Retrospective Study

Optimal Angle of Contralateral Oblique View in Cervical Interlaminar Epidural Injection Depending on the Needle Tip Position

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Background: Chronic neck and upper extremity pain associated with cervical origin is common, and cervical interlaminar epidural steroid injections (CILESIs) are frequently used to manage the symptoms of cervical spinal disorders. However, CILESIs are associated with risks such as dural puncture and cord injury.

Objectives: We aimed to determine the optimal needle tip visualization, in order to minimize CILESIs-induced complications.

Study Design: Retrospective observational study.

Setting: The single center study in Seoul, Republic of Korea.

Methods: Participants were 312 adults with neck or upper extremity pain caused by cervical lesion such as cervical herniated nucleus pulposus (HNPs). They underwent magnetic resonance imaging (MRI). Patients with severe cervical spinal stenosis, prior posterior cervical spine surgery, or other anatomical abnormalities of the vertebral laminae were excluded from the study. By using axial T2-weighted spin-echo MRI, we defined the area between the spinous processes as the anterior posterior zone 1 (APZ1), and the area lateral to the spinous processes as the anterior posterior zone 2 (APZ2). Line 1 was drawn along the ventral margin of lamina that confined APZ1, and line 2 was similarly drawn in order to define APZ2. The angles between the midsagittal line and lines 1 and 2 were defined as angle 1 and angle 2, respectively. Angles were measured at the C5-6, C6-7, and C7-T1 levels, on both right and left sides at each level.

Results: Angle 1 values (in degrees) at right C5-6, left C5-6, right C6-7, left C6-7, right C7-T1, and left C7-T1 were 62.54 ± 10.52, 64.34 ± 9.86, 62.03 ± 10.27, 62.87 ± 10.64, 61.64 ± 11.0, and 62.58 ± 10.83, respectively. Angle 2 values at right C5-6, left C5-6, right C6-7, left C6-7, right C7-T1, and left C7-T1 were 50.44 ± 6.84, 50.77 ± 7.00, 49.15 ± 6.07, 49.89 ± 6.45, 50.84 ± 6.68, and 50.24 ± 6.60, respectively. There were significant differences between angles 1 and 2 at each level.

Limitations: This study is a retrospective review and did not employ controls, blinding, or randomization. Additionally, the optimal CLO angles for CILESIs and cervicothoracic interlaminar epidural steroid injections (CTILESIs) have not been assessed in clinical studies. Another limitation is that we divided lamina into only APZ1 and APZ2.

Conclusions: During CILESIs, a contralateral oblique (CLO) view at 60 degrees is superior to other angles for visualizing the epidural space when the needle tip is placed in the interlaminar space and within the spinous processes margin. When the needle tip is placed in the interlaminar space and lateral to the spinous processes, a CLO view at 50 degrees is most appropriate.

Institutional Review Board (IRB) approval number: S2016-0390-0001

Key words: Chronic neck pain, chronic upper extremity pain, cervical epidural injections, cervical interlaminar steroid injections, steroid, needle tip position, needle tip visualization, fluoroscopy, complication, contralateral oblique view

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Chronic neck and upper extremity pain affects 12.1% – 71.5% of the general adult population (1-3). Neck and upper extremity pain associated with cervical origins has been known to be induced by intervertebral discs, cervical facet joints, ligaments, fascia, muscles, and spinal nerves (1,3). The most common contributors to spinal nerve lesions associated with neck and upper extremity pain are cervical stenosis and herniated nucleus pulposus (HNPs) (1-5). Various conservative therapies are used to treat this pain, including physical therapy, analgesia, and injections (1-3,6).

Despite the ongoing debate regarding long-term effectiveness, cervical interlaminar epidural steroid injections (CILESIs) effectively reduce neck and upper extremity pain, as demonstrated by randomized clinical trials and systematic reviews (1-4). In particular, when disc herniation and stenosis are the origins of pain, CILESIs are widely administered (2,3,7). Cervical transforaminal epidural steroid injections are also performed. However, cervical transforaminal epidural steroid injections are associated with rare but serious neurological complications (1,5,8). CILESIs are also associated with infrequent complications such as dural puncture, epidural hematoma, and injury of the spinal cord, which may result in neuropathic pain or paralysis (1-3,7-9).

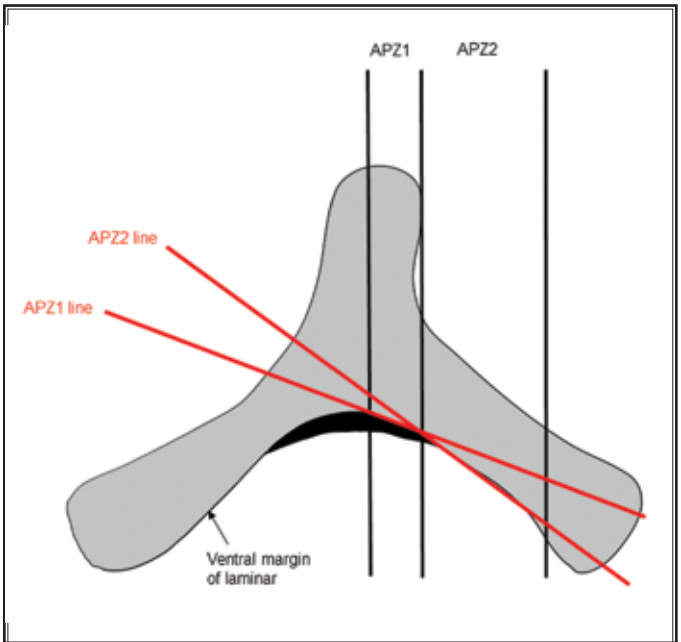

Fig. 1. *Schematic diagram of anterior posterior zone (APZ) lines. The anterior posterior (AP) view of the interlaminar space was divided into 2 zones. AP zone 1 (APZ1) was defined as within the spinous processes margin. The area from the lateral margins of the spinous processes to the lateral margins of the lamina defined AP zone 2 (APZ2). APZ1 and APZ2 lines were drawn along the ventral lamina that confined APZ1 and APZ2, respectively. Owing to the circumferential nature of the epidural space, angles differed between the APZ1 and APZ2 lines.*

Precise visualization of the needle tip during CILESIs is important to avoid complications (5,10,11). However, visualization of the needle using lateral views is often challenging in the lower cervical and cervicothoracic areas (12,13). Various methods have been developed using fluoroscopy to improve visualization, such as caudal manipulation of the shoulders, the swimmer's view, and the contralateral oblique (CLO) view (8,10,14). Gill et al (15) found that the CLO view at 50 degrees, in conjunction with MRI measured obliquity is superior to the lateral view for needle tip visualization, and also provides a consistent landmark for accessing the epidural space. These researchers concluded that a CLO view parallel to the ventral lamina provides the most accurate needle tip visualization (15).

Owing to the circumferential nature of the epidural space (16,17) (Fig. 1), we hypothesized that the ventral laminar margins would have different angles rather than one angle by needle tip position during CIESIs to achieve optimal visualization. Therefore, the CLO angle may be different for CILESIs and cervicothoracic interlaminar epidural steroid injections (CTILESIs), depending on the needle tip position. The objective of the present study was to determine whether the cervical and cervicothoracic ventral margins of lamina have different angles by needle tip position and whether optimal CLO angles differ in CILESIs and CTILESIs.

Methods

Patients

This single-center, retrospective observational study used the institutional registry records of 312 patients who experienced CILESIs and CTILESIs between January and August of 2015. The ethics board approved this study (approval number, S2016-0390-0001). Adult patients with neck or upper extremity pain and confirmed cervical lesion such as cervical HNPs were included. All patients also underwent magnetic resonance imaging (MRI) prior to therapeutic CILESIs or CTILE-

SIs. Patients were excluded from the study if there was severe cervical spinal stenosis indicated by MRI, prior posterior cervical spine surgery, or other anatomical abnormalities associated with the vertebral laminae.

Measurements

Data were collected by measuring angles from axial T2-weighted spin-echo imaging from C5-6 through C7-T1 levels. Axial sections were selected based on traversing the intervertebral discs at each level. When performing CILESIs and CTILESIs using fluoroscopy, the anterior posterior (AP) view of the interlaminar space was divided into 2 zones. AP zone 1 (APZ1) was defined as the area within the spinous processes margin. The area from the lateral margins of the spinous processes to the lateral margins of the lamina defined AP zone 2 (APZ2). On the axial T2-weighted spin-echo MRIs, the lamina was divided using the same AP zones that were used in the fluoroscopic view for measuring the difference of the laminar angle. Among ventral and dorsal lamina, the ventral laminar is adjacent to the epidural space, therefore we measured the angle of the ventral laminar rather than the dorsal lamina (Fig. 1).

The APZ1 and APZ2 lines were drawn along the ventral lamina similarly to the areas that defined APZ1 and APZ2, respectively. Angles on the axial MRI sections were digitally measured using the Asan Medical Center PACS system (PetaVision, version 2.1, Seoul, Korea). One line was drawn along the midline of the spinous processes. This line divided the vertebrae and spinous process into halves. The angle between the midsagittal line and the APZ1 line was defined as the APZ1 angle, and the angle between the midsagittal line and the APZ2 line was defined as the APZ2 angle (Fig. 2). The APZ angle indicates the optimal obliquity for the contralateral angle of the fluoroscope during CILESIs and CTILESIs. These angles were measured at the C5-6, C6-7, and C7-T1 levels, on both the right and left sides at each level (Figs 3, 4).

Data Analyses

Statistical analyses were performed using the statistical package SPSS 21.0 for Windows (SPSS Inc., Chicago, IL, USA). Demographic data were compared using chi-squared or Student's t-tests, as appropriate. The angles at each level are presented as means ± standard deviations (SDs), and confidence intervals (CIs) are given. In order to compare the differences of the angle between APZ1 and APZ2, paired t-tests were conducted on data from each level.

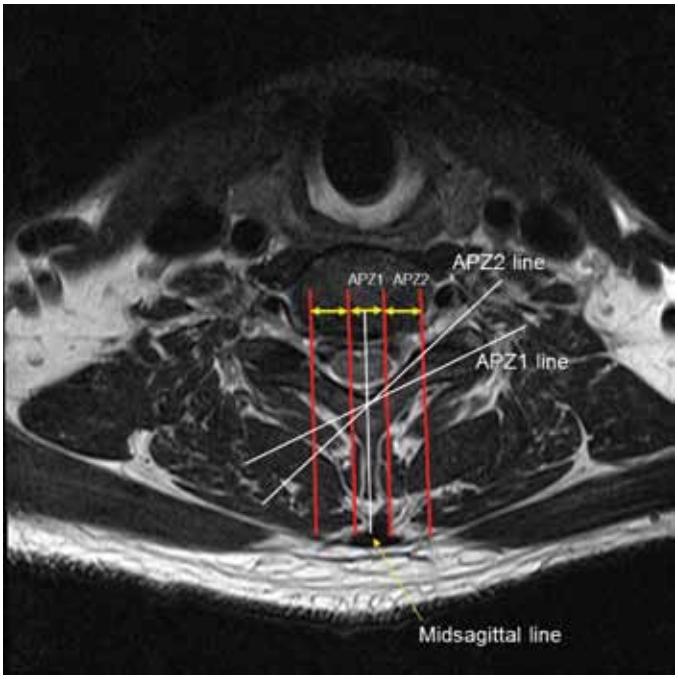

Fig. 2. *Magnetic resonance imaging (MRI) axial T2-weighted images showing the lines used to measure APZ1 and APZ2 angles.*

Results

Demographic characteristics of the patients are presented in Table 1. Patient mean ages (IQR) were 50 (44 – 55) years, with 162 men and 150 women participating.

The mean optimal angle (in degrees) measured in the 312 patients at C5-6, C6-7, and C7-T1 ranged from 49 to 62 (Tables 2 and 3). The APZ1 angles at right C5-6, left C5-6, right C6-7, left C6-7, right C7-T1, and left C7-T1 were 62.54 ± 10.52, 64.34 ± 9.86, 62.03 ± 10.27, 62.87 ± 10.64, 61.64 ± 11.0, and 62.58 ± 10.83, respectively. The APZ2 angles at right C5-6, left C5-6, right C6-7, left C6-7, right C7-T1, and left C7-T1 were 50.44 ± 6.84, 50.77 ± 7.00, 49.15 ± 6.07, 49.89 ± 6.45, 50.84 ± 6.68, and 50.24 ± 6.60, respectively. There were significant differences between the APZ1 and APZ2 angles at each level (Table 4). The differences at right C5-6, left C5-6, right C6-7, left C6-7, right

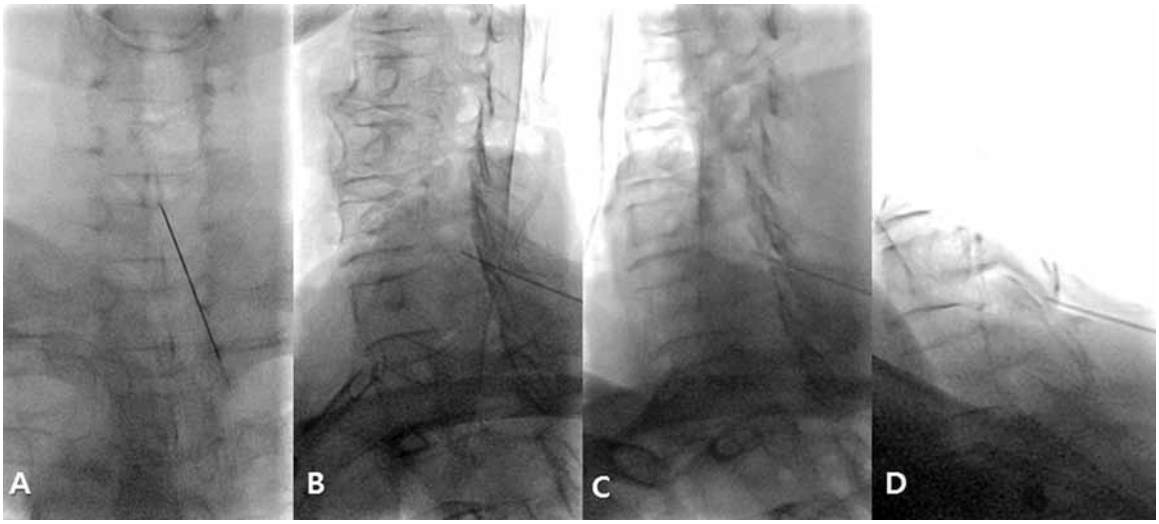

Fig. 3. *Fluoroscopic image of a cervical interlaminar epidural injection. A needle tip placed at the C6-7 interlaminar space, anterior posterior zone 1 (APZ1). Using loss of resistance (LOR), when the needle reached the epidural space, fluoroscopic image at posteroanterior (PA), contralateral oblique (CLO) 50 degrees, CLO 60 degrees, and lateral view was performed. After that, the epidural space is confirmed by contrast dye. (A) PA view (B) CLO view at 50 degrees. The depth of needle is deeper than CLO 60 degrees. (C) CLO view at 60 degrees, which shows the minimal depth of the needle beyond the ventral laminae. (D) Lateral view. Even if the tip of needle is placed at C6-7, the tip of the needle is difficult to see and the depth of insertion cannot be confidently measured.*

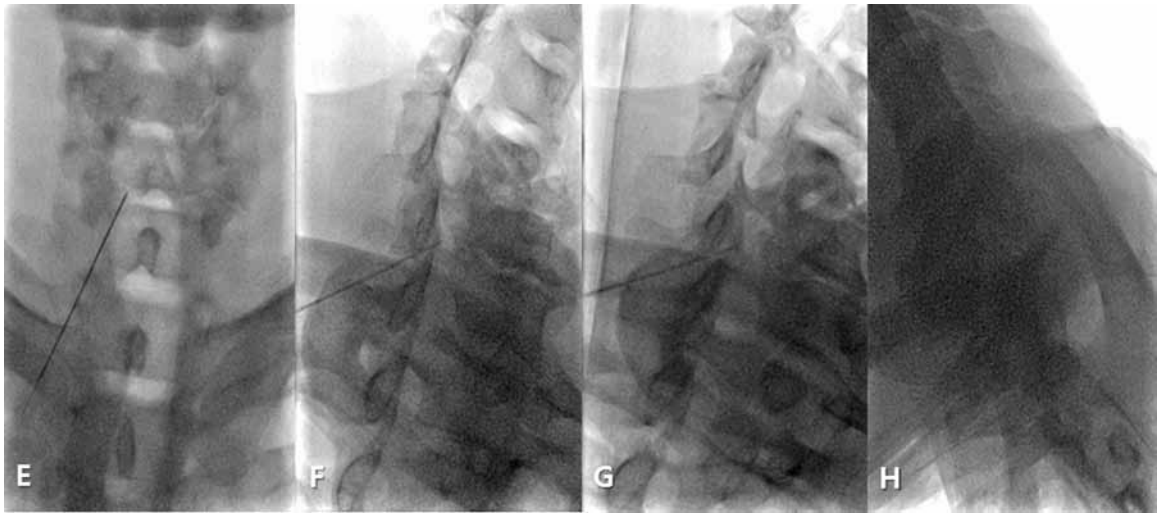

Fig. 4. *Fluoroscopic image of a cervical interlaminar epidural injection. A needle tip placed at the C6-7 interlaminar space, anterior posterior zone 2 (APZ2). Using loss of resistance (LOR), when the needle reached the epidural space, fluoroscopic image at posteroanterior (PA), contralateral oblique (CLO) 50 degrees, CLO 60 degrees, and lateral view was performed. After that, the epidural space is confirmed by contrast dye. (E) PA view (F) CLO view at 50 degrees, which shows the minimal depth of the needle beyond the ventral laminae. (G) CLO view at 60 degrees. The depth of needle is deeper than CLO 50 degrees. (H) Lateral view. The tip of the needle is difficult to see due to the shoulder and the depth of insertion also cannot be identified.*

Table 1. *Baseline characteristics of the patients.*

Parameters	N = 312
Age (years)	50.0 (44.0 - 55.0)
Sex (Male/Female)	162 (51.9%) /150 (48.1%)
Diagnosis (number)	
Cervical radiculopathy	198 (63.5%)
Cervical HIVD	79 (25.3%)
Cervical disorder	22 (7.1%)
Cervical spinal stenosis	11 (3.5%)
Cervical spondylosis	1 (0.3%)
undetermined	1 (0.3%)

Data are expressed medians (interquartile range) or numbers (%)

C7-T1, and left C7-T1 were 12.10 (CI, 10.77 – 13.43), 13.58 (CI, 12.33 – 14.82), 12.88 (CI, 11.63 – 14.13), 12.98 (CI, 11.71 – 14.26), 10.81 (CI, 9.52 – 12.09), and 12.34 (CI, 11.04 – 3.64).

Discussion

Chronic neck and upper extremity pain is very common (1). Similar to acute and chronic low back pain, neck pain also results in considerable socioeconomic and health care costs (18). Furthermore, a substantial number of patients experience severe chronic neck pain (1-4). Cervical pain most commonly originates from cervical HNPs, which account for about 40% of cases (1,2,7). Initial treatment typically consists of conservative strategies such as rest, physiotherapy, and medications. However, cervical steroid injections are frequently performed for patients whose pain is refractory to conservative management (1,2,7,8,10,19).

When performing CILESIs and CTILESIs, accurate visualization of the needle tip is important to avoid spinal cord trauma (5,7,8,15). The incidence of complications associated with CILESIs is relatively rarer than other epidural steroid injections but more catastrophic (5,8). However, poor fluoroscopic imaging of the needle tip at the lower cervical and cervicothoracic levels is well described. This technical difficulty may result in dural puncture, intrathecal steroid injection, neuropathic pain, paralysis, infarction, spinal cord injuries, or death following interlaminar epidural needle insertion (5,16). These severe neurological complications likely result from unintentional needle injury to the spinal cord or accidental injection of particulate corticosteroids into the feeding artery (5,8,10).

Various methods such as caudal manipulation of the shoulders, the swimmer's view use of fluoroscopy, and the CLO view have been employed in order to minimize and avoid severe complications (8,10,13,14). In the lateral fluoroscopic view, reasonable insertion depths have been demonstrated during midline needle insertion. However, these insertions depths are deeper with progressively increasing the distance of the needle insertion site from the midline (15,17,20). Moreover, the lateral view may be obscured frequently by the shoulders in some patients (14,17). Furthermore, due to the circumferential nature of the epidural space, the lateral view is geometrically inaccurate for visualizing the nee-

Table 2. *The anterior posterior zone 1 (APZ1) angle each level.*

Level	Side	Angle (Mean ± SD)
C5-6	Right	62.54 ± 10.52
	Left	64.34 ± 9.86
C6-7	Right	62.03 ± 10.27
	Left	62.87 ± 10.64
C7-T1	Right	61.64 ± 11.00
	Left	62.58 ± 10.83

Data are expressed as the mean ± standard deviation. APZ1 = anterior posterior zone 1.

Table 3. *The anterior posterior zone 2 (APZ2) angle each level.*

Level	Side	Angle (Mean ± SD)
C5-6	Right	50.44 ± 6.84
	Left	50.77 ± 7.00
C6-7	Right	49.15 ± 6.07
	Left	49.89 ± 6.45
C7-T1	Right	50.84 ± 6.68
	Left	50.24 ± 6.60

Data are expressed as the mean ± standard deviation. APZ2 = anterior posterior zone 2.

Table 4. *Difference of the anterior posterior zone 1 (APZ1) angle and the anterior posterior zone 2 (APZ2) angle in cervical vertebra.*

Level	Side	Difference (95% CI)	P value
C5-6	Right	12.10 (10.77 - 13.43)	<0.001
	Left	13.58 (12.33 - 14.82)	<0.001
C6-7	Right	12.88 (11.63 - 14.13)	<0.001
	Left	12.98 (11.71 - 14.26)	<0.001
C7-T1	Right	10.81 (9.52 - 12.09)	<0.001
	Left	12.34 (11.04 - 13.64)	<0.001

APZ1 = anterior posterior zone 1. APZ2 = anterior posterior zone 2.

dle tip in the epidural space, compared to the CLO view (15,17,20).

In cadaver and radiographic imaging studies, CLO views uniformly demonstrate minimal insertion depths regardless of the needle angle, compared to lateral or ipsilateral posterior oblique views. Gill et al (15) found that the CLO view provides excellent visualization of the needle tip during cervical and cervicothoracic epidural access. These authors also found that the CLO view at 50 degrees or at MRI-measured obliquity provides the most consistent and most posterior position of the needle tip at the location of epidural space access (15). The measured angles were determined by measuring the angle of ventral lamina and the midsagittal plane from previous MRIs (15,17,20). These researchers assume that MRI measured angles represent the angles measured with fluoroscopy (15,17). In our study, we also defined the ventral laminar angles from MRIs as representing the angles measured with fluoroscopy. In addition to cervical procedures, CLO views at 50 degrees and at MRI-measured obliquity are useful during thoracic and lumbar epidural steroid injections (ESIs) (20). CLO views are also useful for spinal cord stimulator insertions (21). However, CLO views at 50 degrees or at MRI-measured obliquity during cervical and cervicothoracic epidural access do have some limitations. The depth observed with an oblique view is influenced by the angle of oblique view. Moreover, as observed with a lateral fluoroscopic view, the depth observed with an oblique view is affected by the needle tip position. Especially, in patients with ligamentum flavum hypertrophy, the discrepancy between the needle tip position under fluoroscopy may be increased and the circumferential nature of the epidural space is more exaggerated (15,17).

Due to the circumferential nature of the epidural space, we hypothesized that the angles of the ventral laminar margins would differ based on the needle tip position and that the optimal oblique angle may therefore also differ based on the needle tip position for CILESIs and CTILESIs.

In the present study, we found that the mean optimal angles ranged from 49 degrees to 62 degrees at the lower cervical and cervicothoracic levels. The difference between the APZ1 angle and APZ2 angle at lower cervical and cervicothoracic levels was 10.81 – 13.58 degrees. Therefore, the optimal CLO angle for CILESIs and CTILESIs differs based on the needle tip position. When the needle tip is placed within spinous processes, a CLO view at 60 degrees is superior to other angles for assessing the epidural space. When the needle tip is placed lateral to spinous processes within the lamina, a CLO view at 50 degrees is most appropriate.

Limitations

There are several limitations to our study. This study is a retrospective review and did not employ controls, blinding, or randomization. Additionally, the optimal CLO angles for CILESIs and CTILESIs have not been assessed in clinical studies. However, the aim of the present study was to investigate optimal fluoroscopic angles for CILESIs and CTILESIs based on needle tip position. Another limitation is that we divided lamina into only APZ1 and APZ2. In cervical MRI, the APZ may be further divided. However, it is difficult to identify other than bonny structures such as spinous process and lamina under fluoroscopic guidance. Moreover, in clinical practice, CILESIs and CTILESIs are performed under fluoroscopic view. Therefore, we thought that under fluoroscopic view, APZ1 and APZ2 were enough to divide lamina for analyzing of the optimal CLO angle.

Despite these limitations, the data support clinically relevant conclusions. First, the optimal angles for CILESIs and CTILESIs differ based on needle tip position. Second, the optimal angles differ by approximately 10 degrees between APZ1 and APZ2.

Conclusions

The mean optimal CLO angle for CILESIs and CTILESIs differed based on needle tip position. When the needle tip is placed in the interlaminar space and within the spinous processes margin, a CLO view at 60 degrees is superior to other angles for assessing the epidural space. When the needle tip is placed in the interlaminar space and lateral to the spinous processes margin to lateral margins of the lamina, a CLO view at 50 degrees is most appropriate for performing CILESIs and CTILESIs.

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