



Original Article

Comparison of the acoustic windows for the thoracic paramedian epidural approach after shoulder rotation: The lateral decubitus versus the sitting position



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ABSTRACT

Background: The aim of this study was to compare the mean lengths of the posterior longitudinal ligament (PLL) as the acoustic window during the thoracic paramedian epidural approach after shoulder rotation, while subjects were in the lateral decubitus or in the sitting position.

Methods: Thirty-two adult male volunteers were placed in the right decubitus position or sitting position on a horizontal operating table. To obtain an optimal ultrasound view for the PLL on the right side, thoracic spinal ultrasonography was performed at the T6/7 interspace using the paramedian oblique sagittal plane. PLL length was measured on the ultrasound image before and after right shoulder rotation. **Results:** Before shoulder rotation, the difference in mean PLL length between the sitting (11.1 ± 1.3 mm) and lateral decubitus (10.7 ± 1.2 mm) positions was not statistically significant ($P = 0.05$). Within-position, the before and after comparison revealed that after shoulder rotation, PLL length was significantly increased to 12.2 ± 1.4 mm ($P < 0.001$) and 12.0 ± 1.5 mm ($P < 0.001$) in the sitting and lateral decubitus positions, respectively. However, after shoulder rotation the between-position difference in mean PLL length was not statistically significant ($P = 0.50$).

Conclusions: Shoulder rotation did not result in a statistically significant difference in the dimension of the acoustic target window for paramedian thoracic epidural access in the sitting compared to the lateral decubitus position.

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1. Background

Thoracic epidural access is usually performed for analgesia of acute or chronic pain in the thoracic and upper abdominal regions [1–4]. Compared with intravenous analgesic administration, thoracic epidural block has clinical advantages such as a greater analgesic effect and earlier recovery after surgery [5]. However, performing thoracic epidural access can be a challenge for the anaesthesiologist due to thoracic spine characteristics (e.g., steep spinous process angulation and narrow intervertebral spaces) [6,7]. Patient position can affect the anatomy of the thoracic spine, so the success of thoracic epidural access can depend on the position used. To overcome the anatomical limitations of the

thoracic spine, patient position should be optimised to the best possible extent.

Thoracic epidural access can be performed while the patient is in the sitting or the lateral decubitus position. Results of a previous study comparing the sitting and lateral decubitus positions for thoracic epidural access indicated that the success rates for access are similar for both positions [8,9]. Recently, shoulder rotation was reported to increase the length of the posterior longitudinal ligament (PLL) as a dimension of the acoustic target window for thoracic epidural access in the sitting position in one study [10] and in the lateral position in another study [11]. The two studies used groups of subjects with similar demographic characteristics, and comparison of the results of the two studies suggests that with shoulder rotation, PLL length is longer in the sitting position than in the lateral decubitus position. However, the best position for thoracic epidural access (i.e., sitting or lateral) remains to be

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determined because comparing the results of different studies is inappropriate. The aim of our study was to compare mean PLL length within and between the sitting position and the lateral decubitus position, before and after shoulder rotation, in the same population.

2. Methods

The study was registered with the Clinical Research Information Service (identifier: KCT0002054) after it was approved by the Institutional Review Board. Written informed consent was obtained from 32 healthy volunteers. Subjects whose physical condition allowed them to assume the positions used for thoracic epidural access with shoulder rotation were included in the study. Exclusion criteria included:

- body mass index $> 35 \text{ kg}\cdot\text{m}^{-2}$;
- history of surgery, trauma, or congenital abnormality associated with the spine or shoulders;
- allergy to ultrasound gel.

Data on age, gender, weight, and height were collected from each of the enrolled subjects.

Each subject was placed on a horizontal operating table in the right lateral decubitus position with the cervical and lumbar spine flexed. The hips and knees were flexed to maintain the position for a thoracic epidural block. The subject was asked to hunch their back, to bend and to move their knees towards their abdomen as much as possible and to maintain the position. A pillow was placed under the head to preserve the spinal axis alignment. The subject held a large pillow in his arms and was not allowed to move his shoulders. An assistant operator held the subject's shoulders and knees while the ultrasound examination was performed. A single, experienced investigator performed a thoracic spinal ultrasound on the dependent side of the subject, because thoracic epidural access is usually performed on the dependent side in the lateral decubitus position. After the neutralised lateral position was assumed, the investigator requested each subject to rotate his left shoulder on the same axis as his dependent right shoulder (Fig. 1A). The assistant operator regulated the shoulder position to 30 degrees, which was determined using a protractor application (KHTSXR, Seoul, Korea) on a Samsung Galaxy S5 smartphone (Samsung Electronics Co., Seoul, Korea). The investigator then performed a thoracic spinal ultrasound examination of the shoulder in the rotated lateral position. The subject then sat on an operating table with the feet on a stool to support the legs while bending the hips and knees to 90-degree angles. The subject then

assumed a slouching position of the shoulders that included cervical and lumbar flexion, and exaggeration of the thoracic kyphosis; the arms were around a pillow placed at chest level. A thoracic spinal ultrasound examination was performed in the neutralized sitting position. Each volunteer was asked to rotate their shoulder on the axis of their vertebral column (Fig. 1B). The assistant operator regulated the shoulder position to a 45-degree angle, which was determined using a goniometer. The investigator then performed a thoracic spinal ultrasound examination of the shoulder in the rotated sitting position.

PLL length was measured using a C60x/5-2 MHz curvilinear transducer (M-turbo ultrasound image system, Sonosite, Inc., Bothell, WA, USA) [10]. Optimal images were obtained to identify anatomical structures (e.g., ligamentum flavum, dura mater and PLL) in the thoracic spinal area on the right side of the paramedian oblique sagittal plane [12,13]. The sacral plateau was identified first, and the transducer was then moved cranially in a longitudinal paramedian plane while counting upward, until the T6/7 intervertebral levels were confirmed. The paramedian oblique sagittal view was obtained by placing the transducer 1–2 cm lateral to the midline of the spinous processes, towards the table, and by tilting the transducer cranially and slightly medially to locate the widest part of the interlaminar space. The ultrasonographic view was optimised by adjusting the gain and focus to obtain the best image quality. In the thoracic and lumbar regions, the laminae produced an ultrasound “sawtooth” pattern. The ligamentum flavum and posterior dura were visualised as hyperechoic lines in the interlaminar space. The PLL was identified as a hyperechoic structure in the deeper interlaminar space (Fig. 2). After the operator performed all the ultrasound scans, an anaesthesiologist who was blinded to patient position used the onscreen caliper tool and measured and recorded the lengths of the most superficial and inferior aspects of the PLL. Each entire scan was recorded as a video file and re-measured by a third anaesthesiologist who was blinded to patient position and blinded to the PLL results obtained by the second anaesthesiologist. This second dataset of PLL measurements was used to quantify inter-observer agreement. The mean PLL length was then calculated and was used for the statistical analysis.

Sample size estimation was performed based on the results of a previous study, in which PLL lengths were compared before and after shoulder rotation while the patient was in the lateral decubitus position [11]. We estimated that 32 subjects would be required to provide an effect size of 0.7 with 95% power at the 5% significance level. Statistical analyses were performed using SPSS 19.0 (SPSS Inc., Chicago, IL). Normality tests were performed using the Kolmogorov–Smirnov and the Shapiro–Wilk tests. All results

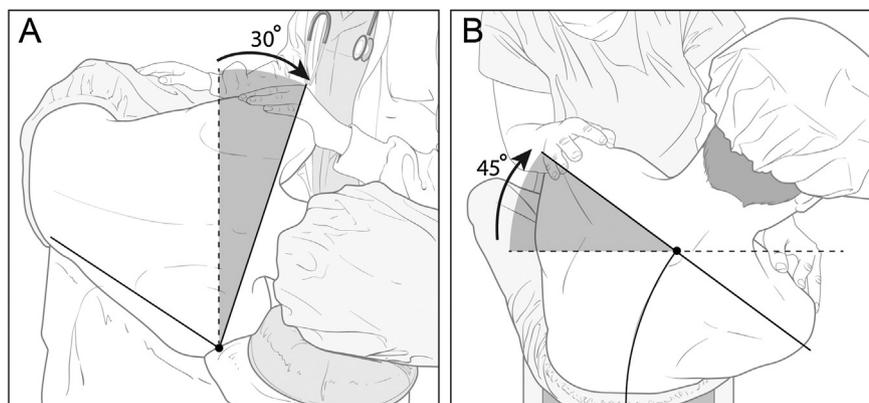


Fig. 1. A. Each subject was placed in the right lateral decubitus position with thoracic spine, hip and knee flexion. The subject was then asked to rotate his left shoulder on the same axis as his dependent right shoulder. B. Slouched shoulder position with cervical and lumbar flexion and bent hips and knees. Each subject was asked to rotate his left shoulder on the same axis as his vertebral column.

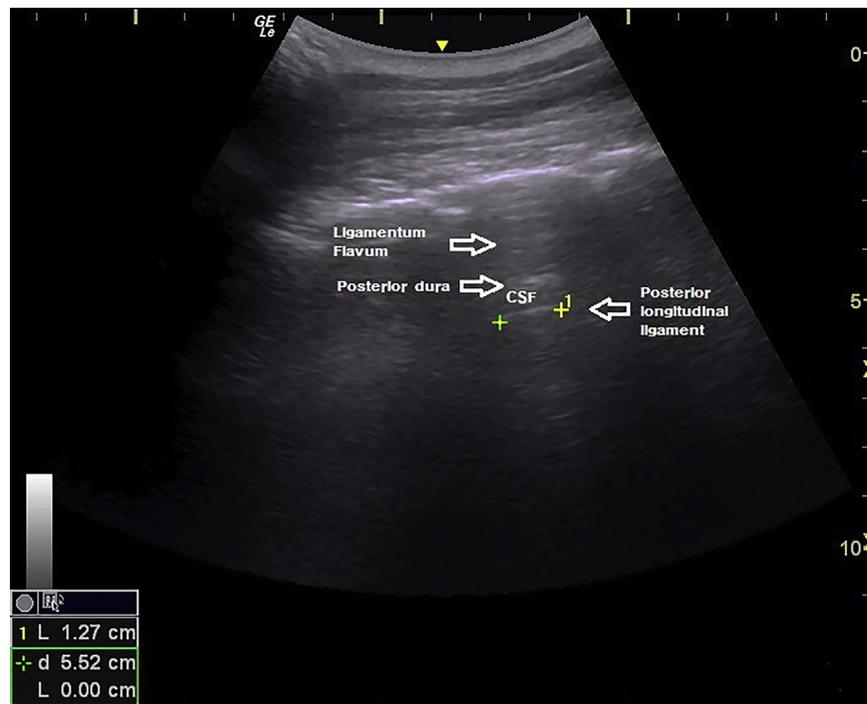


Fig. 2. Paramedian longitudinal ultrasound image showing the lamina, ligamentum flavum (LF)/posterior dura (PD) and the posterior longitudinal ligament (PLL)/posterior vertebral body (PVB) between the laminae of T6 and T7.

were expressed as mean, standard deviation (SD), percentage (%) or median (IQR), values. Data that were collected before and after shoulder rotation were compared using the paired *t*-test. Multiple testing corrections were performed using the Bonferroni correction. Statistical significance was defined as a $P < 0.05$.

3. Results

Thirty-two male volunteers were enrolled in the study. The mean \pm SD values for age, height, weight and body mass index were 27.3 (2.8) years, 174.5 (4.5) cm, 70.3 (9.3) kg and 23.1 (2.6) kg/m⁻², respectively. PLL lengths were successfully measured on 128 ultrasound views of the T6/7 thoracic spines [i.e., 4 ultrasound views were obtained per subject (sitting before shoulder rotation, sitting after shoulder rotation, lateral decubitus before shoulder rotation, lateral decubitus after shoulder rotation)]. There was no statistically significant between-position difference in mean PLL length, before or after shoulder rotation ($P = 0.05$ and $P = 0.50$, respectively) (Table 1). The within-position lengths of the PLL were significantly different before and after shoulder rotation in the sitting position ($P < 0.001$) and in the lateral position ($P < 0.001$). Mean PLL length increased by 1.1 mm and 1.3 mm after shoulder rotation in the sitting position and the lateral decubitus position, respectively.

Table 1
Length of posterior longitudinal ligament on paramedian ultrasound images of thoracic spines in the sitting versus the lateral decubitus position.

	Mean (SD)	<i>P</i> value ^a	<i>P</i> value ^b
<i>Before shoulder rotation (mm)</i>			
Sitting position	11.1 (1.3)	0.05	
Lateral decubitus position	10.7 (1.2)		
<i>After shoulder rotation (mm)</i>			
Sitting position	12.2 (1.4)	0.50	<0.001
Lateral decubitus position	12.0 (1.5)		

^a Sitting position vs. lateral decubitus position.

^b Before shoulder rotation vs. after shoulder rotation.

4. Discussion

In this study, we compared PLL length as the dimension for the acoustic target window for thoracic epidural access in sitting and lateral decubitus positions before and after shoulder rotation in the same subjects. Before shoulder rotation and after shoulder rotation, PLL length was not different between the sitting and the lateral decubitus positions. The results of this study indicated that after shoulder rotation, the sitting and lateral decubitus positions have similar acoustic target window dimensions for thoracic epidural access.

A few studies of the effects of patient position on thoracic epidural access have been published. These studies found that the sitting and lateral decubitus positions have different advantages [14,15]. Thoracic epidural pressure is more negative in the sitting position compared with the lateral decubitus position [9]. However, vagal reflex can occur if thoracic epidural access is performed while the patient is in the sitting position [8]. Therefore, the position used should be selected based on the results of these previous studies, the results of our study, the practitioner's preference and the patient's condition.

This study is the first to compare acoustic target window dimensions in the sitting and lateral decubitus positions with shoulder rotation and to measure the effects on thoracic epidural access, in the same subjects. The mechanism of shoulder rotation in the lateral decubitus position was different from that in the sitting position because the dependent shoulder was mounted on the table in the lateral decubitus position. The values for shoulder rotation in the sitting and lateral decubitus positions were 45 and 30 degrees, respectively. During sitting, the axis of shoulder rotation is the vertebral column; the opposite dependent shoulder is the axis of rotation while the patient is in the lateral decubitus position (Fig. 1) [11]. Two previous studies of the effectiveness of shoulder rotation to increase PLL length for greater thoracic epidural access found that even though the between-study demographic characteristics of the subjects were similar, the mean PLL length in the sitting position (13.8 mm) was

longer than that in the lateral decubitus position (10.6 mm) [10,11]. However, we found no difference in PLL length between the sitting and lateral decubitus positions, with shoulder rotation. One explanation for this result is that shoulder rotation more than 30 degree had no effect on a further increase in PLL length. The range in shoulder rotation can differ between patients. Further evaluation of the appropriate range in shoulder rotation to increase the acoustic target window for thoracic epidural access is needed.

Shoulder rotation increased PLL length by slightly more than 1 mm in both the sitting and in the lateral decubitus positions. This result was consistent with the results of previous studies. Because an epidural needle has a 1-mm diameter, an increase in the acoustic target window of > 1 mm has been proposed to enhance the success rate of neuroaxial access [16]. However, clinical studies are needed to verify that an increase in PLL length is associated with an improvement in thoracic epidural access.

A previous study revealed the effectiveness of shoulder rotation during approach to the lower thoracic level (T9–10) while the patient is in the sitting position [10]. However, the anatomic characteristics of the lower thoracic vertebra are similar to the lumbar vertebra and differ from the mid- and upper- thoracic vertebrae. We investigated the effect of shoulder rotation at the mid-thorax level (T6–7); this location is frequently a target for postoperative analgesia after open thoracotomy and upper abdomen surgeries [17]. At this mid-thorax level, shoulder rotation was an effective method to increase the dimension of the acoustic target window in the sitting position.

This study had several limitations. First, we did not actually perform thoracic epidural access; we measured PLL length on a thoracic spinal ultrasound image. Clinical studies should be performed to confirm that increased PLL length facilitates thoracic epidural access. Second, the ultrasound operator was not blinded to subject position. However, the anaesthesiologists who measured PLL length on the ultrasound images were blinded. Third, the plane used for the thoracic spinal ultrasonography was chosen for the paramedian approach for thoracic epidural access. Our results may not apply to the midline approach. Lastly, all study subjects were young, healthy males. Caution should be used when applying our results to patients with different physical characteristics from subjects of this study such as older patients with underlying disease of the thoracic region.

5. Conclusion

In conclusion, regardless of shoulder rotation, the length of the PLL as the acoustic target window for thoracic epidural access was not different between the sitting and lateral decubitus positions. Further clinical studies are needed to determine differences in the success rates of thoracic epidural access between sitting and lateral decubitus positions.

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Disclosure of interest

The authors declare that they have no competing interest.

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References

- [1] Ahn HJ, Lim HK, Lee YB, et al. The effects of famciclovir and epidural block in the treatment of herpes zoster. *J Dermatol* 2001;28:208–16.
- [2] Hwang SM, Kang YC, Lee YB, Yoon KB, Ahn SK, Choi EH. The effects of epidural blockade on the acute pain in herpes zoster. *Arch Dermatol* 1999;135:1359–64.
- [3] Royse C, Royse A, Soeding P, Blake D, Pang J. Prospective randomized trial of high thoracic epidural analgesia for coronary artery bypass surgery. *Ann Thorac Surg* 2003;75:93–100.
- [4] Simon BJ, Cushman J, Barraco R, et al. Pain management guidelines for blunt thoracic trauma. *J Trauma* 2005;59:1256–67.
- [5] Freise H, Van Aken HK. Risks and benefits of thoracic epidural anaesthesia. *Br J Anaesth* 2011;107:859–68.
- [6] Podder S, Kumar N, Yaddanapudi LN, Chari P. Paramedian lumbar epidural catheter insertion with patients in the sitting position is equally successful in the flexed and unflexed spine. *Anesth Analg* 2004;99:1829–32.
- [7] Wantman A, Hancox N, Howell PR. Techniques for identifying the epidural space: a survey of practice amongst anaesthetists in the UK. *Anaesthesia* 2006;61:370–5.
- [8] Gil NS, Lee JH, Yoon SZ, Jeon Y, Lim YJ, Bahk JH. Comparison of thoracic epidural pressure in the sitting and lateral decubitus positions. *Anesthesiology* 2008;109:67–71.
- [9] Nishi M, Usukaura A, Kidani Y, Tsubokawa T, Yamamoto K. Which is a better position for insertion of a high thoracic epidural catheter: sitting or lateral decubitus? *J Cardiothorac Vasc Anesth* 2006;20:656–8.
- [10] Ramsay N, Walker J, Tang R, Vaghadia H, Sawka A. Flexion-rotation manoeuvre increases dimension of the acoustic target window for paramedian thoracic epidural access. *Br J Anaesth* 2014;112:556–62.
- [11] Byon HJ, Song JH, Song KC, Lim H, Kim H. The effects of shoulder rotation on the acoustic window for thoracic paramedian epidural approach in the lateral decubitus position. *Reg Anesth Pain Med* 2016;41:572–5.
- [12] Furness G, Reilly MP, Kuchi S. An evaluation of ultrasound imaging for identification of lumbar intervertebral level. *Anaesthesia* 2002;57:277–80.
- [13] Grau T, Leipold RW, Horter J, Conradi R, Martin EO, Motsch J. Paramedian access to the epidural space: the optimum window for ultrasound imaging. *J Clin Anesth* 2001;13:213–7.
- [14] Majd SA, Pourfarzam S, Ghasemi H, Yarmohammadi ME, Davati A, Jaberian M. Evaluation of prelumbar puncture position on post lumbar puncture headache. *J Res Med Sci* 2011;16:282–6.
- [15] Mhyre JM, Greenfield ML, Tsen LC, Polley LS. A systematic review of randomized controlled trials that evaluate strategies to avoid epidural vein cannulation during obstetric epidural catheter placement. *Anesth Analg* 2009;108:1232–42.
- [16] Jones AR, Carle C, Columb M. Effect of table tilt on ligamentum flavum length measured using ultrasonography in pregnant women. *Anaesthesia* 2013;68:27–30.
- [17] Visser WA, Liem TH, van Egmond J, Gielen MJ. Extension of sensory blockade after thoracic epidural administration of a test dose of lidocaine at three different levels. *Anesth Analg* 1998;86:332–5.