

Comparison of Intervertebral Space Area by Body Position Using a Three-dimensional Model

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Abstract

Study Objective: The objective of this study was to investigate whether the area of the intervertebral space changes with body position.

Design: Case study.

Setting: Operating room.

Patients: Healthy adult male.

Interventions: A C-arm X-ray fluoroscopy system captured bone condition images of Th9/10, Th10/11, L3/4, and L4/5 of a healthy male volunteer. A three-dimensional (3D) model of the spine was created.

Measurements: We compared the areas of the intervertebral spaces in the supine and flexed body positions at Th9/10, Th10/11, L3/4, and L4/5 in the 3D model. The areas were compared and viewed caudally.

Main Results: In the anteversion position, the areas of the intervertebral spaces were larger by 60% in the thoracic spine and by 100% in the lumbar spine of L4/5.

Conclusions: The intervertebral spaces in the lower thoracic and lumbar spines were larger in the anteversion position. Hence, the anteversion position may be the preferred body position for spinal or epidural anaesthesia.

Keywords: 3D image; Body position; Intervertebral space; Spinal anaesthesia; Spine

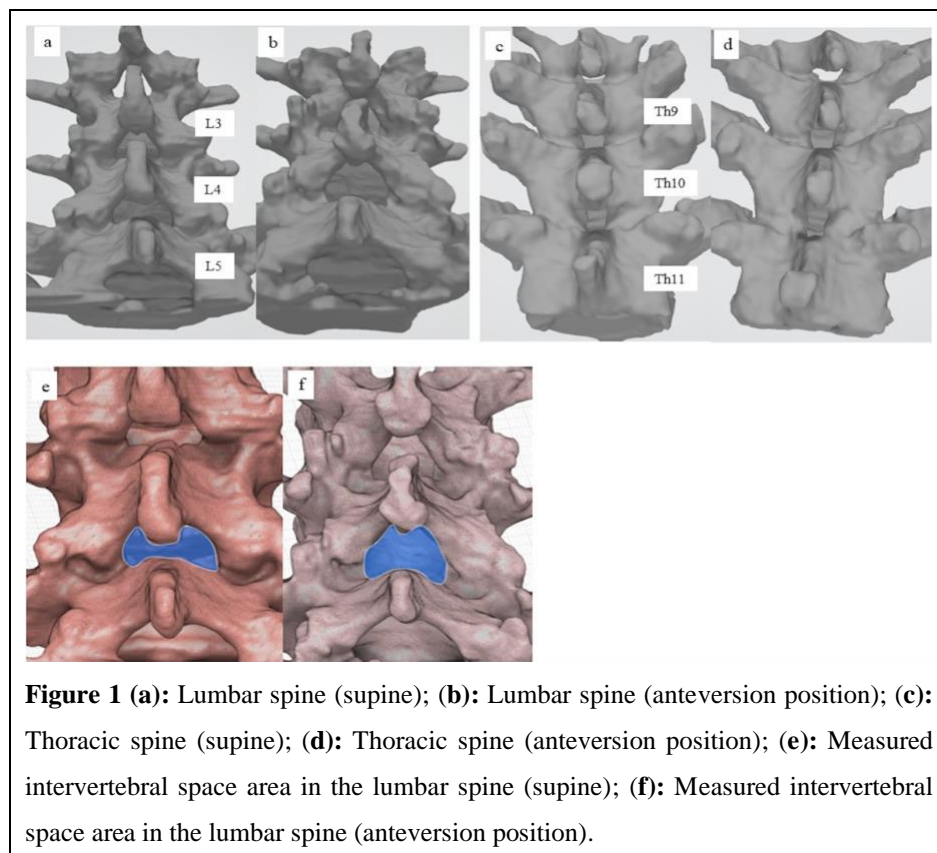
Introduction

When performing spinal or epidural anaesthesia, it has been suggested that the patient should be maintained in a forward-bent position with the neck firmly flexed and knees bent to widen the intervertebral space and facilitate puncture [1]. However, there are no reports on the observed changes in the areas of the intervertebral spaces in the supine and anteversion positions. In this study, we created a 3D model of the spine using a C-arm X-ray fluoroscopy system (Siemens ARCADIS Orbic 3D, Munich, Germany) and compared the areas of the intervertebral spaces in the supine and anteversion positions at Th9, Th10, Th11, L3, L4, and L5.

Materials and Methods

A C-arm X-ray fluoroscopy system can help generate 3D images of bone conditions by rotating the C-arm around the patient. Bone condition images of Th9, Th10, Th11, L3, L4, and L5 of a healthy male volunteer (42 years old, 171 cm, 65 kg) were captured using this system. Imaging was performed in the supine and anteversion positions. A 3D model of the spine was then created, and the differences in the areas of the intervertebral foramina were compared using measurement software (Figure 1). The areas were viewed caudally, a position where the intervertebral space would be the largest, assuming that the puncture was performed using the median approach of spinal anaesthesia. A 3D slicer [2] was used to create the models, and Fusion360 (Autodesk, Inc., San Francisco, California, USA) was used to calculate the area of the intervertebral foramen.

This study was conducted with the approval of the Institutional Review Board of Nagahama Red Cross Hospital (Approval No.: 2022-007), and due consideration was administered to the protection of patient's personal information based on the Declaration of Helsinki of Human Rights. Written informed consent was obtained from the patient.



Results

A comparison of the 3D models showed that the areas of the intervertebral spaces in both the lumbar and thoracic spines were larger in the anteversion position than in the supine position. In the anteversion position, the areas of the intervertebral spaces were larger by 60% in the thoracic spine (Figure 1, Table 1) and by 100% in the lumbar spine of L4/5.

Table 1: Maximum size of each intervertebral space in the supine and anteversion positions.

Area	Supine position	Anteversion position
Th 9/10	0.26 cm ²	0.43 cm ²
Th 10/11	0.26 cm ²	0.46 cm ²
L 3/4	0.94 cm ²	1.19 cm ²
L 4/5	1.17 cm ²	2.42 cm ²

Discussion

Although it has been reported that the distance between the spinous processes widens in the anteversion position [3], no studies have so far compared the areas of the intervertebral spaces in the supine and anteversion positions. The results of this study support the recommendation as described in an anaesthesiology textbook; that is, the patient should be placed in a flexed position during a spinal or epidural puncture [1]. The C-arm X-ray fluoroscopy system, used in this study to create a 3D model, allows imaging of patients in different positions on the operating table with minimal radiation exposure of approximately 20 seconds. This study's limitation was that it was performed on a single, healthy participant. Further attempts should be made to obtain data from older patients with bone deformities and from obese individuals.

Conclusion

In the anteversion position, the intervertebral spaces were larger in the lower thoracic and lumbar spine regions. Hence, the anteversion position may be the preferred body position for spinal or epidural anaesthesia.

Author Contributions

Masashi Fujii: Designed the study and drafted the manuscript.

Tsutomu Shirakawa: Supervised the study and the processing of computer images.

Nobuaki Shime and Yasuyo Kawabata: Drafted the manuscript and supervised the study.

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