



Ultrasonographic measurement of the ligamentum flavum at different angles in the lateral tilt position

Bora Bilal¹ · Aykut Urfalioğlu¹ · Gözen Öksüz¹ · Mahmut Arslan¹ · Ömer Faruk Boran¹ · Adem Doğaner²

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Abstract

The aim of this study was to take ultrasonographic measurements of the length of the ligamentum flavum (LF), the LF–skin distance and the interspinous distance, which are critical for the application of neuraxial anaesthesia, with volunteers in the sitting position and with lateral tilt of the operating table at different angles to evaluate whether the target structures in neuraxial anaesthesia can be better visualised with the lateral tilt position and to determine whether or not these measurements change at different angles. The study included 29 volunteers. For the measurements, the operation table was first set into the neutral position and the length of the LF, the skin–LF distance and the interlaminar distance were measured at between L1–S1 spaces with a paramedian oblique sagittal approach with a linear ultrasound probe. Then the table was moved into 5°, 10° and 15° lateral tilt positions and the LF, LF–skin distance and the interlaminar distance were measured at the L1–S1 interspaces and recorded. At L2–3, L3–4, L4–5 and L5–S1 intervertebral interspaces, as the lateral tilt angle increased, so the measured LF length and interlaminar distance was determined to increase, this increase was statistically significant. In the ultrasonographic measurements of the skin–LF distance, at L3–4 and L4–5 intervertebral interspaces, there was a statistically significant increase. With lateral tilt applied to the table, there was determined to be an increase in ultrasonographic measurements of the LF length in the lumbar intervertebral interspaces. Therefore, for neuraxial blocks applied in the sitting position, the procedure may be facilitated with lateral tilt of the operating table.

Keywords Neuraxial anaesthesia · Ultrasound · Ligamentum flavum

1 Introduction

The use of ultrasonography in neuraxial anaesthesia has increased in recent years [1]. Ultrasonography in neuraxial interventions is applied in two forms as preprocedural or real time. With ultrasonographic evaluation made before a neuraxial intervention, information can be obtained about the spinous process, midline, and transverse processes of the vertebrae, which is helpful in the determination of the optimal needle entry site. Neuraxial blocks made under ultrasound guidance have been reported to have higher success

rates than neuraxial blocks made using anatomic landmarks [2–5].

Although the use of real time ultrasound guidance during the application of neuraxial block has been reported to increase success, the clinical use is not widespread because of requiring specific equipments and technical difficulties.

Positioning is of greater importance in patients where neuraxial blocks are difficult. The flexion of the vertebral column is of particular importance. When a position of sufficient flexion is provided, lumbar lordosis is minimised and thus the neuraxial intervention can be applied more easily. With the patient sitting on the operating table, with the legs hanging towards the floor, and feet supported by moving the operating table into lateral tilt, a position can be achieved that allows neuraxial interventions to be made more comfortably in difficult patients by providing hip and vertebral flexion [6, 7].

Although it is known that lateral tilt of the table facilitates the application of neuraxial block, there is a limited number of studies on specific patient groups in literature related to

✉ Bora Bilal
bilalbora@yahoo.com

¹ Department of Anesthesiology, Faculty of Medicine, Kahramanmaraş Sutcu Imam University, Kahramanmaraş, Turkey

² Department of Biostatistics and Medical Informatics, Faculty of Medicine, Kahramanmaraş Sutcu Imam University, Kahramanmaraş, Turkey

which angle of the table provides the ideal positioning of the critical anatomic structures for the neuraxial block [8].

The aim of this study was to take ultrasonographic measurements of volunteers sitting on the operating table of the length of the ligamentum flavum (LF), the LF–skin distance and the interspinous distance, which are critical for the application of neuraxial anaesthesia, with lateral tilt of the operating table at different angles to evaluate whether the target structures in neuraxial anaesthesia can be better visualised with the lateral tilt position and to determine whether or not these measurements change at different angles.

2 Methods

Power analysis was used to determine the sample size of the study. Reference studies published in this area [8] have been taken into consideration in determining the number of participants. Considering these studies, with an effect size of 0.65 in the repeated measures ANOVA method, it was planned to take 19 individuals to the study at the power of α : 0.05 Type I error level and β : 0.10 Type II error level and 90% test power for repeated measurement in 4 positions. To increase the integrity and accuracy of the statistical tests 29 individuals included in our study.

Approval for the study was granted by the Clinical Research Local Ethics Committee (2016/06-120). The volunteers accepted for participation in the study had no history of vertebral surgery, no congenital or acquired limitation of movement and body mass index (BMI) was $< 35 \text{ kg/m}^2$. The age, height, weight and BMI of all the participants were recorded.

The volunteers were seated on the operating table (Maquet Alphamaxx, Rastatt, Germany) and were instructed to lean forward touching the chin to the chest, relax the shoulders and arch the lower back like an angry cat (Fig. 1). During this procedure, precautions were taken to prevent the subject from falling.

All the ultrasonographic images taken during the study were taken by an anaesthetist experienced in vertebral ultrasonography (B. B.) using a 6–18 MHz linear ultrasound probe (Esaote MyLab Five, Florence, Italy). Although the usual probe for vertebral ultrasonography is low frequency curvilinear probe, high frequency linear probe should use by setting the optimal depth, focus and gain to produce optimal image. The measurements were taken on the ultrasonography device screen by another anaesthetist (G.O.), who was blinded to the angle of the table and the intervertebral level of the image.

The degree of tilt applied to the table was measured, calibrated and checked using a protractor.



Fig. 1 Neutral (0°) and 10° lateral tilt position of operating table

The table was first placed at 0° and for the measurements taken with a linear ultrasound probe at L5–S1 interspace with a paramedian oblique sagittal (PMOS) approach, first the sacral plateau was visualised, then the length of the LF was measured seen as a bright hyperechoic structure between two lamina in the L5–S1 interspace. During the measurement, the distance between the highest and lowest ends that could be seen was taken into consideration, then the skin–LF distance and the L5–S1 interlaminar distance (the distance between the apexes of the acoustic shadows of two lamina) was measured and recorded (Fig. 2). The operating table was then adjusted to 5°, 10°, 15° lateral tilt position and the LF, LF–skin distance and the interlaminar space were measured and recorded. These procedures were repeated in the same way for the L4–5, L3–4, L2–3, and L1–2 interspaces.

2.1 Statistical analysis

Data obtained in the study were analysed statistically using IBM SPSS version 22 software (IBM SPSS for Windows version 22, IBM Corporation, Armonk, New York, USA). Conformity of the data to normal distribution was assessed using the Shapiro–Wilk test.

The difference between the positional measurements in the normal distribution variables was examined by the

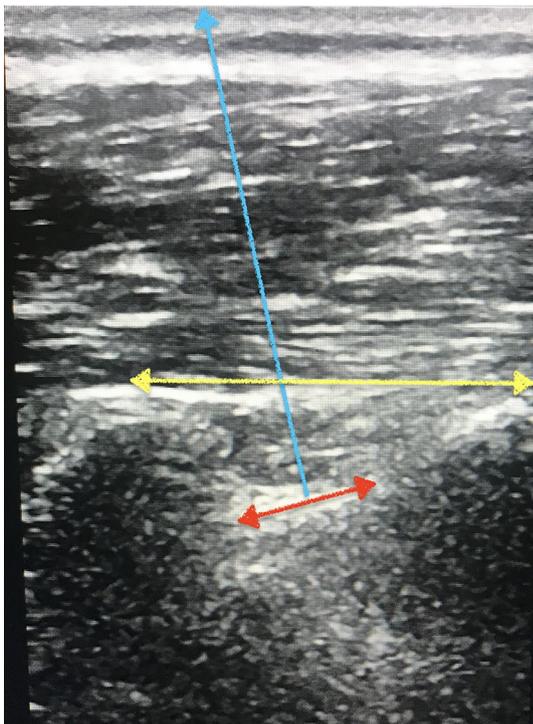


Fig. 2 Paramedian oblique sagittal ultrasonographic view of L2–3 interspaces. Red arrow: ligamentum flavum, yellow arrow: interlaminar distance, blue arrow: skin–LF distance

repeated measures ANOVA method. The Tukey–Kramer multiple-comparison post hoc test, Bonferroni test and Greenhouse–Geisser Correction test was used to assess differences between positions. As statistical parameters, values were stated as mean \pm standard deviation values. Statistical significance was accepted as a value of $p < 0.0125$.

3 Results

The 29 volunteers included in the study comprised 48.3% females and 51.7% males with a mean age of 22.38 years. Mean weight was 66.67 ± 8.78 kg, mean height 171.86 ± 8.05 cm and the mean BMI was calculated as 22.54 ± 2.20 (Table 1).

At L2–3, L3–4, L4–5 and L5–S1 intervertebral interspaces, as the lateral tilt angle increased, so the measured LF length was determined to increase, this increase was statistically significant.

When the interlaminar distance measurements were taken into consideration, there was determined to be an statistically significant increase in interlaminar distance at L2–3, L3–4, L4–5 and L5–S1 intervertebral spaces with increased lateral tilt angle.

In the ultrasonographic measurements of the skin–LF distance, at L3–4 and L4–5 intervertebral interspaces, there was a statistically significant increase (Table 2).

4 Discussion

The results of this study demonstrated that with an increase in lateral tilt angle of the operating table, the measurement of the length of the LF and interlaminar distance increased at L2–3, L3–4, L4–5 and L5–S1 interspaces and this increase was statistically significant. According to the study results, by adjusting the lateral tilt of the operating table with the patient sitting, neuraxial interventions may be more likely to be successful.

Ultrasonographic evaluation of the vertebrae can be applied in the transverse (axial) or longitudinal (sagittal) planes [9]. In the current study, the neuraxial

Table 1 Demographic data of the study participants

	Mean \pm SD	
Age (years)	Mean \pm SD	22.38 \pm 1.84
Weight (kg)	Mean \pm SD	66.67 \pm 8.78
Height (cm)	Mean \pm SD	171.86 \pm 8.05
BMI	Mean \pm SD	22.54 \pm 2.20
Gender		
Female	n (%)	14 (48.3)
Male	n (%)	15 (51.7)

Table 2 Ligamentum flavum, skin–LF and interlaminar distance measured using ultrasonography at 0°, 5°, 10°, 15° of lateral table tilt

	0° Mean ± SD (mm)	5° Mean ± SD (mm)	10° Mean ± SD (mm)	15° Mean ± SD (mm)	F	p
L1–2						
Skin–LF	41.45 ± 7.31	41.36 ± 7.41	41.34 ± 7.37	41.26 ± 7.47	0.276	0.842
LF	8.75 ± 1.13	10.16 ± 6.22	9.35 ± 1.30	9.37 ± 1.29	0.979	0.407
Interlaminar	33.73 ± 2.85 ^{c,d}	33.27 ± 5.40	35.00 ± 2.94 ^{a,d}	35.28 ± 2.91 ^{a,c}	3.302	0.024
L2–3						
Skin–LF	42.21 ± 7.20	41.05 ± 9.89	42.89 ± 7.07	42.98 ± 7.10	1.427	0.241
LF	8.93 ± 1.15 ^{b-d}	9.18 ± 1.13 ^{a,c,d}	9.48 ± 1.20 ^{a,b,d}	9.73 ± 1.11 ^{a-c}	44.932	< 0.001*
Interlaminar	33.73 ± 2.28 ^{b-d}	34.40 ± 1.87 ^a	34.57 ± 1.84 ^a	34.81 ± 1.59 ^a	11.115	< 0.001*
L3–4						
Skin–LF	41.93 ± 6.88 ^b	42.28 ± 6.80 ^a	42.11 ± 6.69	42.19 ± 6.72	4.481	0.006*
LF	8.66 ± 1.09 ^{b-d}	9.17 ± 1.20 ^{a,c,d}	9.43 ± 1.28 ^{a,b,d}	9.65 ± 1.36 ^{a-c}	62.897	< 0.001*
Interlaminar	33.33 ± 2.21 ^{c,d}	33.63 ± 2.72 ^{c,d}	34.06 ± 2.70 ^{a,b,d}	34.66 ± 2.57 ^{a-c}	13.887	< 0.001*
L4–5						
Skin–LF	42.99 ± 5.81 ^{b,c}	43.36 ± 6.24 ^a	43.62 ± 6.06 ^a	43.51 ± 5.98	5.434	0.002*
LF	8.88 ± 1.37 ^{b-d}	9.09 ± 1.26 ^{a,c,d}	9.55 ± 1.33 ^{a,b,d}	9.69 ± 1.40 ^{a-c}	51.137	< 0.001*
Interlaminar	31.56 ± 2.73 ^{b-d}	31.77 ± 2.78 ^{a,c,d}	32.86 ± 2.96 ^{a,b}	33.18 ± 4.00 ^{a,b}	10.435	< 0.001*
L5–S1						
Skin–LF	44.69 ± 6.99	44.98 ± 7.10	45.13 ± 7.21	44.87 ± 7.52	1.933	0.130
LF	9.26 ± 1.08 ^{b-d}	9.84 ± 0.95 ^{a,c,d}	10.15 ± 0.89 ^{a,b}	10.34 ± 0.80 ^{a,b}	41.619	< 0.001*
Interlaminar	32.57 ± 2.60 ^{b-d}	33.05 ± 2.60 ^{a,c,d}	33.42 ± 2.41 ^{a,b,d}	33.79 ± 2.25 ^{a-c}	24.137	< 0.001*

One-way ANOVA; post-hoc; Tukey test; Tamhane T2 test; α 0.05

Bold reflected values are statistically significant

*Difference is statistically significant

^aDifference is statistically significant in comparison with the 0° groups

^bDifference is statistically significant in comparison with the 5° groups

^cDifference is statistically significant in comparison with the 10° groups

^dDifference is statistically significant in comparison with the 15° groups

ultrasonographic evaluation and measurements were made with a PMOS approach. Grau et al. reported that neuraxial structures could be visualised better with the PMOS approach than with the median transverse or median sagittal plane approach [10].

In a study of pregnant subjects, Jones et al. [8] measured the LF at L3–4 at a lateral tilt angle of 0°, 8°, and 15° and reported that the LF length increased with an increase in the lateral tilt angle of the operating table. In our study, LF measurements were taken not at a single level but at L1–2, L2–3, L3–4, L4–5, and L5–S1 interspaces at a lateral tilt position of 0°, 5°, 10° and 15°. The LF length was found to increase with an increase in lateral tilt angle at L2–3, L3–4, L4–5 and L5–S1 interspaces. At L5–S1, although there was an increase in LF length with an increase in the lateral tilt angle, this increase found to be statistically significant between 0°–10°, 0°–15°, 5°–10° and 5°–15°.

When it is considered that the greatest increase of LF length with increased lateral tilt angle of the table was at L3–4 and L4–5 level, it can be said that neuraxial

interventions to be made at these level may be more easily achieved with lateral tilt of the table.

One of the factors affecting success in neuraxial anaesthesia applications is the appropriate position of the patient during the procedure [11]. With the recent introduction of ultrasound use, real-time or pre-procedural ultrasound use in neuraxial blocks has been reported to have positive effects on block success [12]. Shaikh et al. found a significant reduction in block failure, skin punctures and needle redirections with the use of ultrasound [13].

In a study by Chin K. J. et al. of a non-obstetric patient population with poor surface landmarks, there was reported to be an increased first-attempt success rate of neuraxial anaesthesia with preprocedural ultrasound guidance [14].

Previous studies related to the use of ultrasound in neuraxial anaesthesia have generally compared real-time and preprocedural ultrasound guidance use with traditional methods. Taking the results of the current study into consideration, further studies can be planned to evaluate the effect of position in preprocedural ultrasound guidance studies.

Limitations of the current study can be said to be that ultrasonographic measurements are subjective and can show variation according to the experience of the operator. To reduce this, all of the measurements in our study were made by a single operator who was blinded to the degree of tilt applied.

In conclusion, adjusting the operating table with lateral tilt and the patient in a sitting position increased the visibility of the LF on ultrasound which is important in neuraxial anaesthesia, and when it is considered that this increase was statistically significant at L2–3, L3–4, L4–5 and L5–S1 interspaces, applying lateral tilt to the operating table for neuraxial anaesthesia may facilitate the procedure.

5 Conclusion

The results of this study demonstrated an increase in the interlaminar LF length as measured by ultrasound in the lumbar region when lateral tilt was applied to the table. Therefore, neuraxial blocks performed in the sitting position may be facilitated with lateral tilt of the operating table. Further researches should be done that evaluates the contribution of lateral tilt position to clinical practice and examining patient comfort during the lateral tilt position.

Compliance with ethical standards

Conflict of interest The authors report no conflict of interest.

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