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SCIENTIFIC ARTICLE

Fluoroscopic cervical paramidline interlaminar epidural steroid injections for cervical radiculopathy: effectiveness and outcome predictors

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Abstract
Objective The purpose of this study is to analyze the effectiveness of fluoroscopic cervical paramidline interlaminar epidural steroid injection (ESI) as well as to assess outcome predictors.
Methods One hundred forty-three patients (M:F=89:54, mean age=53.1 years old) who received cervical paramidline interlaminar ESIs in 2011 were included in this study. Initial improvements at 2 weeks were assessed. For possible outcome predictors, clinical and MR variables were statistically analyzed using the Mann–Whitney *U*, Chi-square, and Fisher's exact tests.
Results Initial improvements after cervical paramidline interlaminar ESIs at 2 weeks were reported in 115 of 143 patients (80.8 %). Patients with paresthesia only and no pain showed significantly fewer improvements after ESIs (11/19, 57.9 %) than patients with pain (104/124, 83.9 %) (p=0.013). Other variables were not statistically significant outcome predictors.
Conclusions Fluoroscopic paramidline interlaminar cervical ESIs effectively managed cervical radiculopathy, irrespective of the cause or zone of nerve root compression, and patients with paresthesia only experienced fewer improvements.

Keywords Interlaminar epidural injection · Spine intervention · Cervical spine · Steroid

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Introduction

A fluoroscopic epidural steroid injection (ESI) is now a widely used treatment approach for managing spinal pain [1–4]. For cervical radiculopathy, interlaminar or transforaminal ESI can be used [5–9]. There have been several reports on the potential serious complications that can result from cervical transforaminal ESIs [10–13]. At our institute, we prefer fluoroscopic cervical interlaminar ESIs to transforaminal ESIs because they are more comfortable for the patients, seem to be safer, and have proven to be very effective based on personal experience. For several years, we have used paramidline interlaminar ESIs at our institute rather than midline interlaminar ESIs for unilateral cervical radiculopathy to target the symptomatic side.

To our best knowledge, there has been no report to date on the effectiveness of cervical paramidline interlaminar ESIs to manage cervical radiculopathy. The purpose of this study is to analyze the effectiveness of fluoroscopic cervical paramidline interlaminar ESIs in short-term follow-up as well as to assess outcome predictors.

Methods

Patient selection

This study was approved by the institutional review board. Informed consent was waived. Inclusion criteria were patients with (1) fluoroscopic cervical paramidline interlaminar ESIs at our department in 2011; (2) unilateral cervical radiculopathy, such as radiating pain or paresthesia along the arm or trapezius area; (3) the presence of nerve root compression demonstrated on MR less than 2 months before or after a cervical ESI; (4) the presence of follow-up medical records after a cervical ESI.

Based on our electronic database, we found 257 patients who received cervical paramidline interlaminar ESIs in 2011. Among them, 114 patients were excluded due to the following exclusion criteria: (1) no follow-up after ESIs (n=44); (2) a diagnosis of a shoulder disease, such as a rotator cuff tear (n=11); (3) no demonstrable nerve root compression on MR (n=8); (4) no MR done less than two months before or after ESIs (n=51). Finally, 143 patients (M:F=89:54, mean age=53.1 years old; range, 28~81 years) were included in this study.

Injection technique

All cervical paramidline interlaminar ESIs were done using fluoroscopic guidance by one of two experienced spine radiologists who had completed more than 1,000 ESI procedures. The uniplanar (Intergris Allura Xper FD 20; Philips) digital subtraction angiography unit was used for fluoroscopy. Informed consent was obtained from all patients. With patients in the prone position and under sterile preparation, a 22-G spinal needle was advanced into the posterior epidural space at the C6/7 level with a paramidline approach matched on the symptomatic side (Fig. 1). The target point of needle placement for paramidline interlaminar ESI on the AP view is the paramidline point within 5 mm from the midline. Midline can be defined as arbitrary line connecting above and below spinous processes on the AP view. For paramidline approach, we introduce the needle either (1) from the skin outside the spinous process to the paramidline target point (lateral to medial) or (2) from the skin the arbitrary line between the spinous processes to the paramidline target point (medial to lateral).

The landmark for the posterior epidural space was the spinolaminar line using the fluoroscopic lateral view (Fig. 1). If the needle was just posterior to the spinolaminar line from the lateral view, we advanced it very carefully by twirling it and opening the ligamentum flavum with intermittent injections of the contrast agent (Omnipaque 300 [iohexol, 300 mg iodine per milliliter]; Amersham Health, Princeton, NJ, USA) until the contrast agent spread smoothly in the epidural space (Fig. 1). Then, a mixture of 40 mg (1 ml) of triamcinolone acetonide suspension (Tamceton [40 mg/ml]; Hanall Pharmaceutical, Seoul, Korea) and 1.5 ml of normal saline were injected into the epidural space.

Retrospective chart review

In our department, medical charts for spine intervention were recorded in an itemized pattern by one of the two radiologists. In the first visit, the main symptom/s, symptom onset (less than or more than 3 months), numeric rating scale (0~10), and presence of motor weakness were recorded. At follow-up visits, the current and initial 2-week responses were recorded separately. A 5-point patient satisfaction scale (no pain, much improved, slightly improved, no change, aggravated), a numeric rating scale (0~10), and the percentage of residual symptoms (0~100 %) were recorded. Symptom recurrence or the presence of complications was also recorded. From October to November of 2012, one radiologist retrospectively reviewed the patients' medical records and recorded age, sex, chief complaint (pain, paresthesia, both pain and paresthesia, with weakness), numeric rating scale (0~10), symptom onset (less than or more than 3 months), date of MR, follow-up date, initial response at 2 weeks, percentage of residual symptoms at two weeks, presence of complications.

Patients who underwent ESIs in our department were composed of (1) patients who were referred from an outside

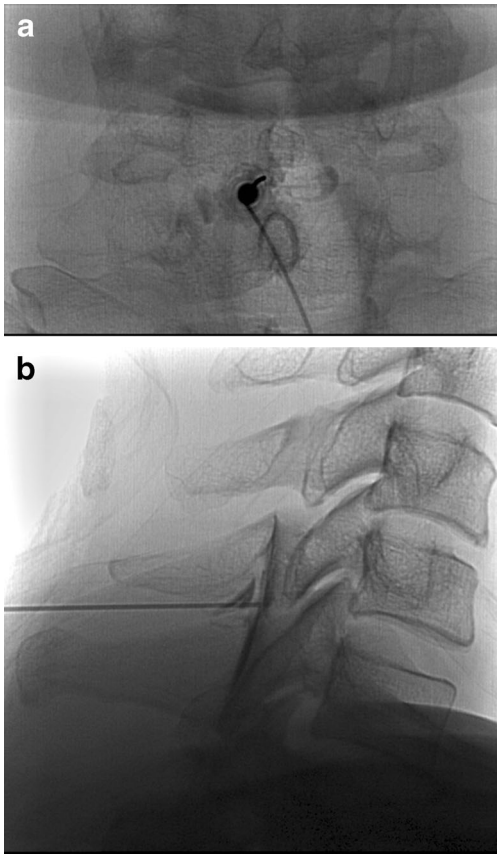

Fig. 1 Captured images during fluoroscopic cervical paramidline interlaminar epidural steroid injections (ESIs). In the postero-anterior view (**a**), the needle tip was placed off the midline and targeted to the symptomatic side for paramidline interlaminar injection. In the lateral view (**b**), the needle tip was just across the spinolaminar line and the contrast agent smoothly filled the posterior epidural space. During the cervical interlaminar ESI, the landmark for the posterior epidural space was the spinolaminar line in the fluoroscopic lateral view (**b**). If the needle was just posterior to the spinolaminar line in the lateral view, we advanced the needle very carefully by twirling the needle and opening the ligamentum flavum with intermittent injections of the contrast agent (Omnipaque 300 [iohexol, 300 mg iodine per milliliter]; Amersham Health, Princeton, NJ, USA) until the contrast agent spread smoothly in the epidural space. Then, a mixture of 40 mg (1 ml) of triamcinolone acetonide suspension (Tamceton [40 mg per milliliter]; Hanall Pharmaceutical, Seoul, Korea) and 1.5 ml of normal saline were injected into the epidural space

hospital, (2) patients who directly visited our department, and (3) patients who were referred from an orthopedic surgeon, neurosurgeon, or rehabilitation physician at our institute.

Initial response were determined as "improved" if there was "much improvement" or "no pain" on the 5-point patients' satisfaction scale, less than 50 % of residual symptoms and reduction of more than 50 % in numeric rating scale at 2 weeks following the procedure. Initial responses were determined as "not improved" if there was "slight improvement," "no change," or "aggravation" on the 5-point patients' satisfaction scale, or if the patients still had at least 50 % of their residual symptoms at 2 weeks post-ESI. For a patient to be placed into the improved category, they had to meet all three criteria. Otherwise, they were considered to be "not improved". Reduction of pain scores from the 0–10 numeric rating scales before and after injection were also calculated.

MR analysis

One radiologist who was unaware of the patients' response after cervical ESIs and was informed of their symptoms only reviewed the cervical MR images, focusing on the causes (herniated disc, spinal stenosis, or both) and zone (paracentral or foraminal) of nerve root compression. The radiologist classified the compression as being caused by a herniated disc, spinal stenosis, or both. Spinal stenosis was defined if the neural foramen or central canal was narrowed due to one or a combination of the following: hypertrophied osteophytes, facet arthrosis, and disc height loss. Patients were classified as having both a herniated disc and spinal stenosis if there was (1) a co-existence of osteophytes and disc herniation and (2) disc herniation beyond the outline of osteophytes. The radiologist also described the zone of nerve root compression as paracentral or foraminal. The paracentral zone was defined as the medial side of the sagittal plane of a pedicle's medial edge, and the foraminal zone was defined as the lateral side of the sagittal plane of a pedicle's medial edge [14]. The radiologist also recorded the total number of spinal levels of nerve root compressions.

Statistical analysis

According to the initial 2-week response to ESIs, patients were classified into two groups based on the above-mentioned criteria: improved or not improved. For the two groups, age and numeric rating scale differences were evaluated using the Mann–Whitney *U* test. Gender and symptom onset (less than or more than 3 months) were evaluated using Fisher's exact test. Different patterns of chief complaints (pain, paresthesia, both pain and paresthesia, or with weakness), the MR diagnosis causing nerve root compression (spinal stenosis, herniated disc, or both), the zone of nerve root compression (paracentral, foraminal, or both), and the total number of spinal levels of nerve root compressions according to the two groups were evaluated using the Chi-square test.

Different patterns of chief complaints, MR diagnoses, numbers of level of nerve compression, and the nerve root compression zones were further classified into two categories for dichotomous analyses. Fisher's exact tests were used to evaluate the difference between the two groups. Different patterns of chief complaints were grouped into two subcategories according to the presence or absence of radiating pain (pain with or without paresthesia versus paresthesia only and no pain). MR diagnoses were classified as the presence or absence spinal stenosis (spinal stenosis only or with herniated intervertebral disc versus herniated disc only). The zone of nerve root compression was divided into two categories: paracentral with or without foraminal versus foraminal only without paracentral. The total number of spinal levels of nerve root compressions was also divided into two subcategories: single versus multiple.

PASW statistics 17.0 (SPSS, Chicago, IL, USA) was used for statistical calculation. A p value of less than 0.05 indicated a significant difference.

Results

The numeric rating scale (NRS, 0 –10) before ESI was 7.03± 1.32 (mean ± standard deviation), ranged from 5 to 10. NRS after ESI was 2.6±2.2 (mean ± standard deviation), ranged from 0 to 10. Reduction of NRS after ESI was 4.43±2.40 (Mean ± standard deviation), ranged from 0 to 10. Initial improvements after cervical paramidline interlaminar ESIs were reported in 115 of 143 patients (80.8 %). Among 28 patients who showed "not improved", 15 patients received transforaminal ESI. Six of these 15 patients (40 %) showed "improvement" after transforaminal ESI.

Clinical variables are demonstrated in Table 1. Eleven (57.9 %) of 19 patients with paresthesia only and no pain showed an initial improvement after cervical paramidline interlaminar ESIs, but 104 (83.9 %) of 124 patients with pain with or without paresthesia showed initial improvements, which was statistically significant (p=0.013). Other clinical variables such as age, sex, and symptom duration were not statistically significant outcome predictors.

MR findings are demonstrated in Table 2. There were no significant outcome predictors in terms of MR findings such as the diagnosis causing radiculopathy (spinal stenosis versus herniated intervertebral disc), the zone of nerve root compression (paracentral versus foraminal), and the total number of spinal levels of nerve root compressions.

Complications were reported in four patients (2.8 %), but all four were temporary minor complications that did not

Table 1 Clinical findings related to patient outcome after cervical paramidline interlaminar epidural steroid injections

	Improved (n=115)	Not improved (n=28)	p value
Age, mean (standard deviation)	53.2 years (10.5)	53.1 years (28)	0.968
Age group			0.317
< 29 years	1 (50.0)	1 (50.0)	
30–39 years	8 (88.9)	1 (11.1)	
40–49 years	33 (76.7)	10 (23.3)	
50–59 years	44 (81.5)	10 (18.5)	
60–69 years	22 (91.7)	2 (8.3)	
> 70 years	7 (63.6)	4 (36.4)	
Numeric rating scale (standard deviation)	7.07 (1.3)	6.88 (1.4)	0.473
Gender			0.200
M	74 (83.1)	15 (16.9)	
F	41 (75.9)	13 (24.1)	
Chief complaint			0.054
Pain only	77 (84.6)	14 (15.4)	
Paresthesia only	11 (57.9)	8 (42.1)	
Pain and paresthesia	25 (83.3)	5 (16.7)	
With weakness	2 (66.7)	1 (33.3)	
Chief complaint (dichotomous analysis)			0.013
Paresthesia only and no pain	11 (57.9)	8 (42.1)	
Pain with or without paresthesia	104 (83.9)	20 (16.1)	
Symptom duration			0.478
Less than 3 months	81 (81.0)	19 (19.0)	
More than 3 months	34 (79.1)	9 (20.9)	

Values inside parentheses indicate percentages, except for age and numeric rating scale. *Values inside parentheses for age and numeric rating scale* indicate standard deviations

Table 2 MR findings related to patient outcome after cervical paramidline interlaminar epidural steroid injections

	Improved (n=115)	Not improved (n=28)	p value
Diagnosis causing radiculopathy			0.566
Spinal stenosis	71 (81.6)	16 (18.4)	
HIVD	35 (81.4)	8 (18.6)	
Both spinal stenosis and HIVD	9 (69.2)	4 (30.8)	
Diagnosis (dichotomous analysis)			0.522
HIVD only	35 (81.4)	8 (18.6)	
Spinal stenosis and/or HIVD	80 (80.0)	20 (20.0)	
Zone of nerve root compression			0.490
Paracentral	18 (90.0)	2 (10.0)	
Foraminal	66 (79.5)	17 (20.5)	
Both paracentral and foraminal	31 (77.5)	9 (22.5)	
Zone of nerve root compression (dichotomous analysis)			0.461
Foraminal only without paracentral	66 (79.5)	17 (20.5)	
Paracentral with or without foraminal	49 (81.7)	11 (18.3)	
Total number of spinal levels of nerve root compressions			0.157
One	58 (81.7)	13 (18.3)	
Two	28 (71.8)	11 (28.2)	
Three	22 (95.7)	1 (4.3)	
Four	6 (66.7)	3 (33.3)	
Five	1 (100)	0 (0.0)	
Total number of spinal levels of nerve root compressions (dichotomous analysis)		0.433	
Single (one)	58 (81.7)	13 (18.3)	
Multiple (more than two)	57 (79.2)	15 (20.8)	

HIVD herniated intervertebral disc

Values inside parentheses indicate percentages

require readmission: itching sensations, facial flushing, dry mouth, and erectile dysfunction.

Discussion

Our study demonstrated that about 80 % of patients experienced an initial improvement following fluoroscopic cervical paramidline interlaminar ESIs. ESIs were less effective for patients with paresthesia and no pain than they were for patients with pain. Other factors did not show any statistically significant differences between the improved and not improved groups.

Fluoroscopic ESIs are widely used to manage cervical or lumbar radiculopathy [1–4, 7]. The advent of fluoroscopy greatly improved the precision and safety of spinal injection techniques. Stojanovic et al. [15] found a 53 % false loss of resistance in cervical interlaminar epidural injections without fluoroscopic confirmation. Anatomic factors such as variability in the ligamentum flavum may contribute to the unreliability of using the loss of resistance technique without fluoroscopic guidance. [10, 11, 16–18].

According to Kwon et al.'s study [8], cervical midline interlaminar ESIs were effective in 55 of 76 patients (72.4 %) in short-term follow-up, and patients with herniated discs had significantly better results than patients with spinal stenosis (86.1 vs. 60.0 %). Compared with Kwon et al.'s study, our study on cervical paramidline interlaminar ESIs demonstrated a slightly better outcome at the initial short-term follow-up (72.4 % versus 80.8 %). One main difference is that our study showed that patients with spinal stenosis had

about the same outcome as those with herniated intervertebral discs (80.0 vs. 81.4 %). We believe that this was because the paramidline approach could deliver drugs to the narrowed neural foramen more effectively than the midline approach because it allows the injection to spread mostly throughout the ipsilateral epidural space.

Based on our experience, cervical paramidline interlaminar ESI have several advantages over cervical transforaminal ESI: they are more comfortable for patients, involve less risk of spinal cord or cerebellar infarct, and are less likely to irritate nerve roots. The advantages of cervical transforaminal ESI over interlaminar ESI are the following: they target one specific nerve root resulting in delivering more concentrated drug close to the lesion and they provide more diagnostic information. However, for transforaminal epidural steroid injections, real-time fluoroscopic checks with contrast injections are mandatory to avoid intra-arterial steroid injections, which can be a cause of distal embolic infarct resulting in either spinal cord or brainstem infarct.

Lee et al. [9] showed that cervical transforaminal epidural steroid injections were effective in 121 of 159 patients (76.1 %) in short-term follow-up. Compared with Lee et al.'s findings on cervical transforaminal ESIs for cervical radiculopathy, our study demonstrated a similar outcome at the initial short-term follow-up (76.1 vs. 80.0 %). Previously, Lee et al. suggested certain conditions in which cervical transforaminal ESIs were required as follows: (1) the surgeon's request to check the exact level of radiculopathy, (2) failed interlaminar ESI, and (3) the inability to perform cervical interlaminar ESI due to a previous laminectomy [9]. Therefore, with the exception of the above conditions, we propose that paramidline interlaminar ESIs replace transforaminal ESIs as the initial procedure for unilateral cervical radiculopathy due to the effectiveness of interlaminar ESIs, irrespective of the cause or location of nerve root compression, and the potential risks of transforaminal ESIs. However, according to our data, slightly more than half of the patients who failed interlaminar ESI underwent a subsequent transforaminal ESI. Of these, 40 % showed improvement.

For those who are inexperienced in the cervical epidural injections, the paramidline approach can be less safe than the midline approach for cervical epidural injection because of small epidural space in the lower cervical spine and smaller in the more lateral epidural space. To reduce risk, it is better that the needle be introduced to the paramidline point within 5 mm of the midline arbitrarily connecting above and below spinous processes on the AP view because the epidural space become narrower in more lateral aspect. According to our experience, even in case of paramidline needle placement within 1–2 mm from the midline, most amount of contrast spreads to the unilateral epidural space. Therefore, to deliver the steroid to the unilateral symptomatic side, slight paramidline needle placement is enough. For the paramidline approach, we introduce the needle obliquely from the skin outside the spinous process to the paramidline point in case of ligament flavum hypertrophy or spinous process hypertrophy. By that trajectory, the needle can penetrate the ligamentum flavum more easily because that trajectory passes the ligamentum flavum more perpendicular and also the needle can avoid hypertrophied spinous process during needle placement.

According to our study, patients with paresthesia and no pain experienced less reduction in their symptoms after ESI than patients with pain (57.9 vs. 83.9 %). We observed that radiating arm pain subsided very quickly in the days immediately following ESI, but paresthesia remained for several months in many cases. This may suggest that pain is more closely related to the inflammatory reactions around the nerve roots. Because the main aim of ESI is to reduce inflammation around the nerve roots, patients with paresthesia only may not benefit as much from ESI as patients with pain. As such, cervical ESIs are considered more prudently in patients with paresthesia only, and these patients should be informed of the potential limitations of undergoing a cervical ESI for their particular condition.

Our study has several limitations. First, it was not a prospective, controlled study. However, follow-up records were recorded in an itemized medical chart; thus follow-up data could be more systemically gathered in a manner similar to prospective studies. Secondly, there was no control group that did not receive ESIs. However, in routine practice, it was very difficult to assign patients who complained of severe pain to the control group for the study purpose. Instead, randomized study will required for comparing the paramidline and midline interlaminar approach, or comparing paramidline interlaminar and transforaminal approach.

In conclusion, fluoroscopic paramidline interlaminar cervical ESIs effectively managed unilateral cervical radiculopathy, irrespective of the cause or zone of nerve root compression, and ESIs were less effective for patients with paresthesia only than patients who had radiating pain.

Conflict of interest The authors declare that they have no conflicts of interest.

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