Prospective Assessment

Volume of Contrast and Selectivity for Lumbar Transforaminal Epidural Steroid Injection

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Background: It has been shown that L4/L5 selective nerve root blocks become nonselective after injecting 1 mL and 0.5 mL of contrast. Volumes of less than 0.5 mL have not been used to determine a volume of definite specificity.

Objective: This study attempts to identify the minimum volume of contrast at which selectivity is maintained without spread to the superior or inferior end plate.

Study Design: Prospective, nonrandomized, observational human study of 70 patients receiving lumbar transforaminal epidural steroid injection.

Methods: Using biplanar imaging, needle tip position was confirmed just caudad to the pedicle shadow at 6 o'clock position in the AP view and mid or ventral aspect of the foramen in the lateral view. Contrast was then injected in aliquots of 0.2 mL to a total volume of 2.0 mL. Fluoroscopic images were recorded at 0.2 mL increments. These images were evaluated to determine which 0.2 mL volume increment was no longer specific. Volume of contrast at which the spread extended to the superior and inferior end plates and crossed the midline to the contralateral side was also recorded.

Results: Three patients had extraforaminal flow and one had an initial intravascular injection. Data were analyzed for 66 patients. Average (s.d) volume of contrast at which selectivity was demonstrated was 0.41 mL (0.26). Superior and inferior spread was noted at 0.82 mL (0.49) and 0.83 mL (0.44), respectively. Seventy-eight point eight percent of SNRB were selective for the specified nerve root after injecting 0.2ml of dye. Selectivity decreased to 33.3% after injecting 0.6 mL; 1.2 mL of dye injected was selective only in 6% of patients. Superior spread of contrast was more common as compared to inferior ($P = 0.016$). Also, initial spread was superior in 50% of cases at L4 level and 64.7% at L5 level ($P < 0.05$).

Limitations: Relatively small number of patients with a nonrandomized design.

Conclusions: Diagnostic selective nerve root blocks limiting injectate to a single, ipsilateral segmental level cannot reliably be considered diagnostically selective with volumes as low as 0.2 mL. Also, spread of the contrast to the superior nerve root was more likely than spread to the inferior nerve root.

Key words: Epidural steroid injections, transforaminal selective nerve root block, contrast flow

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Low back pain secondary to degenerative disc disorders is a significant clinical, social, and public health problem affecting a majority of people. Non-invasive diagnostic options include a thorough history, physical examination, imaging, and/or serologic studies. Within the realm of diagnostic spinal injections, selective nerve root blocks (SNRBs) are used to provide diagnostic and prognostic information in patients with radicular pain. Although the terms "SNRB" and "transforaminal epidural injection" are sometimes used interchangeably, the 2 are different procedures with distinctly separate indications. In transforaminal, epidural steroid injectate is purposefully administered into the epidural space where it spreads to adjacent spinal levels and specifically treats radicular pain. So, the diagnostic information provided by this technique is limited by the lack of specificity. On the other hand, SNRBs temporarily block the offending nerve and are accurate diagnostic and predictive tools for planned decompression procedures (1,2). However, the potential beneficial effects of these procedures, especially transforaminal injections performed with particulate steroids, have been tempered by multiple reports of spinal cord injury and paraplegia (3).

Identification of anatomical origins of chronic radicular pain is a complex process. Many interventional pain physicians believe that SNRBs can selectively diagnose or treat a specific nerve root as a pain generator by anesthetizing or blocking it. On the other hand, some authors have expressed concerns over the diagnostic value of SNRBs, due to the spread of local anesthetic onto adjacent structures (4,5). As the injection should be localized to a particular segment only for diagnostic purposes, a false-positive result can occur when drug volumes greater than required are given, resulting in anesthetizing more than one level.

Furman et al (6) demonstrated that 30% of transforaminal epidural steroid injections (TFESIs) performed were no longer "selective" after injecting 0.5 mL of contrast and 67% were non-selective after injecting 1.0 mL of contrast. However, the authors did not use volume increments of less than 0.5 mL to truly determine a volume of definitive specificity.

Our study was designed to further identify the minimum volume at which these LS- TFESI procedures may still be considered "selective" at their respective intervertebral foramen.

Methods

After Institutional Review Board clearance and written informed consent, 70 patients were enrolled in this prospective, non-randomized observational human study. Patients with one or 2 level lumbar disc herniation (DH) were recruited for the study. Patients with a history of coagulopathy, contrast allergy, and pregnancy were excluded.

Flow patterns were investigated only at one level irrespective of the number of levels intervened. The level of intervention was determined according to a patient's clinical scenario and radiographic imaging.

All procedures were performed in an operating room by a single physician (NPS) who was experienced in performing the procedures. Electrocardiogram, noninvasive blood pressure, and pulse oximetry were monitored in all the patients. Patients were placed in prone position on the operating table. A wedge was placed below the abdomen to obliterate lordosis. The lumbosacral area was prepared and draped in a sterile fashion. A fluoroscopic coaxial view aligning the skin entry point with the anatomical target was utilized. An antero-posterior (AP) view of the targeted level was obtained and the x-ray beam adjusted to square off the nearest endplate of the vertebral body. The fluoroscope was then rotated until an ipsilateral oblique view projected the superior articular process (SAP) of the infrasegmental level in such a way that it appeared to lie under the 6 o'clock position of the target pedicle. The overlying soft tissue was then anesthetized with 1% lidocaine. Using biplanar visualization, the 22G spinal needle was advanced into the "safe triangle" rather inferior to the pedicle and supero-lateral to the exiting spinal nerve. The final needle tip was verified by fluoroscopy in AP and lateral views. In the AP view, it was just caudad to the pedicle shadow under the 6 o'clock position. The lateral view found the tip in the mid or ventral aspect of the foramen.

After needle position confirmation, 2 staged injections were made. The first was to inject the contrast medium, the purpose of which was to verify correct placement of the needle and determine the extent of spread with increasing volume. The second stage involved injection of local anesthetic mixed with corticosteroid.

Contrast (Omnipaque, Bracco Diagnostics, Princeton, NJ) was injected slowly at 0.2 mL increments using a 2 mL syringe (an extension tube system was used for injection and filled and primed with contrast) up to a maximum of 2.0 mL, continuously confirming needle position and monitoring contrast flow spread. Fluoroscopic images were obtained at 0.2 mL increments.

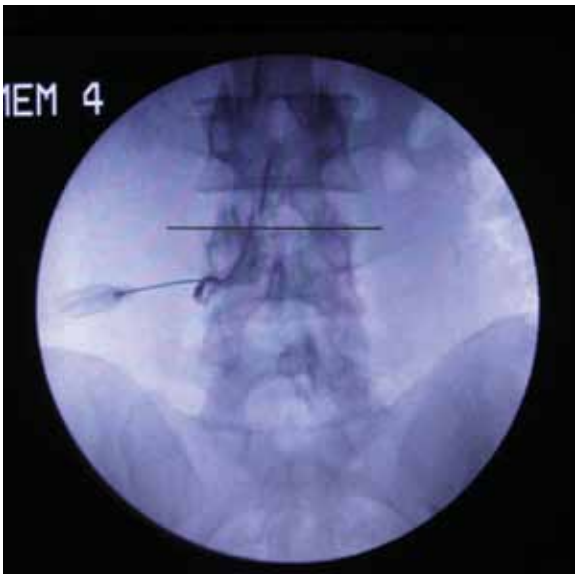

Fig. 1. *Fluoroscopic view of contrast flow crossing the superior end plate of L4.*

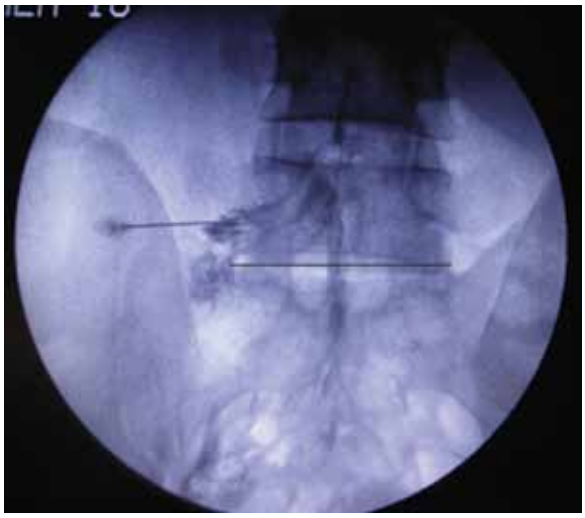

Fig. 2. *Fluoroscopic view of contrast flow crossing the inferior end plate of L4.*

These images were evaluated for adjacent level (superior or inferior) or contralateral side contrast spread. Whenever contrast was noted to flow to an adjacent level or to the contralateral side, injectate volumes were recorded. Contrast was documented as flowing to an adjacent superior level when flow crossed its superior end plate (SEP) (Fig. 1). Contrast was documented as flowing to an adjacent inferior level when flow crossed its inferior end plate (IEP) (Fig. 2). Contrast was documented as flowing to the contralateral side when it crossed the midline. If a fluoroscopically confirmed vascular injection was noted, the patient's data were excluded and they were not included in data analysis.

After completion of this study's protocol data collection, a steroid/anesthetic solution, a 2 mL solution consisting of 40 mg of triamcinolone (Kenacort 40, Bristol-Myers Squibb, Princeton, NJ, USA) and the remainder 1% lidocaine, was administered into the epidural space.

The primary end point was the injectate volume at which the block was still considered selective.

The secondary end point was the preferential spread in an inferior or superior direction with larger volumes of injectate.

Statistical Analysis

Based on the results of a previous study which showed a progressive (though not linear) increase in selectivity with decreasing volumes of contrast, we expected a still lower dose of contrast to be able to maintain selectivity in a greater number of cases. In the absence of data showing a correlation between volume of contrast and selectivity, a formal calculation of the appropriate sample size could not be done. We enrolled 70 patients in our study.

Numerical variables were examined for normality. Demographic data were analyzed using student's t-test and Chi square test. P value < 0.05 was considered significant. Statistical analysis was done using SPSS version 14.0 for Windows (Chicago, IL).

Results

Data are presented as mean ± SD or median (range) where appropriate. Demographic data is summarized in Table 1. Three patients had extraforaminal flow and one had an initial intravascular injection. Data were analyzed for 66 patients. The average (s.d) volume of contrast at which selectivity was demonstrated was 0.41 mL (0.26). Superior and inferior spread was noted

Table 1. *Demographics of patient population.*

Age	41.36 ± 13.32*
Gender (m:f)	54:12
Weight (kg)	64.67 ± 9.16*
Height (cm)	168.12 ± 7.96*

* Data presented as mean ± SD.

Table 2. *Spread of contrast at different injectate volumes.*

Injectate Volume	Frequency of Selective Nerve Root Spread	Cumulative	Cumulative %*
1.2 mL	4	4	6%
1.0 mL	0	4	6%
0.8 mL	0	4	6%
0.6	18	22	33.3%
0.4	12	34	51.5%
0.2	18	52	78.8%
<0.2 mL	14	66	100%

* The cumulative percentage is a total percentage of patients that have reached the landmark as more injectate volume is placed.

Table 3. *Levels and frequency of procedures.*

Level of Herniation	Frequency
L4/L5	18
L5/S1	12
Both L4/L5 and L5/S1	36

at 0.82 mL (0.49) and 0.83 mL (0.44), respectively. Seventy-eight point eight percent of SNRBs were selective for the specified nerve root after injecting 0.2 mL of dye. After injecting 0.4 mL of dye, 51.5% were selective. Selectivity was further decreased to 33.3% after injecting 0.6 mL. One point two milliliter of dye injected was selective only in 6% of patients (Table 2).

Thirty-two patients underwent intervention at the L4 level and 34 at the L5 level (Table 3). The average (s.d) volume of contrast at which selectivity was demonstrated was 0.34 mL (0.18) at L4 and 0.47 mL (0.33) at L5 ($P > 0.05$, Mann-WhitneyU tests). Superior spread of contrast was more common as compared to inferior ($P = 0.016$). Initial spread was superior in 50% of cases at the L4 level and 64.7% at the L5 level ($P < 0.05$). Contralateral spread was seen in 38 out of 66 patients (57.6%). Mean volume at which contralateral spread occurred was 1.46 mL (0.26). Contralateral spread occurred before spread to the superior or inferior end plates in 3 patients.

Discussion

The origin of lumbar radicular symptoms is evident from the clinical presentation and imaging studies in the majority of patients. However, neighboring dermatomes can overlap and complicate differential diagnosis, especially in patients with multilevel intervertebral disc involvement (7). In these patients, SNRB helps in identifying the cause of the symptoms. SNRB should provide selective spread of local anesthetic and any epidural spread during the injection would lose selectivity. Concern over the potential epidural spread of the local anesthetic onto adjacent nerve roots limits the diagnostic utility of SNRBs. One way of minimizing this problem is the use of minimal volumes of local anesthetic (8). The volume of contrast needed to reach a specific site can be recorded and then the same volume of local anesthetic can be used for therapeutic purposes (9).

Vassiliev (5) investigated the spread of 3 mL of water soluble contrast injected at 1 mL increments 10 seconds apart, in a retrospective observational case series. The author found that the magnitude of the spread was proportional to the volume of the injectate. An injectate of 1 mL had a tendency to spread onto medially located nerve roots in 46.1% of patients. Furman et al (6) further demonstrated that 30% of LS-TFESIs became non-selective for specific nerve root after injecting 0.5 mL of contrast.

Our results showed that only 78.8% of SNRBs were selective for the specified nerve root after injecting 0.2 mL of dye. Selectivity further decreased to 51.4% with injection of 0.4% mL of contrast. These results suggest that the diagnostic value of SNRBs even after injection of volume as low as 0.2 mL is not high.

Contralateral spread was observed in 57.5% (38/66) of patients. Our results are similar to the previous studies where authors found contralateral spread in more than 50% of the patients (10). However, even when flow crossed the midline, it rarely completely bathed the contralateral side. Further contrast and steroid solutions have different viscosities and may potentially have different epidural flow characteristics. Therefore, assuming that injectate flow will be similar to contrast flow results, physicians should not rely on treating bilateral pathology with a unilateral procedure.

Superior spread of contrast was more as compared to inferior. This is in contrast to an earlier study by Vassiliev (5) which showed more spread towards the inferior nerve root. The author postulated that the epidural space is discontinuous at the lamina and pedicles while it is widely open at the level of the neural foramen (11). So injectate in the neural foramen takes the path of least resistance and travels along the neural foramen medial to the injected nerve root. However, this seems to be true only in normal individuals. In patients suffering from disc herniation, the area of the intervertebral foramen might be reduced by a laterally herniated disc. Decreased space in the foramen would have prevented

inferior spread, resulting in superior spread in a greater number of patients in our study.

Our study has a disproportionate 54:12 gender ratio. Although women are more likely to report pain than men, the available data for back pain arer not consistent with regards to prevalence by gender and age (12). The possible factor which could be responsible for this in our study can be urban, rural, and socio economic differences. Our institute is a tertiary care government-owned hospital catering mainly to a rural population where women have a higher threshold for labeling a condition as painful and a social difference in upbringing makes it less acceptable for women to report their experience of pain.

One of the limitations of our study is that we did not inject a volume of drug equivalent to that of contrast needed to cross the superior/inferior end plate to study the clinical significance of the findings. Secondly, in the absence of previous data, we conducted a preliminary study with only 70 patients. Thereafter the study was prematurely terminated once "Not for epidural use" was added to triamcinolone's label. A study with a statistically significant sample size using a nonparticulate steroid can be further carried out.

Conclusions

Diagnostic SNRBs limiting injectate to a single, ipsilateral segmental level cannot reliably be considered diagnostically selective with volumes as low as 0.2 mL. Also, spread of the contrast to the superior nerve root was more likely than spread to the inferior nerve root.

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