Rev Bras Anestesiol. 2018;68(3):280–284

Sociedade Brasileira de Anestesiologia

REVISTA BRASILEIRA DE ANESTESIOLOGIA

Publicação Oficial da Sociedade Brasileira de Anestesiologia
www.sba.com.br

SCIENTIFIC ARTICLE

Effect of table tilt and spine flexion–rotation on the acoustic window of the lumbar spine in pregnant women

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Received 24 December 2016; accepted 28 December 2017
Available online 1 February 2018

KEYWORDS
Lumbar ultrassonography;
Anesthesia for cesarean delivery;
Neuraxial anesthesia;
Paravertebral longitudinal ligament

Abstract
Study objective: The purpose of this study was to assess whether application of dorsal table tilt and body rotation to a parturient seated for neuraxial anesthesia increased the size of the paramedian target area for neuraxial needle insertion.
Setting: Labor and Delivery Room.
Patients: Thirty term pregnant women, ASA I–II, scheduled for an elective C-section delivery.
Interventions: Lumbar ultrasonography was performed in four seated positions: (F) lumbar flexion; (FR) as in position F with right shoulder rotation; (FT) as in position F with dorsal table-tilt; (FTR) as in position F with dorsal table-tilt combined with right shoulder rotation.
Measurements: For each position, the size of the 'target area', defined as the visible length of the posterior longitudinal ligament was measured at the L3-L4 interspace.
Main results: The mean posterior longitudinal ligament was 18.4 ± 4 mm in position F, 18.9 ± 5.5 mm in FR, 19 ± 5.3 mm in FT, and 18 ± 5.2 mm in FTR. Mean posterior longitudinal ligament length was not significantly different in the four positions.
Conclusions: These data show that the positions studied did not increase the target area as defined by the length of the posterior longitudinal ligament for the purpose of neuraxial needle insertion in obstetric patients. The maneuvers studied will have limited use in improving spinal needle access in pregnant women.

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https://doi.org/10.1016/j.bjane.2018.01.003

PALAVRAS-CHAVE
Ultrassonografia lombar;
Anestesia para parto cesáreo;
Anestesia neuraxial;
Ligamento longitudinal paravertebral

Efeito da inclinação da mesa e flexão da coluna sobre a janela acústica da coluna lombar em mulheres grávidas

Resumo

Objetivo do estudo: O objetivo deste estudo foi avaliar se a inclinação lateral da mesa cirúrgica e a rotação do corpo de uma parturiente sentada para anestesia neuraxial aumentou o tamanho da área-alvo paramediana para a inserção da agulha neuraxial.

Ambiente: Sala de parto.

Pacientes: Trinta grávidas a termo, ASA I-II, agendadas para cesárea eletiva.

Intervenções: Ultrassonografia lombar foi realizada em quatro posições sentadas: (F) flexão lombar; (FR) como na posição F com rotação do ombro direito; (FT) como na posição F com inclinação lateral da mesa cirúrgica; (FTR) como na posição F com inclinação lateral da mesa cirúrgica combinada com a rotação do ombro direito.

Mensurações: Para cada posição, o tamanho da ''área-alvo'', definido como o comprimento visível do ligamento longitudinal posterior, foi medido no interespaço de L3-L4.

Principais resultados: As médias do ligamento longitudinal posterior foram: 18,4 $\pm$ 4 mm na posição F; 18,9 $\pm$ 5,5 mm na posição FR; 19 $\pm$ 5,3 mm na posição FT e 18 $\pm$ 5,2 mm na posição FTR. O comprimento médio do ligamento longitudinal posterior não foi significativamente diferente nas quatro posições.

Conclusões: Esses dados mostram que as posições avaliadas não aumentaram a área-alvo, conforme definido pelo comprimento do ligamento longitudinal posterior com o objetivo de inserção da agulha neuraxial em pacientes obstétricas. As manobras avaliadas terão um uso limitado na melhora do acesso à agulha espinhal em mulheres grávidas.

Introduction

Spinal and epidural anesthesia are frequently used for surgery and analgesia in obstetric practice. During pregnancy, the epidural space is narrower and deformed by tissue changes, and visibility of the ligamentum flavum, dura mater and epidural space decreased significantly.[1] Hip flexion and dorsal table tilt have been shown to improve the dimensions of the sonographic target window for needle access to the neuraxial space.[2,3] In non-obstetric subjects, flexion with rotation of the spine and dorsal table tilt increased the size of the paramedian acoustic target window in the mid-thoracic region compared to flexion alone.[4] In the obstetric population dorsal table tilt with a sitting flexed position increased the size of the acoustic target area at the L3-4 interspace.[3] However, the effect of dorsal table tilt, flexion and rotation on the lumbar paramedian target window has not been studied in the obstetric population.

The paramedian window provides superior ultrasound images of the structures within the vertebral canal, compared with a transverse midline view.[5–7] The sonographic visualization of the Posterior Longitudinal Ligament (PLL) represents the presence of an open soft-tissue acoustic window between adjacent vertebral laminae.[7] Consequently, increasing the acoustic zone and measurable size of the PLL by body position may theoretically increase the likelihood of free passage for a neuraxial needle.

The objective of this study was to use right paramedian ultrasonography in parturients to assess the effects of dorsal table tilt, flexion and ipsilateral rotation of the lumbar spine on the size of the target area for a paramedian neuraxial needle insertion. The length of the visualized PLL at L3-4 interspace was used as a measure of the 'target area' for the needle.

Methods

Following research ethics board approval by the Clinical Research Ethics Board of the University of British Columbia (H13-03162), we recruited 30 term pregnant women at the BC Women's Hospital & Health Center. The criteria for inclusion in this study were an ASA I or II physical status, age over 19, greater than 37 weeks gestational age, presenting to the Labor and Delivery suite for either an induction of labor or during the first stage of labor (cervical dilation <6 cm). Women were approached when they were not showing clear signs of painful contractions and the procedures were explained to them thoroughly. In addition, women were given approximately 10 min to decide whether they wished to participate in this study, Subjects with a history of previous spinal surgery or trauma, significant spinal anatomical abnormalities, allergy to ultrasound gel, those who already had an epidural catheter in place or those who presented a language barrier were excluded.

Signed informed consent was obtained from all subjects and demographic details, including age, weight, height and Body Mass Index (BMI) were documented.

The L3-4 right paramedian space was independently scanned in all four positions in each subject by two anesthesiologists ('scanners') experienced in neuraxial ultrasonography. The anesthesiologists were blinded to each others' scans. Scans were performed with a Zonare Ultra One ultrasound machine with a 2–6 MHz curved-array transducer (Zonare Medical Systems, Mountainview, CA, USA). The L3-4 interspace was determined by identifying the horizontal hyperechoic line of the sacrum in the parasagittal plane and moving the transducer from L5-S1 cephalad, counting the hyperechoic saw-tooth structures of the vertebral laminae to reach L3-4. The ligamentum flavum was recognized as a characteristic hyperechoic structure seen anterior to the laminae at L3-L4. The PLL measured was the composite hyperechoic line of the anterior dura, PLL and posterior vertebral body, beyond the hypoechoic intrathecal space lying anteriorly to the ligamentum flavum. Previous studies have referred to this as the 'anterior complex' as it is not possible to delineate each structure separately, using currently available ultrasound technology.[7–9] With medial angulation at the interlaminar space, the hyperechoic PLL was identified lying deep to the posterior dura and ligamentum flavum (Fig. 1).

For each position, the scanning anesthesiologist adjusted the transducer to maximize the PLL length and had the image captured. The PLL for each image was measured using the onboard caliper software and recorded, with the scanning anesthesiologist blinded to the value. This procedure was repeated in a total of four seated positions, based on those described in previous studies[3,4]: F, lumbar flexion; FR, lumbar flexion with rightward shoulder rotation; FT, lumbar flexion with table tilt 10° dorsally; FTR, lumbar flexion with table tilt 10° dorsally combined with rightward shoulder rotation (Fig. 2). Table tilt was simulated by placing a foam wedge under the subject's thighs to achieve a 10° tilt measured by the Surface Level application on an iPhone (Apple, Cupertino, CA, USA).

After scanning the subject in all four positions, the first scanning anesthesiologist exited the room and the procedure was repeated with the second scanning anesthesiologist. This was done to determine if the results are reproducible between 'scanners'.

All images were assigned a number based on a random number generator to remove any identifying data, including subject number, date, time, and position. The PLL was re-measured on every saved image by two separate anesthesiologists ('readers') who were not involved with any previous data collection. Both were blinded to the number allocation and each other's measured values. This aimed to remove any bias by the 'scanning' anesthesiologists and test for reproducibility in the measurement of the PLL, between 'readers'.

Figure 2 Position FTR is illustrated with a subject positioned in lumbar flexion, with 10° dorsal table tilt and shoulders rotated to the right.

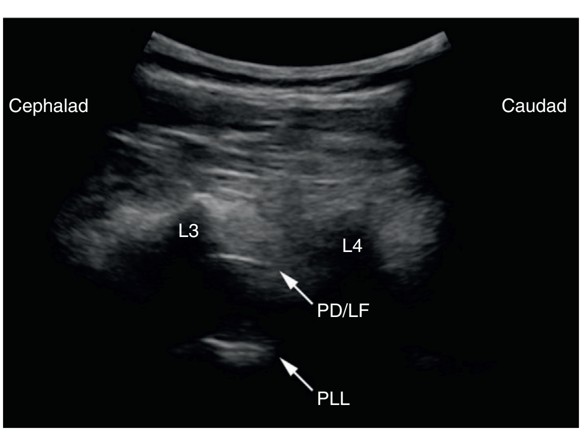

Figure 1 Paramedian longitudinal ultrasound image showing Ligamentum Flavum (LF), Posterior Dura (PD) and the Posterior Longitudinal Ligament (PLL), at the interspace of L3 and L4.

A statistician calculated a minimum sample size of 30 subjects, in order to demonstrate significant change in the mean length of the PLL (acoustic target area), in any of the four positions. This estimation was based on data derived from a similar study, which had used a minimum sample size of 16 subjects, with a 1 mm mean change in 'needle target area' dimensions, a 1 mm SD, and an alpha of 0.05 with a power of 90%.[3]

Repeated measures ANOVA, in pair wise comparisons were conducted on measurements of mean PLL length in each of the positions (with Bonferroni adjustment to maintain the $p < 0.05$). Kolmogorov–Smirnov (Lilliefors Significance Correction) and Shapiro–Wilk checks analyzed the data for normality. Intraclass coefficients (two-way mixed model) evaluated the reliability and reproducibility of the PLL measurements performed by the two 'scanning' anesthesiologists and 'reading' anesthesiologists. All data analyses were performed using Statistical Package for the Social Sciences (SPSS) software (Version 21.0), IBM Corporation, Armonk, NY, USA.

Results

A total of 30 women (ASA class I–II) participated in this study. The mean (SD) age of the subjects was 34.8 (5.0) years, their weight was 79.1 (15.1) kg, their height was 162.1 (6.7) cm, and their body mass index was 30.0 (4.8) kg.m^{-2}. All subjects were at term pregnancy with a mean (SD) gestational age of 39.08 (1.22) weeks.

Table 1 Lengths (Mean ± SD) of the posterior longitudinal ligament (in mm) visualized by right-sided paramedian ultrasonography, at L3-L4 intervertebral level, in 4 seated positions in pregnant subjects, and a summary of statistical differences between each of the four study positions.

Position	PLL length[a] ($n = 30$)
F: flexion	18.4 ± 4.0
FR: flexion + rotation	18.9 ± 5.5
FT: table tilt + flexion	19.0 ± 5.3
FTR: table tilt + flexion and rotation	18.0 ± 5.2

PLL, posterior longitudinal ligament.
[a] p = ns for all positions (ns = non-significant).

The lumbar-sacral junction, lumbar interspaces and epidural space at the level of L3-4, were readily identifiable in all subjects by ultrasonography.[8] The clarity of the PLL image was adequate in all but one volunteer, where the PLL could not be visualized. With the exception of the series of scans from that one volunteer, clear demarcation of the superior and inferior limits of the PLL were evident in all saved images, which enabled exact measurements of PLL length with the on screen caliper tool. There was no loss of saved images during capture, measurement or archiving.

Intraclass correlation (two-way mixed model) coefficients for PLL length by the two scanning anesthesiologists were: F-0.546, FR-0.637, FT-0.457 and FTR-0.687. Intraclass correlation (two-way mixed model) coefficients for measurement of the PLL length by the two independent 'reading' anesthesiologists were: F-0.948, FR-0.966, FT-0.965 and FTR-0.963.

In the pregnant subjects, mean (SD) PLL length was 18.4 (4.0) mm in position F (flexion) and not significantly affected by any of the other positions studied (Table 1).

Discussion

In the present study, we measured the length of the PLL by ultrasonography in pregnant women and found that it was unaffected by table tilt, spine flexion and rotation.

A number of previous studies have used the interspinous distance, ligamentum flavum or PLL to assess various positions, which may enhance access for spinal or epidural needle placement.[1–4] The length of the acoustic target area/ligamentum flavum was shown to significantly increase in pregnant women, at the L3-L4 interspace, by applying increasing dorsal table tilt from 0° to both 8° and 10°, in the sitting flexed position.[3] The effects of exaggerated lumbar flexion/thoracic kyphosis combined with 10° of dorsal table tilt and shoulder rotation were found to significantly increase the length of PLL in the thoracic region in non-pregnant volunteers.[4] However, no previous study has considered the effects of pregnancy and body positioning on the size of the acoustic window in the lumbar spine to optimize paramedian neuraxial access at L3/L4.

The interspace of L3-L4 was selected, as it is the commonest level for spinal and epidural injection for obstetric anesthesia at our institution. Nevertheless, we chose the paramedian approach to identify the PLL over the midline approach because it has higher success rates for this purpose, is technically easier, and facilitates a superior sonographic image of the relevant structures within the vertebral canal.[5–7,10]

Our main finding was that in pregnant subjects across the four positions, mean PLL was unchanged at 18.4 ± 4 mm in the flexed position to 18.0 ± 5.2 mm in the flexed position with 10° dorsal table tilt accompanied by rotation. Our findings are supported by Jones et al. who observed that interlaminar distances did not change significantly in pregnant women when varying degrees (0–15°) of table tilt were applied.[3] Thus, it appears that the gravid uterus does not allow optimization of the paramedian acoustic target window with changes in body position; hence, these maneuvers are unlikely to have any benefit in improving neuraxial access in the obstetric population. All our pregnant subjects were at full term pregnancy. It is possible that subjects in early pregnancy when the uterine dimensions are small may demonstrate changes in PLL with body position that are comparable to those seen in non-pregnant individuals.[4]

The main limitation of this anatomical study is that it is a demonstration of anatomy; namely changes in ultrasonographic visualization of PLL length with body position. On the other hand, there is available evidence of the utility of PLL visualization and ease of spinal anesthesia insertion. In 2011, Weed et al.[11] demonstrated a correlation between poorly visualized PLLs and difficult placement of lumbar spinal anesthesia in 60 patients submitted to orthopedic procedures. In fact, they found that procedure time was shorter (113 vs. 409 s) when comparing well visualized PLL to poorly visualized ones. In addition, number of needle passes (4 vs. 10) and the rate of difficult spinal anesthetic (3:14) were all significantly smaller in the well visualized PLL group.

While it is reasonable to infer that greater ultrasonographic visualization of the PLL and therefore the interlaminar target window is related to technically easier neuraxial needle placement, this has not been demonstrated clinically in the obstetric patient population.

For practical reasons, both the operators and subjects could not be blinded by the study design. The ultrasound 'scanners' setting the calipers on the ultrasound screen for measurement of the PLL, were blinded to the numerical values, which were automatically calculated by the intrinsic software. The two 'reading' anesthesiologists, who were blinded to the subject position, independently identified and re-measured all PLL lengths from the saved images. We found good inter-observer agreement between the 'scanners' and the 'readers'. We aimed to accurately duplicate each position in each volunteer through verbal coaching, but aside from measuring the degree of table tilt, the other positions (the degrees of flexion and rotation) were not objectively measured. However, we do feel that this study accurately reflects what positions are achievable in real clinical practice on a standard maternity ward bed. Both the 'scanners' and the 'readers' were experienced in the use of ultrasound scanning of the spine; therefore gaining optimal images of the PLL by good scanning techniques and correct identification of this structure for measurement was assumed.

In conclusion, positioning pregnant women in a flexed-rotated position with simulated 10° dorsal table tilt does not significantly increase PLL length at the L3-4 interspace compared to flexion alone. Our findings suggest that the gravid uterus and other anatomic considerations of term pregnancy do not allow increases in interlaminar distances and PLL length measurement that were noted in other patient populations.[4] Thus, such maneuvers will have limited use in improving spinal needle access via a paramedian approach in pregnant subjects.

Funding

This work was supported by Internal Department of Anesthesiology[2,3] funding only.

Conflicts of interest

Dr Tang and Dr Sawka both received equipment and travel support from Ultrasonix in 2012. The other authors declare no conflicts of interest.

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