An Operator's Experience of the Loss-of-Resistance Technique in Epidural Injections: An Observational Study

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ABSTRACT

Objective: A successful interlaminar epidural injection relies on correct epidural space needle placement. Most interlaminar epidural steroid injection (ESI) procedures are performed with a blind technique known as loss-of-resistance (LOR) without an imaging guide. This study aims to evaluate the success rate of the LOR technique in interlaminar epidural steroid injection under fluoroscopic control.

Materials and Methods: Patients who underwent interlaminar ESI owing to a history of at least 3 months of chronic low back and leg pain not responding to medications and physical therapies were included in an observational trial. Participants' age was between 27 and 88 years, and they had an American Society of Anesthesiologists physical status of I–III. The patients were placed in a prone position, and a Tuohy needle was introduced at the level of the L5–S1 interlaminar foramen using fluoroscopic image with an anteroposterior view. A lateral view was obtained when the LOR was felt. The procedures that achieved epidural spread by contrast agent in the first attempt were deemed successful. Those that did not and those that had false positive LOR were regarded as unsuccessful.

Results: Interlaminar ESİ was administered to 150 patients. The procedure's success and failure rates were 76% (114 patients) and 24% (36 patients), respectively. A total of 58.3% (21 patients) of patients who underwent an unsuccessful procedure had a false LOR, whereas 41.6% (15 patients) of the same group exhibited other causes. Sex, age, and body mass index (BMI) showed no statistical significance in terms of procedural success. There were statistically significant differences in the distance between the skin and the epidural space according to the body mass index groups.

Conclusion: The LOR technique identified the epidural space in most epidural procedures. However, in some cases, LOR was shown to be inadequate. Therefore, we suggest that the LOR technique must be supported by imaging such as fluoroscopy during epidural injections.

Keywords: Epidural injection, fluoroscopy, lumbar vertebrae

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Introduction

A successful interlaminar epidural injection relies on precise epidural space needle placement through the interlaminar foramen [1]. In clinical practice, the intervertebral space intended for an epidural injection in the lumbar spine is chosen after identifying the L4 location based on anatomical landmarks. The spine is intersected by Tuffier's line at the level of the L4 vertebra or L4-L5 intervertebral space [2] and is a relevant reference point when choosing the intervertebral space for regional anesthesia. The identification of lumbar puncture levels according to this traditional method is inaccurate in overweight patients, patients with chronic spinal degenerative changes and deformities, and those with anatomical variations or abnormalities [3, 4]. The loss-of-resistance (LOR) technique is used for identifying the epidural space along with anatomical landmarks on the basis of density differences of tissues encountered by the needle tip passing through the ligamentum flavum into the epidural space. The LOR is a blind technique. Therefore, multiple attempts may be required, causing pain and discomfort and an increased incidence of the complications, as well as achieving poor satisfaction. Technical difficulties occur when identifying the lumbar epidural interspace using anatomic landmarks and the LOR technique under imaging guidance; however, lumbar injection can eliminate some of these difficulties. In recent years, fluoroscopy or ultrasonography-guided procedures have commonly been used for spinal intervention procedures and have been shown to reduce both epidural access failure

rates and the number of puncture attempts [1, 3, 5-7]. In addition, various systems and devices such as acoustic device, Episure™ AutoDetect™ syringe, Epidural Sensing Management Tool (ESMT), Compuflo®, and non-invasive mechatronic system have been developed to facilitate epidural access [8-13].

Interlaminar epidural steroid injection (ESI) has also been performed for managing chronic low back pain and radicular leg pain secondary to lumbar disk herniation, spinal stenosis, failed back surgery syndrome, and other lumbar vertebrae pathologies [14, 15]. Most interlaminar ESI procedures are performed with a blind technique known as LOR without an imaging guide. This study aims to evaluate the success rate of the LOR technique in interlaminar ESI under fluoroscopic control.

Materials and Methods

The study was approved by the research ethics committee (2018/06/01). In an observational trial, the patients who underwent interlaminar ESI because of a history of at least 3 months of chronic low back and leg pain not responding to medications and physical therapies were selected for the study. They were aged between 27 and 88 years and had an American Society of Anesthesiologists physical status of I–III. All the patients provided written informed consent prior to their participation. Patients who presented with a clinically significant or unstable medical or psychiatric illness, previous surgery on the lumbar spine, unstable neurological deficits, infection, or coagulopathy were excluded.

All the procedures were performed by one physician, experienced in fluoroscopy-guided procedures in an operating room of an ambulatory surgery setting. Routine monitoring (electrocardiography, non-invasive arterial pressure, and oxygen saturation) was performed, and intravenous (IV) access and midazolam 1–2 mg sedation were administered to all the patients. The patients were placed in a prone position to eliminate differences related to patient positioning, with a pillow placed under the abdomen to minimize the lumbar lordosis. The L5-S1 interlaminar foramen was chosen for injection because this foramen is less affected by lumbar lordosis in contrast to the other levels and is usually wider than the other lumbar interlaminar foramina. Patients who underwent the procedure at their upper lumbar levels were excluded. The needle was placed under fluoroscopic imaging with an anteroposterior view to the epidural space to eliminate technical problems and correctly determine the L5–S1 interlaminar foramen. The fluoroscope was angled to optimally demonstrate the L5–S1 interlaminar foramen. The insertion site was aseptically disinfected with povidone and injected with 2% lidocaine. The midline technique was performed, and an 18-gauge 9-cm Tuohy needle was introduced at the level of the L5–S1 interlaminar foramen using fluoroscopy with a tunnel vision approach. The needle was advanced into the epidural space using the LOR technique with a saline solution. An intermittent fluoroscopic image was obtained in the anteroposterior view so that the needle could advance in the midline. A lateral view was obtained when the LOR was felt. It was inspected to verify if the needle tip was at the epidural space line. If the needle tip was not at the epidural space line, it was advanced until it reached it. Once the needle was in position and after negative aspiration for cerebrospinal fluid and blood, 2 cc of contrast dye, iohexol (Omnipaque, GE Healthcare, UK) was injected through the needle to confirm the epidural space distribution in the anteroposterior and lateral views, and it excluded intravascular, subarachnoid, subdural, or soft tissue spread. The needle was repositioned if blood, cerebrospinal fluid, or inappropriate spreading of contrast dye was identified. Thereafter, a 10 mL mixture consisting of 2 mL of 0.5% bupivacaine, 2 mL of triamcinolone acetonide (80 mg), and 6 mL physiological saline was injected into the epidural space. All the patients were monitored for at least 30 min after the procedure.

The procedures that achieved epidural spread of the contrast agent in the first attempt were deemed successful. Those that did not and those that had false positive LOR were regarded as unsuccessful. The distance between the skin and the epidural space and between the point that LOR was felt and the epidural space was measured over the needle. The stiffness degrees of the ligamentum flavum ranged from very soft, soft, normal, stiff, and very stiff.

Statistical Analysis

A power analysis was performed using descriptive statistics to describe continuous variables (medium, standard deviation, minimum, and maximum). Comparisons of non-normally distributed continuous variables between the 2 groups contrary were conducted using the Kruskal-Wallis test. Post-hoc analyses were performed with the Mann-Whitney U test with Bonferroni correction for comparisons between 2 continuous variables that were not normally distributed. The Chi-square (or Fisher's exact test or likelihood ratio as appropriate) test was used to analyze the relations between categorical variables. Spearman's rho correlation coefficient was used to indicate the correlation between 2 continuous variables that were not normally distributed. The level of statistical significance was determined at 0.05. Analyses were performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013).

Main Points

- Loss of resistance technique may be inadequate in epidural injection.
- Fluoroscopy is useful in epidural injection.
- Imaging methods will be used more widely over time in interventional treatments.

Table 1. Demographic characteristics of the patients

Age (years)	60.7 (27–88)
Sex (male/female)	39/111 (26%/74%)
Body mass index (kg/m2)	30.0 (19–47)
Distance from skin to epidural space (mm)	71.0 (40–100)

Results

Demographic characteristics of the patients were determined (Table 1). Interlaminar ESI was administered to 150 patients. The procedure's success and failure rates were 76% (114 patients) and 24% (36 patients), respectively. A total of 58.3% (21 patients) of patients who underwent an unsuccessful procedure had a false LOR, whereas 41.6% (15 patients) of the same group exhibited other causes (Table 2). A false LOR was felt at approximately 19.1 mm (range 5–25) away from the epidural space. The stiffness of the ligamentum flavum was evaluated in 148 patients, but it could not be evaluated in 2 because of the failure to enter the epidural space (Table 3). The distance between the skin and the epidural space was longer than 9 cm, about 100 mm, and 95 mm in 4, 1, and 3 patients, respectively. These patients had their epidural skin accessed by embedding the needle into their skin.

Sex, age, and body mass index (BMI) showed no statistical significance in terms of procedural success (chi-square, p=0.780, p=0.051, and p=0.649, respectively) (Table 4).

The success rate was not affected by the distance between the skin and the epidural space (likelihood ratio, p=0.076) (Table 4).

There were statistically significant differences at distances between the skin and the epidural space according to the BMI groups (Kruskal-Wallis test, p<0.001) (Table 5). Statistically

Table 2. Causes of unsuccessful procedure

Number of patients	Causes
21	False LOR
4	Distance from the skin to the epidural space was more than 90 mm
2	The ligamentum flavum was not felt
2	LOR was not felt
2	The ligamentum flavum was extremely stiff
2	Dural puncture
2	Unable to enter the epidural space
1	The patient felt pain during the procedure

LOR: loss of resistance

Table 3. Stiffness of the ligamentum flavum

	n	%
Very soft	3	2.0
Soft	18	12.2
Normal	98	66.2
Stiff	21	14.2
Very stiff	8	5.4
Total	148	100.0

Table 4. Procedural success in relation to sex, age, BMI, distance between the skin and the epidural space, and total

		Unsuccessful (N/%)	Successful (N/%)
Sex	Male	10 (25.6)	29 (74.4)
	Female	26 (23.4)	85 (76.6)
Age (years)	<50	13 (36.1)	23 (63.9)
	>50	23 (20.2)	91 (79.8)
BMI (kg/m2)	<24.9	6 (23.1)	20 (76.9)
	25–29.9	14 (28.6)	35 (71.4)
	>30	16 (21.3)	59 (78.7)
Distance from the skin to the epidural space (mm)	40–49	2(20)	8 (80)
	50–59	1 (7.1)	13 (92.9)
	60–69	6 (17.6)	28 (82.4)
	70–79	10 (20.8)	38 (79.2)
	>80	17 (38.6)	27 (61.4)
Total		36 (24.0)	114 (76.0)

BMI: body mass index

Table 5. Relation between BMI and distance

	M+SD; N	Med (min-max)
BMI<24.9	58.9+10.9; 26	59 (40-78)
BMI 25–29.9	68.9+11.3; 49	70 (45-95)
BMI >30	76.6+11.4; 75	78 (45-100)

BMI, body mass index
M+SD: mean + standard deviation

Table 6. Post-hoc dual comparison

	p*
BMI<24.9 vs BMI 25–29.9	0.001
BMI<24.9 vs BMI >30	<0.001
BMI 25–29.9 vs BMI >30	<0.001

*Mann-Whitney U test (Bonferroni correction was used. p values under 0.016 were considered to be significant)

significant differences were shown between distances from the skin to the epidural space for all between-group comparisons according to the post-hoc assessment (Table 6).

There were no complications, such as infection or neurologic injury, except for dural puncture in 2 patients and pain during the procedure in 1 patient.

Discussion

The LOR technique is the standard procedure for identifying the epidural space. [16]. During epidural injection, the skin, the supraspinous and interspinous ligaments and the thick fibrous elastic ligamentum flavum are sequentially perforated. However, the needle is sometimes introduced into the soft tissue located 2–3 cm away from the epidural space with caution of potential dural puncture owing to a false LOR that may be felt in the soft tissue. In addition, the paravertebral muscles and degenerate interspinous ligament may cause false LOR [17]. Studies have demonstrated that false LOR is not uncommon during epidural access [18], and the LOR technique has been reported to have a 17% failure rate [19]. Moreover, the success rate has been reported to be only about 60% during the first puncture [20]. Bartynski [21] reported a 25.7% incidence of inaccurate needle tip placement without fluoroscopy for lumbar epidural injections. They used a 20-gauge Tuohy needle with loss of air. In this study, we used an 18-gauge Tuohy needle using saline LOR. Our study demonstrated 24% (36 patients) failure rate. There was false LOR in 14% (21 patients) of the procedures and success at first attempt was 76% (114 patients). Various studies have attempted to reduce the number of attempts and complications when performing the epidural procedure. No reported study researching the effectiveness of the LOR technique has used the same level of vertebra and same patient position solely. Therefore, we believe that our study may contribute to the literature.

Liu et al. [22] have demonstrated that the LOR technique is significantly inferior to the fluoroscopy-guided technique in terms of correct needle placement in the epidural space. The saline LOR technique is most commonly used for identifying the epidural space [23]. Beilin et al. [24] suggested that using 0.9% saline for the LOR technique is associated with better analgesia in contrast to the technique of introducing air in the parturient. We, therefore, chose to use 0.9% saline in this study. Vaira et al. [25] investigated the sensitivity and specificity of the ability of CompuFlo® and confirmed the ability of CompuFlo® to differentiate false from true LOR. CompuFlo® may reduce the total number of attempts [12]. Lechner et al. [8, 9] used an acoustic device to record pressure data during the procedure. Episure™ AutoDetect™ syringe is an LOR syringe with an internal compression spring that applies constant pressure on the plunger and is used to facilitate the epidural access [10].

Qureshi et al. [26] reviewed their experience in lumbar catheter placement under fluoroscopic guidance and observed that it was successful in 42 out of 43 patients. Although 16 patients were on antiplatelet agent medication at the time of catheter insertion, no hemorrhagic complication was observed. A minimal number of spinal needle insertions were required to access the epidural space under fluoroscopic guidance. Therefore, a low risk of hemorrhagic complications can be achieved in spinal interventional procedures.

In recent years, the use of ultrasonography has been increasingly common in anesthetic practice and has been shown to reduce epidural catheter failure rates and the number of puncture attempts. Ultrasound can be used to identify the

epidural space, estimate depth from skin to the epidural space, and the point of insertion. This procedure requires a good knowledge of spinal sono-anatomy and advanced interventional skills. The fluoroscopy-guided procedure is also commonly used for the spinal intervention procedures. However, radiation exposure is a disadvantage of fluoroscopy application [27-29].

The fluoroscopy-guided epidural injection procedure provides direction to adjust the needle and shows correct drug spread via the contrast agent. Fluoroscopy can facilitate epidural access and decrease the rate of complications. Moreover, in patients for whom insertion would not be possible by manually palpable landmark guidance, the fluoroscopy-guided technique has a high success rate with fewer complications [22, 26]. The incidence of dural puncture during fluoroscopic epidural access ranges from 0.5% to 2% [30, 31]. There was a dural puncture rate of 1.33% in our study. Although we adjusted the anteroposterior view with fluoroscopy, 14% (21 patients) and 24% (36 patients) of false and unsuccessful procedures, respectively, using the LOR technique were observed. Epidural access was obtained in 32 patients who underwent an unsuccessful procedure when lateral fluoroscopic image was adjusted. In only 4 patients (dural puncture in 2 patients and unable to enter the epidural space in 2 patients), the procedure could not be performed in lateral fluoroscopic view. Thus, we think that fluoroscopy increases the success of the procedure.

The ligamentum flavum can be located at a depth of 11–12 cm in obese patients, and the spinous processes can be located more than 5 cm below the skin [32]. BMI is the most reliable indicator of skin regarding the lumbar epidural space distance [33, 34]. There were also statistically significant differences between the distances from the skin and the epidural space according to BMI groups in our study. However, it was shown that sex, age, and BMI did not affect the procedural success rate. We believe that further studies with different patient positions and other vertebral levels may reveal different results.

The LOR technique identified the epidural space in most epidural procedures. However, in some cases, LOR was shown to be inadequate. In conclusion, we suggest that the LOR technique must be supported by imaging techniques, such as fluoroscopy, during epidural injections.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Sanko University (2018/06/01).

Informed Consent: Informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The author has no conflict of interest to declare.

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