

Predictors of Prolonged Length of Stay After Lumbar Interbody Fusion: A Multicenter Study

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Abstract

Study Design: Retrospective analysis of a prospectively database.

Objectives: To identify factors associated with prolonged length of stay (LOS) in posterior /transforaminal lumbar interbody fusion (PLIF/TLIF).

Methods: The subjects were patients who underwent PLIF/TLIF at 10 facilities from 2012 to 2014. A total of 1168 such patients with a mean age of 65.9 ± 12.5 years (range 18-87 years) were identified in the database. Operations were PLIF (n = 675), TLIF (n = 443), minimally invasive surgery (MIS)-PLIF (n = 22), and MIS-TLIF (n = 32). Age, gender, body mass index, ambulatory status, comorbidities, perioperative American Society of Anesthesiologists (ASA) grade, operative factors, and complications were examined. LOS was defined as the number of calendar days from the operation to hospital discharge. LOS was categorized as normal (<75th percentile) or prolonged (\geq 75th percentile).

Results: The average LOS was 20.8 ± 9.8 days (range 7-77 days). There was a significant correlation between LOS and age ($P < .05$). Reoperation during hospitalization was performed in 20 cases for surgical site infection (n = 12), epidural hematoma (n = 5), and screw misplacement (n = 3). In multivariate analysis, prolonged LOS was associated with preoperative variables of age ≥ 70 years (odds ratio [OR] 1.87, 95% CI 1.38-2.54), and ASA class \geq III (OR 1.52, 95% CI 1.04-2.25); surgical variables of open procedures (OR 5.84, 95% CI 1.74-19.63), fused levels ≥ 3 (OR 5.17, 95% CI 3.17-8.43), operative time ≥ 300 minutes (OR 1.88, 95% CI 1.15-3.07), and estimated blood loss ≥ 500 mL (OR 1.71, 95% CI 1.07-2.75).

Conclusions: The factors identified in this study should help with obtaining informed consent, surgical planning and complication prevention to reduce health care costs associated with prolonged LOS.

Keywords

length of stay, multicenter, posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), postoperative complications

Introduction

Instrumented posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are common surgical procedures used to treat lumbar spine pathology and have favorable outcomes and low morbidity.¹ Since the initial description of the PLIF technique by Briggs and Milligan in 1944,² the method has evolved with development of additional options of autologous and synthetic bone grafting, advanced spinal segmental fusion techniques, innovative implants

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(including current use of a wide variety of interbody implants), and pedicle screw fixation for posterior instrumentation. In 1982, Harms and Rolinger³ reported a technique via the transforaminal route for insertion of an interbody cage packed with bone graft, which is now referred to as TLIF. These advances in implants and techniques have improved the outcome of spinal fusion using PLIF/TLIF. The operations can also now be performed using mini-open or minimally invasive surgery (MIS).⁴⁻⁶ MIS is increasingly being applied in spine surgery after demonstration of improved clinical outcomes and decreased perioperative morbidity. This approach is also safe and effective for treatment of lumbar pathology in elderly patients. These are important because the recent rapid aging of society has increased the number of elderly patients with progressive degenerative diseases.

We perform PLIF/TLIF with pedicle screw fixation to treat degenerative lumbar disorders with segmental instability. In such cases, it is essential to decompress all involved neural elements and stabilize the affected segments. This method produces satisfactory clinical results, but is associated with surgical complications, with several reports indicating that patients who undergo lumbar arthrodesis have substantially higher complication rates than those who undergo decompression alone.^{7,8} Demands for spinal fusion procedures have increased as a result of the rising elderly population and morbidity associated with open fusion procedures, including substantial blood loss, increased complication rate, and longer hospital stays, may expose this patient population to undesirable surgical risks.⁹⁻¹⁴

Length of stay (LOS) of any surgical patient is mainly a function of patient characteristics (such as age and comorbid conditions), procedure complexity, and postoperative complications or adverse events. Prolonged LOS is also associated with an increased risk of complications and morbidities after surgery, and such complications or severely ill patients increase hospital resource utilization and worsen outcomes.¹⁵⁻¹⁸ Prolonged LOS is also associated with increasing costs for patients and hospitals.^{16,17} Previous studies of increased LOS after spine surgery have identified associations with morbid obesity, metabolic syndrome, open versus minimally invasive surgery, age, chronic obstructive pulmonary disease (COPD), use of antidepressants, unemployment, chronic renal disease, and intraoperative fluid volume.¹⁹⁻²⁴ However, these have generally been small studies that examined isolated factors, leaving significant room for the effects of confounding variables.

In this study, we examined prolonged LOS in PLIF/TLIF in a multicenter study, to identify pre-, intra-, and postoperative factors that are independently associated with prolonged LOS in a multivariate model. This approach may allow modifiable risk factors to be optimized preoperatively, while non-modifiable factors can be used for postoperative management. This information may also be useful for obtaining preoperative informed consent and for inpatient discharge planning.

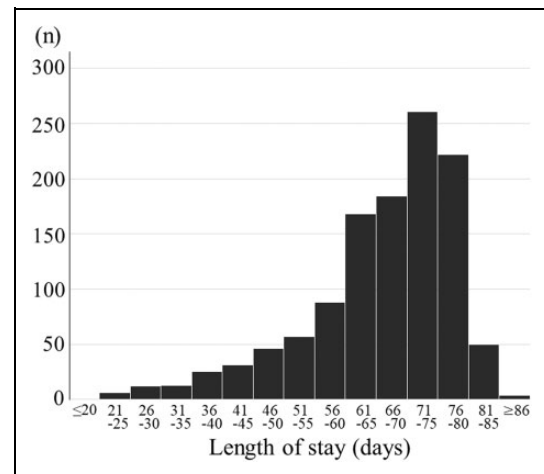


Figure 1. Age distribution (n = 1168).

Materials and Methods

Demographic Data

The study was performed as a retrospective analysis of patients who underwent PLIF/TLIF at 10 facilities from January 2012 to December 2014, using data from a prospectively maintained database. A total of 1168 patients were identified, including 602 males and 566 females. The main indications for the procedure were spondylolisthesis (n = 471), lumbar canal stenosis (n = 449), disc herniation (n = 162), adjacent segment degeneration (ASD; n = 39), and others (n = 47). Previous spinal surgery had been performed in 58 patients. Age ranged from 18 to 87 years, with a mean of 65.9 ± 12.5 years. The age distribution is shown in Figure 1 and the patient characteristics are listed in Table 1. The operations were PLIF (n = 675), TLIF (n = 443), MIS-PLIF (n = 22), and MIS-TLIF (n = 32). The mean operative time was 192.1 ± 90.8 minutes, mean estimated blood loss (EBL) was 481.3 ± 641.9 mL, and the mean range of fusion was 1.3 vertebra with instrumentation. Reoperation was performed in 20 cases. Age, gender, body mass index (BMI), ambulatory status, previous surgery, instrumented level, major medical comorbidities (hypertension, smoking status, diabetes mellitus, heart disease, pulmonary disease, renal disease, depression, anxiety, nonspinal malignancy), perioperative American Society of Anesthesiologists (ASA) grade, operative factors (procedures, number of levels fused, EBL, operative time, reoperation, use of colloids, use of a surgical drain, and LOS), and complications (dural tear, surgical site infection [SSI], pneumonia, deep vein thrombosis, epidural hematoma, and screw misplacement) were examined. The study was approved by our institutional review board (IRB No. 354-3).

Length of Stay

The primary clinical outcome was LOS, which was defined as the number of calendar days from the operation to hospital discharge. Patients were categorized as having a normal LOS

Table 1. Patient Demographics (n = 1168).

Characteristic	n (%)
Age (years)	
18-39	46 (3.9)
40-49	71 (6.1)
50-59	128 (10.9)
60-69	339 (29.0)
70-79	501 (42.9)
≥80	83 (7.1)
Sex	
Female	566 (48.5)
Body mass index (kg/m ²)	
<18	20 (1.7)
18-22	232 (19.9)
22-25	510 (43.7)
25-30	337 (28.9)
>30	69 (5.9)
Ambulation	
Independent	873 (74.7)
Need assistance	272 (23.3)
Wheelchair	23 (2.0)
American Society of Anesthesiologists grade	
I	521 (44.6)
II	587 (50.2)
III	55 (4.7)
IV	5 (0.4)
Comorbidities	
Hypertension	449 (38.3)
Smoker	227 (19.4)
Diabetes mellitus	165 (14.1)
Heart disease	130 (11.1)
Pulmonary disease	54 (4.6)
Renal comorbidities	26 (2.2)
Depression	26 (2.2)
Anxiety	31 (2.6)
Nonspinal malignancy	52 (4.4)
Main indications	
Spondylolisthesis	471 (40.3)
Lumbar spinal stenosis,	449 (38.4)
Disc herniation	162 (13.9)
Adjacent segment degeneration	39 (3.3)
Others	47 (4.0)
Previous spinal surgery	58 (5.0)

(<75th percentile LOS) or prolonged LOS (≥75th percentile LOS).¹⁸ For multivariate analysis, LOS was treated as a continuous variable and the magnitude of the effect of each predictor variable on LOS was determined.

Surgical Technique

Surgical procedures were performed using similar techniques at each hospital. All institutions have multiple spine surgeons, and the details of surgery were determined by spine surgeons who were certified by the Japanese Spine Surgery and Related Research (JSSR) society at each facility. The patient was initially positioned in a prone position. In PLIF, an open midline approach with bilateral muscle strip dissection was used to access the posterior column of the vertebral body. Once the

Table 2. Surgical Variables (n = 1168).

Variable	n (%)
Procedures	
Open PLIF	671 (57.4)
Open TLIF	443 (37.9)
MIS-PLIF	22 (1.9)
MIS-TLIF	32 (2.7)
Number of levels fused	
1	866 (74.1)
2	209 (17.9)
3	72 (6.2)
4	21 (1.8)
Instrumented level	
Above L5-S1	654 (56.0)
Including L5-S1	514 (44.0)
Complications	
Dural tear	50 (4.3)
Surgical site infection	27 (2.3)
Urinary tract infection	16 (1.4)
Pneumonia	11 (0.9)
Deep vein thrombosis	10 (0.8)
Epidural hematoma	9 (0.9)
Screw misplacement	3 (0.3)
Estimated blood loss (mL), mean ± SD	481.1 ± 641.6
Operative time (min), mean ± SD	192.0 ± 90.7
Reoperation	20 (1.7)
Use of colloids	97 (8.3)
Length of stay (days), mean ± SD	20.6 ± 9.8

spinous process and laminae at appropriate levels were identified, laminotomy was performed medial to the facet. Titanium pedicle screws and rods were used for fixation of degenerative instability. Disc and cartilaginous endplates were removed to prepare the graft bed, and local bone morcelized by bone milling with cages was implanted in the anterior and lateral regions of the interbody space. TLIF differed from PLIF in that the spinal canal was entered via unilateral laminectomy and inferior facetectomy, which facilitates bone graft placement. A single unilateral incision was made for bilateral anterior column support and exposure of the disc space while minimizing retraction of the dural sac and nerve root. In MIS, use of percutaneous pedicle screws combined with a tubular retractor system permits performance of minimally invasive PLIF. A surgical drain was used in all cases. Among the 10 facilities in our group, 2 use the MIS strategy.

Data Analysis

Differences between 2 groups were analyzed by Mann-Whitney *U* test or Student *t* test. Univariate and multiple logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for prolonged LOS, using preoperative and perioperative variables. Cutoff values for variables (with an explanation of the derivation of the cutoff in parentheses) were defined as follows. Age 70 years (based on the median age of 69.5 years), BMI 25 and 30 kg/m² (definitions of overweight and obese, respectively), ASA class ≥III, fused

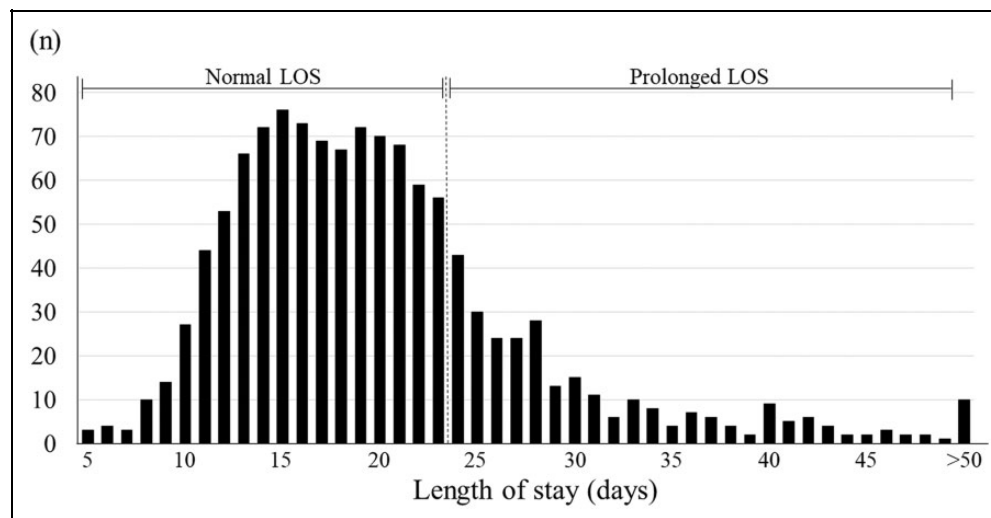


Figure 2. Length of stay (LOS) after posterior/transforaminal lumbar interbody fusion (PLIF/TLIF). Cases with prolonged LOS (≥ 75 th percentile) are shown to the right of the vertical dashed line.

levels 2 and 3, operative time 240 and 300 minutes (chosen for examination as times that were both longer than the average operation time of 192 minutes), and EBL 500 mL (based on the average EBL of 481 mL). A Pearson correlation coefficient was calculated for the correlation between LOS and age. All analyses were conducted using SPSS version 22 for Windows (IBM, Armonk, NY). $P < .05$ was considered to be significant in all analyses.

Results

The demographics, comorbidities, and disease background of the patients are shown in Table 1 and surgical variables are given in Table 2. The main comorbidities were hypertension ($n = 449$), smoker ($n = 227$), diabetes mellitus ($n = 165$), and heart disease ($n = 130$) (Table 1). Perioperative and postoperative complications were dural tear ($n = 50$), SSI ($n = 27$), urinary tract infection ($n = 16$), pneumonia ($n = 11$), deep vein thrombosis ($n = 10$), epidural hematoma ($n = 9$), and screw misplacement ($n = 3$) (Table 2). The average LOS was 20.8 ± 9.8 days (range 7-77 days) (Figure 2), and LOS was significantly correlated with age ($P < .05$) (Figure 3). Reoperation during hospitalization was performed in 20 cases, for SSI ($n = 12$), epidural hematoma ($n = 5$), and screw misplacement ($n = 3$).

The characteristics of patients with normal and prolonged LOS are shown in Table 3. Age ≥ 70 years ($P < .01$), ASA class $\geq III$ ($P < .05$), diabetes mellitus ($P < .01$), hypertension ($P < .01$), cardiac comorbidities ($P < .01$), open procedures ($P < .01$), fused levels ($P < .01$), operative time ($P < .01$), EBL ($P < .01$), dural tear ($P < .05$), SSI ($P < .01$), deep vein thrombosis ($P < .01$), epidural hematoma ($P < .01$), and pneumonia ($P < .01$) were significantly related to prolonged LOS (Table 3).

The results of univariate and multivariate analyses are shown in Tables 4. In multivariate logistic regression,

prolonged LOS was associated with preoperative variables of age ≥ 70 years (OR 1.87, 95% CI 1.38-2.54) and ASA class $\geq III$ (OR 1.52, 95% CI 1.04-2.25); surgical variables of open procedures (OR 5.84, 95% CI 1.74-19.63), fused levels ≥ 3 (OR 5.17, 95% CI 3.17-8.43), operative time ≥ 300 minutes (OR 1.88, 95% CI 1.15-3.07), and EBL ≥ 500 mL (OR 1.71, 95% CI 1.07-2.75) (Table 4).

Discussion

More efficient functional recovery from surgery and capacity improvement are required in hospitals in Japan. A prolonged LOS is likely to increase health care expenditures, and surgeons and providers are constantly seeking ways to improve cost-effectiveness while maintaining or improving outcomes in an era of rising health care costs.²⁵ Shortening the number of hospital days is required by medical system reform, and further expediting discharge will lead to a reduction in medical costs. Hospital LOS is important to patients and providers, and this study was thus designed to determine factors that affect LOS after PLIF/TLIF and the relative effects of each factor on LOS.

Multivariate analysis was performed on preoperative and intraoperative variables in 1168 patients to identify factors affecting LOS that can be used for preoperative informed consent to patient and postoperative management. Similar analyses have been used to identify factors affecting LOS after revision lumbar fusion²⁶ and one-level minimally invasive posterior lumbar interbody fusion and instrumentation.²⁷ These studies showed that age, number of fused levels, fluid balance, narcotic use, and preoperative hemoglobin, among other variables, affect LOS. However, to our knowledge, factors associated with prolonged LOS after PLIF/TLIF, including both open and MIS procedures, have not been determined.

Preoperative age and ASA class $\geq III$ were significant predictors of prolonged LOS in our cohort, but comorbidities such as diabetes mellitus, hypertension, and pulmonary disease were

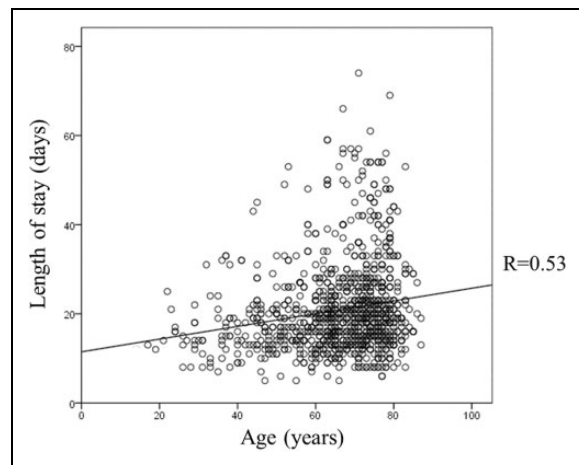


Figure 3. A significant positive correlation was observed between length of stay (LOS) and age ($P < .05$).

not significantly associated with LOS. Thus, the ASA class serves as a general risk factor, while specific comorbidities may already have been treated by the time of surgery. This shows the importance of ASA assessment of the general condition just before surgery. The ASA class is used by anesthesiologists to assess preoperative risk in patients undergoing surgery.²⁸ Our results show that an ASA class \geq III can be used to identify patients with a probable prolonged LOS after elective posterior lumbar fusion. The ASA class takes into account patient comorbidities, but it is of note that this class was independently associated with prolonged LOS.

Open surgical procedures, operative time \geq 300 minutes, EBL \geq 500 mL, and number of fused levels were also significantly associated with prolonged LOS. An increased operative time is generally associated with a more complex case, a greater risk of intraoperative complications, and increased EBL. Multilevel procedures may also be associated with increased operative time and EBL; however, all of these factors were found to be independent predictors with low collinearity in the final multivariate model.

The rate of use of MIS is increasing in Japan. Since the first description of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) in 2003,²⁹ MIS approaches to lumbar spine fusion have been widely adopted. Previous reports have shown shorter hospitalization in patients undergoing MIS procedures, with decreases in LOS ranging from 15.0% to 64.0%.³⁰⁻³⁴ Our results are consistent with these findings. We note that the percentage of procedures performed using MIS in this study is relatively low and lower than the national average, despite the study being performed at multiple centers. This is because most of our facilities still perform open surgery.

The aging of society in Japan has resulted in an increase in the age of patients, and 7.1% of the patients in our cohort were older than 80 years. We have previously reported that an elderly age is a risk factor for postoperative complications in spine surgery.¹²⁻¹⁴ In the current series, complications of SSI, deep vein thrombosis, epidural hematoma, and pneumonia had

Table 3. Characteristics of Patient With Normal and Prolonged LOS After Lumbar Posterior Fixation.

Variable	Normal LOS	Prolonged LOS	P
Total (n)	886	282	
Preoperative variables, %			
Age \geq 70 years	46.6	59.9	<.01
Female	47.6	50.7	NS
BMI $>$ 25 kg/m ²	34.3	35.8	NS
BMI $>$ 30 kg/m ²	5.6	6.7	NS
Ambulation: Independent	75.2	73.4	NS
ASA class \geq III	4.6	8.1	<.05
Previous surgery	4.9	5.0	NS
Comorbidities variables, %			
Smoker	19.6	18.4	NS
Diabetes mellitus	11.2	23.0	<.01
Hypertension	35.2	47.8	<.01
Cardiac comorbidities	9.7	15.6	<.01
Pulmonary comorbidities	4.3	5.3	NS
Renal comorbidities	2.2	2.1	NS
Depression	2.1	2.4	NS
Anxiety	2.4	3.5	NS
Nonspinal malignancy	3.7	6.4	NS
Surgical variables, %			
Open PLIF/TLIF	94.3	98.9	<.01
Fused levels \geq 2	24.7	41.1	<.01
Fused levels \geq 3	4.3	19.1	<.01
Operative time \geq 240 min	4.7	19.9	<.01
Operative time \geq 300 min	13.2	29.7	<.01
EBL \geq 500 mL	17.4	29.7	<.01
Instrumented level (above L5-S1)	56.8	53.5	NS
Complications variables, %			
Urinary tract infection	1.1	2.2	NS
Dural tear	3.6	6.3	<.05
Surgical site infection	0.7	7.4	<.01
Deep vein thrombosis	0.2	2.8	<.01
Epidural hematoma	0.3	2.1	<.01
Pneumonia	0.2	3.2	<.01
Screw misplacement	0.2	0.4	NS
LOS (days), mean \pm SD	16.5 \pm 4.3	38.2 \pm 20.9	<.01

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; EBL, estimated blood loss; LOS, length of stay; NS, nonsignificant; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion.

significant effects on LOS. These are all major life-threatening complications, and particular care is required regarding the surgical indication and procedure for very elderly patients to prevent such complications.

A prolonged LOS was associated with increased health care costs for admission in this cohort, as found in a previous study.³⁵ This emphasizes the value of predicting readmission risk as a cost-containment measure. Furthermore, the average LOS in our cohort was 20.8 days, which was longer than the average LOS after spinal surgery of 3.9 to 18.5 days found in several previous studies.^{26,27,36,37} In our series, many patients had a good wound state after bathing allowed confirmation of the wound condition, but most were not discharged to home until their walking level was satisfactory. That is, the time point

Table 4. Univariate and Multivariate Logistic Regression Analysis for Prolonged Length of Stay.

Variable	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Preoperative variables				
Age ≥ 70 years	2.58 (1.37-5.82)	<.01	1.87 (1.38-2.54)	<.01
ASA class \geq III	2.41 (1.42-5.24)	<.05	1.52 (1.04-2.25)	<.05
Diabetes mellitus	1.42 (1.24-2.78)	<.01		
Hypertension	1.84 (1.04-3.26)	<.01		
Cardiac comorbidities	1.32 (1.09-2.45)	<.01		
Perioperative variables				
Open PLIF/TLIF, %	8.82 (2.17-23.12)	<.01	5.84 (1.74-19.63)	<.01
Fused levels ≥ 2 , %	2.13 (1.37-3.97)	<.01		
Fused levels ≥ 3 , %	6.88 (2.41-12.43)	<.01	5.17 (3.17-8.43)	<.01
Operative time ≥ 240 min, %	1.75 (1.15-3.75)	<.01		
Operative time ≥ 300 min, %	2.74 (1.35-4.64)	<.01	1.88 (1.15-3.07)	<.05
Estimated blood loss ≥ 500 mL, %	2.36 (1.32-3.95)	<.01	1.71 (1.07-2.75)	<.05
Dural tear	1.89 (1.06-4.21)	<.05		

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio adjusted for age; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion.

at which gait stabilized was often used as a criterion for discharge. Furthermore, all patients in Japan have public insurance, and this system uses a fixed payment system that is evaluated based on the Diagnosis Procedure Combination. Thus, it is possible for a patient to reduce their personal hospital fees using public insurance, even in long-term hospitalization. These factors may explain the longer LOS in our study compared to that in other countries, and these features may be peculiar to Japan.

The study has several limitations. First, a number of factors were not captured in tracking of hospital LOS, including socioeconomic factors and availability of staff for discharge. For example, prolonged LOS might result from a patient being unable to obtain personal transportation home, despite being ready for discharge. Second, even without complications, poorly controlled pain is a major reason why patients tend to stay in hospital for longer than the expected time, but we did not collect data for pain. Third, we could not collect details for the amount of crystalloids administered, the time the patient spent in the operating room, and use of cell salvage. However, we investigated age, gender, BMI, ambulatory status, comorbidities, perioperative ASA grade, operative factors, and complications in 1168 cases of PLIF/TLIF, and this detailed data make this report of value for examining risk factors for prolonged LOS.

Conclusions

A multivariate analysis of a prospectively maintained database identified age ≥ 70 years, ASA class \geq III, open surgery, fused levels ≥ 3 , operative time ≥ 300 minutes, and EBL ≥ 500 mL as significant predictors of prolonged LOS in a large multicenter cohort that underwent PLIF/TLIF. These risk factors can be used for obtaining informed consent, surgical planning, and complication prevention in patients receiving spine surgery,

with the goal of reducing health care expenditures by decreasing the number of cases with prolonged LOS.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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