

# Dispersal Pattern of Injectate after Lumbar Interlaminar Epidural Spinal Injection Evaluated with Computerized Tomography

Kevin Paisley<sup>1</sup> Joel Jeffries<sup>1</sup> Mark Monroe<sup>2</sup> Ted Choma<sup>1</sup>

<sup>1</sup> Department of Orthopaedic Surgery, Missouri Orthopaedic Institute, University of Missouri, Columbia, Missouri

<sup>2</sup> Department of Radiology, Advanced Radiology of Columbia, Columbia, Missouri

**Address for correspondence and reprint requests** Kevin Paisley, D.O., Department of Orthopaedic Surgery, Missouri Orthopaedic Institute, University of Missouri, 1100 Virginia Avenue, DC953.00, Columbia, MO 65212 (e-mail: paisleyk@health.missouri.edu).

Global Spine J 2012;2:27–32.

## Abstract

**Study Design** Retrospective analysis of lumbar computed tomographic epidurograms.

**Objective** To evaluate the dispersal pattern of injectate after interlaminar lumbar epidural steroid injections.

**Summary** Prior studies have evaluated the dispersal patterns of injectate after lumbar epidural steroid injections using fluoroscopy with varying results. To date, there have been no studies evaluating the dispersal pattern utilizing computerized tomography.

**Methods** Ten epidurograms were analyzed after lumbar interlaminar epidural steroid injection. The epidurograms were examined, evaluating the dispersal pattern in longitudinal flow as well as circumferential flow. In addition, pain values were assessed with the visual analogue scale.

**Results** Mean diffusion in the rostral direction was 9.8 cm (standard deviation 4.0 cm, range 4.0 to 15.0 cm). Mean diffusion in the caudal direction was 5.4 cm (standard deviation 1.4 cm, range 3.0 to 8.0 cm). Both rostral and caudal flow had a  $p$  value  $< 0.001$ . The circumferential flow was 360 degrees in 9 of 10 cases. In addition, there was significant ( $p = 0.006$ ) reduction in pain.

**Conclusion** Interlaminar lumbar epidural steroid injections are an effective treatment modality for various spine-related conditions. The injectate diffuses throughout the epidural space with nearly uniform circumferential flow as well as significant rostral and caudal flow.

## Keywords

- ▶ spine related conditions
- ▶ lumbar
- ▶ interlaminar
- ▶ epidural
- ▶ steroid
- ▶ injection
- ▶ epidurogram
- ▶ computerized tomography

Epidural steroid injections have had long impact in the treatment of various spine-related conditions, particularly radiculopathy. In 1952, Robecchi and Capra first reported the use of a steroid compound in the epidural space for the treatment of lumbar radicular pain syndrome.<sup>1</sup> The effectiveness of such injections has been studied with various results since then, and a recent meta-analysis showed epidural steroid spinal injections to be beneficial in the treatment of pain and associated radiculopathy with significant short-term improvement.<sup>2</sup>

The efficacy of epidural spinal injections has been attributed to the anatomic location reached by the injectate.<sup>3</sup> Lutz and colleagues postulated that the delivery of the injectate to the ventral aspect of the nerve root sleeve and posterior annulus would lead to the best therapeutic result as this is often the primary location of the pathology. For these reasons, they concluded that transforaminal injection techniques would best allow the injectate to flow to the target site as opposed to the caudal or interlaminar approach.<sup>3</sup> Although the interlaminar route is considered to be safe and less

received  
January 3, 2012  
accepted after revision  
January 27, 2012

Copyright © 2012 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.  
Tel: +1(212) 584-4662.

DOI <http://dx.doi.org/10.1055/s-0032-1307251>.  
ISSN 2192-5682.

technically demanding, these results have led some practitioners to prefer the transforaminal route. However, recent reports have determined significant risks associated with lumbar transforaminal injections including vascular injury to the artery of Adamkiewicz or paralysis.<sup>4,5</sup>

With the potential catastrophic complications of the transforaminal approach in mind, further research was initiated to determine the effectiveness of interlaminar injections to deliver the injectate throughout the epidural space. Multiple prior studies have employed fluoroscopy to evaluate the dispersal pattern of injectate after interlaminar steroid injection.<sup>6-12</sup> The majority of these prior studies found the injected material remained more dorsal and unilateral in the epidural space. Assuming Lutz and colleagues to be correct, this may not be an optimal dispersal. In addition, these prior studies revealed that the injectate did not diffuse greater than one or two vertebral segments cephalad or caudad. Candido et al employed lateral radiographs in their study of 29 patients undergoing lumbar interlaminar epidural steroid injections to determine injectate dispersal. Ventral flow was defined by the presence of contrast material adjacent to the posterior vertebral body. Such flow was documented in all 29 cases. The inherent limitations in sensitivity of lateral radiographs likely diminished the ability to determine the totality of epidural spread of the injectate.<sup>9</sup>

One theory proposed behind the lack of bilateral or circumferential flow is the existence of the plica mediana dorsalis, a band of connective tissue anchoring the dura to the posterior epidural space potentially preventing the spread of injectate to the contralateral side.<sup>13,14</sup> Additionally, Asato and Goto suggested that needle tip position may influence the extent of injectate diffusion.<sup>11</sup> In their study, they found a frequent cause of unilateral epidural blockade was the misplacement of the catheter into the ventral epidural space. Unilateral flow may be sufficient if exclusively unilateral symptoms are present; however, this would be suboptimal if bilateral, symptomatic pathology exists.

## Objective

Appreciating the limitations of fluoroscopy and lateral radiographs to characterize injectate dispersal, this study has employed postinjection computerized tomography (CT) to demonstrate the extent of injectate flow throughout the epidural space. The use of this tool has allowed the determination of caudal, rostral, and circumferential contrast dispersal.

## Methods

The University of Missouri's Institutional Board Review approved this retrospective study. All imaging and patient information was obtained in a deidentified fashion from a single radiology group for analysis.

The patients included in this retrospective study presented to a local radiology center as part of nonoperative treatment for lumbar spine-related pain and radiculopathy. Consent was obtained for the steroid injection with all risks, benefits, and alternatives being discussed prior to injection. Lumbar inter-

laminar epidural steroid injections were performed using the loss of resistance technique. Computerized tomography was performed 15 minutes subsequent to the procedure to determine the accuracy of the injection.

We reviewed the images of 14 consecutive patients that had CT imaging (Siemens Somatom Definition AS+ 128 Slice CT Scanner; Erlangen, Germany) performed post-lumbar epidural steroid injection between July 2009 and September 2010. Four patients were excluded in total, resulting in 10 patients. Inclusion criteria consisted of any lumbar interlaminar epidural spinal injection performed for diagnoses including lumbar radiculopathy, herniated nucleus pulposus, and lumbar spinal stenosis. Exclusion criteria consisted of any history of lumbar spinal surgery, active infection in the spine, or allergy to contents within the injectate (contrast dye, anesthetic, or steroid). Previously operated patients were excluded by the assumption that epidural scarring would alter the injectate dispersal. No patient was excluded due to the severity of pathology at the respective site. Of the patients excluded, one was due to prior lumbar surgery with instrumentation and three due to incomplete records missing patient demographics, pathology, or pre- and postinjection pain assessments.

The injections were performed by a radiologist with extensive experience in administering epidural steroid injections. Sterile technique was utilized with local anesthesia. A 20-gauge Tuohy needle was advanced into the epidural space from the interlaminar approach with the patient in the prone position. Once loss of resistance was identified and a negative aspiration for blood or spinal fluid was confirmed, a total of 13 mL of injectate (9 mL of Kenalog 10 mg/mL [Bristol-Myers Squibb, Sermoneta, Italy], 2 mL of bupivacaine 0.5%, 2 mL of Omnipaque 300 [GE Health, Princeton, NJ]) was delivered to the epidural space. Fifteen minutes after the injection, the patient was scanned, and the dispersal pattern of the injectate was assessed. It was assumed that the dispersal of the contrast reflected the dispersal of the injectate as a whole.

A visual analogue scale was used to assess preinjection pain level (scale of 0 to 10) as well as immediate analgesic affects 15 minutes postinjection.

The CT epidurograms were interpreted by a single radiologist. The circumferential flow was determined in degrees from transverse plane axial images. The axial flow to adjacent levels was determined by identifying the most rostral and caudal identifiable extent of contrast flow and measuring, in centimeters, from the position of the needle tip to these points.

## Data Analysis

We used *t* tests to test the null hypothesis that the average migration was 3.0 cm versus the alternative hypothesis that the average migration was greater than 3.0 cm. The one-sample *t* test was also applied to paired differences in pre- and postinjection pain scores to test for immediate analgesic affects.

## Results

Data were obtained from 10 patients (six women and four men) with a mean age of 69.3 (38 to 84) years. Seven of the included



**Figure 1** Superior extent of contrast dispersion is shown at the level of T11 (the most superior extent that was scanned). All images are from an 82-year-old man with lumbar stenosis who received an L4–5 lumbar interlaminar epidural steroid injection.



**Figure 2** Caudal extent of contrast dispersion is shown (most caudal extent that was scanned).

patients had lumbar stenosis, and the other three patients had herniated discs. The mean diffusion in the rostral direction from the injection site was 9.8 cm with a standard deviation of 4.0 cm and a range of 4.0 to 15.0 cm (►Fig. 1). The mean diffusion in the caudal direction was 5.4 cm with a standard deviation of 1.4 cm and a range of 3.0 to 8.0 cm (►Fig. 2). Both rostral and caudal flow dispersion had a *p* value <0.001 with a null value of 3.0 cm (►Table 1). We used 3.0 cm for our null value as prior studies determined one vertebral level of diffusion to be significant (~3.0 cm).<sup>7,12</sup> Ultimately, the authors felt

as though measuring by centimeters would be more objectively reproducible than measuring by vertebral levels. The circumferential flow was 360 degrees in 9 of 10 patients (90%; ►Fig. 3). The one patient without circumferential flow had displayed contrast diffusion of 270 degrees.

There was a statistically significant (*p* = 0.006) reduction in pain. The mean preinjection visual analogue scale pain score was 5.0 with a standard deviation of 2.8 (minimum of 0 and maximum of 8.0). The mean postinjection pain score was 2.9 with a standard deviation of 2.9 (minimum of 0.0 and maximum of 6.0). The mean reduction of pain score was 2.1 with a standard deviation of 1.9 (minimum of 0.0 and maximum of 5.0).

**Table 1** Migration Data on 10 Patients

Patient	Level	Circ (degree)	Sup migration (cm)	Inf migration (cm)	Pain Score, Preinjection	Pain Score, Postinjection	Gender	Age	Diagnosis
1	L4–L5	360	8	8	5	0	F	38	Disc herniation
2	L4–L5	360	7	5	5	0	F	83	Lumbar stenosis
3	L5–S1	270	4	4	7	6	F	82	Lumbar stenosis
4	L4–L5	360	13	6	1	0	F	77	Lumbar stenosis
5	L4–L5	360	8	5	7	6	M	45	Lumbar stenosis
6	L4–L5	360	13	6	8	5	F	77	Lumbar stenosis
7	L4–L5	360	15	7	0	0	M	82	Lumbar stenosis
8	L5–S1	360	5	5	8	5	F	69	Disc herniation
9	L4–L5	360	15	5	3	1	M	56	Disc herniation
10	L2–L3	360	10	3	6	6	M	84	Lumbar stenosis

Circ, circumferential flow; Sup, superior; Inf, inferior.



**Figure 3** Bilateral foraminal extension is shown at the level of T12–L1.

## Discussion

The use of epidural steroid injections has been steadily increasing in this country, even though the evidence for long-term effectiveness is questionable.<sup>2</sup> Regardless of the long-term effects, the short-term relief of pain and inflammation continues to make epidural steroid injections a reasonable option for the nonoperative treatment for various painful spine conditions. The rationale behind the use of injecting steroids to the epidural space is largely due to belief that anti-inflammatory properties of the steroid neutralizes phospholipase A2 released from degenerative and herniated discs.<sup>15,16</sup> Corticosteroids have long been shown to inhibit prostaglandin synthesis<sup>17</sup> in addition to blocking nociceptive C fiber conduction.<sup>18</sup> For these reasons, Lutz and colleagues, as well as others, have targeted the ventral epidural space. Prior analyses of injectate dispersal have noted wide variability.<sup>6–12</sup> This is the first study that brings to bear the sensitivity and specificity of computerized tomography analysis used to evaluate the epidural space dispersion patterns after contrasted injection.

Prior studies have focused on three main parameters of flow: The first focuses on dorsal versus ventral flow (anterior/posterior plane), the second on unilateral versus bilateral flow (transverse plane), and finally rostral versus caudal flow (axial plane). Our results clearly indicate that the injectate dispersed widely throughout the epidural space. Computerized tomography allowed determination of the amount of ventral and bilateral flow in degrees of circumference. Expressing the data in this fashion provides significantly more detail than has been revealed in earlier studies. In this study, all postinjection CTs demonstrated bilateral and ventral flow, with 360-degree dispersal noted in 9 of 10 patients. This is consistent with the findings of Candido et al who found that 29 of 29 patients receiving interlaminar injection had flow to the anterior space.<sup>9</sup> The finding was documented with lateral radiographs, which may increase the false-positive rate as moderate to severe spondylosis and may be perceived as contrast.

Our findings are in contrast to those of Gallart et al and Fukushige et al.<sup>13,14</sup> The postulated flow-limiting effect of the plica mediana dorsalis was not demonstrated in this study as all postinjection CTs demonstrated 100% bilateral flow and 90% circumferential flow. The reason for this discrepancy is unclear. The incidence of the plica mediana dorsalis is not well documented, and as such our small sample size may be subject to selection bias. It is also possible that our findings differ from those of Gallart et al's results due to unappreciated differences in the technical administration of the injections.

This study demonstrated substantial injectate dispersal in both caudal and rostral directions with the mean dispersal of 5.4 cm in the caudal direction and 9.8 cm rostral. The finding of dominant rostral flow is consistent with the findings of Botwin et al, who noted mean caudad flow of 0.88 levels and the cephalad flow of 1.28 levels.<sup>7</sup> We believe the difference in the two axial plane measurements is due to the direction the needle tip is pointing within the epidural space, as traditionally the needle is in the cephalad direction. Due to the variability in disc and vertebral body heights, flow in this study was recorded as distance from the injection site as this was felt to provide a more consistent method of measurement.

A previous study by Burn et al in 1973 was able to determine significant flow throughout the epidural space in the axial plane.<sup>6</sup> They injected either 20 or 40 mL into the epidural space with radiographs taken postinjection. They found that the two main factors with the most effect on the spread were the volume of injectate and site of injection (lumbar versus caudal). These volumes are considerably more than the typical epidural steroid injections. In this retrospective study, 13 mL of injectate was used, which more closely resembles standard practice as well as other published studies evaluating dispersal patterns of injectate in the epidural space (range 5 to 12 mL).<sup>7–9,12</sup> It is assumed that a lower injected volume will diminish the injectate dispersal.

One technical aspect of our study that may affect the observed flow of contrast in the axial plane was the decision to perform CT scans 15 minutes postinjection. This time, rather than a scan immediately upon injection, was chosen to provide a snapshot in time that would more closely reflect the ability of injectate to diffuse. This more “final” diffusion pattern likely better reflects the scope of the possible region of action for these injections in our opinion. The wide pattern of dispersal noted on all postinjection CTs obtained in this study suggests that use of interlaminar epidural steroid injections as a determiner of pain generator location should be discarded.

Alternatively, the data can be interpreted to support injection at a site adjacent to suspected painful pathology. In certain instances, a practitioner may want to avoid directly injecting a target level due to coexisting pathology such as severe facet arthrosis, high-grade stenosis, high-grade spondylolisthesis, or overlying fusion mass. This study supports an option using an adjacent injection approach immediately caudal to the target, taking advantage of the greater rostral injectate dispersal.



## Limitations

Our study has several limitations, the primary being its retrospective nature and its associated susceptibility to selection bias. However, attempts were made to avoid bias by enrolling consecutive patients as well as determining significant flow of 3.0 cm prior to the preliminary analysis. Another potential weakness is the small number of patients enrolled, calling into question the generalizability of our findings. We would note, however, that in our case series the results were found to be quite consistent and thus a larger patient population was not felt to add any additional statistical significance. This study was limited to only interlaminar injections and did not provide for comparison to caudal and transforaminal injections. Although our data were significant for immediate pain alleviation postinjection ( $p = 0.006$ ), the therapeutic effects were not the primary objective for this study. We also note the lack of long-term follow-up, which limits data on the therapeutic benefit. This is due to the fact that the enrolled patients were referred by outside physicians and not followed long term by the authors. Our final weakness is that we did not account for the specific pathology leading the patient to seek this form of nonoperative treatment.

## Conclusion

Even with the study limitations, our data consistently demonstrated wide diffusion of injectate throughout the epidural space in all three planes with greater detail than any known prior published study.

### Disclosures

Kevin Paisley, None  
 Joel Jeffries, None  
 Mark Monroe, None  
 Ted Choma, None

### Funding

The University of Missouri Orthopaedic Association provided some funding to execute this study.

### IRB

This project complied with the Health Insurance Portability and Accountability Act (HIPAA) and requirements set forth by the University of Missouri's Institutional Review Board.

## References

- 1 Robecchi A, Capra R. [Hydrocortisone (compound F); first clinical experiments in the field of rheumatology]. *Minerva Med* 1952; 43:1259-1263
- 2 Boswell MV, Trescot AM, Datta S, et al; American Society of Interventional Pain Physicians. Interventional techniques: evidence-based practice guidelines in the management of chronic spinal pain. *Pain Physician* 2007;10:7-111
- 3 Lutz GE, Vad VB, Wisneski RJ. Fluoroscopic transforaminal lumbar epidural steroids: an outcome study. *Arch Phys Med Rehabil* 1998;79:1362-1366
- 4 Houten JK, Errico TJ. Paraplegia after lumbosacral nerve root block: report of three cases. *Spine J* 2002;2:70-75
- 5 Huntoon MA, Martin DP. Paralysis after transforaminal epidural injection and previous spinal surgery. *Reg Anesth Pain Med* 2004;29:494-495
- 6 Burn JM, Guyer PB, Langdon L. The spread of solutions injected into the epidural space. A study using epidurograms in patients with the lumbosacral syndrome. *Br J Anaesth* 1973;45:338-345
- 7 Botwin KP, Natalicchio J, Hanna A. Fluoroscopic guided lumbar interlaminar epidural injections: a prospective evaluation of epidurography contrast patterns and anatomical review of the epidural space. *Pain Physician* 2004;7:77-80
- 8 Whitlock EL, Bridwell KH, Gilula LA. Influence of needle tip position on injectate spread in 406 interlaminar lumbar epidural steroid injections. *Radiology* 2007;243:804-811
- 9 Candido KD, Raghavendra MS, Chinthagada M, Badiee S, Trepashko DW. A prospective evaluation of iodinated contrast flow patterns with fluoroscopically guided lumbar epidural steroid injections: the lateral parasagittal interlaminar epidural approach versus the transforaminal epidural approach. *Anesth Analg* 2008; 106:638-644
- 10 Choi YK, Barbella JD. Evaluation of epidurographic contrast patterns with fluoroscopic-guided lumbar interlaminar ventral epidural injection. *Pain Pract* 2009;9:275-281
- 11 Asato F, Goto F. Radiographic findings of unilateral epidural block. *Anesth Analg* 1996;83:519-522
- 12 Weil L, Frauwirth NH, Amirdelfan K, Grant D, Rosenberg JA. Fluoroscopic analysis of lumbar epidural contrast spread after lumbar interlaminar injection. *Arch Phys Med Rehabil* 2008; 89:413-416
- 13 Gallart L, Blanco D, Samsó E, Vidal F. Clinical and radiologic evidence of the epidural plica mediana dorsalis. *Anesth Analg* 1990;71:698-701
- 14 Fukushige T, Kano T, Sano T. Radiographic investigation of unilateral epidural block after single injection. *Anesthesiology* 1997; 87:1574-1575
- 15 Franson RC, Saal JS, Saal JA. Human disc phospholipase A2 is inflammatory. *Spine* 1992;17(6, Suppl):S129-S132
- 16 Olmarker K, Blomquist J, Strömberg J, Nannmark U, Thomsen P, Rydevik B. Inflammatory properties of nucleus pulposus. *Spine* 1995;20:665-669
- 17 Kantrowitz F, Robinson DR, McGuire MB, Levine L. Corticosteroids inhibit prostaglandin production by rheumatoid synovia. *Nature* 1975;258:737-739
- 18 Johansson A, Hao J, Sjölund B. Local corticosteroid application blocks transmission in normal nociceptive C-fibres. *Acta Anaesthesiol Scand* 1990;34:335-338