Master's Thesis of Medicine

Efficacy of the Erector Spinae Plane Block with Sedation for Unilateral Biportal Endoscopic Spine Surgery and Comparison with Other Anesthetic Methods

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Graduate School of Medicine
Seoul National University
Orthopedics Major

Tae Hoon Kang

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Examiner Pf. Jae Hyup Lee

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Graduate School of Medicine
Seoul National University
Orthopedics Major

Tae Hoon Kang

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Tae Hoon Kang
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Abstract

Background: Erector spinae plane block (ESPB) is a new regional anesthesia implemented in 2016. Unilateral biportal endoscopic (UBE) spine surgery, a minimal invasive technique, has been performed under not only general anesthesia (GA) but regional anesthesia including spinal anesthesia (SA). In this regard, ESPB with sedation for UBE can be an alternative to previous anesthetic methods. The aims of this study were to evaluate the efficacy of ESPB with sedation for UBE lumbar decompression and compare it with GA and SA.

Methods: A total of sixty patients who underwent UBE lumbar decompression were retrospectively reviewed. To compare perioperative results of ESPB with other anesthetic methods, a retrospective age matched case-control study design was performed. From October 2021 to July 2022, three groups (20 patients in each group) of patients who underwent UBE lumbar decompressions under each anesthetic method (GA, SA, or ESPB) were formed. The total anesthesia time excluding operation time, postoperative analgesia effects, hospital days and complications

related to anesthetic methods were evaluated.

Results: In the ESPB group, all the operations were performed without change of anesthetic methods and without anesthetic complications. But there were no anesthetic effects in the epidural space, which resulted in additional intravenous fentanyl usage. There were no significant differences in demographic or surgical characteristics between the three groups except for sex ratio. The mean of time from initiation of anesthesia to completion of surgical preparation was 23.3±4.7 minutes in the ESPB group, which was shorter than 32.3±10.8 minutes in the GA (p-value=0.001) or 33.3±6.7 minutes in the SA group (p<0.001). The mean of total anesthesia time was 107.5±30.8 minutes in the ESPB group, which was shorter than 131.0±38.1 minutes in the GA (p=0.002) or 134.3±37.4 minutes in the SA group (p <0.001). The proportion of patients requiring first rescue analgesia within 30 minutes after surgeries was 30% in the ESPB group, which was lower than 85% in the GA (p<0.001) but no significant different with 10% in the SA (p=0.11). The proportion of the cases that additional opioid medications postoperatively were used was 20% in the ESPB group, which was lower than 55% in the GA (p=0.01) but no different with 25% in the SA group (p=0.35). The mean of visual analog scale

(VAS) score of back pain at the discharge day was 2.7±0.5 in the ESPB group, lower than 3.1±0.5 in the GA (p = 0.01) or 3.1±0.6 in the SA group (p = 0.04). The mean of total hospital days in the ESPB was 3.0±0.8, shorter than 3.7±1.8 in the GA (p = 0.02) or 3.8±1.1 in the SA group (p = 0.01). There was no case of postoperative nausea and vomiting in the ESBB even without prophylactic antiemesis.

Conclusion: ESPB with sedation is a viable anesthetic option for UBE lumbar decompression. It has strengths in comparison with GA and SA in terms of total anesthesia time, postoperative analgesic effect and avoidance of complications related with GA or SA.

Keyword: Erector Spinae Plane Block, Unilateral Biportal Endoscopic Spine Surgery, Regional anesthesia, Minimally invasive spine surgery

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Chapter 1. Introduction

Since the 1950s, regional anesthesia (RA), which is mainly composed of neuro-axial anesthesia (NA) has already been used for spine surgeries.[1-3] NA is the administration of local anesthetics into the spinal canal including spinal anesthesia (SA) and epidural anesthesia (EA).[3] Previous studies have shown that local anesthesia (LA) could be a good option too.[4-6] RA and LA could enable patients not eligible for general anesthesia (GA) to get spine surgeries and reduce GA-related complications.[1,4,7,8] In addition, those methods can have lasting analgesic effects postoperatively, fast recovery rate and shorter hospital days.[1-3,9,10]

However, NA has some disadvantages for spine surgeries. First, due to degenerative change or previous instrumentation of the patients with spinal diseases, there is a risk of multiple trial or failure during NA.[2] Second, intraoperative neuromonitoring is impossible with NA because local anesthetics work by blocking voltage-gated sodium channels and reduce the neuro-axial transmission.[10] Third, NA has a rare but risk of nerve damage by needling or direct neurotoxicity on nerve tissue. It could cause radiculopathy, myelopathy or extremely rare but fatal cauda equina

syndromes.[3] Paresthesia induced by SA could be present in the patients with spine pathology.[11] Finally, SA has a time limitation, nearly 2 hours.[12] EA may be freer from the time limitation than SA, but it needs continuous local anesthetic injection via catheter around the surgical field. Spine surgeons may be reluctant to accept the presence of foreign materials like large dose of local anesthetics or catheters around the surgical field.[2]

Erector spinae plane block (ESPB) is a new regional anesthetic method implemented in 2016.[13] Local anesthetics are injected into the erector spinae plane via the needle. The dorsal rami are then gradually anesthetized at various levels as the fluid spreads through the fascia.[14] There were several studies investigating the spread of injected solution in the cadavers or radiocontrast solution in the living participants with imaging modalities, but there is no exact explanation for its mechanism of action yet.[14,15] Many doctors have adapted ESPB to spine surgeries for postoperative analgesia, even though those are performed under GA.[16,17] Some studies showed the use of ESPB as the main anesthesia for hip surgeries and anorectal surgeries.[18,19] In those surgeries, ESPB with intravenous administration of remifentanyl or propofol was applied. [18,19]

Meanwhile, one of the reasons that various anesthetic methods

become possible for spine surgeries is the development of minimally invasive spine surgeries (MISSs). Since surgical incisions are small and soft tissue injuries are less, minimal anesthesia works enough.[1,2] Endoscopic spine surgery (ESS) is a kind of MISSs that can be divided into two categories: full endoscopic surgery and endoscopic assisted surgery.[20] In full endoscopic surgery, endoscopes and instruments work together through one channel. It has been performed under NA and even LA only due to the single incision.[4-6,9,21] Unilateral biportal endoscopy (UBE) spine surgery is one of endoscopic assisted surgeries. Two portals are created; one for an endoscope and one for surgical instruments. Some advocates of UBE have maintained that UBE provides more degree of freedom in motion of the endoscope and its instruments than full endoscopic surgeries.[22] UBE spine surgeries have been performed under not only GA but NA too.[23-25] However, to the best of our knowledge, UBE cases under RA but not NA have not been reported yet. If UBE spine surgery is possible under ESPB with sedation, it can be helpful to avoid the disadvantages of GA or SA.

We hypothesized that ESPB with sedation for UBE spine surgeries should be possible and have advantages compared to GA and SA, in terms of total anesthesia time excluding operation time,

postoperative analgesic effect, hospital days, and complications related to anesthetic methods like intubation or neuraxial blockage.

The purpose of study was to verify the efficacy of ESPB with sedation for UBE lumbar decompression by comparing with GA and SA.

Chapter 2. Methods

Research ethics

As this was a retrospective case-control study reviewing patients' medical records after surgeries, consents to participate in this study were exempted. This study was reviewed by a public IRB (P01-202208-01-022).

Materials

From May to July 2022, there were 20 cases of UBE lumbar hemilaminectomies under ESPB with sedation. The diagnoses were spinal stenoses without segmental instabilities. As this is a kind of preliminary study, we set up the limited indications that were treated by lumbar decompression only and took less than 3 hours.[26]

To evaluation the results with other anesthetic methods, we chose a retrospective matched case-control study design.

Previously, there were 65 cases of UBE lumbar decompression for spinal stenosis from October 2021 to April 2022. There were 35 cases under GA and 30 cases under SA. According to our experience, SA was usually performed for old patients to avoid the GA. To remove the effect of age in comparison, 15

youngest patients under GA and 10 eldest patients under SA were excluded. As a result, three groups consisting of 20 cases each under GA, SA, and ESPB were formed. To evaluate the validity of comparison between three groups, demographic and surgical characteristics were reviewed first.

Demographic data including age, sex, height, and weight were obtained. The American Society of Anesthesiologists physical status (ASA) scores and presence of underlying diseases such as diabetes were evaluated. Preoperative laboratory findings, such as hemoglobin (Hb), prothrombin time (PT), and activated partial thromboplastin time (aPTT) were obtained. Whether anti-thrombotic drugs were taken was checked. All anti-thrombotic drugs were stopped before one week of the surgery. To check the severity of preoperative symptoms, preoperative Visual analog scale (VAS) back, leg scores and preoperative Oswestry Disability Index (ODI) scores were checked. There were no differences in demographic factors except a sex ratio and preoperative leg pain VAS scores. About laboratory data, there were no significant difference except aPTT but the data were in the normal range. (Table 1)

Table 1. Demographic data of GA, SA and ESPB groups

	GA	SA	ESPB	Average /total	P value
Age	66.4± 6.2	70.3± 7.1	64.0± 15.6	67.1± 10.9	0.16
Sex (F/M)	16/4	8/12	13/7	37/23	0.03 GA/ESPB 0.3 GA/SA 0.01 SA/ESPB 0.11
Height (m)	1.57± 0.08	1.62± 0.08	1.60± 0.09	1.60± 0.11	0.18
Weight (kg)	62.2± 12.3	65.9± 8.9	63.8± 12.1	63.61± 11.3	0.58
BMI (kg/m^2)	25.1± 3.9	25.0± 3.0	24.9± 3.9	25.0± 3.6	0.98
ASA score	2.0± 0.4	2.0± 0.5	2.1± 0.7	2.0± 0.5	0.93
Diabetes (%)	4/20 (20)	7/20 (35)	7/20 (35)	18/60 (30)	0.64
Preoperative Hb (g/dL)	13.5± 1.2	13.8± 1.3	13.5± 1.4	13.6± 1.2	0.72
Preoperative PT (sec)	12.8± 1.2	12.7± 1.3	12.8± 1.0	12.8± 1.2	0.97
Preoperative aPTT (sec)	31.8± 5.3	28.2± 2.2	28.6± 2.5	29.6± 3.9	0.01 GA/ESPB 0.04 GA/SA 0.01 SA/ESPB 1.00
Antithrombotic use (%)	1/20 (5)	5/20 (25)	4/20 (20)	10/60 (16.7)	0.31
Preoperative VAS back	6.4± 2.7	5.5± 2.9	6.1± 2.5	6.0± 2.7	0.54
Preoperative VAS	8.1±	6.45±	7.3±	7.3±2.4	0.02

leg	2.3	2.0	2.6		GA/ESPB 0.22 GA/SA 0.01 SA/ESPB 0.12
Preoperative ODI	20.3± 6.8	15.9± 6.1	18.8± 7.9	18.3± 7.1	0.13

GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block; BMI: Body mass index; ASA: The American Society of Anesthesiologists physical status; Hb: Hemoglobin; PT: Prothrombin time; aPTT: activated partial thromboplastin time; VAS: Visual Analog Scale; ODI: Oswestry Disability Index.

For surgical data, the level of decompression and skin to skin operation time were checked. Whether it was a revision surgery and whether a discectomy was performed were also checked. There were no statistical differences in them. (Table 2)

Table 2. Surgical data of GA, SA and ESPB groups

	GA	SA	ESPB	Average /Total	P value
The number of surgical levels (1,2,≥3)	9/8/3	7/10/3	8/12/0	24/10/6	
The mean of surgical levels	1.8±0.9	1.8±0.7	1.6±0.5	1.7±0.7	0.57
Revision cases (%)	5/20 (25)	5/20 (25)	5/20 (25)	15/60 (25)	1
Discectomy (%)	7/20 (35)	6/20 (30)	9/20 (45)	22/60 (37)	0.61

Skin to skin operation time [range] (min)	82.0± 33.4 [30-130]	92.5± 37.6 [50-170]	78.5± 30.2 [30-135]	84.3± 33.8	0.42

GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block;

How to do ESPB with sedation

ESPB with intravenous (IV) administration of dexmedetomidine or propofol was applied for the surgery. When a patient entered the operating room (OR), the patient could lie down prone on the spine table for him or herself. Before the ESPB, 0.03 mg/kg of midazolam was administered intravenously for anxiolysis. With C-arm fluoroscopy, an 18-gauge spinal needle was placed on the surface of upper transverse processes corresponding to the level of decompression. Which side of transverse processes was confirmed according to the planned side of hemilaminectomy. A radio-opaque contrast was injected via the needle. Whether it spread well following the erector spinae plane and did not enter the blood vessel was checked. (Figure 1)

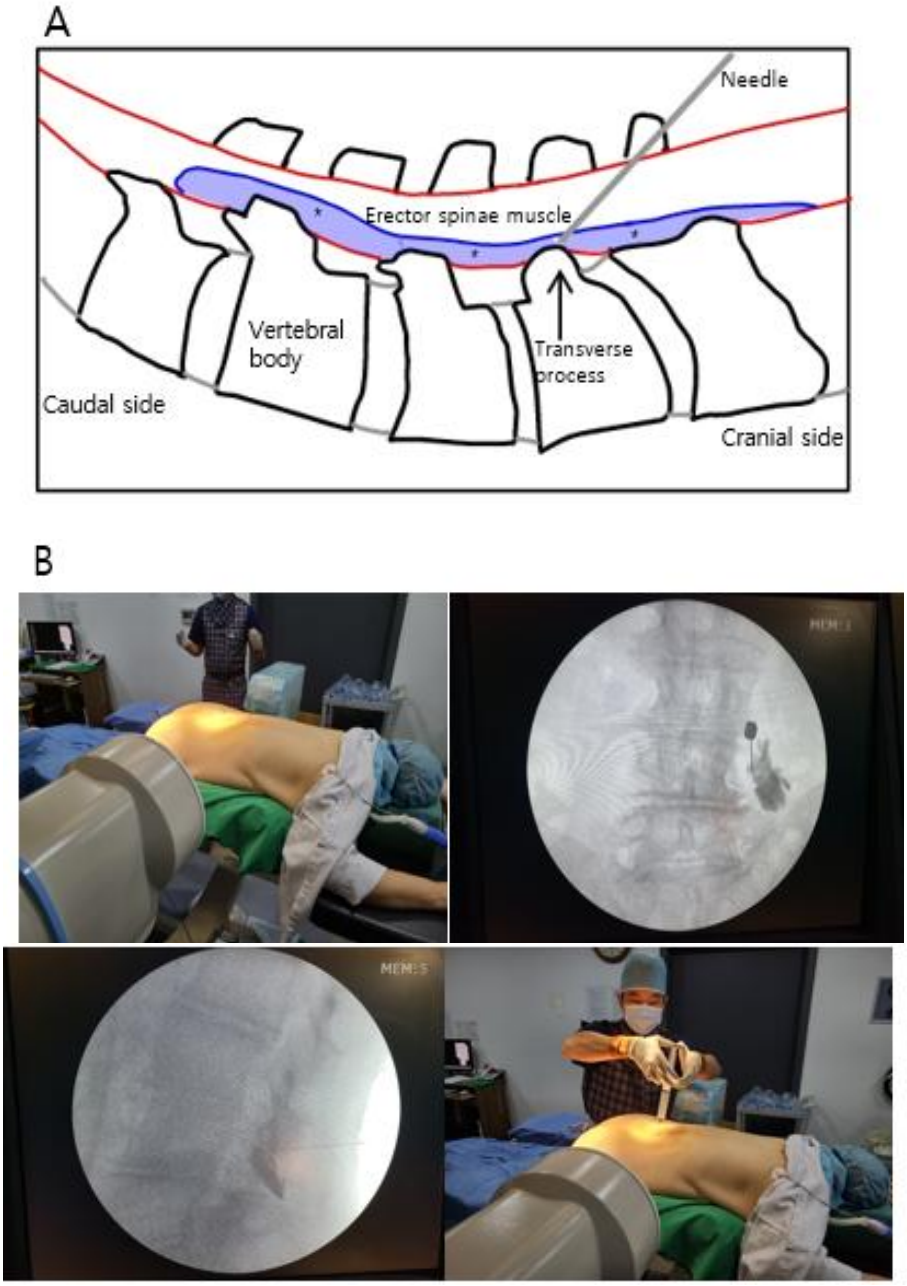

Figure 1. A – A schematic diagram showing a mixed fluid of local anesthetics. *: The fluid injected via a needle and spreading in the erector spinae plane. B– Pictures during procedure, including needle insertion using fluoroscopy, contrast spread following the erector spinae plane, and slow injection.

A mixture of 2% lidocaine 7.5 ml, 0.375% ropivacaine 22.5 ml, and 1:1000 epinephrine (1 mg/1 ml) 0.2 ml was slowly injected. Total amount of mixture was 30 ml. Additional 2 ml of 1% lidocaine was injected at each portal site. During the operation, intravenous 25 mcg shot of fentanyl was prepared for additional pain control and injected if the anesthesiologist judged that the patient in sedation felt pain.

Patient breathed spontaneously during the operation with oxygen delivery via nasal cannula. The patient's head lied comfortably on a soft cover that could support the face in a prone position. Dexmedetomidine (Precedex, Pfizer Korea, South Korea) was mainly used with an infusion pump at 0.5−1 μg/kg/hr for 10 minutes of induction and 0.1−0.3 μg/kg/hr thereafter. Previous studies showed that the dexmedetomidine is contraindicated in patients with hemodynamic instability, second or third atrioventricular block and severe bradycardia.[27] Propofol (Anepol, Hana, South Korea) was used via an infusion pump at 1.5 to 2.5 mg/kg/hr for those patients. Anesthesiologists continuously monitored the patient's respiration and vital signs such as blood pressure, electrocardiogram, O_2 saturation, and $EtCO_2$ monitor. If there were signs of respiratory depression, the infusion rate was

reduced, and the patient was awakened. Positional change to supine position and tracheal intubation was planned for respiratory failure refractory to those management.

Anesthetic methods of GA and SA

GA and SA were performed according to the routine manner in our hospital. In GA, Anesthesia was induced with administration of 1–1.25 mg/kg of propofol, 1 μg/kg of fentanyl, and 0.6 mg/kg of rocuronium before tracheal intubation. After tracheal intubation, anesthetic maintenance was by inhaled anesthetics, sevoflurane. In SA, patients got the blind needle puncture and injection via interlaminar space in lateral decubitus position. 10–13 mg of 0.5% heavy bupivacaine with 0.1 ml of 1:1000 epinephrine (1 mg/1 ml) was injected. 0.05 mg/kg of midazolam was used intravenously for anxiolysis. If the patient want sedation, IV sedation was performed in the same way with ESPB procedure.

Surgical procedures

Partial hemilaminectomy with UBE was performed for decompression. A discectomy was also performed if acute herniated disc tissues were present. It was performed using an arthroscopic

surgical system (4-mm size, 30-degree arthroscope, Arthrex Inc., USA) and an automated pressure-controlled pump system with pressure set at 30 to 35 mmHg during surgery (Flosteady, Stryker Inc., USA). While maintaining continuous fluid irrigation through surgical portals, an arthroscopic tissue shaver (TPS Irrigation console, Stryker Inc., USA) was used for tissue dissection. A bipolar radiofrequency thermo-controlled ablator (Quantum Arthrocare, Smith&Nephew Inc., UK) was used for cauterization. An arthroscopic burr (TPS Irrigation console, Stryker Inc., USA) was used for bone resection.

The patient was prone on the spine table with slight hip flexion. The surgeon stood on the left side of the patient. (Figure 2) The hemilaminectomy was performed on the side of more prominent symptom. Two portals were made for each level of surgery. Two 1 cm skin incisions were made vertically along the lateral margin of the spinous process on the side of hemilaminectomy. (Figure 3) The cranial portal was made at the level of the upper lumbar pedicle and the caudal portal was made at the level of the lower lumbar pedicle. The distance between the two portals was least 2 cm. (Figure 4) Serial dilation to interlaminar space and minimal muscle detachment were performed first. After

that, the area of bony resection included inferior portion of the upper lamina, superior portion of the lower lamina, and medial half facets. Posterior decompression was performed by removing the ligament flavum and checking the central dural sac and ipsilateral exiting and traversing roots. For those with bilateral symptoms, additional removal of the contralateral ligament flavum was done and contralateral exiting and traversing roots were checked. (Figure 5) If a transforaminal approach was required, portals were made on the more lateral side and a surgical approach was performed via Kambin triangles (Figure 6). Each drain was placed near at the epidural space in every level of decompression, and subcutaneous tissue sutures of surgical portals were done. An additional surgery at a different level was performed if needed.

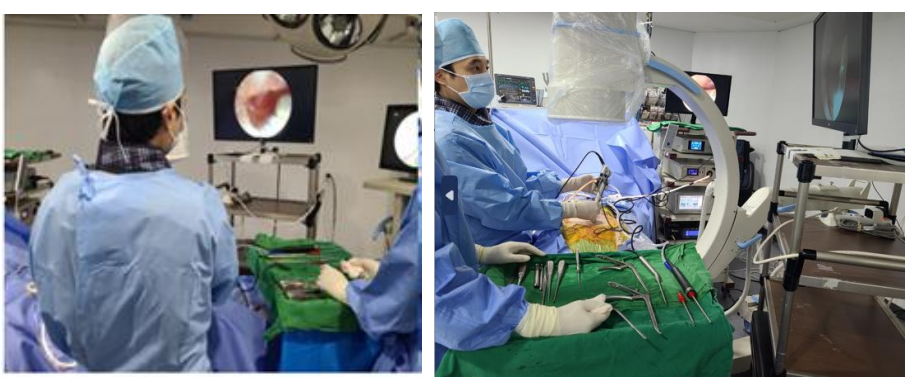

Figure 2. Pictures that the surgeon stood on the left side of the patient and performed the right side lumbar hemilaminectomy using unilateral biportal endoscopy.

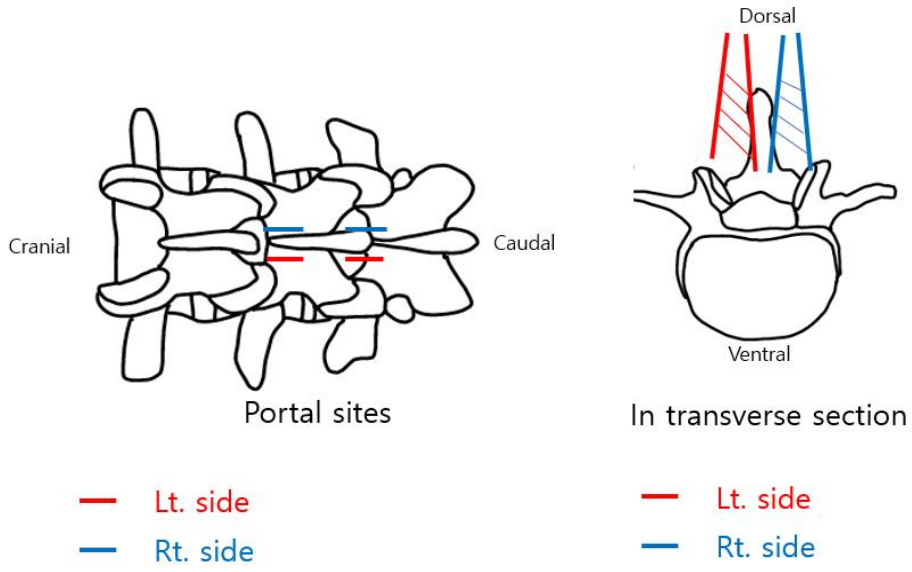

Figure 3. Left – A schematic diagram of surgical portals by unilateral biportal endoscopic lumbar interlaminar decompression, with red ones for the left side and blue ones for the right side. Right – A schematic diagram of the endoscopic surgical fields before hemilaminectomies in transverse section (Red area: Left side approach, blue area: Right side approach)

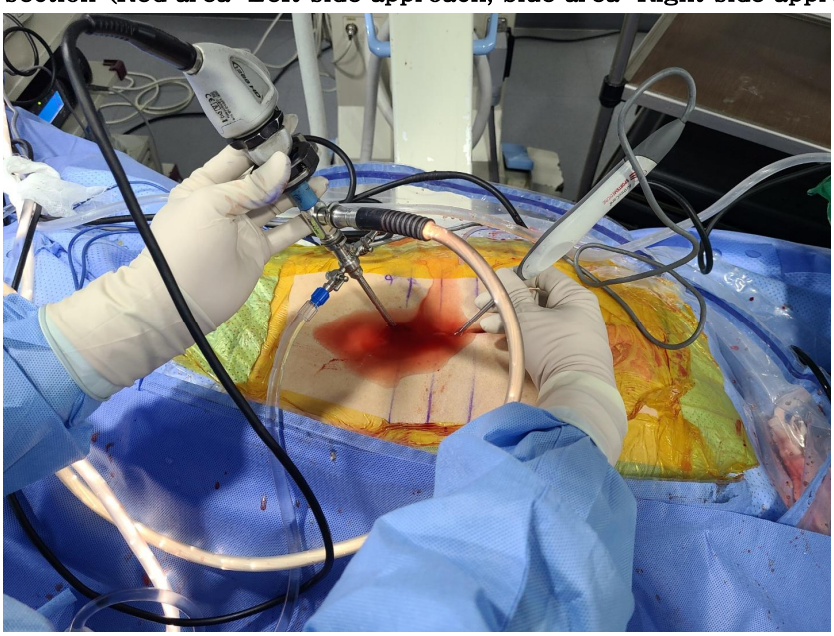

Figure 4 – A picture of unilateral biportal endoscopic right side lumbar hemilaminectomy (left hand : the endoscope, right hand : Arthrocare, one of the endoscopic devices).

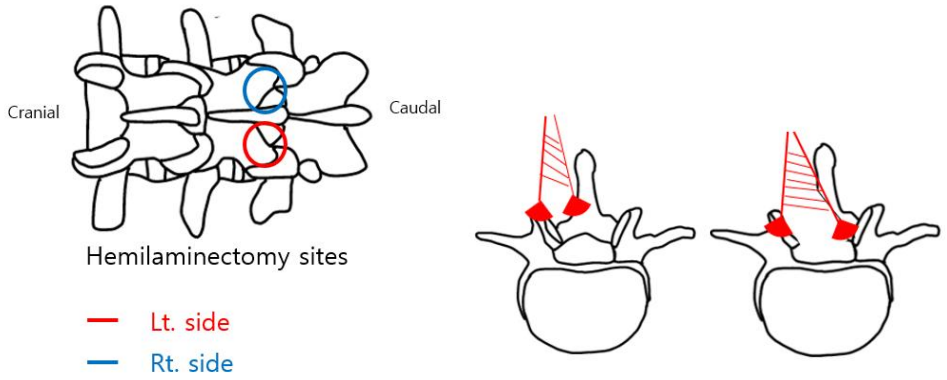

Figure 5. Left – A schematic diagram of the hemilaminectomy area. (Red circle: Left hemilaminectomy, blue circle: Right hemilaminectomy) Right – A schematic diagram of widened surgical field around the spinal canal using 30-degree scope before and after hemilaminectomy. (Red circular sector: the available additional visible field using a 30-degree scope)

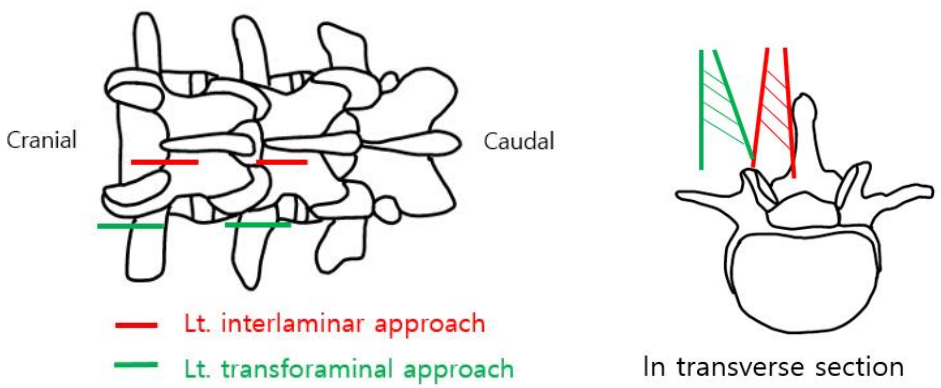

Figure 6. Left – A schematic diagram of surgical portals by unilateral biportal endoscopic lumbar transforaminal approach. Right – A schematic diagram of the endoscopic surgical fields in transverse section (Green area: Left side transforaminal approach)

Comparisons of intraoperative and postoperative findings between three groups

First, to evaluate the total anesthesia time excluding operation time, the concept of three different time spans was created; First, the time span of preparation is the time from initiation of anesthesia to completion of surgical preparation (which includes anesthesia induction and surgical preparation). Second, the time span of exiting is the time from the end of surgical procedure to leaving the OR. The time span of total operating room is the total time in the OR, same with the total anesthesia time. (Figure 7) (Table 3)

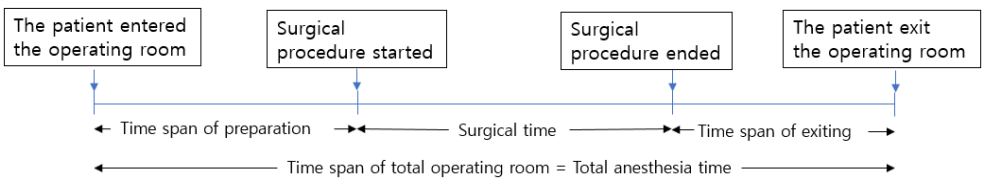

Figure 7. A schematic diagram showing the concept of time spans

Second, to evaluate the postoperative analgesic effect, we checked the amount and timing of IV acetaminophen and opioid use. When the patient arrived at the ward after the surgery, nurses immediately assessed the severity of pain. If the patient complained of pain, 1g of IV acetaminophen was used first as first rescue analgesia. If the pain did not subside, 50 mg of IV tramadol was used when NRS score was 5 or 6. When the score was 7 or higher, 50 mg of IV pethidine was used. After postoperative day (POD) #1,

the patient got 1 g of IV acetaminophen twice a day. We checked the proportion of patients requiring first rescue analgesia within 30 minutes after the surgeries, the time of first analgesic administration after the surgery, and the total amount of IV acetaminophen. We also checked same things about IV opioids. (Table 4)

Patients could be discharged at POD #1 or later if there were no acute complications and the patient felt that the pain was tolerable to go home. The patients were asked the VAS scores of back pain and leg pain at the discharge day. We compared the postoperative VAS scores and hospital days too. (Table 5)

Third, we evaluated the incidence of complications related to anesthetic methods. Previous studies showed that postoperative nausea and vomiting (PONV) is a well-known complication that the patients feel miserable and related to the gas anesthetics of GA.[2] There was a report there was no difference of PONV event between GA and SA.[10] As a result, in our hospital, antiemetic drugs were prophylactically used in the GA and SA groups. IV ondansetron which is one of the 5-hydroxy-tryptamine receptor 3 antagonists was used. Each patient in the GA and SA groups received intravenous administration of 2.5 mg ondansetron one hour

before surgery at ward.[28] But no prophylactic antiemesis drugs were used in the ESPB group. We checked whether PONV events happen or not. The symptoms, sore throat and postoperative atelectasis, which are known complications of endotracheal intubation were reviewed. The postoperative hypotension events known as possible complication of SA were reviewed.[2]

Meanwhile, we routinely checked the amount of postoperative drainage fluid and each drain was removed when the amount was less than 50 ml during 12 hours. We also checked if postoperative cerebrospinal fluid (CSF) leak via drain happens or not. Because the CSF leak following spinal surgery is a common surgical complication. The main reason of the CSF leak is the iatrogenic surgical durotomy, and when it happened during the operation, we figured the size of it and repaired it with fibrin sealant patches or dural clips. However, postoperative CSF leak without confirmed durotomies could occur with other reasons. Dural punctures from SA or EA is a rare but possible cause of CSF leak.[29] Therefore, we checked postoperative amount of drainage and intraoperative iatrogenic surgical durotomies events. We also checked incidence of postoperative CSF leak via drain without iatrogenic durotomies.(Table 6)[10]

Statistical analysis

All data were analyzed using SPSS Ver 20 (IBM, U.S.A). One-way analysis of variance or Kruskal Wallis test was performed for continuous variables (age, height, weight, BMI, ASA score, preoperative laboratory data, operation levels, operation time, postoperative drainage amount, anesthetic time spans, hospital days, preoperative and postoperative VAS scores, preoperative ODI scores, the time of first analgesic administration, total dose of analgesics). The chi-square test or Fisher's exact test was performed for categorical variables. (The ratios of diabetes, revision cases, discectomies and antithrombin uses, the proportion of patients requiring first rescue analgesia and the proportion of patients requiring additional intravenous opioid, incidence of complications) To see pair-wise differences in values between the three groups, post hoc analysis was conducted using a Bonferroni test with a significance level of 5% and a 95% confidence interval.

Chapter 3. Results

All lumbar decompression surgeries under ESPB were performed without any complications. There was no case to change the anesthetic method during the operation. There was no case that the patient remembered intraoperative pain or complained about it when asked postoperatively. Immediate postoperative neurologic motor examination was possible in all cases.

We figured out the phenomenon that the epidural space was not anesthetized in ESPB. It was noted that patients felt pain during procedure around the roots, especially inflamed one. We noticed that pains by patients' moaning sound or movement of bodies. Some patients, though in sedation, were saying that he or she felt the radiating pain during the decompression around inflamed roots but they couldn't remember it postoperatively. As a preliminary study, we couldn't expect this phenomenon and record all the exact details of the events. We used routinely intravenous 50 μg of fentanyl prepared during the epidural procedures. The pains provoked in the epidural space were controlled by it.

During the block procedure, there was an event that an insufficient dose was injected compared to the original plan. The patient had hypertension history and her preoperative systolic blood

pressure (SBP) in the ward was near 170 mmHg. The patient's SBP increased up to 200 mmHg after 10 ml of anesthetics injection. We stopped the injection and waited. The systolic blood pressure went down below 170 mmHg in 5 minutes. We decided to start the operation without adding the anesthetic method. The surgical time was 55 minutes and the routine use of fentanyl worked enough for pain control. The operation ended up well.

Total anesthesia time excluding operation time

Table 3. The three time spans associated with anesthesia in the three groups.

	GA	SA	ESPB	P value
The time span of preparation (min)	32.3±10.8	33.3±6.7	23.0±4.7	<0.01 GA/ESPB <0.01 GA/SA 0.4 SA/ESPB <0.01
The time span of exiting (min)	14.75±2.6	5	5	<0.01 GA/ESPB <0.01 GA/SA <0.01 SA/ESPB 1.00

The time span of total operating room (min)	131.0±38.1	134.3±37.4	107.5±30.8	0.04 GA/ESPB <0.01 GA/SA 0.4 SA/ESPB <0.01

GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block; The time span of preparation: the time from initiation of anesthesia to completion of surgical preparation. The time span of exiting: the time from the end of surgical procedure to leaving the operating room. The time span of total operating room: the total time in the operating room, same with total anesthesia time.

The time spans of preparation, exiting and total operating room in the ESPB group were shorter than those in the GA or SA groups. The mean of the time span of preparation in the ESPB group was 23 ±4.7 minutes, which was shorter than 32.3±10.8 minutes in the GA group (p−value = 0.001) or 33.3±6.7 minutes in the SA group (p<0.001). The mean of the time span of exiting in the GA group was 14.75 minutes, which was longer than 5 minutes in the SA and ESPB groups. In SA and ESPB groups, patients could exit the OR soon without procedures like extubation. All data were 5 minutes because the minimum unit was 5 minutes. As a result, the mean of time span of total operating room was 107.5±30.8 minutes in the ESPB group, which significantly shorter than 131.0±38.1 in the GA group (p = 0.002) or 134.3±37.4 in the SA group (p<0.001).

Amount and timing of intravenous acetaminophen and opioid use

Table 4. Amount and timing of intravenous acetaminophen and opioid use for postoperative pain control in three groups

	GA	SA	ESPB	Average /Total	P value
The proportion of cases requiring first rescue analgesia within 30 minutes after the surgeries (%)	17/20 (85)	2/20 (10)	6/20 (30)	25/60	<0.01 GA/ESPB <0.01 GA/SA <0.01 SA/ESPB 0.11
Time of first analgesic administration after the surgery (min)	33.9± 133.9	227.1± 134.5	332.8± 406.7	197.9± 283.6	<0.01 GA/ESPB <0.01 GA/SA <0.01 SA/ESPB 0.80
Total dose of IV acetaminophen (g)	4.2± 2.0	4.2± 1.8	3.3± 0.9	3.9± 1.7	0.23 GA/ESPB 0.11 GA/SA 0.97 SA/ESPB 0.17
Additional IV opioid use cases (%)	11/20 (55)	5/20 (25)	4/20 (20)	20/60	0.02 GA/ESPB 0.01

					GA/SA 0.04 SA/ESPB 0.35
Type of opioid (pethidine/tramadol)	9/3	3/2	1/3	13/8	
Time of IV opioid administration after the surgery (hour)	2.6± 2.2	12.8± 10.8	12.8± 6.6	6.8± 7.5	0.03 GA/ESPB 0.01 GA/SA 0.09 SA/ESPB 1.00
Total dose of IV opioid (ample)	0.65± 0.67	0.25± 0.44	0.20± 0.52	0.37± 0.58	0.02 GA/ESPB 0.01 GA/SA 0.04 SA/ESPB 0.50

GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block; IV: Intravenous.

In terms of postoperative pain management, ESPB was no different from SA, but was superior to GA. There was a statistically significant difference in the proportion of cases requiring first rescue analgesia within 30 minutes after the surgeries: 85% in the GA, which was higher than 10% in the SA ($p<0.001$) or 30% in the

ESPB group ($p<0.001$). About the time of first analgesic administration, it was 33.85±133.9 minutes in the GA group, shorter than 332.8±406.7 minutes in the ESPB ($p<0.001$) or 227.1 ±134.5 minutes in the SA group ($p<0.001$). However, in those two factors, there was no significant difference between SA and ESPB groups. In the GA group, 55% of patients needed IV opioid medication postoperatively. However, only 25% in the SA and 15% in the ESPB group needed it ($p=0.04$ and $p=0.02$, respectively). Patients in the GA group got opioid drugs at 2.6±2.2 hours after the operation, which was shorter than 12.8±6.6 hours of the ESPB ($p=0.01$) or shorter but not statistically significant than 12.8±10.8 hours of the SA group ($p=0.09$). Consequently, the total amount of it in the GA group was significantly more than that in the SA group ($p=0.041$) or the ESPB group ($p=0.01$). However, there was no significant difference in opioid consumption between SA and ESPB groups.

Postoperative pain VAS scores on the day of discharge and hospital days

Table 5. The postoperative pain VAS scores on the day of discharge and hospital days

	GA	SA	ESPB	Average	P value
Postoperative VAS back score	3.1±0.5	3.1±0.6	2.7±0.5	3.0±0.5	0.03 GA/ESPB 0.01 GA/SA 0.95 SA/ESPB 0.04
Postoperative VAS leg score	2.3±1.5	2.1±1.5	2.5±1.1	2.3±1.4	0.96 GA/ESPB 0.70 GA/SA 0.82 SA/ESPB 0.58
Days from surgery to discharge	1.9±1.3	1.8±0.9	1.2±0.4	1.6±1.0	0.08 GA/ESPB 0.07 GA/SA 0.81 SA/ESPB 0.03
Total hospital days	3.7±1.8	3.8±1.1	3.0±0.8	3.5±1.3	0.05 GA/ESPB 0.02 GA/SA 0.29 SA/ESPB 0.01

GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block; VAS: Visual Analog Scale

Compared to GA and SA, the ESPB group showed lower VAS back scores on the days of discharge and shorter hospital stays. The mean of VAS score of back pain on the days of discharge was 2.7±0.5 in the ESPB group, lower than 3.1±0.5 in the GA (p=0.01) or 3.1±0.6 in the SA group (p=0.04). However, there was no statistically significant difference in VAS leg scores between the groups. In the ESPB group, the discharge was possible at 1.2±0.4 days later after the surgery, which was significantly shorter than

1.8±0.9 days in the SA group (p=0.03) and shorter but not statistically significant than 1.9±1.3 days in the GA group(p=0.07). The mean of total hospital days in the ESPB group was 3.0±0.8, shorter than 3.7±1.8 days in the GA (p=0.02), or 3.75±1.1 days in the SA group (p=0.01).

Complications related to anesthetic methods

Table 6. Complications related to anesthetic methods

	GA	SA	ESPB	Average/ Total	p-value
Postoperative nausea and vomiting (%)	1/20* (5)	0/20* (0)	0/20 (0)	1/60 (1.7)	NS
Sore throat (%)	2/20 (10)	0/20 (0)	0/20 (0)	2/60 (3.3)	NS
Postoperative atelectasis (%)	0/20 (0)	0/20 (0)	0/20 (0)	0/60 (0)	NS
Postoperative hypotension event (%)	0/20 (0)	2/20 (10)	0/20 (0)	2/60 (3.3)	NS
Total amount of drainage (ml)	92.5± 74.8	139.1 ±88.0	109.0 ±51.5	113.5± 74.4	0.13 GA/ESPB 1.00 GA/SA 0.18 SA/ESPB 0.62
Intraoperative confirmed iatrogenic durotomy (%)	1/20 (5)	3/20 (15)	0/20 (0)	4/60 (6.7)	NS

Postoperative CSF leak via drain without confirmed durotomies (%)	0/19 (0)	3/17 (18)	0/20 (0)	3/56 (7.1)	NS
Total confirmed or suspected dural injury (%)	1/20 (5)	6/20 (30)	0/20 (0)	7/60 (11.7)	GA/ESPB NS GA/SA 0.05 SA/ESPB <0.01

*GA: General anesthesia; SA: Spinal anesthesia; ESPB: Erector spinae plane block; CSF: cerebrospinal fluid; NS: No significance. *: with prophylactic antiemetics used;*

There was no PONV event and complication related to the intubation or neuraxial blockage in the ESPB groups. One patient of the GA group complained PONV and got administrated IV 2.5 mg of ondansetron postoperatively. In the GA group, two patients complained of sore throat. There were no postoperative atelectasis cases in any of the three groups. In the SA group, two patients showed postoperative hypotension and were administrated IV 20 mg of ephedrine in the ward for elevating blood pressure.

There was no significant difference in total amount of drainage between three groups. There were one case in GA and three cases in SA group of confirmed durotomies during the operation. There were three cases of postoperative CSF leak via drain without confirmed durotomies in the SA group only. The

incidence of total confirmed or suspected dural injuries was 30% in the SA group, which was higher than 5% in the GA (p=0.05) or 0% in the ESPB group (p=0.001).

To analyze these results specifically, we reviewed all confirmed or suspected dural injuries (Table 7). In two cases (case #5 and #6), dural puncture was performed at the same level of decompression. In the case #7, the level of dural puncture was unchecked. As a result, total confirmed or suspected dura injury events occurred in 6 cases of the SA group. Among them, two cases (case #4, #7) required readmissions after the discharge.

Table 7. All cases with confirmed or suspected dural injuries in three groups

Case	Age	Sex	Surgical level	Revision	Anesthesia	SA puncture level	Dural tear level	Tear type	Tear lesion	Tear size	Repair method	Surgical time (min)	Total drainage (ml)	Discharge day	Re-admission
1	75	F	2 (L34, L45)	x	GA	none	L34	Iatrogenic	Central dura	<5mm	Dural clip + fibrin sealant patch	130	206	POD#2	x
2	75	F	1 (L34)	o	SA	Unchecked	L34	Iatrogenic	Lt. root sheath	<5mm	fibrin sealant patch	60	76	POD#3	x
3	76	M	1 (L45)	o	SA	Unchecked	L45	Iatrogenic	Central dura	<5mm	Dural clip + fibrin sealant patch	65	299	POD#2	0
4	74	F	2 (L34, L45)	x	SA	Unchecked	L34	Iatrogenic	Central dura	<5mm	Dural clip + fibrin sealant patch	170	114	POD#3	x
5	68	M	2 (L34, L45)	x	SA	L45	Not found in endoscope				None	170	289	POD#3	x
6	72	M	3 (L34, L45, L5S1)	x	SA	L45	Not found in endoscope				None	135	290	POD#2	x
7	63	M	1 (L45)	x	SA	Unchecked	Not found in endoscope				None	75	200	POD#1	0

GA: General anesthesia SA: Spinal anesthesia ESPB: Erector spinae plane block POD: Postoperative day

4. Discussion

This study showed that UBE lumbar decompression was possible under ESPB with sedation, but no analgesic effect of ESPB in the epidural space resulted in the need of additional fentanyl use and sedation. And it showed that compared to GA or SA, ESPB had shorter total anesthesia time excluding operation time, more postoperative analgesic effect, shorter hospital days and less complications related to previous anesthetic methods. To the best of our knowledge, this is the first study to report spine surgeries under ESPB with sedation and the first study combining UBE and ESPB.

There were some considerations when we first adapted ESPB to UBE. We chose ropivacaine as a long-acting local anesthetics because many studies showed that ropivacaine had less cardiotoxicity and produced less motor block in epidural space.[30] For a rapid anesthetic effect, we used a mixture of short-acting lidocaine and long-acting ropivacaine.[14,18,19] Some reports showed that it took time for local anesthetics to spread via the erector spinae plane.[16] Even after spreading, ESPB showed an irregular pattern of cutaneous blockage.[14] Thus, about 2 ml of 1% lidocaine

was applied for the surgical incisions. ESPB was performed on only one side of the transverse process to maximize the volume effect within the safety margin of lidocaine usage.[14] Because one side hemilaminectomy worked enough to decompress bilaterally, only one side regional anesthesia was performed. Our mixture contained about 40% of the maximal safe dose for lidocaine and 33% for ropivacaine.[31-33] The cumulative effect was about 73%, which was less than the maximal safe dose.[31] Moreover, to escape intravasation-induced systematic toxicity, we checked if there was blood regurgitation or not and if the contrast spread well via erector spinae plane, not into blood vessels using fluoroscopic images. In addition, epinephrine was added for local vasoconstriction. The injection of mixture was performed slowly for 2 minutes to check whether initial symptoms of systematic toxicity such as desensitization around the mouth and seizures occurred.[33] As a result, there were no cases showing systematic toxicity. Lipid solution which is helpful to reduce lidocaine toxicity was prepared to be administrated.[32,33]

Our result showed that ESPB had the shortest time from initiation of anesthesia to completion of surgical preparation. This might be related to that the patient position during ESPB was the

same as an actual surgical position. GA should be performed in the supine position and medical staff should change the patient to prone. SA should also be performed in the lateral decubitus position first and additional position change is needed. In ESPB, the patient laid down prone on the operating table for spine surgery with consciousness for herself or himself without further position change. In addition, the anesthetic method itself was short and easy. The needle was placed on the transverse process without any obstacles following fluoroscopy. As a result, the total anesthesia time was the shortest in the ESPB group. It could diminish the complications of patients' long duration in the OR.[34-36] The efficient management of OR could be possible by reducing the operating room turnover time from the hospital's point of view.[37]

This study suggested curiosities about the lasting time of ESPB and accurate postoperative analgesic effects. According to previous study, the lasting time of ESPB postoperative analgesia varies from 4 to 72 hours.[14-16] In our study in the ESPB group, the surgical time varied from 30 to 135 minutes, which additional anesthetics were not needed. But there are other spine surgeries which take longer operation time like fusion. Considering the first analgesia demand time, we assumed that those surgeries with ESPB could be possible,

but additional studies are needed to figure out safety margin of operation time with ESPB. This study also used the postoperative analgesics usage to analyze the postoperative analgesic effects. It was a kind of indirect analysis which could result in incorrect deduction. Additional examinations like skin pin prick tests or questionnaires after the surgery would be helpful to it.

In the ESPB group, the mean of VAS back pain scores on the day of discharge was lowest, accompanied with fast discharge. It seemed that the analgesic effect of ESPB and less complications could make the patient willing to get discharged faster. But it should be proved by using surveys to the patients. Although similar postoperative analgesic effects between ESPB and SA were shown, higher VAS back scores and longer hospital stays in the SA group may be related to prolonged hospitalization and residual pains due to dural injuries. Due to the retrospective study design and small cases numbers, this interpretation has a limitation too.

This study presented the possible relationship between the dural puncture of SA and arthroscopic spine surgeries. In our cases, there were 3 cases of postoperative CSF leak without confirmed durotomy lesions in the SA group only. It may be related to unrecognized surgical durotomies but there were no cases in other

anesthetic methods. Also, although the incidence of unrecognized durotomy in conventional open spine surgeries was up to 6.8%[38],to the best of our knowledge, there is no report of it in UBE. Previous study showed that durotomy of SA in open spine surgeries does not result in the CSF leak.[10] But, the UBE surgery was a kind of arthroscopic surgery that the water pressure of epidural space was 30 mmHg, higher than the natural intradural pressure of the human which is approximately 11 mmHg.[39] It could result in the pressure gap between epidural and intradural space and this could bring water pressure-induced additional injury at the punctured dura due to spinal needle insertion. Following studies are needed to prove it. But considering our results, avoiding the repeated SA trials or the dural puncture at the same level of decompression may be helpful to reduce the risk of dural injury and CSF leakage in UBE spine surgeries.

It was possible to check the neurology examination right after the surgeries in the ESPB group due to saving motor functions. This could enable intraoperative neuromonitoring devices or wake-up tests too. Previous reports show the intraoperative neuromonitoring device was possible with ESPB too.[40] If the patient is awakened up from sedation and ordered to move the lower limbs, wake-up tests

would be possible in our procedure. Further studies should be needed to prove it.

We found out that the epidural space was not anesthetized in ESPB. Adequate methods to anesthetize epidural space would be helpful like injecting local anesthetics to the epidural space.[21] But it could result in motor nerve block by which the both of intraoperative neuromonitoring and postoperative rapid walking could be limited. As a result, it wasn't performed in our study, but additional study of it would be helpful to patients which are refractory to IV pain controls. This phenomenon also has some advantages. Evaluating which part is the causative lesion in multilevel lumbar stenosis is challenging. In our procedure, if a patient feels pain during the procedure around inflamed neural tissue, it could give surgeons some assurance of the causative lesion. And also, there are some angiogenesis and adhesions around the inflamed nerves, which could bring some risks of vessel injuries or neural injuries during the procedure. A pain evoked during the procedure could make the surgeon think that the lesion could be with inflammatory changes and more cautious to deal with the lesion.

There are some limitations in our study. First, the number of subjects as small because this was a preliminary study on UBE

under ESPB. Therefore, generalizing the results should be warned. Second, this study is a retrospective case control study. To get rid of the aging effect, age matching was performed. There is a risk of selection bias even though we tried our best. Also, the sex ratio was not matched. The sex ratio can influence the consequence of surgery such as pain intensities or hospital days. Third, as a preliminary study, we couldn't predict the phenomenon that the epidural space is not anesthetized. We couldn't check and analyze the exact characteristics of this phenomenon. Fortunately, planned IV fentanyl administration could control the pain but it could cause fentanyl related complications like respiratory depression. Additional methods to control the pain would be needed. Forth, there are some risks of airway maintenance in prone position with sedation. Especially additional fentanyl usage could be hazardous to self-breathing. In our study, there was no suggestion of exact inclusion criteria because of the lack of previous studies. It seems desirable to exclude patients with a high risk of airway maintenance like overweight or obstructive sleep apnea. When saturation maintenance is complex, turning the patient to a supine position and tracheal intubation is crucial. This did not happen in our study population. However, it seems necessary to establish objective

inclusion criteria.

Chapter 5. Conclusion

ESPB with sedation is a viable anesthetic option for UBE lumbar decompression. It has strengths in comparison with GA and SA including the short total anesthesia time, postoperative analgesic effect, and avoidance of complications related with GA and SA. But there are some limitations including the ineffectiveness in the epidural space and the caution of airway maintenance.

Abstract

배경: 척추 기립근 면 마취는 2016년에 시작된 새로운 부위 마취법이다. 양방향 내시경은 미세 침습 척추 수술의 일환으로 전신 마취뿐만 아니라 부위 마취 하에도 시행되어 왔다. 척추 기립근 면 마취 하에 양방향 내시경을 시행하는 것은 기존의 마취방법과 다른 하나의 방법이 될 수 있다. 이번 연구는 척추 기립근 면 마취 하에 양방향 내시경을 이용한 요추 감압술의 효용성을 분석하고 이를 전신 마취와 척추 마취와 비교하기로 하였다.

방법: 양방향 내시경을 이용한 요추 감압술을 받은 60례의 사례를 후향적으로 분석하였다. 비교 연구를 위하여 연령이 유사한 후향적 환자 대조군 연구 방법을 사용하였다. 2021년 10월부터 2022년 7월까지 전신 마취와 척추 마취 그리고 척추 기립근 면 마취를 시행한 뒤 요추 감압술을 받은 각각 20례로 구성된 3개의 군을 비교하였다. 마취소요시간, 수술 후 진통효과, 입원 기간, 마취와 관련된 부작용 발생 여부를 평가하였다.

결과: 척추 기립근 면 마취의 경우, 모든 수술은 다른 마취 방법으로 바꾸거나, 부작용이 발생하는 경우 없이 종료되었다. 다만 경막외 공간은 마취효과가 없어서 추가적인 경정맥을 통한 펜타닐 사용이 필요하였다. 세 군 간에는 성별을 제외한 인구학적 그리고 수술 관련 인자들의 차이가 없었다. 마취를 시작한 뒤 수술준비가 종료될 때까지의

시간을 보았을 때 척추 기립근 면 마취에서 23.3±4.7 분으로 32.3±10.8 분인 전신마취나 (p-value=0.001) 33.3±6.7 분인 척추 마취보다 (p<0.001) 짧았다. 수술장내 체류 시간 또한 척추 기립근 면 마취군에서 107.5±30.8 분으로 131.0±38.1 분인 전신마취 (p=0.002)나, 134.3±37.4 분인 척추마취보다 (p<0.001) 짧았다. 수술종료 후 30 분 이내에 진통제가 필요했던 경우가 척추 기립근 면 마취에서 30%로 이는 85%인 전신마취 보다 유의하게 낮았고 (p<0.001), 10%인 척추마취와는 통계적인 차이가 없었다 (p=0.11). 추가적인 마약성 진통제가 필요했던 경우가 척추 기립근 면 마취에서 20%로, 55%였던 전신마취보다 유의하게 낮았고 (p=0.01), 25%였던 척추마취와는 통계적인 차이가 없었다 (p=0.35). 척추 기립근 면 마취에서 퇴원 당일 요통의 통증사정 점수의 경우 2.7±0.5로 3.1±0.5 전신 마취나 (p=0.01) 3.1±0.6인 척추 마취 (p=0.04)보다 낮았다. 척추 기립근 면 마취의 경우 전체 입원 기간도 3.0±0.8 일로, 3.7±1.8 일인 전신 마취(p=0.02)나 3.8±1.1 일인 척추 마취보다 짧았다 (p=0.01). 예방적으로 항구토제를 사용하지 않았음에도 척추 기립근 면 마취군 내에서는 수술 후 구역 및 구토감이 없었다. 또한 기도 삽관과 관련된 부작용이나 척추마취와 관련된 경막 손상과 같은 부작용 또한 없었다.

결론: 척추 기립근 면 마취 하에 양방향 내시경을 이용한 요추 감압술이 가능하였다. 전신마취와 척추마취와 비교하였을 때, 마취시간이 짧고,

수술 후 진통효과가 있으며, 이전 마취 방법과 관련된 부작용을 피할 수 있다는 장점을 가지고 있다. 하지만 경막외 공간이 마취되지 않는 점과, 엎드린 진정 상태이기에 기도유지에 어려움이 있다는 점은 주의가 필요하다.

색인어: 척추 기립근 면 마취, 양방향 내시경 척추 수술, 부분마취, 미세 침습 척추 수술

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