Original Article

Global Spine Journal
2019, Vol. 9(4) 403-408
© The Author(s) 2018
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/2192568218797090
journals.sagepub.com/home/gsj

Predictive Factors for Discharge Destination Following Posterior Lumbar Spinal Fusion: A Canadian Spine Outcome and Research Network (CSORN) Study

Mina W. Morcos, MD, MSc, FRCSC[1], Fan Jiang, MD, FRCSC[1], Greg McIntosh, MSc[2], Henry Ahn, MD, FRCSC[3], Nicolas Dea, MD, MSc, FRCSC[4], Edward Abraham, MD, FRCSC[5], Jerome Paquet, MD, FRCSC[6], Andrew Natara, MD, FRCSC[7], Michael Johnson, MD, FRCSC[8], Neil Manson, MD, FRCSC[9], Charles Fisher, MD, FRCSC[10], Raja Rampersaud, MD, FRCSC[3], Kenneth Thomas, MD, FRCSC[11], Hamilton Hall, MD, FRCSC[3], and Michael Weber, MD, PhD, FRCSC[1]

Abstract

Study Design: Ambispective cohort study.

Objective: Patients spend on average 3 to 7 days in hospital after lumbar fusion surgery. Patients who are unable to be discharged home may require a prolonged hospital stay while awaiting a bed at a rehabilitation facility, adding cost and imposing a considerable burden on the health care system. Our objective is to identify patient or procedure related predictors of discharge destination for patients undergoing posterior lumbar fusion.

Methods: Analysis of data from the Canadian Spine Outcomes and Research Network. Patients who underwent lumbar fusion for degenerative pathology between 2008 and 2015 were identified. Multivariable logistic regression analysis was used to identify independent predictors of the discharge destination.

Results: A total of 643 patients were identified from the database, 87.1% of the patients (N = 560) were discharged home while 12.9% (N = 83) required discharge to nonhome facilities. Using multivariate logistic regression analysis, the predictors for discharge to a facility rather than home were identified including: increasing age (odds ratio [OR] 1.045, 95% confidence interval [CI]

[1] McGill University, Montreal, Quebec, Canada
[2] Canadian Spine Outcomes and Research Network, Markdale, Ontario, Canada
[3] University of Toronto, Toronto, Ontario, Canada
[4] University of Sherbrooke, Sherbrooke, Quebec, Canada
[5] Dalhousie University, Halifax, Nova Scotia, Canada
[6] Laval University, Quebec City, Quebec, Canada
[7] University of Alberta, Edmonton, Alberta, Canada
[8] University of Winnipeg, Winnipeg, Manitoba, Canada
[9] Canada East Spine, Saint John, New Brunswick, Canada
[10] Vancouver General Hospital/University of British Columbia, Vancouver, British Columbia, Canada
[11] University of Calgary, Calgary, Alberta, Canada

Corresponding Author:
Mina W. Morcos, Division of Orthopaedic Surgery, McGill University, 651 dela Montagne # 307, Montreal, Quebec, H3C 0G2, Canada.
Email: mina.wahbamorcos@mail.mcgill.ca

1.017-1.075, $P < .002$), increasing body mass index (BMI) (OR 1.069, 95% CI 1.021-1.118, $P < .004$), increasing disability score (OR 1.025, 95% CI 1.004-1.046, $P < .02$), living alone preoperatively (OR 1.916, 95% CI 1.004-3.654, $P < .05$), increasing operating time (OR 1.005, 95% CI 1.003-1.008, $P < .0001$), need for blood transfusion (OR 3.32, 95% CI 1.687-6.528, $P < .001$), and multilevel fusion surgery (OR 1.142, 95% CI 1.007-1.297, $P < .04$).

Conclusions: Older age, high BMI, living alone, high disability score, extended surgical time, blood transfusion, and multilevel fusion are significant factors that increase the odds of being discharged to facilities other than home.

Level of Evidence: Level 3.

Keywords
lumbar, spine, fusion, CSORN, predictors, discharge, rehabilitation, home, orthopedics, spine surgery.

Introduction

Posterior lumbar fusion (PLF) is a common spinal procedure. Patients undergoing spinal fusion usually spend between 3 and 7 days in hospital at an average cost of approximately US$1000 per day.[1] Inpatient hospital charges correlate to length of stay (LOS),[2,3] helping make PLF one of the most expensive surgeries used to treat spinal pathology and a significant burden to the health care system.[4]

Prolonged length of stay has been associated with increased patient complications, increased demand on the physician's time and decreased operating room availability due to filled postoperative beds.[5] Many studies have identified factors associated with increased LOS following PLF with an aim to improve patient counselling and postoperative planning. Basques et al[6] showed that older patients, higher body mass index (BMI), American Society of Anesthesiologists (ASA) class, and operative times were predictive factors for increased LOS. One factor not accounted for in most studies is the time spent waiting for a rehabilitation or nursing home bed. While most of the studies addressing factors associated with discharge to rehabilitation centers looked at arthroplasty population, recently, Aldebeyan et al,[7] using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, showed that age, female sex, comorbidities, LOS, operative time, and multilevel surgery were associated with discharging patients to a facility other than home after PLF.

Using data from the Canadian Spine Outcomes and Research Network (CSORN), the same issue can be examined for the first time in a single payer universal health care system. The CSORN is a national network of health care centers geographically distributed across Canada. By examining specific data and outcomes from a public funded health care system, information can be garnered to not only improve aspects of Canada's health care system, but those of countries using different health care models. The aim of this study was to determine the preoperative and intraoperative predictive factors associated with discharging patients to a facility rather than home after PLF using the CSORN database.

Materials and Methods

Design

This was an ambispective analysis of data from the CSORN. This is a national prospective registry of consecutive patients with back pain.

CSORN is an active group of more than 50 neurosurgical and orthopedic spine surgeons from 18 tertiary care academic and nonacademic hospitals across Canada that prospectively collects data on pre- and postsurgical measures and outcomes of different spinal pathologies and surgical techniques used to treat patients with spinal conditions. The database serves as a national registry created to answer research questions and to facilitate the implementation of best practices. A national database research coordinator audits data quality and performance and sends reports to each contributing hospital site coordinator on a quarterly basis. Reports track data completion and follow up rates to facilitate internal data validation at each site. A national privacy and security framework was created for CSORN that includes a governance structure, standard operating procedures, training processes, physical and technical security, and privacy impact assessments. All participating sites obtained Research Ethics Board (REB) approval prior to any data collection. Decisions regarding data collection, storage and analysis are independent of any particular company or commercial interest. Data collection is done by the treating surgeons who recorded operative and post-operative variables while research coordinators, unaware of the study hypothesis, collected patient-reported outcome measures (PROMs) at baseline, 3 months, 12 months, and 24 months postoperatively. Collection was in person, via post, or by employing an online patient portal. Baseline PROMs were repeated for those waiting longer than 6 weeks prior to surgery. PROMs included a modified Oswestry Score, the Neck Disability Index, visual analog scale, the EuroQol EQ5D, the SF-12 Physical and Mental Component Summary.

Data Collection

This study included all adult patients identified in CSORN who prior to admission were living at home and underwent elective PLF, including posterolateral instrumented fusion, transforaminal lumbar interbody fusion, and posterior lumbar interbody fusion between October 2008 and September 2015. Both open posterior approaches and minimally invasive surgery were included. Exclusion criteria included emergency cases, revision surgery, tumor, infection, deformity and trauma.

Identified preoperative patient characteristics included age, gender, body mass index (BMI), comorbidities, ASA, working status, ODI score, compensation and living arrangements. Operative and post-operative data included type of procedure, levels of fusion, operating time, blood loss, need for transfusion, length of hospital stay and postoperative adverse events. Only data from the index admission was used.

Discharge Destination

Discharge destinations in the CSORN database are categorized as (1) home, no supervision; (2) home, supervised (health care professional); (3) in-patient rehabilitation: (4) short-term convalescent care; (5) nursing home; and (6) hospital to hospital transfer. For the purpose of this study, the discharge destination was dichotomized into home versus any other facility.

Statistical Analysis

The independent variables used for prognostic modeling were measured on either categorical or continuous scales. Using a backward stepwise, conditional, statistical selection procedure, multivariable logistic regression was used to model the relationship between the prognostic variables of interest and the binary outcome, discharge destination (home vs any other).

To obtain unbiased internal assessment of accuracy[8] data-splitting technique was used to develop and test the multivariable models, whereby a 67% random sample of the full dataset was used for model development (Build sample), and the entire dataset was used for model validation (Test sample). In model development, the significance level was set at $P = .10$.[9] All analyses were conducted using IBM SPSS Statistics version 24.

Results

A total of 695 patients with elective PLF were identified in the CSORN registry, 52 patients were excluded due to missing information. Of the 643 patients included in the study, 560 (87.1%) were discharged home versus 83 (12.9%) who were discharged to a facility rather than sent home. Out of the 83 patients going to a facility 3.6% were discharged to another hospital, 8.7% were discharged to rehabilitation center, 0.3% were discharged to nursing home, 0.2% where discharged to short term convalescent care and 0.5% were discharged to other facilities. Table 1 presents the patient demographics and clinical features and the relevant operative information. The cohort was 44.9% male and 55.1% female. Those who were discharged to a facility rather than sent home were significantly older (65.3 vs 59.4 years, $P < .001$) with a high BMI (30.4 vs 28.5 kg/m^2, $P < .008$). When comparing patients' comorbidities between the 2 groups, patients who were discharged to a

Table 1. Demographics, Clinical Features, and Operative Information for the Patients Who Underwent Lumbar Fusion Surgery.

	Rehabilitation (n = 83)	Home (n = 560)	*P*
Patient demographics			
Age (y), mean ± SD	65.3 ± 14.1	59.4 ± 13.1	<.001
Gender, n (%)			<.313
Male	34 (41)	255 (46)	
Female	49 (59)	305 (54)	
Total comorbidities, mean ± SD	2.79 ± 2.04	3.22 ± 2.01	<.001
Working, n (%)			<.01
Not working	13 (57)	115 (43)	
Working	10 (43)	152 (57)	
BMI (kg/m^2), mean ± SD	30.4 ± 5.7	28.5 ± 5.8	<.008
Baseline disability score, mean ± SD	57.4 ± 14.2	48.5 ± 15.4	<.001
Exercise, n (%)			<.097
No	44 (57)	245 (47)	
Yes	33 (43)	276 (53)	
Compensation, n (%)			<.792
No	46 (78)	371 (79)	
Yes	13 (22)	96 (21)	
ASA class, n (%)			<.001
1	2 (2)	65 (12)	
2	36 (44)	298 (55)	
3	43 (53)	174 (32)	
4	1 (1)	4 (1)	
Living arrangements, n (%)			<.089
Alone	21 (28)	100 (19)	
Not alone	55 (72)	420 (81)	
Operative characteristics			
Transfusion, n (%)			<.001
No	35 (42)	476 (85)	
Yes	48 (58)	83 (15)	
Adverse events (<12 wk), n (%)			<.307
No	78 (94)	507 (91)	
Yes	5 (6)	53 (9)	
Adverse events (>12 wk), n (%)			<.178
No	83 (100)	548 (98)	
Yes	0 (0)	12 (2)	
LOS (d), n (%)			<.001
0-3	7 (9)	187 (34)	
4+	75 (91)	364 (66)	
Levels of fusion, n (%)			<.001
1	12 (15)	286 (53)	
2	11 (13)	109 (20)	
≥3	59 (72)	144 (27)	
Intraoperative blood loss (mL), mean ± SD	1021.1 ± 710.6	528.1 ± 464.6	<.001
Operative time (min), mean ± SD	303.5 ± 121.8	203.9 ± 93.5	<.001

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; LOS, length of stay.

Table 2. Multivariable Logistic Regression Analysis: Significant Predictive Factors for Discharging to a Facility Rather Than Going Home After Lumbar Fusion.

Predictive Factors	OR	95% CI	*P*
Age (years)	1.045	1.017-1.075	<.002
BMI (kg/m^2)	1.069	1.021-1.118	<.004
Living alone	1.916	1.004-3.654	<.05
Disability score (%)	1.025	1.004-1.046	<.02
Levels of fusion >1	1.142	1.007-1.297	<.04
Transfusion (mL)	3.318	1.687-6.528	<.001
Operating time (min)	1.005	1.003-1.008	<.0001

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

facility had higher disability scores (57.4 vs 48.5, $P < .001$) and higher ASA classifications ($P < .001$). Patients discharged home were more likely to be living with someone ($P < .008$).

Intraoperative characteristics were different between groups. Patients discharged to a facility were more likely to have received a blood transfusion ($P < .001$), to have had a longer operative time (303.5 $\pm$ 121.8 minutes, $P < .001$), higher intraoperative blood loss (1021.1 $\pm$ 710.6 mL, $P < .001$), longer hospital length of stay ($P < .001$), and a lumbar fusion of more than 3 levels (72% vs 27%, $P < .001$).

Multivariable Analysis

Using the build sample, multivariable logistic regression analysis of multiple potential factors revealed seven significant predictive factors for discharging patients to a facility rather than sending them home after posterior lumbar fusion (Table 2).

For each 10-year increase in age, the odds of discharging to a facility increased by 43%. For each one-unit increase in BMI, the odds of discharging to a facility increased by 6%. Those who live alone had 1.9 times the odds of discharging to a facility rather than returning home. For each 10 points increase in disability score, the odds of discharging to a facility increased by 24%. Reviewing operative factors, for each 60-minute increase in operating room time, the odds of discharging to a facility increased by 30%. Patients who required blood transfusion had 3.3 times the odds of going to a facility. Finally, the odds of not being discharged home increased with multilevel fusion; 14% for each level fused beyond the initial level.

Discussion

Patients discharge destination after posterior lumbar fusion is a significant concern for patients and their loved ones. Alteration in the discharge care path is also a significant burden to health care providers, institutions and the health care system itself. This study determines the preoperative and intraoperative predictive factors associated with patients being discharged to a facility rather than being allowed to return home. Using the CSORN registry, we were able to examine a representative sample of the Canadian population and determined that 1 in 8 patients (12.9%) undergoing PLF was discharged to a facility.

Multivariate logistic analysis revealed seven independent predictive factors affecting the discharge destination. Table 2 displays the 4 preoperative factors (older age, high BMI, living alone, and high disability score) and three operative factors (prolonged operative time, the need for blood transfusion and multilevel fusion surgery), which had an impact.

In this study, we were able to identify living status and disability score to be a predictor factor for patients being discharged to another destination than home, which to our knowledge have not been previously identified. Patients living alone had 1.9 times the odds to be discharged to a facility while those with disability scores more than 40 were unlikely to be sent directly home. Munin et al[10] looked at the predictive factors for inpatient rehabilitation programs versus discharging home after total hip and knee arthroplasty surgeries and found that living alone was significant. Aldebeyan et al[7] showed that patients with decreased functional status were at higher risk of being discharged to a facility other than home. Prompt identification of these preoperative patient factors would obviously be important.

It comes as no surprise that age was an independent factor for patients being unable to go home after spinal fusion. Compared with young patients, the older patients typically require a longer time to recuperate and heal and therefore more likely to necessitate longer rehabilitation stay.[11] Age has been shown in multiple studies to be a predictive factor for an increase in length of stay following spine surgery.[12,13] Zhen et al[13] suggested that age was the only significant predictor of LOS. Additionally, age has been shown to be a significant determining factor for postsurgical rehabilitation after arthroplasty procedures.[10]

Another preoperative predictive factor was high BMI. Multiple previous studies have shown that obesity is associated with numerous complications and an increase in length of stay following fusion surgery.[6,14-16] Obesity can complicate postoperative recovery and delay rehabilitation. In this study, we found that high BMI was associated with an increase in the number of patients who could not be discharged directly home. This corresponds with previous studies showing an association between obesity and increased LOS and the need for rehabilitation facilities. Basques et al[6] identified BMI >40 kg/m^2 as being associated with extended LOS. Also, Aldebeyan et al,[7] using the NSQIP database, showed that BMI $\geq$30 kg/m^2 was an independent predictive factor for determining which patients were discharged to facilities rather than returning home.

Operative factors that were associated with discharging to a facility included prolonged operative time and the need for blood transfusion; these findings are in accordance with previous studies.[7,13,17] For every additional 60 minutes of surgery, the odds of patients not being discharged home increased by 30% and patients that required blood transfusion had 3.3 times the odd of not going home. Prolonged operative time is usually associated with more complex cases which in turn can lead to higher likelihood of intraoperative complication and increased blood loss requiring blood transfusion. It is not surprising therefore that Morcos et al[18] showed that patients who required blood transfusion following posterior lumbar fusion were more likely to have an extended hospital LOS (>4 days).

Finally, multilevel fusion is a predictor of discharge to a facility. For each additional level the odds for not going directly home increased by 14%. In multiple studies, multilevel fusion has been associated with increased operative time, blood loss, need for blood transfusion, and prolonged hospital LOS.[13,18,19] Basques et al[6] showed that although multilevel fusion was associated with increased operative time and intraoperative blood transfusion, it was also an independent predictive factor for prolonged LOS.

In this study, we managed to identify multiple predictor factors, pre- and perioperatively, that should guide surgeons in making the decision to whether their patients will be able to go home or will need to be transferred to another facility postoperatively. Furthermore, these factors can help the surgeon and the patient to have proper expectations and therefore increase patient cooperation and satisfaction postoperatively. In addition, early discharge planning can expedite the application for rehabilitation or other facilities, therefore decreasing the LOS and ultimately reducing the cost associated with inpatient hospital charges.

One limitation of this study was that some relevant data was not included in the CSORN registry including reasons for an extended LOS, and whether the LOS was associated with bed availability or was more procedure dependent. Also, since this is a multicenter database, discharge protocols for individual hospital were not available. Any specific inconsistencies in policy for patient discharge and placement and their impact on the final decisions could not be identified. Despite these limitations, the CSORN registry provides the largest series of patients available in Canada and enabled a robust determination of predictive factors associated with the selection of discharge location following PLF.

Conclusion

Using the CSORN database, we identified that 12.9% of patients undergoing elective posterior lumbar fusion were not able to go directly home after surgery. We identified 7 significant perioperative predictors of discharge destination. These factors were increased age, high BMI, living alone, high disability score, extended surgical time, blood transfusion, and multilevel fusion surgery. Recognizing these factors can be beneficial in preoperative planning and patient counseling to achieve realistic postsurgical expectations. Recognizing these factors will assist the provision of necessary services and expedite admission into appropriate rehabilitation facilities, reducing the hospital LOS and decreasing hospital and health care costs.

Acknowledgments

The authors thank the following people for their dedicated and diligent data collection efforts: Dr Guy Hogan, Dr Vic Sahajpal, Georgina, Eastern Health, St John's, Newfoundland and Labrador; Dr Edward Abraham, Eden Daly, Canada East Spine Center, Saint John Regional Hospital—orthopaedics, St John, New Brunswick; Dr George Kolyvas, Derek Gaudet, Canada East Spine Center, Saint John Regional Hospital—neurosurgery, St John, New Brunswick; Dr David Alexander, Dr William Oxner, Dr Andrew Glennie, QEII Health Sciences Centre—orthopaedics, Halifax, Nova Scotia; Dr Sean Christie, Anita McPhee, QEII Health Sciences Centre—neurosurgery, Halifax, Nova Scotia; Dr Jean-Francois Roy, Dr Patrice Montminy, Sonya Breton, CHU de Québec—Hôpital St-François d'Assise, Quebec City, Quebec; Dr David Mercier, Dr Alexandre Denault, Sylvine Cottin, Myriam Martin, CHA Hôpital Enfant-Jésus, Quebec City, Quebec; Dr Jeff Golan, Sir Mortimer B. Davis General Hospital, Montreal, Quebec; Dr Peter Jarzem, Francis Colagiacomo, Montreal General Hospital MUHC, Montreal, Quebec; Dr Philippe Phan, Dr Stephen Kingwell, Darren Roffey, Ottawa Hospital, Ottawa, Ontario; Antonietta Fazio, University Health Network, Toronto Western Hospital, Toronto, Ontario; Dr Albert Yee, Dr Michael Ford, Aimee Theriault, Monica Kunz, Sunnybrook Health Sciences Centre, Toronto, Ontario; Dr Howard Ginsberg, Kayee Tung, St Michael's Hospital, Toronto, Ontario Dr Parham Rasoulinejad, Lori Nutt, Jennifer Fleming-Urquhart, London Health Sciences Centre—Victoria Hospital, London, Ontario; Dr Michael Goytan, Kim Bertone, Winnipeg Health Sciences Centre, Winnipeg, Manitoba; Dr Richard Fox, Mathew Herman, University of Alberta Hospital Site, Edmonton, Alberta; Dr Brad Jacobs, Dr Jacques Bouchard, Dr Ganesh Swamy, Dr Peter Lewkonia, Yvette Andreas, Ish Bains, University of Calgary, Foothills Medical Centre, Calgary, Alberta; Dr Marcel Dvorak, Dr Scott Paquette, Dr John Street, Dr Brian Kwon, Dr Tamir Ailon, Amanda Bigiolli, Leilani Reichl, University of British Columbia, Vancouver General Hospital, Vancouver, British Columbia; Daria McLaney, Glenys MacIsaac, Stuart Lawrence, Rick Hansen Institute, Vancouver, British Columbia; Tracy Wong, Vancouver Island Health Authority, Victoria, British Columbia.

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.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Yeom JS, Buchowski JM, Shen HX, Liu G, Bunmaprasert T, Riew KD. Effect of fibrin sealant on drain output and duration of hospitalization after multilevel anterior cervical fusion: a retrospective matched pair analysis. *Spine (Phila Pa 1976)*. 2008;33: E543-E547.
2. Pelton MA, Phillips FM, Singh K. A comparison of perioperative costs and outcomes in patients with and without workers' compensation claims treated with minimally invasive or open transforaminal lumbar interbody fusion. *Spine (Phila Pa 1976)*. 2012; 37:1914-1919.
3. Peng CW, Yue WM, Poh SY, Yeo W, Tan SB. Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar interbody fusion. *Spine (Phila Pa 1976)*. 2009; 34:1385-1389.

4. Starkweather A. Posterior lumbar interbody fusion: an old concept with new techniques. *J Neurosci Nurs*. 2006;38:13-20,30.
5. Gruskay JA, Fu M, Bohl DD, Webb ML, Grauer JN. Factors affecting length of stay after elective posterior lumbar spine surgery: a multivariate analysis. *Spine J*. 2015;15:1188-1195.
6. Basques BA, Fu MC, Buerba RA, Bohl DD, Golinvaux NS, Grauer JN. Using the ACS-NSQIP to identify factors affecting hospital length of stay after elective posterior lumbar fusion. *Spine (Phila Pa 1976)*. 2014;39:497-502.
7. Aldebeyan S, Aoude A, Fortin M, et al. Predictors of discharge destination after lumbar spine fusion surgery. *Spine (Phila Pa 1976)*. 2016;41:1535-1541.
8. Harrell FE Jr, Lee KL, Mark DB. Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. *Stat Med*. 1996; 15:361-387.
9. Collett D. *Modelling Survival Data in Medical Research*. London, England: Chapman & Hall; 1994.
10. Munin MC, Kwoh CK, Glynn N, Crossett L, Rubash HE. Predicting discharge outcome after elective hip and knee arthroplasty. *Am J Phys Med Rehabil*. 1995;74:294-301.
11. Gosain A, DiPietro LA. Aging and wound healing. *World J Surg*. 2004;28:321-326.
12. Nie H, Hao J, Peng C, Ou Y, Quan Z, An H. Clinical outcomes of discectomy in octogenarian patients with lumbar disc herniation. *J Spinal Disord Tech*. 2013;26:74-78.
13. Zheng F, Cammisa FP Jr, Sandhu HS, Girardi FP, Khan SN. Factors predicting hospital stay, operative time, blood loss, and transfusion in patients undergoing revision posterior lumbar spine decompression, fusion, and segmental instrumentation. *Spine (Phila Pa 1976)*. 2002;27:818-824.
14. Memtsoudis SG, Kirksey M, Ma Y, et al. Metabolic syndrome and lumbar spine fusion surgery: epidemiology and perioperative outcomes. *Spine (Phila Pa 1976)*. 2012;37:989-995.
15. Kalanithi PA, Arrigo R, Boakye M. Morbid obesity increases cost and complication rates in spinal arthrodesis. *Spine (Phila Pa 1976)*. 2012;37:982-988.
16. Walid MS, Zaytseva NV. The impact of chronic obstructive pulmonary disease and obesity on length of stay and cost of spine surgery. *Indian J Orthop*. 2010;44:424-427.
17. Siemionow K, Pelton MA, Hoskins JA, Singh K. Predictive factors of hospital stay in patients undergoing minimally invasive transforaminal lumbar interbody fusion and instrumentation. *Spine (Phila Pa 1976)*. 2012;37:2046-2054.
18. Morcos MW, Jiang F, McIntosh G, et al. Predictors of blood transfusion in posterior lumbar spinal fusion: a Canadian Spine Outcome and Research Network (CSORN) study. *Spine (Phila Pa 1976)*. 2018;43: E35-E39.
19. Basques BA, Anandasivam NS, Webb ML, et al. Risk factors for blood transfusion with primary posterior lumbar fusion. *Spine (Phila Pa 1976)*. 2015;40:1792-1797.