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Risk factors for perioperative complications following unilateral biportal endoscopic spine surgery

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KEY WORDS

lumbar disc herniation, lumbar spinal stenosis, perioperative complications, risk factor, unilateral biportal endoscopy

ABSTRACT

INTRODUCTION Unilateral biportal endoscopy (UBE) is a minimally invasive technique that has gradually gained popularity in the field of spine surgery.

AIM The aim of this study was to identify independent risk factors associated with the occurrence of perioperative complications following UBE surgery through a comprehensive retrospective analysis.

MATERIALS AND METHODS Consecutive patients who underwent UBE at the Department of Orthopedics of Beijing Friendship Hospital between June 2021 and July 2024 were retrospectively analyzed. Data on demographic characteristics, comorbidities, surgery-related parameters, and perioperative complications were extracted from medical records, and patients who did and did not develop complications were compared. Potential risk factors for perioperative complications were evaluated using univariable and multivariable logistic regression analyses.

RESULTS In a cohort of 322 patients, perioperative complications were observed in 20 individuals, yielding an overall incidence rate of 6.8%. Occurrence of perioperative complications was associated with higher body mass index (BMI >28 kg/m^2; P <0.001), diabetes mellitus (P <0.001), depression (P <0.001), preoperative analgesia (P = 0.03), American Society of Anesthesiologists classifiation (P <0.001), and longer operative time (>180 minutes; P <0.001). In the multivariable logistic regression analysis, surgery duration longer than 180 minutes (odds ratio [OR], 2.8; 95% CI, 1.5–5.4), depression (OR, 2.5; 95% CI, 1.3–4.7), and BMI greater than 28 kg/m^2 (OR, 3.1; 95% CI, 1.7–5.9) were identified as independent risk factors for complications.

CONCLUSIONS This study demonstrates that UBE surgery is an effective and safe minimally invasive technique for the management of lumbar degenerative diseases, with a relatively low complication rate of 6.8%. Longer operative time, preoperative depression, and a higher BMI were identified as independent risk factors for the occurrence of perioperative complications.

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INTRODUCTION Endoscopic spine surgery has become a cornerstone in the management of various degenerative spinal diseases.[1] Among the endoscopic techniques, unilateral biportal endoscopy (UBE) has emerged as a favored minimally invasive approach, as it is associated with reduced tissue disruption and expedited postoperative recovery.[2-5] UBE requires only 2 small incisions, thus offering significant technical benefits.[6] Nevertheless, intra- and postoperative complications remain an important concern for clinicians. Understanding and analyzing the risk factors for these complications is essential to improve surgical safety and patient prognosis.

Although extensive research has been conducted on complications and their associated risk factors in traditional open and single-channel endoscopic spinal surgeries, there are few studies specifically examining UBE-related complications.[1,7-10] Given the growing adoption of UBE in clinical practice, there is a pressing need for a systematic analysis of its complication profile. Such an endeavor would not only aid in reducing complication rates but also provide

an evidence-based framework for improving clinical decision-making.

AIM The aim of this study was to identify independent risk factors associated with the occurrence of complications during and after UBE surgery through a comprehensive retrospective analysis. By systematically collecting and evaluating clinical data, this study investigated the relationship between patient-specific characteristics, surgical parameters, and perioperative complications. Our findings not only contribute to a deeper understanding of UBE-specific complications but also offer a scientific foundation for optimizing surgical techniques and perioperative management strategies. Ultimately, the results are expected to offer novel insights into the field of spine surgery and support efforts to enhance the safety and effectiveness of UBE procedures.

MATERIALS AND METHODS **Patient selection** Consecutive patients who underwent UBE surgery at the Department of Orthopedics of Beijing Friendship Hospital between June 2021 and July 2024 were retrospectively analyzed. The surgical approaches included endoscopic discectomy, lateral recess decompression, unilateral laminectomy with bilateral decompression (UBE-ULBD), and unilateral biportal endoscopic lumbar interbody fusion. All procedures were performed by the same medical team.

The patients met the study inclusion criteria if they were older than 18 years, were diagnosed with a degenerative lumbar spine disease (including lumbar spinal stenosis, lumbar disc herniation, and lumbar spondylolisthesis), and underwent UBE surgery. Exclusion criteria encompassed 1) age below 18 years; 2) a history of prior lumbar spine surgery, including lumbar decompression surgery or lumbar interbody fusion surgery performed at the same level; and 3) a presence of spinal infections, tumors, or tuberculosis.

Surgical technique A patient was placed prone on a spine bed under general anesthesia. Using C-arm fluoroscopy, the surface projections of the midline, intervertebral space level, and pedicles were determined, and the surgical table was adjusted to make the target intervertebral space as perpendicular to the floor as possible. Two 2-cm incisions were made, 1.5 cm superior and inferior to the intervertebral space level, respectively, in the medial line of the ipsilateral pedicle. The left incision was used as an observation channel and the right one served as a working channel. The deep fascia was incised perpendicularly to the skin incision. The bilateral channels were dilated using a graduated dilatation cannula, with both dilatation cannulas accessing the lamina and intervertebral space and intersecting at the location of the lamina and intervertebral space. The surgeon held the spinal endoscope in the left hand and the instruments in the right hand. Endoscopic lenses and instruments were passed through the channels into the surgical site and manipulated in an aqueous medium. The saline height was adjusted to ensure that it was kept at a distance of approximately 70 to 100 cm from the incision.

The soft tissue on the surface of the intervertebral space was handled using radiofrequency probes (BONSS, Jiangsu, China), leading to gradual exposure of the inferior margin of the superior lamina, the base of the spinous processes, the articular process joints, and the superior margin of the inferior lamina. The bone (including part of the inferior margin of the lamina, the superior margin of the lamina, and the articular process) was partially removed using a grinder, a bone cutter, and a lamina biter, and the ipsilateral ligamentum flavum was resected following exposure of the distal end of the ipsilateral ligamentum flavum; the decompression range was up to the inner wall of the pedicle. Part of the base of the spinous process was then removed with a grinding drill. The contralateral ligamentum flavum was decompressed using the contralateral pedicle wall as a reference. Finally, complete resection of the bilateral ligamentum flavum was performed. After confirming complete decompression, radiofrequency probes were used for hemostasis. The incision was then closed, and a drain was placed.

Data collection and analysis Patient data were obtained from the electronic medical record system of the Beijing Friendship Hospital. The collected demographic and surgical data included age, sex, occupation, place of residence, body mass index (BMI), weight, height, presence of comorbidities, such as hypertension (ie, blood pressure ≥140/90 mm Hg), diabetes mellitus, coronary artery disease, osteoporosis, cerebrovascular disease, or hyperlipidemia, history of smoking, history of alcohol consumption, history of surgery, duration of pain, presence of anxiety or depression, history of allergies, duration of surgery, duration of hospitalization, diagnosis, number of fusion levels, American Society of Anesthesiologists (ASA) classification, total blood loss, and occurrence of perioperative complications. Perioperative complications were defined as complications that occurred intraoperatively or up to 6 weeks after the surgery.[11] Two investigators were responsible for data extraction, and the third investigator checked the accuracy of the data. All data were entered into a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, Washington, United States) for consistency checking and data cleaning.

Statistical analysis Univariable and multivariable logistic regression analyses were conducted to identify independent risk factors for perioperative complications. Stepwise regression was employed prior to the multivariable analysis to select variables. The variables demonstrating significant correlations (P <0.1) in the univariable analysis were included in the multivariable model. The R studio 4.4.0 package (The R Foundation

for Statistical Computing, Vienna, Austria) was used for statistical analysis. Continuous variables are presented as mean (SD). Categorical variables are shown as number (percentage). The *t* test or Mann–Whitney test was used for comparison of continuous variables, while the χ^2 test or Fisher exact test was employed to compare categorical variables. All statistical tests were 2-tailed, with a *P* value of less than 0.05 deemed significant.

Ethics statement The experimental protocol was reviewed and approved by the Ethics Committee of the Beijing Friendship Hospital (2022KY087). The study was conducted in accordance with the experimental protocol and the Declaration of Helsinki, and informed consent was obtained from all participants. Except for routine treatment during hospitalization, the patients did not receive any other treatment related to this study and were not exposed to additional risks.

RESULTS **General characteristics** A total of 322 patients (160 men, 162 women) at a mean (SD) age of 59.1 (14.3) years (range, 19–75 years) met the inclusion criteria. More than 80% of the study population were older than 40 years. The mean (SD) BMI of the patients was 26 (3.6) kg/m^2. Details regarding demographic characteristics and perioperative outcomes are shown in **TABLE 1**.

Perioperative complications In a cohort of 322 patients, perioperative complications were observed in 20 cases, yielding an overall incidence rate of 6.8%. The most prevalent complication was dural tear, occurring in 8 patients (2.5%). All instances of dural rupture were managed intraoperatively through the application of an artificial dural patch. Other notable complications included wound infection and delayed wound healing (3 patients [0.9%] each). Most of these cases responded favorably to antibiotic therapy and routine wound care, except for 1 patient who developed a deep wound infection necessitating intravenous antibiotics and surgical debridement.

Postoperative recurrence of disc herniation was recorded in 3 patients (0.9%). One individual experienced exacerbation of lower extremity pain on the second postoperative day, which was promptly managed with revision surgery, resulting in symptom resolution. The other 2 patients presented with early postoperative recurrences. One of them underwent open posterior lumbar revision surgery, while the other was successfully treated with a conservative approach.

Postoperative epidural hematomas were reported in 2 patients (0.6%), both of whom exhibited acute worsening of lower extremity symptoms. Diagnosis was confirmed on postoperative computed tomography (CT) or magnetic resonance imaging (MRI). One patient achieved symptomatic improvement with conservative treatment, whereas the other required surgical evacuation of the hematoma. Additionally, 1 patient developed transient postoperative lower extremity hypomobility, which resolved completely after 3 months of conservative treatment.

Univariable and multivariable analysis Univariable analysis showed that factors such as diabetes, longer surgery duration (>180 min), depression, preoperative analgesia, ASA classification, and BMI were significantly associated with perioperative complications after UBE surgery (**TABLE 1**).

In multivariable logistic regression analysis, surgery duration longer than 180 minutes (odds ratio [OR], 2.8; 95% CI, 1.5–5.4), depression (OR, 2.5; 95% CI, 1.3–4.7), and BMI greater than 28 kg/m^2 (OR, 3.1; 95% CI, 1.7–5.9) were identified as independent risk factors for complications. These variables remained significantly associated with complications even after adjustment for other factors (**TABLE 2**).

DISCUSSION UBE has emerged as a promising minimally invasive technique in spinal surgery, offering benefits such as reduced tissue trauma and faster recovery times.[12] The results of a recent meta-analysis of 528 patients undergoing UBE surgery showed significant improvement in both Visual Analog Scale and Oswestry Disability Index scores after UBE surgery, as compared with preoperative results. These findings demonstrate that UBE is associated with favorable clinical outcomes.[13] However, similarly to all surgical procedures, UBE is not without risks, particularly in terms of perioperative complications. The incidence of such complications, including infections, nerve injuries, and dural rupture, remains a critical concern for clinicians.[14] Despite growing adoption of UBE, there are few comprehensive studies investigating perioperative complications specifically associated with this technique, as well as the factors that may predispose patients to these adverse outcomes. Identifying these factors is crucial not only for improving surgical outcomes but also for developing targeted strategies to mitigate risks. In this study, we noted an overall complication rate of 6.8%, and identified 3 factors associated with an increased risk of complications, including operative time greater than 180 minutes, depression, and BMI greater than 28 kg/m^2.

Prolonged operative time has been consistently associated with an increased risk of perioperative complications in all types of surgery.[15-17] For UBE surgeries, an operative time longer than 180 minutes may result in a higher incidence of complications, such as infection, increased blood loss, and delayed wound healing.[18] There are several mechanisms behind effect. First, prolonged surgical time increases the duration of tissue exposure to the external environment, thus enhancing the risk of infection. In addition, prolonged surgery may lead to more bleeding and tissue damage, as well as extended postoperative recovery time, all of which may affect the complication rates. Second, prolonged anesthesia places an additional burden on the patient's physiological

TABLE 1 Characteristics of patients with and without complications following unilateral biportal endoscopic spine surgery

Parameter		Patients without complications (n = 302)	Patients with complications (n = 20)	*P* value
Age, y, mean (SD)		58.92 (14.3)	63 (9.7)	0.36
Age group, y	18–39	48 (15.9)	0	–
	40–59	62 (20.5)	6 (30)	
	≥60	192 (63.6)	14 (70)	
Sex	Men	152 (50.3)	8 (40)	0.53
	Women	150 (49.7)	12 (60)	
Occupation (manual work)		189 (62.6)	13 (65)	>0.99
Area of residence (rural)		106 (35.1)	8 (40)	0.84
Educational attainment (≥12 years)		119 (39.4)	9 (45)	0.6
BMI, kg/m^2, mean (SD)		25.88 (6.1)	28.97 (10.5)	0.01
BMI >28 kg/m^2		32 (10.6)	12 (60)	<0.001
Hypertension		142 (47)	12 (60)	0.43
Diabetes		40 (13.2)	12 (60)	<0.001
Coronary artery disease		14 (4.6)	2 (10)	0.46
Current smoking		50 (16.6)	2 (10)	0.59
Alcohol consumption		30 (9.9)	0	0.99
Osteoporosis		118 (39.1)	8 (40)	0.95
Cerebrovascular disease		24 (7.9)	4 (20)	0.21
Hyperlipidemia		50 (16.6)	6 (30)	0.29
History of surgery		178 (58.9)	16 (80)	0.2
Chronic pain (>3 years)		116 (38.4)	14 (70)	0.06
Anxiety		78 (25.8)	6 (30)	0.77
Depression		48 (15.9)	16 (80)	<0.001
Preoperative analgesia		56 (18.5)	10 (50)	0.03
ASA classification	I	136 (45)	4 (20)	<0.001
	II	140 (46.4)	8 (40)	
	III–IV	26 (8.6)	8 (40)	
Diagnosis	Radiculopathy with IVD	180 (59.6)	12 (60)	0.87
	Spinal stenosis	118 (39.1)	8 (40)	
	Cauda equina	4 (1.3)	0	
Operated segment	L1–L2	2 (0.7)	0	0.44
	L2–L3	4 (1.3)	0	
	L3–L4	24 (7.9)	0	
	L4–L5	182 (60.3)	10 (50)	
	L5–S1	56 (18.5)	6 (30)	
	Multilevel	34 (11.3)	4 (20)	
Type of surgery	Discectomy	170 (56.3)	8 (40)	0.33
	Lateral recess decompression	76 (25.2)	8 (40)	
	ULBD	46 (15.2)	4 (20)	
	Other	10 (3.3)	0	
Total blood loss, ml, mean (SD)		56.77 (20.6)	68.50 (28.7)	0.67
Surgical duration, min, mean (SD)		125.45 (30.1)	146 (25.6)	0.32
Surgical duration ≥180 min		38 (12.6)	14 (70)	<0.001
Total hospitalization costs, RMB, mean (SD)		47 573.37 (300.5)	48 507.43 (250.4)	0.66
Length of hospitalization, d, mean (SD)		9.2 (2.2)	12 (4.5)	0.17

Data are presented as number (percentage) unless indicated otherwise.

P <0.05 was considered significant.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; IVD, intervertebral disc degeneration; RMB, Chinese yuan renminbi; ULBD, unilateral laminectomy with bilateral decompression

TABLE 2 Multivariable analysis of factors independently associated with complications following unilateral biportal endoscopic surgery

Variable		OR	95% CI	*P* value
Diabetes		5.48	0.43–70.52	0.19
Surgical duration ≥180 min		16.61	1.7–162.42	0.02
Depression		9.32	1.11–78.64	0.04
Preoperative analgesia		2.65	0.29–24.57	0.39
ASA classification	I	Reference	–	–
	II	0.65	0.04–9.51	0.75
	III–IV	3.53	0.23–54.59	0.37
BMI >28 kg/m^2		16.13	1.62–160.24	0.02

Abbreviations: OR, odds ratio; others, see **TABLE 1**

function and may cause anesthesia-related complications, such as cardiovascular and respiratory problems. It also increases the risk of postoperative cognitive dysfunction, especially in elderly patients.[19] Third, prolonged surgical times often reflect the complexity and difficulty of the procedure, and complex surgeries are inherently more prone to complications. Long and demanding procedures are also a great test of the physical strength and concentration of the surgical team, and may increase the risk for operational errors and complications. All things considered, shortening the duration of surgery as much as possible by optimizing the surgical process and improving surgical efficiency could significantly reduce the incidence of postoperative complications in spine surgery and improve the quality of patient postoperative recovery.

Psychiatric disorders, particularly depression, have been identified as important risk factors for postoperative complications. Chronic pain is often accompanied by a depressive state. Depression significantly influences the development of postoperative complications in spine surgery, and its mechanisms of action are complex and multifaceted. Biologically, patients with depression often present with abnormal immune function, including decreased lymphocyte activity and elevated levels of proinflammatory cytokines, leading to poor wound healing and increased risk of infection. In addition, depression is associated with dysregulation of the hypothalamic-pituitary--adrenal axis, causing elevation of cortisol levels, which further impairs immune response and tissue repair.[20] On a psychological level, depressed patients are more sensitive to pain perception, which not only makes postoperative pain management more difficult but may also lead to overuse of analgesic medications (especially opioids), increasing the risk of complications such as respiratory depression and gastrointestinal problems. Behaviorally, depression often leads to poor adherence to postoperative care, including decreased willingness to take medications on schedule, attend regular follow-up appointments, and participate in physical therapy, all of which increase the risk of poor wound healing and undetected complications.[21] In addition, depression is often associated with poor lifestyle habits, such as smoking, inadequate diet, and lack of exercise, which further impact postoperative recovery. Therefore, comprehensive preoperative assessment and multidisciplinary collaborative management of depression, combined with psychological support and optimized rehabilitation programs, are essential to reduce the incidence of perioperative complications and improve the prognosis of patients undergoing spine surgery.[22] In patients scheduled for UBE surgery, mental health status should be carefully assessed preoperatively. Interventions such as preoperative counseling, optimized antidepressant treatment, and postoperative psychological support may help reduce the risks and improve overall surgical outcomes.

BMI greater than 28 kg/m^2 was shown to have a significant impact on the development of perioperative complications in spine surgery. This association involves several mechanisms. First, high BMI is closely associated with greater intraoperative technical difficulty. Excess adipose tissue restricts the surgical field of view and reduces the operating space, which makes the surgical procedure more complex and elevates the risk of intraoperative blood loss and postoperative infection.[23,24] In addition, high BMI affects anesthesia management and increases the likelihood of anesthesia-related complications, such as difficult airway management and postoperative respiratory depression. During the postoperative recovery phase, patients with obesity tend to experience limited mobility and greater difficulty in rehabilitation, which may further prolong hospitalization and postoperative recovery time.[25] To mitigate these risks, comprehensive preoperative assessment, individualized surgical and anesthetic plans, and specialist postoperative care and rehabilitation support should be provided to optimize surgical outcomes and quality of postoperative recovery in patients with high BMI.

This study has several limitations that should be considered when interpreting the findings. First, its retrospective design makes it inherently subject to a selection bias and incomplete data collection, potentially impacting the accuracy and reliability of the results. Second, the relatively small sample size, as compared with multicenter

retrospective studies, may limit the statistical power, particularly in the analysis of rare complications. However, it appears to be a common limitation of many single-center studies exploring endoscopic spinal surgery. The main reason for that is the relatively low complication rate of endoscopic spinal procedures such as UBE, as compared with conventional open surgery. Furthermore, as this was a single-center study, there may be considerable variability in surgical techniques, postoperative management, and patient selection criteria in comparison with other institutions, which affects generalizability of the outcomes. Consequently, future research should include larger, multicenter cohorts to validate these findings and enhance their applicability across diverse clinical settings.

CONCLUSIONS This study demonstrated that UBE surgery is an effective and safe minimally invasive technique for the management of lumbar degenerative diseases, with a relatively low complication rate of 6.8%. Additionally, we identified operative time greater than 180 minutes, preoperative depression, and a BMI greater than 28 kg/m^2 as independent risk factors for the occurrence of perioperative complications. These findings suggest that careful patient selection and optimization of these risk factors are crucial for minimizing complication rates and improving surgical outcomes in patients undergoing UBE procedures.

ARTICLE INFORMATION

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CONTRIBUTION STATEMENT JS and ZZ made substantial contributions to the conception of the work. JS and ZF were responsible for the acquisition and analysis of data. JS and HM drafted the manuscript. HM performed data management and statistical analysis. QF revised the manuscript critically for important intellectual content. All authors approved the final version to be published.

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CONFLICT OF INTEREST None declared.

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