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Article

Crucial Insights: Post-Op Spinal Infections in Lumbar Fusion

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Abstract: Postoperative spinal infections following lumbar fusion with posterior lumbar interbody fusion (PLIF) are a concerning complication, particularly in cases of degenerative spinal disease. However, factors contributing to infection risk remain unclear. This retrospective study analyzed data from 124 adults who underwent instrumented fusion for degenerative spinal conditions between 2015 and 2020. Multivariate proportional hazards regression identified risk factors associated with surgical site infections (SSI). Results revealed a 16.9% incidence of SSI, with 92.4% of cases showing positive microbiological cultures. Prolonged hospital stay, prior surgeries, advanced age, diabetes, and obesity were correlated with infection risk. Notably, 95% of infected patients were successfully treated with surgical intervention or antibiotics without hardware removal. This underscores the importance of early identification and intervention in managing postoperative spinal infections, mitigating the need for hardware removal and improving patient outcomes.

Keywords: Spinal fusion, Posterior lumbar interbody fusion (PLIF), Surgical site infection, Risk factors, Treatment outcomes

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1. Introduction

The lumbar interbody fusion posteriorly (PLIF) is a procedure extensively utilized in spinal surgery to manage cases of spondylolisthesis and stenosis of the spinal canal due to its effective operative procedure. Nevertheless, as with all surgical procedures, postoperative complications may impede the surgical efficacy of PLIF. De Kunder et al. (1) Conducted a meta-analysis. Consisting of 192 studies, and deduced that the group undergoing posterior lumbar intervertebral body fusion (PLIF) manifested a significantly higher frequency of complications compared to those undergoing transforaminal lumbar interbody fusion (TLIF), With an absolute disparity rate that is twice as much (17.0% compared to 8.7%). The presence of infection at the site of operation, a common complication, exhibits a variable incidence rate that fluctuates between 0% to 20.0%. Significant fallouts from SSI manifest themselves after spinal surgeries. Consequently, SSI is linked with 11 supplementary days of hospitalization for patients and a 20% incremented jeopardy of readmission within 30 days following surgery. (2,4) Furthermore, the augmented expenses incurred from prolonged hospitalization and

treatment also pose a matter of apprehension for the public. In the preceding decade, multiple perilous facets linked with SSI ensuing spinal fusion have been recognized, constituting a conceptual underpinning for fabricating a peril anticipation model and augmenting patient verdict-making abilities. Recent meta-analyses have determined that diabetes, protracted surgical duration, corpulence, surgical procedure (distinguishing posterior from other techniques), quantity of operated segments, utilization of instrumentation (contrasted with non-instrumentation), and use of open surgery (as opposed to minimally invasive surgery) serve as prognosticators for surgical site infections. (5,7) Based on the presented evidence, it can be deduced that individuals who undergo PLIF and instrumentation procedures face an increased likelihood of encountering surgical site infections. Nevertheless, there exists a limited number of investigations that distinctly classify postoperative SSIs in this particular subgroup, and a majority of the existing discoveries are derived from studies conducted in Western nations.

This is concerning as certain clinical parameters, for instance, the measurement of the body mass index (BMI) and the occurrence rate of osteoporosis., and comorbidities, display significant variations between Western and Asian populations. (8,9)

The current investigation aims to first examine the incidence rate of infections at the site of operation following posterolateral interbody fusion (PLIF) and transpedicular screw fixation at our medical institution from 2015 to June 2020. Additionally, it seeks to evaluate various perioperative factors to determine their independent association with SSI occurrence.

2. Materials and Methods

This retrospective analysis, we have attained the endorsement of the ethics committee of our medical hospital. Due to the retrospective nature of the study and the use of anonymized data, the committee waived the obligation of securing informed consent. Individuals afflicted with degenerative lumbar condition and subjected to posterior lumbar interbody fusion (PLIF) inclusive of instrumentation during the period of July 2015 and June 2020 were deemed eligible for data extraction and subsequent analysis.

The state Characteristics for involve encompassed the presence of clinical signs and symptoms with Radiological-based indications of spinal degenerative pathology in the lumbar region, including protruded disc in the lumbar spine, spondylolisthesis in the lumbar spine, spinal lumbar stenosis, and related pathologies. Additionally, eligible patients were required to be aged 20 or above, have undergone surgical intervention through lumbar interbody fusion by posterior approach (PLIF) accompanied by transpedicular screw fixation, possess comprehensive medical documentation, and have undergone a requisite follow-up period of no less than 12 months.

Characteristic for Exclusion: the study encompassed a range of factors, including incomplete medical records, loss to follow-up, lumbar surgeries alternative to PLIF surgery or PLIF surgery with instrumentation, presence of spinal lumbar tumors, a medical history comprising of previous lumbar surgical intervention (excluding injections of epidural, biopsy taking by needle, vertebroplasty, or kyphoplasty), and prior lumbar spine radiation.

A solitary administration of prophylactic antibiotics (such as ceftriaxone or ceftazidime) was customarily carried out within a time frame of 20 minutes prior to the incision in the skin. Furthermore, in procedures with an interval exceeding two hours. An extra dosage was administered, along with the type and duration of antibiotic prophylaxis following surgery was not standardized. This was mainly dependent on the preference and experience of the surgeon. The identification and confirmation of

infections at the site of operation are based on the guidelines established in 2017.Guidelines promulgated by the US Institute for Disease Control and Prevention (CDC) which are designed to prevent the onset of infection at the site of operation.

A postoperative infectious condition affecting both skin and subcutaneous tissues, occurring within the span of 30 days following surgical intervention, is referred to as a "Superficial infection" at the operative site. It is distinguished by manifestations and signs of erythema, sensitivity, increased temperature, and uneasiness on the afflicted region. Conversely, "Deep infection" at the site of infection this is an infection that penetrates the fascia and musculature. It is noteworthy that the emergence of this condition usually occurs within a year of the implant installation and presents itself with symptoms such as fever, discomfort, tenderness, persistent wound drainage or separation, abscess, or gangrene. This situation calls for a surgical procedure involving the removal of the implanted object through meticulous debridement.

The medical documents of patients were thoroughly examined to determine occurrences of operative site infections, as indicated or manifested in the records, both during their hospitalization and through the acquisition of outpatient notes during their scheduled appointments. The post-operative infection was validated through telephonic consultations to verify the presence of residual infection in patients one year following the surgical intervention. The microbial colonies present in the patients who experienced infections at the site of operation were examined meticulously to identify the causative microorganisms responsible for the infection, in addition to their susceptibility to antibiotics.

The collated data encompassed a diverse range of factors such as patient demographics, coexisting conditions, past surgeries, operative levels, fused segments, decompressed areas, existence of cerebrospinal fluid (CSF) leakage, duration of hospitalization, perioperative mishaps, infection of the wound, and antibiotic therapy. Morbid Obesity has been identified as having a body mass index exceeding 35; however, less significant levels of obesity were not systematically documented. To guarantee the comprehensiveness of potential infections (both operative and non-operative), the postsurgical clinical notes were utilized, and the CDC delineation of infection was employed in lieu of ICD-9 codes.

For individuals suffering from degenerative spinal conditions exhibiting clinical signs and image finding of instability., or who were at risk of self-inducing instability, the preferred treatment was instrumented fusion. Prior to surgery, patients underwent thorough medical evaluations, including an inclusive assessment of comorbidities. Using a Betadine or Chlorhexidine antiseptic solution for pre-operative skin preparation. the surgical site was appropriately cleansed before making the incision. Within 30 minutes of incision, the patient was administered Intravenous antibiotics, with Ceftriaxone (1 mg) being the common choice unless the individual had a penicillin-based sensitivity; in such a case, clindamycin (500 mg) was employed; this was typically repeated every 4 hours, with the clindamycin dosage occurring at intervals of 8 hours. Drains were inserted at surgical and only taken out When the rate of draining was reduced to lower than 50 milliliters each day. Antimicrobials were customarily administered for a day post-surgery or until the removal of the drain. Surgeons displayed varied inclinations with regard to the selection of machinery for instrumented fusion.

The statistical analysis consisted of utilizing the mean in combination with its corresponding standard deviation (SD) for the continuous variables, while the count, along with its corresponding percentage, was used for the categorical data. To compare categorical data, we employed either the Chi-square or Fisher's exact tests, whereas the student’s t-test or Mann-Whitney U-test was utilized for continuous variables. Variables that exhibited statistical significance with a P-value below 0.1 the covariates were integrated into the multivariate logistic regression model for adjusted analyses. The

technique of stepwise backward elimination was utilized. To eliminate variables that did not exhibit independent association with SSI when P<0.10. The final model retained each variable's effect size, expressed as confidence intervals (95% CIs) odds ratios (ORs) with corresponding 95%.

The Hosmer-Lemeshow (H-L) test was employed to assess the adequacy of the last model's fit., with P>0.05 indicating a satisfactory outcome. Moreover, the Nagelkerke R2 was employed to measure the goodness-of-fit, where a greater value denoted a superior result. An outcome was regarded as statistically significant if P<0.05. The SPSS 25.0 software package (IBM, Armonk, NY) was employed for all data analyses.

3. Results

Twenty-one individuals were detected with a surgical site infection. The outcome showed an incidence rate of 16.9% (95% confidence interval, 2.2% to 4.6%). The cohort of patients who experienced SSIs consisted of 6 males and 15 females, with an average age of 52.8 years (standard deviation, 16.6 years).

The median outset time of the surgical site infections (SSIs) they occurred ten days post-operation. The earliest incidence was observed on the Fifth day after the surgical procedure, while the end one was recorded on day 45 after the operation. Out of the total 21 instances of Surgical Site Infections (SSIs), 16 were regarded as superficial infections, while the remaining five were categorized as profound or deep-seated infections. Regular microbiological cultures were conducted on all patients diagnosed with SSIs, among which 18 (85.7%) returned positive outcomes. However, in the case of two of the patients experiencing deep infection and one with superficial infection at the site of operation, no identifiable microorganisms could be isolated. Seven SSIs were attributed to mixed bacterial infections, while the remaining 14 were caused by a single bacterium each. Please refer to Figures 1, 2,3, and 4 for more information on the causative organisms.

Nine cases of SSI (42.8%) were diagnosed as having multiple strains of drug-resistant bacteria. Among these strains, meticillin-resistant coagulase-negative staphylococcus (MRCNS) was observed in the majority of cases (55.5%).

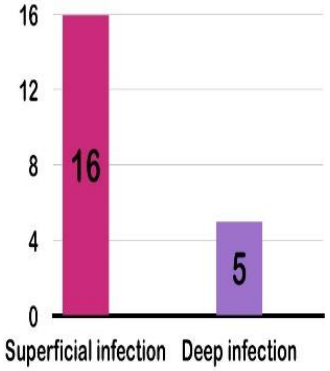

Figure 1 Location of SSI

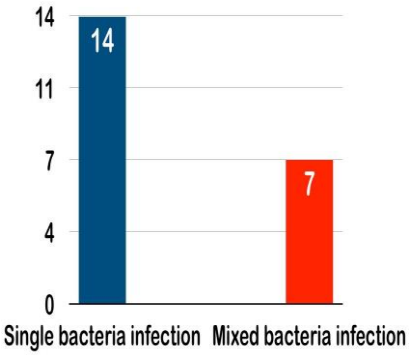

Figure 2 Types of Bacterial Infections

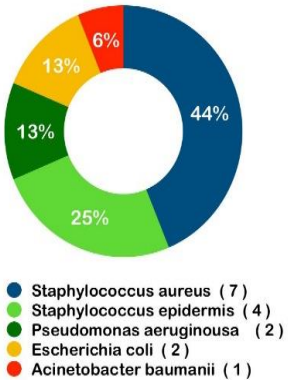

Figure 3 Causative of Single bacterial infection

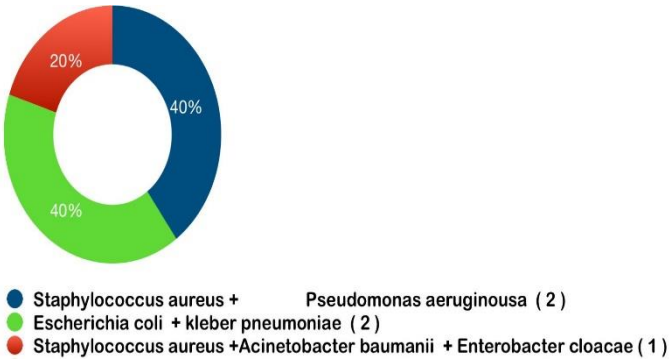

Figure 4 Causative of Mixed bacterial infection

Before the surgical intervention, 17 (13.7%) had coronary artery affliction,15 of the patients (12%) presented with diabetes, 12 (9.6%) suffered from morbid obesity, 4 (3.2%) had chronic obstructive respiratory disease, 2 (1.6%) were diagnosed with sleep apnea, 3 (2.4%) suffered from atrial fibrillation, and 52 (41.9%) were habitual smokers. Prior spinal surgical procedures had been administered to 23 of the patients (18.5%). The median quantities of surgically intervened segments, fused interbody levels, and decompressed segments were 3 (with an interquartile range of 2–4), 3 (with an interquartile range of 2–3), and 2 (with an interquartile range of 1–3), sequentially. Two patients (constituting 1.6% of the sample) experienced a cerebrospinal fluid (CSF) leak. The duration of hospitalization was five days as the median (Interquartile Range (IQR) 3-6).

The determination of the postoperative infection took place after approximately 0.5 months (with an interquartile range of 0.25-0.9 months). Among all the cases, 13 (61%) had undergone a surgical procedure comprising incision, drainage, and/or debridement of the infection, while 1 (4.7%) had their hardware extracted as a crucial measure to prevent and control contagion. The frequency of surgical intervention was greater in situations where infections occurred subfascially when compared to cases of superficial infections (90% vs 30%, p = 0.0009). Out of the patients necessitating a subsequent

surgery, a mere 7% required a twin purging to wholly eliminate the infection, as compared to the remaining twelve patients (93%) who only needed a sole purging. Eleven patients (84%) underwent primary closure, while two patients (15%) received negative pressure wound therapy, namely, wound VAC (vacuum-assisted closure).

Seventeen participants (equivalent to 73%) received antibiotics intravenously for a median span of 1.5 months (with an interquartile range of 0.7-1.5 months), whereas a minor fraction of four individuals (equivalent to 19%) received antibiotics oraly for a median span of 0.6 months (with an interquartile range of 0.5-1.3 months). After a median follow-up duration of 12 months (interquartile range of 6-26 months), none of the patients (0%) exhibited any indications of recurring infection as determined by CBC, ESR, and CRP.

Univariate proportional hazards regression analysis It has been disclosed that a number of factors were associated with spinal infection after surgical procedures, including advanced age, prolonged hospitalization, diabetes patients, obesity, atrial fibrillation, prior surgical history, and The quantity of levels operated on and fused surgically. the occurrence of perioperative urinary tract infection, and the development of cerebrospinal fluid (CSF) leak. Other clinical characteristic, such as cigarette smoking and the number of spinal decompressed and interbody fused segments, showed no significant association with infection after operations.

Several factors contributed to an elevated risk of infection, which included diabetes (RR 6.683 [95% CI 1.422–19.737]; p = 0.02), obesity (RR 7.216 [95% CI 1.932–8.338]; p = 0.005), lengthy hospitalization (RR 1.188 [95% CI 1.055–1.185]; p = 0.003), aging (RR 1.008 [95% CI 1.001–1.012]; p = 0.049), as well as past surgical spine surgery (RR 2.994 [95% CI 1.263–9.346]; p = 0.009).

Table 1 Various factors accounted for an increased possibility of SSI

Factors	Incidence
Diabetes	(RR 6.683 [95% CI 1.422–19.737], p = 0.02)
Obesity	(RR 7.216 [95% CI 1.932–8.338], p = 0.005)
Prolonged duration of hospitalization	(RR 1.188 [95% CI 1.055–1.185], p = 0.003)
Aging	(RR 1.008 [95% CI 1.001–1.012], p = 0.049)
Prior spine surgery	RR 2.994 [95% CI 1.263–9.346], p = 0.009)

The variables demonstrating the most conspicuous correlation with an elevated risk of infection after the operation, as per distinct analyses, were an age surpassing 70 years, more than two spinal segments operated previously, and staying in a hospital extending beyond seven days.

4. Discussion

Among the 124 consecutive persons who underwent lumbar transpedicular fixation and posterior interbody fusion for spinal degenerative disease, a total of 21 person (16.9%) developed postoperative spinal infections. In 76.1% of the affected individuals, the infection was superficial, while in 23.8% of cases, it was below the fascia During the one-year postoperative follow-up period.

Nine cases (42.8%) of SSI were found to have multiple drug-resistant strains, with meticillin-resistant coagulase-negative staphylococcus (MRCNS) being the most frequent, accounting for 5 cases (55.5%). The frequency of surgical intervention exhibited a remarkable increase in the instances where the infections were subfascial in comparison with superficial infections (90% versus 30%, p = 0.0009).

The variables that exhibited an augmented probability of infection within this patient cohort included an age exceeding 70 years, a diabetic condition, corpulence, antecedent spinal operations, coupled with a hospital stay that exceeded five days.

Of the entire cohort, 13 cases (61%) underwent a surgical intervention that encompassed an incision and/or excision, drainage, and/or debridement of the infection. Meanwhile, 1 case (4.7%) necessitated the extraction of the hardware as a crucial measure for the prevention and management of contagion.

Prolonged administration of antibiotics beyond a duration of three days, coupled with diminished lymphocyte count lower than 1.1 × 109/L, have been established as being autonomously correlated with SSI.

The frequency of surgical site infections (SSIs) subsequent to lumbar fusion exhibited variation contingent upon the surgical method employed, with rates ranging from 0% to 20%.2,6 This is consistent with our findings, which revealed an incidence rate of 16.9 %. These differences in incidence rates can be attributed to variations in methodologic study, characteristics of patients, SSI definition, and follow-up periods. Ter Gunne et al. assessed a total of 3174 persons who were subject to diverse forms of spinal surgery. The study revealed that 132 patients contracted spinal infections in their postoperative period.3

The findings from de Kunder et al.'s meta-analysis indicate that there is a notable disparity between the outcomes of transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF), with the latter showing a higher incidence of infections (2.8% as compared to 1.6%) and overall complications (17.0% compared to 8.7%).

This outcome is plausibly credited to the bilateral approach practiced in PLIF, which culminates in comparatively extended traction on proximal tissues and consequently escalates the likelihood of bacterial colonization.

Olsen et al. examined 2316 patients who underwent orthopedic surgery on the spine, among whom 635 did not receive instrumented fusion; the likelihood of acquiring an infection was discovered to be elevated in individuals possessing diabetes. Elevated serum glucose levels, obesity, non-cervical spine surgery cases, and an increased number of residents involved in the surgical procedure.2

Individuals who have undergone surgical interventions in their lumbar spinal region. in the past and/or have been hospitalized for a longer period of time are also susceptible to an elevated susceptibility to infection. Similar to obesity, patients with a history of lumbar surgery usually encounter extended surgical durations, amplified procedural intricacy, and a likelihood for durotomies.29

Comorbidities like chronic cardiac ailments, renal insufficiency, and diabetes mellitus are consequential risk factors for adverse events following surgical procedures. Our research indicates that these conditions individually escalate the chances of surgical site infections (SSI), with an especially formidable correlation ranging from 2.88 to 4.23. Heart disease and diabetes mellitus have long been established as SSI risk factors in a variety of surgical disciplines. The root causes are typically linked to a compromised microcirculation status of the surgical regions' neighboring tissues; these conditions could be caused by venous insufficiency, iatrogenic microvascular injury, or diabetic vasculopathy. 11,14.

In research conducted by Claus and his associates 20. in relation to preoperative complications following TLIF, it was determined that age did not serve as a forecaster of major or minor complications. Elderly patients exhibit not only diminished immune system efficacy but also a reduced capacity to endure prolonged operative interventions, diminished physiological reserves and escalated likelihood of postoperative complications in comparison to younger patients.28

This study revealed that patients with advanced age recorded an elevated likelihood of postoperative spinal infection, and those surpassing the age of 70 displayed

the highest proclivity towards infection. This discovery has been observed by Kurtz and colleagues in prior investigations of persons undergoing any form of spinal surgery.26Blam et al. exclusively assessed cases with trauma, where 57% of whom suffered from cervical spine injuries. The study concluded that out of 256 trauma patients, 24 individuals experienced infections.24Likewise, it was discovered by Sponseller and his colleagues that out of 210 patients who underwent surgery for neuromuscular scoliosis, 25 of them succumbed to postoperative infections. Out of this group of 25 individuals, 16 presented with myelomeningoceles and 9 with cerebral palsy. It was further observed that the risk of infection was augmented by the extent of cognitive debilitation as well as the implementation of allograft procedures.25 A contemporary investigation conducted by Li et al. 17. was unable to demonstrate a significant discovery in their analysis of lumbar fusion surgery, despite the fact that the length of antibiotic prophylaxis usage after surgery resembled ours (3.0 compared to 2.6 days). Another research carried out by Leslie et al22 This study entailed a prospective comparative analysis aimed at evaluating the effectiveness of administering preoperative measures.

Ceftriaxone-only regimen against before operation plus after operation ceftriaxone regimen in spinal fusion. The study revealed an absolute variation in SSI incidence, encompassing 3.3% for the before-plus-after regimen and 1.3% for the before-only regimen. The dissimilarity, however, was not statistically significant, primarily owing to the comparatively diminutive sample size. In a comparative study evaluating postoperative outcomes following the administration of antibiotic prophylaxis for a duration of one day as opposed to five days, researchers observed an identical incidence of complications in the surgical wound (28.6% as compared to 27.9%).10 The selection and duration of prophylactic antibiotics administered postoperatively are primarily determined by the regimen, which is influenced by the treating surgeon's preferences and experience. We categorized the cases into two parts in a random fashion upon their prophylactic antibiotic usage: greater than three days and less than or equal to 3 days. It was revealed that the latter group had a 2.3 times higher probability for the risk of surgical site infection. A recent examination undertaken by Li et al. 17 failed to reveal a substantial outcome in their research centered on lumbar fusion surgery, despite the fact that the duration of antibiotic use post-surgery was quite similar to ours (specifically, 3.0 versus 2.6 days, which was overall comparable).

This study provides a multitude of valuable insights, both in terms of its strengths and limitations. The degree of infection risk remains uncertain. Due to the inclusion of diverse patient populations in prior studies, the outcomes may not be easily extrapolated to individuals undergoing instrumented fusion and posterior lumbar interbody fusion for lumbar spinal degenerative conditions.30

The study at hand distinguishes factors that are autonomously concomitant with infection among this particular person’s population. Advanced age, diabetes, corpulence, past surgical history in the lumbar spine, and prolonged hospitalization were all distinctly concomitant with infection. A person presenting with these characteristics ought to be regarded as subject to more stringent implementation of infection control measures, comprising of aseptic procedure, Extended period of antibiotics before operation, and conceivably closer examination. It has come to our realization that hardware removal, as a means of infection prevention, is often unnecessary.

However, it is worth noting that this research was subject to certain limitations. Primarily, the study was not designed with the intention of evaluating the efficacy of sterilization methodologies or antibiotic regimens administered before and after operation. As such, the surgical process details such as sterilization methodologies, antibiotic regimen before operation, and times were not consistently recorded, negating any possibilities for impact evaluation on the results. In addition, a small subset of individuals was lost during follow-up, which may have resulted in the exclusion of

individuals who suffered from delayed infections or sought treatment elsewhere. Furthermore, the hardware type utilized was not systematically documented, preventing an analysis of any potential correlation between hardware type and post-operative infection incidences.

This study was also insufficient in determining whether hardware removal was a prerequisite for infection treatment, as only 4.7% of the 21 patients who encountered postoperative wound infections necessitated hardware removal. It is crucial to conduct larger studies with more extensive follow-up periods for a definitive prognosis

5. Conclusion

Lumbar fusion in the posterior with PLIF is a surgical remedy that is gaining prominence in the management of degenerative spinal disease. However, despite its increasing utilization, the aftermath of spinal infection remains a feared complication. According to this study, postoperative infection affected roughly 16.9% of patients, with an established correlation between this risk and a host of factors, such as prolonged hospital stay, previous surgical interventions, advanced age, diabetes, and obesity. However, it is noteworthy that 95% of infected patients received successful treatment with surgical interventions or antibiotic medication without necessitating the removal of hardware.

REFERENCES

[1] de Kunder SL, van Kuijk SMJ, Rijkers K, et al. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in lumbar spondylolisthesis: a systematic review and meta-analysis. Spine J. 2017;17 (11):1712-1721.

[2] Olsen MA, Nepple JJ, Riew KD, et al. Risk factors for surgical site infection following orthopaedic spinal operations. J Bone Joint Surg Am. 2008;90 (1):62-69.

[3] Pull ter Gunne AF, Mohamed AS, Skolasky RL, van Laarhoven CJ, Cohen DB: The presentation, incidence, etiology, and treatment of surgical site infections after spinal surgery. Spine (Phila Pa 1976) 35:1323–1328, 2010

[4] Blumberg TJ, Woelber E, Bellabarba C, Bransford R, Spina N. Predictors of increased cost and length of stay in the treatment of postoperative spine surgical site infection. Spine J. 2018;18 (2):300-306.

[5] Fei Q, Li J, Lin J, et al. Risk factors for surgical site infection after spinal surgery: a meta-analysis. World Neurosurg. 2016;95:507-515.

[6] Yan DL, Pei FX, Li J, Soo CL. Comparative study of PILF and TLIF treatment in adult degenerative spondylolisthesis. Eur Spine J. 2008;17 (10):1311-1316.

[7] Zhou J, Wang R, Huo X, Xiong W, Kang L, Xue Y. Incidence of surgical site infection after spine surgery: a systematic review and meta-analysis. Spine. 2020;45 (3):208-216.

[8] Melton LJ. The prevalence of osteoporosis. J Bone Miner Res. 2010;12 (11):1769-1771.

[9] Moltó A, Etcheto A, Désirée VDH, et al. Prevalence of comorbidities and evaluation of their screening in spondyloarthritis: results of the international cross-sectional ASAS-COMOSPA study. Ann Rheum Dis. 2015;75 (6):1016-1023.

[10] Berríos-Torres SI, Umscheid CA, Bratzler DW, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg. 2017;152:784-791.

[11] Sun Y, Wang H, Tang Y, et al. Incidence and risk factors for surgical site infection after open reduction and internal fixation of ankle fracture: a retrospective multicenter study. Medicine. 2018;97 (7):9901-9906.

[12] Wimmer C, Gluch H, Franzreb M, Ogon M. Predisposing factors for infection in spine surgery: a survey of 850 spinal procedures. Clin Spine Surg. 1998;11 (2):124-128.

[13] Thangarajah T, Prasad PSV, Narayan B. Surgical site infections following open reduction and internal fixation of ankle fractures. Open Orthopaed J. 2009;3 (1):56-60.

[14] Deng H, Chan A, Ammanuel S, et al. Risk factors for deep surgical site infection following thoracolumbar spinal surgery. J Neurosurg Spine. 2019;32 (2):292-301.

[15] Miao J, Chen D. Risk factors for incision infection after spinal surgery. Chin J Spin Cord. 2010;3:246-249.

[16] Xu X, Zhang D. Retrospective study of orthopedic surgical site infection rate and risk factors. Chin J Infect Contr. 2010;02:109-111.

[17] Li Z, Liu P, Zhang C, et al. Incidence, prevalence, and analysis of risk factors for surgical site infection after lumbar fusion surgery: ≥2-year follow-up retrospective study. World Neurosurg. 2019;131:e460-e467.

[18] Liu JM, Deng HL, Chen XY, et al. Risk factors for surgical site infection after posterior lumbar spinal surgery. Spine. 2018;43 (10):732-737.

[19] Huang L, Cai Z, Chen K, et al. Multifactor analysis of risk factors for complications after posterior lumbar fusion. Chin J Orthop. 2017;37 (020):1285-1293.

[20] Claus CF, Lytle E, Tong D, et al. Elderly as a predictor for perioperative complications in patients undergoing multilevel minimally invasive Transforaminal lumbar Interbody fusion: a regression modeling study. Spine. 2020;45:735-740.

[21] Shi A. Effect of psychological intervention on preoperative tension of patients undergoing surgery. Chin J Misdiagn. 2005;5 (10):1933-1933.

[22] Hellbusch LC, Helzer-Julin M, Doran SE, et al. Single-dose vs multiple-dose antibiotic prophylaxis in instrumented lumbar fusion—a prospective study. Surg Neurol. 2008;70 (6):622-627.discussion 627.

[23] Gu W, Tu L, Liang Z, et al. Incidence and risk factors for infection in spine surgery: a prospective multicenter study of 1764 instrumented spinal procedures. Am J Infect Control. 2018;46 (1):8-13.

[24] Blam OG, Vaccaro AR, Vanichkachorn JS, Albert TJ, Hilibrand AS, Minnich JM, et al. Risk factors for surgical site infection in the patient with spinal injury. Spine (Phila Pa 1976) 28:1475–1480, 2003

[25] Sponseller PD, LaPorte DM, Hungerford MW, Eck K, Bridwell KH, Lenke LG: Deep wound infections after neuromuscular scoliosis surgery: a multicenter study of risk factors and treatment outcomes. Spine (Phila Pa 1976) 25:2461–2466, 2000

[26] Kurtz SM, Lau E, Ong KL, Carreon L, Watson H, Albert T, et al. Infection risk for primary and revision instrumented lumbar spine fusion in the Medicare population. Clinical article. J Neurosurg Spine 17:342–347, 2012

[27] Fang A, Hu SS, Endres N, Bradford DS: Risk factors for infection after spinal surgery. Spine (Phila Pa 1976) 30:1460–1465, 2005

[28] Laigle-Donadey F, Delattre JY: Glioma in the elderly. Curr Opin Oncol 18:644–647, 2006

[29] Wimmer C, Gluch H, Franzreb M, Ogon M: Predisposing factors for infection in spine surgery: a survey of 850 spinal procedures. J Spinal Disord 11:124–128, 1998

[30] Olsen MA, Mayfield J, Lauryssen C, Polish LB, Jones M, Vest J, et al. Risk factors for surgical site infection in spinal surgery. J Neurosurg 98 (2 Suppl):149–155, 2003