Risk Factors for Incidence of Postoperative Spinal Epidural Hematoma Following Multilevel Microendoscopic Laminectomy

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Abstract:

Introduction: Due to the narrow portal of entry, microendoscopic laminectomy (MEL) is associated with a risk of postoperative spinal epidural hematoma (POSEH). This risk might be higher when performing multiple-level (m-) MEL. The purpose of this study is to clarify the incidence rate of POSEH following single-level (s-) and m-MEL by each interlaminar level and identify the risk factors for POSEH following m-MEL.

Methods: A total of 379 patients underwent MEL of the lumbar spine (s-MEL, n=141; m-MEL, n=238). We determined the incidence of POSEH following s-MEL and m-MEL by each interlaminar level. For m-MEL, we clarified the correlation between POSEH and possible risk factors, such as operative findings, the sequence of operated interlaminar levels, and the preoperative cross-sectional dural area (CSA) on magnetic resonance imaging.

Results: The incidence rate at L2/3 was significantly higher than that at L3/4 and L4/5. Patients who underwent L2/3 decompression at the end of the procedure showed a higher incidence of POSEH at the L2/3 level. Preoperative spinal stenosis was associated with POSEH at the L2/3 level, and CSA of 56 mm^2 was a predictive factor for POSEH. Logistic regression analysis revealed that both were significant risk factors.

Conclusions: In patients undergoing m-MEL, the incidence of POSEH is highest at the L2/3 level, and treatment of the L2/3 level at the end of the procedure and the presence of spinal stenosis are risk factors for POSEH.

Keywords:

spinal epidural hematoma, laminectomy, spinal stenosis

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Introduction

Despite its low incidence, postoperative spinal epidural hematoma (POSEH) is a serious complication after spine surgery[1-3]. Due to the narrow portal of entry, microendoscopic laminectomy (MEL) is associated with a risk of POSEH, and this risk may be even higher in patients undergoing multiple-level MEL (m-MEL).

Several risk factors for POSEH have been identified, including the patient's background factors and the performance of multilevel surgery[4,5]. High blood pressure (BP) is also a frequently described risk factor[1,6]. Interlaminar space rebleeding that occurs soon after surgery may lead to POSEH regardless of the effectiveness of postoperative suction drainage[7,8]. Some reports have described the correlation between the sagittal alignment and POSEH[3,5], indicating that kyphotic alignment might lead to a narrow canal space followed by the development of POSEH.

Previous research indicates that the distribution or incidence of POSEH may differ among various interlaminar spaces. The purpose of this study was to clarify the incidence rate of POSEH following single-level MEL (s-MEL) and m-MEL by each interlaminar space and identify the risk factors for m-MEL, including patients' characteristics and radiographic and operative findings.

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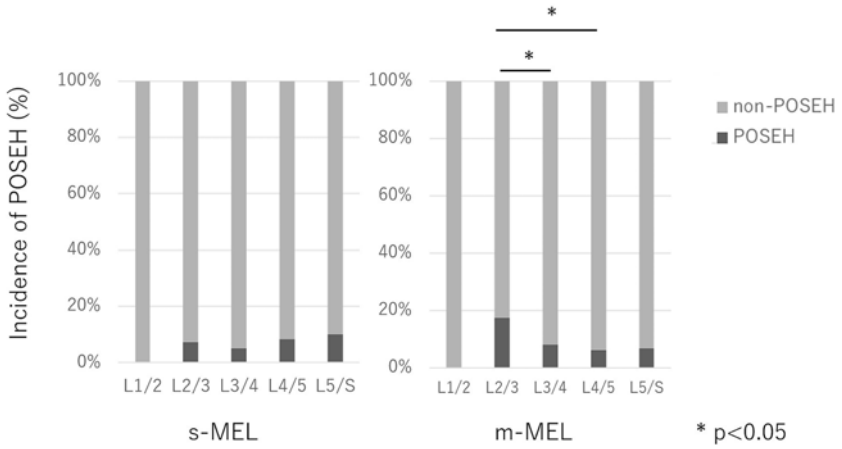

Figure 1. Distribution of incidence of POSEH following s-MEL and m-MEL by each interlaminar level. In the m-MEL group, the incidence rate at the L2/3 level was significantly higher than that at the L3/4 and L4/5 levels. [Abbreviations] MEL, microendoscopic laminectomy; POSEH, postoperative spinal epidural hematoma *p<0.05

Materials and Methods

Patients

We retrospectively reviewed the data of 379 patients who underwent MEL of the lumbar spine at 1 medical institution from January 2016 to April 2020. Clinical data were collected from the patients' charts according to our institution's ethics guidelines. This study has been approved by the IRB of the author's affiliated institution. MEL was performed in all cases of lumbar decompression surgery. Postoperative epidural suction drains were removed on the second postoperative day. We asked patients to stop anticoagulant and antiplatelet medication preoperatively according to guidelines for management of anticoagulant and antiplatelet therapy in cardiovascular disease produced by the Japan Circulation Society. Patients restarted the medication 1 day after the removal of drainage tubes. Patients underwent magnetic resonance imaging (MRI) when they experienced severe pain or exhibited neurological deficits after the surgery. In addition to MRI finding of hematoma compressing the dura as previously described[9], our diagnostic criteria of POSEH included neurological deficits or postoperative back or leg pain more than visual analog scale 8 resistant to nonopioid analgesics.

We decided the surgical level responsible for the symptom according to the combination of motor testing and MRI finding. If there were several interlaminar spaces with hematomas and we could not identify which surgical level was responsible for the symptom, several hematomas were regarded as POSEHs.

Clinical and radiological evaluation

We clarified the incidence rate of POSEH following s-MEL and m-MEL by each interlaminar space. For m-MEL, we collected the following data regarding possible risk factors for POSEH: patient characteristics, postoperative BP (upon leaving operating room), operative time, and intraoperative blood loss per one decompression level. Patient characteristics included age, sex, body mass index (BMI), and American Society of Anesthesiologists physical status (ASA-PS). Since our data showed that the incidence rate of POSEH was highest at the L2/3 level, we collected further data to identify the risk factors for POSEH only at the L2/3 level. Specifically, we measured the preoperative dural sac area in the axial MRI view and checked whether the L2/3 interlaminar space was treated at the end of the procedure to verify the correlation between POSEH and a short interval of time before extubation.

Statistical analysis

Data are presented as mean ± standard deviation. Differences between the POSEH and non-POSEH groups were evaluated by Pearson's chi-square test and Student's t test. We used a logistic regression model to extract risk factors for POSEH and estimated the odds ratios (ORs) and 95% confidence intervals (95% CI). A receiver operating characteristic (ROC) curve was created to predict the incidence of POSEH with reference to the dural sac area. The data analysis was conducted with the JMP statistical software package, ver. 9.0.2 (SAS Institute, Cary, NC, USA). A p-value of <0.05 was considered statistically significant.

Results

The distribution of the incidence of POSEH is shown in Fig. 1. A total of 141 patients underwent s-MEL and 238 underwent m-MEL. In the s-MEL group, 11 patients developed POSEH with the following incidence rates: L1/2, 0/2 patients (0.0%); L2/3, 1/14 patients (7.1%); L3/4, 1/20 patients (5.0%); L4/5, 8/95 patients (8.5%); and L5/S, 1/10 patients (9.0%). In the m-MEL group, 28 patients developed POSEH with the following incidence rates: L1/2, 0 patients

(0.0%); L2/3, 13/75 patients (17.3%); L3/4, 16/199 patients (8.0%); L4/5, 13/210 patients (6.2%); and L5/S, 3/44 patients (7.1%). Eight out of 28 cases showed neurological deficits and required revision surgery to remove POSEH. After the revision surgery, they recovered from the symptom. In the m-MEL group, the incidence rate at the L2/3 level was significantly higher than that at the L3/4 and L4/5 levels (p=0.02 and p<0.01). The mean age of the patients in the m-MEL group was significantly higher than that of the patients in the s-MEL group (72.1±10.5 vs. 67.8±14.8, respectively; p<0.01). There was no difference in sex between the two groups (data not shown).

The clinical and operative parameters of m-MEL are summarized in Table 1, 2. In the POSEH group, 22 of 28 patients were male and 6 of 28 patients were female. The mean age and BMI of the patients in the POSEH group were 72.1±7.6 years and 24.8±3.7 kg/m^2, respectively. The average ASA-PS was 1.89. Similarly, in the non-POSEH group, 127 of 210 patients were female. The mean age and BMI in the POSEH group were 72.1±10.8 years and 24.8±3.6 kg/m^2, respectively. The average ASA-PS was 2.06. There were no significant differences in these parameters between the POSEH and non-POSEH groups. For operative parameters, the operating time per one decompression level in POSEH group was significantly shorter than that of non-POSEH group (69.5±26.8 vs. 82.6±21.6, p=0.02). POSEH group had a higher number of decompression levels than non-POSEH group (2.5±0.6 vs. 2.2±0.5, p=0.03). There was no significant difference in blood loss per one decompression level (15.3±15.4 vs. 13.2±16, p=0.53) or postoperative BP on le (146.7±24.9 vs. 140±24.2 min, p=0.19) between the two groups.

The results of the univariate analysis for risk factors at the L2/3 level are summarized in Table 3. The representative MRI findings for a patient with POSEH at the L2/3 after m-MEL are shown in Fig. 2. The L2/3 level was treated at the end of the procedure in 10 of 13 patients (76.9%) in the POSEH group but in only 26 of 62 patients (41.9%) in the non-POSEH group (p<0.05). There was no significant difference in the number of decompression levels (2.6±0.6 vs. 2.8±0.6, p=0.17) or operating time (81.3±23.3 vs. 61.8±32.8 min, p=0.06) per one decompression level between the two groups. The dural sac area was significantly smaller in the POSEH group than in the non-POSEH group (54.8±23.2 vs. 77.3±24.8 mm^2, p<0.01). The average dural sac area was 73.4 mm^2 (range, 33-133 mm^2) among all patients who underwent L2/3 MEL. The ROC curve demonstrated that a cross-sectional dural area (CSA) of 56 mm^2 on preoperative MRI was a predictive factor for POSEH (sensitivity, 0.77; 1−specificity, 0.23; area under the curve, 0.77) (Fig. 3). The results of the logistic regression are summarized in Table 4. The analysis revealed that both treatment of the L2/3 level at the end of the procedure (OR, 4.8; 95% CI, 1.06-21.4)

Table 1. Clinical Parameters of m-MEL Patients.

Variable	POSEH (n=28)	Non-POSEH (n=210)	p-value
Gender Male/female	22/6	127/83	0.06
Age	72.1±7.6	72.1±10.8	0.99
BMI	24.8±3.7	24.8±3.6	0.95
ASA-PS			
1	4	19	0.06
2	23	160	
3	1	31	

[Abbreviations] ASA-PS, American Society of Anesthesiologists physical status; BMI, body mass index; n, number of patients; POSEH, postoperative spinal epidural hematoma

Table 2. Operative Parameters of m-MEL Patients.

Variable	POSEH (n=28)	non-POSEH (n=210)	p-value
Operating time per one decompression level (min)	69.5±26.8	82.6±21.6	**0.02**
Blood loss per one decompression level (ml)	15.3±15.4	13.2±16	0.53
Number of decompression level	2.5±0.6	2.2±0.5	**0.03**
Postoperative blood pressure on leaving operation room	146.7±24.9	140±24.2	0.19

[Abbreviations] n, number of patients; POSEH, postoperative spinal epidural hematoma

Table 3. Risk Factors for POSEH at L2/3 Level among m-MEL Patients.

Variable	POSEH (n=13)	non-POSEH (n=62)	p-value
Age	71.3±7.8	71.3±9.5	0.99
Gender (male/female)	11/2	39/23	0.19
Dural sac area (mm^2)	54.8	77.3	**<0.01**
Number of L2/3 treated	10 (76.9%)	26 (41.9%)	**0.02**
Number of decompression level	2.6±0.6	2.8±0.6	0.17
Operating time per one decompression level (min)	81.3±23.3	61.8±32.8	0.06

[Abbreviations] n, number of patients

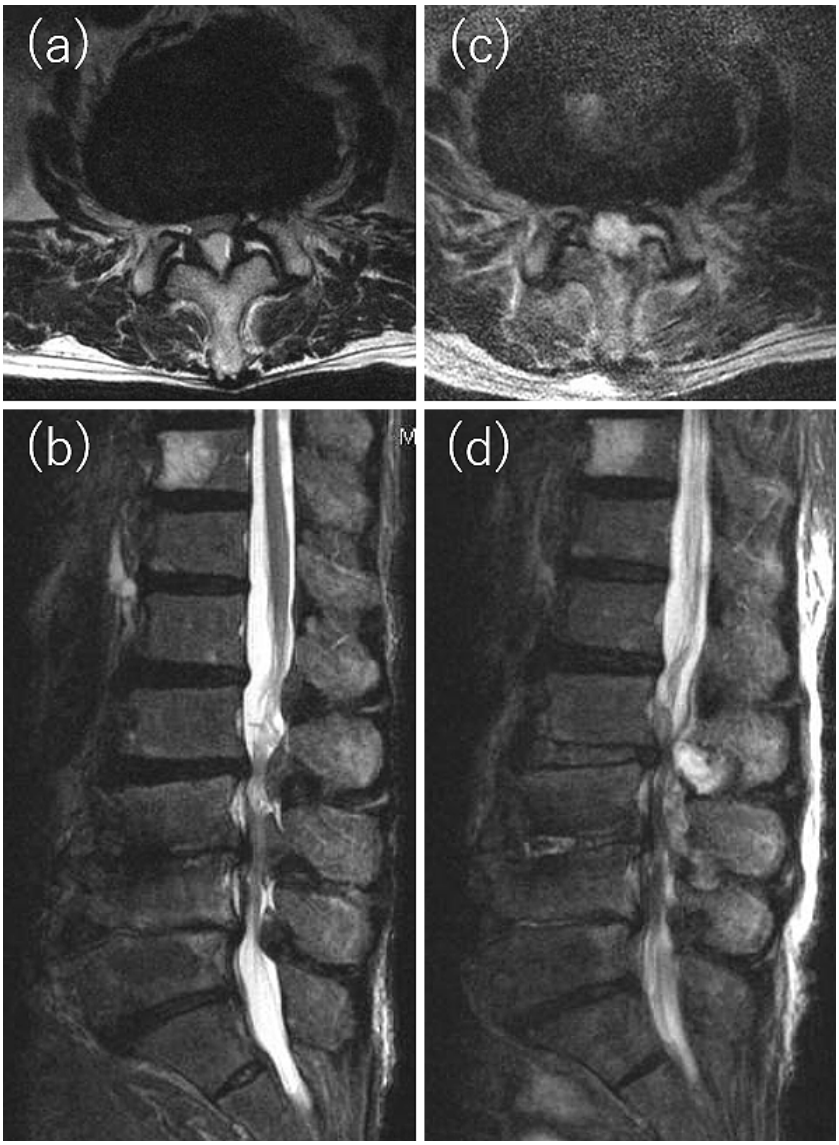

Figure 2. Representative MRI findings. (a) Preoperative axial plane at L2/3. (b) Preoperative sagittal plane. (c) POSEH at L2/3. (d) POSEH after L2/3, L3/4, and L4/5 MEL [Abbreviations] MEL, microendoscopic laminectomy; POSEH, postoperative spinal epidural hematoma

and the presence of spinal stenosis (OR, 9.1; 95% CI, 2.25-36.69) were significant risk factors for POSEH.

Discussion

This study revealed that the distribution of POSEH differed between patients undergoing m-MEL and s-MEL and that the incidence of POSEH was highest at L2/3 among all interlaminar spaces. Severe dural stenosis at L2/3 and treatment of L2/3 at the end of the procedure contributed to the incidence of POSEH. Since POSEH is a severe complication, many researchers have investigated the incidence rate of POSEH, finding that the incidence is dependent upon the number of decompression levels[5]. According to a previous paper, the use of endoscopy may influence the incidence rate due to the narrow portal of entry[10]. Considering this background, the incidence rate of POSEH is potentially higher after m-MEL than after s-MEL. In this study, we clarified the distribution of POSEH after m-MEL by each interlaminar space to identify the risk factors for POSEH. Interestingly, the distribution of POSEH differed between m-MEL and s-MEL, and the incidence was highest at L2/3 among all interlaminar spaces. To the best of our knowledge, this is the first study to show the incidence rate of POSEH by each interlaminar space.

This study also showed that a CSA of <56 mm^2 on preoperative MRI was a cause of POSEH. It can be hypothesized that a decompressed dural sac may develop re-stenosis after surgery if the preoperative stenosis is severe. A narrow dural sac area seems to be correlated with spondylolisthetic change in the lumbar spine[11]. Lumbar hypolordosis also leads to a narrowing of the dead space, which can raise the pressure exerted on the dural sac by the POSEH[3,5]. Our study included no data regarding radiographic degenerative

change or alignment in the lumbar spine, but our investigation of the CSA may help surgeons to take precautions against POSEH. In this study, we clarified that the incidence of POSEH is highest at the L2/3 level in patients undergoing m-MEL. Hong et al.[12] analyzed the spinal cord dural sac thickness and found that the dural thickness was lowest at L2/3. Considering this observation, thinning of the dural sac may lead to re-stenosis followed by POSEH. Our results indicate that patients with severe lumbar spinal stenosis should be monitored for POSEH after m-MEL.

We also proposed that treatment of the L2/3 interlaminar space at the end of the procedure was a possible cause of POSEH. This is a reasonable outcome considering the findings of other studies published to date. Kao et al.[1] showed that the BP at the time of admission was significantly higher in the POSEH group than in the non-POSEH group. Some authors have also concluded that a >50-mmHg increase in BP after extubation was a critical risk factor for POSEH regardless of the number of decompression levels[6,13]. These findings indicate that a low BP or a long interval of time to achieve complete hemostasis may prevent rebleeding after surgery. Although the present study did not show that a high postoperative BP was associated with the incidence of POSEH, treatment of the interlaminar space at the end of the procedure is likely to cause rebleeding due to the shorter interval of time before returning to a normal BP, potentially leading to the development of POSEH.

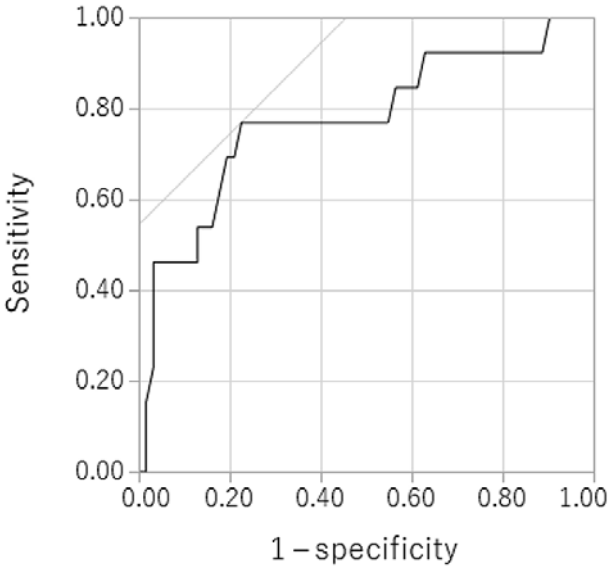

Figure 3. The receiver operating characteristic curve showed that a dural sac area of 56 mm^2 was the threshold value for the incidence of POSEH (sensitivity, 0.77; 1−specificity, 0.23; area under the curve, 0.77). [Abbreviations] POSEH, postoperative spinal epidural hematoma

This study has several limitations. First, it was possible that our defined POSEH was not the cause of the symptom but simply represented postoperative changes. If there were several interlaminar spaces with hematomas, we could not definitively identify which surgical level was responsible for the symptom. This point was the most complicated subject for the study about m-MEL. Eight out of 28 cases with neurological deficits required revision surgery to remove POSEH, and we verified the finding POSEH compressed the dura. However, there was no way to validate the accuracy for our diagnostic criteria among patients without revision surgeries. Since the present study was conducted in one medical institute and the evaluation for POSEH was checked by several orthopedic surgeons, the distribution rate of POSEH among all interlaminar spaces would be reliable in the present study. We added the content as the limitation into the "Discussion" part. Second, we cannot explain the main cause of the difference in the incidence of POSEH between m-MEL and s-MEL. Although we did not evaluate the radiographic alignment of the lumbar spine, patients in the m-MEL group were more likely to show degenerative change due to their older age compared with patients in the s-MEL group. Sigmundsson et al.[11] showed the correlation between multilevel stenosis and spondylolisthetic change in the lumbar spine. These observations suggest that the severity of compression of the epidural venous plexus or dural sac in the lumbar spine may differ between m-MEL and s-MEL. The last limitation is that we focused on the L2/3 interlaminar space and did not clarify all of the data from L1/2 to L5/S. Considering the differences in the facet joint orientation and spondylolisthetic change among the interlaminar spaces, the risk factors for POSEH may differ by each space. However, considering that the incidence of POSEH was highest at the L2/3 level, our observation may be useful to reduce the occurrence of POSEH.

In conclusion, for patients undergoing m-MEL, the incidence of POSEH is highest at the L2/3 level, and both treat-

Table 4. Logistic Regression Model.

Variable	POSEH/total cases (n)	OR (95% CI)	*p*-value
L2/3 was treated at last			
Yes	10/37	4.8 (1.06 21.4)	0.04
No	3/38		
Dural sac area (mm^2)			
>=56	4/53	9.1 (2.25 36.69)	<0.01
<56	9/22		

[Abbreviations] CI, confidence interval; L, lumbar; n, number of patients; OR, odds ratio; POSEH, postoperative spinal epidural hematoma

ment of L2/3 at the end of the procedure and the presence of spinal stenosis are risk factors for POSEH. Treatment of the interlaminar space at the end of the procedure is likely to cause rebleeding due to the shorter interval of time before returning to a normal BP, potentially leading to the development of POSEH. Aggressive hemostasis and suction drainage may be necessary to prevent POSEH in patients with severe preoperative spinal stenosis at the L2/3 level.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

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Author Contributions: HB carried out the literature review and drafted the manuscript. AI and RI participated in the development of the methodology. All authors participated in the data discussion. TA was involved in the study design and data discussion, helped to draft the manuscript, and gave a final approval of the version to be published. All authors read and approved the final manuscript.

Ethical Approval: 229 in Kyushu Central Hospital

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