Contralateral Oblique View Is Superior to the Lateral View for Lumbar Epidural Access

Jatinder S. Gill, MD,* Jyotsna V. Nagda, MD,* Musa M. Aner, MD,* John C. Keel, MD,† and Thomas T. Simopoulos, MD*

*Department of Anesthesiology, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts; †Department of Physical Medicine and Rehabilitation, New England Baptist Hospital, Harvard Medical School, Boston, Massachusetts, USA

Correspondence to: Jatinder S. Gill, MD, Department of Anesthesiology, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Avenue, Boston, MA, USA. Tel: 617-278-8000; Fax: 617-278-8065; E-mail: jsgill@bidmc.harvard.edu.


Abstract

Objective. The purpose of this study was to perform a comparative analysis of the contralateral oblique (CLO) view and the lateral view for lumbar interlaminar epidural access.

Design. After the epidural space was accessed, fluoroscopic images at eight different angles (antero-posterior view, multiple CLO, and lateral view) were prospectively obtained. Visualization and location of needle tip relative to bony landmarks were analyzed. The epidural location of the needle was subsequently confirmed by contrast injection and analysis in multiple views.

Results. Visualization of the needle tip and the relevant radiologic landmarks was superior in the CLO view. The needle tip location in the epidural space was most consistent at a CLO angle of 45°.

Conclusion. This study shows that the CLO view for lumbar interlaminar epidural access offers clear advantages over the lateral view on many clinically important grounds: the needle tip visualization is better, the important radiological landmarks are better visualized, and the needle tip when placed in the epidural space presents a more precise relationship to these landmarks. All of these differences were highly significant. Thus, when using this view, the needle may be directly placed in very close vicinity to the epidural space and true loss of resistance expected soon thereafter. In addition, this view provides the ability to plot the cranio-caudad needle trajectory. The combination of these factors is likely to improve the ease and efficiency of epidural access. The crisp visualization of the final moments of epidural access could also translate to improved safety and accuracy. In light of this, it is suggested that a CLO view at 45° be considered the preferred view for gauging needle depth during interlaminar lumbar epidural access.

Key Words. Epidural (Injection Space); Fluoroscopy

Introduction

The lumbar epidural space is commonly accessed for therapeutic purposes such as epidural steroid injection. Fluoroscopic technique is helpful in depositing the medication at the correct level and on the correct side [1]. Studies have shown that false loss of resistance (LOR) is not uncommon during epidural access [2]. This might lead to deposition of the medication outside the epidural space. Furthermore, the incidence of dural puncture during fluoroscopic epidural access ranges from 0.5% to 2% [1,3]. The lateral view is therefore commonly used to assess the depth of the needle tip during fluoroscopic epidural access and to circumvent the problem of false LOR such that if the loss is detected before the spinolaminar junction, it would be recognized as a false loss. The CLO view can be used similarly and has been shown to be superior to the lateral view for cervical and cervico-thoracic epidural access [4]. The ventral interlaminar line in the CLO view serves as a surrogate for the posterior boundary of the epidural space. In a recent safe use initiative by an expert multidisciplinary working group from several national organizations, it was
recommended that multiple views be utilized for fluoroscopic epidural access [5]. It is imperative that the practitioner have a good understanding of various views so that the epidural space can be accessed efficiently and safely. A review of the literature on this matter reveals that there are no studies that define the spatial parameters of the lumbar epidural space in the lateral or contralateral oblique view. Nor are there any studies that analyze the clarity of the needle tip visualization. The optimal angle for a CLO view in the cervical and cervico-thoracic space has been defined [4]. The optimal angle for the CLO view in the lumbar epidural space remains undefined. The study was therefore undertaken to fill this critical gap in the literature.

**Methods**

In this study, we evaluated needle position and visualization at several angles in images obtained by fluoroscopy in subjects undergoing lumbar epidural steroid injections. Contrast was thereafter injected, and spread patterns were visualized in different views. The study was approved by the institutional review board and conducted in an outpatient pain clinic of an academic medical center. The inclusion criteria for the study were adult patients who were undergoing therapeutic lumbar epidural steroid injection with fluoroscopic guidance. Thus, standard exclusion criteria that apply to elective epidural steroid injections, such as pregnancy, were automatically enforced. Additional exclusions included non-availability of magnetic resonance imaging (MRI) images pre-procedure, prior posterior lumbar spine surgery (as this often involves laminectomy, and lamina is a key radiographic landmark for this view), and hypersensitivity to contrast agent. The injections were performed under local anesthesia with occasional supplementation with nurse-administered sedation. The procedure was performed by either a resident or fellow physician under the supervision of one of the study investigators. The fluoroscopy unit employed was OEC 9900 Elite (OEC Medical Systems, Salt Lake City, UT, USA). Informed written consent to participate in the study was obtained from all study subjects. The subjects were placed in the prone position with a pillow under the abdomen to counteract the lumbar lordosis. A 17- or 20-gauge Tuohy needle was used for interlaminar epidural access. The epidural space was accessed under fluoroscopic guidance and with loss of resistance to saline technique. There was no specific protocol regarding the views used for accessing the space. It is, however, the standard practice for all the investigators in this study to use the CLO view as the preferred view for accessing the epidural space. If the needle was deemed to be in the epidural space when loss occurred, then a true antero-posterior (AP) view was obtained. The fluoroscope and the bed were adjusted in order to obtain a true AP, and all oblique and lateral rotations were made based on this as a zero-degree reference point.

Then eight fluoroscopic views were obtained: AP, lateral, CLO at 30° (CLO30), 40° (CLO40), 45° (CLO45), 50° (CLO50), the isointense angle (CLOI), and the measured angle (CLOm) (Figure 1). The isointense angle was determined by the angulation at which the ventral and dorsal margins of the laminae were of equal radiographic intensity subjectively, thus theoretically representing a true coaxial view through the lamina. The measured angle was determined by measuring the angle of the superior lamina with the midsagittal plane on MRI. Centricity PACS software (GE Healthcare, Barrington, IL, USA) was used to measure the angle in the following fashion. The angle was measured on the axial T2 image at the upper edge of the lamina but where both the lamina and the spinous process were well visualized. The midpoint between the two articular pillars was located. A line was drawn from this point and passed through the exact midline of the spinous process. A second line was drawn parallel to the lamina on the side the angle was being calculated. This line was drawn parallel to the lamina through the middle. If there was any discrepancy between the dorsal and ventral laminar angulation, then the line was drawn parallel to the ventral laminar margin. The angle of intersection of the two lines was measured by the Centricity software and represented the measured angle (Figure 1).

The lateral view was optimized with fluoroscopic adjustments only, e.g., collimation, increased peak kilovoltage (kVP), height adjustment, or cephalo-caudal motion; no position changes requiring subject motion were performed. The injection of contrast medium (Isovue-M 300, Bracco Diagnostics, Inc., Princeton, NJ, USA) confirmed epidural spread in the AP, multiple CLO, and lateral views. All of the images were electronically stored for analysis. Contrast spread patterns were reviewed and are pending analysis. These will be presented at a future date.

**Statistical Analysis**

This was a pilot study designed to investigate the boundaries of the lumbar epidural space and contrast spread patterns in multiple views. Given the pilot nature of the study and the additional radiation exposure to the subjects of around 0.11 milliSievert, the sample size was determined by the institutional review board. The oblique and lateral images were analyzed for needle tip visualization subjectively graded as 1 (clearly visualized without ambiguity), 2 (poorly visualized or visualized with effort), or 3 (not visualized). The majority vote among three reviewers (study investigators) determined the grade. McNemar’s test was used to compare the needle tip visualization in CLO view with the needle tip visualization in the lateral view. To objectively describe and demarcate the final needle position in the AP, lateral, and CLO views, the following methodology was employed. The AP view of the interlaminar space was divided into three zones. AP Zone 1 (APZ1) extends within the lateral margin of the spinous process from one side to the other. The area from the lateral margin of the spinous process to the lateral margin of the interlaminar opening was divided into two equal zones, AP...
Zone 2 (APZ2) medially and AP Zone 3 (APZ3) laterally (Figure 2). This is similar to the method used in classifying the cervical and cervico-thoracic epidural space in a previous study published by the authors [4].

In the oblique view, the following methods were used. We first identified the ventral margin of the lamina above and below, and the most anterior part of these laminae were connected by a conceptualized line, the ventral interlaminar line (VILL) (Figure 3). All references to the visualization of the VILL in this article are based on this methodology. The needle tip was defined as being significantly before the VILL, just before the VILL (less than the bevel length subjectively), on the VILL, just after the VILL (less than the bevel length subjectively), or significantly after the VILL. These regions were defined as $-2, -1, 0, +1$ and $+2$, respectively (Figure 4).

In the lateral view the inferior spinolaminar junction was first identified (Figure 5). Needle tips were analyzed for lying before the inferior spinolaminar junction, on the inferior spinolaminar junction, or anterior to the inferior spinolaminar junction. The region anterior to the inferior spinolaminar junction was divided into three zones. The boundary of Zone 1 extended from the inferior spinolaminar junction to the facet joint line. The facet

**Figure 1** (A) Line B is at $52^\circ$ to the sagittal plane and runs parallel to the ventral margin of lamina. This is the measured angle, or $\text{CLOm}$. (B) Different angles used: A-AP, B-$30^\circ$, C-$40^\circ$, D-$45^\circ$, E-$50^\circ$, F-$52^\circ$ (CLOm), G-lateral.
joint lucency representing Zones 2 and 3 lay anterior to this (Figure 6). The number of times the needle tip lay on the inferior spinolaminar junction in the lateral view was compared to the number of times the needle lay on the VILL in the oblique view using McNemar’s test. Exact confidence intervals (CIs) for proportions were calculated for needle positions for CLO30, CLO40, CLO45, CLO50, CLOi, and CLOm. We used exact McNemar tests to compare the proportion of needles visualized on the VILL at CLO 30, CLO 40, CLO 45, CLO 50, and CLOm. For the lateral view we calculated the proportions and the exact confidence intervals for needle tip location in each of the zones. We also looked for correlations between where the needle lay in the AP versus the lateral zones using the kappa coefficient. The reliability of the interlaminar area in the CLO view for predicting the cephalo-caudad angle for needle insertion was evaluated for each subject and compared with the lateral view using McNemar’s test (Figures 3 and 5). Different oblique views were subjectively analyzed by majority vote to determine whether an isointense appearance was visualized at more than one angle. We also graded the quality of visualization of the laminar margin at different CLO angles, with Grade 1 denoting a well visualized laminar margin and Grade 2 a not well visualized margin (Figure 7). This was compared for different CLO views using McNemar’s test. We additionally compared the clarity of the inferred VILL to the clarity of the inferior spinolaminar junction.

Results

A total of 30 subjects were recruited for the study. Of these, two were excluded. One subject had vasovagal symptoms and the injection was not completed. In the second subject, the needle tip could not be visualized because of metallic artifact overlay.

Patient Demographics

There were 18 women and 10 men in the study. The mean age was 60 years, with a range from 27 to 91 years. Injections were performed as follows:

![Figure 2](https://academic.oup.com/painmedicine/article-abstract/17/5/839/1752699/Contralateral-Oblique-View-Is-Superior-to-the/842)

**Figure 2** AP Zone 1 (APZ1) extends within the lateral margin of the spinous process from one side to the other. The area from the lateral margin of the spinous process to the lateral margin of the interlaminar opening was divided into two equal zones, AP Zone 2 (APZ2) medially and AP Zone 3 (APZ3) laterally. The needle is seen in the L4-L5 interlaminar space at the junction of APZ1 and APZ2.

![Figure 3](https://academic.oup.com/painmedicine/article-abstract/17/5/839/1752699/Contralateral-Oblique-View-Is-Superior-to-the/842)

**Figure 3** Fluoroscopic contralateral oblique (CLO) view at 45°. The ventral interlaminar line (VILL) is an imaginary line connecting the ventral laminar margins. Note the needle tip lies on the VILL. Note also how the lumbar laminae course in a posterior-inferior direction. The interlaminar opening is clearly visualized, and the needle trajectory can be plotted to pass through the interlaminar recess.
sixteen at L5-S1, eight at L4-5, three at L3-4, and one at L2-3.

Accuracy of Needle Tip Placement in Epidural Space

The accuracy of needle tip placement in the epidural space was 100%, as confirmed by the contrast spread pattern on lateral and multiple oblique projections. The post-contrast study images were reviewed by the three study investigators. There was unanimous agreement for epidural spread of contrast.

Needle Tip Visualization

As is apparent from Table 1, the needle tip in the lateral view was poorly visualized in 8 of the 28 subjects and not visualized in 2 of the 28. In contrast, the needle tip was well visualized in all subjects in all CLO projections. Needle tip visualization was superior in the oblique view (100% Grade 1) compared to the lateral view (65% Grade 1, CI 0.46–0.81). This was found to be statistically significant using McNemar’s test with a continuity correction ($P < 0.01$).

Needle Tip Location in Oblique View

The location of needle tips is presented in Table 2. The isointense view was excluded from the analysis because the isointensity of the lamina was judged to be too subjective a measure. By consensus among the three investigators, the isointense appearance could be seen at more than one angle. It is clear that an angle of 45° has the highest number of needle tips that can access the epidural space at the VILL and no needle tips that can access the epidural space before the VILL. Four needles were seen slightly anterior to the VILL, and two needles were significantly anterior. The thickness of the ligamentum flavum (LF) ranged from 4.4 to 4.9 mm on the MRI in these four subjects where the needle tip was

Figure 4  Different needle positions. (A) Just before the ventral interlaminar line (VILL) ($-1$), (B) on VILL (0), (C) just after VILL ($+1$), (D) significantly anterior to VILL ($+2$). Note that the contrast outlines the hypertrophied ligamentum flavum. This ligamentum hypertrophy is the reason the needle is seen at $+2$. 

Contralateral Oblique View for Lumbar Epidural Access
slightly anterior. In the other two subjects where the needle tip appeared to be significantly anterior, the thickness of the LF was 6.6 and 7.7 mm and was seen to project in front of the VILL. There was a statistically significant difference in needle tip location at the VILL between CLO30 and CLO45 ($P = 0.003$) and between CLO40 and CLO45 ($P = 0.02$). No statistically significant difference was found between CLO45 and CLO50 or between CLO45 and CLOm. For both CLO50 and CLOm in 5 of the 28 subjects, the epidural space could

---

**Figure 5** Lateral view. SSLJ: superior spinolaminar junction, SLL: spinolaminar line, ISLJ: inferior spinolaminar junction, FJL: facet joint line. The loss of resistance may occur anywhere between the ISLJ to beyond the FJL. Note that the ISLJ is overexposed in comparison to the vertebral body. The interlaminar opening is not visualized.

**Figure 6** The region anterior to the inferior spinolaminar junction was divided into three zones. The boundary of Zone 1 is from the inferior spinolaminar junction (ISLJ) to the facet joint line (FJL), the boundary of Zone 2 is within the confines of the FJL, and Zone 3 is anterior to this. ISLJ: inferior spinolaminar junction; 1: Zone 1, 2: Zone 2, 3: Zone 3.
be accessed just before the VILL. Of the five needles where the needle lay just before the VILL at CLO50 and CLOm, the needle tip was seen to lie very close to the VILL such that the bevel almost reached the VILL, and this distance was less than the length of the needle bevel (Figure 4). A review of the epidural space on the MRI at the point of access revealed that a slight forward motion of needle tip to reach the VILL would not have violated the dura mater and the needle tip would still safely lie in the epidural space.

Needle Tip Location in Lateral View

The needle tips were distributed over all three zones (Table 3). Two needle tips were not visualized. No needle tip was visualized before the inferior spinolaminar junction. Three needle tips were visualized at the spinolaminar junction. Of these, one needle was from AP Zone 1 and two needles were from AP Zone 2. A review of the MRI at the level of access revealed that the LF was very thin in two of these subjects and absent in one (Figure 8) and that the spinal canal had more of an oval appearance with the posterior canal margin nearly parallel to the coronal plane (Figure 8). Of the 26 needles or needle tips that were visualized in both the AP and lateral views, only in 10 subjects was a correlation seen between the AP and lateral zones. The kappa coefficient associated with this was 0.0867 (CI: −0.1981 to 0.3714), indicating slight or no agreement between viewing modes.

Visualization of The Radiological Landmarks and Analysis of Relative Needle Tip Location

VILL was well conceptualized based on the ventral laminar margin above and below in all subjects, whereas SLJ was well visualized for 13 of the 28 subjects, and this was statistically significant ($P = 0.0003$). The needle tip was located at the SLJ in 3 subjects compared to its being located at the VILL in 22 subjects, providing statistically superior ($P = 0.0001$) consistency for needle tip location when using these landmarks.

The clarity of the laminar visualization was statistically superior at CLO45 compared to CLO30 ($P < 0.0001$), and there was no statistically significant difference in the clarity of the laminar visualization at CLO45 as compared to CLO40, CLO50, or CLOm (Table 4).

Prediction of the Needle Trajectory

In all CLO projections the cephalo-caudad angle and the trajectory of the needle were clearly predictable as the interlaminar opening could be clearly visualized in all subjects. The lateral view failed to provide visualization of the interlaminar recess in all subjects; hence, unambiguous landmarks to predict the cranio-caudad trajectory were not available. The trajectory was not easily predictable in this view.
Conversely, excessive obliquity would overestimate the depth of the lamina, and the needle might appear to be superficial in relation to the VILL (Figures 11 and 12). This relationship between needle tip location and angle of obliquity was not as strong as in the cervical spine [4]. CLO45 proved to be the most reliable, with 22 of the 28 needle tips localized to the VILL and the remaining being anterior. At CLO45, needle projection beyond the VILL correlated with LF hypertrophy at the point of access (Figure 10). Thus, it can be stated that CLO45 provides the highest likelihood that the needle will be localized to the VILL and that in subjects with LF hypertrophy it may be expected to appear more anterior, but only if the hypertrophy is present at the point of access. The other possibility to be entertained for significantly anterior location may be a midline needle that has veered slightly ipsilaterally. The CLO50 and CLOm are close to the angle of the lamina at the superiormost margin of the lamina. Access of the epidural space is inferior to this at the interlaminar area, where an angle of 45° provided the most consistency without the occurrence of loss before the VILL. It is important to point out that, although the needle tips were seen slightly before the VILL in 5 of the 28 subjects in CLO50 and CLOm, the needles were all extremely close (Figure 4). A review of the epidural space on the MRI at the point of access revealed that a forward motion of the needle tip toward the VILL would still have maintained the needle safely in the epidural space, which was more expansive at that location. This phenomenon is clearly illustrated and described in detail in Figure 12. As expected, given the close proximity of CLO50 and CLOm angulations, the needle tips were similarly localized.

The lateral view failed to provide a consistent location for the needle tips, which were widely distributed, from the spinolaminar junction to beyond the visualized facet joint line. The spinolaminar junction is to the lateral view what the VILL is to the CLO view. The consistency of needle localizing to this red line landmark was dramatically different with the 3/28 needles seen at the spinolaminar junction in the lateral view and the 22/28 needle tips localizing to the VILL at CLO45. This is likely related to the fact that the lateral view is a linear view visualizing a curvilinear boundary. Analysis of the anatomy of the lateral view reveals that the needle can be safely advanced to the spinolaminar junction as the epidural space lies anterior to this bony landmark (Figure 5). The

### Table 2
Dispersion of needle tips in CLO view:

<table>
<thead>
<tr>
<th>CLO view (angle)</th>
<th>–2</th>
<th>–1</th>
<th>0 (VILL)</th>
<th>+1</th>
<th>+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO30</td>
<td>0</td>
<td>0</td>
<td>7 (0.25 CI 0.09–0.41)</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>CLO40</td>
<td>0</td>
<td>0</td>
<td>15 (0.54 CI 0.36–0.73)</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>CLO45</td>
<td>0</td>
<td>0</td>
<td>22 (0.79 CI 0.64–0.94)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>CLO50</td>
<td>0</td>
<td>5</td>
<td>18 (0.64 CI 0.46–0.82)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>CLOm</td>
<td>0</td>
<td>5</td>
<td>19 (0.68 CI 0.51–0.85)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 3
Needle tip visualization AP to lateral correlation: APZ = antero-posterior zone, LZ = lateral zone

<table>
<thead>
<tr>
<th>AP zone</th>
<th>LZ 1</th>
<th>LZ 2</th>
<th>LZ 3</th>
<th>NOT VIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>APZ1 (9)</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>APZ2 (16)</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>APZ3 (3)</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>APZ1,2,3 (28)</td>
<td>13 (0.5 CI 0.31–0.69)</td>
<td>8 (0.31 CI 0.13–0.49)</td>
<td>5 (0.19 CI 0.04–0.34)</td>
<td>2</td>
</tr>
</tbody>
</table>

### Discussion
This is a pilot study designed to investigate the spatial boundaries of the posterior lumbar epidural space and to perform a comparative analysis of the lateral and contralateral oblique views so as to better understand their merits and limitations. The CLO view was analyzed from multiple angles to identify the angle that provides the greatest consistency in needle tip location. The two views were compared for consistency of needle tip location, clarity of needle tip visualization, clarity of visualization of important radiologic landmarks, and the ability to predict the needle trajectory for epidural access.

CLO45 provided the most consistent location for the needle tip, and in no circumstances was the tip seen before the VILL. A brief review of the anatomical details is instructive in understanding the intricacies of where the needle tip would be located in relation to the VILL at various CLO angles. The epidural space is posteriorly bounded by the LF that connects the ventral laminar margins but does not project beyond; hence, the epidural space would be expected to lie on the VILL (Figure 9). If the LF is hypertrophied and projects beyond the VILL, then the epidural space might be expected to lie beyond the VILL (Figure 10). This hypothesis assumes that the CLO angle is coaxial to the lamina. Lesser angles of obliquity will underestimate the true depth of the lamina, and the needle will appear deceptively deep, as seen at CLO30 (Figure 11). Conversely, excessive obliquity would overestimate the
lamina has a postero-inferior orientation, and hence the superior spinolaminar junction will lie anterior to the inferior spinolaminar junction. The two are connected by the spinolaminar line (Figure 5). To ensure that the needle does not get advanced too far such as to breach the dura mater, it is imperative that the loss of resistance be initiated as the inferior spinolaminar junction (more posterior) is approached. The distance the needle advances anterior to this landmark will depend on the thickness of the LF and the AP zone of entry. Since the lateral view is a linear view to visualize a curvilinear space, midline needles might appear superficial to the parasagittal needles. The loss of resistance occurred at spinolaminar junction in three subjects, from the spinolaminar junction to the posterior margin of the facet joint lucency (Zone 1) in 10 subjects, within the facet lucency (Zone 2) in 8 subjects, and beyond this (Zone 3) in 5 subjects (Figure 6). Not only was there a wide distribution in which the needle tip appeared in the lateral view, but there was also no correlation between the AP and lateral zones in this regard. The lack of correlation in this regard was surprising, and this could in part relate to the inconsistency in the size of the LF as well as the ambiguity in visualizing the needle tip and the important radiologic landmarks in this view. The inconsistency in which the loss of resistance occurred in the lateral view created uncertainty. Additionally, the spinolaminar junction was well visualized in only 13 of the 28 subjects. The reason for this is that the higher peak kilovoltage required to visualize the anterior spine structures in the lumbar region leads to over-penetration in this relatively superficial layer (Figure 5). The inconsistency of the needle location, combined with poor visualization of an important bony landmark in the lateral view, compares starkly with the CLO view where greater consistency of needle location and an excellent ability to visualize the ventral laminar margins and, hence, the VILL were observed.

In addition to the ability to visualize the bony landmarks and consistency in needle tip location, the ability to visualize the needle tip itself is also very important. In the lateral view, the needle tip was poorly visualized in eight subjects and not visualized in two subjects. Difficulty in visualizing the needle tip in the lateral view is a well-recognized problem in the lower cervical and cervicothoracic area, but this problem is not as well recognized in the lumbar view. The difficulty in visualization is secondary to the overlay of the iliac crest at L5-S1 and

**Table 4** Visualization of the laminar margins subjectively determined by majority vote with well visualized as Grade 1 or not well visualized as Grade 2

<table>
<thead>
<tr>
<th>CLO view (angle)</th>
<th>Lam grade 1</th>
<th>Lam grade 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO30</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>CLO40</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>CLO45</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>CLO50</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>CLOm</td>
<td>21</td>
<td>7</td>
</tr>
</tbody>
</table>

**Figure 8** L5-S1 T2 axial cut in interlaminar area; ligamentum flavum is minimal to absent in this axial cut. The posterior canal margin is almost parallel to the coronal plane. In this patient, the needle placed in Zone 2 AP accessed the epidural space at the spinolaminar junction in the lateral view. The needle should not be advanced beyond the spinolaminar junction without initiating loss of resistance. The loss of resistance at this level may be very subtle.
sometimes at L4-5 and the radiological impedance created by the buttocks, especially in obese subjects. This difficulty in visualizing the final moments of needle tip progression renders fluoroscopic epidural access essentially blind. Whether this leads to greater risk of dural puncture is unknown, but lack of visualization often does create a feeling of lack of control when it is most needed. In comparison, in the CLO view, the needle tip was well visualized in all subjects.

In addition to the aforementioned aspects, it is also helpful to determine whether the view can provide assistance in plotting needle trajectory. The medio-lateral orientation can only be provided by the AP view. The CLO

---

**Figure 9** Contralateral oblique view at 45° (A) corresponding to parasagittal MRI T2 sequence (B) in the same subject. Note that, despite the significant thickness of the normal ligamentum, it does not violate the ventral interlaminar line (VILL). The ligamentum flavum thickens to fill the void created by the posterior laminar angulation and to bridge the interlaminar area. The needle tip is seen at the VILL.

**Figure 10** Fluoroscopic contralateral oblique view at 45° and MRI correlate parasagittal in the same patient: The ligamentum flavum (LF) is hypertrophied and extends anterior to the ventral interlaminar line (VILL). The needle tip is accordingly and expectedly anterior to the VILL. The contrast outlines the hypertrophic ligament.
view provided needle trajectory that was easily predictable in the cranio-caudad orientation, but the lateral view fails to provide this because the interlaminar opening cannot be seen in this view.

The presence of an unambiguous radiological landmark (VILL) for the posterior epidural space in the CLO view allows the needle to be placed very close to the epidural space prior to initiating the loss of resistance maneuver. All investigators in this study were well versed in the use of the CLO view and use this preferentially for epidural access. They have thus learned by experience and based on geometric analysis that it is safe to advance a needle close to the VILL prior to initiating loss of resistance. This method proved to be 100% accurate. On this basis, it can be stated that when using the VILL in the

Figure 11  In (A), The line of view is co-axial with the lamina, and the needle tip's relation to the ventral laminar margin is accurately reflected. In (B), the line represents CLO30, and the visualized ventral margin of the lamina is posterior to the true ventral margin, and the needle tip appears deeper. The converse of this is seen in (C), where overangulation has caused the needle tip localized in the epidural space, to be visualized just before the ventral laminar margin. N: needle.

Figure 12  (A) represents a sagittal T2 weighted axial cut through L4 vertebra at the superior laminar margin, and (B) represents the interlaminar L4-5 cut in the same patient. Note that the posterior margin of the epidural space has a more acute angle with the sagittal plane in figure (B). In (B), the 54° angle creates the possibility of a midline needle tip accessing the epidural space while appearing to lie just before the ventral interlaminar line (VILL). This was seen in 5 of 28 cases at CLOm and CLO50. However, note how the epidural space extends anterior to the CLO54 line. Accordingly, in none of the 5 of 28 cases was there any safety concern. Note also that CLO45 does not show this phenomenon, and the needle tip was not shown before the VILL in any patients.
CLO view as a radiological surrogate for the posterior epidural space, the loss of resistance is highly accurate and the possibility of false LOR may be eliminated.

This is a pilot study, and the findings should be interpreted in light of this fact. The needle tip was localized to the VILL at CLO45 in 22 out of 28 subjects and to the spinolaminar junction in 3 out of 28 subjects; it is unlikely that this clear advantage of the CLO view would be negated by a larger study. The number of times the needle tip was not well visualized in the lateral view was surprising. A large study could show that needle tip visualization is not as dismal as reported by us, but, given the far superior visualization in the CLO view, it is unlikely that the lateral view could compete on this ground. A larger study could also show that a correlation does indeed exist as to where the needle is inserted in the AP zone and where it ends up in the lateral zone. Given that a theoretical basis does exist for this lack of correlation (namely, the variability in the size of the LF), as well as ambiguity in the visualization of the needle tip and radiological landmarks, it is unlikely that this correlation would be so strong as to warrant relying on it clinically. Given the far superior visualization of the ventral interlaminar line compared to the inferior spinolaminar junction, this advantage of the CLO view is also unlikely to be negated by a larger study. In none of the subjects was the epidural space accessed before the VILL at CLO45. Whereas a larger study could show that at times the epidural space may be accessed before the VILL at CLO45, we think this unlikely given the geometric basis (Figure 12), and if it were to happen, it would not be clinically significant given the small play within the epidural space. Even at higher angles up to 55° where the epidural space was accessed before the VILL, this distance before the VILL was miniscule (Figure 4) and advancing up to the VILL would not have violated the dura mater. Our own clinical experience in a large number of patients is also consistent with these observations. Nevertheless, given the small sample size, this concern is of sufficient import, and a LOR maneuver should be initiated just before the VILL.

Conclusion

This study shows that the use of the CLO view is a reliable tool for directly and safely placing needles very close to the lumbar epidural space prior to beginning a LOR. Furthermore, it provides clear needle tip visualization, pristine view of requisite anatomic landmarks, and the ability to project the needle path in the cranio-caudal orientation during needle advancement.

In this regard, CLO45 provides the highest degree of assurance that a needle tip in the epidural space will localize directly at the VILL. The needle tip may, however, appear anterior to the VILL in a significant proportion of patients, and this may relate to LF hypertrophy at the point of access. Further obliquity is not required and may compromise the utility of this view. A lesser angle of obliquity gives a progressively anterior location of the needle tip and may be used with this understanding. The combination of a well-visualized needle tip and a well-visualized endpoint, as well as the ability to plot the course, is likely to make epidural access easier and faster and might eliminate the phenomenon of false LOR. By virtue of the precision and crisp visualization of the needle tip, it could also help reduce the chances of unintentional dural puncture. Although not addressed in this study, the inherent advantages of this view may also translate into lower levels of radiation exposure for patient and operator as well as shorter procedural times compared to the lateral view. In comparison, the lateral view is suboptimal in terms of providing a consistent location of the needle tip in the epidural space in relation to anatomic landmarks. In addition, the needle tip is often poorly visualized, as are the anatomic landmarks themselves. The lateral view also fails to provide unambiguous landmarks that might help in plotting needle trajectory during needle advancement.

Given the multiple advantages of the CLO view, we believe it should replace the lateral view as the preferred view for gauging needle depth during lumbar epidural access. The lateral view may be used as needed but with an understanding of its limitations. Knowledge of all three views and understanding of the spinal anatomy remain important for safe and efficient epidural access.

Acknowledgments

We acknowledge the statistical support from the Center of Anesthesia Care Excellence at Beth Israel Deaconess Medical Center.

References


