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An Original Contribution

# Epidurography Contrast Patterns with Fluoroscopic Guided Lumbar Transforaminal Epidural Injections: A Prospective Evaluation

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*Background :* Lumbar transforaminal epidural injections have been utilized in the treatment of radicular pain with proven success. It was postulated that interlaminar epidural injections result in a dorsal flow of contrast while transforaminal epidural steroid injections showed good ventral flow limited to one single spinal motion segment. There have been no published studies evaluating epidurography/contrast patterns utilizing fluoroscopy.

*Objective:* To evaluate the pattern and spread of epidural contrast during fluoroscopically guided lumbar transforaminal epidural steroid injections.

*Design:* A prospective study of case series of 20 consecutive patients receiving lumbar transforaminal epidural injections.

*Methods:* Patients had either herniated nucleus pulposus or lumbar spinal stenosis. All patients received their injection by one of five physicians trained in this technique. Once the needle tip was felt to be in the anterior epidural space anteroposterior and a lateral radiographs were obtained after a total of 2 mL of iopamidol (Isovue®) contrast was injected. Epidurograms were reviewed by a physician trained in fluoroscopic injections. Patterns were recorded as unilateral, bilateral, dorsal or ventral. Ventral flow, both cephalad and caudal, and number of lumbar intervertebral levels of flow were recorded as well.

*Results:* Ventral contrast flow occurred in all 20 injections. Unilateral contrast flow was noted in all injections. The mean number of levels of flow of contrast cephalad and caudad from the injection site were 1.13 and 0.6 levels, respectively, but these differences were not statistically significant. There were no significant differences in contrast flow noted between patients with herniated nucleus pulposus or lumbar spinal stenosis. Vascular injection patterns were noted with 2 injections, which required repositioning of the needles.

*Conclusion:* Contrast appeared ventrally and unilaterally in all injections. Dorsal flow occurred in 20% of these injections. No contrast flow crossed the midline. The observed contrast flow patterns should be studied clinically to determine whether they have any effect on clinical outcome. Intravascular injections were noted in 10% of cases.

*Keywords:* Epidural injections, transforaminal epidural injections, herniated nucleus pulposus, lumbar spinal stenosis, fluoroscopy

Lumbar transforaminal epidural injections have been utilized in the treatment of radicular pain with proven success in the treatment of patients with herniated nucleus pulposus (HNP) or lumbar spinal stenosis (LSS) (1-6). The technique is not new, and was described in the early 1950's by Robechhi and Capra (7), who injected steroids on to the S1 nerve root for treatment of sciatica. This method was further modified by Derby et al (8). Their technique allows the needle position to be placed in the anterior epidural space without pain provocation. The needle is placed medial to the ventral intertransverse membrane and positioned just below the midportion of the pedicle. This places the needle in a "safe triangle" that has a base tangential to the pedicle, a side in line with the outer margin of the intervertebral foramen, and a hypotenuse coincident with the upper margin of the spinal nerve and dorsal root ganglion. Thus, the needle will lie above and lateral to the nerve. In this location medications can be instilled in the anterior epidural space. There has been a description of the flow pattern observed in this technique compared with interlaminar techniques presented by Andrade and Eckman (9) using computed tomography in 1992. They postulated that interlaminar epidural injections result in a dorsal flow of contrast while foraminal approach showed good ventral flow limited to one single spinal motion segment.

In a review of the literature however, we found no published study, which evaluated the epidurography/contrast patterns utilizing fluoroscopy. Thus, we present a case study of the fluoroscopic epidurograms obtained in lumbar transforaminal injections.

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## Methods

Twenty consecutive patients presented to a multidisciplinary spine care practice with complaints of low back pain and radicular pain. As part of the non-operative treatment plan, patients received a combination of anti-inflammatories, analgesics, referral to physical therapy and fluoroscopically guided transforaminal lumbar epidural steroid injections.

All epidural injections were performed in an ambulatory surgery center by one of five physicians with extensive experience in fluoroscopically guided lumbar transforaminal epidural injections. A prospective case series of twenty injections on twenty consecutive patients were included in the study. Inclusion criteria consisted of any injection performed in consecutive patients for the treatment lumbar radicular pain from either HNP (herniated nucleus pulposus) or LSS (lumbar stenosis). The diagnosis was based upon the clinician performing the procedure noting it on the patient's chart.

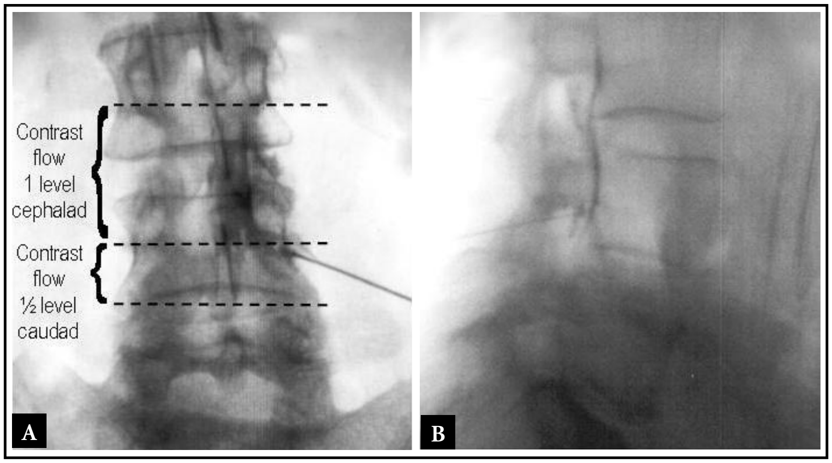


Fig. 1. *AP radiograph (left) of transforaminal injection at L4-5 intervertebral level. Note contrast appears to flow cephalad 1 level to the superior pedicle, does not cross the midline. Lateral radiograph (right) shows ventral flow of contrast cephalad 1 level to the superior pedicle from injection site*

Exclusion criteria consisted of any history of lumbar spinal surgery, allergy to contrast dye, any active infection in the lumbar area or allergy to anesthetic or corticosteroids.

### Informed Consent

After explaining the nature of the investigation, and the associated risks, informed consent was obtained from all participants. All participants were provided with an opportunity to discuss and/or participate in the study. Appropriate precautions were taken to protect the identity of the patients participating in this study.

The technique used in all 20 injections was standardized. Patients were placed in the prone position on a radiology table. Their backs were prepped using an iodine-based antiseptic solution and an alcohol solution (Povidone-Iodine USP; Clinipad Corp, Rocky Hill, CT). Using a fluoroscope (OEC Compact 7600, Salt Lake City, UT), and a 22 gauge 3.5 inch/90-mm spinal needle (Quincke type point, luer lock, Spinocan: Becton Dickinson, Franklin Lakes, NJ) were guided under fluoroscopic guidance to the dorsal/ventral aspect of the neural foramen at the suspected symptomatic radicular level. An anteroposterior (AP) fluoroscopic view (Fig. 1A) was obtained to assure that the needle was directed to approximately the 5:30 position on the right and the 6:30 position on the left, using the pedicle as a clock face. A lateral fluoroscopic view (Fig. 1B) was used to confirm that the needle was positioned just beneath the pedicle in the anterior epidural space. Aspirations were routinely performed. If negative for aspirate, 2ml Iopamidol (Isovue M-300) (Bracco Diagnostics, Princeton, NJ) was injected to confirm epidural flow of the injectate and to rule out intravascular, intrathecal or soft tissue penetration. If contrast flow was not visualized medial to the pedicle, the needle was placed at another intervertebral level. Once the epidurogram/extradural myelogram was obtained, an AP and lateral radiograph were then obtained by a radiologic technician. The radiologic technician gave all radiographs to an independent physician who was trained in fluoroscopic injections but did not perform the injections on the involved patients. The physician evaluated the contrast pattern observed on the epidurograms. The contrast patterns were described as unilateral, bilateral, ventral or dorsal. The ventral flow was also described as being cephalad or caudad. The number of lumbar intervertebral levels of flow was recorded. A level of flow was defined as being from the pedicle at the site of injection to the pedicle cephalad or caudad. Thus if an injection was performed at the L4-5 level and contrast reached the superior pedicle of L3 it would be recorded as one level of flow cephalad. If the contrast reached the L5 pedicle inferiorly, it would be recorded as one level of caudad flow (Fig. 1). Patients also received 1 ml 1% of preservative free lidocaine and 80 mg Kenalog® (triamcinolone acetate) following radiographic evaluation.

Statistical analysis was performed to determine whether there was a significant difference in levels of contrast flow cephalad and caudal in the ventral epidural space in HNP vs LSS patient injections. We also compared contrast flow in HNP vs LSS patient injections to the level that the injections were performed.

## Results

Data were obtained from 20 consecutive fluoroscopically guided transforaminal epidural steroid injections on 20 dif-

Table 1. *Mean levels of contrast spread caudally and cephalad from injection site (one level defined as being from the pedicle at site of injection to the pedicle cephalad or caudad) (mean ± SD)*

| Contrast Flow | | L4-L5 | L5-S1 | Total | *P* value |
|---|---|---|---|---|---|
| Caudad | HNP | 0.5 ± 0.0 (7) | 0.67 ± 0.29 (3) | 0.55 ± 0.16 (10) | 0.133 |
| | LSS | 0.6 ± 0.22 (5) | 0.7 ± 0.27 (5) | 0.65 ± 0.24 (10) | 0.545 |
| | Total | 0.54 ± 0.14 (12) | 0.69 ± 0.26 (8) | 0.6 ± 0.21 (20) | 0.122 |
| | | | | *P* value 0.288 | |
| Cephalad | HNP | 1.4 ± 0.35 (7) | 0.83 ± 0.29 (3) | 1.25 ± 0.42 (10) | 0.032 |
| | LSS | 1.0 ± 0.5 (5) | 1.00 ± 0.35 (5) | 1.0 ± 0.41 (10) | 1.000 |
| | Total | 1.25 ± 0.45 (12) | 0.94 ± 0.2 (8) | 1.13 ± 0.43 (20) | 0.109 |
| | | | | *P* value 0.196 | |

ferent patients. There were 12 male and 8 female patients. Ten injections were performed in patients who had lumbar spinal stenosis (LSS) and ten in patients with herniated nucleus pulposus (HNP). The mean age of the LSS patients was 71 years (55-85) and the HNP patients 50 years (39-66). The mean height (cm) of the LSS patients was 172 cm (160-180.3), and the mean height of the HNP patients was 169 cm (154.9 – 185.4).

During three injections in LSS patients the needle had to be relocated to another intervertebral level as no flow of contrast was visualized medial to the pedicle by the spinal interventionalist. The needle did not have to be relocated with HNP patient injections.

The injections were performed at either the L4-5 or L5-S1 intervertebral levels; 8 were at L5-S1 and 12 at L4-5 levels. Of the HNP injections 3 were at L5-S1 and 7 at L4-5. Of the LSS injections 5 were at L5-S1 and 5 at L4-5.

All epidurograms demonstrated contrast flow in the ventral epidural space. All epidurograms also demonstrated that contrast spread only unilaterally; no contrast crossed the midline. In four injections (20%) dorsal spread of contrast was noted, but ventral flow was noted in all four of these injections as well.

A detailed analysis of epidural contrast spread is shown in Table 1. The average number of levels of contrast spread caudad from the injection site to the inferior pedicle was 0.6 levels for all injections. The average number of levels of contrast spread cephalad from the site of injection to the next superior pedicle was 1.13 levels for all injections. There was slightly more cephalad flow at the L4/5 level than the L5/S1 level in patients with HNP. However, there was no significance difference in overall flow patterns between patients with LSS and HNP. Intravascular injection patterns were noted in 2 of the 20 injections, which required that the needles be repositioned. There were no adverse sequelae with the injections.

## Anatomy of the Anterior Epidural Space

Very few studies have actually been performed to anatomically dissect the lateral and anterior epidural space. The lateral epidural compartments contain nerves and fat, and the anterior compartment contains veins and fat. Hogan (10) evaluated the cryomicrotome appearance of the anterior epidural space and described that the anterior space appears to be filled with veins, which rarely cross the midplane of the posterior longitudinal ligament (PLL) and its lateral membrane. This is a finding identified by other authors (11, 12).

The epidural space is filled by a thin layer of areolar connective tissue termed the epidural membrane (13). This membrane surrounds the dural sac and lines the surface of the lamina and pedicles posteriorly and laterally. Ventrally it lines the vertebral bodies and also passes medially deep to the posterior longitudinal ligament where it attaches to the anterior surface of the deep portion of the ligament (10, 13). This membrane has been observed by several authors and has even been described as being able to constrain the migration of extruded fragments of disc material by blocking the passage of such material out of the anterior epidural space (14, 15). The epidural membrane laterally is drawn to form a circumneural sheath around the dural sleeve of the nerve roots and spinal nerve. An anterior midline septum has been identified which divides the anterior compartment (14). Hogan et al (16) also found there was a midline tongue of connective tissue seen to extend from the disc, reaching caudad and to a lesser degree cephalad in the PLL and the posterior vertebral body. This was not present at the mid vertebral levels. Some authors have described the incomplete fibrous septum covering the foraminal outlet of the nerve root canal (17). This same septum however, could not be visualized in the work done by Hogan et al (16).

The dural sac and nerve root sleeves are tethered to the vertebral bodies and pedicles by the meningo-vertebral ligaments or the ligaments of Hofmann (18-20). These ligaments are present both ventrally and laterally. The ventral ligaments bridge from the ventral dura to the posterior longitudinal ligament. The lateral ligament bridges the lateral dural sac to the periosteum of the pedicles and the capsule of the zygapophyseal joint. The intertransverse ligaments (membranes) span the intertransverse space. The intertransverse space being the area between the transverse process above and below the vertebral bodies and blending anteriorly with the anterior longitudinal ligament. The ligaments form a sheet-like membrane which covers the outer end of the intervertebral foramen.

## Discussion

Epidural steroid injections have been used in the treatment of lumbar radicular pain syndromes since 1952 (21). They were first reported in the United States in 1960 and found to benefit conditions causing nerve root irritation (22).

These injections were performed "blind" (without fluoroscopic guidance) using an interlaminar "loss of resistance" technique. In experienced hands, improper localization of the epidural space using blind technique has been shown to occur in 13-30% of attempted injections (23, 24).

The lumbar transforaminal epidural injection technique since being introduced by Derby et al (8) has been routinely utilized in the treatment of radicular pain syndromes. Several authors have evaluated the transforaminal epidural technique in the treatment of both HNP (1-4, 6, 25, 26) and lumbar spinal stenosis (5).

The technique has been described as safe with minimal adverse reactions (27-29). The proposed benefit of the transforaminal epidural technique is to place higher concentrations of corticosteroid and anesthetic preparations close to the nerve root/disc interface. These are performed utilizing epidurography.

The history of epidurography dates back to 1921. The first viewing of the epidural space was performed, reportedly by accident, by Sicard and Forestier using lipoidal as a contrast agent (30). Using both air and a water-soluble contrast medium, perabrodil, radiographic examination of the epidural space was again described in 1941 (31, 32).

Metrizamide, a nonionic agent approved by the FDA for myelography in 1978 was used to visualize the lumbar epidural space in the 1980's by Hatten (33), who proposed epidurography as a valuable tool providing clinicians with important anatomical information when myelography was equivocal, or there were confusing or non-diagnostic physical findings.

These early studies (30-33) utilized a caudal approach with catheters rather than a single injection at a specific site. Emphasis was placed on evaluation of transverse, caudad and cephalad flow. Minimal attention was given to analyzing the extent of anterior or ventral flow.

More recently, spinal interventionalists have employed a form of epidurography to confirm accuracy of contrast-enhanced fluoroscopically guided selective injections. Injections with anesthetic and corticosteroid preparations have been used extensively to treat low back pain and radicular symptoms arising from compressive lesions, such as disc herniations and spinal stenosis.

It has been suggested that the efficacy of such injections is dependent upon several factors including:

1. The particular approach employed, i.e., transforaminal vs. interlaminar vs. caudal. Proponents of the transforaminal approach argue that increased efficacy is obtained by more ventral placement of the injectate near the disc-nerve root interface.
2. The anatomic variation of epidural space.
3. The flow of injectate.
4. The skill of the interventionalist.
5. The type and extent of the pathology.

Of the 20 patient injections we studied, all had contrast flow ventrally and unilaterally. Thus, 100% of these injections appeared to reach the ventral epidural space where the presumed inflammatory process resides. This may affect clinical outcome. All injections resulted in unilateral contrast flow, which indicates that in a patient with bilateral radicular symptoms, bilateral injections would seem appropriate. Clinical outcome studies should be done to assess the clinical significance of these observations.

Statistical analysis did not reveal a statistical difference between cephalad or caudad contrast flow in LSS patients as compared to HNP patients. There was no significant statistical difference in the mean number of levels of contrast flow based upon the level the injection was performed. There are several shortcomings to this study. The overall number of patients is small and the few numbers of LSS to HNP patients makes it difficult to draw conclusions as to the clinical significance of these contrast patterns with respect to diagnosis. Moreover, higher volumes of injectate may result in different flow patterns.

## Conclusion

Contrast spread ventrally and unilaterally in all injections. Dorsal flow occurred in 20% of these injections. No contrast crossed the midline. Caudad contrast flow was less than cephalad flow. Intravascular needle placement occurred in 10% of injections. The observed contrast flow patterns need to be studied further to determine if they can predict clinical outcome.

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