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Examining the Accuracy of Ultrasound-Guided Lumbar Transforaminal Injection Controlled by Fluoroscopic Imaging in Patients with Lumbar Radiculopathy: A Modified Technique

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ABSTRACT

AIM: To present a new sonographic approach for lumbar transforamianal injection and compared it with traditional fluoroscopic-guided approach.

MATERIAL and METHODS: This interventional clinical study was conducted on 30 patients with a history of radicular low-back pain and a recent MRI indicating root compression. On the prone position, with the curve of ultrasound transducer on the parasagittal oblique position, a peripheral venous catheter (# 16) was advanced to the lamina through out-of-plane technique. Then, the transducer position was changed to axial position and an epidural catheter was placed about 8 cm away from midline and advanced under sonography guide with the in-plane technique to the intervertebral foramen. The level and the situation of needle was controlled with fluoroscopy and documented when the corticosteroid (triamcinolone) was injected. Also, pain scores for patients were documented and analyzed with SPSS-22 software.

RESULTS: After controlling with fluoroscopy, from all 38 levels of injection, 36 levels were correctly achieved. Of all 36 injections on right levels, all injections were performed in the correct position (in intervertebral foramen). The patients' pain dramatically decreased during the first month after injection ($p<0.001$), but after that, it remained unchanged.

CONCLUSION: In our study, transforaminal injection was administered using the modified new technique, which was found to be safe and accurate in comparison with the fluoroscopy, as the popular gold standard technique.

KEYWORDS: Transforaminal injection, Sonography, Fluoroscopy, Root compression, Low back pain

INTRODUCTION

Low Back Pain (LBP) is a very common problem (2,8). Approximately 40 percent of patients with LBP have some degree of radicular pain, a condition, which is often due to nerve root irritation and inflammation caused by disc herniation (1,11).

In the recent decades, steroid injection in the epidural space has become popular as a non-surgical treatment of radiating pain secondary to herniated lumbar disc (10).

Some studies have reported successful outcomes for transforaminal injection into low grade herniated disc (up to 75% success rate) (4), while this percentage has declined to 26% among cases with high degree of herniated disc.

The main issue in the treatment of patients with radiating pain is to avoid unnecessary surgery, but on the other hand, debilitating pain should not be prolonged if non-surgical treatments are not successful (7). Over the past few years, innovative ultrasound-guided technique has been suggested

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to access the lumbar transforaminal space (3,12). The advantages of this method are low radiation exposure and lower need for hospital equipment (5).

To date, a few ultrasound-guided injection methods in the transforaminal space have been explained. Considering some factors, such as novelty of ultrasound in Transforaminal injection and limited number of related studies as well as injection approaches, we decided to take a new approach in this study and examine its accuracy in comparison with the popular gold standard method (fluoroscopy).

MATERIAL and METHODS

This interventional clinical study was conducted on 30 patients with a history of radicular low back pain (LBP) and a recent MRI indicating nerve root compression. The process of study was explained for all patients and written consent was obtained. This study was confirmed by our institutional ethical committee. It was also conducted from April 2016 to November 2017 in Iran (Clinical Trial Registration Number: IRCT20200805048309N1).

In the present study, inclusion criteria were low back pain and radicular pain of one or both lower extremities with pressure and stenosis of the nerve root canal in one or more levels evident in a recent MRI and not alleviated by initial conservative treatment.

On the other hand, patients with contraindication for epidural injection, overweight (30<BMI), previous epidural injection, non-stable neurological problems such as cauda equina syndrome, and patients, who were not willing to participate were excluded from the study.

Injection Technique

In prone position, a pillow was first placed under the patient's abdomen to neutralize the lumbar lordosis. After preping and draping, spinal central line was marked with a sterile marker. Also a horizontal line was drawn along the upper edge of the iliac crest marking the probable level of the fourth lumbar vertebra (L4). A third line was also drawn about 8 cm away from the first line (central spinal line) (Figure 1). The latter line marked the site of the main injection. Ultrasonic device is placed on the opposite side in front of the doctor, and the doctor is stationed in position for injection.

Spine Level

After using sterile Lidocaine gel, the curve probe of ultrasonography device (TIC2-8, Samsung, Korea) was placed in parasagittal oblique position and maneuvered from upper lumbar spine to lower levels to find the spinus process and lamina of vertebras. The lamina was distinguishable from next level lamina by a curved echoic line. The sacrum was also founded by a continuous echoic surface after L5 level. At the juncture between L5 and S1 lumbar vertebrae, the first non-continuous echo was marked as L5-S1. Then, the transducer was moved upward and other levels were marked consecutively. After detecting the target level, injection was performed. The target vertebrae lamina was determined by the curve probe in the parasagittal oblique view. By moving the probe from midline to lateral side, the following structures were detectable in order: spinous process, lamina, intervertebral joint, and transverse process (Figure 2). After that, local anesthesia was administered by the subcutaneous and deep injection of Lidocaine 1% after which a #16 peripheral catheterization needle (Meditrex, India) was vertically inserted under ultrasonic guidance via out-of-plane technique to the most prominent site of lamina. The most prominent site of lamina also could be confirmed by sensing the needle placement on bony prominence of lamina (Figure 2). This needle will be the guide for the main needle. This process is repeated for patients with more than one level stenosis.

Without using the sonography, after injection of local anesthetics, a #17 epidural needle (Epidural Catheterization set, 3c-05400-E 19Ga, Ireland) was inserted about 8 cm away from the midline just parallel to the first needle in paravertebral fascia and musculature (this line was previously marked). At

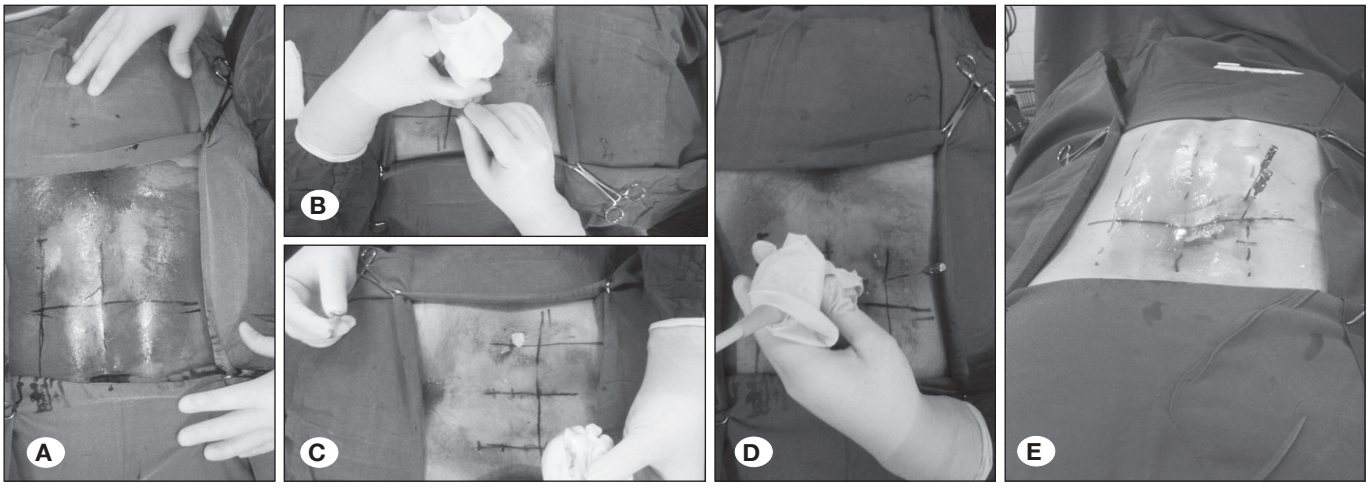

Figure 1: The steps of preparations and injection: praping, draping and marking **(A)**, insertion peripheral catheter in parasagittal approach **(B)**, the inserted catheter **(C)**, inserting epidural catheter parallel to peripheral catheter, bringing the peripheral catheter out and continuing the path of epidural needle sonographic guided **(D)** and the final position of epidural needle **(E)**.

this stage, the first needle had been previously discarded and Epidural needle was moved down toward the transforaminal space guided by sonography (at axial position) though in-plane technique. Afterwards, the needle was advanced to the lateral margin of lamina (pars interarticularis). Later, by the walking technique, the needle was advanced from lateral margin of the pars interarticularis and inferior margin of the transverse process toward the foramen. When the needle was in contact with the bone (the posterior wall of vertebral body), it was stopped (Figure 3). During this process, lidocaine could be injected for patient numbing. Conscious patients may experience a sharp radiculating pain, which is one of the most accurate signs of correct needle position in the foramina.

After placement of the needle, its position was checked by the fluoroscope (08888518, Siemens, Germany) in posteroanterior (PA), lateral, and oblique views and also a PA view after injection of visipaque (Figure 4). Accuracy or inaccuracy of

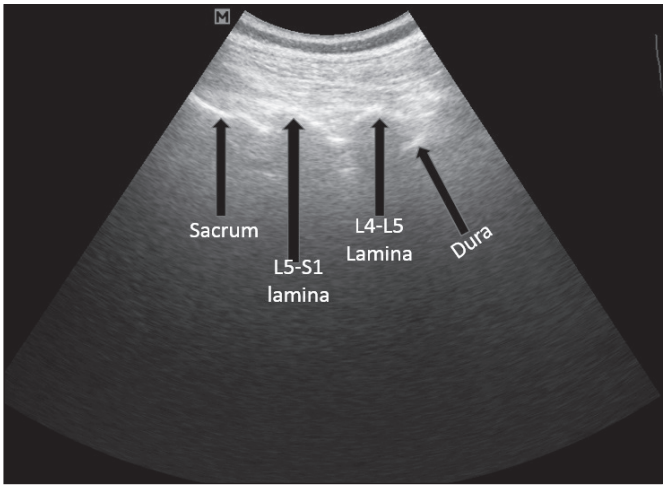

Figure 2: The median parasagittal oblique view. First the sacrum was found. The lamina of lumbar vertebras has horse-head-like view, which was distinctive from sacrum. Other components are determined in picture. The peripheral catheter inserted to the most prominent site of lamina. In dynamic sonography the needle would be apparent by mobilizing the needle.

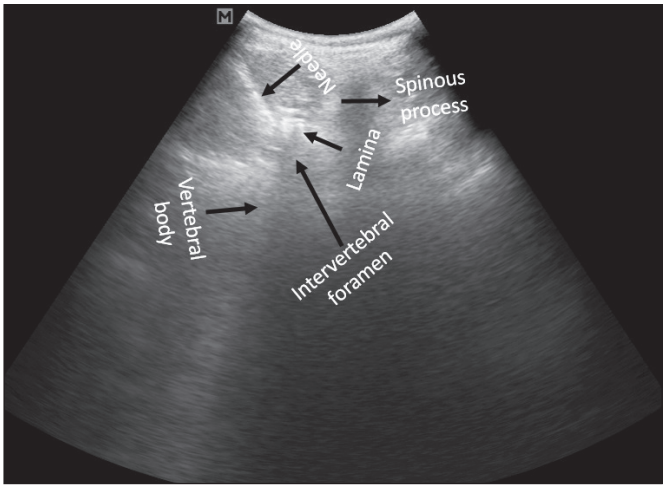

Figure 3: Final sonographic view in axial approach. Intervertebral disc is determined, which would be between the border of vertebral body and lamina in this view. The epidural needle parallel to the peripheral catheter is pushed forward toward intervertebral foramen under guide of sonography in axial approach and is stopped at the edge of the foramen. In this picture, the root is distinguishable, which is not always recognizable.

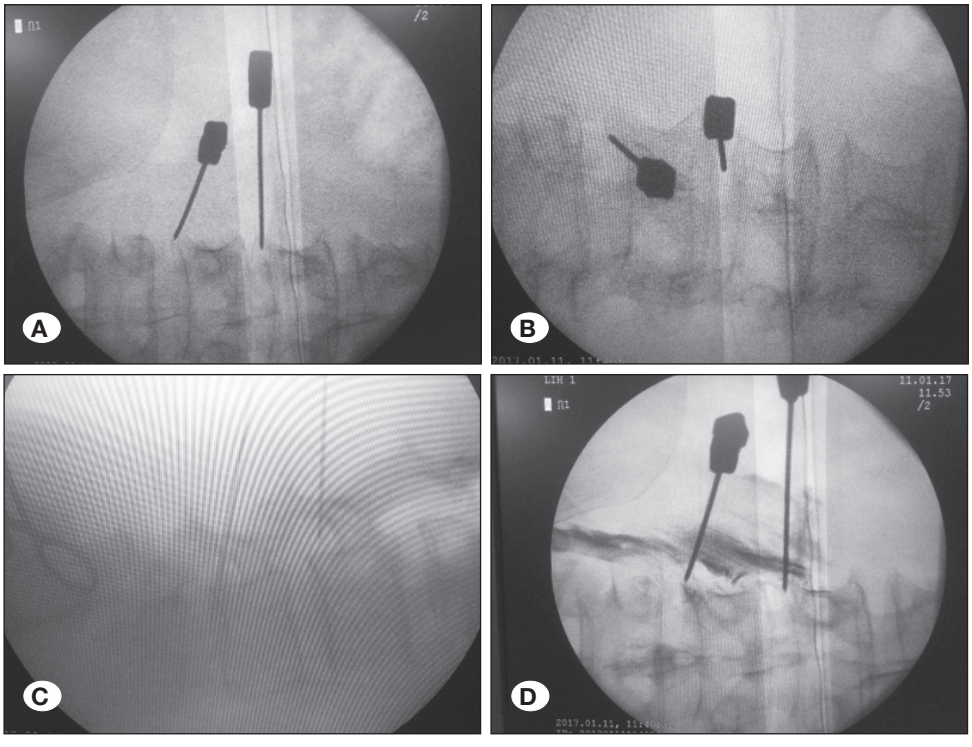

Figure 4: Fluoroscopic control radiographies at PA **(A)**, oblique **(B)**, lateral **(D)** and post dye injection, which showed off the root **(D)**.

both level and site of the injection were also documented. After confirmation of the needle position, 1.5 ml of lidocaine 1% and 2 ml of triamcinolone 40mg were injected via needle into transforaminal space.

All recorded data were transferred to SPSS-21 software and analyzed by descriptive statistics.

RESULTS

Overall, 38 level sites were injected in 30 patients. 10 (33/3%) patients were men and 20 (66/6%) were women. The mean age of patients was 57.05 ± 12.12. Their mean weight, height and BMI were 69.52 ± 11.37, 163.44 ± 8.05 and 26.08 ± 4.53, respectively.

Of all 38 levels, 15 injections were at L3-L4, 16 at L4-L5, and 7 at L5-S1. Of all the injections, injection in 36 levels were confirmed via fluoroscopy correct. Of the two incorrect injections, one patient had a previous surgery at L4-L5 level and another patient had spondylolisthesis and spontaneous fusion at L4-L5 level.

Moreover, all the 36 correct level injections were administered in intervertebral foramen so that the dye was dispersed into foramina and also the spinal root.

DISCUSSION

Injection is an attractive treatment option for pain control. It is also considered an adjuvant therapy alongside rehabilitation. Injections around the nerve root in the lumbar area using CT scan and fluoroscopy is the method of choice, while the ultrasound has been proposed as a reliable modality to observe and recognize the anatomical structures around the lumbar spine. Usability of real time sonography in injection has been also proved. The present study evaluated the accuracy of transforaminal injection with the aid of ultrasonography and compared it with the popular gold standard method, which is fluoroscopy.

The first study, which focused on the feasible approach for the transforaminal injection was conducted by Galiano et al. (3). In this study, which was performed on cadavers, the in-line technique was proposed as the most accurate technique for injection. This study used the axial view for the injections and moved the spinal needle until the transforaminal space was reached. The needle site was also checked by CT scan. They also suggested halting needle progression when it reaches the dorsal foraminal opening laterally to the superior articular process. However, it seems unlikely for the injected substance to extend to the ventral epidural compartment (the recommended location for transforaminal injection) when the needle was placed dorsally and laterally. Another study that applied this method on live volunteers was conducted by Gofeld et al. and they suggested that the Galiano et al.'s method was feasible and accurate but as he had used cadavers for his study, his method of injection in live patients had a major predicament so that the needle could unintentionally go through the root and result in a catastrophe (6). Thenceforth, Gofeld et al. tried to modify the Galiano's technique. He suggested that the needle should be halted at the most medially visible shadow of vertebral body. This helps the physician prevent unintentional nerve injury and disperse dye in the epidural transforaminal space in the best way.

Both the two above- mentioned studies used the axial view for the injection; however, Galiano used cadavers and Gofeld did not report the patients` level of consciousness. Based on experiments, using only one of these approaches needed repeated change of needle direction, which could be painful for patient. Therefore, the patient needs to be maintained at a given level of unconsciousness. In the present study, initially a needle was used as a guide to specify the exact position of the main needle before advancement under sonography. This double-approach technique helped us maintain the patients at a conscious level and do the procedure under only local anesthesia. Maintaining of patients consciousness also helped us prevent nerve injury, as the patients could inform us about sensing a sharp pain when the needle came into contact with the nerve root. We also used an epidural needle. The spinal needles used in Galiano et al.'s and Gofeld's studies were highly sharp-pointed and thin. This could cause uncontrolled advancement of needle with low forces, while the epidural needle with its hard body makes controlling the advancement and maneuvers much more feasible. This, indeed, could be apparent in arterial injection, which obligated Gofeld et al. to change the needle in cases of arterial injections into one with a blunt tip. In the present study, since the epidural needle had a blunted tip; we had no cases of arterial puncture.

Another study, which tried to propose an approach for the transforaminal injection guided by sonography was performed by Kim et al. (9). They compared two approaches, paramedian sagittal and paramedian sagittal oblique. They also attempted to find the transverse processes. Then, using a bent spinal needle guided by sonography (in plane), they advanced the needle into the intertransverse ligament. They finally suggested that paramedian oblique approach had better results and intraforaminal disperse of dye occurred in 87.5% of cases. However, the present study as well as Gofeld and Galiano et al.'s studies had more satisfactory results than Kim's study. We proposed that unlike our approach, finding the intertransverse ligament via sonography and visualizing the transforaminal space underneath that is difficult and unsafe and has no additional advantages over the proposed technique in the present study.

Last study, in attempted to propose an approach for transforaminal injection was conducted by Yang et al. (13). This study was a clinical trial and divided the patients into two groups. In the first group, injections were performed with fluoroscopy guide, while in the second one, sonography-guided injections were administered followed by fluoroscopy. In Yang et al.'s study, the probe was initially in axial position and the needle was advanced at 45 degrees to the lamina (with the in-plane technique). Then, probe position changed to paragittal view to make sure that the needle is at the center of facet joint adjacent to foramina. Afterward, the needle was pulled back a bit and the physician tried to push it beneath the lamina until the *loss of resistance* test became positive.

This technique seemed to be very difficult and time-vesting. However, the authors reported that the time required for their procedure was significantly lower than the time needed for fluoroscopy. On the other hand, in Yang et al.'s study, the *loss of resistance* test seemed to be unlikely, as they used spinal needle for injection and checking the *loss of resistance* by this needle in transforaminal space seemed unlikely (13). On the other hand, transforaminal injection was done through paraspinal soft tissues and muscles and a small amount of bleeding is inevitable, which in turn makes the *loss of resistance* test impossible; however, they did not reported the level of consciousness in their patients. As we mentioned earlier, in the present work, epidural needle was used and our patients were conscious, distinctive characteristics of our study.

CONCLUSION

Ultrasound-guided injection is a newly proposed approach in transforaminal epidural injection. In this study, we strived to suggest a modification of the in-plane technique of Galiano et al. and Gofeld et al. (3,6). We found that this technique is safer and also easier to perform. We also concluded that this technique could be carried out under local anesthesia which helps the physicians conduct the procedure at an outpatient setting. Nevertheless, more studies with clinical trial design are needed to compare only-sonography-without-fluoroscopy-control way with the fluoroscopic- guided-only technique. Besides, we suggested epidural needle for these injections as they have a blunt tip and solid body, which gave rise to better handling and safer injection.

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