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The Role of Fluoroscopy in Cervical Epidural Steroid Injections

An Analysis of Contrast Dispersal Patterns

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Study Design. A multicenter, retrospective analysis of cervical epidurograms.

Objectives. To determine the effectiveness of the loss of resistance (LOR) technique in identifying the cervical epidural space. To delineate the pattern of epidural contrast spread during cervical epidural steroid injections.

Background. Previous studies have shown that if performed without fluoroscopy, the LOR technique can result in inaccurate needle placement in up to 30% of lumbar epidural steroid injections. To date, no study has examined accuracy of LOR technique and pattern of radiographic contrast spread in cervical epidural levels.

Methods. Epidurograms of 38 cervical epidural steroid injections in 31 patients were reviewed. The number of LOR attempts and pattern of contrast spread was analyzed. The effects of age, gender, MRI results, previous cervical laminectomy, and the physician's level of training were correlated with results.

Results. The authors found a 53% rate of false LOR during the first attempt to enter the epidural space. Unilateral epidural contrast spread was found in 51% and ventral epidural spread was found in 28% of cases. The average number of cervical vertebral levels covered with 2 mL of contrast was 3.14, with significantly wider spread noted in those patients who had not undergone previous cervical laminectomy. Other variables did not influence the accuracy of needle placement and pattern of epidural contrast spread.

Conclusions. The loss of resistance technique may not be an adequate method for ensuring accurate needle placement in blindly performed cervical epidural injections. The use of epidurography can improve the accuracy of needle placement and medication delivery to targeted areas of pathology. [Key Words: injection epidural, steroids, fluoroscopy] **Spine 2002;27:509–514**

Cervical epidural steroid injections (CESIs) are widely used to treat acute and chronic pain conditions involving the head, neck, and upper extremities.[4–6,20,23] In clinical practice, the most commonly used technique for identifying the epidural space is the loss of resistance to air or saline (LOR) technique. Cervical epidural injections are often performed in a "blind" manner, without fluoroscopic guidance. Previous reports[26,27] have suggested that the LOR technique (without fluoroscopic guidance) may be inadequate for identifying the lumbar epidural space. These studies found false positive LOR rates of up to 30%.

Anatomic studies have found high rates of discontinuity in the ligamentum flavum in the cervical region.[11] Because this ligament plays an essential role in the LOR technique, this variability potentially can lead to a higher rate of false positive identifications during CESIs. The present authors postulate that the accuracy of the LOR technique in the cervical region may be even lower than in the lumbar region because of its unpredictable anatomy. To date, there are no published studies assessing the accuracy of the cervical LOR technique as confirmed by epidurography.

It has been established that fluoroscopic guidance is a useful tool for locating the epidural space. Fredman et al reported that more than 50% of "blind" lumbar epidurals were actually performed at a level other than the one intended.[8] In this same study, the researchers found that in only 12 of 47 cases did the 5 mL of contrast injected actually spread to the area of pathology. In a study evaluating the accuracy of blind caudal injection, Renfrew et al found that caudals performed without fluoroscopic guidance led to a 52% incidence of erroneous needle placement.[19]

In the cervical region, the proximity of the spinal cord coupled with a smaller cervical epidural space as compared with lumbar levels can make CESIs prone to rare but serious complications if the procedure is blindly performed. Inadvertent dural puncture may lead to postdural puncture headaches and even arachnoiditis if steroids are administered intrathecally.[1] Epidural abscess,[25] epidural hematoma,[28] and permanent spinal cord injury can occur after CESI.[10,18] The chances of an unrecognized intravascular or intrathecal injection during blind epidural steroid injections (ESIs) are increased.[19] There are several reports of neuropathic pain following CESI.[7,22]

The use of fluoroscopy may diminish these risks. In a large study, involving 669 CESIs and performed with fluoroscopy and epidurography, Johnson et al reported only one complication.[14] The same study reported a low

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prevalence of adverse effects at 4 of 5489, including cervical, thoracic, and lumbar ESIs combined. Botwin et al found a 9.6% complication rate in fluoroscopically guided lumbar ESI in a study involving 322 patients. All of the complications were minor. No occurrence of dural puncture was reported in this study.[3]

Patient comfort assumes a high degree of importance during these procedures. A factor that contributes to patient discomfort is difficulty in locating the epidural space. At times, it may require several attempts before the epidural space is finally penetrated. These patients are often sedated to decrease their level of anxiety. Unfortunately, sedating patients before nerve blocks may increase the risk of unrecognized intraneural, intrathecal and intravascular injection. In addition to reducing the chances of these occurrences, the use of fluoroscopy may obviate the need for conscious sedation. Johnson et al reported that patients experienced less discomfort with fluoroscopically guided ESIs than when the procedures were performed blindly.[14]

■ Methods

The study was conducted at one academic center and two private pain management clinics. The research was approved by the Institutional Review Board. A standard protocol for performing CESIs was used in each center. At the academic center, attending physicians and house staff in all levels of training performed the procedures, whereas at the 2 private practice settings, the clinicians were all attendings with extensive experience in performing CESIs using epidurography.

Thirty-eight CESIs were performed in 31 patients (three patients had two, and two patients had three CESIs). The patients ranged in age from 31 to 65 years (mean, 42.6; SD, 8.3 years). Seventeen female and 14 male patients participated in the study. The distribution of CESIs by cervical level was as follows: C_{4-5} (3), C_{5-6} (13), C_{6-7} (18), and C_7 T_1 (4). The indications for CESIs were symptoms and signs of cervical radiculopathy with one of the following MRI findings: herniated nucleus pulposus, spinal stenosis, or degenerative changes.

The procedures were performed in the following manner. The patient was placed in the prone position on a fluoroscopy table. A blanket was placed under the patient's chest, and the head was flexed forward to rest on a 1-liter bag of fluid. To facilitate lateral fluoroscopy, the patient's arms were positioned at the side.

Using an Anteroposterior (AP) view, the desired cervical interlaminar space was located. After anesthetizing the skin with 1% lidocaine, a 22-gauge Touhy needle was inserted using a coaxial (tunneled) view just lateral to the midline (ipsilateral to the patient's symptoms), so that it was aligned with the lateral border of the spinous process. During advancement of the needle, AP images were taken as needed to ensure the continuation of a true coaxial view. In all instances, the epidural space was located by using loss of resistance to air. After LOR was encountered, accuracy of needle placement was assessed by the injection of 0.5 mL of Omnipaque 240 contrast medium. AP, lateral, and oblique fluoroscopic views were screened. In the event that the senior physician was not satisfied that the contrast medium spread was consistent with epidural injection, the needle was repositioned and the process was repeated until adequate contrast medium spread was obtained. When the needle was confirmed to be in the epidural space, a total of 2 mL of contrast medium was injected into the epidural space. AP, lateral, and oblique radiographs were taken. Finally, 2 mL of 40 mg/mL triamcinolone was administered into the epidural space.

Data Analysis. The patients' charts and radiographic images were reviewed without identifiers for number of LOR attempts required to achieve adequate epidural dye spread, patients' ages or genders, previous cervical MRI results, history of previous cervical laminectomy, and the physician's level of training.

The physician who performed the procedure analyzed the epidurograms for the number of LOR attempts. The rate of false positive LOR was calculated by dividing the false LORs by the total number of patients (or first CESI attempts) and multiplying the result by 100. Fisher's exact tests and two-sample t-tests were used to examine the effects of age, gender, MRI results, previous surgery, and the physician's level of training on the success of LOR.

Three reviewers (two blinded, independent physicians well-versed in reading epidurograms and the physician who performed the procedure) analyzed the epidurograms for pattern of epidural contrast spread. The following parameters were evaluated by each reviewer: a) unilateral (only left or right) contrast spread; b) presence or absence of dye spread into the ventral epidural space; c) longitudinal (number of vertebral levels) contrast spread; d) intrathecal spread; and e) adequate coverage of desired area of pathology. Mean values from the three reviewers were used as the final evaluation for continuous outcomes. In the absence of a consensus, the majority opinion was utilized for dichotomous (yes/no) outcomes (*i.e.*, spread into the ventral epidural space). The values for each category were analyzed according to the patients' ages, genders, MRI results, previous surgery, and the physician's training level using Fisher's exact tests or two-sample t-tests.

■ Results

The LOR Technique

In 47% of first attempts the Touhy epidural needle was found to be in the epidural space. Twenty out of the 38 CESIs required a second attempt to locate the epidural space, five CESIs required a third try, and in one CESI a fourth attempt was necessary (Figures 1 and 2). In cases requiring repositioning of the needle, the success rate improved to 75% on the second and third tries, and 100% (1 out of 1) by the fourth. None of the variables were found to be a statistically significant predictor of difficulty in locating the epidural space, including the cervical level at which CESIs were performed (Table 1).

Unilateral Contrast Media Spread

In the 38 epidurograms analyzed, unilateral contrast spread (Figure 3) was found to occur in 19 cases (51%), whereas the three reviewers could not determine the result in one epidurogram. None of the factors influenced the rate of unilateral contrast spread (Table 2.).

Ventral Epidural Spread and Number of Cervical Levels Covered

In 11 out of the 38 epidurograms (28%) examined, the presence of contrast media in the ventral epidural space

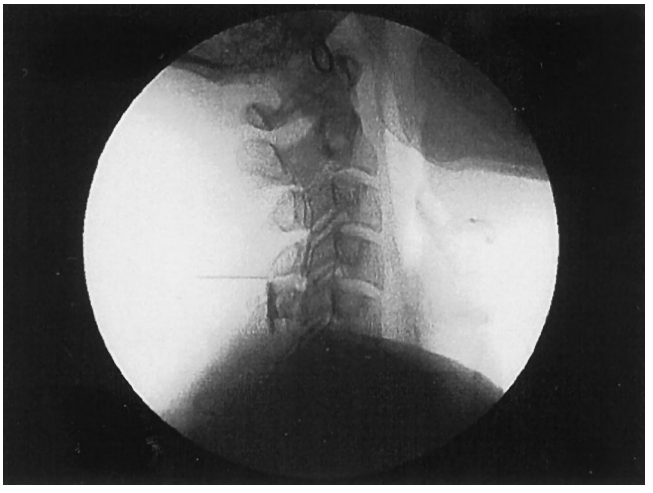

Figure 1. CESI fluoroscopic image at C4–C5 in lateral view. Contrast medium injected after false loss of resistance spreads outside the epidural space.

Table 1. Influence of Variables on Accuracy of First Attempt Loss of Resistance (LOR)

	No. of CESI	First Attempt True LOR [no. (%)]
Age (yr)		
31–45	27	14 (51.9)
46–65	11	4 (35.4)
Gender		
Male	21	11 (53)
Female	17	7 (41)
MRI findings		
Herniated nucleus pulposus	33	16 (48)
Spinal stenosis	2	0
Degenerative changes	3	2 (67)
History of surgery		
Cervical laminectomy	8	2 (25)
No previous surgery	30	16 (53)
Level of training		
Resident physicians	10	3 (33)
Fellow physicians	5	2 (40)
All physicians in training	15	5 (33)
Attending physicians	23	13 (57)

was observed. None of the variables tested was found to correlate significantly with the spread of contrast media into the ventral epidural space (Table 2).

On average, the 2 mL of contrast covered 3.14 (SD, 0.99) cervical vertebral levels (range, 1–6). Patients who had no previous spinal surgery were found to have a greater spread of contrast than those who had undergone previous laminectomies (mean, 3.28 *vs.* 2.51) with statistically significant difference ($P < 0.03$). None of the other variables tested was found to correlate significantly with the rate of longitudinal contrast spread (Table 2).

Intrathecal Contrast Media Spread and Spread to Desired Pathology

No radiographs examined revealed the presence of intrathecal contrast. The desired area of pathology was reached in 100% of cases.

■ Discussion

Loss of Resistance Technique

When compared with previous studies in the lumbar region, the high rate of false LOR in the present report may be explained, in part, by cervical anatomy. The discontinuity of ligamentum flavum in cervical levels,[11] can contribute to a lesser ability to locate the epidural space. This is because the change in feel and pressure noted when traversing this tissue plays a major role in the LOR technique. The higher rate of false LOR in patients who underwent previous laminectomy (75%) *vs.* that in surgery-free patients (47%) was expected, although the results did not attain statistical significance.

The LOR technique is considered a reliable tool for epidural anesthesia in daily clinical practice. The LOR failure rate for the placement of lumbar epidural catheters has been shown to be less than 10%.[8,29]

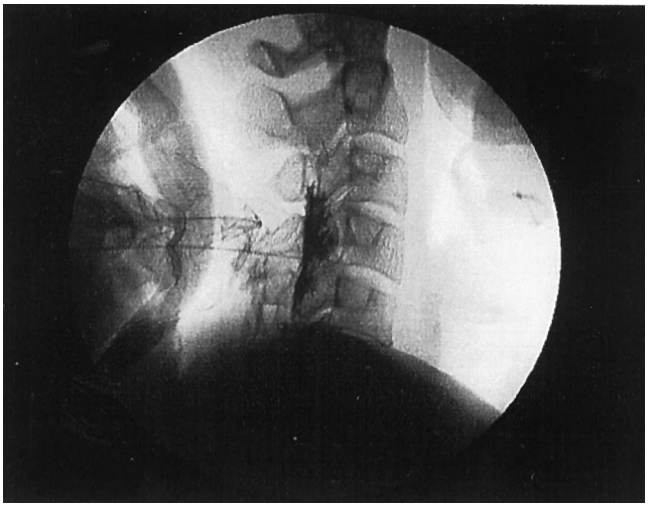

Figure 2. Repeated loss of resistance attempt in the same patient as in Figure 1. Adequate epidural contrast medium spread.

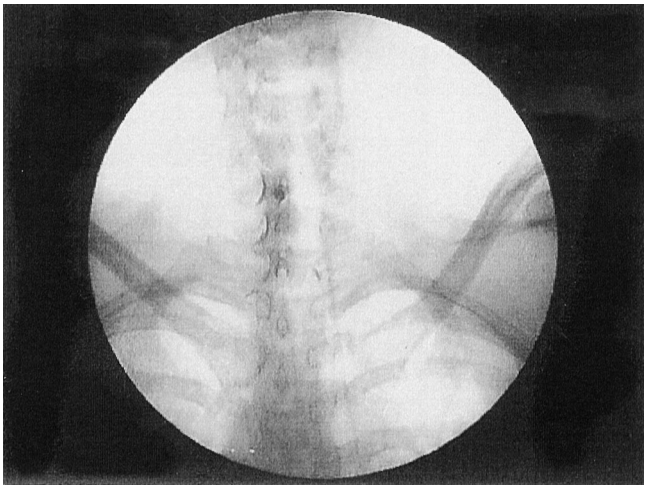

Figure 3. CESI fluoroscopic image at C6–C7 inches Antero-Posterior view. Note unilateral contrast spread to the left side.

Table 2. Pattern of Epidural Contrast (2 mL) Spread: Unilateral, Ventral, and No. of Cervical Vertebral Levels Covered

	Unilateral Spread [n (%)]	Ventral Spread [n (%)]	Longitudinal Contrast Spread, Cervical Levels Covered (n) (SD)
All epidurograms (n = 38)	19 (51)	11 (28)	3.14 (0.99)
Age			
31–45 yr (n = 26)	12 (46)	9 (35)	3.25 (0.15)
46–65 yr (n = 11)	7 (64)	3 (27)	2.93 (0.33)
Gender			
Male	10 (59)	3 (17)	2.94 (0.25)
Female	9 (42)	7 (33)	3.30 (0.15)
MRI findings			
Herniated nucleus pulposus	18 (55)	9 (27)	3.16 (0.15)
Spinal stenosis	1 (50)	0	2.83 (0.50)
Degenerative changes	0	2 (67)	3.08 (0.66)
History of surgery			
Cervical laminectomy	4 (57)	2 (29)	2.52 (0.26)*
No previous surgery	14 (47)	9 (30)	3.28 (0.15)*

* Statistically significant, $P < 0.03$.

Conversely, when epidural space was located for placement of steroids without the use of catheter, White et al reported a false positive LOR rate of 25–30% for lumbar and thoracic ESIs, even in the hands of experienced physicians.[26,27] The present authors found a 53% false positive LOR rate in cervical levels.

Other than the injection location, there are several possible explanations for the higher incidence of false positive LOR rates in Freedman's study and other studies. During the placement of an epidural catheter, when LOR is encountered and the catheter does not thread easily, the epidural needle usually is repositioned and the procedure repeated. When ESIs are performed blindly without a catheter and the additional information of being able to thread the catheter is not available, LOR alone is assumed to indicate entry into the epidural space. The act of inserting an epidural catheter may mitigate against erroneous injections. There are no studies in adults ascertaining the failure rate of threading an epidural catheter once LOR is established.

The size of the needle can be another factor that may influence the success of LOR technique. When an epidural catheter is used, a larger-diameter needle (17G) is used in comparison with the needle used in steroid injections (20–22G). The role the size of the needle plays in the success rate of ESIs is uncertain but the present study suggests that a smaller-diameter needle may lessen the chances of locating epidural space.

However, the use of an epidural catheter by no means guarantees delivery of the medication to targeted areas. Fredman et al found that, in 26% of cases in which steroids were administered through a catheter confirmed by fluoroscopy to be in the lumbar epidural space, the medication did not reach the area of pathology.[8]

Unilateral Contrast Media Spread

The fact that unilateral contrast spread was observed in 51% of patients was not surprising in the context of the authors' practices, where CESIs are routinely performed and medications are injected on the side of pathology under fluoroscopic guidance. The impact time and patient position on the spread of unilaterally administered solution has yet to be studied. The finding of 51% unilateral dye spread may be caused by the plica mediana dorsalis, a thin septum partitioning the posterior epidural space. Although it has not been demonstrated in cervical levels, the plica mediana dorsalis represents a potential barrier dividing the posterior epidural space into compartments and obstructing the free flow of injectate in the lumbar,[2,9,21] and 56% of thoracic[24] levels as determined by CT and MR epidurography. However, anatomic studies[13] and epiduroscopy[12] have not confirmed the presence of epidural fibrous barriers in lumbar levels. Posterior midline tissue was seen by epiduroscopy as a normal epidural fat.[12] What role, if any, this plays in limiting contrast spread in cervical area requires further investigation.

In patients who underwent previous laminectomies, the higher incidence of unilateral contrast spread may be explained by the presence of epidural adhesions, although differences did not reach statistical significance.

Contrary to the authors' findings, in clinical practice using epidural anesthesia in an operative setting, one-sided blocks are infrequent. One explanation for this may be the higher potency and larger volumes of solution used to obtain surgical anesthesia. In fact, a recent study showed that the greater the volume of injectate, the more symmetric the distribution of contrast.[12] This same study also found a correlation between the spread of solution and the location of the epidural catheter, with catheters located in the midline yielding even more contrast spread. In contrast to epidurals used to provide surgical analgesia, the present authors inject only a fraction of injectate and intentionally enter the epidural space lateral to the midline. One potential drawback of injecting an increased volume of steroid solution is that the concentration of the drug that reaches the area of pathology is more dilute. What effect this has on clinical outcome is still not known.

Longitudinal and Anterior Contrast Media Spread

On average, the 2 mL of contrast covered 3.14 (SD, 0.99) cervical levels. Based on the unproven but intuitive supposition that a higher concentration of steroids is associated with a better outcome, the use of a higher, more dilute volume of solution would be less effective when fluoroscopy is used. The decreased longitudinal spread in patients with previous laminectomy may be explained by presence of scar tissue in the epidural space limiting the uniform spread of injectate. The implications for this finding are important as even the single placement of an epidural catheter can produce alterations in epidural anatomy by the formation of scar tissue.[15] In view of this fact, it might be better to approach epidural space transforaminally[16,17] in patients with previous surgery, as op-

posed to either above or below the incision, or even caudally in lumbar cases.[14]

The spread of contrast into the anterior epidural space, located between the dura and anterior longitudinal ligament, was observed in less then one third of the authors' cases. This is in agreement with the findings of Tomczak et al, who noted a 24% incidence of ventral epidural contrast spread in thoracic levels.[24] The clinical significance of this finding is not clear.

Volume

In clinical practice, the typical volumes of steroids injected into the cervical epidural space vary from 2 to 5 mL.[14] In the present study, the authors did not analyze the spread of epidural contrast in volumes larger than 2 mL. It is possible that larger volumes may increase significantly the rate of bilateral epidural and longitudinal contrast spread. Johnson et al reported a case of bilateral cervical epidural contrast spread using 4–5 mL of contrast material and recommended 5–6 mL of contrast volume based on their clinical observation.[14] The present authors' clinical experience suggests that volumes even higher than 4–6 mL might be needed to assure consistent bilateral epidural contrast spread. It also seems intuitive that volume of contrast should match the volume of steroids administered to predict the final epidural steroid solution spread. Future studies might better address this issue.

Other Factors

It is important to note that the CESIs in the present study were not performed blindly (*i.e.*, without fluoroscopy). As previously stated, when performed without radiographic assistance, the practitioner is faced with a number of obstacles, including the potential for false LOR, unilateral contrast spread, inaccurate entry level, and failure of the medication to reach the targeted destination.[8] When taken together, these considerations can undermine the effectiveness and increase the risk of complications of CESIs.

The results of the present study do not address the difference between contrast media and steroid solution spread. The differences in chemical properties of these two solutions may result in different patterns of its epidural spread. Further CESI studies using radiolabeled steroid may better address this question.

■ Conclusion

Based on the finding of the present study, and those of other investigators, the authors recommend the routine use of epidurography for CESIs. The authors also recommend the placement of epidural steroids ipsilateral to the side of pathology, based on high rates of unilateral epidural contrast spread found in this study. The use of small volumes of epidural steroid solution (2 mL) seems to adequately cover the desired area of pathology and higher volumes frequently used in clinical practice may not be justified. When fluoroscopy cannot be used, higher volumes of solution volumes may need to be administered to achieve medication delivery to targeted areas. Possibly, larger needles may help to achieve better success in locating the epidural space if fluoroscopy is not used. It is not clear whether fluoroscopy improves functional and pain level outcomes in CESIs. Future studies are needed to assess the long-term benefits of this approach.

■ Key Points

- Previous studies have shown that epidural steroid injections (ESI), if performed without fluoroscopic guidance, can result in erroneous drug placement in lumbar levels. There are no published studies on the accuracy of ESI technique in cervical levels and pattern of cervical epidural contrast spread.
- The result of this study suggest that loss of resistance technique is a poor tool for locating the epidural space in cervical ESI if used without fluoroscopic guidance.
- The authors of this study found unilateral cervical epidural contrast media spread in 51% of their cases, suggesting that cervical ESI should be performed ipsilateral to patients' symptoms.
- The results of this study suggest that fluoroscopy and epidurography can improve the accuracy of needle placement and medication delivery to targeted areas of pathology in cervical ESI.

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