C-Arm Fluoroscope Angle Settings for Fluoroscopically Guided Lumbar Transforaminal Epidural Injections

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Abstract

Background Data. Minimizing fluoroscopy time in spine interventions is critical for time of procedure as well as radiation safety of the patient and medical personnel. Specific fluoroscopy angle settings for fluoroscopically guided L4-S1 transforaminal epidural injections (TFEIs) have not been described.

Objectives. To describe the most common encountered settings for the C-arm fluoroscope angles for fluoroscopically guided L4-S1 (TFEI).

Methods. Each subject was placed in prone position on a flat fluoroscopy table without utilizing any device to alter innate lumbar spine curvature. The data from 246 consecutive patients at their first encounter in the fluoroscopy suite for a single level subpedicular lumbosacral TFEI was retrospectively analyzed. Most procedures occurred at the L4-5, L5-S1, and S1 levels (227 subjects). The C-arm angles including the oblique, cephalad/caudal were recorded for each subject upon observing final needle positioning for successful completion of the procedure according to ISIS Guidelines.

Results. For the L4-5 level, 71% of cases had oblique angle of 30°±5° and 94% of cases had neutral cephalad/caudal tilt (0°±5°) observed. For the L5-S1, 72% of cases had oblique angle of 30°±5° and 62% of cases had cephalad tilt angle of 15°±5° observed. For the S1 level, 73% of cases had oblique angle of 5°±5° and 69% of cases had cephalad tilt angle of 15°±5° observed.

Discussion/Conclusion. This retrospective descriptive study suggests fluoroscope angles for L4-S1 TFEI as a starting point before fine tuning views accounting for individual anatomy. Angles suggested for each level (oblique/cephalad tilt angles) are as follows: L4-5 (30°/0°), L5-S1 (30°/15°), and S1 (5°/15°). Prospective studies using these guidelines would need to be undertaken to prove reproducibility between interventionalists, time efficiency, and radiation exposure reduction.

Key Words. Epidural (Injection Space); Fluoroscopy; Interventional; Spine; Safety

Introduction

Transforaminal epidural injections (TFEIs) have been used to treat lower back and radicular leg pain since the early 1950s [1]. The traditional technique used is the subpedicular approach [2,3]. The lumbar TFEI technique using C-arm fluoroscopy for visualization allows a high concentration of corticosteroid to be delivered precisely to the target site [4,5]. Literature reviews have consistently demonstrated supportive evidence for the clinical success in relief of pain symptoms [6–8].
Over the last 60 years, modifications and alternative versions have been recommended in relation to the approach and needle placement, as well as to improve methods of visualization [9–14]. These changes have been made in an effort to decrease the harmful effects of radiation [15], reduce complications [16–19], and improve pain control. Studies have focused on minimizing the damage of stochastic and deterministic injuries that are the result from radiation encountered during the procedure [20,21]. Overall, they have been demonstrated to decrease the radiation dosage to the body while maintaining the quality of images necessary for clinically successful delivery of corticosteroids.

Fluoroscopically guided transforaminal epidural steroid injections use specific C-arm angle settings to accurately visualize target structures with various C-arm angle settings (ie. oblique, cephalad, caudal tilt). A trajectory view is used to accurately visualize anatomical structures prior to needle insertion. The International Spine Intervention Society practice guidelines [22] describe the traditional subpedicular approach to TFEI [3,26]. The subpedicular approach requires some degree of obliquity and/or cephalad/caudal tilt to begin the procedure. Multiple images are captured in order to find the appropriate trajectory view prior. To our knowledge there have not been any studies that look at specific C-arm angles settings for specific spinal levels to be used in lumbar therapeutic TFEI. On this basis, it is our objective to report the most commonly encountered angles for the C-arm fluoroscope during visualization of these procedures, in our practice.

Various approaches to the TFEI technique have focused on the reducing complications of intravascular or intrathecal uptake and direct injury to the nerve. The “safe triangle” was described as a location where delivery of medication could be accomplished with minimal risk of complications [2,3,22]. The “Scotty dog” is sometimes used as positional landmark orienting the needle approach [22–24]. In this manner, the fluoroscope should be positioned oblique ipsilaterally to allow for the proper visualization of the “safe triangle.” The target needle is then advanced below the “chin” of the Scotty dog. Anatomically, this represents a position that is adjacent to the pars interarticularis and inferior to the pedicle [23]. Another described landmark is the lateral margin of the superior articular process [25]. Normal anatomy of the lumbar spine varies in patients. During the evolutionary development of Homo sapiens toward an upright, erect posture, spinal curvature adjusted under gravity and motion [26]. Disorders and pathology affecting the natural curvature, such as excessive lordosis and degenerative spondylolisthesis may alter the architecture increasing the difficulty of visualization.

This study was developed to advance the guidelines for initial fluoroscopy settings for the above named procedures that would reduce the ambiguity in protocols and potentially increase safety and decrease the total radiation exposure required to complete these procedures.

Methods

This study was conducted at a major university hospital with a protocol approved by the hospital/university institutional review board.

The data from 223 consecutive patients undergoing a first time 263 single level lumbar transforaminal epidural injections were retrospectively reviewed in our study. Only data from patients that underwent successful completion of the procedures, as per guidelines [22], were included. Patient data was eligible for inclusion if the patient was undergoing their first encounter in the fluoroscopy suite for a single level (L4-L5, L5-S1, S1) injection, or first injection at each level of a multilevel unilateral TFEI. Patients undergoing their first injection of a single level bilateral TFEI were included. The second injection was excluded from the data set. Procedures were excluded for patients undergoing repeated injection of a previously recorded level because prior angle data collected at the initial procedure guided initial fluoroscopy angle settings on subsequent procedures.

All of the procedures were performed at a large university hospital in a fluoroscopy suite by a single interventional spine attending physiatrist (CP). A single radiology technologist (CM) with over 10-year experience in spine procedures, operated the C-arm and recorded the angles for all cases. Data including patient identifiers, side of procedure, level of procedure, type of procedure, and angles of oblique, cephalad, and caudal were recorded at the time of the procedure. A Siemens Siremobil Compact L fluoroscopy C-arm (Siemens, Malvern, PA, USA) was used for all cases on the same radiolucent procedure table. Each subject was placed in the prone position on a flat procedure table. There were no external devices used to alter patients’ natural lumbar spine curvature. Sterile technique was maintained throughout the procedure. Procedure technique followed the described subpedicular approach for transforaminal epidural steroid injections. The identification of the targeted intervertebral foramen began with anteroposterior fluoroscopic images to determine level, such that the X-ray beam passed tangentially to the inferior vertebral endplate of the upper of the two vertebras of the target segment. The subpedicular approach was used for all procedures [21]. Visualization of the target point, the posterior surface of the vertebral body adjacent to the caudal border of the pedicle above the target nerve, opposite the sagittal bisector of pedicle (“six o’clock” position of the pedicle) [22], was obtained using various degrees of oblique, cephalad, and/or caudal tilt of the C-arm fluoroscope. After the subpedicular space was maximally exposed in the oblique view, the radiology technologist recorded the degrees oblique, cephalad, or caudal. The skin was anesthetized with injection of local anesthetic (1% Lidocaine) over the target point. A 22-guage 3.5-, 5-, 7-, or 8-inch Quincke spinal needle was placed such that the needle tip was co-axial to the...
beam of the C-arm and in optimal trajectory. Under intermittent fluoroscopic guidance, the needle was advanced maintaining target in the oblique view. Needle tip position was confirmed with the anteroposterior and lateral views. The C-arm was returned to the anteroposterior position for injection of contrast material, iohexol, or gadolinium (for patients with known allergies to contrast) under live fluoroscopy. Contrast injected confirmed epidural flow pattern without intravascular or intrathecal uptake. Once a satisfactory contrast flow pattern was obtained, the therapeutic volume of 2 mL of 1% lidocaine and 1.6 mL of dexamethasone 10 mg/mL was then delivered. All needles were withdrawn and the procedure terminated.

Data collection and descriptive statistical analysis was performed using Microsoft Excel (Redmon, WA). Data was recorded for patients receiving lumbar transforaminal or selective spinal nerve injections. Patient identifiers were removed and each received a subjective number. For each subject, the following parameters were recorded: sex, age, side of procedure, level of procedure, degrees oblique, degrees cephalad or caudal. For cases that required no cephalad nor caudal tilt, the arbitrarily received the assignment of 0 (zero) degrees of tilt. Descriptive statistics including ranges and modes were derived. The data was not normally distributed. We decided to use modes to identify the most frequent settings for C-arm angles for certain levels of transforaminal epidural injections. We did not use average or median since it would have added no useful information.

Results

Demographics for age, sex, and levels studied are given by Table 1. The analysis of the angles settings used in procedures previously described showed that the L4-5 neuroforaminal level (L4 nerve root) had a total of 70 procedures. Seventy-one percent (71%) of procedures had oblique tilt of 30° ± 5°. There were 93 procedures analyzed for the L5-S1 neuroforaminal level. Seventy-two percent (72%) of the procedures had oblique tilt of 30° ± 5°. Sixty-two percent (62%) had cephalad tilt of 15° ± 5°. One hundred percent (100%) had 0° ± 5° of tilt. There were 71 total procedures analyzed at the S1 neuroforaminal level. Seventy-three percent (73%) of those procedures had oblique tilt of 5° ± 5°. Sixty-nine

<table>
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<th>Nerve root level</th>
<th>Number of procedures</th>
<th>Number of subjects</th>
<th>Age range</th>
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<tr>
<td>L1</td>
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<td>1</td>
<td>0-44</td>
</tr>
<tr>
<td>L2</td>
<td>7</td>
<td>7</td>
<td>3-4</td>
</tr>
<tr>
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<td>11</td>
<td>8-3</td>
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<tr>
<td>L4</td>
<td>70</td>
<td>66</td>
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</tr>
<tr>
<td>L5</td>
<td>93</td>
<td>90</td>
<td>45-93</td>
</tr>
<tr>
<td>S1</td>
<td>71</td>
<td>71</td>
<td>34-91</td>
</tr>
<tr>
<td>Total</td>
<td>255</td>
<td>246</td>
<td>118</td>
</tr>
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</table>

Figure 1  (A) Obliquity for L4-5 level, (B) cephalad/caudal for L4-5 level.
Figure 2  (A) Obliquity for L5-S1 level, (B) cephalad/caudal for L5-S1 level.

Figure 3  (A) Obliquity for S1 level, (B) cephalad/caudal for S1 level.
percent (69%) had cephalad tilt of 15° ± 5°. Ninety-nine percent (99%) of procedures had caudal tilt of 0° ± 5° (Table 2).

A visual depiction of angles of oblique, cephalad, caudal for L4-5, L5-S1, and S1 levels are given by Figures 1–3. Among them the most frequently injected level was the L5-S1 level. The most commonly used angle settings at L5-S1 level were 30° obliquity and 15° cephalad tilt. The data shows that for the L4-5 level was 30° obliquity without cephalad and/or caudal tilt.

The most common angle setting in S1 TFEI was 5° oblique and 15° cephalad tilt. Traditional approach to this level injection would use an AP view with some degree of caudal tilt. Our results show the most commonly used angles involved oblique as well as cephalad tilt. There were no patients that received caudal tilt out of a total of 91 procedures.

Discussion

The incorporation of C-arm fluoroscopic imaging to visualize the needle trajectory for lumbar TFEI has been operator dependent. Our aim of this study was to assess and report the most common C-arm fluoroscopic angles we used in our trajectory view after successful completion of L4, L5, and S1 TFEI. This study suggests fluoroscope angles for L4-5, L5-S1, and S1 TFEI as a starting point before fine tuning views accounting for individual anatomy. C-arm fluoroscope angles suggested for each level (oblique/cephalad/caudal tilt angles) are given below

• L4-5 TFEI 30° oblique and 0° tilt
• L5-S1 TFEI 30° oblique and 15° cephalad tilt
• S1 TFEI 5° oblique and 15° cephalad tilt

Variations in anatomy may alter how much obliquity is used in transforaminal injections. For example, the posterior sacral S1 foramen may be better visualized without using the oblique in some patients, whereas other patients may require less cephalad tilt. In cases where foraminal stenosis is present, there is less access to the intervertebral foramen requiring adjustment of the fluoroscope. The use of cephalad tilt for the L5-S1 level makes sense because of the blocking by the ilium, which obscures visualization. For the L4-5 level, the oblique view is expected because the pars intercatalis can be seen found between a true lateral and a true AP view of the corresponding level. The pedicle can be visualized with some degree of obliquity. In the AP view without any obliquity, the posterior sacral S1 foramen is not always predictable as the ventral foramen is often the more easily seen structure. The use of oblique tilt correlates with Fish et al., who reported predictable visualization of the S1 posterior sacral foramen with use of the “Scotty dog” as a visual guidance to find the superomedial border of the foramen [5].

The scoliotic spine may not result in the preferred trajectory view. Angle adjustments in the cephalad or caudal position may be needed in order to line up the corresponding superior endplate [23]. These differences can increase the time spent locating the preferred starting position and number of images captured.

Incorporation of preset angles to guide the operator in locating target and trajectory can have multiple benefits. Providing these initial angles to interventionalists in training can be helpful as a suggested place to start before fine tuning the oblique view. The interventionalist can potentially decrease procedure time and reduce radiation exposure to the patient and procedure room staff.

The drawback of our study was the assessment of three vertebral levels by a single interventionalist in an academic spine practice using a subpedicular approach.
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Other approaches could yield different results. The data reported are a reflection of our own personal practices, and are not necessarily ideal or the only angles that could be used; others might care to use a steeper obliquity, or use a different approach for lumbar TFEI. Also, for patients that underwent bilateral procedures, only the initial injection side was included. This was done to exclude bias that could occur after performing the first injection. We believe that an interventionalist is more apt to reapply the same fluoroscopic setting based on the results of the previous injection. There was selective bias to which side was preferred for the initial injection of a planned bilateral procedure.

The patient population did not exclude for any anatomical variation and was reflective of what was encountered at this particular academic center. Neither body habitus nor anatomical deformities of the lumbar spine (e.g., Sacralized L5, Lumbarized S1, Scoliosis, Increased lumbar lordosis) were adjusted when positioned prone on the table. Body mass index (BMI) was not routinely recorded for all patients; however, it has previously been shown that there is no correlation between BMI and needle depth to epidural space or distance to the target. The differences in body habitus were not believed to affect the landmarks used during TFEI procedures and should not be expected to influence our findings. The degree of angulation is based on fluoroscopic views between the zygapophysial joint and the vertebral body.

Future studies of interest include examining the reduction in radiation exposure after implementing the recommended initial angle settings. While our study did not document the fluoroscopy time for each procedure nor the radiation exposure dose per procedure we believe these would both decrease for the performing interventionalist. Additionally, the accuracy of each recommended angle settings could be strengthened by a larger, multi-centered study involving more than just one interventionalist to prove reproducibility.

In summary, this study suggests fluoroscope angles for L4-5, L5-S1, and S1 TFEI as a starting point before fine tuning views accounting for individual anatomy. C-arm fluoroscope angles suggested for each level (oblique/cephalad/caudal tilt angles) are given below:

- L4-5 TFEI 30° oblique and 0° tilt
- L5-S1 TFEI 30° oblique and 15° cephalad tilt
- S1 TFEI 5° oblique and 15° cephalad tilt

References


