Anesth Pain Med 2017; 12: 132-136
https://doi.org/10.17085/apm.2017.12.2.132

■ Clinical Research ■
pISSN 1975-5171 • eISSN 2383-7977

The Skin-to-epidural distance of parturients by ultrasonography: sitting position versus left lateral position

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Background: Pre-procedural lumbar ultrasound scanning is a reliable tool to estimate the skin to epidural distance (SED). We conducted an observational study to compare the SED between the sitting position and lateral position using pre-procedural ultrasound imaging of the lumbar spine in parturients.

Methods: Using a 2-5 MHz curvilinear transducer, we obtained images of the lumbar interspaces from L2-3 to L5-S1 in the paramedian sagittal oblique view. The individual distance from the skin to the ligamentum flavum-dura mater unit was measured at the level of L2-3, L3-4, L4-5, and L5-S1 in the left lateral position (distance in lateral position; D-lat). Subsequently, participants were placed in the sitting position, and the distance was measured in the same manner (distance in sitting position; D-sit). Data were grouped according to body mass index (BMI; kg/m^2) measurements of $\geq$ 25 or $<$ 25 and analyzed. The primary outcome was the change determined by ultrasound between D-lat and D-sit at the same lumbar level according to position.

Results: Thirty parturients were studied. The difference between D-lat and D-sit in the same lumbar level was not statistically significant. The mean changes between D-lat and D-sit in the same lumbar level were less than 0.18 cm. In BMI $\geq$ 25 group, the difference between D-lat and D-sit were greater than that of BMI $<$ 25 group at L3-4 level (P = 0.042).

Conclusions: It is important for clinicians to consider that position change is associated with greater differences in SED in obese parturients (BMI $\geq$ 25) compared with thin parturients (BMI $<$ 25). For obese parturients, the sitting position may be helpful. **(Anesth Pain Med 2017; 12: 132-136)**

Received: June 17, 2016.
Revised: 1st, September 18, 2016; 2nd, November 19, 2016.
Accepted: November 21, 2016.

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It was presented The 91th Annual Scientific Meeting of the Korean Society of Anesthesiologists, November 2014, Lotte Hotel World, Seoul, Korea.

Key Words: Epidural, Obstetric, Ultrasound.

INTRODUCTION

Epidural block is widely performed for labor analgesia in obstetrics. However, parturients may have unfavorable conditions for the performance of epidural anesthesia. The overall failure rate for labor epidural analgesia has been reported to be 12% [1]. Placement of an epidural catheter to provide effective labor analgesia in parturients may be affected by various factors. Many studies have been performed to predict the skin to epidural distance (SED) in various populations [2]. The factors influencing the SED in parturients are body mass index (BMI), ethnicity [3], and position [4,5].

Ultrasonography of the spine has become a well-described technique that can be applied to facilitate neuraxial and lumbar plexus blockade [6]. Ultrasonography is a useful means to detect the point of skin puncture [7], to decrease the complication rate [8] for neuraxial blockade. Ultrasound imaging may also permit more accurate prediction of the distance to the epidural and intrathecal spaces and more accurate identification of intervertebral levels [9]. Pre-procedural lumbar ultrasound scanning is a reliable method to estimate the SED. Previous reports regarding the SED have been mostly retrospective reviews of clinical records concerning real needle depth [4,10]. In the past, it was impossible to assess the real needle depth multiple times with a single parturient. Pre-procedural lumbar ultrasound scanning offers the great advantage of allowing estimation of the SED in an individual patient for each level repeatedly. It also can estimate the change in the distance depending on the parturients' position.

We conducted an observational study to compare the SED between sitting position and lateral position using pre-procedural ultrasound imaging of the lumbar spine of parturients.

MATERIALS AND METHODS

This study was conducted with the full approval of the Institutional Review Board and written informed consent was obtained from all participants. Inclusion criteria were parturients requesting epidural labor analgesia, age between 18 and 40 years, American Society of Anesthesiologists physical status I or II, and gestational age more than 37 weeks. Patients were excluded if they had spinal deformities or history of spinal surgery. All patients underwent ultrasound imaging of the lumbar spine immediately prior to placement of the epidural catheter. Pre-procedural ultrasound scanning was performed by one anesthesiologist in a nonsterile manner. Using a 2–5 MHz curved probe (M-Turbo™; SonoSite Canada Inc., Canada), the distance was measured with the built-in caliper on the ultrasound system. Initially all participants were placed in the left lateral position (patient lay on her side with both legs flexed and the spine flexed as much as possible) and the anesthesiologist marked each participant's Tuffier's line. The probe was placed in a longitudinal axis over Tuffier's line, 1 to 2 cm lateral to the midline of the back, and tilted gradually oblique to the midline to obtain a paramedian sagittal oblique view of the lumbar vertebrae. The probe was then shifted cephalad to detect the interspaces by counting the level of lumbar vertebrae. We identified the ligamentum flavum-dura mater unit and the anterior complex (anterior dura mater, posterior longitudinal ligament). After the optimal image was frozen, the individual distance from the skin to the inner aspect of the ligamentum flavum-dura mater unit was measured at the level of L2-3, L3-4, L4-5, and L5-S1 (distance in lateral position; D-lat; cm). Subsequently, the participants were placed in the sitting position (patient sat on the bed with both legs flexed and the spine flexed as much as possible), and the scanning was performed in the same manner. The individual distance from the skin to the inner aspect of the ligamentum flavum-dura mater unit was measured at the level of L2-3, L3-4, L4-5, and L5-S1 (distance in sitting position; D-sit; cm) (Fig. 1).

The anesthesiologist then performed placement of the epidural catheter via a midline approach in the sitting position. The procedure level and puncture site were selected with palpation. The epidural space was confirmed by the loss-of-resistance technique with air. After the epidural space was identified, a sterile marking pen was used to mark the entry point of the Tuohy needle right on the skin, and the real needle depth was measured using a ruler to the nearest millimeter.

The primary outcome was the changes between D-lat and D-sit at the same lumbar level according to position as determined by ultrasound in the paramedian sagittal oblique view. Secondary outcomes included real needle depth from the skin to the epidural space in the sitting position, failed epidural rate, and accidental dural puncture rate. The definition of failure was lack of sensory block after adequate dosing or inability to insert the epidural catheter.

We planned a study of a continuous response variable from matched pairs of the D-lat and D-sit. Previous data [4] indicate that the difference in matched pairs is normally distributed, with a standard deviation of 0.95. If the true difference in the matched pairs is 0.5, for $\alpha < 0.05$ with a power of 80%, we planned the study with 30 parturients.

All statistical analyses were performed using statistical software SPSS (version 18.0, SPSS Inc., USA). Data are presented as the mean ± SD. The Shapiro-Wilk test was used to check the normality of the data. The paired t-test or signed rank test was used to determine the change between D-lat and D-sit. Data were grouped and analyzed according to BMI $\geq$ 25 or $<$ 25 and compared using Student's t-test or the Mann-Whitney *U* test. A P value $<$ 0.05 was considered statistically significant [11].

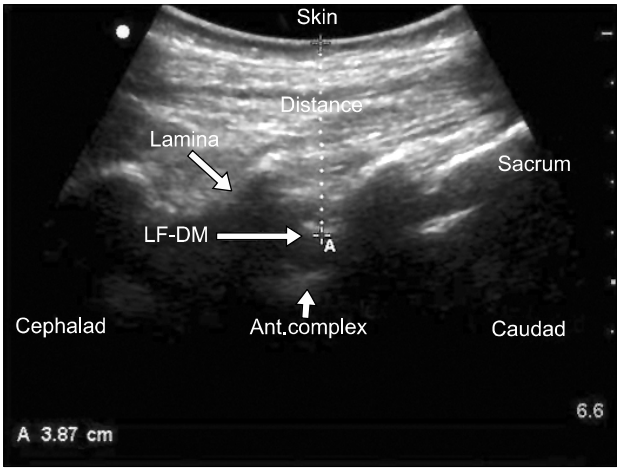

Fig. 1. Ultrasound measurement the distance from the skin to the ligamentum flavum-dura mater Unit (LF-DM) in the paramedian sagittal oblique view. Anterior complex; anterior dura mater and posterior longitudinal ligament.

RESULTS

Thirty parturients were recruited and all of the data were analyzed. The BMI of the total patient population was 25.7 ± 2.4 kg/m^2. Patients were divided into a group with BMI ≥ 25 (n = 11) and a group with BMI < 25 (n = 19) (Table 1).

Overall, the changes between D-lat and D-sit (the value of D-sit minus D-lat) at the same lumbar level according to position were not statistically significant (Table 2).

Table 3 shows the grouped data of ultrasound measurement of the SED depending on position and BMI. The differences in SED varied depending on the lumbar level. In the group with BMI ≥ 25, the difference between D-lat and D-sit was greater than that of the group with BMI < 25 at the L3-4 level (−0.31 ± 0.40 vs. 0.17 ± 0.48, P = 0.042). In the group with BMI ≥ 25, D-lat was greater than D-sit at the L3-4 level (4.72 ± 0.61 vs. 4.42 ± 0.66, P = 0.011).

D-lat of the group with BMI ≥ 25 (4.72 ± 0.61) was significantly greater than that of the group with BMI < 25 (4.13 ± 0.25) at the L3-4 level (P = 0.004). D-lat of the group with BMI ≥ 25 (4.82 ± 0.95) was significantly greater than that of the group with BMI < 25 (4.12 ± 0.33) at theL4-5 level (P = 0.019).

The real needle depth (cm) from the skin to the epidural space at the L2-3 level, L3-4 level, and L4-5 level was 4.57 ± 0.12, 4.74 ± 1.01, and 5.10 ± 0.68, respectively.

There were no cases with failed epidural block nor accidental dural puncture.

DISCUSSION

Pregnancy is associated with tissue edema and weight gain, which can obscure anatomical landmarks, resulting in difficulty in finding the epidural space. The interspinal ligament is softer and its structures inhomogeneous, which can imitate an untimely loss of resistance. Furthermore, the epidural space is deeper and the interspinal space ascends at a steeper angle. The epidural space is narrowed and, therefore, the "safetyzone" between perforation of the ligamentum flavum and puncture of the dura is small [7,12].

The factors influencing the SED are various, and include position in parturients. It has been shown that the SED is greater when epidural puncture is performed in the lateral position than in procedures performed in the sitting position [4]. However, there were many limitations in determining the factors influencing the SED. First, it was only possible to estimate the distance one time through the real needle depth during the procedure. Second, the data comprised the different parturients' values. Third, there was a great bias in selection of the parturients' position for the procedure at that time.

Since Currie performed ultrasound measurement of parturients' SED [13], ultrasound for epidural analgesia has been widely used for determination of an epidural insertion

Table 2. Ultrasound Measurement of the Skin-to-epidural Distance Depending on Position

	D-Lat (cm)	D-Sit (cm)	P value
L2/3	4.17 ± 0.51	4.19 ± 0.65	0.919
L3/4	4.52 ± 0.57	4.38 ± 0.59	0.168
L4/5	4.61 ± 0.83	4.62 ± 0.75	0.952
L5/S1	4.69 ± 0.83	4.61 ± 0.82	0.191

Values are presented as mean ± SD. D-lat: Distance in lateral position (cm), D-sit: Distance in sitting position (cm). P values were determined using paired t-test.

Table 1. Demographic Data of the Total Parturients and Subgroups

	Total	BMI < 25	BMI ≥ 25	P value
Number of patients	30	11	19	
ASA (I/II)	28/2	10/1	18/1	
Age (yr)	32.5 ± 3.4	32.4 ± 3.9	32.5 ± 3.2	0.902
Height (cm)	161.0 ± 6.0	160.0 ± 5.9	160.9 ± 6.5	0.696
Weight (kg)	66.6 ± 9.5	60.7 ± 4.9	70.0 ± 10.0*	0.008
Body mass index (kg/m^2)	25.7 ± 2.4	23.7 ± 0.9	26.9 ± 2.1*	0.000
Gestational age (weeks)	39.7 ± 1.3	39.7 ± 0.9	39.7 ± 1.5	0.436

Values are presented as mean ± SD. *P < 0.05: comparison between the group with BMI < 25 and the group with BMI ≥ 25. ASA: American Society of Anesthesiologists physical status.

Table 3. Ultrasound Measurement of the Skin-to-epidural Distance depending on Position and BMI

		D-Lat (cm)	D-Sit (cm)	Difference (cm)	P value
L2-3	BMI < 25	3.94 ± 0.26	3.92 ± 0.54	−0.03 ± 0.49	0.901
	BMI ≥ 25	4.29 ± 0.63	4.29 ± 0.64	−0.003 ± 0.46	0.982
L3-4	BMI < 25	4.13 ± 0.25	4.30 ± 0.44	0.17 ± 0.48	0.366
	BMI ≥ 25	4.72 ± 0.61†	4.42 ± 0.66	−0.31 ± 0.40*	0.011
L4-5	BMI < 25	4.12 ± 0.33	4.38 ± 0.47	0.17 ± 0.49	0.172
	BMI ≥ 25	4.82 ± 0.95‡	4.69 ± 0.82	−0.04 ± 0.29	0.122
L5-S1	BMI < 25	4.50 ± 0.69	4.19 ± 0.50	−0.31 ± 0.90	0.324
	BMI ≥ 25	4.87 ± 0.96	4.78 ± 0.87	−0.09 ± 0.35	0.311

Values are presented as mean ± SD. D-lat: Distance in lateral position (cm), D-sit: Distance in sitting position (cm). Difference is the value of D-Sit minus D-Lat. P: comparison between D-lat and the D-sit. *P = 0.042: comparison between the difference of BMI < 25 and the difference of BMI ≥ 25 in the same level. †P = 0.004, comparison between D-lat of BMI < 25 and D-lat of BMI ≥ 25 in the same level. ‡P = 0.019, comparison between D-lat of BMI < 25 and D-lat of BMI ≥ 25 in the same level.

point, estimation of the angle of the needle during insertion, and measurement of the SED [9]. Ultrasound pre-assessment of lumbar SED has been shown to correlate well with actual puncture depth in obese parturients [14]. The present study is the first report of the SED of the individual lumbar spine level depending on position in parturients.

We obtained images in the paramedian sagittal oblique view. The estimates of the ultrasound-determined SED in the paramedian sagittal oblique view are comparable to those in the transverse plane for midline puncture [15]. In our experience, there were some cases that were poorly visible in the transverse plane. First, the views of the upper lumbar level tend to be inconclusive due to the different angle of the spinous processes. Second, the views of the parturients with developed back muscles also tend to be inconclusive. Previous reports compared the quality of images with the transverse or median longitudinal and paramedian longitudinal approaches. These reports suggested that the paramedian longitudinal approach is optimal for lumbar epidural scanning [16]. Therefore, we selected the paramedian sagittal oblique view for assessment in the present study.

However, the change can be greater in obese parturients. The mean BMI of participants in the present study was 26, and the mean SED was 4.5 cm. The subjects were thinner and the SED was shorter than those of previous studies [10,17]. We demonstrated that the SED can change significantly with patient movement from the sitting to the lateral position in parturients with BMI greater than 25. Furthermore, these results were similar to the findings of Hamilton et al. [5], which showed that the epidural catheter moved significantly in obese patients. Several studies have reported that BMI has correlations with the SED [3,10]. BMI is not only a factor that affects the SED of parturients on ultrasound imaging, but it also influences changes in SED with patient movement from the sitting to the lateral position. Further studies of the general population including greater number of obese subjects may enlarge on these observations and elucidate obvious differences.

The changes in the SED from the skin to the epidural space differed depending on the lumbar level. The spine curvature may influence the changes in distances. The maximal lumbar lordosis occurred at the L4-5 level [18], and the spinal curvature demonstrated a tendency toward lumbar kyphosis in parturients [19]. The maximal change of the SED from the skin to the epidural space according to position was identified at the L3-4 level in the present study. The findings of the current study using pre-procedural ultrasound can be utilized for further studies regarding epidural catheter movement or spinal curvature in parturients.

Currie reported the causes of the differences between ultrasound-estimated SED and the real needle depth. These included several factors: the ultrasound probe and epidural needle being at different angles to the skin, the epidural needle being off midline in trajectory, and the blunt epidural needle causing tissue deformation [13]. The limitations of the present study are the small number of subjects and the fact that we obtained only paramedian sagittal oblique views. After scanning, we performed the epidural procedure via a midline approach. The real needle depth can be altered by the redirection of the trajectory and the choice of approach.

We concluded that placement of parturients in either the sitting or lateral position did not reliably correspond to either lengthening or shortening of the SED at the lumbar level.

Clinicians should consider that position change is associated with greater differences in SED in obese parturients (BMI ≥ 25) compared with thin parturients (BMI < 25). For obese parturients, the sitting position may be helpful.

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