

นิพนธ์ต้นฉบับ

ความชำนาญในการผ่าตัดหอนรองกระดูกสันหลังผ่านกล้องเอ็นโดสโคป

ณรงค์ศักดิ์ บำรุงถิ่น, พ.บ.

โรงพยาบาลปากช่องนานา จังหวัดนครราชสีมา

Received: July 14, 2020 Revised: August 13, 2020 Accepted: November 16, 2020

บทคัดย่อ

ที่มาของปัญหา: การผ่าตัดผ่านกล้องเอ็นโดสโคปต้องอาศัยทักษะและความชำนาญในการผ่าตัดสูง ผู้วิจัยสนใจศึกษาผลของความชำนาญในการผ่าตัดหอนรองกระดูกสันหลังผ่านกล้องเอ็นโดสโคป

วัตถุประสงค์: ศึกษาผลของความชำนาญในการผ่าตัดหอนรองกระดูกสันหลังผ่านกล้องเอ็นโดสโคป

วิธีการศึกษา: ผู้ป่วยได้รับการผ่าตัดหอนรองกระดูกสันหลังผ่านกล้องเอ็นโดสโคปจำนวน 60 ราย แบ่งออกเป็น 6 กลุ่ม กลุ่มละ 10 คน ตามลำดับการผ่าตัด บันทึกที่ระยะเวลาการผ่าตัด ระยะเวลาการนอนโรงพยาบาล ความเจ็บปวดขณะพักและขณะทำกิจกรรม ความสามารถในการทำกิจวัตรประจำวันและภาวะแทรกซ้อน บันทึกข้อมูลก่อนและหลังการผ่าตัดวันที่ 1 เดือนที่ 2 และ 6 ใช้สถิติ One-way ANOVA, Kruskal Wallis test, Friedman's test และ Chi-square test วิเคราะห์ข้อมูล

กำหนดระดับนัยสำคัญ $p = 0.05$

ผลการศึกษา: พบว่าอาการปวดขณะพักและทำกิจกรรมมีค่าลดลงอย่างมีนัยสำคัญ ($p < 0.001$) ความสามารถในการทำกิจกรรมมีค่าเพิ่มขึ้นอย่างมีนัยสำคัญ ($p < 0.001$) การเปรียบเทียบผลลัพธ์ทางคลินิกของผู้ป่วยระหว่างกลุ่มไม่แตกต่างกัน แต่พบว่า ระยะเวลาในการผ่าตัดและอัตราการผ่าตัดซ้ำมีค่าแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p < 0.001$ และ $p = 0.02$ ตามลำดับ)

สรุป: ปริมาณการผ่าตัด ทักษะและความชำนาญของ ศัลยแพทย์เป็นปัจจัยที่มีผลต่อความสำเร็จในการผ่าตัด แต่อย่างไรก็ตาม ควรพิจารณาถึงปัจจัยอื่นๆ ด้วย เช่น พยาธิสภาพและเทคนิคการผ่าตัด เป็นต้น

คำสำคัญ: ความชำนาญการผ่าตัด, หอนรองกระดูกเคลื่อน, การผ่าตัดผ่านกล้อง

ORIGINAL ARTICLE

Learning Curve of Percutaneous Endoscopic Lumbar Discectomy Based on the Period of Surgery: A Retrospective Comparative study

Narongsak Bamrungthin, M.D.

Pak Chong Na Na Hospital, Nakhon Ratchasima Province, Thailand

ABSTRACT

BACKGROUND: The learning curve of percutaneous endoscopic lumbar discectomy (PELD) was steep.

OBJECTIVE: To evaluate the learning curve, clinical outcomes and the complications based on the period of surgery in patients with lumbar disc herniation who underwent PELD by a single surgeon.

METHODS: Sixty patients with lumbar disc herniation who underwent PELD were included and assigned to six groups that contained 10 participants each (Groups A to F), which was categorized by the consecutive period of operation. The operative time, length of stay (LOS), resting VAS, activity VAS, ODI score, and complications were recorded during the preoperative period and on day one, at two months, and six months after the surgery. Statistical analysis was used by one-way ANOVA, the Kruskal Wallis

test, Friedman's test, and Chi-square test.

RESULTS: The resting VAS and activity VAS were decreased and statistically significant ($p < 0.001$). The ODI score was increased significantly ($p < 0.001$). The clinical results showed no difference between the groups, and the operative time and re-surgery rate showed significant difference between the groups ($p < 0.001$ and $p = 0.02$, respectively).

CONCLUSIONS: The learning curve was steep, and the amount of surgical experience had an influence on the learning curve for PELD. However, pathology and surgical techniques should also be considered.

KEYWORDS: learning curve, percutaneous endoscopic lumbar discectomy, lumbar disc herniation

INTRODUCTION

Lumbar disc herniation is the most common cause of low back pain and sciatica in adolescents, which there are several treatment options^{1,2} Non-surgical treatment includes complete bed rest, medication and physical therapy, whereas surgical treatment comprises open surgery, micro endoscopic and percutaneous endoscopic discectomy.³ Most patients with lumbar disc herniation recover through non-surgical treatment, while only 1 - 5% of cases need surgical treatment.^{1,4} In recent years, interest has increased in applying endoscopic spinal surgery for the treatment of lumbar disc herniation. In addition, percutaneous endoscopic lumbar discectomy (PELD) is a novel technique for minimal invasive spine surgery for the decompression and removal of nucleus pulposus. Furthermore, the advantages of minimally invasive procedures are the preservation of the bone structure and lumbar mobility, minimal blood loss, rapid recovery, reduced hospital stay and post-operative morbidity.⁵⁻⁷ However, PELD has an anatomical limitation for endoscopic insertion and two different operative approaches consisting of the transforaminal (TF) and interlaminar (IL) techniques. Although many studies have shown PELD is a safe and effective minimally invasive spine surgical technique, it has been challenging and the PELD learning curve has been steep.⁶⁻¹⁵ Nonetheless, a few studies have specifically addressed this aspect. In this study, the author conducted the learning curve and clinical outcomes of the first 60 cases retrospectively in the order of 10 cases in each group with PELD by a single surgeon's experience.

The purpose of the present study was to evaluate the learning curve, clinical outcomes, and complications based on the period of PELD in patients with lumbar disc herniation by a single surgeon.

METHODS

Sample and method

This retrospective study was performed on 60 patients with lumbar disc herniation who underwent PELD from October 2013 to September 2015. The patients were assigned into six groups that comprised 10 participants each (Groups A to F) categorized by the period of operation. The inclusion criteria consisted of (1) patients with a single level of lumbar disc herniation diagnosed by magnetic resonance image (MRI), and (2) treatment failure after at least six weeks of conservative management. The exclusion criteria were as follows: (1) patients with a migrated sequestered disc above or below the mid-pedicle level, (2) patients with spinal instability, (3) patients with spinal stenosis, (4) patients with recurrent lumbar disc herniation, and (5) patients who had undergone previous back surgery. This present study was approved by the Chaiyaphum Hospital Ethics Committee (Approval no. 023/2020). All surgical procedures were performed by a single surgeon.

Assessment

Data were recorded, including the operative time, length of stay (LOS), clinical outcomes and post-operative complications. Clinical outcomes were assessed by the resting visual analog scale (VAS), activity VAS and the Oswestry Disability Index (ODI) during the preoperative period and on day one, at two months, and six months after the surgery. All data were obtained from a chart review and telephone interview.

Statistical analysis

All statistical analyses used the SPSS version 23.0. The Kolmogorov-Smirnov test was utilized to confirm the normality of the data. A homogeneity of the variance test of the baseline characteristics and outcome variables was performed using one-way ANOVA with the categorical variables being expressed

as a number and frequency. The normally distributed continuous variables were expressed as a mean and standard deviation (SD), and the skewed distributed continuous variables were stated as a median and interquartile range (IQR). Friedman's test was also used for the within-group comparison of the continuous variables. For the between-group comparison, demographic data were carried out using the Kruskal-Wallis test or one-way ANOVA for the continuous variable, and the Chi-square test was used for the between-group comparison of the categorical variables. The statistically significant difference was considered at $p < 0.05$.

RESULTS

Demographic data

Seventy-four patients diagnosed with lumbar disc herniation who underwent PELD were recruited between October 2013 and September 2015. Only 60 patients met the inclusion criteria, whereas nine patients had lumbar disc herniation with spinal stenosis, two patients had spine surgery at more than one level, and three patients had previous spine surgery, so they were excluded from the study. The demographic data including age, gender, type of approach, level of surgery, and the preoperative clinical outcome showed no significant difference between all groups (Table 1).

Table 1 Demographic data.

	Group						p-value
	A	B	C	D	E	F	
No. of patients	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	
Mean age	46.6 ± 12.7	44.0 ± 10.6	45.9 ± 5.2	40.6 ± 13.5	43.2 ± 11.8	41.6 ± 8.7	0.79
Sex (male : female)	5:5	5:5	3:7	8:2	3:6	6:4	0.20
Surgical technique (TF : IL)	4:6	4:6	4:6	5:5	7:3	6:4	0.66
Level of surgery							
L3 – L4	1	0	1	1	0	1	0.82
L4 – L5	6	7	8	8	7	4	0.40
L5 – S1	3	3	1	1	3	5	0.32
Onset (months)	2.0 (7.0)	1.0 (5.0)	3.0 (10.0)	2.0 (6.0)	3.5 (4.0)	3.0 (8.0)	0.57
Preoperative resting VAS (0-10)	5.8 (3.3)	4.5 (1.0)	5.5 (3.5)	6.2 (2.9)	5.7 (4.9)	7.0 (2.2)	0.21
Preoperative activity VAS (0-10)	8.4 (2.5)	9.4 (2.3)	9.3 (1.6)	7.8 (2.0)	8.1 (2.1)	9.1 (2.2)	0.47

Operative time

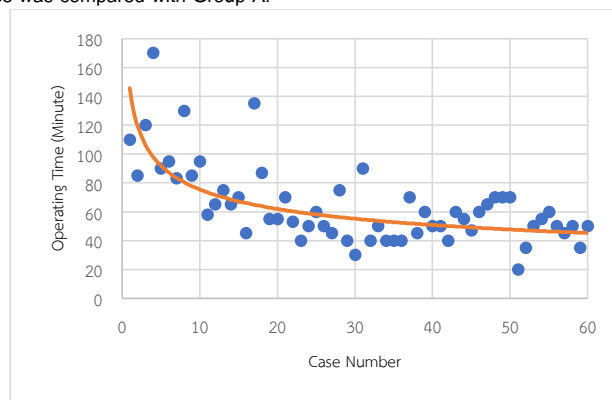
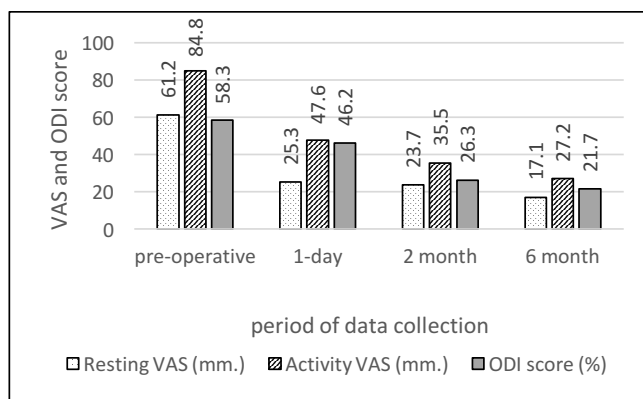
The overall mean ($\pm$ SD) of the operative time of all patients was 64.1 ± 27.3 minutes. The operative time decreased over the period of time (Groups A to C) and tapered to steady after the thirtieth case. The operative time (median and IQR) of Group A (Nos. 1 - 10), Group B (Nos. 11 - 20), Group C (Nos. 21 - 30), Group D (Nos. 31 - 40), Group E (Nos. 41 - 50) and Group F (Nos. 51 - 60) were 95 (38), 65 (23), 50 (23), 47.5 (23), 60 (21) and 50 (16) minutes, respectively.

The operative time of Groups B to F compared with the first group of operation (Group A) showed a statistically significant time reduction ($p = 0.001$). The change in operative time over the series of surgeries correlated with the use of a logarithmic curve-fit regression analysis (Table 2 and Figure 1). The overall the LOS for all patients was about four or five days, and there was no difference of the LOS in each group (Table 2).

Table 2 Comparison of the clinical outcomes in each group.

Variable	Group						Statistical Value	p-value
	A	B	C	D	E	F		
Operative time (Minutes)	95 (38)	65 (23)*	50 (23)*	47.5 (23)*	60 (21)*	50 (16)*	30.88	0.001
LOS (days)	4.5 (4)	3 (3)	4 (1)	3 (4)	3.5 (2)	2.5 (3)	2.24	0.81
Resting VAS								
Preoperative	5.8 (3.3)	4.5 (1.0)	5.5 (3.5)	6.2 (2.9)	5.7 (4.9)	7.0 (2.2)	7.15	0.21
1-day post-operative	2.8 (4.3)	2.0 (2.6)	2.3 (3.9)	2.0 (2.9)	2.6 (1.9)	1.5 (1.4)	4.81	0.43
2 months post-operative	2.6 (3.5)	1.7 (3.6)	2.3 (5.4)	1.3 (1.2)	1.9 (3.2)	1.5 (2.2)	2.60	0.24
6 months post-operative	1.1 (2.1)	1.5 (2.2)	2.0 (1.9)	0.6 (1.7)	1.9 (2.1)	1.0 (0.7)	3.61	0.60
Preoperative	8.4 (2.5)	9.4 (2.3)	9.3 (1.6)	7.8 (2.0)	8.1 (2.1)	9.1 (2.2)	4.51	0.47
1-day post-operative	6.3 (3.6)	4.0 (1.8)	5.7 (6.0)	4.1 (1.8)	5.1 (3.7)	3.8 (3.6)	6.74	0.24
2 months post-operative	3.8 (3.6)	4.5 (2.1)	4.9 (5.1)	3.0 (2.2)	3.0 (2.4)	3.0 (3.0)	3.00	0.75
6 months post-operative	2.1 (1.5)	3.5 (4.2)	3.1 (1.8)	1.2 (1.8)	3.6 (1.7)	1.8 (1.5)	11.21	0.05
ODI								
Preoperative	30.0 (19.3)	52.0 (32.0)	64.0 (14.5)	55.0 (29.5)	36.9 (21.6)	65.0 (36.5)	1.90	0.96
1-day post-operative	64.0 (26.5)	40.0 (30.6)	51.1 (30.8)	27.7 (22.6)	55.2 (46.1)	50.0 (39.0)	2.12	0.07
2 months post-operative	32.0 (39.0)	24.4 (16.6)	27.5 (28.0)	19.7 (22.5)	15.0 (29.5)	18.0 (29.5)	0.31	0.90
6 months post-operative	14.0 (46.0)	18.0 (22.0)	8.0 (19.0)	28.0 (27.3)	28.0 (27.3)	15.0 (33.0)	1.08	0.38

*The significant difference was compared with Group A.

**Figure 1** Operative time of the consecutive PELD cases.**Figure 2** Comparison of the overall clinical outcomes in the pre and post-operative phases.

Clinical outcomes

The overall resting VAS and activity VAS were significantly decreased when compared with the preoperative period ($p = 0.001$). Fifty-two patients (86.6%) had significant improvement of leg pain immediately after surgery and were able to walk immediately after recovery from the general anesthesia. There was no difference of the resting and activity VAS between the groups. The overall ODI score increased significantly when compared with the preoperative period ($p = 0.001$), and there was no difference of the ODI between the groups (Table 2).

Complications

After surgery, the author found six patients (10.0%) had revision surgery, eight patients (13.3%) had residual leg pain, 11 patients (18.3%) had paresthesia, and seven patients (11.3%) were transient motor deficit, which the symptoms were completely recovered during the follow-up period. There was only a significant difference in the revision surgery between these six groups ($p = 0.02$). Moreover, most complications occurred in the early phase of surgery (Table 3). Additionally, 54 patients (90.0%) reported no post-operative complications and showed good and excellent clinical outcomes.

Table 3 Comparison of the complications in each group.

Complications	Group						Total (60)	p-value
	A	B	C	D	E	F		
Persistent leg pain	2 (20.0)	4 (40.0)	1 (10.0)	0 (0.0)	0 (0.0)	1 (10.0)	8 (13.3)	0.05
Dysesthesia	1 (10.0)	3 (30.0)	2 (20.0)	1 (10.0)	2 (20.0)	2 (20.0)	11 (18.3)	0.85
Transient motor deficit	1 (10.0)	3 (30.0)	2 (20.0)	0 (0.0)	0 (0.0)	1 (10.0)	7 (11.3)	0.20
Re-surgery	0 (0.0)	4 (40.0)	1 (10.0)	0 (0.0)	0 (0.0)	1 (10.0)	6 (10.0)	0.02

DISCUSSION

This study demonstrated that percutaneous endoscopic lumbar discectomy is a safe and effective method for lumbar disc herniation treatment. This retrospective study comprised 60 patients who had undergone PELD to evaluate the learning curve of PELD. The patients were assigned into six groups categorized by the period of operation. The operative time, length of stay (LOS), resting VAS, activity VAS, ODI score, and post-operative complications were compared between the groups. Fifty-four patients (90.0%) had significant improved leg pain immediately after surgery and had good and excellent outcomes. The resting and activity VAS decreased significantly in every group ($p = 0.001$), whereas the ODI score increased significantly ($p = 0.001$) when compared with the preoperative period. Thus, it was found that PELD reduced the pressure on the nerves from the effect of the herniated disc to relieve leg pain and paresthesia, and allow the patients to move immediately after surgery. The results of PELD were equivalent to a conventional open discectomy, which

would possibly become a gold standard.⁵⁻⁸ The results of the present study were similar to previous studies. For example, Ahn et.al.¹² reported a post-operative VAS score for the back and leg that decreased significantly in the early and late groups. Hence, the learning curve of PELD seemed to be acceptable. Insufficient preparation of PELD was related to a higher tendency of a longer delayed operation time, operative failure, and re-surgery.

The operative time rapidly decreased over the early cases and tapered to steady after about the twentieth to the thirtieth case. The operative time of Groups B to F showed a statistically significant decrease compared with the first group ($p < 0.001$). Therefore, the results of the present study were consistent with a previous study that reported the operative time was rapidly reduced in the early phase after the twenty-second to thirty-fifth cases.^{9, 12-13} The percentage of the post-operative complications was similar to the previous study, which reported the complication rate of 8.3-11.0%.^{6, 10-14} The present results suggested that PELD has a steep learning

curve, but should be acceptable and approved by significant reduction of the operative time and overall complications after 30 cases of PELD surgery. Five patients (83.3%) of revision surgery were found in the first 30 cases of experience. The results of the present study were also consistent with Sclafani et al.¹⁰ who reported the complications associated with the initial learning curve of minimally invasive spine surgery. As such, the learning curve was overcome for the operative time and complications as a function of the case number in the 30 consecutive cases.

Nevertheless, there were some limitations in this study. The author did not evaluate other factors that could influence the initial outcomes of PELD; such as, the amount of cadaveric practices or epidural nerve block and the number of PELD cases, as the surgeon used to be an assistant before performing the surgery by himself. The severity or difficult types of disc herniation, which could affect the outcome, were also not reported. Therefore, further research could investigate the learning curve of PELD based surgical pathology, techniques, and other factors that could affect the learning curve of PELD.

Conflicts of Interest: The author declared there were no potential conflicts of interest.

Financial Support: None

Acknowledgement

The author would like to thank the PELD patients for giving their time to conduct this study. Their generosity allowed the author to gain new knowledge.

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