Retrospective Study

Correlation Between the Extent of Injectate Spread and Clinical Outcomes in Cervical Interlaminar Epidural Injection

Ji Yeong Kim, MD[1], Sungwon Yang, MD[2], Donghyun Kim, MD[2], Youngkyung Park, MD[2], and Young Hoon Kim, MD, PhD[2]

From: [1]Department of Anesthesiology and Pain Medicine, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea; [2]Department of Anesthesiology and Pain Medicine, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

Address Correspondence:
Young Hoon Kim, MD, PhD
Department of Anesthesiology and Pain Medicine, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 222, Banpo-daero, Seocho-gu,
Seoul 06591, Republic of Korea
E-mail: anekyh@catholic.ac.kr

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Background: Cervical interlaminar epidural injection (CILEI) is commonly used to treat acute or chronic pain that affects the head, neck, and upper extremities. Thus far, studies on CILEI have focused on determining the optimal volume of contrast medium or analyzing the spread of contrast medium during a CILEI. To our knowledge, few studies have attempted to assess the correlation between epidurogram patterns and clinical outcomes of CILEI.

Objectives: This study aimed to investigate the relationship between contrast medium spread and pain relief after a CILEI in patients who complained of neck and/or unilateral upper extremity pain.

Study Design: Retrospective cohort study.

Setting: Tertiary university hospital.

Methods: Patient demographics, pain duration, and radiographic findings, including cervical simple radiograph and magnetic resonance imaging, were reviewed from medical records. The spread pattern of contrast medium during a CILEI was analyzed based on anteroposterior (AP) and lateral fluoroscopic views. The spread pattern in the AP view was classified into 4 categories using predetermined anatomical references, including the medial border, bisector, and lateral border of the articular pillar at the targeted vertebral level. The spread pattern in the lateral view was divided into 2 groups based on whether the contrast medium was present at the ventral epidural space. Every CILEI procedure was performed under fluoroscopic guidance by skilled experts. A responsive outcome was defined as a reduction in the numeric rating scale for pain by more than 50% at one month postoperatively compared to preoperatively.

Results: Among 656 patients, 526 were excluded from the analysis according to predetermined criteria. The remaining 130 patients were analyzed, and 78 (60%) patients showed responsive results one month after a CILEI. According to a multivariable logistic regression analysis, the negative predictors of a CILEI were long symptom duration (P = 0.045), high grade of central stenosis (P = 0.022), and limited spread of contrast medium solely within the central canal in the AP view (P = 0.008).

Limitations: The limitations of this study include its retrospective design, absence of clinical parameters other than pain intensity, and short follow-up period.

Conclusions: If the duration of symptoms is lengthy, central stenosis is severe, or contrast medium spread is limitedly solely within the central canal and does not reach the dorsal root ganglion any further, the outcome after a CILEI is likely to be poor. Therefore, efforts should be made to spread injectate around the dorsal root ganglion at the target level.

Key words: Cervical interlaminar epidural injection, cervical transforaminal epidural injection, contrast medium, dorsal epidural space, dorsal root ganglion, epidurogram, injectate, spread pattern, ventral epidural space

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Cervical interlaminar epidural injection (CILEI) is widely used in clinical practice to control acute, chronic, or cancer-related pain in the face, head, shoulder, or upper extremities (1-7). Accordingly, clinicians have conducted several clinical trials on CILEI, with these trials demonstrating that the effect of a CILEI is influenced by the anatomical spread of the injected solution within the epidural space. The dispersion of the injectate is affected by various factors such as drug volume; needle insertion position; injection rate; epidural space contexture; and patient posture, age, height, and weight (8).

Among these, the volume of a CILEI is conventionally viewed as a significant factor in determining the degree to which injectate spreads and has been a major issue in previous studies (8,9). Kim et al (4) compared the proportion of patients with contrast medium observed in the ventral epidural space (VES) among all cases when administered at volumes of one, 2, and 3 mL each. Consequently, 2 mL appeared to be sufficient for ventral and longitudinal spread. Lee et al (10) administered 2.5 mL, 5 mL, and 10 mL of contrast medium and suggested that a volume of 5 mL was sufficient for the upper and lower cervical spines. Park et al (11) administered 3 mL, 4.5 mL, and 6 mL of contrast medium to different patients and observed that there was no difference in the degree of cephalad ventral and bilateral spread. Therefore, 3 mL was considered sufficient to treat neck and upper extremity pain caused by lower cervical degenerative disease. Goldstein et al (12) confirmed by magnetic resonance imaging (MRI) that an almost uniform circumferential dispersal occurred in multiple levels of the top and bottom of the epidural space with an injectate of 10.1 mL.

However, the studies presented above primarily analyzed the dispersion pattern of contrast medium during a CILEI (4,10,11). To date, few studies have analyzed the correlation between the diffusion of contrast medium and clinical outcome after a CILEI.

We analyzed the diffusion pattern of the subdivided contrast medium and assumed that the clinical results would be better if the contrast medium was closer to the VES or around the dorsal root ganglion (DRG). Therefore, this study aimed to analyze the correlation between whether the contrast medium diffuses to the VES or around the DRG and the clinical outcome after a CILEI.

Methods

Patients

This retrospective study was approved by the Ethical Committee of Seoul St. Mary's Hospital (approval number: KC21RISI0338), which waved the requirement for informed consent. This study was registered with CRIS (Clinical Research Information Service of the Korea National Institute of Health, https://cris.nih.go.kr/cris/index.jsp, KCT0006398). All procedures were performed according to the tenets of the 2013 Declaration of Helsinki.

Following institutional review board approval, we analyzed the medical records of 656 patients who underwent a CILEI at a tertiary hospital pain center from January 1, 2020 through December 31, 2020. The inclusion criteria were 1) neck pain radiating to the unilateral upper extremity, 2) numeric rating scale (NRS-11) pain score of ≥ 5, 3) diagnosis of cervical spinal stenosis or intervertebral disc herniation confirmed using MRI or computed tomography and patient-reported concordant pain, and 4) no history of a CILEI within the previous 6 months. The exclusion criteria were 1) any history of cervical spine surgery, 2) a history of cervical neuroplasty or nucleoplasty within the previous 6 months, 3) peripheral vascular disease or any other condition potentially responsible for the patient's presenting signs and symptoms, 4) pain in both upper limbs, 5) presence of malignancy, 6) a history of automobile accident, and 7) NRS-11 pain score < 5.

Procedure and Fluoroscopic Evaluation

All epidural injections were performed using the paramedian approach at the C6–C7 level. Patients were instructed to lie prone with a pillow under their chest. The skin on the cervical and upper thoracic spine was disinfected with povidone-iodine. After the target location was confirmed using a radiographic imaging device (ARCADIS Ordic, Siemens AG), 1% lidocaine local anesthesia was administered. A 22G 80 mm Tuohy needle (Unilever) was inserted. If the physician felt that resistance was lost using the loss-of-resistance technique, 0.5 mL of contrast medium (iohexol) was injected. Entry into the epidural space was confirmed through anteroposterior (AP), lateral, and contralateral oblique fluoroscopic views. If the epidural space was not confirmed or vascular uptake was shown on fluoroscopic images, the needle was adjusted and then injection of 0.5-mL of contrast medium was repeated to confirm entry into the epidural space. Only after entry was confirmed by the contrast medium pattern, an additional 2.5 mL of contrast medium was injected. Subsequently, 5 mL of 0.4% lidocaine only or, in some cases, a mixed solution of 5 mL of 0.4% of lidocaine with 5 mg of dexamethasone was injected.

After all drug injections were completed, AP and lateral views were taken to confirm the final contrast medium distribution. Data analysis was performed based on the final fluoroscopic AP and lateral images. Each procedure was performed by one of 3 pain physicians, each of whom have more than 10 years experience in this field. After the procedure, vital signs and occurrence of adverse events were monitored for 30 minutes at the outpatient clinic. Finally, the pain physicians performing the procedure confirmed that there were no neurologic symptoms and allowed the patients to be discharged.

Data Collection

Patient demographic and clinical data, including age, gender, height, weight, and pain duration were recorded. The findings of radiographic examinations, including plain radiography and cervical MRI, were reviewed to assess the side of the lesion (unilateral or bilateral), vertebral levels as a causative lesion, the grade of central stenosis, the grade of foraminal stenosis, the presence of spondylolisthesis, and the presence of ossification of the posterior longitudinal ligament. Stenosis severity was graded according to the standard classification (13,14). In patients with multiple levels of central stenosis, the grade level of the most severe stenosis was selected. The contributory spine level was determined by a pain physician with more than 10 years clinical experience by combining the patient's symptoms, examination findings, and radiologic findings.

The extent of contrast medium spread was assessed from the AP and lateral fluoroscopic views at the cervical and thoracic level. In the lateral views, whether the contrast medium was in the VES or dorsal epidural space was evaluated. In the AP views, the extent of contrast medium spread was graded by dividing the target level into 4 stages: grade 1 indicated the contrast medium filling in the central canal, medial foramen, lateral foramen, and beyond the lateral border of articular pillar; grade 2 indicated the contrast medium filling in the central canal, medial foramen, and lateral foramen; grade 3 indicated the contrast medium filling in the central canal and medial foramen; and grade 4 indicated the contrast medium filling solely in the central canal (Figs. 1 and 2).

Causative lesions were classified as "C4–C5 and above" or "C5–C6 and below." If a causative lesion spanned multiple levels and included at least one of the above levels in addition to C4–C5, it was classified as "C4–C5 and above."

Assessing whether the contrast medium reached the VES at the target level was based on the method of

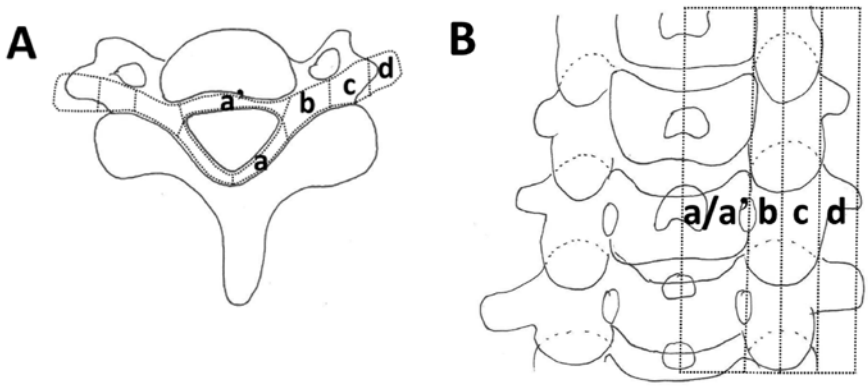

Fig. 1. *Schematic illustration of the extent of contrast medium spread, which was graded into 4 stages on the anteroposterior view at the target level. Grade 1 indicates the contrast medium filling in the central canal, medial foramen, lateral foramen, and beyond the lateral border of the articular pillar (a [and/or a'] + b + c + d); grade 2 indicates the contrast medium filling in the central canal, medial foramen, and lateral foramen (a [and/or a'] + b + c); grade 3 indicates the contrast medium filling in the central canal and medial foramen (a [and/or a'] + b); and grade 4 indicates the contrast medium filling solely in the central canal (a and/or a'). (A) Axial view of the cervical spine and (B) anteroposterior view of the cervical spine. a, dorsal epidural space; a', ventral epidural space; b, medial foramen (indicated by contrast medium filling from the medial border of the articular pillar to the bisector of the articular pillar); c, lateral foramen (indicated by the contrast medium filling from the bisector of the articular pillar to the lateral border of the articular pillar); and d, runoff (indicated by contrast medium filling beyond the lateral border of the articular pillar).*

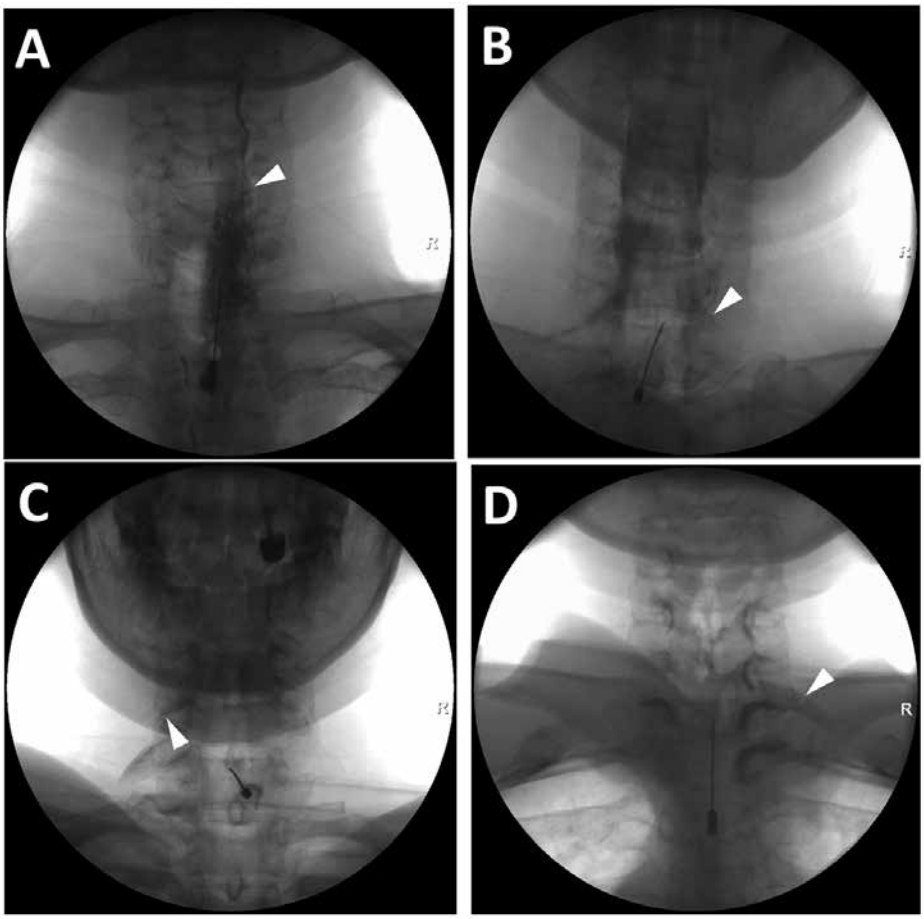

Fig. 2. *Anteroposterior view of an epidural injection performed at the C6–C7 interspace. (A) Contrast medium pattern shows grade 4 at the right C5–C6 foramen (arrowhead). (B) Grade 3 at the right C6–C7 foramen (arrowhead). (C) Grade 2 at the left C5–C6 foramen (arrowhead). (D) Grade 1 at the right C6–C7 foramen.*

Gill et al (15), who defined ventral spread as only when the spread along the posterior vertebral body line appeared in the lateral fluoroscopic view (Fig. 3).

Definition of Responsive Outcome

A responsive outcome was defined as a combination of greater than 50% pain relief according to the NRS-11 pain score at the patient's one-month follow-up visit. Patients who were lost during the one-month follow-up (n = 18) were excluded from the analysis.

Statistical Analysis

Continuous demographic data from the "responsive" and "nonresponsive" groups were compared by using Student's t test or the Mann–Whitney U test and were documented as the means with standard deviation (SD) or the median and interquartile ranges. Categorical demographic data were compared using Pearson's χ^2 test or Fisher's exact test and were reported as numbers or percentages. The comparison of pain scores before and after the procedure in each group was analyzed using the paired t test or Wilcoxon's signed-rank test. The most relevant factors associated with responsive patients were included in the univariable logistic regression analysis. Covariables associated with the outcomes on univariable analysis were included in a multivariable statistical model. The final multivariable logistic regression analysis was performed to determine the relationship between the degree of pain improvement after the procedure and contrast medium diffusion patterns.

Normality of distribution for the data sets with con-

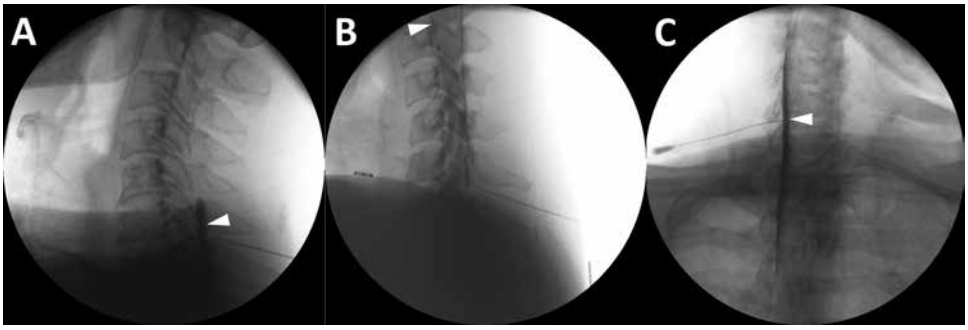

Fig. 3. *Lateral and contralateral oblique views of an epidural injection performed at the C6–C7 interspace. (A) Lateral view shows only dorsal epidural spread of the contrast medium (arrowhead). (B) Lateral view including ventral epidural spread (arrowhead). (C) Contralateral oblique view confirming epidural space (arrowhead).*

tinuous variables was checked using the Kolmogorov-Smirnov tests. Statistical significance was set at the 0.05 probability level. Data analysis was performed with IBM SPSS Statistics version 24.0 (IBM Corp).

Results

Patient Characteristics

Among the 656 patients initially enrolled in this study, 526 were excluded per our exclusion criteria (Fig. 4). A total of 165 patients had other diseases that could explain the symptoms, 155 had bilateral symptoms, and 78 had a history of neuroplasty or nucleoplasty. Moreover, 46 patients had symptoms that occurred after an automobile accident, 43 had a history of spinal surgery, 21 had a preprocedural NRS-11 pain score < 5, and 18 did not return to the outpatient clinic for follow-up. Therefore, the remaining 130 patients were analyzed. Patient characteristics are given in Table 1.

The median pain duration reported by these 130 patients was 2 months. There were 21 patients (16.2%) with a higher target lesion than C4–C5, and there were 34 patients (26.2%) with grade 2 or 3 central stenosis. The contrast medium spread patterns were classified as grade 1 in 12 patients (9.2%), grade 2 in 28 patients (21.5%), grade 3 in 56 patients (43.1%), and grade 4 in 34 patients (26.2%). In total, one patient (0.8%) had the contrast medium reach the VES of the target location.

Comparison of the Responsive and Nonresponsive Outcome Groups

The demographic characteristics of the responsive and nonresponsive groups one month after a CILEI are summarized in Table 1. Among the 130 patients,

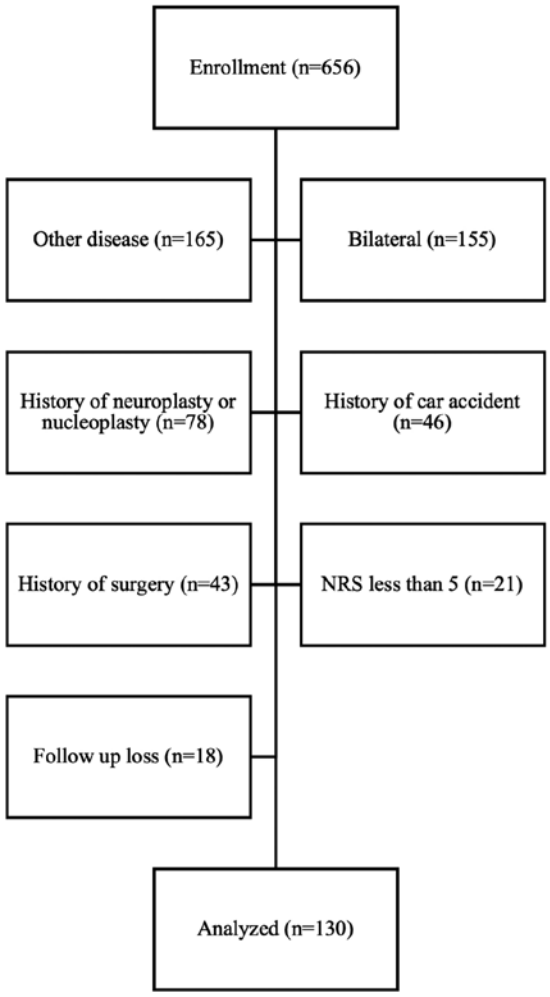

Fig. 4. *Schematic diagram of the study.*

Table 1. *Comparison of demographic and clinical variables between the responsive and nonresponsive outcome groups according to their NRS-11 pain scores.*

Variable	Total (n = 130)	Responsive (n = 78)	Nonresponsive (n = 52)	*P* Value
Age (years), mean ± SD	57.9 ± 12.9	57.4 ± 12.5	58.6 ± 13.6	0.553
Gender (men), n (%)	72 (55.4)	38 (48.7)	34 (65.4)	0.061
BMI (kg/m^2), mean ± SD	24.0 ± 3.5	23.6 ± 3.2	24.7 ± 3.8	0.175
NRS-11 pain score, mean ± SD				
Before the procedure	7.0 ± 1.2	7.2 ± 1.3	6.9 ± 1.0	0.308
4 weeks postprocedure	3.7 ± 1.8	2.5 ± 1.0	5.6 ± 1.1	< 0.001*
Duration of symptoms (months), median (IQR)	2.0 (5.0)	2.0 (4.3)	3.0 (7.0)	0.039*
Right side, n (%)	59 (45.4)	34 (43.6)	25 (48.1)	0.615
Lesions at C4-C5 and above, n (%)	21 (16.2)	7 (9.0)	14 (26.9)	0.006*
Grade 2 or 3 of central stenosis, n (%)	34 (26.2)	13 (16.7)	21 (40.4)	0.003*
Foraminal stenosis, n (%)	64 (49.2)	34 (43.6)	30 (57.7)	0.115
Spondylolisthesis, n (%)	7 (5.4)	2 (2.6)	5 (9.6)	0.115
Ossification of posterior longitudinal ligament, n (%)	8 (6.2)	4 (5.1)	4 (7.7)	0.713
Contrast medium spread pattern, n (%)†				
Grade 1	12 (9.2)	8 (10.3)	4 (7.7)	0.621
Grade 2	28 (21.5)	19 (24.4)	9 (17.3)	0.338
Grade 3	56 (43.1)	45 (57.7)	11 (21.2)	< 0.001*
Grade 4	34 (26.2)	6 (7.7)	28 (53.9)	< 0.001*
Contrast spread to ventral epidural space, n (%)	1 (0.8)	0 (0)	1 (1.9)	1.000

P values are obtained using Pearson's χ^2 test or Fisher's exact test and Student's t test or the Mann–Whitney U test. *indicates a significant difference. †Grade 1 indicates the contrast medium filling in the dorsal epidural space, medial foramen, lateral foramen, and beyond the lateral border of articular pillar; grade 2 in the dorsal epidural space, medial foramen and lateral foramen; grade 3 in the dorsal epidural space and medial foramen; and grade 4 only in the dorsal epidural space. SD: standard deviation; BMI: body mass index; NRS-11: numeric rating scale; IQR: interquartile range.

78 (60%) showed responsive results and 52 (40%) had nonresponsive results one month after a CILEI according to the definitions of response described in this study. The mean NRS-11 pain score ± SD decreased from 7.0 ± 1.2 before the procedure to 3.7 ± 1.8 one month after the procedure. The likelihood of a responsive outcome at one month decreased when symptoms lasted longer (P = 0.039); when lesions were at C4–C5 and above (P = 0.006); with severe central stenosis (P = 0.003); and when there was a grade 3 or grade 4 of the contrast medium spread pattern (P < 0.001). There was no significant difference between both groups in terms of the contrast medium reaching the VES at the target location.

Identifying Predictors Associated with the Outcome of a CILEI

The results of the logistic regression model estimating the association between demographic and clinical characteristics and outcome are shown in Table 2. Univariable logistic regression analysis showed that duration of symptoms (P = 0.014), lesions at C4–C5 and above (P = 0.009), grade 2 or 3 central stenosis (P = 0.003), and grade 4 contrast medium spread pattern (P = 0.003) were significant factors associated with a responsive outcome at one month after a CILEI. These clinical variables were included in the multivariable logistic regression analysis, which showed that the duration of symptoms (adjusted odds ratio [aOR] = 1.113; P = 0.045), grade 2 or 3 central stenosis (aOR = 3.611; P = 0.022), and grade 4 contrast medium spread pattern (aOR = 8.994; P = 0.008) were negative predictors of a responsive CILEI.

Complications

No patients experienced serious complications such as intrathecal injection or dura puncture. When blood vessel injection of the contrast medium was observed before the final injection of the drug, the needle was readjusted to avoid the blood vessel.

One patient experienced slight weakness immediately after the procedure, but no abnormal findings

Table 2. *Factors associated with nonresponsive outcomes after cervical interlaminar epidural injection.*

Variable	Univariable Analysis			Multivariable Analysis		
	Odds ratio	95% CI	*P* value	Odds ratio	95% CI	*P* value
Age	1.007	0.980–1.035	0.598			
Women	0.503	0.244–1.037	0.063			
BMI	1.093	0.985–1.212	0.094			
Duration of symptoms	1.118	1.023–1.223	0.014*	1.113	1.002–1.236	0.045*
Right side	1.198	0.592–2.424	0.615			
Lesions at C4-C5 and above	3.737	1.390–10.048	0.009*	1.755	0.510–6.033	0.372
Grade 2 or 3 of central stenosis	3.387	1.502–7.639	0.003*	3.611	1.202–10.848	0.022*
Foraminal stenosis	1.765	0.868–3.586	0.116			
Spondylolisthesis	4.043	0.754–21.683	0.103			
Ossification of posterior longitudinal ligament	1.542	0.368–6.460	0.554			
Contrast medium spread pattern†						
Grade 1	1.000	–	–	1.000	–	–
Grade 2	0.947	0.225–3.993	0.941	1.612	0.328–7.928	0.557
Grade 3	0.489	0.124–1.923	0.306	0.443	0.100–1.957	0.282
Grade 4	9.333	2.105–41.384	0.003*	8.994	1.778–45.495	0.008*

*indicates a significant difference. † Grade 1 indicates the contrast medium filling in the central canal, medial foramen, lateral foramen, and beyond the lateral border of the articular pillar; grade 2 indicates filling in the central canal, medial foramen, and lateral foramen; grade 3 indicates filling in the central canal and medial foramen; and grade 4 indicates filling solely in the central canal. CI, confidence interval; BMI, body mass index.

were found on repeated neurological examination. After a few hours of observation in the clinic, the patient was discharged because the symptom disappeared.

Discussion

The significance of this study is that it is, to our knowledge, the first to suggest the importance of the injectate to reach the DRG when performing a CILEI. It is not sufficient for the solution injectate to remain solely in the central canal. Allowing the injectate to spread around the DRG might be relevant for improving CILEI outcomes. Moreover, a long period of pain and severe central stenosis were also associated with a poor prognosis after a CILEI.

Previous studies have used a volume of 2–7 mL during a CILEI (4,10,16,17). These studies focused on investigating whether the degree of contrast medium diffusion varies (4,10,11). To our knowledge, only Park et al (11) have tried to evaluate the correlation between the volume of injectate and pain score reduction. However, there has been no report directly assessing the correlation between the contrast medium spread pattern and clinical outcomes. Moreover, it is worth noting that we studied whether the contrast medium diffused well at the causative level rather than at the injection level; nevertheless, previous studies have not examined how the contrast medium spreads at the causative target level.

The clinical significance of the DRG during a cervical epidural injection has been mentioned in several studies. Yabuki et al (18) reported that the better the injectate moves around the DRG, the better the blood flow and the better the resulting treatment effect will be when performing a nerve root block. The importance of contrast medium runoff around the DRG during a cervical epidural injection has also been noted (19,20).

As also demonstrated in this study, if the DRG is considered to be an important anatomical structure associated with clinical effectiveness, then a cervical transforaminal epidural injection (CTFEI) could be assumed to be more effective than a CILEI. However, Lee et al (21) previously proved that CTFEI and CILEI showed no significant difference in clinical efficacy. They insisted that CILEI is conventionally relatively safer than CTFEI, considering the possibility of catastrophic complications, including cerebral or spinal cord infarct and transient ischemic infarct, in the latter (22-24).

In this study, symptom duration was suggested to be associated with CILEI effects. Central sensitization could be suggested as the responsible mechanism for the outcome (25,26). The grade of central stenosis

was also related to a post-CILEI prognosis in this study. However, a post-CILEI prognosis was not related to the grade of foraminal stenosis. The authors of the current study speculate that a narrowed central canal would severely limit contrast medium diffusion. Since the central canal has a relatively large space compared to the neural foramen, the effect of interfering with injectate spread may be greater.

Contrary to our previous assumption, ventral spread at the target lesion was independent of the clinical outcome of a CILEI and was rare when using approximately 3 mL of contrast medium in this study. The rate of ventral spread observed in this study is much lower than the average spread in previous reports (4,12,27,28). Kim et al (4) reported that 90% of cases showed ventral spread when performing a CILEI using 2 mL of contrast medium. Using MRI, Goldstein et al (12) reported that the ratio of ventral spread during a CILEI is 100% when using 10.1 mL of contrast medium. Using computed tomography, Amrhein et al (27) reported that the rate of ventral spread was 65% when using 5 mL of contrast medium for a CILEI. Lee et al (28) used 3 mL of contrast medium during a CILEI and reported that the midline approach achieved a VES rate of 57%, and that the paramedian approach achieved a VES rate of 88%.

Only the study by Gill et al (15) reported that no true ventral spread was observed in any patient during a CILEI. We believe that the method adopted by them should be used to accurately determine ventral spread. They defined ventral spread as occurring only when there was spread along the posterior vertebral body line in the lateral view (15).

Lateral spread from the spinolaminar line to the area covering the articular pillar was classified as a lateral spread rather than a true ventral spread (15). We believe that the relatively high prevalence of ventral spread reported in previous studies (4,12,27,28) was the result of mistaking lateral spread for ventral spread. Furthermore, previous studies did not consider whether ventral spread was present at the causative lesion level (4,12,27,28). Conversely, we focused on a target level analysis, assuming that going to a nontarget level of VES would have little clinical significance.

Since the ventral spread at the targeted level itself was very rare in our study, the causal relation between VES and clinical outcomes cannot be excluded. Future studies with larger sample sizes and a greater number of patients who reach the target level VES will be capable of further analyzing this causal relationship.

Our study also showed that the level of causative lesion ("C4–C5 and above" or "C5–C6 and below") was not affected by a CILEI. It is likely that the drug would need to reach the level of the lesion to improve symptoms. However, in cases of causative lesions in the upper cervical spine, needle insertion at the C5–C6 level or above should be avoided (29). This is because it could be difficult to determine the epidural space with the loss-of-resistance technique at the upper cervical levels due to a gap from the midline in the center of the ligamentum flavum (30,31).

According to United States Food and Drug Administration investigations and Multi-Society Pain Workgroup recommendations regarding the prevention of neurologic complications after epidural steroid injection, a CILEI should be performed at the C7–T1 level and occasionally at the C6–C7 level to avoid catastrophic neurologic complications (29). Although Manchikanti et al (32) insisted that the risk of dural puncture was similar regardless of whether a CILEI was performed at the C5–C6, C6–C7, or C7–T1 level, the needle was inserted at the C6–C7 level regardless of the target level in all cases of our study as part of the protocol. Further, all CILEIs were performed using the paramedian approach in our study. This is because the paramedian approach, inserting the needle more toward the symptomatic side, has also been the standard protocol for patients with unilateral symptoms in our center, even though a CILEI can be performed by several approaches, as reported by Choi et al (24).

Contrary to our expectation, there was no relationship between the level of the causative lesion and the clinical effect of the CILEI. The reason for this is presumed to be that several cases where one patient had multiple levels of lesions at the same time were included. For patients with multiple causative levels, clinical symptoms may improve, even if the drug reaches only some lesions. Further studies are required to evaluate whether the effect of a CILEI is influenced by whether the target region is in the upper or lower cervical spine.

Limitations

This study has several limitations. Due to the study's retrospective nature, a questionnaire for functional evaluation was not conducted; doing so would have provided us with additional objective data on patient characteristics. Also, because it was a retrospective design, patients who did not visit the outpatient clinic after one month had to be excluded from the analysis, which may have affected the study results (follow-up loss rate = 12.2%

[18/148]). Moreover, there may have been practitioner variability since the procedures were performed by 3 practitioners. However, all practitioners had more than 10 years of experience in this field and performed the procedures with a common procedure manual. Furthermore, the follow-up period after the CILEI was as short as one month; this short duration does not allow clinicians to accurately assess long-term outcomes. Finally, cases with symptoms in both upper extremities or solely neck pain were excluded from further analysis; therefore, results may have differed from the actual clinical situation.

Conclusion

In conclusion, clinical outcomes after a CILEI are likely to be poor if symptoms persist for a long time, if central stenosis is severe, or if the contrast medium is restricted solely within the central canal and does not reach the DRG. Therefore, it may be clinically useful to inject drugs to reach the DRG of the pathological lesion during a CILEI.

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