Clinical and radiographic outcomes for microsurgical unilateral laminotomy for bilateral decompression of lumbar spinal stenosis for elderly patients-A retrospective cohort study

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Research article

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Abstract

Background

Recently, unilateral laminotomy for bilateral decompression (ULBD) has become a alternative to conventional decompression for symptomatic lumbar spinal stenosis (LSS),and this minimally invasive surgical technique has shown a satisfactory outcomes and low complications. However, the influence of old age on the risk of postoperative complications and clinical outcome is not well understood.

OBJECTIVE

The purpose of this study was to evaluate clinical and radiographic outcomes and complication rates after ULBD in elderly patients.

Study Design

Single center retrospective observational study.

Setting

All data was from the affiliated people's hospital of Jiangsu University.

METHODS

In this study, 39 elderly patients were treated for lumbar spinal stenosis by ULBD between January 2016 and January 2018. Follow-up consisted of radiologic investigations, Visual Analog Scale, Oswestry Disability Index, and 36-Item Short-Form Health Survey at 6 and 12 months postoperatively. Preoperative comorbidity, postoperative complications and revision surgery rates were also analyzed.

RESULTS

There were 12 female patients and 27 male patients with a mean age of 75.83 ± 9.16 years. 20 patients had one levels of spinal stenosis, 13 patients had two levels of stenosis, 6 patients had three levels of stenosis. Average follow-up time was 14.6 ± 7.8 months (range, 6–24 months), Total complications were 10.2%(4/39),and reoperation rate was 2.5%(1/39). Oswestry Disability Index scores decreased significantly (from 32.26 ± 6.82 to 11.44 ± 2.50 at 6 months and 10.56 ± 2.29 at 12 months), and 36-Item Short-Form Health Survey parameter scores demonstrated a significant improvement in the follow-up results.

Limitation

A multi-center study is recommended to confirm our findings and explore the factors related to clinical and radiographic outcomes.

CONCLUSIONS

ULBD for lumbar spinal stenosis is a safe and effective treatment for elderly patients, improves these patients' quality of life and does not pose an increased risk of complications.

Introduction

The growth in the aging population in recent times has been accompanied by an increase in the prevalence of degenerative spinal diseases. Lumbar spinal stenosis (LSS) is a condition that causes low back pain, leg pain, intermittent claudication and neurological disorders. Symptomatic LSS can have a severe impact on functionality and quality of life and remains the most common indication for surgical intervention on the spine [1, 2]. The primary objective of surgical intervention for LSS is decompression of the symptomatic neural elements and to preserve or achieve mechanical stability [3].

Conventional laminectomy is a straightforward surgical procedure providing adequate decompression and have good-to-excellent outcomes in 64% of patients [4]. However, using this treatment modality results in the loss of important posterior elements that are necessary for spinal stability; it also causes damage to the facet joint frequently. Consequently, the procedure may lead to spinal instability and secondary intervertebral fixation and fusion. Therefore, many geriatric patients are reluctant to undergo such surgeries, based on the belief that old patients are at high risk for serious surgical complications, poor outcome, and even mortality.

Recently, a minimally invasive technique that has gained popularity over the past years is unilateral laminotomy for bilateral decompression (ULBD), the procedure requires a unilateral exposure and muscle retraction, thereby minimizing iatrogenic injury to the paraspinal muscles and the spinous process/interspinous ligament midline tension band structures [5] (Fig. 1). This approach significantly reduces soft tissue injury and intraoperative bleeding. As a result, patients experience less postoperative pain and can usually be mobilized and discharged early.

Since elder patients may have comorbidities, it is important to consider those parameters in choosing appropriate surgical interventions for this age group. For this reason, an appropriate operative procedure should be used to answer two major questions: (1) Does this procedure decrease morbidity and mortality rates? (2) Does this procedure decompress the neural elements adequately to improve symptoms? Therefore, the aim of the present study was to evaluate complication rates and outcomes after minimally invasive ULBD in elderly patients.

Materials And Methods

After approval from approved by the Ethics Committee of the Affiliated People's Hospital of Jiangsu University, we retrospectively collected medical records of patients who underwent ULBD lumbar decompression surgery between January 2016 and January 2018. All surgeries were performed by one senior chief surgeon. Inclusion criteria included LSS patients older than 65 years. Patients excluded from the study were those who had a previous history of LSS surgery, spinal instability, lumbar

spondylolisthesis, overweight patients with a body mass index (BMI) over 40, psychiatric disorders such as schizophrenia, schizoaffective disorder, bipolar disorder and major depressive disorder, peripheral neurological disease, or severe heart, lung, kidney, or liver disease.

The study cohort included a total of 39 patients. Demographic data and preoperative Data (Table 1), including medical history, medical comorbidities, BMI, and American Society of Anesthesiologists (ASA) score, were recorded. To simplify the presentation of the medical history data, we classified patients' comorbidities into 7 categories: cardiac, endocrine, metabolic, gastrointestinal, pulmonary, renal, multiple comorbidity. Operative data included number of operated spinal level, operation time and blood loss. Clinical outcomes included hospital length of stay, postsurgical complications, revision surgery, and mortality. Preoperative and postoperative cross-sectional area of the lumbar spinal canal was calculated from computed tomography (CT).

Follow-up consisted of the Visual Analog Scale (VAS), Oswestry Disability Index (ODI) questionnaire and 36-Item Short-Form Health Survey (SF-36) 6 and 12 months postoperatively. Flexion-extension lumbar radiographs were obtained again at 6, 12 months postoperatively and spinal instability was defined as a sagittal plane translation of ≥ 5 mm on flexion-extension radiographs (Radiological evaluation was judged by two observers blinded). Patient-reported outcomes were collected via face-to-face assessment or by using telephone interviews.

Unilateral Laminotomy For Bilateral Decompression Technique

The microscopic decompression procedure has been previously described [6, 7]. In brief, we made a 3-5 cm midline incision after fluoroscopic confirmation of surgical level. After skin incision, the multifidus muscle was dissected unilaterally from the spinous process and lamina using a Cobb elevator and retracted by a Taylor retractor. After detachment of paraspinal muscles, ipsilateral laminotomy was performed using a burr and Kerrison punches, followed by flavectomy using microscope. To view the contralateral side, the operation table and microscope were tilted approximately 15 to 25°. For decompression, undercutting of the spinous process and contralateral lamina was performed using a burr and Kerrison punches, followed by flavectomy. After contralateral laminotomy and flavectomy, complete neural decompression was confirmed by restoration of dural pulsation (Fig. 2).

Statistics

All statistical analyses were performed using SPSS 15.0 (SPSS, Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine whether the distributions were significantly different. The data are shown as the mean $\pm$ standard deviation for continuous variables, the median (maximum-minimum) for ordinal variables, and the frequency with percent for categorical variables. A one-way analysis of variance (ANOVA) was used to assess the significant differences between groups. The Kruskal-Wallis test

was employed to compare nonparametric data and to test the significant differences between median values. The chi-square test was used for categorical comparisons. In case of multiple comparisons, the Bonferroni adjustment was used to control type I errors; and P-value less than 0.05 was considered statistically significant.

Results

A total of 39 patients (12 female, 27 male) with spinal stenosis were included in the study. The mean age of the patients was 75.83 ± 9.16 years (range, 65–87 years). 22 patients had one level of spinal stenosis, 11 patients had two levels of spinal stenosis, 6 patients had three levels of spinal stenosis. Average follow-up time was 14 months (range, 6–24 months). No cases of infection were found in our study. The operation time, blood loss and length of hospitalization were recorded (Table 2). There were total four complications, two dural tear (repaired primarily), one neurologic deficit (postoperative weakness of great toe dorsiflexion on the contralateral operative side, which was relieved spontaneously), one symptom was no improvement (reoperation with laminectomy and fusion).

Radiographic Analysis

CT showed the mean postoperative cross-sectional area of the spinal canal were more significant larger than preoperation and mean postoperative lateral recess height were higher than before surgery (Fig. 3–4), these results were not significant between 6 months and 12 months follow-up (Table 3). No significant abnormal motion in the sagittal planes were observed on flexion-extension lumbar radiographs at 6 and 12 months postoperatively, compared with the preoperation (Table 3).

Clinical Outcomes

Analysis of low back and leg pain VAS scores showed significant improvements in clinical outcomes from before surgery to 6 months and 12 months after surgery (Tables 4). However, these changes were not significant between 6 months and 12 months during follow-up period.

ODI scores decreased significantly in 6 months and 12 months follow-up, evaluations from a mean preoperative score of 31.37 ± 8.61 to 12.44 ± 3.50 at 6 months and 12.30 ± 2.67 at 12 months, (Table 4), and we did not detect the significant differences in 6 months and 12 months.

Comparison of preoperative and 6 months and 12 months follow-up, SF-36 scores demonstrated a significant improvement except in the areas of emotional role. There were no significant differences in 6 months and 12 months scores of SF-36 (Table 4).

Discussion

In the elderly population, low back pain is a very common health issue. Degenerative lumbar stenosis is one of the most common causes of these conditions. Randomized trials indicate that for symptomatic LSS patients, decompression offers greater efficacy than nonsurgical treatments[6]. However, the effect of age as an independent risk factor is well understood, it has been related to an increased risk of morbidity after open spine surgery[8]. Other studies have found morbidity and complication rates were higher in elders compared with younger patients after spine surgery, and this finding might be due to the high prevalence of multiple medical comorbidities in this aged group[9, 10]. Therefore, it is very important to make a choice which surgical procedure is appropriate, especially in geriatric patients, for whom the surgical challenge is their physical, psychologic, and social frailty. For this reason, simple Minimally invasive surgical (MIS) decompression surgery methods were preferred to decrease morbidity and mortality rates.

MIS approaches involve muscle-splitting techniques to access the spine, leaving intact the midline structures that support muscles and ligaments and decreasing intraoperative blood loss and postoperative pain[11]. One such recently described MIS technique is unilateral laminotomy for bilateral decompression (ULBD). This technique uses the microendoscopic tubular-retractor system to preserve the facet joints and neural arch of the contralateral side, limits postoperative destabilization, and protects the neural structures from extensive trauma. Ang et al[12], retrospectively reviewed the outcomes of 113 patients, measured by VAS for back and leg pain, the North American Spine Society score on neurogenic symptoms, found they were comparable between the ULBD and the open lumbar laminotomy groups, but ULBD was associated with the lower blood loss, the shorter hospital stay, the lower percentage of complications and the need for revisions. Although other studies have confirmed similar results[13], however, for elderly LSS patients over 75 years old, studies on the complications, clinical and radiographic outcomes of ULBD surgeries have seldom been reported.

In this study, the mean age of patients was 75.83 years, and nearly half of these patients had two or more levels of stenosis. We found that ULBD was associated with significant improvement in low back and leg pain as well as ODI and SF-36 at 6 months in most patients, this improvement persisted at 12 months follow-up. Moreover, patients in the current series tolerated the surgical procedure well, even though many had comorbidities such as hypertension, congestive heart failure, diabetes mellitus, chronic obstructive pulmonary disease. Katz et al[14], found that after decompressive laminectomy, elderly patients with greater medical comorbidity and functional disability were significantly less satisfied with the results of surgery. Transfeldt et al[15], reported that patients undergoing open surgical decompression, with an average age of 76.4 years, the complication rate was 21%-40%. In our study the total complication rate were 10.2% and these results demonstrated that satisfactory outcomes in elderly patients. We speculate that these good outcomes and low complications of the ULBD result from several inherent advantages of the MIS technique. MIS technique can reduce the inflammatory and stress response after surgery. Postsurgical stress response was found to contribute to imbalance in autonomic, endocrine, and immune systems. It was also found to promote hypertension, cardiac dysrhythmias, and myocardial infarctions in the immediate perioperative period[16]. Elderly frail patients suffering from multiple medical

comorbidities and limited physiologic reserve are vulnerable to stress and may therefore especially benefit from MIS procedures that minimize these risks.

Another advantage of ULBD is the decreased wound infection. Aging and a comorbid condition, such as vasculopathy, can lead to delayed wound healing that may jeopardize patient outcomes either by direct influence on spinal muscle rehabilitation[17]. ULBD surgery results in smaller skin incisions that facilitate wound healing and decrease the risk of wound complications in old population, maybe for this reason, no wound infections in our study. And this MIS procedure also can reduce blood loss[18]. The cardiovascular and pulmonary compensatory mechanisms are of limited capacity in older patients because age decreases the contractility and increases the stiffness of the left ventricle[19]. These alterations may impair the patient from tolerating large volume shifts, which can lead to life-threatening complications in geriatric patients.

Dural tears were the most common complication in ULBD. It was thought that with the unilateral approach, especially in severe elderly LSS patients, access to the opposite lateral spinal canal may require significant dural sac retraction, with a possibly higher risk of tears of the spinal dura mater. Accidental dural tears occurred in 2 patients (4.4%) in our study. However, the rate of dural tears in our series was similar to the previously documented average results from microsurgical ULBD of LSS (0%-18%)[18]. This rate was comparable or lower than the rates reported in most series of decompressive surgery for LSS with a published overall incidence of dural tears approaching 14%[20]. To our experiences, in cases with bilateral radiculopathy or severe stenosis, do not rush this stage of the procedure. Allowing contralateral microscopic visualization and using angled curets slowly create more room to perform the decompression could reduce the incident of dural tears. If an iatrogenic injury to the dura is encountered, it is best to close it immediately. This may require some special long shaft suture instruments to achieve watertight closure.

For ULBD, another main goal of surgery was adequate decompression of the neural elements. We utilized CT to measurements of the cross-sectional area of the spinal canal and lateral recess heights and postoperative CT demonstrated decompression was enough. In contrast to our results, Thomé et al. [21] found that the ULBD was associated with less sufficient decompression than the bilateral laminotomy, even if the difference was not significant. This finding may suggest that the ULBD approach provides a worse view of the contralateral recess due to the limited exposure via a unilateral approach. However, Moisi et al [22]. concluded in their technical note that the ULBD approach could provide better visualization of the contralateral recess. Our selection of the decompression strategy using the ULBD technique was based on patients' symptoms and severity of LSS. For elderly patients with facet hyperplasia, ipsilateral facetectomy was routinely performed to obtain an adequate decompression for foraminal and lateral recess stenosis, it provided enough space and abduction angle to allow undermining of the ventral aspect of the spinous process and contralateral lamina, and the posterior midline osteoligamentous structures and contralateral ligamentum flavum could be resected to expose the contralateral side, which allow contralaterally facetectomy and provide complete decompression of the dural sac and contralateral nerve root.

During lumbar decompression surgery, the extent of preservation of the bilateral facet joint is an important factor for maintaining spinal stability[23]. Traditional standard decompression involves widely facetectomy and some removal of the posterior spinal structures. As a result, the approach can lead to postoperative destabilization, which can lead to the need for spinal fusion and in turn is associated with increased comorbidities in elderly patients. Mariconda et al[24]. indicated that high rates of reoperation in open decompression, ranged 11–30%. In our study, we performed adequate decompression of the spinal stenosis and no secondary instability was found in this ULBD procedure. Miyazaki et al[25]. reported the average percent facet joint preservation on ULBD was significantly smaller in conventional decompression surgery, ULBD preserved 60–83% of the facet joint on the approach side and > 90% of the facet joint on the contralateral side. By contrast, traditional approach only retain $\leq 40\%$ percent of the facet[26]. Therefore, we thought this MIS method can reduce the risk of postoperative spinal instability at the surgical site due to satisfactory preservation of the facet joint.

Conclusions

Our experience supports the use of the ULBD as a less invasive technique for symptomatic LSS to conservative treatment that allows for adequate decompression of neural elements at the affected level. After the relief of symptoms, the general health and mental conditions of patients can also be significantly improved. The results of this study indicate that ULBD surgery is a safe and effective treatment for elderly patients and does not pose an increased risk of complications.

Limitations

Our study has several limitations. First of all we have our study with a limited number of patients, the sample size was not sufficient to yield substantial effects. Second limitation, we were not able to compare beneficial results from ULBD in this age group with outcomes from those of an open surgical intervention in a similar age-grouped patient cohort. Finally, this was a retrospective study, and the indications for this surgical procedure were limited in patients with LSS. Additional studies with larger samples and longer follow-up periods should be performed to confirm the present results.

Abbreviations

ULBD

Unilateral laminotomy for bilateral decompression

LSS

Lumbar spinal stenosis

ODI

Oswestry Disability Index

SF-36

36-Item Short-Form Health Survey

ASA

Declarations

Ethics approval and consent to participate

Ethical approval for this study was granted by the Affiliated People's Hospital of Jiangsu University, China, and all patients or authorized relatives gave informed consent

Consent for publication

We have obtained consent for publication.

Availability of data and materials

Data will not be available because consent and ethical approval was not obtained for sharing. Additionally, all available data has been summarized in the text of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

BL brought forward the subject and guided the writing. BL drafted the manuscript. BL performed the critical editing and participated in the constructive outline, discussions, and editing. All authors read and approved the final manuscript.

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Tables

Table 1 Patient demographics and comorbidities

Parameter	Value (n, %, Mean $\pm$ SD)
Age	75.83 $\pm$ 9.16
Gender (female/male)	12/27
BMI (kg/m ²)	23.8 $\pm$ 2.3
Number of stenotic levels	
One level	20 (51.3%)
Two levels	13 (33.3%)
Three levels	6(15.4%)
Laterality	
Unilateral	17 (43.6%)
Bilateral	22(56.4%)
Level of stenosis	
L2 L3	4 (10.3%)
L3 L4	9 (23.1%)
L4 L5	16 (41%)
L5 S1	10(25.6%)
Comorbidity	
Cardiac	10(25.6%)
Endocrine	7 (17.9%)
Metabolic	5 (12.8%)
Gastrointestinal	4 (10.3%)
Pulmonary	6 (15.4%)
Renal	2 (5.1%)
Multiple comorbidity	7(17.9%)
ASA score	2.72 $\pm$ 0.76
Follow-up (months)	14.6 $\pm$ 7.8

Table 2 operative data

Parameter	Value(n, %, Mean $\pm$ SD)
Duration of operation (min)	
1-level op	45.2 $\pm$ 9.4
2-level op	88.5 $\pm$ 17.4
3-level op	133.6 $\pm$ 37.5
Estimated blood loss (mL)	
1-level op	80.5 $\pm$ 12.8
2-level op	145.7 $\pm$ 55.7
3-level op	279.4 $\pm$ 70.3
Length of hospitalization (d)	5.4 $\pm$ 1.9
Total complications (n/rate)	4/10.3%
Dural tear	2/5.1%
Neurologic deficit	1/2.6%
Reoperation	1/2.6%

Table 3 Comparison of Radiographic data Preoperatively, at 6 months Follow-Up, and at 12 Months Follow-Up for Patients(Mean $\pm$ SD)

	Preoperation	6m	12m	P-value
cross-sectional area (mm ²)	55.8±26.6	138.8±30.5	135.2±35.7	P _{6m-po} =0.001 P _{6m-12m} =0.27
bilateral lateral recess height (mm)	1.8±0.6	4.6±2.2	4.4±1.6	P _{6m-po} =0.01 P _{6m-12m} =0.53
unilateral lateral Recess height(mm)	2.5±0.7	4.1±1.3	4.0±0.9	P _{6m-po} =0.01 P _{6m-12m} =0.59
dynamic motion Flexion-extension(mm)	2.2±1.5	2.3±1.7	2.5±1.4	P _{6m-po} =0.72 P _{6m-12m} =0.35

P_{6m-po}compared preoperation with6 months follow-Up;

P_{6m-12m}compared 6 months with12 months follow-Up

Table 4 Oswestry Disability Index(ODI), Visual Analog Scale(VAS) and 36-Item Short-Form Health Survey Scores Preoperatively ,at 6 Months and 12 Months Follow-Up(Mean ± SD)

	Preoperation	6m	12m	P-value
ODI	31.37±8.61	12.44± 3.50	12.30± 2.67	P _{6m-po} =0.001 P _{6m-12m} =0.38
Back pain VAS	5.4 ± 1.6	1.8 ± 0.7	1.9±0.3	P _{6m-po} =0.001 P _{6m-12m} =0.26
Leg pain VAS	6.6 ± 2.8	1.4 ± 0.6	1.2 ± 0.2	P _{6m-po} =0.001 P _{6m-12m} =0.17
SF-36				
Physical function	58.67±5.23	72.45 ± 5.31	71.86 ±4.68	P _{6m-po} =0.001 P _{6m-12m} =0.51
Physical role	29.56 ± 8.77	49.01± 9.22	49.11± 8.75	P _{6m-po} =0.001 P _{6m-12m} =0.69
Body pain	40.11 ±4.11	68.25 ±7.53	68.29 ±7.75	P _{6m-po} =0.001 P _{6m-12m} =0.44
General health	52.27 ±4.25	58.26±3.13	57.23 ±4.54	P _{6m-po} =0.01 P _{6m-12m} =0.39
Vitality/energy	41.73 ± 3.11	58.97±5.21	59.12 ±5.18	P _{6m-po} =0.01 P _{6m-12m} =0.41
Social function	40.32±5.41	51.54 ±6.27	52.33 ±6.09	P _{6m-po} =0.01 P _{6m-12m} =0.36
Emotional role	63.62 ±5.73	63.72± 5.73	63.69 ±5.76	P _{6m-po} =0.31 P _{6m-12m} =0.40
Mental health	43.36 ±5.80	63.37± 5.77	63.34± 5.82	P _{6m-po} =0.001 P _{6m-12m} =0.22

P_{6m-po} compared preoperation with 6 months Follow-Up;

P_{6m-12m} compared 6 month/ with12 months Follow-Up

Figures

Figure 1

CT scans of traditional decompression and ULBD procedures. Spinal lumbar canal stenosis(A). Traditional decompression approach removed most posterior elements and resected a large portion of the bilateral facet joints (B); ULBD indicated that a laminotomy was performed by removing a portion of the superior and inferior laminae at the segment, and a small part of the medial facet. Deep cortical surface of contralateral lamina was undercut and drilling was extended to the contralateral medial facet(C).

Figure 2

ULBD for spinal lumbar canal stenosis. The inferior half of the L4 lamina has been drilled and the base of the spinous process to expose the ligamentum flavum bilaterally(A); Decompression of the contralateral side. (B). The tubular retractor is angled beneath the spinous process.

Figure 3

Preoperative computed tomography of L3-L4,L4-L5 stenosis (A-B), and postoperative computed tomography (C-D) obtained in one patient undergoing ULBD for 2-level stenosis.

Figure 4

Preoperative (A) and postoperative (B) T2-weighted magnetic resonance imaging of L4-L5 stenosis.