Anatomical configuration of the spinal column in the supine position. I. A study using magnetic resonance imaging

Y. HIRABAYASHI, R. SHIMIZU, K. SAITO, H. FUKUDA AND M. FURUSE

Summary
In order to clarify the anatomical configuration of the spinal column in the supine position, we have examined T1-weighted sagittal midline magnetic resonance images of the spinal column in 20 healthy volunteers (11 men, nine women) in the supine position. The mean maximum angles of decline of the lumbar spinal canal in men and women were 12.6 (SD 3.9)° and 13.4 (3.3)° in the cephalad direction, respectively. The maximum angles of incline of the upper thoracic spinal canal in men and women were 20.3 (4.0)° and 18.5 (2.5)°, respectively. The median highest points of the lumbar spinal canal in men and women were located at L4 (range L3–4 to L4) and L4 (L4), respectively. The lowest point of the thoracic spinal canal was located at T8 (T7–T9) in both men and women. We have demonstrated that both lumbar lordosis and thoracic kyphosis differ between individuals, particularly with respect to the lowest point of the thoracic spinal canal, which is located between T7 and T9. (Br. J. Anaesth. 1995; 75: 3–5)

Key words

The anatomical configuration of the spinal column significantly affects the spread of subarachnoid anaesthetic solutions that move under the influence of gravity [1, 2]. It is widely accepted that, in the supine position, the lumbar spinal column slopes downward, 8–12° in the cephalad direction [3], and that the highest and lowest points of the spinal canal are at L3 and T5–6, respectively [2, 4–8]. However, few objective data are available to support these views.

Magnetic resonance (MR) imaging provides accurate information on the structure of the spinal column [9]. We have studied the anatomical configuration of the spinal column by MR imaging in supine healthy volunteers.

Subjects and methods
The institutional review board approved our study and informed consent was obtained from all subjects. We studied 20 healthy Japanese volunteers (11 men, nine women) aged 16–63 yr (median 35 yr). Subjects with back complaints were excluded. MR imaging examinations were performed with the subject in the supine position, with the legs extended horizontally and a head-rest (1 cm thick) placed under the head on the MR platform. T1-weighted sagittal images of the cervical, thoracic and lumbar spine were obtained by the MR imager (MRT-200/FXIII super version, Toshiba Corporation, Tokyo, Japan) operating at 1.5 T with single conventional surface coil. Technical specifications included a repetition time of 320–430 ms, an echo time of 15 ms, a slice thickness of 4 mm, slice numbers of 11 and a field of view of 30 cm. The sagittal midline images of the cervical, thoracic and lumbar spine were aligned to determine the following: maximum angle of decline of the lumbar spinal canal in the cephalad direction against the plane of the MR platform, maximum angle of incline of the upper thoracic spinal canal against the plane of the MR platform, highest and lowest points of the spinal canal and levels of termination of the spinal cord and dural sac (fig. 1). The nearest vertebral body and intervertebral disc were used in determining the highest and lowest points (e.g. L1 indicated the body of the first lumbar vertebra; L1–2 showed the intervertebral disc between the first and second lumbar vertebrae).

Men and women were compared by Student’s unpaired t test for parametric data and by the Mann–Whitney U test for non-parametric data. Correlation between age and measurements was evaluated by correlation coefficient (r) and the Spearman rank correlation coefficient (p) as appropriate. P < 0.05 was considered statistically significant.

Results
Height and weight were significantly greater in men than in women, while body mass index did not differ. Although the ranges of age were similar between men and women, mean age was less in men than in women (table 1).

There were no significant differences between men and women in the maximum angles of incline

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spinal canal was located at L4 (range L3–4 to L4). The lowest point of the thoracic spinal canal was located at T8 (T7–T9) (fig. 2). The spinal cord terminated at L1 (T12–L1 to L1) and the dural sac terminated at S2 (S2 to S2–3).

There were no significant effects of age on maximum angle of decline (p = 0.05), angle of incline (p = 0.21), highest point (p = 0.18), lowest point (p = 0.17) or termination of the spinal cord (p = 0.34) and dural sac (p = 0.06). Figure 3 shows a representative sagittal midline MR image of the spinal column.

Table 2  Maximum angle of decline of the lumbar spinal canal (decline), maximum angle of incline of the upper thoracic spinal canal (incline), highest and lowest points of the spinal canal (high and low points), and levels of termination of the spinal cord and dural sac (spinal cord and dural sac) in men and women (mean (SD) and range).

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>28 (16–59)*</td>
<td>45 (18–63)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172 (6)**</td>
<td>154 (5)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70 (13)**</td>
<td>54 (3)</td>
</tr>
<tr>
<td>Body mass index (kg m(^{-2}))</td>
<td>23.5 (3.3)</td>
<td>22.7 (1.6)</td>
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<td></td>
<td>[19.8–29.9]</td>
<td>[20.1–25.8]</td>
</tr>
</tbody>
</table>

Table 2  Maximum angle of decline of the lumbar spinal canal (decline), maximum angle of incline of the upper thoracic spinal canal (incline), highest and lowest points of the spinal canal (high and low points), and levels of termination of the spinal cord and dural sac (spinal cord and dural sac) in men and women (mean (SD) and range).

**Discussion**

We have demonstrated that both lumbar lordosis and thoracic kyphosis differ among individuals, particularly with respect to the lowest point of the thoracic spinal canal, which was located between T7 and T9.

In the first decade of the 20th century, Barker [10] made models of the spinal canal from glass tubes based on a frozen section of the horizontal female cadaver and concluded that in the supine position the high point of the canal was L3 and that there was a decline to T5 or T6. The principles established, by Barker are valid today. However, to our knowledge there are no studies demonstrating that in the supine subject the highest and lowest points of the spinal canal are located at L3 and T5–T6, respectively. Our results were not in accordance with this traditional concept, particularly with respect to the lowest point of the thoracic spinal canal. MR imaging makes it possible to evaluate accurately the anatomical configuration of the spinal column in supine volunteers.

Lumbar lordosis can be reduced by flexing the legs [3], and thoracic kyphosis may be increased by placing a pillow under the head. These would obviously influence the interpretation of MR images. In our routine anaesthetic practice, the patient is placed in the supine position with the legs extended horizontally after subarachnoid injection of a local anaesthetic. A thin pillow is also placed under the patient’s head for comfort. In this study, therefore, the legs were extended horizontally and a head-rest was placed under the head in each volunteer. We were careful to standardize the position so that all MR images were obtained under the same conditions.
When a patient is turned to the supine position after midlumbar subarachnoid injection of a hyperbaric solution, the solution spreads downwards from the injection site under the influence of gravity in both caudal and cephalad directions [2, 11]. With respect to the cephalad direction, the injectate can be expected to pool in the lowest point of the thoracic hollow. In this study, sagittal midline MR images showed that the lowest point of the thoracic hollow was not at T5–T6, but between T7 and T9. These findings are consistent with the study of Kitahara, Kuri and Yoshida [11], which showed that radioactive iodine-labelled hyperbaric dibucaine accumulates at the lower thoracic region in supine patients.

Accentuation or elimination of thoracic kyphosis affects the distribution of a hyperbaric anaesthetic solution pooling in the thoracic hollow [1, 12]. Particularly in the upper thoracic region, the degree of incline may determine the cephalad extent of spread of the solution. We found individual variations in the lowest point of the thoracic hollow and also in the degree of incline and decline. These individual variations may explain, in part, the fact that a uniform dose of a hyperbaric anaesthetic solution shows variable spread in clinical practice.

The results of this study can be applied directly only to subjects of the same race and within the same range of age, height and weight and body mass index of the subjects in this study. The ranges of height, weight and body mass index in our subjects encompass the majority of Japanese adults. Although there may be differences in the curvature of the spinal column among subjects with different racial characteristics, the highest and lowest points, and the levels of termination of the spinal cord and the dural sac identified in this study, are similar to those given in standard textbooks of MR imaging [13–15] and anatomy [16, 17]. However, further study is required to clarify questions concerning racial differences. Finally, we failed to demonstrate in this small study how age and sex influence curvature of the spinal column. However, the results within each group indicated a greater angle of decline in women, which is consistent with the larger buttocks of women, and a greater incline in men, which is consistent with their larger shoulders. These results were not significantly different, but if more volunteers were studied they would almost certainly become significant. To assess the effect of age or sex on the curvature of the spinal column, it would have been preferable to have studied a group of volunteers of uniform age or sex and a substantially greater population.

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References