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ORIGINAL RESEARCH

Awake Unilateral Biportal Endoscopic Decompression Under Local Anesthesia for Degenerative Lumbar Spinal Stenosis in the Elderly: A Feasibility Study with Technique Note

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Purpose: Here, we introduce a novel strategy of awake unilateral biportal endoscopic (UBE) decompression, which applies conscious sedation combined with stepwise local anesthesia (LA) as an alternative to general anesthesia (GA). The study aims to evaluate the feasibility of awake UBE decompression for degenerative lumbar spinal stenosis (DLSS) in elderly patients.

Patients and Methods: This retrospective study included 31 consecutive patients who received awake UBE decompression for DLSS in our institution from January 2021 to March 2022. Clinical results were evaluated using patient-reported outcomes measures (PROM) including visual analog scale for leg pain (VAS-LP), Oswestry Disability Index (ODI), and modified MacNab criteria. The anesthesia effectiveness and intraoperative experience were evaluated by intraoperative VAS and satisfaction rating system.

Results: UBE decompression was successfully performed in all patients under LA combined with conscious sedation. 26 (83.9%) patients rated the intraoperative experience as satisfactory (excellent or good) and 5 (16.1%) as fair. The mean intraoperative VAS was 3.41±1.26. The VAS and ODI at each follow-up stage after surgery were significantly improved compared to preoperative scores ($p <$ 0.01). At the last follow-up, 28 patients (90.3%) classified the surgical outcome as good or excellent, and 3 (9.7%) as fair. There were no serious complications or adverse reactions observed in the study.

Conclusion: Our preliminary results suggest that awake UBE decompression is a feasible and promising alternative for elderly patients with DLSS.

Keywords: awake spinal surgery, local anesthesia, degenerative lumbar disease, biportal endoscopic spine surgery, enhanced recovery after surgery

Introduction

DLSS is a clinical syndrome characterized by neurogenic claudication or radicular pain. The pathogenesis is narrowing of the lumbar spinal canal caused by degeneration of discs, facet joints, and ligamentum flavum, leading to compression of neural structure.[1,2] Conservative treatment options like physical therapy and medication are usually tried first, but surgery may be necessary if these methods are not effective.[3] Traditional surgical methods for DLSS include open laminectomy or laminotomy, which involves extensive paravertebral muscle anatomy and disruption of posterior stabilizing structures that may be associated with postoperative instability and paravertebral muscle atrophy.[4] Additionally, the use of GA during these procedures poses a potential risk, especially for elderly patients with comorbidities.[5–7] As a result, awake spinal surgery (ASS), a new strategy combining minimally invasive techniques with conscious LA, is increasingly promoted.[8,9] Several studies have demonstrated the benefits of ASS in reducing complications and accelerating postoperative recovery.[10–13]

Received: 9 October 2023
Accepted: 2 January 2024
Published: 6 January 2024

In recent years, unilateral biportal endoscopy (UBE) technique has gained popularity in the field of spine surgery. This technique utilizes two small incisions, one to introduce arthroscope for observation and the other to introduce instruments for manipulation. UBE combines the advantages of microscopy and percutaneous uniportal endoscopy: Minimal tissue damage, clear vision, flexible and efficient operation.[14,15] UBE decompression has been established as an effective alternative to microscopic decompressive laminectomy for DLSS.[16] UBE surgery is typically performed under general anesthesia or epidural anesthesia, and there are few reports about UBE under conscious LA.[17] Here, we present a novel strategy of "awake UBE decompression" using conscious sedation combined with stepwise LA as an alternative to GA and report early clinical results. The aim of this study is to evaluate the feasibility of awake UBE decompression protocol for DLSS in the elderly population.

Materials and Methods

This study was approved by the ethics committee of our institution, and the patient's informed consent form was exempted, given the retrospective observational nature. The consecutive patients who received awake UBE decompression for DLSS in our institution from January 2021 to March 2022 were included. The regimen of awake local anesthesia was determined according to the patient's physical condition and preferences. ALL surgeries were performed by the senior physician (Da Liu) with extensive experience in spinal endoscopic surgery.

The indications were: 1) neurogenic claudication or radiculopathy symptoms refractory to conservative management for at least three months; 2) DLSS confirmed by radiology; 3) age 65 years or above. The exclusion criteria included: 1) segmental instability; 2) spondylolisthesis greater than grade I; 3) stenosis caused by disc herniation; 4) complicated with spinal infection, trauma, or tumor; 5) previous surgical history at target level; 6) follow-up time < 1 year.

Operation Technique

The patient lay prone on the operating table with the belly suspended. Patients undergo prone position exercises prior to surgery to prevent intolerance of prolonged intraoperative positions. The electrocardiogram, oxygen saturation and blood pressure monitoring and nasal catheter oxygen supply were performed routinely. Dexmedetomidine hydrochloride was administered intravenously for sedation, and an anesthesiologist adjusted the titration rate to ensure communication between the patient and operating room personnel. A waterproof sterile drape was applied after fluoroscopic localization of the target segment and incisions.

We used a stepwise anesthesia strategy, which included routine LA in the posterior region of the lamina window and epidural injection. Firstly, we performed local infiltration anesthesia in the incision area. The LA solution was prepared by mixing 2% lidocaine 10mL, 1% ropivacaine 10mL and 0.9% saline 20mL. Approximately 15–20mL of anesthetic mixture was injected into the incision area, including skin, subcutaneous tissue, fascia, muscles, lamina periosteum, and medial facet joint areas with a 5 gauge syringe needle.

Secondly, we established the view portal and working portal. We incised the skin and fascia and inserted serial dilators to expand the intramuscular septum. A blunt dissector was used to detach soft tissue from the lamina. A 30° arthroscope (Smith and Nephew, USA) was introduced through the cranial incision, and continuous saline irrigation was initiated. The surgeon can maneuver the surgical instruments flexibly through the caudal channel.

Thirdly, we exposed the ligamentum flavum and injected ropivacaine into the epidural space. Radiofrequency ablation (Smith and Nephew, USA), Kerrison punch, and forceps were used to dissect and clear soft tissue around the spinolaminar junction and interlaminar space. An 18 gauge spinal needle was then inserted through the ligamentum flavum and into the midline region of the epidural space (Figure 1A). Under endoscopy, epidural puncture is more operationally straightforward, enabling better control of puncture depth and enhancing safety. We injected 5 mL of 1% ropivacaine into the posterior epidural space after confirmation of the needle tip position by aspirating the syringe. We recommend injecting before opening the ligamentum flavum to prevent the irrigation fluid from entering the epidural space and diluting the anesthetic or flushing it away.

Fourthly, routine unilateral laminotomy for bilateral decompression (ULBD) was performed as described in the previous studies.[14,16] Ipsilateral laminotomy was performed with endoscopic high-speed burr and osteotomes. Then the hypertrophic ligamentum flavum and the medial part of the superior articular process were excised with Kerrison

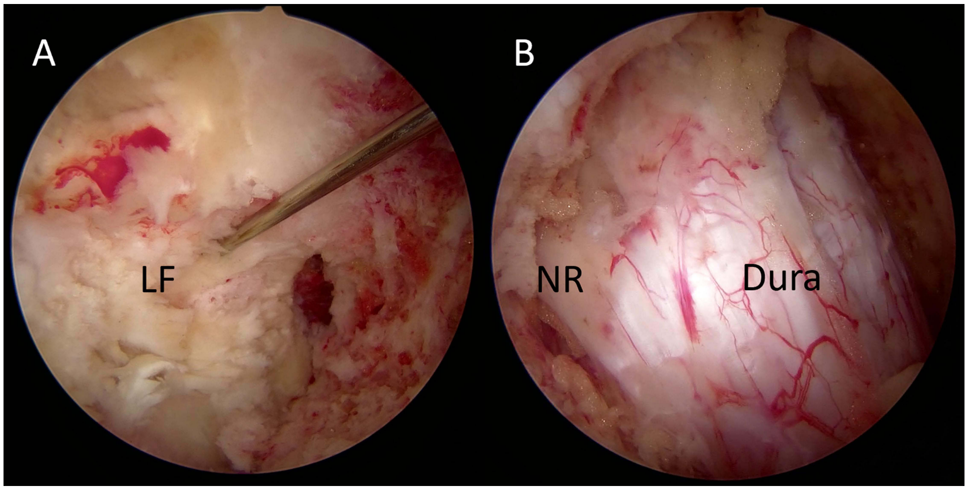

Figure 1 (**A**) Ropivacaine is injected into the epidural space using a spinal needle. (**B**) Dural sac and nerve root after decompression. LF, ligamentum flavum; NR, nerve root.

punches and curettes. If the arthroscope and instruments were obstructed, resected part of the spinous process base using a high-speed burr as needed. Contralateral decompression was then performed using the "over the top" technique until the dural sac regained pulsation and the contralateral nerve root was released (Figure 1B).

Outcome Evaluation

The demographics, perioperative data, complications and adverse reactions, including postoperative nausea and vomiting (PONV) and delirium (POD) were collected from the patients' medical records. Patients were asked to describe intraoperative pain intensity using visual analogue scale (VAS). In addition, we introduced a four-level grading system of excellent, good, fair, and poor for patients to evaluate their intraoperative experience. Clinical results were evaluated using PROM, including VAS-LP, ODI, and modified MacNab criteria.[18,19] The postoperative VAS-LP and ODI questionnaires were conducted at 3 months, 6 months, and 12 months after surgery, and modified MacNab criteria questionnaire was conducted at the last follow-up.

Statistical Analysis

Statistical analysis was performed using SPSS 22.0 (IBM, Chicago, USA). Continuous variables are expressed as means ± standard deviations. The normality of the data was assessed using the Shapiro–Wilk test. Both the ODI and the VAS-LP were found to follow a normal distribution. Subsequently, repeated measures analysis of variance (ANOVA) and *t*-tests were employed for comparisons. A p value < 0.05 was considered statistically significant.

Results

General Information

A total of 31 (13 male and 18 female) consecutive patients undergoing awake UBE decompression were included in the study. The demographics are listed in Table 1. The average age was 70.49 ± 9.21 years (range 65–89 years). The mean follow-up period was 16.46 ± 3.19 months (range 12–24 months). 4 patients underwent two-level decompression, while the rest underwent single-level decompression. A total of 35 spinal levels were operated, including 2 at L2–3, 8 at L3-4, 16 at L4-5, and 9 at L5–S1 level. According to the ASA classification, 24 patients were classified as III and 7 as II.

Intraoperative Experience and Complications

UBE decompression was successfully performed in all patients under LA, and no one converted to GA or terminated the procedure. The operation-related variables are shown in Table 2. The operation time (from LA injection to incision closure) was 62.85 ± 30.40 minutes. 26 (83.9%) patients rated the intraoperative experience as satisfactory (excellent or

Table 1 Patient Demographic and Clinical Characteristics

Characteristics	Value
Age (year)	74.09±6.93
Sex, male (n)	13 (41.9)
BMI (kg/m²)	23.80±5.71
ASA classification (n)	
II	7 (22.6)
III	24 (77.4)
Level involved (n)	
L2-3	2 (6.5)
L3-4	8 (16.1)
L4-5	16 (51.6)
L5-S1	9 (25.8)
Levels of decompression (n)	
One	27 (87.1)
Two	4 (12.9)
Follow-up time (month)	16.46 ± 3.19

Note: Values are presented as number (%) or mean ± standard deviation.
Abbreviations: BMI, body mass index; ASA classification, The American Society of Anesthesiologists Physical Status classification.

Table 2 Surgical Variables

Variable	Value
Operation time (min)	62.85±30.40
Intraoperative satisfaction (n)	
Excellent	17 (54.9)
Good	9 (29.0)
Fair	5 (16.1)
Intraoperative VAS	3.41±1.26
Postoperative hospital stays (day)	2.90±1.48
Complications and adverse reactions (n)	
Intraoperative neck pain	1
Transient lower limb numbness	3

Note: Values are presented as number (%) or mean ± standard deviation.
Abbreviation: VAS, visual analogue scale.

Table 3 Patient-Reported Outcomes Measures

Time Period	VAS-LP	ODI
Preoperative	5.93±2.80	67.51±16.93
3 Months Postoperative	1.87±1.02*	20.10±11.53*
6 Months Postoperative	1.61±0.62*	17.63±12.94*
12 Months Postoperative	1.54±0.72*	16.86±9.04*

Notes: *Compared to preoperatively, p < 0.001.
Abbreviations: VAS-LP, visual analogue scale for leg pain; ODI, Oswestry Disability Index.

good) and 5 (16.1%) as fair. The mean intraoperative VAS was 3.41±1.26. There were no serious complications such as dural tear, root injury, or infections. One patient experienced neck pain during surgery, which was relieved after controlling irrigation pressure and improving outflow. Three patients experienced transient postoperative lower limb numbness. No patient experienced postoperative nausea, vomiting and delirium. The postoperative hospital stay was 2.90 ±1.48 days.

Clinical Results

Patient-reported outcomes for each follow-up period are shown in Table 3. The mean preoperative VAS-LP was 5.93 ± 2.80, and in subsequent follow-up (postoperative 3 months, 6 months, 12 months), it was 1.87±1.02, 1.61±0.62, and 1.54 ±0.72, respectively. The mean preoperative ODI was 67.51±16.93, which improved to 20.10±11.53, 17.63±12.94, and 16.93±9.04 at the same follow-up times, respectively. The VAS and ODI scores at each follow-up stage after surgery were significantly improved compared to preoperative scores (p < 0.01). Based on the modified Macnab criteria questionnaire collected at the last follow-up, 28 patients (90.3%) reported good or excellent, and 3 (9.7%) reported fair results (Figure 2). The pre- and post-operative images of a typical case were displayed in Figure 3.

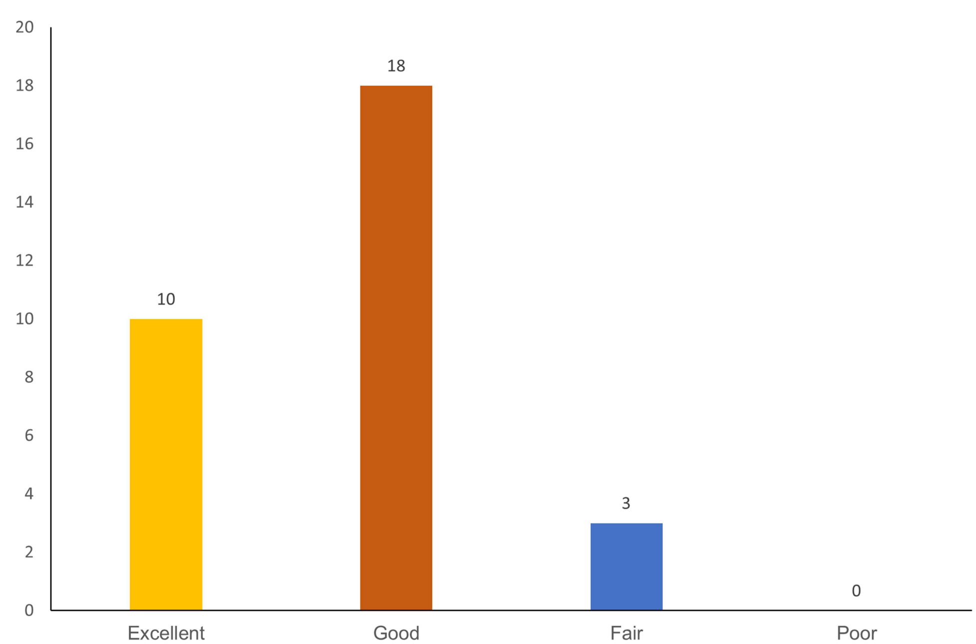

Figure 2 Clinical outcomes based on the modified Macnab criteria at last follow-up.

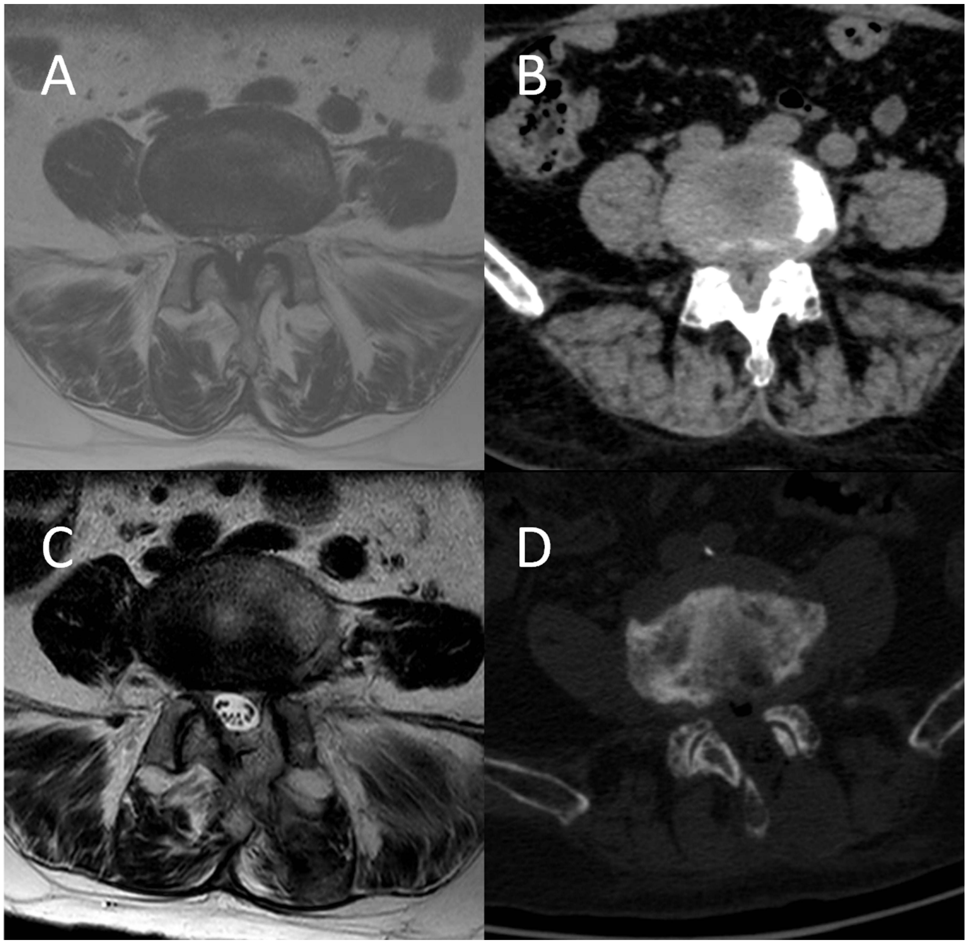

Figure 3 Typical case: A 75-year-old female patient complained of neurogenic claudication and was diagnosed with L4-5 degenerative lumbar spinal stenosis. (**A** and **B**) Preoperative axial MR and CT images at L4-5. (**C** and **D**) Postoperative axial MR and CT images.
Abbreviations: MR, magnetic resonance; CT, computed tomography.

Discussion

With the intensification of population aging, the surgical demand related to DLSS will become increasingly common. In addition to the advanced age and comorbid conditions, the invasiveness of surgery and the physiological effects of anesthesia are related to the perioperative morbidity and mortality risks of elderly patients. Awake endoscopic spinal surgery is attractive for patients, especially for the elderly with multiple comorbidities due to its minimal surgical trauma and anesthesia requirements. Uniportal endoscopy under LA has been applied to spinal fusion, decompression, and discectomy, and demonstrated the advantages in reducing complications, accelerating postoperative recovery, and reducing medical costs.[20–24] The emerging UBE technique has certain technical advantages over uniportal endoscopy for decompression procedures, and the learning curve is relatively gentle.[14,15] Epidural anesthesia is proposed as an alternative to GA in UBE. The advantages of epidural anesthesia compared to GA have been demonstrated, including better postoperative analgesia, reduced blood loss, better hemodynamic characteristics, reduced stress response, and lower medical costs.[6,25] However, we believe that LA is more convenient and time-saving, and allows for immediate postoperative neurological examination compared to epidural anesthesia. In addition, LA can avoid some specific complications of epidural anesthesia, such as total spinal anesthesia and postoperative urinary retention.[26–28] Here, we introduced a novel strategy of awake UBE decompression for DLSS in elderly patients and reported clinical results at a minimal 1-year follow-up.

All 31 consecutive patients underwent successful UBE decompression under stepwise LA and conscious sedation, and none were converted to GA or aborted midway. Over 80% of patients (26/31) reported transient mild or tolerable pain during surgery and rated the intraoperative experience as excellent or good. In a study comparing the effect of GA and LA in uniportal endoscopic interlaminar discectomy, Ye reported that 50% of patients in the LA group had an unsatisfactory intraoperative experience, with 20% experiencing intolerable pain.[22] Because Ye's study did not describe the technical details of LA, we hypothesized that the differences in results might be due to the following reasons. First, the UBLD procedure produced far less nerve traction than posterior interlaminar discectomy, which reduces intraoperative pain at the source. Second, we used a stepwise LA strategy, involving routine infiltration anesthesia from the skin to the lamina and epidural injection. Epidural injection of ropivacaine helps with pain control, and several studies describing epidural injection procedures have reported similar anesthetic effects.[29–31] No dural tear or cerebrospinal fluid leakage occurred in the study, indicating the safety of epidural puncture under endoscopic vision, although the risk of the procedure increases accordingly in a narrow spinal canal. Third, we applied dexmedetomidine intravenously, which has the effect of sobering sedation, alleviating anxiety, and assisting in pain relief.[32] Fourth, our patients underwent preoperative prone position exercises to avoid situations where they could not tolerate the intraoperative position.[33]

Significant leg pain relief and functional improvement were observed postoperatively. At the postoperative 1-year follow-up, the VAS-LP decreased from 5.93±2.80 before surgery to 1.54±0.72, and the ODI decreased from the initial 67.51 ± 16.93 to 16.86 ± 9.04. The overall success rate of the surgery is 90.3%, based on the modified Macnab criteria at the last follow-up. The results are comparable to those observed in the cohort receiving conventional UBE decompression under GA.[15,34–36] This suggests that the awake UBE decompression procedure can achieve effective neurological decompression and clinical improvement in the elderly population, while long-term results require further observation.

The primary advantage of awake UBE is that it allows patient's intraoperative feedback. There is concern that intraoperative manipulation and the thermal effects of monopolar electrocoagulation may cause damage to fragile dural sac and neural structures.[37–39] Physicians are also alert to the possibility of elevated epidural hydrostatic pressure and intracranial hypertension (ICH) caused by continuous irrigation, which can lead to seizures and even death.[40–42] In GA surgery, neurophysiological monitoring is required to determine the state of nerves, resulting in increased medical costs. However, in an awake UBE decompression procedure, surgeons can assess the neurological state and the proximity of the device to neural structures based on real-time feedback from patients, even in cases where bleeding causes blurred vision. We believe that this self-neuromonitoring model helps avoid intraoperative complications. There were no dural tears or nerve root injuries in our series. Three patients experienced transient lower limb numbness which spontaneously resolved within 48 hours after surgery. One patient reported intraoperative neck pain, which is considered a prodromal symptom of ICH.[40] Upon receiving this warning signal, the physician immediately reduced the irrigation pressure and facilitated fluid outflow by lengthening the fascial incision in the working channel. The patient's neck pain was gradually relieved and the surgery was successfully completed without other adverse events.

Another advantage of ASS is that it reduces the adverse events associated with GA and facilitates postoperative recovery.[43,44] A meta-analysis indicates that avoiding GA in lumbar spine surgery is associated with less post-anesthesia care unit and hospital stay, better postoperative analgesia, shorter fasting time, and less PONV.[45] In our study, patients undergoing awake UBE decompression procedure were exempted from routine fasting and indwelling catheters and were allowed to perform ambulation on the day of surgery, which is in line with the principle of accelerating postoperative recovery. There were no PONV, urinary retention, or POD observed in our cases. POD often occurs in elderly patients undergoing major surgery and is associated with prolonged hospital stays, increased morbidity and mortality.[46] Known risk factors include advanced age, frailty, dysfunction, massive blood loss, and long surgical duration.[47] Although the effect of anesthesia type on POD remains controversial, the use of dexmedetomidine rather than propofol, lighter sedation levels, good pain control, and early mobilization have been found to reduce the incidence of POD.[48] Therefore, we believe that awake UBE decompression helps prevent POD in elderly patients due to minimal tissue trauma and blood loss, reduced exposure to anesthetics, as well as enhanced recovery protocol.

A major limitation of our study is the retrospective observational nature of the study. The risk of bias and the lack of a control group result in a low level of evidence for the study. Secondly, the sample size is small and the follow-up period is relatively short. However, the authors conducted this study to investigate the feasibility of awake UBE decompression in elderly patients, not to validate this method. However, our preliminary results indicate that awake UBE decompression is feasible for selected elderly patients. Further large-sample prospective comparative studies are needed to verify the advantages of this new strategy in terms of complications, postoperative recovery, and cost-effectiveness.

Conclusion

Our preliminary results suggest that awake UBE decompression under LA is feasible for elderly patients with DLSS. For UBE decompression, the anesthetic strategy introduced in this study is safe, easy to implement, and able to reduce anesthesia-related adverse reactions, and therefore may be a promising alternative to GA for selected cases, especially for elderly patients with multiple morbidities.

Abbreviations

UBE, unilateral biportal endoscopy; LA, local anesthesia; GA, general anesthesia; DLSS, degenerative lumbar spinal stenosis; PROM, patient-reported outcomes measures; VAS, visual analog scale; ODI, Oswestry disability index; ASS, awake spinal surgery; ULBD, unilateral laminotomy for bilateral decompression; PONV, postoperative nausea and vomiting; POD, postoperative delirium; ICH, intracranial hypertension; CT, computed tomography; MRI, magnetic resonance imaging.

Ethics Approval and Informed Consent

This study was approved by the ethics committee of Shengjing Hospital of China Medical University (2023PS854K), and the patient's informed consent form was exempted, given the retrospective observational nature. This study was conducted in accordance with the Declaration of Helsinki.

Funding

This work was supported by grants from the Liaoning Province Key Research and Development Project (JH2/202, 1686036606770), 345 Talent Project and Outstanding Scientific Fund of Shengjing Hospital. The funders had no role in in any of the stages from study design to submission of the paper for publication.

Disclosure

The authors report no conflicts of interest in this work.

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