ENDOSCOPIC DECOMPRESSION IN LUMBAR SPINAL STENOSIS: RADIOLOGICAL AND CLINICAL RESULTS

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Summary

The aim of the study is to evaluate the results of surgical treatment using the method of biportal unilateral interlaminotomy with bilateral decompression (ULBD) and to analyze complications in patients operated on for degenerative lumbar spinal stenosis.

Materials and methods. A total of 51 patients were analyzed with the average age of 58±16.4 years, who had lumbar spinal stenosis and underwent bilateral decompression using unilateral interlaminotomy (ULBD) at the Spine Surgery Clinic of the State Institution «ITO NAMS of Ukraine».

Results. According to the study results, immediately after ULBD surgery, the level of pain syndrome in the back and lower limbs significantly decreased. In the post-operative period, the pain score by VAS decreased from 4.9 ± 2.3 cm to 3.2 ± 0.5 cm, and in the lower limbs from 5.6 ± 2.1 cm to 1.2 ± 0.7 cm. However, the high level of back pain still remains due to the pain in the operated segment and the wound. After 3 months, the pain score by VAS (back) was 1.1 ± 0.7 cm and 1.4 ± 0.4 cm in the legs (p < 0.05). Positive dynamics of VAS (back) continued after 6 months and 12 months with scores of 1.3 ± 0.5 cm and 0.9 ± 0.6 cm, respectively (p < 0.05). Pain syndrome reduction in the lower limbs maintained at the level of 0.9 ± 0.7 cm and 0.8 ± 0.6 cm after 6 months and 12 months, respectively (p < 0.05). The evaluation of results by MRI in the preoperative and post-operative period (the next day after the surgery) showed that the cross-sectional area increased from 1,01±0.05 cm² to 2.01±0.02 cm² on average. The average length of hospital stay for patients was 2±1.2 days.

Conclusions. The ULBD technique is an effective method for decompression of the spinal canal in patients with lumbar spinal stenosis. Unilateral laminotomy with bilateral decompression technique (ULBD) allows reducing muscle dissection and decreasing the degree of damage to the posterior structures of the spine.

Key words: stenosis, endoscopic biportal decompression method, treatment

INTRODUCTION

Lumbar spinal stenosis (LSS) is a severe disease characterized by neurogenic intermittent claudication, and pain in the lower limbs and lower back. Conservative treatment of lumbar spinal stenosis produces positive results only in the early stages of the disease [5-7]. Standard surgical options for the treatment of lumbar spinal stenosis include open decompressive laminectomy, foraminotomy, and spinal fusion. Currently, the gold standard for the treatment of lumbar stenosis that is resistant to conservative treatment is laminectomy with facet preservation [2, 9], but significant detachment of paraspinal muscles leads to their atrophy due to ischemia and denervation [4, 14]. In addition, mandatory resection of bone components increases blood loss, leading to longer hospital stays and to the risk of complications such as postoperative pain and infection [9, 6, 13].

Among the endoscopic surgical methods for treating degenerative spinal stenosis, a popular technique is the decompression of the spinal canal with preservation of
the posterior structures [16, 10], including unilateral laminotomy for bilateral decompression (ULBD). In ULBD, complete bilateral decompression is achieved by performing ipsilateral laminotomy while preserving the integrity of the posterior supporting structures [11]. This method allows for a reduction in muscle dissection and a decrease in the degree of damage to the posterior structures of the spine.

However, regarding the use of the ULBD technique in the treatment of lumbar spinal stenosis, only general principles have been formulated, which require supplementation and an assessment of the risk of complications. The above statement highlights the importance of further study of this problem.

THE AIM OF THE STUDY

To evaluate the results of surgical treatment using the method of biportal unilateral interlaminotomy with bilateral decompression (ULBD) and to analyze complications in patients operated on for degenerative lumbar spinal stenosis.

MATERIALS AND METHODS

A prospective study was conducted. A total of 51 patients were analyzed, including 25 men and 26 women with the average age of 58±16.4 years, who had lumbar spinal stenosis and underwent bilateral decompression using unilateral interlaminotomy (ULBD) at the Spine Surgery Clinic of the State Institution «Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine» from September 2021 to September 2022.

The enrollment criteria for the study were: (1) back pain or radiating leg pain associated with lumbar spinal stenosis; (2) progressive neurogenic intermittent claudication; (3) ineffectiveness of conservative treatment. The exclusion criteria were: (1) unstable spinal segment; (2) spondylolisthesis higher than first degree; and (3) concomitant oncological or infectious diseases.

Patients reported comorbidities such as arterial hypertension (40%), diabetes mellitus (9%), and cardiovascular diseases (15%). According to the number of decompressed levels: decompression was performed on one level on 34 patients, on two levels on 14 patients, and on three levels on 3 patients. On the examined patients, decompression was performed on L2-L3 (n=5), L3-L4 (n=17), L4-L5 (n=34), and L5-S1 (n=15) (table 1).

The average follow-up duration from the time of surgery was 16.3 ±2.1 months.

Methods. The intensity of pain was assessed using the visual analog scale (VAS, cm), patient satisfaction and quality of life were evaluated using the Oswestry Low Back Pain Disability Questionnaire (ODI) at 1, 3, 6, and 12 months post-operatively. The Oswestry index, which characterizes the degree of functional impairment of the patient, was evaluated in the range from 0 (absence of impairment) to 100% (absolute impairment). Perioperative complications data were also evaluated. The results of decompression were assessed using pre- and post-operative MRI (1 day after the surgery), (figure 1).

The measurement of the cross-sectional area of the spinal canal was performed using T2-weighted MRI at the level of the affected disc’s midline with the Radiant Dicom program for Windows (Figure 1). The data were recorded in an Excel spreadsheet. Statistical analysis was performed using Excel 2019 for Windows and the Statistica 6.0 software.

Statistical processing of the results was carried out using Microsoft Excel and Statistica 8.0 (StatSoft Inc.) application programs. Analysis of repeated changes was performed using the Wilcoxon test. The data obtained as a result of the research were processed using methods of mathematical statistics: Determined: the number of samples (n); mean arithmetic value (x); variance (S^2); mean square deviation (S). The Mann-Whitney test was used. The existence of a relationship between the studied indicators was studied using the Fisher test. The chosen level of reliability P corresponded to 95%, and the accepted level of statistical significance was 0.05 (p=0.05).

Surgical technique. Prior to the operation, the level was determined under X-ray control. The upper incision was made at the level of the lower edge of the vertebral arch required by the level. A conductor was introduced through the incision, and a dilator system was sequentially mounted on it to expand the muscular channel, followed by the installation of a trocar with an endoscope. The lower incision was made 3 cm caudally. The muscular channel was formed using a dilator system. The physiological saline delivery system was connected to the endoscope. After forming a triangulation between the arthroscope and instruments and the adjustment of fluid drainage, the soft tissues surrounding the intralaminar space were removed using a radiofrequency vaporizer. When the target intralaminar space’s yellow ligament and lower arch were completely exposed, ipsilateral interlaminotomy was performed using an arthroscopic drill and osteotome. The ipsilateral yellow ligament was removed until the dural sac and the nerve root were completely exposed. Partial facetectomy was performed on the ipsilateral side. The yellow ligament was removed until the dural sac and the nerve root were completely exposed. Partial facetectomy was performed on the contralateral side. Hemostasis for epidural bleeding was performed using radiofrequency coagulation electrodes. In case of bleeding from bone, hemostasis was performed using bone wax. After decompression, a drainage tube was placed and the wound was sutured.
Table 1

Characteristics of patients in the observation groups

<table>
<thead>
<tr>
<th>Parameters</th>
<th>(n = 51)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>58 ± 16,4</td>
</tr>
<tr>
<td>Gender [n (%)]</td>
<td>male 25 (49)</td>
</tr>
<tr>
<td>Time of observation (months)</td>
<td>16,3 ± 2,1</td>
</tr>
<tr>
<td>The level of decompression [n (%)]</td>
<td></td>
</tr>
<tr>
<td>L2 – L3</td>
<td>5(9,8)</td>
</tr>
<tr>
<td>L3 – L4</td>
<td>17 (33,3)</td>
</tr>
<tr>
<td>L4 – L5</td>
<td>34 (66,6)</td>
</tr>
<tr>
<td>L5 – S1</td>
<td>15 (29,4)</td>
</tr>
</tbody>
</table>

Fig. 1. Measurement of the cross-sectional area of the spinal cord using the Radiant Dicom program

RESULTS

In the initial examination of patients, the average score of pain syndrome in the lower limbs according to VAS was 5,6±2,1 cm, and the severity of back pain in the group on average was moderate and corresponded to 4,9±2,3 cm according to VAS. The average duration of back pain in patients with LSS was 14,5±7,4 months and usually correlated (r=0,9, strong correlation) with the duration of radiating pain in the lower limbs – 13,3±8,1 months; the average duration of symptoms of neurogenic intermittent claudication in the group was 13,1±6,7 months.

According to the study results, immediately after ULBD surgery, the level of pain syndrome in the back and lower limbs significantly decreased. In the post-operative period, the pain score in the back by VAS decreased from 4,9±2,3 cm to 3,2±0,5 cm, and in the lower limbs from 5,6±2,1 cm to 1,2±0,7 cm (p <0,05, table 2).

Table 2

Dynamics of treatment results in patients with lumbar spinal stenosis using the ULBD, (n=51)

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Before surgery</th>
<th>After surgery</th>
<th>After 1 month</th>
<th>After 3 months</th>
<th>After 6 months</th>
<th>After 12 months</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS, back, cm</td>
<td>4,9±2,3</td>
<td>3,2±0,5</td>
<td>2,4±0,5*</td>
<td>1,1±0,7*</td>
<td>0,9±0,7*</td>
<td>p &lt;0,05</td>
<td></td>
</tr>
<tr>
<td>VAS, lower limbs, cm</td>
<td>5,6±2,1</td>
<td>1,2±0,7*</td>
<td>1,3±0,5*</td>
<td>1,4±0,4*</td>
<td>0,9±0,7*</td>
<td>p &lt;0,05</td>
<td></td>
</tr>
<tr>
<td>ODI – Oswestry Disability Index, %</td>
<td>64,2±12,3</td>
<td>55,1±9,9</td>
<td>40,5±7,3</td>
<td>30,1±6,9*</td>
<td>34,3±6,6*</td>
<td>32,1±5,2*</td>
<td>p &lt;0,05</td>
</tr>
</tbody>
</table>
However, the high level of back pain still remains due to the pain in the operated segment and the wound. After 3 months, the pain score by VAS (back) was 1.1 ± 0.7 cm and 1.4 ± 0.4 cm in the legs (p < 0.05). Positive dynamics of VAS (back) continued after 6 months and 12 months with scores of 1.3 ± 0.5 cm and 0.9 ± 0.6 cm, respectively (p < 0.05). Pain syndrome reduction in the lower limbs maintained at the level of 0.9 ± 0.7 cm and 0.8 ± 0.6 cm after 6 months and 12 months, respectively (p < 0.05), (figure 2).

The study of subjective assessment of well-being using the Oswestry Disability Index (ODI) questionnaire before the start of treatment and after its completion showed a significant improvement in quality of life after 3 months of observations. Before the operation, the ODI index was 64.2 ± 12.3 %, after 3 months — 30.1 ± 6.9 %, and at the time of examination after 6 and 12 months — 32.1 ± 5.2 % (p < 0.05), which corresponded to satisfactory results (table 2), (figure 3).

The evaluation of results by MRI in the preoperative and post-operative period (the next day after the surgery) showed that the cross-sectional area increased from 1.01±0.05 cm² to 2.01±0.02 cm² on average. The average length of hospital stay for patients was 2±1.2 days.

Perioperative complications. Considering the age of the patients and the high prevalence of concomitant diseases, we did not find a significant influence of these factors on the results of ULBD treatment for PPS. The average blood loss was 30±10 ml. Surgical complications
were identified in 5 patients: 3 cases of focal durotomy and 2 cases of post-operative hematoma. Cerebrospinal fluid leakage was not observed in cases of durotomy. Dural tears were not sutured due to the small size of the opening, but in 2 cases, a collagen patch was applied. All complications were treated conservatively, and no further consequences were observed. No other serious complications, such as wound infection, nerve root injury, vascular injury, or deep vein thrombosis, were observed.

**DISCUSSION**

In a retrospective study by Takahashi H. et al., the results of treatment of 50 patients with lumbar spinal stenosis (LSS) who underwent unilateral laminotomy for bilateral decompression (ULBD) were presented. According to VAS results before the operation, the back pain score was 51.5 ± 32.5 during movement, 63.0 ± 30.1 while standing, and 37.8 ± 31.8 while sitting. After the operation, back pain in a standing position significantly improved compared to sitting (p < 0.05). The authors concluded that ULBD improves back pain in all positions. In addition, symmetrical improvement of back pain with ULBD suggests that asymmetrical invasion in the paraspinal muscles and facet joints is not associated with residual back pain [15].

In a retrospective study by Dong Hwa Heo et al. [3], it was noted that transcutaneous uniportal or biportal endoscopic access to the lumbar spine can be effective in treating central stenosis of the lumbar spine and an alternative to conventional decompression.

In a study by Yoshikane K. et al., the results of treatment with endoscopic unilateral laminotomy for bilateral decompression (ULBD) in patients with LSS were presented. A total of 129 patients who underwent ULBD for single-level LSS were retrospectively reviewed. Clinical outcomes were assessed using the Japanese Orthopedic Association Back Pain Evaluation Questionnaire and the Numeric Rating Scale (NRS) for back pain, leg pain, and numbness. All domains of the NRS questionnaire significantly improved during the observation period. According to the Macnab questionnaire, 80% of patients rated their condition as excellent. The authors have concluded that ULBD provides a relatively favorable outcome in patients with LSS [17].

Therefore, our research results coincide with the results of studies by Dong Hwa Heo [3] and Yoshikane K. [17] on the low-trauma ULBD and the absence of serious complications after this operation, as well as the possibility of early verticalization and discharge of patients as soon as possible.

**CONCLUSIONS**

The ULBD technique is an effective method for decompression of the spinal canal in patients with lumbar spinal stenosis. Unilateral laminotomy with bilateral decompression technique (ULBD) allows reducing muscle dissection and decreasing the degree of damage to the posterior structures of the spine. Due to its low trauma, this method helps to reduce blood loss, which leads to an earlier hospital discharge (2 ± 1.2 days) and earlier rehabilitation of such patients compares with open methods.

Thus, the assessment of MRI results in the pre- and postoperative period (the day after the operation) showed that the average cross-sectional area increased from 1.01 ± 0.05 cm² to 2.01 ± 0.02 cm². The study of the subjective assessment of well-being according to the Oswestry questionnaire (Oswestry Disability Index (ODI) before the start of treatment and after its completion showed a significant improvement in the quality of life closest to the follow-up period after 3 months. Serious complications such as wound infection, root damage, blood vessel damage and deep vein thrombosis was not observed after this operation.

The perspective of further research is to evaluate the long-term results of the treatment of lumbar spinal stenosis by endoscopic biportal decompression after 5 years or more.

**COMPLIANCE WITH ETHICAL REQUIREMENTS**

The study was carried out in accordance with the standards set forth in the Helsinki Declaration of the World Medical Association «Ethical principles for conducting scientific medical research involving human subjects.» Voluntary consent was obtained from all participants before the study.

**FUNDING AND CONFLICT OF INTEREST**

The authors of the manuscript consciously certify the absence of actual or potential conflict of interest regarding the results of this work with pharmaceutical companies, manufacturers of biomedical devices, other organizations whose products, services, financial support may be related to the subject of the provided materials or who sponsored the conducted research.

**AUTHORS’ CONTRIBUTION TO THE ARTICLE**

1. Vasyl I. Melenko – wrote the manuscript
2. Iakiv V. Fishchenko – performed the experiments and analyzed the data
3. Lyudmila D. Kravchuk – wrote the manuscript
REFERENCES


**Резюме**

**ЕНДОСКОПІЧНА ДЕКОМПРЕСІЯ ПРИ ПОПЕРЕКОВОМУ СПІНАЛЬНОМУ СТЕНОЗІ: РАДІОЛОГІЧНІ ТА КЛІНІЧНІ РЕЗУЛЬТАТИ**

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Мета дослідження – оцінити результати хірургічного лікування методом біпортальної ендоскопії (ULBD) та проаналізувати ускладнення у хворих, оперованих з приводу дегенеративного стенозу поперекового відділу хребта.

Матеріали та методи. Проаналізовано результати лікування 51 пацієнта, (середній вік 58±16,4 років) з діагнозом стеноз поперекового відділу хребта, які перенесли біпортальну ендоскопічну декомпресію (ULBD) в клініці хірургії хребта зі спінальним (нейрохірургічним) центром ДУ «ІТО НАМН України».

Результати. Згідно з результатами дослідження, одразу після операції ULBD достовірно знизився рівень больового синдрому в спині та нижніх кінцівках. У післяопераційному періоді показник болю в спині за VAS знизився з 4,9 ± 2,3 см до 3,2 ± 0,5 см, а в нижніх кінцівках з 5,6 ± 2,1 см до 1,2 ± 0,7 см. При цьому високий показник больових відчуттів у спині на ранньому післяопераційному періоді був обумовлений травматизацією тканин в зоні втручання. Через 3 місяці після операції оцінка болю за VAS (спина) становила 1,1 ± 0,7 см та 1,4 ± 0,4 см у ногах (p < 0,05). Позитивна динаміка VAS (спина) зберігалася через 6 місяців і 12 місяців 1,3 ± 0,5 см і 0,9 ± 0,6 см, відповідно (p < 0,05). Покращення стану в нижніх кінцівках зберігалось на рівні 0,9 ± 0,7 см і 1,8 ± 0,6 см через 6 місяців і 12 місяців, відповідно (p < 0,05). Порівняльна оцінка за МРТ у передоперативному та післяоперативному періоді (на наступну добу після операції) показала, що площа поперечного зрізу в середньому зросла з 1,01±0,05 см² до 2,01±0,02 см². Середня тривалість перебування пацієнтів у стаціонарі становила 2±1,2 доби.

Висновки. ULBD є ефективним методом декомпресії спинномозкового каналу у пацієнтів зі стенозом поперекового відділу хребта. Біпортальна ендоскопічна декомпресія (ULBD) дозволяє зменшити розсічення м’язів і зменшити ступінь ураження задніх структур хребта.

Ключові слова: стеноз, метод ендоскопічної біпортальної декомпресії, лікування