Retrospective Review

Reliability and Safety of Contra-Lateral Oblique View for Interlaminar Epidural Needle Placement

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Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 12-08-2014
Revised manuscript received: 04-26-2016
Accepted for publication: 06-14-2016

Free full manuscript: www.painphysicianjournal.com

Cord trauma is a risk with a cervical and thoracic interlaminar epidural approach to the epidural space. Intermittent lateral fluoroscopic imaging to detect needle depth is often cumbersome and may be difficult to interpret. In comparison, the contra-lateral oblique (CLO) fluoroscopic view is efficient and easy to interpret. However, the in vivo reliability and safety of this technique has not been formally investigated.

The senior author collected fluoroscopic images on 278 consecutive patients undergoing an interlaminar epidural block at the T1-T2 level performed using a 17 gauge Tuohy needle. Before catheter placement, anterior-posterior (AP) and CLO fluoroscopic images were saved with the needle at the ligamentum flavum and the needle just through the ligamentum flavum.

We randomly selected the images of 40 cases that included the paired CLO images (total 80 images) documenting the views at and through the ligamentum flavum. Three interventionalists were asked to review, in a blinded fashion, the randomly selected, paired CLO images and to score each image, recording whether the 17 gauge needle was in or out of the epidural space to determine the accuracy and reliability of this technique.

There was a 97.5%, 95%, and 93.8% agreement between each reviewing physician and the senior author resulting in a correlation using the Kappa statistic value of 0.950, 0.875, and 0.874, respectively ($P < 0.001$). The 3 reviewing physicians disagreed with the senior author's correct answer in 2.5%, 5%, and 6.2%, respectively, however, the disagreement occurred primarily because of poor image quality. Agreement between the 3 reviewing physicians was 93.8%, 96.3%, and 90%, with a Kappa value of 0.875, 0.924, and 0.799, respectively ($P < 0.001$). There was 100% technical success in the 278 case series without "wet taps," provocation of pain during entry, or any other immediate post procedural complication.

We conclude the CLO view provides an efficient and reliable method to visualize needle tip depth in relation to the epidural space. The close inter-observer agreement was possible with minimal physician instruction.

Key words: Cervical interlaminar, cervical epidural, contra-lateral oblique, fluoroscopic imaging

Pain Physician 2017; 20:E65-E73

The distance between the ligamentum flavum and the dura and spinal cord is typically less than 3 – 5 mm in the cervical and high thoracic spine (1). The narrow space and the intermittent absence of the ligamentum flavum in the midline increase the risk of inadvertent dural and cord puncture by an advancing needle tip (2). The standard technique for mitigating this risk during a cervical/thoracic epidural injection is monitoring depth using the lateral fluoroscopic view. Logistically inconvenient, the lateral view requires rotating the C-arm 90 degrees while maintaining sterility. More important, images are often hard to accurately evaluate due the patient's shoulders overlapping the spine and obscuring the fluoroscopic image at the low cervical and high thoracic segment of the needle target.

The mid-2000s saw the dissemination of an alternate fluoroscopic view that was more convenient and provided a better view of needle depth. Perhaps evolving independently in several centers, the technique was labeled the contralateral oblique view (CLO) as first described by Whitworth in 2008 (3). More recently published studies conclude that the CLO projection is a better and simpler technique for visualizing needle depth compared to the lateral view (3-9). Intra- and inter-observer reliability have not been reported.

Beginning in 2009 during the initial and subsequent usage of the CLO fluoroscopic technique, we obtained, as per our standard practice protocol, anterior-posterior (AP) and CLO views before and after passing a 17 gauge Tuohy needle through the ligamentum flavum. Randomization and blind evaluation of these images allowed determination of inter-observer agreement of the needle tip position relative to the epidural space.

Methods

Protocol

In April 2009, the senior author added the CLO view to validate needle entry into the epidural space. As per our usual and customary protocol, AP and CLO fluoroscopic images were viewed and saved before and after the needle was advanced through the ligamentum flavum, and after catheter insertion and contrast verification. As part of our ongoing audit of complications related to specific techniques, the senior author performed and saved AP and CLO fluoroscopy views on 278 consecutive patients from April 2009 to August 2012 while performing a cervical interlaminar epidural block using a catheter technique at the T1-2 levels. All of the patients understood and agreed that we may use their treatment information for research purposes. A series of images were saved demonstrating the tip of the 17 gauge Tuohy needle on the ligamentum flavum, through the ligamentum flavum, and after catheter advancement, with confirmatory spread of 1 – 2 mL of contrast medium within the epidural space (Fig. 1).

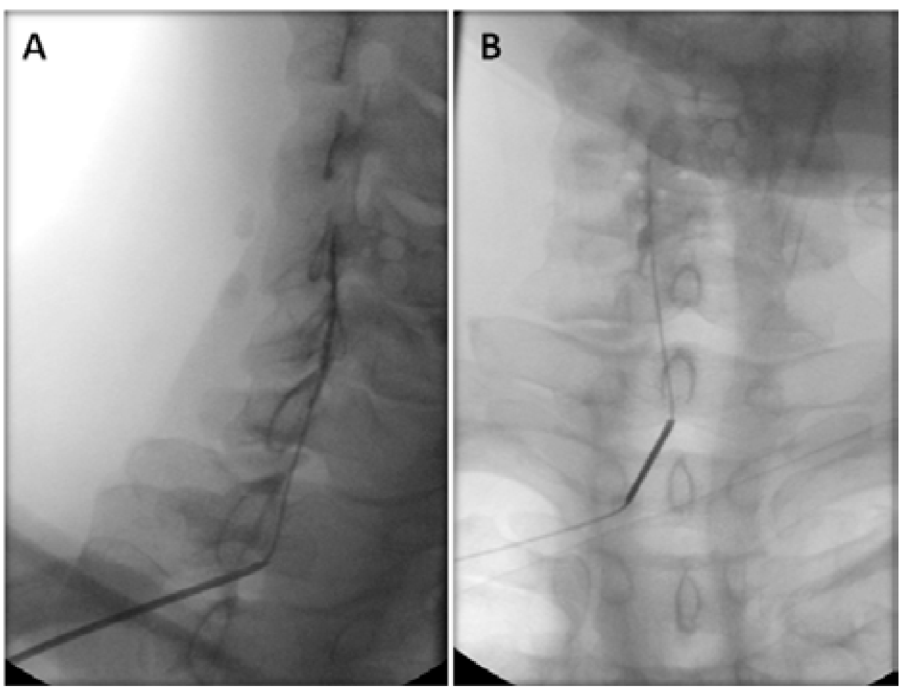

Fig. 1. *Placement of an epidural catheter via correctly positioned 17G Touhy needle through the ligamentum flavum, with confirmatory spread of contrast medium (A: CLO view; B: AP view).*

A CLO view before and after passage of the 17 gauge needle through the ligamentum flavum was assigned a number that was unknown to the reviewing physicians. Two of the physicians performed lumbar epidural injections, but not cervical interlaminar injections. The third physician had 14 years' experience performing occasional cervical interlaminar injections. The physicians were given written and verbal instructions for CLO interpretation including recognizing the interlaminar line and recognizing the needle tip position on the CLO. The qualification was simply the needle tip proximal or on the interlaminar line was not through the ligament and the proximal needle bevel beyond the interlaminar line was through the ligament. The physicians were blinded and did not consult with each other. The senior author reviewed all cases where there was disagreement. The images were saved only after the needle was in the epidural space and documented by passage of the catheter. Prior to blinded evaluation these images were marked as in or out. All other patient information including their names, identifications, and time sequence were removed from the images to maintain blinding and for patients' confidentiality. No contrast was injected during the initial entry and thus images with the catheter in place were not given to the evaluating physicians.

The 40 cases were recruited using random sampling from the 278 consecutive patients who underwent interlaminar epidural injection for chronic and subacute neck pain with a proximal and distal radicular component. To draw a random sample from the patients, each patient was numbered sequentially. Forty numbers between one and 278 were randomly generated by a computer. Each number had an equal chance to be generated by the computer (in order to fill the simple random sampling requirement of an equal chance for every unit). The research assistant provided 80 images (formally paired images of 40 cases), randomly assembled, to the study physicians for their evaluation. The study physicians were asked to review the images and record whether the 17 gauge needle was in or out of the epidural space evaluating the views at and through the ligamentum flavum. The study physicians were instructed not to seek any other information about the patients or the procedure.

Technique

All interlaminar epidural injections were performed by the senior author at the surgical suite of an ambulatory surgical center. Each patient was placed in the prone position with the neck slightly flexed. The skin was sterilely prepped and draped, with strict sterile technique being maintained throughout the entire procedure. Most patients underwent light sedation, with vital signs being continuously monitored. Prior to the placement of the Tuohy needle, the skin and subcutaneous and deep muscular tissues along the trajectory of the needle were infiltrated with 1% lidocaine, toward the lamina of the caudal level (typically T2, of the T1-2 segment) on the ipsilateral side of the planned catheter placement. The technique used was similar the same in all cases. A 17 gauge needle was necessary to pass the catheter cephalad. A catheter was advanced in all cervical and high thoracic interlaminar epidural injections.

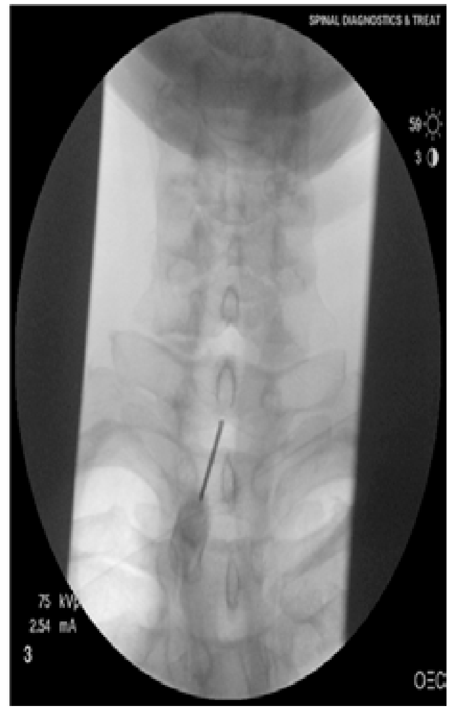

Fig. 2. *An example of a Touhy needle positioning in AP view at the interlaminar space.*

The 17 gauge needle was advanced to the edge of the lamina using intermittent AP fluoroscopy until the bony landmark was clearly felt. The needle tip was redirected without significantly withdrawing the needle to point at a location ~2 mm to the ipsilateral side of the midline (Fig. 2). The needle was advanced using intermittent AP monitoring until the resistance of the

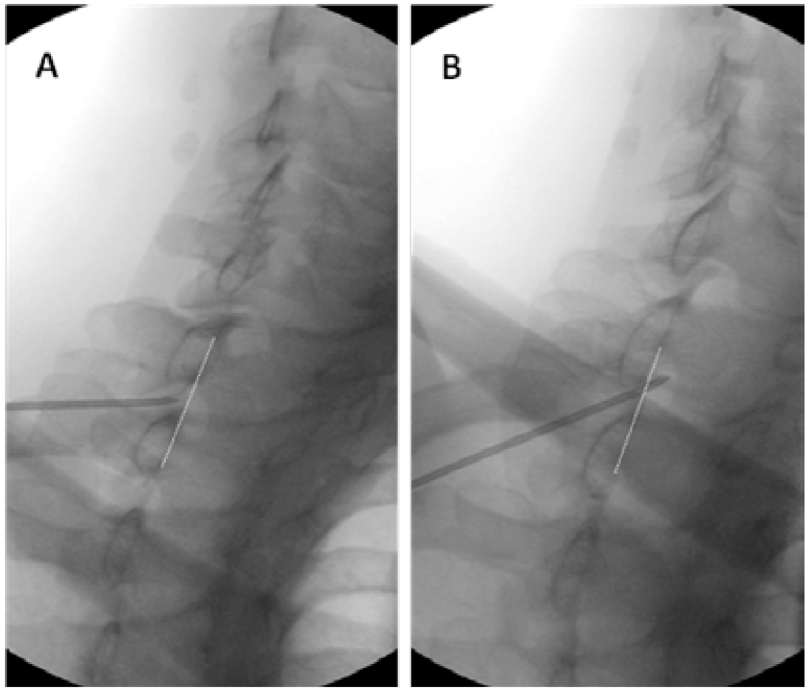

Fig. 3. *CLO fluoroscopy views of the 17G Tuohy needle tip projection "at the" ligamentum flavum (A) and "through" the ligamentum flavum (B) in relation to the interlaminar line.*

ligamentum flavum was felt at a position just below the upper lamina. In the few cases where the ligament could not be felt within 1 cm of a needle advancement, a CLO view was used to determine the needle depth within the spinal canal (Fig. 3). The depth of penetration and the relation of the needle tip to the interlaminar line was documented and the AP and CLO fluoroscopic images saved. For the CLO image projection, the intensifier tube was obliquely rotated to 45 ± 2 degree angle opposite the side of needle insertion (Fig. 3A).

Loss of resistance to fluid pressure during needle advancement through the ligamentum flavum was used to identify the epidural space. The depth of the needle tip in relation to the interlaminar line was confirmed by the AP and CLO views (Fig. 3B). These images were digitally saved. When resistance of the ligamentum flavum was not clearly felt, the CLO view was intermittently checked during needle advancement. A catheter was then advanced ipsilaterally to the target segment that correlated to the level of the patient's symptomatology, and 1 mL of contrast medium was injected, confirming epidural spread of the material. Fluoroscopic AP and CLO views were digitally saved (Fig. 1). For most therapeutic procedures, 2 mL of 1% xylocaine mixed with 40 mg Kenalog (current protocol uses 10 mg decadron) was then injected through the catheter. The needle and catheter were removed and a dressing applied. Patients were brought to a recovery room for the monitoring.

Statistical Analysis

Cohen's Kappa test was used to examine the strength of the association between the different interventionists' opinion scores after their review of the randomly selected, non-paired CLO images (e.g., study physician A and B or senior author and study physician A.) Kappa statistics are appropriate for looking at associations between categorical variables that have the same number of categories. We adopted Fleiss et al's (10) interpretations of Kappa 0.75 as excellent, 0.40 to 0.75 as fair to good, and below 0.40 as poor. In all the analyses, a *P*-value of < 0.05 was considered as statistically significant.

Results

Demographics

Table 1 shows the demographic and clinical characteristics of the patients included in the study. The average patient's age was 54.9 ± 11.9 years (range, 27 – 85); 40% men and 60% women. The mean height of the patients was 66.7 ± 3.9 inches (range, 61 – 74) and mean weight was 175.9 ± 35.7 pounds (range, 115 – 290).

Outcome

Three interventionalists were asked to review in a blinded fashion the randomly selected, paired CLO images and to score each image, recording whether the 17 gauge needle tip was at or through the ligamentum flavum. Their answers were independently compared to the impressions of the senior author, who performed the injections, as shown in Table 2. We specifically asked 2 interventionalists that do not perform cervical epidural injections to determine the ease and the accuracy of this fluoroscopic technique, even for inexperienced physicians.

Table 1. *Demographic and clinical characteristics of study patients.*

Age (years)	54.9 ± 11.9
Gender Male (%) Female (%)	 40.0% 60.0%
Height (inches)	66.7 ± 3.9
Weight (pounds)	175.9 ± 35.7
Duration of symptoms (yrs)	9.6 ± 10.7
Previous Surgery (%)	22.2%
Work-related injury Yes (%) No (%)	 33.3% 66.7%
Motor vehicle accident Yes (%) No (%)	 16.7% 83.3%
Litigation Yes (%) No (%)	 16.7% 83.3%

Table 2. *Comparison of image evaluation scores between study physicians and a senior author performing injections.*

Answer Scores				
Case number	Interventionalist perfoming injections	Three blinded physicians		
		A	B	C
1-1	At	At	At	At
1-2	Through	Through	Through	Through
2-1	At	At	At	At
2-2	Through	Through	Through	Through
3-1	At	At	At	At
3-3	Through	Through	Through	Through
4-1	At	At	Through	Through
4-2	Through	Through	Through	Through
5-1	At	At	At	At
5-2	Through	At	Through	Through
6-1	At	Through	Through	Through
6-2	Through	Through	Through	Through
7-1	At	At	At	At
7-2	Through	Through	Through	Through
8-1	At	At	At	At
8-2	Through	Through	Through	Through
9-1	At	At	At	Through
9-2	Through	Through	Through	Through
10-1	At	At	At	At
10-2	Through	At	Through	Through
11-1	At	Through	At	At
11-2	Through	Through	Through	Through
12-1	Through	Through	Through	Through
12-2	Through	Through	Through	Through
13-1	At	At	At	At

Answer Scores				
Case number	Interventionalist perfoming injections	Three blinded physicians		
		A	B	C
13-2	Through	Through	Through	Through
14-1	At	At	At	At
14-2	Through	Through	Through	Through
15-1	At	At	At	At
15-2	Through	Through	Through	Through
16-1	At	At	At	At
16-2	Through	Through	Through	Through
17-1	At	At	At	At
17-2	Through	Through	Through	Through
18-1	At	At	At	At
18-2	Through	Through	Through	Through
19-1	At	At	At	At
19-2	Through	Through	Through	Through
20-1	At	At	At	At
20-2	Through	Through	Through	Through
21-1	At	At	At	At
21-2	Through	Through	Through	Through
22-1	At	At	At	At
22-2	Through	Through	Through	Through
23-1	At	At	At	At
23-2	Through	Through	Through	Through
24-1	At	At	At	At
24-2	Through	Through	Through	Through
25-1	At	At	At	At
25-2	Through	Through	Through	Through

Table 2 (cont). *Comparison of image evaluation scores between study physicians and a senior author performing injections.*

Answer Scores				
Case number	Interventionalist perfoming injections	Three blinded physicians		
		A	B	C
26-1	At	At	At	At
26-2	Through	Through	Through	Through
27-1	At	At	At	Through
27-2	Through	Through	Through	Through
28-1	At	At	At	At
28-2	Through	Through	Through	Through
29-1	At	At	At	Through
29-2	Through	Through	Through	Through
30-1	At	At	At	At
30-2	Through	Through	Through	Through
31-1	At	At	At	At
31-2	Through	Through	Through	Through
32-1	At	At	At	At
32-2	Through	Through	Through	Through
33-1	At	At	At	At

Answer Scores				
Case number	Interventionalist perfoming injections	Three blinded physicians		
		A	B	C
33-2	Through	Through	Through	Through
34-1	At	At	At	At
34-2	Through	Through	Through	Through
35-1	Through	Through	Through	Through
35-2	Through	Through	Through	Through
36-1	At	At	At	At
36-2	Through	Through	Through	Through
37-1	At	At	At	At
37-2	Through	Through	Through	Through
38-1	At	At	At	At
38-2	Through	Through	Through	Through
39-1	At	At	At	At
39-2	Through	Through	Through	Through
40-1	At	At	At	At
40-2	Through	At	Through	Through

Randomization and blind evaluation of these images allowed determination of inter-observer agreement of the needle tip position relative to the epidural space, summarized in Table 3.

There was a 97.5%, 95%, and 93.8% agreement between each study physician and the senior author. The agreement with the images analysis was excellent (10), with Kappa statistic values of 0.950, 0.875, and 0.874 for the study physicians and the senior author, respectively ($P < 0.001$). Confidence intervals for the values were 0.902 – 0.998, 0.803 – 0.948, and 0.801 – 0.947, respectively, as shown Table 3. The study physicians disagreed with the senior author's correct answer in 2.5%, 5%, and 6.2%, respectively, however, the disagreement occurred primarily because of the poor quality of printed fluoroscopic images. Agreement between the study physicians was excellent (10), 93.8%, 96.3%, and 90%, with a Kappa value of 0.875, 0.925, and 0.799, respectively ($P < 0.001$). Confidence intervals for the values were 0.803 – 0.948, 0.867 – 0.983, and 0.711 – 0.887, respectively, as shown Table 3. There were no reported complications, with a 100% technical procedural success rate in the 278 case series, including absence of "wet taps," provocation of pain upon needle entry, or any immediate post procedural complications directly attributed to needle placement into the epidural space.

Table 3. *Independent correlation of the answer scores between physicians with inter-observer agreement evaluation.*

Doctors	Agree	Disagree	Kappa value	95% CI	*P*
Senior author v. Study physician A	93.8% (75/80)	6.25% (5/80)	0.875	0.803 – 0.948	0.000
Study physician A v. Study physician B	93.8% (75/80)	6.25% (5/80)	0.875	0.803 – 0.948	0.000
Senior author v. Study physician B	97.5% (78/80)	2.5% (2/80)	0.950	0.902 – 0.998	0.000
Study physician A v. Study physician C	90.0% (72/80)	10.0% (8/80)	0.799	0.711 – 0.887	0.000
Senior author v. Study physician C	95.0% (76/80)	5.0% (4/80)	0.874	0.801 – 0.947	0.000
Study physician B v. Study physician C	96.3% (77/80)	3.75% (3/80)	0.925	0.867 – 0.983	0.000

CI: Confidence Intervals

Discussion

Safe and efficient cervical/thoracic interlaminar epidural injections are possible when an interventionalist is able to control the needle tip during its advancement, and be able to consistently and accurately determine the needle positioning at the ligament flavum, within the ligament, and through the ligament. Using the AP view, the approximate depth to the epidural space may be determined by contacting the lamina. In most cases after advancing the needle tip 1 cm, one will clearly feel the ligamentum flavum, however ligament thickness is often inconsistent and may be absent in the midline (11,12). In addition, a false loss of resistance may be encountered in 53% of cases (13) prior to reaching the ligamentum flavum. Prior to this audit, when the ligamentum flavum was not clearly felt within 1cm, we either re-established depth by withdrawing the needle and retouching lamina, moved to another level/side, or used a lateral fluoroscopic projection to visualize needle tip depth.

At inception, our audit was designed to evaluate the safety of this technique by confirming and documenting needle depth using the CLO view. Specifically, our audit sought to document patient safety via the consistency and accuracy of the CLO view with the tip of the epidural needle on the ligament and when the needle bevel was through the ligament. In ~90% of the cases the ligamentum flavum was clearly felt and passage through the ligament was clearly recognized by loss of resistance. The recorded fluoroscopic images on these cases represented the case samples (Fig. 3).

Fig. 4. *Positioning of the fluoroscopy tube at the contra-lateral oblique 45±2 degree angle.*

The standard lateral projection protocol to guide needle depth during an epidural injection was a practice standard, but was never validated. The technique was anecdotally considered unreliable by many interventionalists. A "Rapid and Reproducible Fluoroscopic Needle Endpoint for Cervical Interlaminar Epidural Steroid Injections" was presented at the American Academy of Pain Medicine by Whitworth in February 2008 (3). He described a technique that he learned from his associate, Dr. Kirk Puttlitz. He used a 30 degrees contra-lateral oblique projection of the fluoroscopy tube to determine needle depth. In his experience, he felt that the images consistently and reliably projected of the needle tip in direct relation to the "Puttiltz" (interlaminar) line.

In 2012, Landers, Dreyfuss, and Bogduk (4) described the anatomical landmarks of the interlaminar line and the projection of the needle tip in relation to this line using anatomical dissections and fluoroscopic images. In 2014 Gill et al (9) compared the reliability of the lateral fluoroscopic view compared to the CLO view at different angles to predict the accuracy of the needle tip position. They studied 24 patients using fluoroscopic images and found the CLO view superior to the lateral projection The needle tip was clearly visualized at all CLO projections at 50 degrees.

The degree of c-arm rotation affects the perceived needle depth (14,15). Although Gill et al (9) found the needle depth best evaluated at ~50 degrees, we found that at between 40 and 47 degrees the needle tip depth was easy to judge, on average 45 ± 2 degrees (Fig. 4). Verbally explaining landmark depth rules in relation to the interlaminar line allowed 2 interventional physicians that had never performed cervical interlaminar injections and one moderately experienced interventional physician

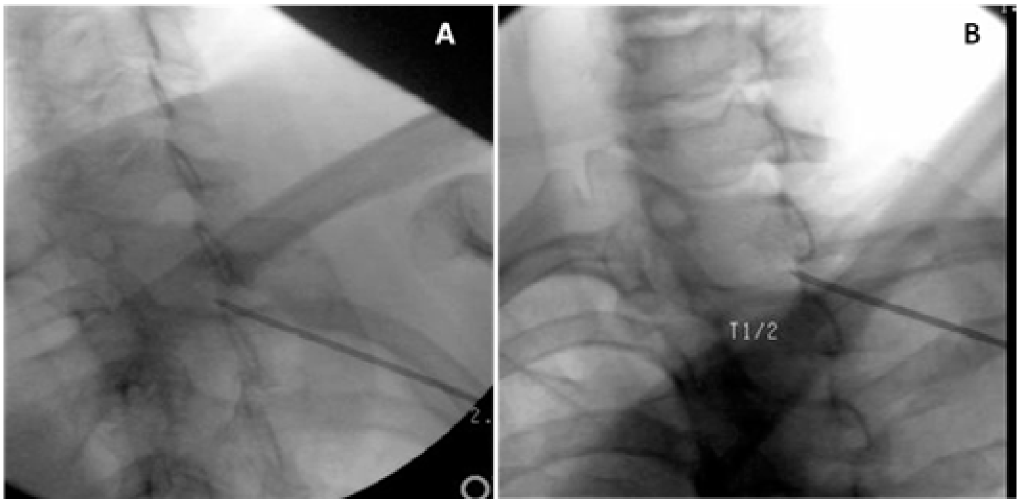

Fig. 5. *An example of differences of opinions between performing physician and study physicians in determining the location of the Tuohy needle position on the CLO views (A: Needle is at the ligamentum flavum; B: Needle is not in the epidural space , not through the ligamentum flavum).*

to accurately determine needle depth with close inter-observer agreement. When wrong, the physicians thought the needle tip was already through the ligamentum flavum rather than on the ligament. This error is a safer mistake as further advancement would be halted, rather than mistakenly observing the needle tip still not through the ligamentum flavum thinking that further advancement is necessary. In our observation, these differences in opinion were mostly attributed to the suboptimal image quality (Fig. 5).

Respecting physician time commitment, we chose a randomized sample of 40 cases (80 images) rather than evaluating all consecutive cases. Because the patients were part of our routine audit, we did not compare results with a lateral view. Finally we did not study intra-observer accuracy as the first author performed all the blocks and blinding could not be guaranteed.

Conclusion

We conclude the CLO view provides an efficient and reliable method to visualize needle tip depth in relation to the epidural space. The close inter-observer agreement was possible with minimal physician instruction. There were no complications in the 278 cases.

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