North American Spine Society Journal (NASSJ) 20 (2024) 100549

Contents lists available at ScienceDirect

North American Spine Society Journal (NASSJ)

journal homepage: www.elsevier.com/locate/xnsj

Clinical Studies

Rate and risk factors for inpatient falls following single-level posterior lumbar fusion: A national registry study

Michael J. Gouzoulis, BS, Sahir S. Jabbouri, MD, Anthony E. Seddio, BS, Jay Moran, MD, Wesley Day, BS, Philip P. Ratnasamy, BS, Jonathan N. Grauer, MD*

Department of Orthopaedics and Rehabilitation, Yale School of Medicine, New Haven, CT

ARTICLE INFO

Keywords:
Spine
Inpatient Falls
Posterior lumbar fusion
PLF
Pearldiver
Single-level

ABSTRACT

Background: Posterior lumbar fusion (PLF) is frequently considered for various spinal pathologies. While many outcome metrics have been assessed, to our knowledge, there has yet to be literature specifically investigating inpatient falls (IPFs) and its risk factors.

Methods: Adult patients who underwent single-level PLF were abstracted from the 2010–Q1 2022 M161Ortho PearlDiver Database. Patients who had an IPF were determined based on administrative coding. Various patient variables were extracted and variables independently associated with IPFs were assessed with multivariate logistic regression. Incidence of secondary injuries and cost incurred related to the IPF were determined.

Results: Of the 342,890 patients who underwent PLF, IPF was identified for 4,379 (1.4%). Independent predictors of an IPF in decreasing odds ratio (OR) order were those with: active psychosis (OR=3.35), active delirium (OR=2.83), history of falling (OR=2.47), commercial insurance (OR=1.59 relative to Medicare), Medicaid insurance (OR=1.47 relative to Medicare), dementia (OR=1.17), older age (OR=1.12 per decade), alcohol use disorder (O=1.11), higher comorbidity (OR=1.08 per Elixhauser comorbidity index point) ($p<.05$ for each).

Of patients with IPF, 44 (1.0%) sustained a head injury, and 42 (1.0%) sustained a fracture. On average, those with IPF incurred greater inpatient costs compared to patients who did not ($36,865 vs. $33,921, $p<.001$).

Conclusion: In this national sample of patients who underwent single-level PLF, postoperative IPFs were identified for 1.4% and were associated with defined patient variables. These findings have potential patient outcome, financial, and medicolegal implications and should help guide refinement of fall prevention programs.

Introduction

Posterior lumbar fusion (PLF) is frequently considered for various spinal pathologies [1,2]. While many outcome metrics have been assessed [3–6], postoperative inpatient falls (IPFs) have not been thoroughly investigated in this patient population.

The incidence of inpatient falls across hospitals and units has been found to range from 0.9% to 2.0% [7–9]. Kobayashi et al. found that orthopaedic patients were the most likely to suffer a fall than any other patient in the hospital [10]. This may be attributed to impaired walking, pain with mobilization, and weakness [11].

It has been estimated that approximately 30% of IPFs result in minor injury, while nearly 8% result in moderate to severe injury [12,13]. Orthopedics patients being shown to be at nearly 4-fold increased risk for serious postoperative adverse events after experiencing an inpatient fall [7]. Further, IPFs have been associated with extended hospital stays, higher healthcare costs, and poorer long-term outcomes [14].

Hospitals often have various guidelines for preventing IPFs, focused on identifying high-risk patients and various fall prevention strategies [8]. Past literature suggests that factors such as history of falls, gait abnormalities, mental status, and specific drugs, such as benzodiazepines have been associated with increase fall risk within the hospital [15].

For spine surgery, Wilson et al. investigated trends in complications of PLF using the Premier Healthcare Database, and found patients fall at a rate of 5.0–8.3 per 1,000 inpatient days [16], however they did not investigate the specific risk factors for these falls. Prior literature has

FDA device/drug status: Not applicable.

Author disclosures: ***MJG:*** Nothing to disclose. ***SSJ:*** Nothing to disclose. ***AES:*** Nothing to disclose. ***JM:*** Nothing to disclose. ***WD:*** Nothing to disclose. ***PPR:*** Nothing to disclose. ***JNG:*** Board of Directors: NASSJ (D).

Given his role as Editor in Chief, Jonathan Grauer, MD had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to Tobias Mattei, MD.

* Corresponding author. Department of Orthopaedics and Rehabilitation, Yale School of Medicine, PO Box 208071, New Haven, CT 06520-8071.
E-mail address: jonathan.grauer@yale.edu (J.N. Grauer).

https://doi.org/10.1016/j.xnsj.2024.100549
Received 26 June 2024; Received in revised form 7 August 2024; Accepted 9 August 2024
Available online 14 August 2024

looked at specific risk factors for falls following hip [17], knee [17,18], and shoulder [19] surgery, however, to our knowledge, there has been no investigation into risk factors for falling following spine surgery.

The current study aimed to define the rate and risk factors of IPF following PLF utilized a large national, multi-insurance database. It was hoped that defining such variables could help evolve care pathways to minimize their occurrence.

Methods

Study cohort

The current study used the 2010–Q1 2022 M161Ortho PearlDiver Mariner Patient Claims Database (PearlDiver Technologies, Colorado Springs, CO, USA), a large national insurance claims data set that contains both inpatient and outpatient patient information from across the United States. This has frequently been used in the orthopaedic/spine literature [20–24]. Our Institutional Review Board has exempted studies using this dataset exempt from reviewed as it is data is output in de-identified/aggregated form.

All patients who underwent single-level PLF with or without interbody fusion were identified using International Classification of Disease (ICD)-9/10 procedural codes. Patients were excluded from the study if they underwent concurrent anterior fusion or had additional level coding to ensure a homogenous patient cohort of only single level fusions. Other exclusions included patients who were: under eighteen years of age or presented for trauma, neoplasm, or infection.

Inpatients Falls were identified using ICD-9/10 codes. Falls were determined to be inpatient if they occurred on the day of the patient's surgery until they are discharged out of the hospital.

Patient characteristics

Patient demographic/characteristics were tabulated and divided based on those who did not and did have an IPF following surgery. The following were included in analysis: patient's age (standard deviation [SD]), sex, Elixhauser Comorbidity Index (ECI, a common index used in orthopaedic literature to determine the relative comorbidity burden of the patient [25]), insurance (Medicare, Medicaid, Commercial). In addition, specific comorbidities were assessed, including: alcohol use disorder, dementia, active delirium history of falls, and active psychosis.

Secondary injuries, length of stay, and cost of fall

Secondary injuries following IPFs were then determined. The following variables were aggregated: head injury, which includes all blunt trauma, concussion, hemorrhage or other injury related to the head and fractures caused by the fall. Fractures were then subcategorized into lower extremity and upper extremity fractures.

Hospital length of stay (LOS) (SD) of the patient and the average cost of the patient's stay (SD) was determined and divided based whether the patient had IPF or not postoperatively.

Statistical analysis

Univariate analysis was done to compare patient demographics between patients who did not and did have an IPF. Continuous variables (age, ECI, LOS, cost of stay) were compared using a Welch t-test, while all categorial variables (sex, insurance plan, and comorbidities [alcohol use disorder, dementia, active delirium during stay, history of falls, and active psychosis]) were compared using a chi square test.

Multivariable logistical regression was then performed in order to determine independent risk factors for falling during one's inpatient stay. Multivariate analysis controlled for the falling variables: patient's age, ECI, sex, insurance plan, history of falls, alcohol use disorder, dementia, active delirium, and active psychosis.

Table 1
Patient characteristics of those who did not versus those who did have inpatient falls following posterior lumbar fusion.

	No inpatient falls	Inpatient fall	p-value
Total	338,511 (98.6%)	4,379 (1.4%)	
Age ± SD (y)	60.6±12.6	62.9±12.4	**<.001**
Sex			.18
Female	196,386 (58.0%)	2,601 (59.4%)	
Male	142,124 (42.0%)	1,778 (40.6%)	
ECI ± SD	4.6±3.3	6.0±3.9	**<.001**
Comorbidities			
Alcohol use disorder	27,931 (8.3%)	463 (10.6%)	**<.001**
Dementia	21,005 (6.2%)	409 (9.3%)	**<.001**
Active delirium	2,501 (0.7%)	124 (2.8%)	**<.001**
History of falls	11,669 (3.5%)	493 (11.3%)	**<.001**
Active psychosis	814 (0.2%)	47 (1.1%)	**<.001**
Insurance			**<.001**
Medicare	96,434 (28.5%)	1,049 (24.0%)	
Medicaid	14,913 (4.4%)	195 (4.5%)	
Commercial	218,942 (64.7%)	2,981 (68.1%)	

Bolding indicates significance of $p < 0.05$.

Table 2
Multivariate analysis of factors predictive of inpatient falls following posterior lumbar fusion.

	Odds ratio (95% CI)	p-value
Total		
Age (per decade)	1.12 (1.09–1.15)	**<.001**
Sex (Ref = female)		.33
Male	0.97 (0.91–1.03)	
ECI (per point)	1.08 (1.07–1.09)	**<.001**
Comorbidity		
Alcohol use disorder	1.11 (1.00–1.23)	**.04**
Dementia	1.17 (1.05–1.30)	**.004**
History of falls	2.47 (2.23–2.73)	**<.001**
Active delirium	2.83 (2.33–3.40)	**<.001**
Active psychosis	3.35 (2.44–4.48)	**<.001**
Insurance (Ref = medicare)		
Medicaid	1.47 (1.25–1.72)	**<.001**
Commercial	1.59 (1.48–1.72)	**<.001**

Bolding indicates significance of $p < 0.05$.

All statistical analysis was performed using the RSuite statistical software in PearlDiver Mariner Patient Claims Database (PearlDiver Technologies, Colorado Springs, CO, USA). All figures were created using GraphPad Prism 10 (GraphPad Software, San Diego, CA, USA). Significance was defined as $p<.05$.

Results

Study cohort

A total of 342,890 patients were undergoing single-level PLF were identified. Of those, IPFs were identified for 4,379 patients (1.4%).

Predictive factors for inpatient falls

Patients who fell were older (62.9 vs. 60.6 years old), and had a higher comorbidity burden/ECI (6.0 vs. 4.6) and of different insurance distribution) ($p<.001$ for each). Lastly, patients who fell were more likely to have alcohol use disorder (10.6% vs. 8.3%), dementia (9.3% vs. 6.2%), active delirium (2.8% vs. 0.7%), a history of falling (11.3% vs. 3.5%), and active psychosis (1.1% vs. 0.2%) ($p<.001$ for all). (Table 1).

Multivariate analysis was performed to determine factors independently associated with increased odds of IPFs (Table 3). In decreasing odds order, these included: active psychosis (OR=3.35), active delirium (OR=2.83), history of falling (OR=2.47), commercial insurance (OR=1.59), Medicaid insurance (OR=1.47), dementia (OR=1.17),

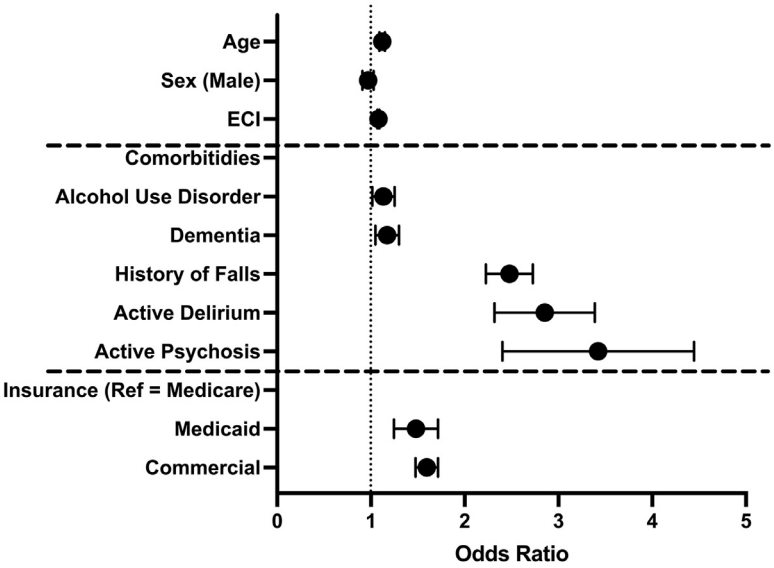

Fig. 1. A forest plot of the odds ratio from the multivariate analysis showing the predictive factors for falling during one's inpatient stay following posterior lumbar fusion.

Table 3
Length of stay and secondary injuries between those who did and did not suffer an inpatient fall.

	No inpatient falls	Inpatient fall	p-value
LOS (d)	5.3±5.9	12.3±12.9	**<.001**
Secondary injury			
Head injury	-	44 (1.0%)	-
All fractures	-	42 (1.0%)	-
Lower extremity fracture	-	30 (0.7%)	-
Upper extremity fracture	-	15 (0.3%)	-
Spinal fracture	-	*	-

Bolding indicates significance of $p < 0.05$.
* Indicates 10 or less patients.

age (OR=1.12 per decade), alcohol use disorder (OR=1.11), and ECI (OR=1.08 per point) (p<.05 for each, Table 2 and Fig. 1).

Injuries, length of stay, and costs associated with inpatient falls

Of the 4,379 (1.4%) of patients with IPF, head injury was sustained by 44 (1.0%). Additionally, fractures resulted for 42 (1.0%) (Table 2).

Patients who fell had to stay significantly longer in the hospital postoperatively, from 5.3±5.9 days for those who didn't suffer a fall to 12.3±12.9 days for those who did (p<.001). In terms of incremental costs associated with those who had IPFs, the average cost of stay for those who fell following their surgery was $36,865±$39,686, while the average cost of stay for those who did not was $33,921±$35,496 (p<.001).

Discussion

IPFs are clearly an important quality metric for which care algorithm are in place to minimize. The current study investigated fall risk in patients who underwent single-level PLF between 2010 and 2022. Of the 342,890 patients included in this study, IPFs were identified for 4,379 patients (1.4%). Although this number is relatively low, it poses risk for significant morbidity [26,27]. Thus, to improve outcomes of our patients, it is important to identify risk factors for IPFs and to gain a sense of their impact.

The current study identified IPFs to be of independently greater odds for those who were older (OR=1.12 per decade) and greater comorbidity (OR=1.08 per point ECI). Similarly, in a cross-sectional study evaluating postoperative patients, da Mata et al. [28] found increased age to be associated with increased risk of falls postoperatively. Church et al. [26] evaluated 30-day postoperative falls in surgical patients and found that older age, functional dependence, lower albumin, and a higher American Society of Anesthesia Score (ASA) to be associated with increased fall risk. Along these lines, low preoperative muscle mass has also been shown to be a risk factor for outpatient falls after surgery in patients with lumbar spinal stenosis [29].

Specific comorbidities were found to be independently associated with IPFs. Multiple factors associated with confusion were found to be indecently associated with IPFs. These included active psychosis (OR=3.35), active delirium (OR=2.83), dementia (OR = 1.17), and alcohol use disorder (OR=1.11). Postoperative delirium incidence following spine surgery has been reported to be 3.3%–18% with variation likely depending on factors such as surgical duration, blood loss and postoperative bedrest duration [30,31]. Delirium has also been shown to be associated with increased LOS, healthcare costs and mortality in lumbar spine surgery patients [31]. The literature has also shown an increased risk of falls in patients with dementia as well as those with active psychosis history who are on antipsychotic medications [31,32]. In fact, Stubbs et al. demonstrated that older patients utilizing mental health services had double the incidence of falls and 4 times the incidence of hip fractures compared with the general population [33]. Alcohol use disorder is a known risk factor for developing delirium tremens which increases fall risk, especially in the elderly [34,35]. Appropriate screening for alcohol use disorder and prevention of alcohol withdrawal in the perioperative setting is critical [32,33].

In addition, IPFs were independently associated with a history of falls (OR=2.47). Thus, identification of patients with a history of falls via preoperative screening is imperative. Fujita et all evaluated stride length in elderly patients with lumbar spinal stenosis and found a short stride, indicating a potential increased fall risk, in patients 80 years of age and older, those with worse lumbar function scores and presence of lower extremity motor deficits and a forward-bent posture [36]. In a study by Lubetzky et al., static and dynamic balance testing was performed preoperatively and following lumbar spine surgery. The authors found that the risk of falling was higher than expected as 26% of patients remained a high fall risk postoperatively based on dynamic balance testing [37]. This highlights the importance of adequate preoperative screening and close postoperative monitoring with physical therapy/nursing staff in these patients.

Both commercial insurance (OR=1.47) and Medicaid insurance (OR=1.47) had an increase odd of falling compared to patients with Medicare insurance. Although the exact etiology of this increase odd is

unclear, a potential explanation for this difference could be attributed to potential difference in length of stay of hospitalization. The present study did not control for this difference, and this it may have affected time to discharge amongst the different insurances.

Lee et al evaluated sagittal balance on risk of falls after minimally invasive lateral lumbar interbody surgery combined with posterior surgery versus PLF alone in patients with lumbar spinal stenosis [38]. The authors found that patients who underwent the combined procedure with correction of sagittal balance had a lower incidence of falls than patients who underwent PLF alone and had residual sagittal imbalance [38]. Given that optimal sagittal alignment is known to improve body balance and reduce risk of falls, it is important to restore this parameter while also minimizing fusion levels [39,40]. However, given the limitations of database studies, our study did not evaluate radiographic sagittal alignment.

There were clearly significant impacts to IPFs identified in the current study. One measure of this is that IPFs resulted in head injuries (1.0% of those who fell) and fractures (1.0%) of those who fell. Patients who fell also had significantly longer LOS than those who did not (12.3 days vs. 5.3 days) and were associated with greater costs ($36,865±$39,686 vs. $33,921±$35,496)).

Limitations of this study include the use of insurance claims dataset to gather patient information, which is reliant on accurate coding of ICD and CPT codes. Specifically, it relies on proper and accurate coding of falls during an inpatient stay, making it possible that the number of falls reported in the study might underreport the true total from lack of coding. Whether the patient underwent a minimally invasive surgery or an open surgery is not possible to determine. This could pose an additional risk factor for whether a patient suffered a fall. Similarly, while efforts were made to select for an elective patient population through exclusion criteria, it is possible some patients were emergent cases. Additionally, it was not possible to capture when the fall occurred during the inpatient stay, only if 1 occurred, making it not possible to provide chronologic data. Lastly, the coding of alcohol use disorder is broad, and may not capture how much alcohol the patient regularly consumes, if they have recently become sober, and does not address any hospital intervention to minimize withdrawals.

In summary, the present study identified falls following surgery as an uncommon, but not infrequent, occurrence following PLF. Falls are an important healthcare metrics for hospitals, and pose significant risk of harm for patients. Thus, recognizing at risk patients via comprehensive preoperative screening based on recognized risk factors can help surgeons better plan and minimize patient morbidity, LOS, and healthcare associated costs.

Declarations of competing interests

Michael Gouzoulis received James G Hirsch Medical Student Fellowship from Yale University School of Medicine. Jonathan N Grauer is Editor-in-Chief of North American Spine Society Journal and a member of the North American Spine Society Board of Directors.

References

[1] Yamaguchi JT, Weiss HK, Garcia RM, et al. Trends in national utilization of posterior lumbar fusion and 30-day reoperation and readmission rates from 2006-2016. Clin Neurol Neurosurg 2020;199:106310.

[2] Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg 2015;1(1):2–18.

[3] Dhodapkar MM, Halperin SJ, Joo PY, et al. Weight loss makes the difference: perioperative outcomes following posterior lumbar fusion in patients with and without weight loss following bariatric surgery. Spine J 2023;23(10):1506–11.

[4] Kammien AJ, Zhu JR, Gillinov SM, Gouzoulis MJ, Grauer JN. Adverse events after posterior lumbar fusion are not sufficiently characterized with 30-day follow-up: a database study. J Am Acad Orthop Surg 2022;30(11):528–33.

[5] Gouzoulis MJ, Kammien AJ, Zhu JR, Gillinov SM, Moore HG, Grauer JN. Single-level posterior lumbar fusions in patients with Ehlers Danlos Syndrome not found to be associated with increased postoperative adverse events or five-year reoperations. N Am Spine Soc J 2022;11:100136.

[6] LeRoy TE, Moon AS, Gedman M, Aidlen JP, Rogerson A. Impact of body mass index on opioid consumption in lumbar spine fusion surgery. N Am Spine Soc J 2021;6:100060.

[7] Mandl LA, Lyman S, Quinlan P, Bailey T, Katz J, Magid SK. Falls among patients who had elective orthopaedic surgery: a decade of experience from a musculoskeletal specialty hospital. J Orthop Sports Phys Ther 2013;43(2):91–96.

[8] LeLaurin JH, Shorr RI. Preventing falls in hospitalized patients: state of the science. Clin Geriatr Med 2019;35(2):273–83.

[9] Mikos M, Banas T, Czerw A, Banas B, Strzępek Ł, Curyło M. Hospital inpatient falls across clinical departments. Int J Environ Res Public Health 2021;18(15).

[10] Kobayashi K, Ando K, Inagaki Y, et al. Characteristics of falls in orthopedic patients during hospitalization. Nagoya J Med Sci 2018;80(3):341–9.

[11] Stel VS, Smit JH, Pluijm SM, Lips P. Balance and mobility performance as treatable risk factors for recurrent falling in older persons. J Clin Epidemiol 2003;56(7):659–68.

[12] Halfon P, Eggli Y, Van Melle G, Vagnair A. Risk of falls for hospitalized patients: a predictive model based on routinely available data. J Clin Epidemiol 2001;54(12):1258–66.

[13] Hitcho EB, Krauss MJ, Birge S, et al. Characteristics and circumstances of falls in a hospital setting: a prospective analysis. J Gen Intern Med 2004;19(7):732–739.

[14] Bates DW, Pruess K, Souney P, Platt R. Serious falls in hospitalized patients: correlates and resource utilization. Am J Med 1995;99(2):137–43.

[15] Lindberg DS, Prosperi M, Bjarnadottir RI, et al. Identification of important factors in an inpatient fall risk prediction model to improve the quality of care using EHR and electronic administrative data: a machine-learning approach. Int J Med Inform 2020;143:104272.

[16] Wilson LA, Fiasconaro M, Liu J, et al. Trends in comorbidities and complications among patients undergoing inpatient spine surgery. Spine (Phila Pa 1976) 2020;45(18):1299–308.

[17] Memtsoudis SG, Dy CJ, Ma Y, Chiu YL, Della Valle AG, Mazumdar M. In-hospital patient falls after total joint arthroplasty: incidence, demographics, and risk factors in the United States. J Arthroplasty 2012;27(6):823–8.

[18] Memtsoudis SG, Danninger T, Rasul R, et al. Inpatient falls after total knee arthroplasty: the role of anesthesia type and peripheral nerve blocks. Anesthesiology 2014;120(3):551–63.

[19] Menendez ME, Ring D, Jawa A. Inpatient falls after shoulder arthroplasty. J Shoulder Elbow Surg 2017;26(1):14–19.

[20] Dhodapkar MM, Gouzoulis MJ, Halperin SJ, Modrak M, Yoo BJ, Grauer JN. Urgent care versus emergency department utilization for foot and ankle fractures. J Am Acad Orthop Surg 2023;31(18):984–9.

[21] Gillinov SM, Burroughs PJ, Moore HG, Rubin LE, Frumberg DB, Grauer JN. Total hip arthroplasty in patients with classic hemophilia: a matched comparison of 90-day outcomes and 5-year implant survival. J Arthroplasty 2022;37(7):1333–1337.

[22] Gouzoulis MJ, Joo PY, Caruana DL, Kammien AJ, Rubio DR, Grauer JN. Incidental durotomy after posterior lumbar decompression surgery associated with increased risk for venous thromboembolism. J Am Acad Orthop Surg 2023;31(8):e445–ee50.

[23] Ratnasamy PP, Kammien AJ, Gouzoulis MJ, Oh I, Grauer JN. Emergency department visits within 90 days of total ankle replacement. Foot Ankle Orthop 2022;7(4):24730114221134255.

[24] Burroughs PJ, Kahan JB, Moore HG, Grauer JN, Gardner EC. Temporal utilization of physical therapy visits after anterior cruciate ligament reconstruction. Orthop J Sports Med 2021;9(2):2325967120982293.

[25] Baron RB, Neifert SN, Ranson WA, et al. A comparison of the elixhauser and charlson comorbidity indices: predicting in-hospital complications following anterior lumbar interbody fusions. World Neurosurg 2020;144:e353–ee60.

[26] Church S, Robinson TN, Angles EM, Tran ZV, Wallace JI. Postoperative falls in the acute hospital setting: characteristics, risk factors, and outcomes in males. Am J Surg 2011;201(2):197–202.

[27] Najafpour Z, Godarzi Z, Arab M, Yaseri M. Risk factors for falls in hospital in-patients: a prospective nested case control study. Int J Health Policy Manag 2019;8(5):300–306.

[28] Mata L, Azevedo C, Policarpo AG, Moraes JT. Factors associated with the risk of fall in adults in the postoperative period: a cross-sectional study. Rev Lat Am Enfermagem 2017;25:e2904.

[29] Wada T, Tanishima S, Kitsuda Y, Osaki M, Nagashima H, Hagino H. Preoperative low muscle mass is a predictor of falls within 12 months of surgery in patients with lumbar spinal stenosis. BMC Geriatr 2020;20(1):516.

[30] Morino T, Hino M, Yamaoka S, et al. Risk factors for delirium after spine surgery: an age-matched analysis. Asian Spine J 2018;12(4):703–9.

[31] Fineberg SJ, Nandyala SV, Marquez-Lara A, Oglesby M, Patel AA, Singh K. Incidence and risk factors for postoperative delirium after lumbar spine surgery. Spine (Phila Pa 1976) 2013;38(20):1790–6.

[32] Vun JSH, Ahmadi M, Panteli M, Pountos I, Giannoudis PV. Dementia and fragility fractures: issues and solutions. Injury 2017;48(Suppl 7):S10–16.

[33] Stubbs B, Perara G, Koyanagi A, et al. Risk of hospitalized falls and hip fractures in 22,103 older adults receiving mental health care vs 161,603 controls: a large cohort study. J Am Med Dir Assoc 2020;21(12):1893–9.

[34] Zamorano DP, Lim PK, Haghverdian BA, Gupta R. Perioperative management of the orthopaedic patient and alcohol use, abuse, and withdrawal. J Am Acad Orthop Surg 2019;27(6):e249–ee57.

[35] Mulkey MA, Olson DM. Delirium tremens in the older adult. J Neurosci Nurs 2020;52(6):316–21.

[36] Fujita N, Sakurai A, Miyamoto A, et al. Stride length of elderly patients with lumbar spinal stenosis: multi-center study using the two-step test. J Orthop Sci 2019;24(5):787–92.
[37] Lubetzky AV, Soroka A, Harel D, et al. Static and dynamic balance in adults undergoing lumbar spine surgery: screening and prediction of postsurgical outcomes. J Am Acad Orthop Surg 2020;28(13):e553–e5e9.
[38] Lee BH, Yang JH, Kim HS, et al. Effect of sagittal balance on risk of falling after lateral lumbar interbody fusion surgery combined with posterior surgery. Yonsei Med J 2017;58(6):1177–85.
[39] Lee BH, Park JO, Kim HS, et al. Spinal sagittal balance status affects postoperative actual falls and quality of life after decompression and fusion in-situ surgery in patients with lumbar spinal stenosis. Clin Neurol Neurosurg 2016;148:52–9.
[40] Imagama S, Ito Z, Wakao N, et al. Influence of spinal sagittal alignment, body balance, muscle strength, and physical ability on falling of middle-aged and elderly males. Eur Spine J 2013;22(6):1346–53.