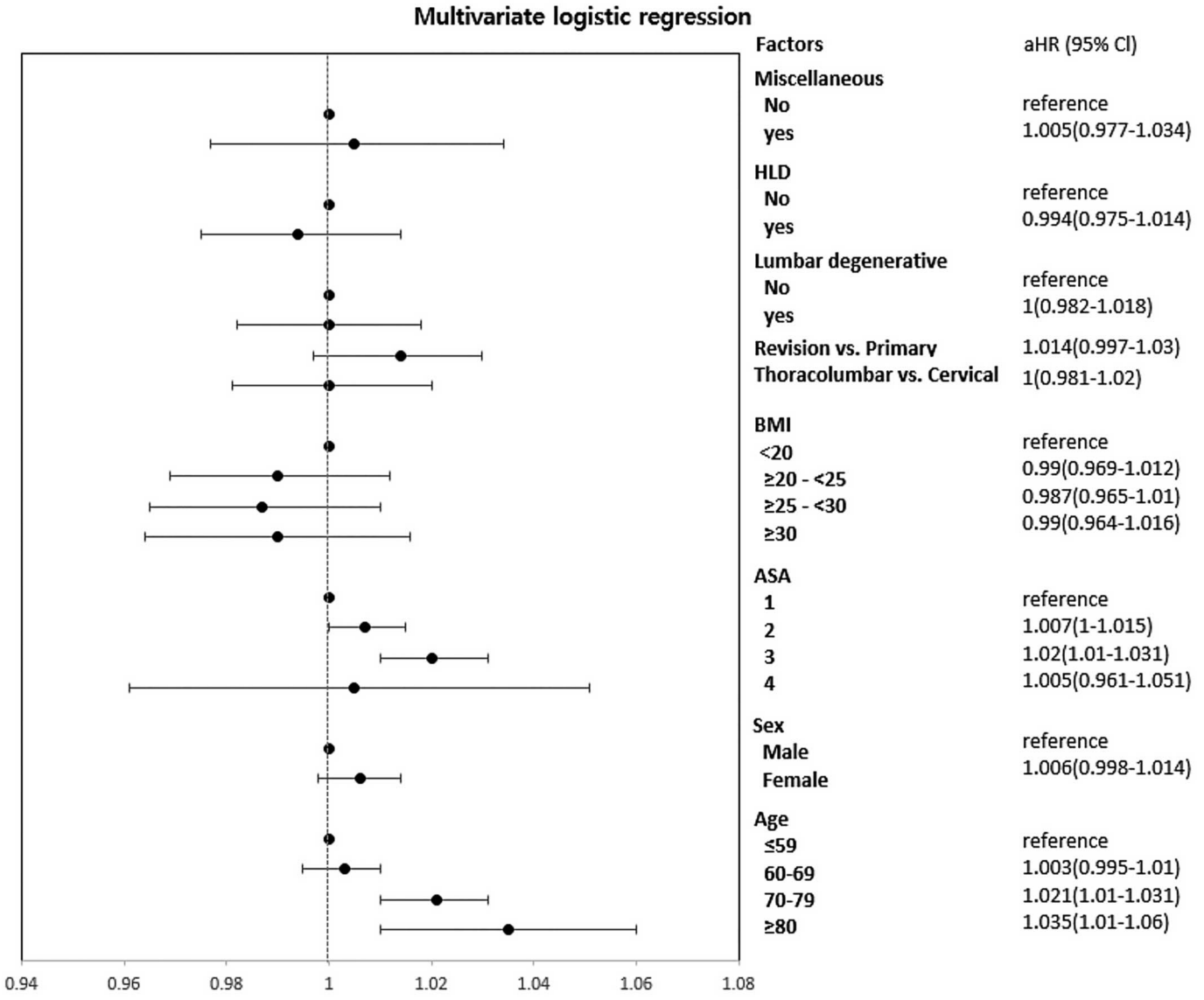

Fig. 2

Multivariable logistic regression analysis of in-hospital patient falls (including all patients). aHR = adjusted hazard ratio, CI = confidence interval, HLD = herniated lumbar disc, BMI = body mass index, and ASA = American Society of Anesthesiologists score.

After 2 weeks postoperatively, the total number of falls was 28 (21.9%). Thus, more than half of the in-hospital falls occurred during the first postoperative week. The average length of hospital stay after surgery was 9.4 days. However, the hospital stays of some patients who experienced postoperative complications or infections were substantially longer. The time period between 6 P.M. and 10 P.M. had the lowest fall rate within the day. Among the 128 in-hospital falls, 14 (11%) caused morbidities, including rib fractures (4 falls), spine fractures (4 falls), extremity fractures (3 falls: 1 metatarsal bone fracture, 1 distal radial fracture, and 1 lateral malleolar fracture), and contusions (3 falls). None of these cases required operative treatment, and no deaths occurred as a result of an in-hospital fall after spine surgery (Table II).

Fall-Prevention Service and Protocol

A timeline of the annual incidence of in-hospital patient falls and fall-prevention strategies is shown in Figure 4. The in-hospital fall rate was highest in 2017, and its distribution serially increased and decreased. After the introduction of the comprehensive nursing care service and the implementation of the in-hospital fall protocol, the fall incidences decreased in the following year but increased in the year after. Furthermore, the fall rate increased in the years following the official start of the care service.

Discussion

In this large retrospective study, we investigated the incidence of postoperative in-hospital falls, including 4,892 patients who underwent spine surgery over a period of nearly 11 years

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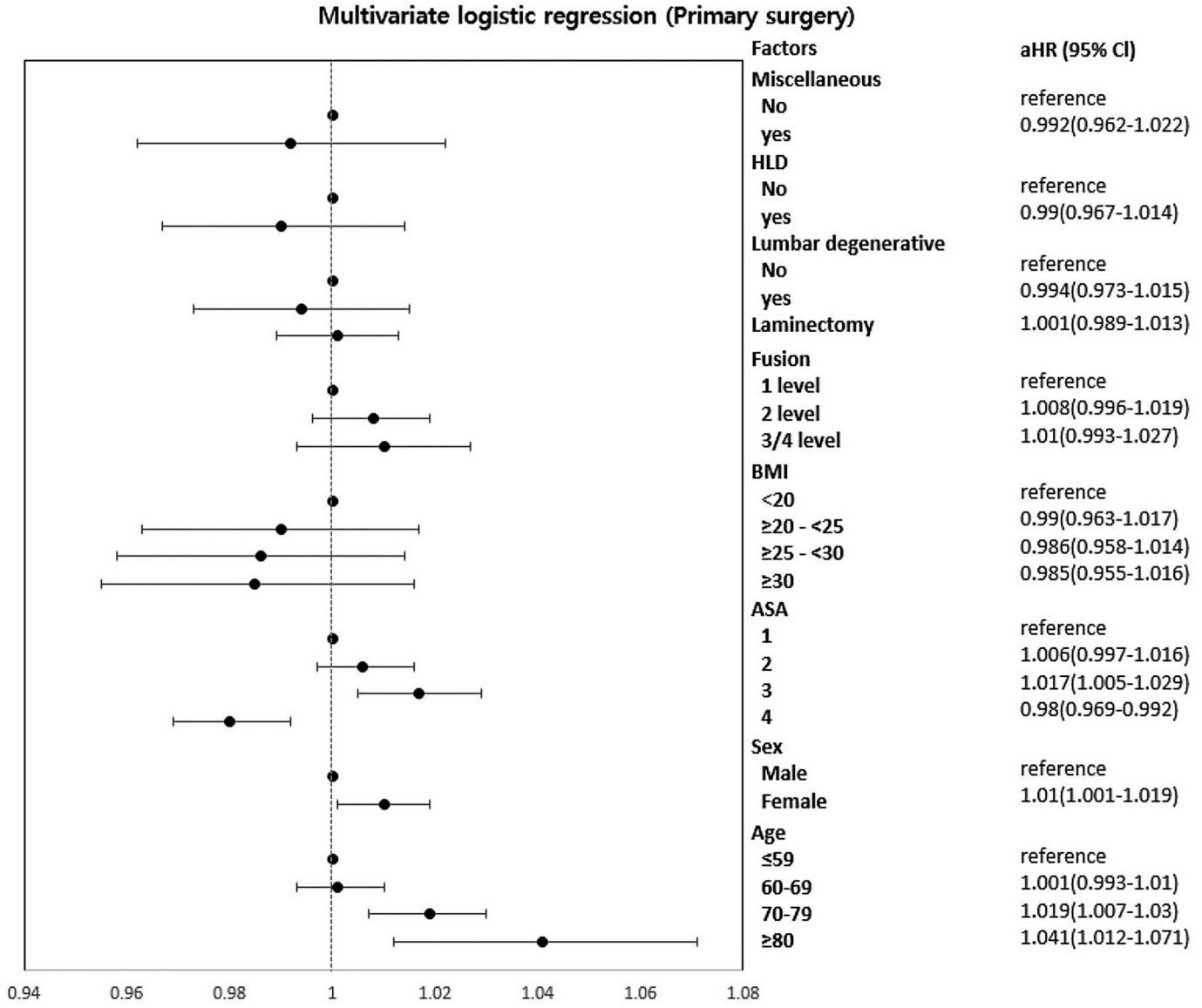

Fig. 3

Multivariable logistic regression of in-hospital falls in the subgroup of patients who underwent primary surgery. aHR = adjusted hazard ratio, CI = confidence interval, HLD = herniated lumbar disc, BMI = body mass index, and ASA = American Society of Anesthesiologists score.

The overall incidence of in-hospital falls after spine surgery was 2.31%, which is consistent with the findings of previous studies that reported the incidences of falls for a whole hospital and for patients undergoing total knee replacement[4,5,21].

According to our statistical analysis of the demographic data, older age, female sex, and a higher ASA score were independently associated with a higher fall rate. Older patients and those with high ASA scores tended to have a poor general condition, which could increase the likelihood of a fall, and other studies have shown similar results[4-6,21,22]. However, no significant relationship was noted between BMI and in-hospital falls, which conflicts with results from another study[22]. Thus, when establishing a fall-prevention strategy in orthopaedic wards, BMI should not necessarily be included as a risk factor because of the conflicting results of the studies.

Patients who underwent thoracolumbar spine surgery, had revision surgery, or who had a greater number of fusion levels fell more frequently in the hospital according to our study. However, those who underwent cervical spine surgery had a lower fall rate, which may be because this type of surgery had a low impact on ambulation. These results are consistent with the findings of a recent study demonstrating that patients with a greater burden of comorbidities undergoing complicated surgeries are at a higher risk of falling[23]. No significant difference was observed when patients were subgrouped by diagnosis, and this may be attributed to the diversity and overlapping of various spine etiologies, diagnoses, and surgical techniques. Thus, we believe that risk-prevention strategies should focus on patients who are older, female patients, and those with a greater number

TABLE II Fall Characteristics and Injury Data

	No. of Falls	%
Time of fall (n = 128)		
6 A.M.–10 A.M.	23	18
10 A.M.–2 P.M.	26	20.3
2 P.M.–6 P.M.	30	23.4
6 P.M.–10 P.M.	17	13.3
10 P.M.–6 A.M.	32	25
Injury (n = 128)		
No	114	89.1
Yes	14	10.9
Type of injury (n =14)		
Rib fracture	4	28.6
Spine fracture	4	28.6
Extremity fracture	3	21.4
Contusion	3	21.4
Requiring operation	0	0
Death	0	0

of comorbidities, with a greater number of fusion levels, and who are undergoing revision surgery.

Notably, in this study, over half of all falls were experienced by patients during the first week following spine surgery. The highest frequency of falls occurred at 3 to 7 days postoperatively. Another study focusing on patients who had undergone total joint replacement also reported the highest fall rates during the early stage of recovery (postoperative days 1 to 3), which aligns with our findings[4]. Additionally, approximately 20% of the falls occurred after the second week postoperatively. These results are unique and emphasize the importance of providing patient and guardian education closer to the discharge date and maintaining vigilance in environments outside of hospitals, such as a patient's home. Fall-prevention plans during this period should be structured differently than those of the early postoperative periods.

The time period of 6 P.M. to 10 P.M. had the lowest fall rate among times of day, potentially owing to less activity by patients, as most ambulation trials at our hospital occur from 8:30 A.M. to 5:30 P.M. and most patients are awake and alert during that time. Notably, time periods other than 6 P.M. to 10 P.M. showed similar fall rates, indicating that nurses or nursing assistants should monitor their postoperative patients with care and awareness at all times. "Fall" was defined as being found sitting or lying on the floor, and no patients were injured during the immediate postsurgical recovery phase.

Among the 128 falls in this study, 14 caused morbidities. Falls caused rib fractures in 4 patients; nonoperative management was eventually decided upon, following patient consultation with the cardiovascular surgery department. Four falls resulted in compression fractures of vertebral bodies other than the levels that had been treated surgically; all compression fractures were treated conservatively with an orthosis owing to minimal height loss and lack of neurological symptoms. Three patients had contusions, with or without abrasion wounds and bruises. Another 3 patients had an extremity fracture each; these included a lateral malleolar fracture, a distal radial fracture, and a metatarsal bone fracture, and none were treated surgically. The lateral malleolar and metatarsal bone fractures were treated nonoperatively owing to the patients' advanced age and the fact that the fractures were minimally displaced. In

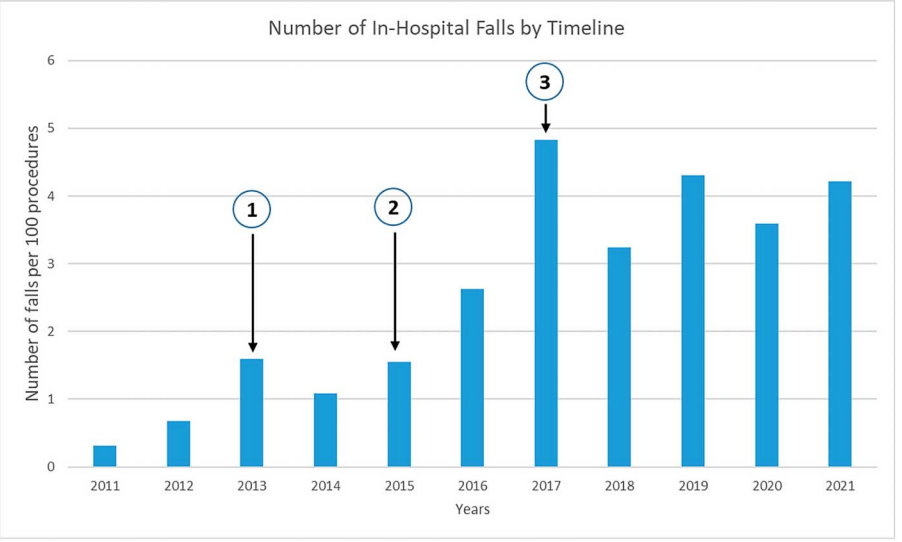

Fig. 4

Incidence of in-hospital patient falls over time and relative to the introduction of the comprehensive nursing care service and in-hospital fall protocol.

the patient with a distal radial fracture, closed reduction followed by splinting and casting was successfully performed. No deaths were reported from falls, and none of the patients injured from falls required reoperation.

The annual number of falls per 100 procedures after spine surgery was <1 in 2011 and 2012. The rate subsequently increased or decreased each year at our hospital, but fall incidences reported in the literature tend to be increasing[1,2,4]. Regarding the 3 main milestones of fall-prevention strategies in our hospital, the immediate impact of first introducing a comprehensive nursing care service and the official launch of a fall protocol seemed promising, as the rate decreased in the following year. However, the increase in fall rate was greatest from 2015 to 2017, which were the 2 years following the official establishment of the comprehensive nursing care service. We can interpret this trend in the fall rate in either of 2 ways. First, we can conclude that the newly implemented care service and fall protocol are failures that need revision because the overall incidence rate increased annually. Second, we can consider the comprehensive nursing care service and in-hospital fall protocol as partial successes because more falls experienced by patients were reported to medical teams and the patients were treated medically without delay or without the falls being ignored during the hospitalization period. The comprehensive nursing care service allowed the allotment of more nurses and nursing assistants in each ward, resulting in frequent rounding and patient monitoring. The in-hospital fall protocol allowed imaging studies for every patient who fell and faster notification to many medical team members. The increase in the annual number of reported in-hospital patient falls might have been caused by an increase in notifications regarding injured patients owing to these implemented strategies. Thus, we may need more time for serial follow-up of annual fall incidences to truly assess fall-prevention strategies.

One strength of this study is the large sample size of approximately 5,300 spine procedures. To our knowledge, this is one of the first studies to date to specifically focus on in-hospital falls after spine surgery. Our data are strengthened by the univariable and multivariable analyses.

We acknowledge the limitations of this study imposed by its retrospective design, such as reporting bias and selection bias. However, information on all patients within the investigation period was included. Furthermore, it is important to acknowledge several other potential limitations of this study. First, the inclusion of different admitting departments, such as orthopaedics and neurosurgery, could have introduced variability in the patient population and treatment approaches. Second, the use of different routine rehabilitation protocols may have influenced the outcomes measured. Third, the fact that the surgeries were performed by a total of 8 different staff members could have introduced variability in surgical techniques and expertise. Fourth, there may have been variations in the details of the operative procedures used. Notably, these factors may have changed over the nearly 11-year period of the study. To address these limitations, future research should aim to control for these factors. This is particularly important considering the recent introduction and widespread utilization of many minimally invasive techniques. By controlling for these variables, more accurate and reliable results can be obtained, providing a clearer understanding of the impact of these procedures on patient outcomes.

In conclusion, we found that patients of advanced age, with more comorbidities, who are female, or who were undergoing procedures involving a greater number of fusion levels or revision were more vulnerable to falls during their hospital stays. As in-hospital falls can lead to devastating outcomes, devising fall-prevention strategies is necessary for hospitals and national health-care systems. Consideration of the risk factors revealed in this study may lead to the development of better preventive strategies.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A618). ■

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