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ORIGINAL ARTICLE

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Differences in lumbar dural sac dimension in supine and lateral positions in late pregnancy: a magnetic resonance imaging study

Fei Xu,[a,†] Ying Liu,[b,†] Yuan Wei,[c] Yangyu Zhao,[c] Huishu Yuan,[b,‡] Xiangyang Guo[a,‡]
[a]*Department of Anesthesiology, Peking University Third Hospital, Beijing, China*
[b]*Department of Radiology, Peking University Third Hospital, Beijing, China*
[c]*Department of Obstetrics and Gynecology, Peking University Third Hospital, Beijing, China*

ABSTRACT
Background: This study was designed to quantitatively investigate differences in lumbar dural sac dimensions between the lateral and supine positions in late pregnancy.
Methods: Ten healthy volunteers with singleton pregnancies at 28–39 weeks of gestation were included. Magnetic resonance imaging was performed in random order while subjects were in the left lateral and supine positions. Lumbosacral axial scans were obtained at the L1–2, L2–3, L3–4, L4–5 and L5–S1 intervertebral disc levels. The axial section area, anteroposterior maximum diameter and transversal maximum diameter of the dural sac were measured and differences between these parameters in the lateral and supine positions were compared.
Results: The axial section areas of the dural sac at L1–2 ($P<0.001$), L2–3 ($P=0.001$), L3–4 ($P<0.001$) and L4–5 ($P=0.005$) and the transversal maximum diameter of the dural sac at L1–2 ($P<0.001$), L2–3 ($P<0.001$), L3–4 ($P<0.001$) and L4–5 ($P=0.001$) were greater in the lateral position compared with the supine position. The anteroposterior maximum diameter of the dural sac at L4–5 was greater in the lateral position compared with the supine position ($P=0.019$) but there were no significant differences at other levels. The magnitude of the differences in axial section area and transverse maximal diameter were similar among the levels studied.
Conclusions: The axial section area and the transversal maximum diameter of the dural sac in the lumbar area are reduced in the supine compared with the lateral position in late pregnancy.

Keywords: Magnetic resonance imaging; Epidural venous plexus; Obstetric; Positional change

Introduction

The spread of anesthetic level is enhanced and less local anesthetic is needed during spinal anesthesia in pregnant compared with non-pregnant patients.[1–5] Many possible factors have been investigated to explain this, including change of nerve sensitivity,[6–9] physiological and biochemical alterations of cerebrospinal fluid (CSF),[1,2] changes in spine curvature,[10] different positions,[11,12] and compression of the dural sac associated with the engorged epidural venous plexus leading to a decrease in subarachnoid space volume.[13–15] However, the mechanism of this phenomenon is still not fully clarified.

Our preliminary observation indicated that the postural change from the lateral to the supine position can significantly affect sensory block levels after intrathecal injection of plain bupivacaine for cesarean section. A possible mechanism is that changing position from lateral to supine may result in engorgement of the epidural venous plexus, which would compress the dural sac and induce bulk cephalad movement of CSF containing local anesthetic, producing a more extensive block level.[16] Therefore, we designed the present study to quantitatively investigate differences in the dimensions of the dural sac in the supine and lateral positions in late pregnancy.

Methods

The local ethics committee (Peking University Third Hospital, Beijing, China) approved all study procedures and the trial was prospectively registered at the Chinese Clinical Trial Registry (ChiCTR-ONC-14004868) on 28

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Correspondence to: Xiangyang Guo, Department of Anesthesiology, Peking University Third Hospital, Beijing 100191, China.
E-mail address: xiangyangguoby@163.com
†Fei Xu and Ying Liu are joint first authors.
‡Xiangyang Guo and Huishu Yuan are co-corresponding authors.

June 2014. Ten pregnant volunteers were enrolled after giving written informed consent. Inclusion criteria included: American Society of Anesthesiologists physical status I–II, 20–35 years of age, singleton pregnancy at 28–39 weeks of gestation, weight 55–90 kg and height 150–170 cm. Subjects with spinal malformations, lumbar disease or pregnancy-induced hypertension or with previous magnetic resonance imaging (MRI) results reported as abnormal were excluded.

When subjects arrived in the MRI room, the order of scanning (lateral first or supine first) was randomly allocated by drawing of sealed envelopes. A statistician (Lin Hua, Associate Professor, School of Biomedical Engineering, Capital Medical University, Beijing, China) used Rand A 1.0 software (Randomization Adviser 1.0, Beijing, China) to generate random numbers, and based on these numbers made random allocation cards which were put into the envelopes. Another independent researcher opened one sealed envelope and informed the radiologist to perform the examination in the order indicated by the card in the envelope. The MRI examinations were performed for each subject while they were in the left lateral and supine positions. When supine, subjects were not tilted.

Lumbosacral axial scans were obtained at intervertebral disc levels using an MRI system (Siemens Sonata, Erlangen, Germany) operating at 1.5 T. The body coil was used in the lateral position, and the spinal coil was used in the supine position. T2-weighted axial images were obtained with a fast-spin echo sequence, included a 5190-ms repetition time, a 102-ms echo time, a 160×256-image matrix, and 4-mm slice thickness with 0.4-mm intervals. From the L1–2 to the L5–S1 intervertebral disc, a total of five levels were scanned; each intervertebral disc was scanned at three layers, and the middle layer was used for analysis. A senior radiologist who was unaware of the purpose of the study measured the axial section area, anteroposterior maximum diameter and transversal maximum diameter of the dural sac using the PACS (Picture Archiving and Communication Systems, GE Healthcare, Barrington, IL, USA). All measurements were performed three times, and mean values were used for analysis. The difference in axial section area, anteroposterior maximum diameter and transversal maximum diameter between the lateral position and supine position were calculated.

Statistical analysis

In our preliminary investigation, we observed three pregnant women in the lateral and supine positions and obtained values for mean and standard deviation (SD) of the axial section area. Sample size estimate was performed based on the difference between the means of the two groups (28.2 mm^2) and the higher SD of the two groups (26.9 mm^2) obtained from this preliminary experiment. For a two-tailed comparison, with $\beta=0.2$ and $\alpha=0.05$, a sample size of 10 patients in each group was required. Sample size estimation was performed using SASA 1.0 software (Sample Size Adviser 1.0, Beijing, China). Differences in dural sac measurements in the lateral and supine positions were compared using the paired t test. Changes in measurements between the supine and lateral positions among the five disc levels were analyzed using one-way analysis of variance and the Tukey test was used for multiple comparisons.

Results

Patient characteristics are presented in Table 1. Because of fat in the vertebral canal from L5 to the sacrococcygeal region in all 10 subjects (Fig. 1), and the axial section area of the dural sac at this level was small, the boundary of the dura sac was sometimes not clear and so measurements at this level were discarded.

Typical MRI scans are shown in Fig. 2. In the lateral position, the epidural venous plexus appeared shrunken at the intervertebral disc levels and the cross-sectional shape of the dural sac was oval. In comparison, in the supine position, the epidural venous plexus was engorged, the dural sac was compressed and the cross-sectional shape of the dural sac was almost round.

The axial section area of the dural sac at the L1–2 ($P<0.001$), L2–3 ($P=0.001$), L3–4 ($P<0.001$) and L4–5 ($P=0.005$) disc levels was larger in the lateral position than in the supine position (Table 2). The transversal maximum diameter of the dural sac at the L1–2 ($P<0.001$), L2–3 ($P<0.001$), L3–4 ($P<0.001$) and L4–5 ($P=0.001$) disc levels was larger in the lateral than in the supine position (Table 3). The anteroposterior maximum diameter of the dural sac at the L4–5 disc level was greater in the lateral than in the supine position ($P=0.019$) but there were no significant differences at other levels (Table 4). The magnitude of the difference in axial cross-section area and transverse maximal diameter was similar at all four disc levels (Table 5). The percentage reductions in cross-sectional area between the lateral and supine positions at the L1–2, L2–3, L3–4 and L4–5 disc levels were $12.7 \pm 6.9\%$, $12.9 \pm 8.9\%$, $14.1\% \pm 6.3\%$ and $16.1 \pm 13.3\%$, respectively; these differences were similar among the different levels ($P=0.8$).

Discussion

Previous studies have demonstrated that the dural sac is compressed by the epidural venous plexus in the supine position in late pregnancy.[13–15] The proposed mechanism is that the inferior vena cava is compressed by the pregnant uterus when the patient lies supine, resulting in diversion of a proportion of venous return from the lower limbs and pelvic organs to the vertebral venous system, causing the epidural venous plexus to