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Retrospective Evaluation

Spread of Contrast During L4 and L5 Nerve Root Infiltration Under Fluoroscopic Guidance

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Background: Lumbar selective nerve root blocks have been performed to establish the origin of lumbar radiculopathy in clinically difficult cases. The diagnostic ability of selective nerve root blocks remains controversial because of concern over potential spread of an injectate onto adjacent structures.

Objective: To investigate the spread of different volumes of water-soluble contrast during L4 and L5 selective nerve root blocks.

Design: Retrospective, observational case series.

Methods: Analysis of medical records and X-ray images obtained during L4 and L5 selective nerve root blocks.

Results: During L4 selective nerve root block 1 ml of contrast spread onto L5 nerve roots in 46.1% of subjects and during L5 nerve root block 1 ml of contrast spread onto S1 nerve root in 57.7%. There was statistically significant difference ($p<0.0001$) between spread of contrast onto the medially located nerve root in the same lumbar segment and nerve roots in the lumbar segment above.

Conclusions: Injection of 1 ml of contrast under fluoroscopic guidance does not guarantee selective spread of the contrast around L4 or L5 nerve roots only. There is also spread toward the more medial nerve root in the same spinal segment during L4 and L5 nerve root infiltration. These findings suggest that it is possible to differentiate between L4 and L5 nerve root pathology using a sequential nerve root blocks under fluoroscopic guidance.

Key words: Selective nerve root block, Lumbar radiculopathy, Fluoroscopic guidance

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The evaluation of chronic lumbar radicular pain is often a complex process. Many interventional pain physicians believe that selective nerve root block (SNRB) performed under fluoroscopic guidance can be helpful in identifying anatomical origins of pain (1-3). Others have questioned the diagnostic value of SNRB, due to concern that the local anesthetic may spread onto adjacent structures (4).

SNRB should, theoretically, confirm or, alternately, rule out a clinically-based suspicion of specific nerve root involvement and thus be helpful in guiding therapeutic or surgical intervention.

The technique of SNRB has been described in detail (5-7). A spinal needle is inserted using a postero-lateral approach under fluoroscopic guidance in the majority of cases. Injection of contrast delineates the selected nerve root and confirms the correct needle position. The subsequent response to the injection of either a small volume of local anesthetic or a therapeutic mixture of local anesthetic and anti-inflammatory steroids is believed to carry diagnostic and therapeutic value.

This study was designed to investigate the spread of different volumes of water-soluble contrast during fluoroscopically guided L4 and L5 SNRBs with the possible of generating the hypothesis that the sequential SRNBS could add diagnostic insight into the origin of the pain.

Method

This study was approved by the Hospital Ethics Committee functioning as an IRB. Patient identification was eliminated at the earliest stage of data collection according to HIPAA regulations. Because the study was based on existing medical records and all patient identifiers were eliminated no informed consent was necessary. The study was designed as an observational (a case series), retrospective study based on the analysis of medical records and AP X-ray images obtained during fluoroscopically guided L4 and L5 selective nerve root blocks.

Thirty-nine consecutive patients with chronic lumbar radiculopathy were evaluated using SNRBs during the calendar year 2003. These patients presented a diagnostic dilemma. Their symptoms were ambiguous and included various combinations of low back, thigh, and leg pain, which frequently varied from the classic dermatomal distribution. It was believed that the patients had lumbar radiculopathy, but the spinal level of origin of the symptoms was not clearly identified because the degenerative process involved several levels of the lumbar spinal column. These patients had not had surgery and showed no significant motor weakness, sensory deficit or diminished reflexes. MRI studies were equivocal and showed multi-level lumbar intervertebral disc degeneration along with spinal central or foraminal stenosis without nerve root impingement. Neither clinical presentation nor imaging studies clearly explained the symptoms. The patients required additional evaluation for possible surgical treatment and were candidates for SNRBs to help identify the origins of their pain.

Thirteen patients received L4 SNRB and 26 patients L5 SNRB. All patients received the block in prone position under local anesthesia with 3-5 mL of 1% Lidocaine using a postero-lateral approach for insertion of a 22-gauge Quincke type spinal needle under fluoroscopic guidance.

An AP view of the targeted level was obtained and the X-ray beam adjusted parallel to the vertebral endplates of the vertebral body and then tilted laterally until the lamina receded medially and the superior articular process was exposed. If the ileac crest obscured view of the superior articular process at the L5 level, the X-ray beam was tilted cephalad until the ileac crest receded caudally. The target point was on an imaginary line connecting centers of pedicles next to the lateral aspect of the superior articular process. When the tip of the needle has reached the depth of the posterior portion of the facet joint the X-ray beam was adjusted to a lateral view. The tip of the needle was then directed to the point located in the center of the foramen in the caudal-cranial direction and in the posterior part of the foramen in the dorsal-ventral direction. If a paresthesia was encountered, the needle was withdrawn 1-2 mm. If the paresthesia remained the needle was withdrawn further and redirected into a slightly cranial position remaining in the posterior part of the foramen. An AP view was utilized to confirm placement of the tip of the needle at or lateral of the line that connected the center of adjacent pedicles. This X-ray served as a baseline. A total of 3 mL of water-soluble non-ionic contrast (Isovue-M 200; Bracco Diagnostics, Inc.) was injected in 1 mL increments 10 seconds apart and additional X-ray images were obtained (Figs. 1 and 2). During this retrospective review X-ray images were reexamined for spread of contrast onto L3, L4, L5, and S1 nerve roots. Positive "Spread" was defined as visualization of the adjacent nerve root with contrast.

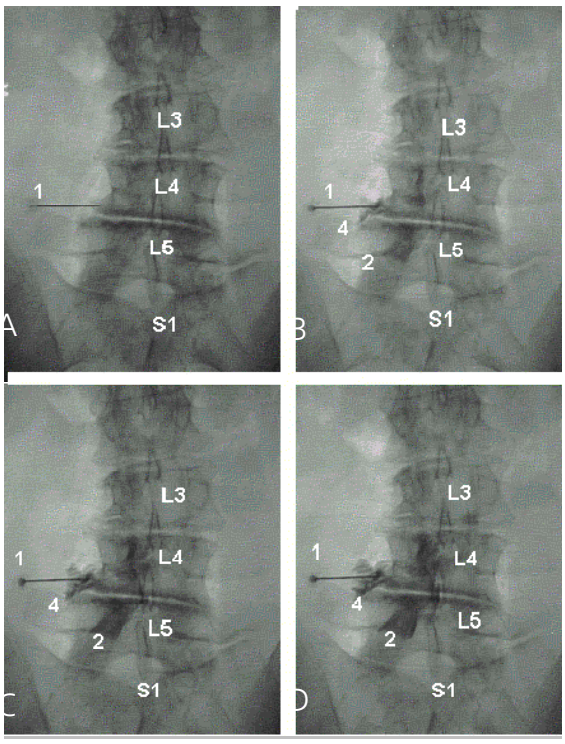

Fig. 1. *Spread of the contrast during L4 SNRB. A – baseline; B – 1 ml, C – 2 ml, D – 3 ml has been injected; B, C, and D – contrast is visible along L4 and L5 nerve roots; 1 – 22-gauge spinal needle; 2 – L5 nerve root; 4–L4 nerve root.*

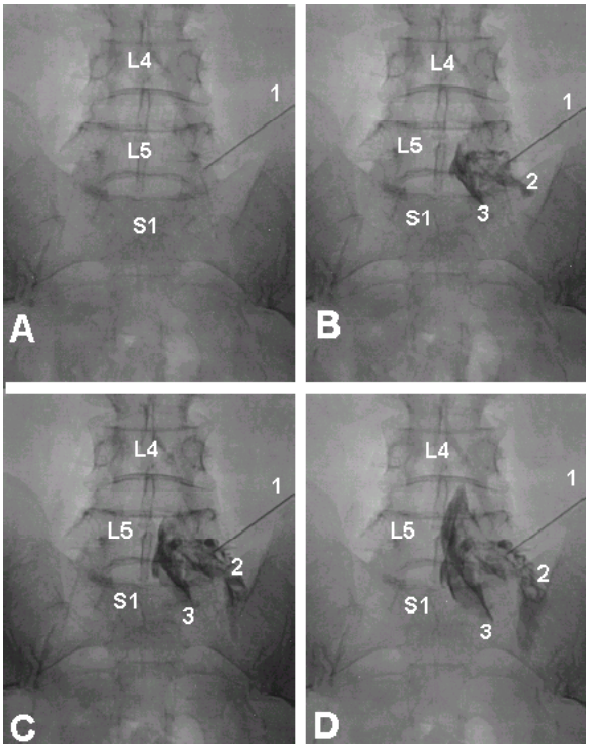

Fig. 2. *Spread of the contrast during L5 SNRB. A – baseline; B – 1 ml, C – 2 ml, D – 3 ml has been injected; B, C, and D – contrast is visible along L5 and S1 nerve roots; 1 – 22-gauge spinal needle; 2 – L5 nerve root; 3 – S1 nerve root.*

Statistical Analysis

The McNemar's test has been used for statistical analysis of results. McNemar's Test is a non-parametric test used when only nominal data are available, e.g., present versus absent ("spread") identification. McNemar's Test is generally used when the data consist of paired observations of labels. The labels were present or absent "spread" onto adjacent nerve roots. The presence or absence of the delineation of a nerve root by contrast located above an injected level has been indicated in the column and nerve root below in the row. The cells have been filled with the number of pairs that show the following types of paired events: 1) no delineation by contrast of either the nerve root above or the nerve root below, 2) delineation of the nerve root above, but not below, 3) delineation of the nerve root below, but not above, 4) delineation of both nerve roots above and below the injection level.

Results

Patient demographic data are presented in Table 1. Approximately 50% of patients in both groups reported transient paraesthesia in corresponding dermatomal distribution during the procedure.

Volume-spread relationships for L4 selective nerve root infiltration are presented in Table 2. Contrast spread onto the L5 nerve root in 6 patients (46.1%) when 1 mL of contrast was injected. When 2-3 mL was used contrast was visible at the L5 nerve root in 8 patients (61.5%). There was no spread of contrast onto L3 nerve root.

The volume-spread relationships for L5 selective nerve root infiltration are presented in Table 3. The contrast spread onto the S1 nerve root in 15 patients (57.7%) when 1-2 mL of contrast was injected. When 3 mL was used contrast spread onto the S1 nerve root in 18 patients (69.2 %). Contrast spread onto the L4 nerve root when 2-3 mL was injected in 2 patients

Table 1. *Demographic data of patients, who received L4 and L5 selective nerve root blocks.*

	L4 Level	L5 Level
Number of patients	13	26
Male	31% (4)	35% (9)
Female	69% (9)	65% (17)
Average age	54.2	64.0
Body Mass Index (Average)	31.3	26.2
Paresthesia	38% (5)	50% (13)

(7.8%). There was no spread of contrast ontothe L4 nerve root when 1 mL was injected.

Spread of contrast along the nerve root at the level above and below the injection level differs significantly ($p < 0.0001$).

Discussion

In a majority of patients, the origin of lumbar radicular symptoms is evident from the clinical presentation and imaging studies. However, neighboring dermatomes can overlap, complicating the differential diagnosis, especially with multilevel intervertebral disc involvement (3). For example, pain in the L5 dermatomal distribution, according to dermatomal chart, may be caused by an L4 radiculopathy. In these complicated clinical situations, SNRBs may provide additional information, which can help to identify the cause of the symptoms. The diagnostic utility of SNRBs remains controversial, mostly because of concern over potential epidural spread of the local anesthetic onto nearby anatomical structures, particularly onto other lumbar nerve roots. To minimize this problem, the use of minimal volumes of local anesthetic has been recommended (8). Also, use of fluoroscopic guidance for this procedure has become the standard of care for interventional pain physicians. The technique of SNRB has been described in detail (5-7) and should provide selective spread of local anesthetic. However any epidural spread during the injection would make it a transforaminal epidural injection and the injection would lose selectivity.

In many aspects, the technique of the needle placement during transforaminal epidural injection is similar to SNRB. The target point for transforaminal epidural injections lies at the caudal border of the pedicle adjacent to the target nerve root.

The target point for SNRB lies at the distal part of the dorsal root ganglion. The position of the tip of the needle in this situation lies on a line drawn lateral to the centers of the pedicles. This position is slightly more lateral and caudal than the target point of transforaminal epidural injections.

Table 2. *Spread of the contrast during L4 selective nerve root block*

Number of patients	13	13	13
Volume of the contrast injected	1 ml	2 ml	3 ml
Number of patients with contrast visible along L3 nerve root	0	0	0
Number of patients with contrast visible along L4 nerve root	13	13	13
Number of patients with contrast visible along L5 nerve root	6	8	8

Table 3. *Spread of the contrast during L5 elective nerve root block.*

Number of patients	26	26	26
Volume of the contrast injected	1 ml	2 ml	3 ml
Number of patients with contrast visible along L4 nerve root	0	2	2
Number of patients with contrast visible along L5 nerve root	26	26	26
Number of patients with contrast visible along S1 nerve root	15	15	18

In this study, the tendency of injectate to spread onto nearby structures during SNRB (Figs. 1 and 2) was observed. The magnitude of the spread is proportional to the volume of the injectate. Even a volume as low as 1 mL has a tendency to spread onto more medially located nerve roots inside the spinal canal (Tables 2 and 3). This observation questions the ability of small volumes of an injectate to selectively surround targeted structures. On the other hand, contrast has a minimal chance to spread onto nerve roots from the lumbar segment above the injected nerve root.

The preferential spread of the contrast onto medially located nerve roots in the targeted segment can be explained by examination of the anatomy of the lumbar epidural space. Anatomical studies in normal specimens indicated that no fibrous contents were present (9), and no barriers to continuous flow in the lateral recess to adjacent segments should exist. Coronal sections through the spinal canal showed the epidural space to be widely open at the level of the neural foramen. The lumbar epidural space was found to be discontinuous at the level of the lamina and pedicles, with repeated segmentation of epidural contents in the longitudinal axis. Segmentation is produced by close contact of dura with the pedicle, pos-

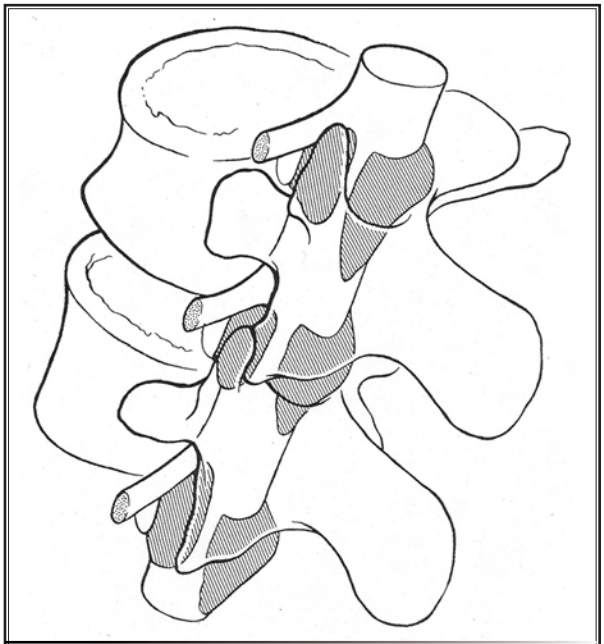

Fig. 3. *A drawing of the compartments of the epidural space (stippled) as seen in cryomicrotomy. The epidural contents are discontinuous circumferentially. Where no contents are represented, the dura is in contact with the spinal canal wall. The pedicles are concealed behind the transverse processes.*

Adapted from Hogan QH (10)

terior longitudinal ligament, and lamina dorsally (Fig. 3). The epidural space in between these structures is filled with fatty tissue, blood vessels and nerve roots (10).

Based on the above-described anatomic structures, injectate introduced through the neural foramen should take the path of least resistance and travel through the lateral epidural space, medial to the injected nerve root.

The closest medially located anatomical structure is the adjacent nerve root; for the L5 neural foramen this is the lateral aspect of the S1 nerve and for the L4 neural foramen, this is the lateral aspect of the L5 nerve root.

These anatomical features and the observed tendency of the injectate to spread during SNRB may present an opportunity to differentiate between an L4 and L5 nerve root pathology using certain sequences of SNRBs. For example, if diagnosis has to be made between L4 and L5 radiculopathy, an L5 SNRB should be performed first. L5 SNRB will tend to block pain from L5 and S1 nerve roots but may not relieve pain originating from L4. If a subsequent L4 SNRB is performed (despite a high probability of anaesthesia spreading to L5 nerve root), pain relief may point to an L4 radiculopathy.

This study has several limitations in that it is observational and by definition does not involve randomization.

Conclusions

It was observed that during L4 and L5 nerve root infiltration, contrast spreads towards the more medial nerve root. Selective L4 nerve root injections employing a small volume of contrast (1 ml) demonstrated undesired spread to the L5 nerve root in 46.1% of injections. L5 nerve root injections showed similar results with spread to the S1 nerve root 57.7% of the time. Spread to the inferior (medial) nerve root was signifcantly ($p<0.0001$) more likely than spread to the nerve root at the level above. It also was observed that in both cases the degree of the spread was proportional to the volume of contrast used. Our observations suggest that selective nerve root blocks should not be viewed as "absolute" nerve root blocks or as limited to the territory of the targeted nerve.

One potentially useful conclusion of the study is that sequential SNRBs starting at L5, and then L4 level could be used to differentiate between L4 and L5 involvement. However this hypothesis should be further investigated using an experimental study design that addresses this issue prospectively.

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