Global Spine Journal
2023, Vol. 13(2) 563–574
© The Author(s) 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/21925682221116823
journals.sagepub.com/home/gsj

Risk Factors for 30-day Unplanned Readmission following Surgery for Lumbar Degenerative Diseases: A Systematic Review

Liang-Yi Chen, MD[1,†], Yu Chang, MD[1,†], Chia-En Wong, MD[1], Kuan-Yu Chi, MD[2], Jung-Shun Lee, MD, MSc[3,4], Chi-Chen Huang, MD[1], and Po-Hsuan Lee, MD[1]

Abstract

Study design: Systematic review.

Objectives: Surgical procedures for lumbar degenerative diseases (LDD), which have emerged in the 21-century, are commonly practiced worldwide. Regarding financial burdens and health costs, readmissions within 30days following surgery are inconvenient. We performed a systematic review to integrate real-world evidence and report the current risk factors associated with 30-day readmission following surgery for LDD.

Methods: The Cochrane Library, Embase, and Medline electronic databases were searched from inception to April 2022 to identify relevant studies reporting risk factors for 30-day readmission following surgery for LDD.

Results: Thirty-six studies were included in the review. Potential risk factors were identified in the included studies that reported multivariate analysis results, including age, race, obesity, higher American Society of Anesthesiologists score, anemia, bleeding disorder, chronic pulmonary disease, heart failure, dependent status, depression, diabetes, frailty, malnutrition, chronic steroid use, surgeries with anterior approach, multilevel spinal surgeries, perioperative transfusion, presence of postoperative complications, prolonged operative time, and prolonged length of stay.

Conclusions: There are several potential perioperative risk factors associated with unplanned readmission following surgery for LDD. Preoperatively identifying patients that are at increased risk of readmission is critical for achieving the best possible outcomes.

Keywords

lumbar degenerative diseases, readmission, risk factors, spine surgery

Introduction

With the increase in average life expectancy, lumbar degenerative diseases (LDD), including spondylolisthesis, disc degeneration, and spinal stenosis, are becoming increasingly common worldwide.[1] LDD often induce lower back pain, lower extremity numbness or pain, claudication, and disability,[1] which results in negative effects on the patient's

[1] Section of Neurosurgery, Department of Surgery, College of Medicine, National Cheng Kung University, National Cheng Kung University Hospital, Tainan, Taiwan
[2] Department of Education, Center for Evidence-Based Medicine, Taipei Medical University Hospital, Taipei, Taiwan
[3] Institute of Basic Medical Sciences, College of Medicine, National Cheng Kung University, Tainan, Taiwan
[4] Department of Cell Biology and Anatomy, College of Medicine, National Cheng Kung University, Tainan, Taiwan

[†]These authors have contributed equally to this work and share the first authorship.

Corresponding Authors:
Po-Hsuan Lee, Attending Doctor, Section of Neurosurgery, Department of Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, No. 138, Shengli Rd, North District, Tainan 704, Taiwan.
Email: ftl053@gmail.com

Chi-Chen Huang, Attending Doctor, Section of Neurosurgery, Department of Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University Hospital, Tainan, Taiwan.
Email: charles042085@hotmail.com

quality of life. Surgical treatment is indicated for patients in whom medical therapy fails. With advances in patient care and medical technologies, an increasing number of patients are willing to undergo surgery. Therefore, surgical procedures for LDD, such as decompression, discectomy, fusion and implantation of prostheses, have emerged in the 21st century.[2] Spine surgery and related care expenditures significantly contribute to healthcare economics.[3] Regarding financial burdens and health costs, readmissions within 30 days following surgery (30-day readmission) are troublesome.[4,5]

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP)[6] has registered 30-day readmissions following spine surgery in the database since 2011.[7] The incidence of 30-day readmissions following spine surgery for LDD is approximately 5-10%, varying according to the procedure.[8,9] Although several studies aimed to identify predictors of 30-day readmissions from either nationwide or institutional databases, the reported risk factors or predictors were not consistent in the literature.

From the literature review, only 1 meta-analysis in 2014,[10] summarized the predictors of 30-day readmission following not only surgeries for LDD but all spinal surgeries. Therefore, a great diversity of spinal pathologies, including tumors, deformities, trauma, infection, and degeneration were included at the surgical level, encompassing the cervical, thoracic, and lumbar spine. In recent years, there has been an increase in publications focusing on readmission following surgeries for LDD. Therefore, we aimed to perform a systematic review to integrate real-world evidence and update the risk factors associated with 30-day readmission following surgery for LDD.

Methods

We conducted the present systematic review based on the Cochrane Handbook for Systematic Reviews and Interventions[11] and reported the results following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and Meta-analysis Of Observational Studies in Epidemiology guidelines (eMethods 1 and 2 in the supplementary information). This review was registered on the PROSPERO online platform (ID: CRD42022312510). Electronic databases of the Cochrane library, Embase and Medline were searched, from the inception of the database until April 2022 encompassing all languages. Two investigators (LYC and YC) independently conducted the search to identify relevant studies to be included, and any discrepancy was addressed by reaching a consensus or by consulting senior reviewers (PHL, CCH and JSL). The search details are presented in eMethod 3 in the supplementary information.

Eligibility Criteria

The articles meeting the following criteria were included:

(1) Prospective/retrospective cohort or case-control studies were included; in contrast, case reports, editorials, letters to the editor, review articles, and conference abstracts were excluded; (2) studies reporting at least 1 risk factor for 30-day readmission following spine surgeries were included; (3) studies of spine surgeries with non-degenerative conditions were excluded (eg, traumatic injuries, infections, deformities, or tumors); (4) studies with less than 20 readmitted patients were excluded; and (5) studies of robotic surgeries and endoscopic spine surgeries were excluded because of the apparent variation compared to conventional surgical procedures.

Data Extraction

Two investigators independently extracted relevant information from the tables or results of eligible articles. Extracted data included the first author's name, publication year, country where the study was conducted, data source, inclusion criteria, exclusion criteria, follow-up time, number of participants, and significant risk factors for readmission with multivariable adjustment.

Quality Assessment

Two investigators independently completed a critical appraisal of the included literature using the Quality In Prognosis Studies (QUIPS) tool.[12] The domains included patient selection, study attrition, measurement of prognostic factors, outcome measurement, study confounding, statistical analysis, and reporting, which were rated as having a low, moderate, or high risk of bias. Any item on which assessors did not reach consensus was addressed through discussion with a third investigator (JSL).

Results

Study Selection

Our search strategy identified 6482 references from the Cochrane Library, Embase, and Medline electronic databases. After screening the titles and abstracts, we excluded duplicates (n = 676) and irrelevant references (n = 5714). The remaining 92 studies were retrieved for full-text review, 36[7-9,13-45] of which were included in the review. (Figure 1).

Study Characteristics and Risk Factors

A total of 36 studies[7-9,13-45] were included (Table 1). Of these, 26[7,13-18,20-22,24,25,27,28,33-40,42-45] were retrospective cohort studies, 1[23] was a prospective cohort study and 9[8,9,19,26,29-32,41] were case-control studies. Among them, 20[7,9,15-17,23,25,26,29,32-36,38-40,42,44,45] included patients from the NSQIP database, 2 from State Inpatient Databases (SID)[13,28], 3 from Nationwide Readmissions Database (NRD)[8,18,41], 4 from the Medicare

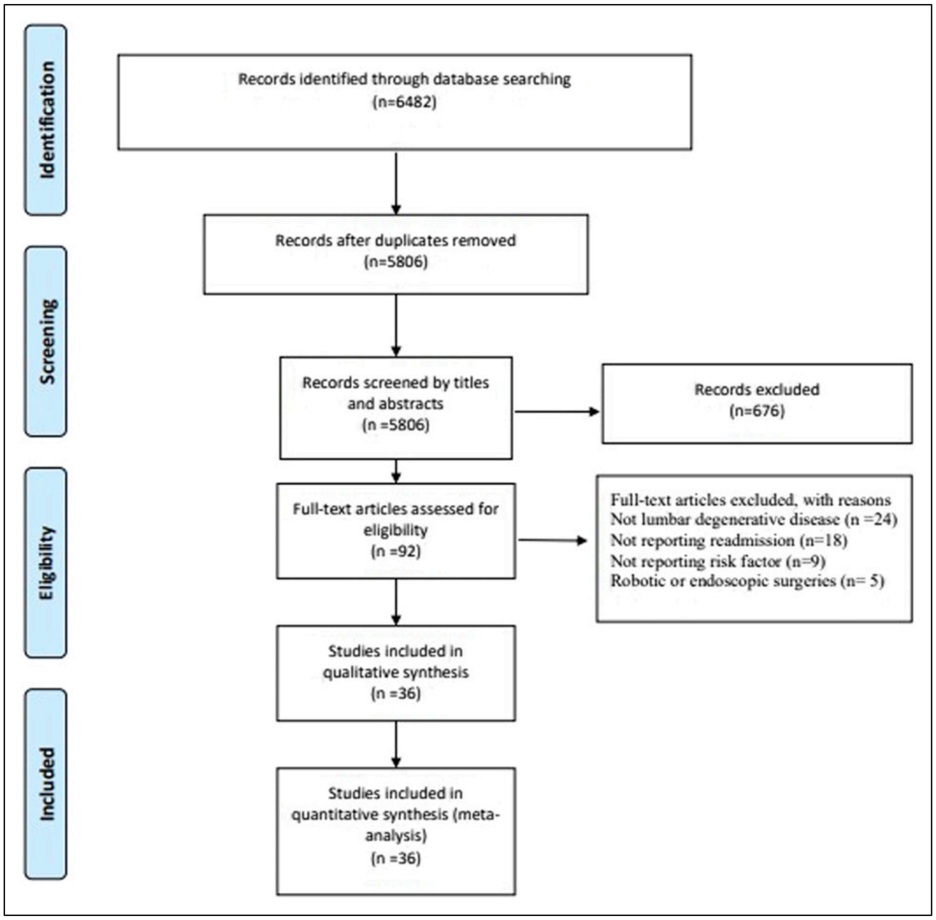

Figure 1. PRISMA diagram. We initially extracted 6482 potential references. Eventually, 36 studies fulfilled the eligibility criteria, and were included.

database[20,24,37,43], 2 from the Quality Outcomes Database (QOD)[21,22], and 3 from institutional database[14,19,31]. In addition, 1 study[30] enrolled patients from both the NSQIP and NRD and another 1[27] enrolled patients from the QOD, DaneSpine database and Japan Multicenter Spine Database (JAMSD).

Quality Assessment of the Included Studies

The quality assessment of the inclusion studies using QUISP is summarized in Supplemental eTable 1.

A total of 23 studies[7-9,14,15,19,20,23,26,28-33,35,38-43,45] were defined as having a moderate risk of bias and 13 [13,16-18,21,22,24,25,27,34,36,37,44] were deemed to have a high risk of bias.

Risk Factors for 30-day Readmission

The risk factors with multivariate analysis reported in more than 2 studies are summarized in Supplemental eTable 1 and 2 in the supplementary information.

Patient Risk Factors (eTable 1)

Fifteen studies[7,8,15,19,20,25,26,28-31,35,40,42,43] reported the association of age and readmission with multivariate adjusted odds ratio, with significant correlation observed in 6 studies[7,19,20,25,26,43] using linear regression and 6[8,15,28,35,40,42] using cut-off value of age.

Five studies investigated the risk of readmission in different races,[13,20,25,28,43] with Black patients exhibiting a significantly higher risk. The impact of obesity was analyzed in 10[7,8,18,25,28,30,31,39-41] studies, 5[8,18,28,30,39,41] of which reported obesity as a significant risk factor, 2[18,40] reported that body mass index (BMI) > 30 was associated with a higher risk of readmission and 1[30] found similar correlation using linear regression of BMI.

Eleven studies[7-9,20,25,28,31,39,40,42,43] compared the incidence of readmission between men and women with only 5 studies[20,28,39,40,42] reporting a significant difference (4 of the studies reported a higher risk for females[28,39,40,42] and 1 for males[20]). There was no difference in the risk of readmission between inpatient and outpatient surgery.[16,30] The impact of the American Society of Antitheology (ASA) score was

Table 1. Characteristics of Included Studies.

Study	Study Design	Database	Inclusion Period	Inclusion Criteria	Exclusion Criteria	Sample Size	Significant Risk Factors
Badhiwala 2019[15]	RC	NSQIP	2011-2015	Lumbar spinal fusion for spondylolisthesis	Admission from acute care hospital, emergency department, or nursing home	2238	N/A
Blaginykh 2020[16]	RC	NSQIP	2012-2016	Elective posterior and posterolateral lumbar fusion	N/A	29 830	N/A
Chan 2021[17]	RC	NSQIP	2010-2018	Posterior lumbar decompression with or without single level posterior fusion for spondylolisthesis	N/A	15 658	Frailty score, BMI
Darveau 2021[23]	PC	NSQIP	2012-2018	Laminectomy and fusion for lumbar stenosis	End organ failure, admission more than 1 day preoperatively, not arriving home, pregnancy, or missing hematocrit	16 329	Blood transfusion
Elsamadicy 2021[25]	RC	NSQIP	2010-2016	Spinal decompression and fusion for spondylolisthesis	N/A	5296	Age, black race, malnourished, pneumonia, UTI
Garcia 2016[26]	RCC	NSQIP	2006-2013	Elective single level ALIF	Emergent, urgent unplanned cases	2042	Age, pneumonia, wound infection
Garcia 2017[9]	RCC	NSQIP	2011-2013	Elective single level TLIF	Emergent, urgent unplanned cases	4992	Severe COPD, ASA, operative time, SSI, UTI
Kim 2014[29]	RCC	NSQIP	2011	Lumbar decompression for degenerative disease	N/A	7016	Anemia, dependent functional status, OP time, ASA class 4
Kurian 2020[30]	RCC	NSQIP NRD	2014-2015	PLF	Concurrent ACDF, trauma, tumors, or infections	15 025 120 977	Age, BMI, obesity, dependent status, steroid use, DM, dyspnea, dialysis, LOS, discharge to rehabilitation settings
Lee 2018[32]	RCC	NSQIP	2011-2012	PLF, PLIF and TLIF	Spinal deformity surgery, anterior lumbar fusion, emergency surgery	2301	LOS, bleeding disorder, insulin dependent, wound complication, thromboembolism, transfusion
Malik 2018[33]	RC	NSQIP	2012-2016	Elective 1-2-level PLF for degenerative pathologies	Multi-level fusion, fracture, fusion for malignancy	23 481	Discharge to skilled care or rehabilitation facilities
Malik 2019[34]	RC	NSQIP	2013-2016	ALIF	Concurrent posterior approaches or laminoplasty/laminectomies, revision surgery, hybrid procedures	4011	N/A
Malik 2019[35]	RC	NSQIP	2012-2016	1- 2-Level PLF for degenerative spinal pathology	Deformity, malignancy, or fracture cases	19 179	Chronic steroid use, age, bleeding disorder, ASA, LOS, COPD, 2-level, operative time, complications

(continued)

Table 1. (continued)

Study	Study Design	Database	Inclusion Period	Inclusion Criteria	Exclusion Criteria	Sample Size	Significant Risk Factors
Phan 2019[36]	RC	NSQIP	2005-2012	PLIF or TLIF or PLF	Deformity surgery, combined anterior approaches, nonelective surgery, pregnancy, ventilator dependent, preoperative sepsis, LOS >365 days, CNS tumor, malignancy, acute renal failure	2410	Hypoalbuminemia, bleeding disorder
Ranson 2018[39]	RC	NSQIP	2011-2014	Elective PLF	Pneumonia, sepsis, or cardiopulmonary resuscitation prior to surgery, pregnancy contaminated wound open wound or prior operation within 30 days, spinal trauma or neoplasm	22 909	Super obesity female
Samuel 2020[40]	RC	NSQIP	2013-2017	Lumbar discectomy	Infection, fracture, or neoplasms, simultaneous spinal fusion or cervical spine surgery; corpectomy, osteotomy, or vertebral column resection for spinal deformity	62 690	Female, obesity, age, multi-level surgery
Wahood 2019[42]	RC	NSQIP	2011-2015	Lumbar decompression, lumbo-sacral decompression, posterior lumbar fusion or lumbosacral fusion	Fractures, cysts, or tumors	60 222	Female, age, BMI, dependent status, CHF, COPD, dialysis, disseminated cancer, steroid use, bleeding disorder
Weaver 2019[44]	RC	NSQIP	2012-2016	Elective PLF for degenerative spine pathology	Primary thoracolumbar fracture, malignancy, or deformity	23 516	Modified 5-Item frailty Index
Webb 2017[45]	RC	NSQIP	2012-2014	Lumbar laminotomy or discectomy	Additional procedures or multilevel procedures	20 376	ASA class 3 or 4, prolonged operative time
Katz 2019[7]	RC	NSQIP	2005-2015	ALIF or PLIF	Emergency or nonelective procedures, or spinal deformity surgery	26 336	COPD, disseminated cancer, ASA, complications
Qin 2016[38]	RC	NSQIP	2005-2013	ALIF, PLIF, lumbar discectomy or decompression	N/A	51 277	DM
Aladdin 2019[13]	RC	HCUP-SID	2007-2014	Lumbar spinal fusion surgery	Combined cervical fusion procedure	267 976	Black race
Jain 2019[28]	RC	HCUP-SID	2005-2010	1-2 level lumbar spine fusion	Bone cancer/ metastases, infection, and trauma	92 262	Age, female, hispanic, black race, insurance, anterior approach, CVD, lung disease, CHF, DM, rheumatic disease, drug abuse, electrolyte disorder, osteoporosis, obesity, malnutrition
Chen 2021[18]	RC	HCUP-NRD	2013-2017	Elective single and multilevel lumbar spine fusion	Malnourished, anorexic, or underweight patients, and surgical indications of trauma or neoplasm	86 697	BMI

(continued)

Table 1. (continued)

Study	Study Design	Database	Inclusion Period	Inclusion Criteria	Exclusion Criteria	Sample Size	Significant Risk Factors
Elsamadicy 2018[8]	RCC	HCUP-NRD	2013-2014	Elective lumbar discectomy, laminectomy, or spinal fusion for degenerative disease	N/A	144 123	Age, insurance status, COPD, depression, DM, HTN, anemia, obesity
Taree 2021[41]	RCC	HCUP-NRD	2012-2014	PLF for intervertebral disk disorders, ankylosing spondylitis or spondylolisthesis	Nonelective surgery, LOS >365 d discharged against medical advice CNS cancer, current chemotherapy or radiation	65 121	Insurance, deficiency anemia, obesity, depression, DM, psychosis, liver disease, renal failure
Cook 2018[20]	RC	Medicare	2012-2014	Age > 65, lumbar spinal fusion for disc herniation, disc degeneration, spinal stenosis, instability, and miscellaneous thoracolumbar disorders	Surgery not performed in an acute short-stay hospital, infection, neoplasia, spina bifida, trauma, fracture, death in hospital or within 30 days of discharge, discharge against medical advice	261 558	Age, male, black race, LOS, elixhauser score, discharge to rehabilitation settings
Donnally 2019[24]	RC	Medicare	2005-2014	1-2-Level lumbar spinal fusion for a degenerative lumbar spine condition	Trauma, infection, metastasis of the spine, revision surgery, concomitant cervical, thoracic, ALIF, PLIF or TLIF	18 692	Fibromyalgia
Puvanesarajah 2016[37]	RC	Medicare	2005-2012	PLIF, PLF or lumbosacral spinal fusion surgery for degenerative disease	Prior trauma, infection, cancer, revision surgery, ≥ 3 levels, concurrent fusion	52 567	Obesity
Wang 2012[43]	RC	Medicare	2003-2007	Elective spine procedures for degenerative conditions in the lumbosacral spine	Beneficiaries enrolled in a health Maintenance organization	284 640	Age, fusions, anterior approach, black race, charlson comorbidity index
Cook 2021[21]	RC	QOD	2012-2016	Lumbar surgery for degenerative lumbar disorders	N/A	39 732	Revision surgery
Cook 2021[22]	RC	QOD	2012-2018	Lumbar surgery for degenerative lumbar disorders	Spine infection, tumor, fracture, traumatic dislocation, and neurologic paralysis	57 199	Baseline oswestry disability index
Glassman 2017[27]	RC	QOD DaneSpine JAMSD	NA	Lumbar fusion for degenerative disease	NA	2653 1993 3798	Gender, employment status, database
Cho 20 202[19]	RCC	Institution	2005-2012	Elective lumbar surgery for degenerative disease	N/A	3933	Previous surgery, fusion surgery, operative time, ICU admission, LOS, medical expenses
Lee 2019[31]	RCC	Institution	2005-2015	Age > 70, degenerative lumbar spinal surgery	Tumors, deformities, trauma, or infection	1248	Abnormal electrocardiography
Arrighi-Allisan 2022	RC	Institution	2008-2016	PLF	Surgery for tumors, trauma, and infections	3226	DM

ACDF, anterior cervical discectomy and fusion, ALIF, anterior lumbar interbody fusion, ASA, american society of anesthesiologists, BMI, body mass index, CHF, chronic heart failure, COPD, chronic obstructive pulmonary disease, CVD, cardiovascular disease, DM, diabetes mellitus, HTN, hypertension, LOS, length of stay, N/A, not applicable, NRD, national readmissions database, NSQIP, national surgical quality improvement program, PC, prospective cochort, PLF, posterior lumbar fusion, PLIF, posterior lumbar interbody fusion, RC, retrospective cohort, RCC, retrospective case control reported in 8 studies.[7,9,25,29-31,35,45] Kim et al[29] reported that ASA 4 was a significant risk factor compared to ASA 1. Katz,[7] Malik[35] and Webb[45] reported that ASA 3 or 4 was significantly associated with readmission compared with ASA 1 or 2. Garcia[9] also reported ASA was a significant risk factor using linear regression. Increased rates of readmission were observed in 4 of the 5 studies reporting bleeding disorder.[32,35,36,42] Anemia was considered as a risk factor in 3 of the 4 studies where it was reported.[8,29,41] Chronic pulmonary disease (non-specified) was reported in 8 studies,[7-9,26,28,29,35,42] of which, Elsamadicy[8] and Jain[28] considered it as a significant risk factor. Among these studies, 5 reported a history of chronic obstructive pulmonary disease (COPD)[7,9,26,35,42] associated with readmission. Eleven studies[7,8,14,28-32,38,41,42] reported diabetes mellitus (DM) as a potential risk factor, 9[7,8,14,28,30,32,38,41,42] of which showed statistically significant results in this regard. Three studies[7,28,42] reported heart failure and 2 of them[28,42] found that patients with heart failure had a higher risk of readmission. Five studies[8,29-31,42] reported hypertension and only 1[8] considered it as a significant risk factor. Two studies[8,28] investigated the impact of hypothyroidism and found no significant differences. The impact of underlying malignancy on the risk of readmission was investigated in 3 studies[7,28,42] with only Wahood[42] reporting a significant risk in patients with disseminated cancer. Three studies[7,30,42] investigated the influence of hemodialysis (HD) and 2[30,42] of them reported significant higher risk. Two studies investigated the impact of comorbidity with 1 using the Charlson comorbidity index[43] and the other using the Elixhauser score.[20] A higher frailty index was associated with higher risk of readmission in 3 studies.[17,25,44] A higher Oswestry disability index was associated with a higher risk of readmission in 1 study.[22] Three studies[29,30,42] reported that patients with dependent status had a higher risk of readmission. Regarding preoperative nutritional status, 3 studies[25,28,36] found malnutrition to be a significant risk factor for readmission. Two studies[8,28] found that depression significantly increased readmission rates. Six studies[7,25,29,30,35,42] compared readmission rates between patients with baseline chronic steroids and non-users and significant detrimental effect was found in 3 studies.[30,35,42] There are 2 studies[28,30] reporting alcohol abuse with significant elevated risk of readmission in 1.[30]

Perioperative Risk Factors (eTable 2)

Three studies[19,31,43] compared the incidence of readmission following decompression alone vs fusion, and only 1 study[43] showed a significant difference. Two studies[28,43] investigated surgical approaches, and patients receiving surgery with anterior approach have higher 30-day readmission rate compared to posterior approach. Regarding postoperative complications, Malik,[35] Katz[7] and Lee[32] reported that non-specific complications were associated with a higher incidence of readmission. Garcia[9,26] identified surgical site infection, pneumonia, and urinary tract infection (UTI) as significant risk factors, and Elsamadicy[25] found that adverse events including pneumonia and UTI are predictors of readmission. Four studies[7,21,28,40] compared readmission in patients undergoing primary vs revision surgery, and Cook[21] and Katz[7] found revision surgery to be associated with a higher risk of readmission; however no difference was found in the other 2 studies.[28,40]

The impact of prolonged operative time was reported in 5 studies[9,19,29,35,45] with significant findings observed in 3 studies[9,19,29] using linear regression and 2 using cut-off values (151[45] and 210[35] minutes). Three studies[31,35,40] reported relevant results regarding surgical levels, and multi-level surgeries led to a higher risk of readmission in 2 studies[35,40] but no significant difference in the other 1 that reported surgical level by linear regression.[31] Two studies[23,32] reported post/intra-operative blood transfusion and an increased risk of readmission was noted. Six studies[19,20,30-32,35] reported the association between prolonged length of stay (LOS) and readmission rate with a positive correlation was observed in 5 studies.[19,20,30,32,35] The impact of discharge destination was reported in 4 studies[20,30,33,34] and discharge to inpatient care facilities[33] or rehabilitation-based facilities[20,30] was associated with higher risk of readmission.

Discussion

To our best knowledge, this is the first systematic review to provide an overview of predictors of 30-day readmission following spine surgeries for LDD. We identified potential risk factors associated with 30-day readmission, including age, race, obesity, higher ASA score, anemia, bleeding disorder, chronic pulmonary disease, heart failure, dependent status, depression, DM, frailty, malnutrition, chronic steroid use, surgeries with an anterior approach, multi-level spinal surgeries, perioperative transfusion, presence of postoperative complications, prolonged operative time, and prolonged LOS, which were categorized into patient risk factors and perioperative risk factors in the following discussion.

Patient Risk Factors

Spine surgery can be safely performed in older patients and old age alone is not a contraindication for lumbar surgery.[46] However, the prevalence of co-occurring chronic diseases and disorders increases greatly with age,[47] which may negatively impact postoperative condition, recovery, and quality of life. In addition, an increase in aging bone, the degeneration of discs and facet joints, and the wasting of ligaments and muscles may lead to great destabilization and imbalance of the spine.[48] Owing to the severity of degeneration in older patients, surgical procedures have become more complex, such as longer instrumented segments, which are associated with a higher risk of complications and relatively worse clinical outcomes.[49] Based on our review, patients over 70-year-old exhibited much higher risk of 30-day readmission, which could be related not only to the surgical procedures but also to the patients' preoperative condition.

Obesity imposes more loading on axial bones and inevitably accelerate spinal degeneration.[50,51] Furthermore, compared to the general population, obesity can lead to more adverse events following lumbar spine surgery,[52] including increased surgical time, extended length of stay, wound complications, higher blood loss, urinary complications and thromboembolism events,[53] which subsequently lead to a higher incidence of unplanned readmission. Obesity is defined as a BMI ≥30, with morbid obesity being defined as a BMI ≥40. While the prevalence of obesity is on the increase, there are limited studies investigating strategies for weight loss before spine surgery in obese patients (BMI 30-40).[52] The benefits of bariatric procedures for morbid obesity before spine surgery have been reported in several studies, including fewer overall and wound-related complications, reduced in-hospital mortality, and improved healthcare utilization.[54-56]

Unplanned readmission may be related to underlying diseases and medical conditions, not the surgical procedures themselves. DM,[57] COPD[58] and heart failure[59] are common medical problems with high prevalence among older adults. Most included studies demonstrated a positive correlation of these conditions and unplanned readmission following surgery. Moreover, patients undergoing HD are vulnerable during the perioperative periods and the maintenance of stable homeostasis during hospitalization is a clinical challenge for surgeons and nephrologist.[60] On the surgical aspect, both DM and renal failure negatively impact wound healing and increases the risk of surgical site infection, which may further necessitate readmission and inpatient managements.[61]

Anemia and bleeding disorders are associated with a higher risk of unplanned readmissions.[8,25,29,41] Intraoperative transfusion may be required in patients with unstable hemodynamics. However, transfusion has been reported as an independent predictor of adverse postoperative outcomes,[62,63] postoperative infection,[64] and prolonged hospital stay,[65] which could explain the higher unplanned readmission rate.[23]

It is evident that patients' underlying comorbidities are detrimental to their postoperative outcomes and recovery. In this line, a positive correlation between overall comorbidities and the incidence of readmission following lumbar spinal fusion surgery has been shown.[20,43] This finding is in consistence with that higher ASA is also a significant risk factor in several studies.[9,29,35,45] There are studies[17,44] investigating the association of frailty index and unplanned readmission of patients receiving elective spinal fusion surgery, which yield the similar results. General functional status is also associated with postoperative morbidity and mortality.[29,42] Performance assessment can partially reflect the aforementioned medical comorbidities since patients with multiple underlying medical co-morbidities usually have worse functional status. Malnutrition impairs wound healing postoperatively and compromise the immune system against infection, therefore, associated with several adverse events including wound complications and surgical site infections in not only spine surgery but other orthopedic surgery.[66-68] It should be noted that presence postoperative adverse event is a strong predictor for unplanned readmission. Identifying malnourished patients and preoperative nutrition support may have benefit on postoperative outcome.[69]

Chronic steroid use is associated with poor wound healing, infection, and minor or major complications following surgery.[70] Moreover, patients receiving steroids have poor bone quality, which increases the risk of implant loosening and readmission.[71] No doubt, chronic steroid use increases the risks 30-day readmission following surgery for LDD.

Aside from the patients' physical medical conditions, mental issues, such as affective disorders, are topics of interest in multiple medical and surgical fields. Affective disorders, especially depression is associated with chronic back pain in general population and unsatisfactory outcomes in spine surgeries.[72] This is evident from the result of 2 large population-based studies[8,28] in which patients with depression were associated with higher 30-day readmission following surgeries for LDD.

Perioperative Risk Factors

With the growing number of lumbar spinal surgeries for LDD and the increasing variety of fusion techniques, it is important to clarify the comparative risk of complications and postoperative outcomes of various types of surgery. Surgical complexity may influence its results and potential complications owing to prolonged surgical time, increased tissue damage, and blood loss. Our review demonstrated that anterior lumbar surgeries were associated with a higher risk of readmission. Anatomically, in order to access to the vertebrae, the anterior approach requires the dissection and retraction of abdominal vessels, while the posterior approach needs the subperiosteal muscle dissection. The great vessels overly the disc spaces, and their retraction is essential when exploring the discs of interest through an anterior approach. Direct vascular injury can result in immediate complications and mortality, but may not necessitate readmission within 30days. However, prolonged retraction of the great vessels during ALIF may be associated with a higher risk of DVT than posterior lumbar surgery.[73] Furthermore, since the posterior approach is standard for most spinal pathologies, it is the most commonly practiced procedure for spinal surgeons and particularly for entry-level residents.[74] Owing to the complex vascular anatomy and lower frequency of utilization, the anterior approach may impose an increased risk of vascular and wound events, resulting in a higher readmission rate than the posterior approach.[75] However, only 2 studies[28,43] have compared the 30-day readmission risk of the anterior and posterior approaches. Wang et al[43] grouped patients into anterior, posterior, and concomitant anterior and posterior approach groups. Their analysis found that an anterior only approach was associated with a significantly higher incidence of readmission compared to the posterior only approach. In the other study, Jain et al[28] investigated patients undergoing posterior lumbar fusion, and found that patients operated on through a concomitant anterior approach experienced a significantly higher risk of readmission. Due to the limited data obtained from these studies, as well as their heterogeneity, further studies focusing on readmission with respect to surgical approach are warranted.

At the surgical level, multi-level spinal surgery is associated with a prolonged operative time, subsequently lead to postoperative complications and unplanned readmission.[76] However, Lee et al.[31] Reported that multi-level spinal surgery is not a significant risk factor, possibly because of advances in minimally invasive surgical techniques combined with appropriate patient selection.

The prevalence of complications following spine surgery is reported in around 20-40%[77,78] of the patients, and is associated with increased morbidity, mortality, length of hospital stay, and health costs.[77] In our review, postoperative UTI, pneumonia, thromboembolism, and wound infection, were highly associated with unplanned readmission. The incidence of complications following surgery for degenerative spine disease is lower than that for trauma, infectious or malignant etiologies, which may be the result of underreporting owing to the retrospective design of most studies. The complication rate is associated with not only the complexity of the surgery but also the surgeons' experience, which could constitute a potential bias that may be challenging to take in consideration. Moreover, there is a lack of a generalized classification system assessing complications following spinal surgery, which makes it difficult to determine its impact on postoperative outcomes. Therefore, a robust correlation between postoperative complications and unplanned readmission should be clarified with large-scale and well-designed prospective studies.

Limitations

The present systematic review had some limitations. First, we included only studies that focused on LDD. Therefore, surgeries for deformities, fractures, and spinal tumors were excluded. Also, based on our inclusion criteria, some newly developed procedures such as endoscopic spine surgery or robotic spine surgery were not included in our review.

Second, nearly half of the included studies were from the NSQIP databases, and the duplication of cohorts made the quantitative analysis of risk factors impracticable. In addition, studies from national databases or single institutions were included, and considerable variations in patient characteristics and sample sizes were observed. Third, we believe that short-term outcomes, including unplanned readmission, were influenced by the surgeon's technical experience, which could represent a potential performance bias.

Conclusions

Through a systematic review, we identified the predictors of 30-day unplanned readmission in patients undergoing surgery for LDD. These findings may be used to identify patients at a higher risk of readmission, for whom caution should be exercised by clinicians.

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.

ORCID iDs

Jung-Shun Lee https://orcid.org/0000-0003-4268-2161
Po-Hsuan Lee https://orcid.org/0000-0003-4034-9234

Supplemental Material

Supplemental material for this article is available online.

References

1. Ravindra VM, Senglaub SS, Rattani A, Dewan MC, Hartl R, Bisson E. Degenerative lumbar spine disease: Estimating global incidence and worldwide volume. *Global Spine J*. 2018;8(8): 784-794.
2. Grotle M, Småstuen MC, Fjeld O, Grovle L, Helgeland J, Storheim K. Lumbar spine surgery across 15 years: trends, complications and reoperations in a longitudinal observational study from Norway. *BMJ Open*. 2019;9(8):e028743.
3. Martin BI, Deyo RA, Mirza SK, et al. Expenditures and health status among adults with back and neck problems. *JAMA*. 2008; 299(6):656-664.
4. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the medicare fee-for-service program. *N Engl J Med*. 2009;360(14):1418-1428.
5. Weissman JS, Ayanian JZ, Chasan-Taber S, Sherwood MJ, Roth C, Epstein AM. Hospital readmissions and quality of care. *Med Care*. 1999;37(5):490-501.
6. Rock AK, Opalak CF, Workman KG, Broaddus WC. Safety outcomes following spine and cranial neurosurgery: Evidence from the national surgical quality improvement program. *J Neurosurg Anesthesiol*. 2018;30(4):328-336.
7. Katz AD, Perfetti DC, Job A, Willinger M, Goldstein J, Kiridly D. Comparative analysis of 30-day readmission, reoperation, and morbidity between lumbar disc arthroplasty performed in the inpatient and outpatient settings utilizing the ACS-NSQIP dataset. *Global Spine J*. 2021;11(5):640-648.
8. Elsamadicy AA, Ren X, Kemeny H, Charalambous L, Sergesketter AR, Rahimpour S. Independent associations with 30- and 90-day unplanned readmissions after elective lumbar spine surgery: a national trend analysis of 144 123 patients. *Neurosurgery*. 2019;84(3):758-767.
9. Garcia RM, Khanna R, Dahdaleh NS, Cybulski G, Lam S, Smith ZA. Thirty-day readmission risk factors following single-level

transforaminal lumbar interbody fusion (TLIF) for 4992 patients from the ACS-NSQIP database. *Global Spine J*. 2017;7(3):220-226.
10. Bernatz JT, Anderson PA. Thirty-day readmission rates in spine surgery: Systematic review and meta-analysis. *Neurosurg Focus*. 2015;39(4):E7.
11. Higgins JPTTJ, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds*Cochrane Handbook for Systematic Reviews of Interventions*. 2021. Available from: www.training.cochrane.org/handbook.(updated February 2021).
12. Hayden JA, Côté P, Bombardier C. Evaluation of the quality of prognosis studies in systematic reviews. *Ann Intern Med*. 2006;144(6):427-437.
13. Aladdin DEH, Tangel V, Lui B, Pryor KO, Witkin LR, White RS. Black race as a social determinant of health and outcomes after lumbar spinal fusion surgery: A multistate analysis. *Spine (Phila Pa 1976)*. 2007 to 20142020;45(10):701-711.
14. Arrighi-Allisan AE, Neifert SN, Gal JS, Zeldin L, Zimering JH, Gilligan JT. Diabetes is predictive of postoperative outcomes and readmission following posterior lumbar fusion. *Global Spine J*. 2022;12(2):229-236.
15. Badhiwala JH, Karmur BS, Hachem LD, Wilson JRF, Jiang F, Jaja B. The effect of older age on the perioperative outcomes of spinal fusion surgery in patients with lumbar degenerative disc disease with spondylolisthesis: A propensity score-matched analysis. *Neurosurgery*. 2020;87(4):672-678.
16. Blaginykh E, Alvi MA, Goyal A, Yolcu YU, Kerezoudis P, Sebastian AS. Outpatient versus inpatient posterior lumbar fusion for low-risk patients: An analysis of thirty-day outcomes from the national surgical quality improvement program. *World Neurosurg*. 2020;142:e487-e493.
17. Chan V, Witiw CD, Wilson JR, Wilson JR, Coyte P, Fehlings MG. Frailty is an important predictor of 30-day morbidity in patients treated for lumbar spondylolisthesis using a posterior surgical approach. *Spine J*. 2021;22:286-295.
18. Chen XT, Shahrestani S, Ballatori AM, Ton A, Buser Z, Wang JC. The influence of body mass index in obese and morbidly obese patients on complications and 30- and 90-day readmissions following lumbar spine fusion. *Spine (Phila Pa 1976)*. 2021;46(14):965-972.
19. Cho PG, Kim TH, Lee H, Ji GY, Park SH, Shin DA. Incidence, reasons, and risk factors for 30-day readmission after lumbar spine surgery for degenerative spinal disease. *Sci Rep*. 2020;10(1):12672.
20. Cook C, Coronado RA, Bettger JP, Graham JE. The association of discharge destination with 30-day rehospitalization rates among older adults receiving lumbar spinal fusion surgery. *Musculoskelet Sci Pract*. 2018;34:77-82.
21. Cook CE, Garcia AN, Park C, Gottfried O. True differences in poor outcome risks between revision and primary lumbar spine surgeries. *HSS J*. 2021;17(2):192-199.
22. Cook CE, Garcia AN, Wright A, Shaffrey C, Gottfried O. Measurement properties of the oswestry disability index in recipients of lumbar spine surgery. *Spine (Phila Pa 1976)*. 2021;46(2):E118-E125.
23. Darveau SC, Pertsch NJ, Toms SA, Weil RJ. Short term outcomes associated with patients requiring blood transfusion following elective laminectomy and fusion for lumbar stenosis: A propensity-matched analysis. *J Clin Neurosci*. 2021;90:184-190.
24. Donnally CJ 3rd, Vakharia RM, Rush AJ 3rd, Damodar D, Vakharia AJ, Goz V. Fibromyalgia as a predictor of increased postoperative complications, readmission rates, and hospital costs in patients undergoing posterior lumbar spine fusion. *Spine (Phila Pa 1976)*. 2019;44(4):E233-E238.
25. Elsamadicy AA, Freedman IG, Koo AB, David WB, Reeves BC, Havlik J. Modified-frailty index does not independently predict complications, hospital length of stay or 30-day readmission rates following posterior lumbar decompression and fusion for spondylolisthesis. *Spine J*. 2021;21(11):1812-1821.
26. Garcia RM, Choy W, DiDomenico JD, Barrington N, Dahdaleh NS, Rodriguez HE. Thirty-day readmission rate and risk factors for patients undergoing single level elective anterior lumbar interbody fusion (ALIF). *J Clin Neurosci*. 2016;32:104-108.
27. Glassman S, Carreon LY, Andersen M, Asher A, Eiskjær S, Gehrchen M. Predictors of hospital readmission and surgical site infection in the united states, denmark, and japan: is risk stratification a universal language? *Spine (Phila Pa 1976)*. 2017;42(17):1311-1315.
28. Jain D, Singh P, Kardile M, Berven SH. A validated preoperative score for predicting 30-day readmission after 1-2 level elective posterior lumbar fusion. *Eur Spine J*. 2019;28(7):1690-1696.
29. Kim BD, Smith TR, Lim S, Cybulski GR, Kim JY. Predictors of unplanned readmission in patients undergoing lumbar decompression: multi-institutional analysis of 7016 patients. *J Neurosurg Spine*. 2014;20(6):606-616.
30. Kurian SJ, Wahood W, Yolcu YU, Blaginykh E, Goyal A, Sebastian AS. Risk factors for unplanned readmissions following anterior cervical discectomy and fusion and posterior lumbar fusion procedures: comparison of two national databases. *World Neurosurg*. 2020;143:e613-e630.
31. Lee JJ, An SB, Kim TW, Shin DA, Yi S, Kim KN. Analysis of risk factors associated with hospital readmission within 360 days after degenerative lumbar spine surgery in elderly patients. *World Neurosurg*. 2019;126:e196-e207.
32. Lee NJ, Kothari P, Phan K, Shin JI, Cutler HS, Lakomkin N. Incidence and risk factors for 30-day unplanned readmissions after elective posterior lumbar fusion. *Spine (Phila Pa 1976)*. 2018;43(1):41-48.
33. Malik AT, Jain N, Kim J, Yu E, Khan SN. Continued inpatient care after elective 1- to 2-level posterior lumbar fusions increases 30-day postdischarge readmissions and complications. *Clin Spine Surg*. 2018;31(9):E453-e459.
34. Malik AT, Kim J, Yu E, Khan SN. Discharge to inpatient care facility after anterior lumbar interbody fusion: incidence, predictors, and postdischarge outcomes. *World Neurosurg*. 2019;122:e584-e590.
35. Malik AT, Xie J, Xi R, Yu E, Kim J, Khan SN. Risk factors for post-discharge complications and readmissions in home-discharges after elective posterior lumbar fusions. *Clin Neurol Neurosurg*. 2019;185:105501.

36. Phan K, Ranson W, White SJW, Cheung ZB, Kim J, Shin JI. Thirty-day perioperative complications, prolonged length of stay, and readmission following elective posterior lumbar fusion associated with poor nutritional status. *Global Spine J*. 2019; 9(4):417-423.
37. Puvanesarajah V, Werner BC, Cancienne JM, Jain A, Pehlivan H, Shimer AL. Morbid obesity and lumbar fusion in patients older than 65 years: complications, readmissions, costs, and length of stay. *Spine (Phila Pa 1976)*. 2017;42(2):122-127.
38. Qin C, Kim JYS, Hsu WK. Impact of insulin dependence on lumbar surgery outcomes: an nsqip analysis of 51, 277 patients. *Spine (Phila Pa 1976)*. 2016;41(11):E687-E693.
39. Ranson WA, Cheung ZB, Di Capua J, Lee NJ, Ukogu C, Jacobs S. Risk factors for perioperative complications in morbidly obese patients undergoing elective posterior lumbar fusion. *Global Spine J*. 2018;8(8):795-802.
40. Samuel AM, Morse K, Lovecchio F, Maza N, Vaishnav AS, Katsuura Y. Early failures after lumbar discectomy surgery: an analysis of 62 690 patients. *Global Spine J*. 2021;11(7):1025-1031.
41. Taree A, Mikhail CM, Markowitz J, Ranson WA, Choi B, Schwartz JT. Risk factors for 30- and 90-day readmissions due to surgical site infection following posterior lumbar fusion. *Clin Spine Surg*. 2021;34(4):E216-E222.
42. Wahood W, Yolcu Y, Alvi MA, Goyal A, Long TR, Bydon M. Assessing the differences in outcomes between general and non-general anesthesia in spine surgery: Results from a national registry. *Clin Neurol Neurosurg*. 2019;180:79-86.
43. Wang MC, Shivakoti M, Sparapani RA, Guo C, Laud PW, Nattinger AB. Thirty-day readmissions after elective spine surgery for degenerative conditions among US Medicare beneficiaries. *Spine J*. 2012;12(10):902-911.
44. Weaver DJ, Malik AT, Jain N, Yu E, Kim J, Khan SN. The modified 5-item frailty index: a concise and useful tool for assessing the impact of frailty on postoperative morbidity following elective posterior lumbar fusions. *World Neurosurg*. 2019;124:e626-e632.
45. Webb ML, Nelson SJ, Save AV, Cui JJ, Lukasiewicz AM, Samuel AM. Of 20, 376 lumbar discectomies, 2.6% of patients readmitted within 30 days: Surgical site infection, pain, and thromboembolic events are the most common reasons for re-admission. *Spine (Phila Pa 1976)*. 2017;42(16):1267-1273.
46. Watanabe T, Kanayama M, Takahata M, Oda I, Suda K, Abe Y. Perioperative complications of spine surgery in patients 80 years of age or older: a multicenter prospective cohort study. *J Neurosurg Spine*. 2019;32(4):622-630.
47. Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition–multimorbidity. *JAMA*. 2012; 307(23):2493-2494.
48. Benoist M. Natural history of the aging spine. *Eur Spine J*. 2003; 12(Suppl 2):S86-S89.
49. Liao JC, Chiu PY, Chen WJ, Chen LH, Niu CC. Surgical outcomes after instrumented lumbar surgery in patients of eighty years of age and older. *BMC Muscoskel Disord*. 2016;17(1):402.
50. Heuch I, Hagen K, Heuch I, Nygaard Ø, Zwart JA. The impact of body mass index on the prevalence of low back pain: The HUNT study. *Spine (Phila Pa 1976)*. 2010;35(7):764-768.
51. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between obesity and low back pain: A meta-analysis. *Am J Epidemiol*. 2010;171(2):135-154.
52. Jackson KL 2nd, Devine JG. The effects of obesity on spine surgery: A systematic review of the literature. *Global Spine J*. 2016;6(4):394-400.
53. Goyal A, Elminawy M, Kerezoudis P, Lu VM, Yolcu Y, Alvi MA. Impact of obesity on outcomes following lumbar spine surgery: A systematic review and meta-analysis. *Clin Neurol Neurosurg*. 2019;177:27-36.
54. Han L, Han H, Wang L, Ruan Y, Wei X, He J. Prior bariatric surgery is associated with lower complications, in-hospital mortality, and healthcare utilization after elective spine fusion surgery. *Surg Obes Relat Dis*. 2020;16(6):760-767.
55. Jain D, Berven SH, Carter J, Zhang AL, Deviren V. Bariatric surgery before elective posterior lumbar fusion is associated with reduced medical complications and infection. *Spine J*. 2018;18(9):1526-1532.
56. Passias PG, Horn SR, Vasquez-Montes D, Shepard N, Segreto FA, Bortz CA. Prior bariatric surgery lowers complication rates following spine surgery in obese patients. *Acta Neurochir (Wien)*. 2018;160(12):2459-2465.
57. Rathmann W, Giani G. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care*. 2004; 27(10):2568-2569.
58. Buist AS, McBurnie MA, Vollmer WM, Gillespie S, Burney P, Mannino DM. International variation in the prevalence of COPD (the BOLD Study): A population-based prevalence study. *Lancet*. 2007;370(9589):741-750.
59. Emmons-Bell S, Johnson C, Roth G. *Prevalence, Incidence and Survival of Heart Failure: A Systematic Review*. Heart; 2022.
60. Trainor D, Borthwick E, Ferguson A. Perioperative management of the hemodialysis patient. *Semin Dial*. 2011;24(3):314-326.
61. Guo S, Dipietro LA. Factors affecting wound healing. *J Dent Res*. 2010;89(3):219-229.
62. Berenholtz SM, Pronovost PJ, Mullany D, Garrett E, Ness P, Dorman T. Predictors of transfusion for spinal surgery in Maryland, 1997 to 2000. *Transfusion*. 2002;42(2):183-189.
63. Blanchette CM, Wang PF, Joshi AV, Asmussen M, Saunders W, Kruse P. Cost and utilization of blood transfusion associated with spinal surgeries in the United States. *Eur Spine J*. 2007;16(3):353-363.
64. He YK, Li HZ, Lu HD. Is blood transfusion associated with an increased risk of infection among spine surgery patients?: A meta-analysis. *Medicine (Baltim)*. 2019;98(28):e16287.
65. Seicean A, Alan N, Seicean S, Neuhauser D, Weil RJ. The effect of blood transfusion on short-term, perioperative outcomes in elective spine surgery. *J Clin Neurosci*. 2014;21(9):1579-1585.
66. Del Savio GC, Zelicof SB, Wexler LM, Byrne DW, Reddy PD, Fish D. Preoperative nutritional status and outcome of elective total hip replacement. *Clin Orthop Relat Res*. 1996(326): 153-161.
67. Jaberi FM, Parvizi J, Haytmanek CT, Joshi A, Purtill J. Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. *Clin Orthop Relat Res*. 2008; 466(6):1368-1371.

68. Tsantes AG, Papadopoulos DV, Lytras T, Mavrogenis A, Koulouvaris P. Association of malnutrition with surgical site infection following spinal surgery: systematic review and meta-analysis. *J Hosp Infect*. 2020;104(1):111-119.
69. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ. Evaluation of malnutrition in orthopaedic surgery. *J Am Acad Orthop Surg*. 2014;22(3):193-199.
70. Aziz KT, Best MJ, Ren M, Nayar SK, Timothy Kreulen R, Gupta HO, et al. The impact of chronic steroid use on early postoperative complications in shoulder surgery. *Phys Sportsmed*. 2021;49(2):223-228.
71. Marie-Hardy L, Pascal-Moussellard H, Barnaba A, Bonaccorsi R, Scemama C. Screw loosening in posterior spine fusion: prevalence and risk factors. *Global Spine J*. 2020;10(5):598-602.
72. Adogwa O, Elsamadicy AA, Mehta AI, Vasquez RA, Cheng J, Karikari IO. Association between baseline affective disorders and 30-day readmission rates in patients undergoing elective spine surgery. *World Neurosurg*. 2016;94:432-436.
73. Inamasu J, Guiot BH. Vascular injury and complication in neurosurgical spine surgery. *Acta Neurochir (Wien)*. 2006;148(4):375-387.
74. Cloward RB. The treatment of ruptured lumbar intervertebral discs; criteria for spinal fusion. *Am J Surg*. 1953;86(2):145-151.
75. Chi KY, Cheng SH, Kuo YK, Lin EY, Kang YN. Safety of lumbar interbody fusion procedures for degenerative disc disease: A systematic review with network meta-analysis of prospective studies. *Global Spine J*. 2021;11(5):751-760.
76. Chang Y, Chi KY, Tai TW, Cheng YS, Lee PH, Huang CC. Risk factors for postoperative urinary retention following elective spine surgery: A meta-analysis. *Spine J*. 2021;21(11):1802-1811.
77. Camino Willhuber G, Elizondo C, Slullitel P. Analysis of postoperative complications in spinal surgery, hospital length of stay, and unplanned readmission: Application of dindo-clavien classification to spine surgery. *Global Spine J*. 2019;9(3):279-286.
78. Cho KJ, Suk SI, Park SR, Kim JH, Kim SS, Choi WK. Complications in posterior fusion and instrumentation for degenerative lumbar scoliosis. *Spine (Phila Pa 1976*. 2007;32(20):2232-2237.