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# Cephalic Spreading Levels After Volumetric Caudal Epidural Injections in Chronic Low Back Pain

The volumetric caudal epidural steroid injection has been advocated to facilitate the delivery of medications to the lesion site. This study was aimed to examine the actual spreading patterns of this technique, using epidurogram. A total of 32 patients with chronic low back pain accompanied by radiculopathy of various causes (degenerative spondylosis, herniated nucleus pulposus, spondylolisthesis, and spinal stenosis) were included. The volumetric caudal epidural injection of the 10 mL mixture of contrast medium 5 mL, 0.5% bupivacaine 1 mL, triamcinolone 1.5 mL (60 mg) and normal saline 25 mL was performed. Immediately after the cessation of the first spread, the subsequent solution of another 10 mL of contrast medium 5 mL, 0.5% bupivacaine 1 mL and normal saline 4 mL was injected. This procedure was repeated serially until the total volume to be 50 mL. Continuous fluoroscopic imaging was obtained after each injection. Average time taken to complete the study was 37 sec per every 10 mL. The spreading levels of the mixture were distributed mainly at mid to lower lumbar area in the majority of the patients. During the subsequent injections, the levels were not changed significantly. This was thought to be due to the minimal resistance in cephalad direction, anatomic variations and Starling effect of epidural space.

Key Words: *Epidural Space; Anesthesia, Epidural; Injection, Epidural; Low Back Pain*

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## INTRODUCTION

For the analgesic effectiveness of epidural corticosteroid, the volume and route of injection would have a considerable influence on the distribution of solutions and final target site concentration, therefore, on the clinical benefits (1).

The caudal epidural steroid injection is a commonly used and well-established technique for the management of chronic low back pain with or without lumbar radiculopathy, although certain technical limitations do exist due to the inconsistent anatomy, which occasionally mandates the use of fluoroscopy. The greatest concern is, however, that since the injectate will usually take the pathway of least resistance, generally far from the target site, it would not necessarily deliver intended steroids to lumbar or sacral nerve roots.

To overcome this problem, Cyriax and Daly had advocated the use of volumetric caudal epidural injection (VCEI) using 25 to 50 mL of the mixture containing local anesthetics, normal saline, and steroid (2, 3). It was claimed that even though some of the injectate might escape through sacral foramen, such epidural injections via sacral hiatus would go cephalad. Using large volume of drugs, they reported long-lasting effects in a fair number of patients. These were possibly secondary to the enhanced spread of steroid, or to the mechanical forces generated intradurally and epidurally by the larger volume used (2).

Up to now, however, the actual spreading level of this technique has not been well documented in human subjects. This study was conducted to investigate the cephalic ascending level of drugs with epidurogram using fluoroscopy after volumetric caudal epidural steroid injection in our outpatient chronic low back pain population.

## MATERIALS AND METHODS

The Institutional Review Board of Hallym University, approved the protocol for this study. Informed consent

was obtained prior to the enrollment in each patient.

Data were collected from July 1999 to December 1999 in outpatient pain clinic. Patients who had a history of prior back surgery, or other anomalies including kyphosis or scoliosis, were excluded. Other exclusion criteria were history of allergic reaction to contrast material, previous epidural injection, cauda equina syndrome, hemorrhagic diasthesis, neurologic disorder, local skin infection, and pilonidal cyst, etc.

Thirty-two patients, including 13 males and 19 females, ranging in age from 20 to 76 yr were enrolled in the study (Table 1). All had symptomatic radiculopathy with the diagnoses of degenerative spondylosis (DS, n=15), herniated nucleus pulposus (HNP, n=12) at L4-5, spondylolisthesis (SL, n=3), and spinal stenosis (SS, n=2). These diagnoses were documented by the orthopedic consultations including physical examination, dynamic views of lumbosacral radiographys and MRIs, etc.

The procedure was performed in the operating room. Precautions for bleeding tendency were undertaken. The patients were positioned accordingly, and routine preparation and draping were done in the sterile fashion. Intravenous catheter was placed in the dorsum of hand and locked with heparin. Monitors for EKG, blood pressure and pulse oximetry were applied.

Needle puncture site was anesthetized liberally from skin and subcutaneous tissue down to the periosteum with 1% lidocaine 2-5 mL. Twenty-two gauge spinal needle, 3.5 inches (B. Braun, Melsungen, Germany) was introduced into sacral hiatus under the fluoroscopic (9600 Mobile Imaging System®, OEC Medical systems Inc., Salt Lake City, UT, U.S.A.) guidance and advanced to cephalad direction. The needle tip was not allowed to advance beyond the two sacral segments to avoid penetration into the intrathecal space. The final needle position within the caudal epidural space was confirmed with anteroposterior (AP) and lateral fluoroscopic projection.

The needle position was additionally confirmed to be in a right position by negative regurgitation of blood or cerebrospinal fluid while the patient was asked to perform Valsalva's maneuver. Approximately 1-2 mL of Iohexol 20% (Omnipaque®, Nycomed Imaging As, Oslo, Norway) was injected and correct the needle position was documented with AP and lateral fluoroscopic view.

**Table 1.** Demographic data of the study patients

| | Total (n=32) |
|---|---|
| Age (yr) | 53.9±16.9 |
| Male/Female | 13/19 |
| Height (cm) | 158.3±3.8 |
| Weight (kg) | 54.1±3.4 |
| Average duration of injection per every 10 mL (sec) | 36.9±4.8 |

Values are expressed as mean±standard deviation

All the radiographic findings were evaluated by one of our pain clinic anesthesiologists, who were blinded to the study. The typical rivulet in lateral and Christmas tree appearance in AP epidurogram without leakage into the subcutaneous tissue, rectum, intrathecal space or epidural vein were considered as correct placement. If the epidural veins were visualized, the needle was re-positioned. If only one side of the epidural space is filled, the procedure was stopped and the patient was dropped out. If the contrast spread into intrathecal space, the procedure was abandoned and the patient was warned of subsequent postdural puncture headache.

The mixture was serially administered to assess the change in ascending levels according to repeated injections. The injection rate was approximately 10 mL/min without any interruption or delay during the injection to minimize the retracing. A total of 10 mL of Iohexol 5 mL, triamcinolone acetonide 60 mg in 1.5 mL (Triam® 40 mg/mL, Shin-Poong Pharmaceutical Co. Ltd., Seoul, Korea), 0.5% bupivacaine 1 mL (0.5% Bupivacaine®, Myung-Moon Pharmaceutical Co. Ltd., Seoul, Korea), and the rest of normal saline was injected. Immediately after the cessation of the spread of the first injection, the level of spread was assessed by epidurogram.

The second injection of another 10 mL mixture of Iohexol 5 mL, 0.5 % bupivacaine 1 mL and normal saline 4 mL was administered. And again after the cessation of the spread of injectate, the level was assessed by fluoroscopy as described earlier. Without any delay during the procedure, three more successive injections were repeated with the same mixture, until the total amounts of injectate to be 50 mL. Photographic documentation of the degree of cephalad spread of injectate was obtained by the continuous fluoroscopic imaging during the injection until the cessation of spread each time. The time duration taken to complete the study was measured and recorded.

The injection rate was controlled in such a manner that the patients could tolerate the paresthesia, temporary numbness or any dull aching pain radiating down to uni- or bi-lateral lower extremities. Occasionally the pain was so severe that the injection had to be either interrupted for a few time or slowed down. If this occurred, the patients were deleted in the final analysis.

After the procedure, each patient was transported to recovery room and observed by nursing staff. Instructions were given to check vital signs (noninvasive blood pressure, pulse, and respiration rates) and deep tendon reflexes in lower extremities every 15 min. The abilities to ambulate and void without any nausea or vomiting were documented in all patients before the discharge home.

Statistical analysis program was SAS version 6.12 for windows (Cary, NC, U.S.A.). Demographic data was analyzed with descriptive statistics.

## RESULTS

Demographic data including mean age, weight, height, and the average duration of injections are presented in Table 1. The failure rate of initial needle placement was 12.5% (4 cases) in our series. Attempts for the needle replacement were successful in all these patients. Average time taken to complete the study was approximately 37 sec per every 10 mL.

Epidurographic findings by fluoroscopy after the first and subsequent injections, revealed that the median ascending levels were L3-4 and L3 (Fig. 1). After the completion of the last injection, the increase of the level of cephalad spread was not significant, that is, approximately by a half vertebral body height, compared with the first one.

The differences in spreading levels between the first and last injections in regard to disease categories were as follow: two cases (one in HNP and one in SL) showed no ascent; four cases (two in SL, one in HNP and one in DS) showed an ascent by one vertebral body height; and the rests (n=26) by a half vertebral body height. However, the difference in each category was too small to disclose any statistical significance.

No complications were noted in relation to the placement of needle or injected medications.

## DISCUSSION

It has been well known for many years that serially injected local anesthetics would retrace the current block and not always contribute to a further cephalad spread. We radiographically documented, that the first injection could reach far enough to mid to lower lumbar area consistently, and in this area, the subsequent injections acted more likely as "re-painting" rather than "building blocks", in that they could not result in significant further spread.

As for the reasons of this finding, Grundy and his colleagues (4) predicted 30 yr ago that when fluid was injected into the epidural space, it would take the path of "least resistance", e.g., cephalad direction. With a small volume, such as 10 mL, the path was along the central axis of the epidural space with minimal spillage out into the lateral intervertebral foramina, even in young patient and this would have medications reach the target area with a lesion.

Additionally, the epidural spreading level is well known to be not linearly volume-dependent despite the increasing volume of injectate. Anatomically, the capacity of epidural space varies considerably according to the different spinal segments, being the largest in sacral area

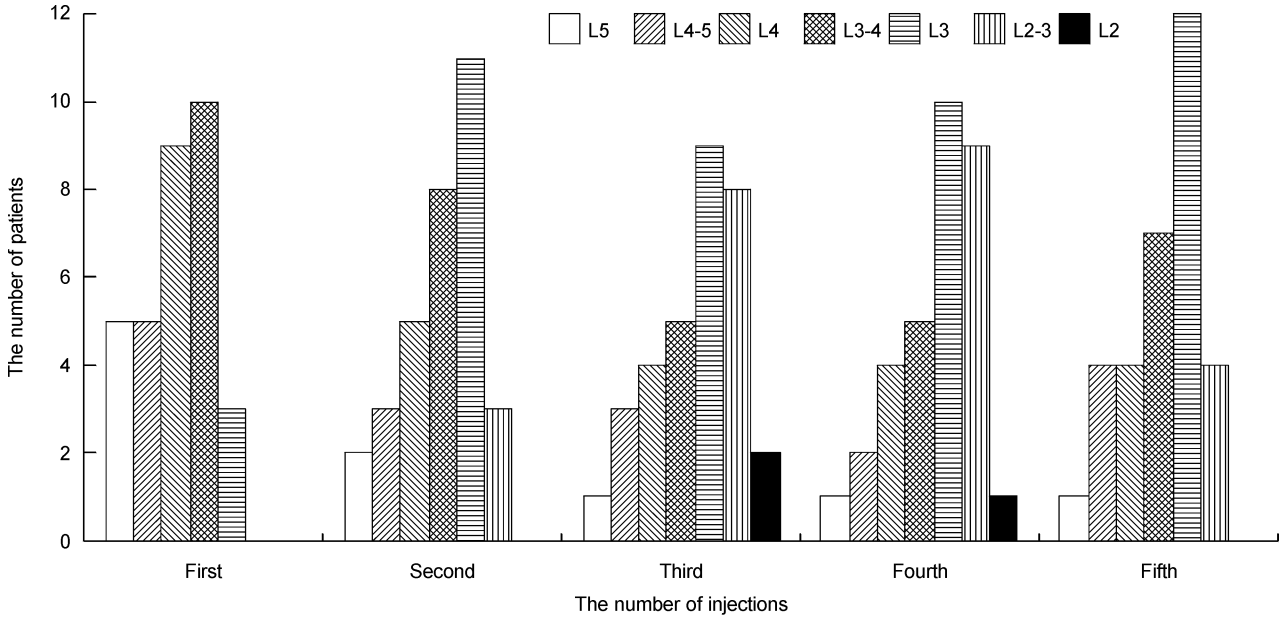


Fig. 1. The comparison of ascending levels regardless of the disease category during the serial injections. The injectates are distributed mainly at mid to lower lumbar area without further increasing the levels. X axis describes the number of injections and Y axis the number of patients. L, lumbar.

and narrowest in cervical spine with the thoraco-lumbar space to be intermediate (5, 6). Leakage of anesthetic solution from the epidural space varies greatly with location. Greater leakage can occur from the sacral epidural space than any other spinal level (7). Clinically, Grundy and his associates (4) have reported that no direct relationship between the volume of injected solution and the number of blocked segments. Burn and his colleagues (8) also have shown that there was a wide variation in the levels achieved with the same volume, and stated that it would be impossible to predict accurately the level to which a given volume of solution would ascend in any particular case. In other words, it is quite possible that cephalad spread could have been limited because some patients had anterior leakage of solution through the sacral foramen. Perhaps some patients had more cephalad spread because solution stayed more posteriorly, while others had more solution pooled in the anterior epidural space. This interpatient variability and unpredictability could explain our findings that revealed no significant increase in the spreading levels even after the repeated injections.

Lastly, Starling effect of epidural space could be considered. If a larger volume is used as a single injection, there will be more leakage through the sacral foramen with certain amount placed in caudal epidural space. In the rabbit model, Kim and co-workers (9) demonstrated that the epidural space behaved like Starling resistor during injection into the space, maintaining constant pressure whenever filled up to or above its capacity. This implies increasing leakage of injectate from the epidural space with increasing injected volume. Similarly, Burn and his colleagues (8) showed that 40 mL injection via the lumbar route had increased lateral spread and stated that a volume of 20 mL at L3-4 should be adequate in the treatment of lumbosciatic syndrome. Likewise, Grundy and his associates (4) reported the number of anesthetized segments per 1 mL was not increased proportionally according to the increase of injected anesthetic volume. In our study, the epidurogram demonstrated the both the first and series of subsequent injections of 10 mL behaved as if they were well within the range of this 'Starling' capacity.

In our preliminary analysis, the patients in the HNP group were significantly younger than those in the DS group ($37.3\pm13.2$ vs. $65.1\pm9.5$ yr, mean$\pm$SD, $p<0.05$). Previously, Bromage's findings of a strong inverse linear relationship between age and epidural dose requirement had been challenged (10). Burn and his colleagues (8) found that either the bony capacity of the epidural space or its anatomical changes by aging probably bear no relation to the extent of vertical spread of solution in epidural space. In addition, Park and his associates (11) shown that only a minimal effect of age on the level of epidural anesthesia achieved by epidural injection of different volumes of local anesthetics. Likewise, Grundy et al. (4) reported a similar finding that the magnitude of age effect was small. Due to the considerable variations among the patients, the anatomical changes by aging do not affect the overall heights of cephalad migration of the anesthetic mixture. Thus, this factor would not have influenced our results. Other variables in our study, including sex, weight, height, and injection speed were of no statistical significance, as shown in the previous studies (8).

There are a few limitations to be argued in our results. First, it is not clear whether the repeated injections of 10 mL up to a total of 50 mL in our study would behave the same way as a single injection of 50 mL. To overcome this problem, the speed of injection was kept less than 10 mL per min. This injection speed was almost same as a bolus injection.

Secondly, the limitations in the accuracy of measurements of epidural spreading levels of volumetric epidural caudal injections were inevitable. Even without a previous history of lumbar surgery, those who had chronic symptomatic low back pain with or without radiculopathy, tend to have epidural space scarring and stenosis of vertebral foramen. To overcome this, normal volunteers are needed, ideally younger than 30 yr old and without any history of chronic low back pain as a control group.

In conclusion, we have epidurographically documented that the repeated volumetric caudal epidural injections of 10 mL could consistently reach the low to mid lumbar level, and the levels were not significantly changed by the subsequent injections. This appears to be due to the mechanical and anatomical characteristics of sacral epidural space.

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