Soft tissue anatomy within the vertebral canal in pregnant women

Y. HIRABAYASHI, R. SHIMIZU, H. FUKUDA, K. SAITO AND T. IGARASHI

Summary

To clarify pregnancy-induced changes in soft tissue anatomy within the vertebral canal, we have studied magnetic resonance (MR) images of the lumbar spine in three women. In each subject, T2-weighted axial MR images were obtained both before pregnancy and at 32 weeks' gestation, and the paired images were compared. The extradural venous plexus was engorged significantly in supine parturients. In addition, the engorged extradural venous plexus displaced the dura away from the wall of the vertebral canal in a posterior direction, which resulted in a decrease in the volume of the cerebrospinal fluid in the dural sac. These findings confirmed the long-held concept that the engorged extradural venous plexus in supine parturients decreases the effective capacity of the extradural and subarachnoid spaces. (Br. J. Anaesth. 1996; 77: 153–156)

Key words


Obstruction of the inferior vena cava by the enlarged pregnant uterus impairs the return of venous blood from the legs and pelvis to the heart [1, 2]. The collateral circulation includes the intraosseous vertebral veins, paravertebral veins and extradural venous plexus. Of these, the engorged extradural venous plexus is expected to decrease the effective capacity of the extradural and subarachnoid spaces [3–5], and parturients may require less anaesthetic agent for induction of extradural or spinal anaesthesia.

Although the engorged extradural venous plexus during pregnancy has been demonstrated well by radiological studies of the inferior vena cava [1, 2, 5], few objective data are available to confirm the decrease in the capacity of the extradural and subarachnoid spaces. Magnetic resonance (MR) imaging provides detailed information on soft tissue anatomy within the vertebral canal [6, 7]. To clarify pregnancy-induced changes in soft tissue anatomy within the vertebral canal, we performed MR imaging both before and during pregnancy in volunteers.

Results

ANATOMY IN NON-PREGNANT STATE

The extradural space around the dura varied in shape and size depending on the longitudinal site of the axial slices. At the level of the intervertebral disc, the anterior extradural space was absent as the annular ligament of the disc was in direct contact with the dural sac (fig. 1A). The fat-filled posterior extradural space which was enclosed by the ligamentum flavum, the articular capsule and the dura was present posteriorly. The fat in this space, appearing as a triangle, had a high signal and was uniform (white). The lateral and posterior extradural spaces were discontinuous, separated by areas of contact of the dura with the ligamentum flavum. At the level of the pedicles, virtually no contents were identified in the extradural space except veins anteriorly (fig. 2A). At the level of the lamina, the extradural space, which contained nerve roots, vessels and fat, opened up laterally to the dura (fig. 3A).

Subjects and methods

The Institutional Review Board approved our study and informed consent was obtained from three women aged 28, 30 and 31 yr. MR imaging examinations were performed twice in each subject: before pregnancy (non-pregnant) and at 32 weeks' gestation (pregnancy). All MR images were obtained with the subject supine and with the legs extended. T2-weighted axial MR images of the second and third lumbar vertebrae were obtained using an MR imaging system (MRT-200/FXIII super version, Toshiba Corporation, Tokyo, Japan) operating at 1.5 T with a single surface coil. Technical specifications included a repetition time of 3000 ms, echo time of 112 ms, slice thickness of 4 mm, number of slices of 9 and a field of view of 15 cm. On each slice level, we compared the paired images (non-pregnant vs pregnancy) with each other in the same subject. Measurements obtained from MR images included the following: maximum distance between the anterior surface of the ligamentum flavum and the dura; area of the fat-filled posterior extradural space at the level of the intervertebral disc between the second and third lumbar vertebrae; and area of the dural sac at the level of the intervertebral disc between the second and third lumbar vertebrae. The areas were measured using a digital planimeter (KP-90N, Uchida Yoko, Ltd, Tokyo, Japan).

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CHANGES IN ANATOMY DURING PREGNANCY

With the parturient supine, the enlarged pregnant uterus pressed down the abdominal aorta and inferior vena cava against the vertebral body. In particular, the inferior vena cava was almost totally obstructed (figs 1B, 2B and 3B). The extradural venous plexus was substantially engorged. The engorgement was noted in the anterior vertebral veins (figs 1B, 2B and 3B). The engorged anterior vertebral veins displaced the anterior internal vertebral veins, which displaced the dura away from the wall of the vertebral canal in a posterior direction.

**Figure 1** T2-weighted MR images showing an axial section through the L2–3 intervertebral disc before pregnancy (A) and at 32 weeks' gestation (B). AA = Abdominal aorta, IVC = inferior vena cava, IVD = intervertebral disc, CE = cauda equina, SAP = superior articular process, IAP = inferior articular process, LF = ligamentum flavum, F = posteromedial extradural fat, AIVV = anterior internal vertebral vein. The anterior extradural space is absent as the annular ligament of the disc is in direct contact with the dural sac. During pregnancy, the anterior vertebral veins are engorged, particularly on both sides of the extradural space. The fat-filled posterior extradural space which is enclosed by the ligamentum flavum, the articular capsule and the dura remains unchanged during pregnancy. The fat in this space, appearing as a triangle, has a high signal and is uniform (white).

**Figure 2** T2-weighted MR images showing an axial section at the level of the pedicles of L3 before pregnancy (A) and at 32 weeks' gestation (B). AA = Abdominal aorta, IVC = inferior vena cava, VB = vertebral body, P = pedicle, CE = cauda equina, AIVV = anterior internal vertebral vein. Virtually no contents are identified in the extradural space except veins anteriorly before pregnancy (A). The anterior vertebral veins are substantially engorged during pregnancy (B).

**Figure 3** T2-weighted MR images showing an axial section at the level of the lamina of L3 before pregnancy (A) and at 32 weeks' gestation (B). AA = Abdominal aorta, IVC = inferior vena cava, VB = vertebral body, L = lamina, SP = spinous process, CE = cauda equina, AIVV = anterior internal vertebral vein. The engorged anterior internal vertebral veins displace the dura away from the wall of the vertebral canal in a posterior direction (B).
Extradural anatomy and pregnancy

Table 1  Body weight and measurements in the three women before pregnancy (non-pregnant) and at 32 weeks’ gestation (pregnancy)

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Non-pregnant</th>
<th>Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient No. 1</td>
<td>53</td>
<td>60</td>
</tr>
<tr>
<td>Patient No. 2</td>
<td>37</td>
<td>47</td>
</tr>
<tr>
<td>Patient No. 3</td>
<td>45</td>
<td>51</td>
</tr>
<tr>
<td>Ligamentum flavum-dura mater (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient No. 1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Patient No. 2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Patient No. 3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Area of the posterior extradural space at L2–3 (cm²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient No. 1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Patient No. 2</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Patient No. 3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Area of the dural sac at L2–3 (cm²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient No. 1</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Patient No. 2</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Patient No. 3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

the dura away from the wall of the vertebral canal in a posterior direction (figs 2n and 3n), which resulted in a decrease in the volume of cerebrospinal fluid in the dural sac. The fat-filled posterior extradural space remained unchanged during pregnancy (fig. 1b). Measurements obtained are documented in table 1.

Discussion

Injection of a given dose of local anaesthetics into the extradural space or subarachnoid space produces more extensive segmental block in late pregnancy than at other times [3–5, 8]. Possible explanations for this increased sensitivity to regional anaesthesia include anatomical and hormonal changes associated with pregnancy [9–14].

The dural sac is enclosed completely by the rigid vertebral canal and tissues of the central nervous system are incompressible. Because the volume of the intradural contents remains unchanged, the volumes of blood and CSF within the vertebral canal must vary in inverse relationship to each other [5]. In the later stages of pregnancy the gravid uterus compresses both the inferior vena cava and abdominal aorta, whenever the gravid lies in the supine position [1, 2, 15]. Obstruction of the inferior vena cava diverts a proportion of the venous return from the legs and pelvic structure into the vertebral venous system, which is composed of three freely communicating valveless networks: intrasosseous vertebral veins, paravertebral veins and the extradural venous plexus [16]. Of these, the engorged extradural venous plexus is expected to decrease the effective capacity of the extradural [3] and subarachnoid spaces [4, 5]. These decreased spaces are considered to be one of the reasons for pregnancy-induced enhancement of regional anaesthesia.

Examination of the soft tissue anatomy within the vertebral canal has been performed by radiographic methods such as extradurography [17], extradural venography [16, 18], myelography [5] and computed tomography [19]. Because these radiographic examinations include fetal hazards for exposure to x-rays, changes in soft tissue anatomy during pregnancy have not been investigated fully, although they are traditionally considered to influence significantly the spread of regional anaesthesia in parturients. In contrast with radiographic examinations, MR imaging, without the use of x-rays, provides detailed information on soft tissue anatomy within the vertebral canal [6, 7]. The signal intensity of circulating blood is extremely low on T2-weighted MR images, and hence not only large vessels but also small vessels can be identified without the use of contrast media. The intensity of CSF in the adjacent dural sac appears slightly higher than that of extradural fat. Thus T2-weighted MR images provided quantitative data on the effective capacity of the extradural and subarachnoid spaces.

The extradural venous plexus was engorged significantly in our supine parturients. In addition, the engorged extradural venous plexus displaced the dura away from the wall of the vertebral canal in a posterior direction, which resulted in a decrease in the volume of cerebrospinal fluid in the dural sac. These findings confirm the long-held concept that the engorged extradural venous plexus in supine parturients decreases the effective capacity of the extradural and subarachnoid spaces [3–5], and parturients may therefore require less anaesthetic agent for induction of extradural or spinal anaesthesia.

A surprising finding was that the fat-filled posterior extradural space remained unchanged during pregnancy, although the anterior and lateral extradural space significantly altered its feature. The extradural venous plexus is composed of two vertical channels, the anterior vertebral veins that course the length of the vertebral canal, hugging the backs of the vertebral bodies and intervertebral discs [16]. The anterior vertebral veins, consisting of medial and lateral components, lie medial to the pedicles and bulge laterally as they cross the intervertebral disc spaces. The findings observed in the MR images of our parturients were consistent with engorgement of the anterior vertebral veins. On the other hand, there is increasing evidence to indicate that the posterior vertebral veins are rudimentary or do not exist [16, 18, 20, 21], although anatomy texts always describe such a system [22–27]. Indeed, a review of 1200 lumbar extradural venograms demonstrated that the posterior vertebral veins were not seen during venography [16]. Failure of the posterior extradural space to alter during pregnancy probably confirms the absence of a system of posterior vertebral veins.

The number of subjects examined in this study was small. Within-subject comparison, however, made it possible to demonstrate clearly the pregnancy-induced changes in soft tissue anatomy within the vertebral canal in the later stages of pregnancy. In addition, we have demonstrated occlusion of the inferior vena cava in the supine position at 32 weeks’ gestation. This supports the recommendation that pregnant women, especially during the later stages of pregnancy, should never be
allowed to adopt the supine position, although our parturients did not complain of any discomfort during the examination.

Acknowledgements

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References