Anatomical configuration of the spinal column in the supine position. III. Comparison of adolescent and adult volunteers

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Summary
To clarify the anatomical configuration of the spinal column in the adolescent in the supine position, we have studied 10 adolescent (13–17 yr) and 10 adult (26–38 yr) volunteers using magnetic resonance imaging. T1-weighted sagittal midline magnetic resonance images of the spinal column were obtained with subjects in the supine position. The maximum angles of decline of the lumbar spinal canal did not differ between the adolescent (mean 13.6° (SD 3.3)°) and adult (12.4 (3.8)°) groups. The maximum angles of incline of the upper thoracic spinal canal were smaller in the adolescent group (15.9 (4.7)°) than in the adult group (26.4 (5.8)°). The median highest point of the lumbar spinal canal was located at L4 (range L3–4 to L4–5) in both groups. The lowest points of the thoracic spinal canal in the adolescent and adult groups were located at T8–9 (T7 to T9) and T8 (T6–7 to T9), respectively. This study showed that thoracic kyphotic curvature in adolescents was reduced significantly in the supine position compared with that in adults. This maximized thoracic kyphosis may explain, in part, the enhanced cephalad spread of subarachnoid hyperbaric anaesthetic solutions in adolescents. (Br. J. Anaesth. 1996; 76: 508–510)

Key words

Subjects and methods
The Institutional Review Board approved our study and informed consent was obtained from all subjects or parents. We studied 10 adolescent (13–17 yr, five boys) and 10 adults (26–38 yr, five men) Japanese healthy volunteers. 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 headrest (1 cm in thickness) placed under the head on the MR platform. T1-weighted sagittal images of the cervical, thoracic and lumbar spine were obtained using an MR imaging system (MRT-200/FXIII super version, Toshiba Corporation, Tokyo, Japan) operating at 1.5 T with a 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, a number of slices 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, the highest and lowest points of the spinal canal, and the levels of termination of the spinal cord and dural sac. 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).

The adolescent and adult groups were compared by Student’s unpaired t test for parametric data and by the Mann–Whitney U test for non-parametric data. In addition, to assess differences between males and females, maximum angles of decline and incline of the spinal canal were compared by Student’s unpaired t test. P < 0.05 was considered statistically significant.

Results
There were no differences between the adolescent and adult groups in height, weight or body mass index (table 1).

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Curvature of the spinal column in adolescents

There was no difference between the adolescent and adult groups in the maximum angle of decline of the lumbar spinal canal (mean 11.7 (SD 2.4) (range 8–16) vs. 14.3 (4.1) (8–20.5)°) or in the maximum angle of incline of the upper thoracic spinal canal (21.1 (7.4) (9–34.5)° vs 21.2 (8.0) (7.5–36)°). Figure 1 shows representative sagittal midline MR images of an adolescent girl and an adult woman.

Discussion

This study in healthy volunteers has demonstrated that thoracic kyphotic curvature in adolescents was reduced significantly in the supine position compared with that in adults.

In the adult in the standing position, it is widely accepted that the spinal column exhibits four curvatures in the sagittal plane: cervical—posterior concavity, thoracic—posterior convexity, lumbar—posterior concavity and sacral—posterior convexity [8]. Does the spinal column in the adolescent in the standing position exhibit the same four curvatures as in the adult? We cannot make definitive statements because no MR images in the standing position are available. What we can say, however, is that our study performed in the supine position demonstrated that the curvature of the spinal column in the adolescent differed significantly from that in the adult. The MR images from the adults verified the presence of the four curvatures in the supine position. In contrast, in the adolescents in the supine position, the thoracic kyphotic curvature was found to disappear substantially. Because the spinal column in the adolescent is expected to have a greater flexibility, it may become straight while the teenager is lying supine on a flat platform.
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 [3, 4]. The solution migrating to cephalad pools in the lowest region of the thoracic hollow and thus thoracic kyphotic curvature may affect the distribution of this pool [5]. Our study demonstrated that the adolescent has a minimized thoracic kyphotic curvature in the supine position. This minimal thoracic kyphosis may allow the drug to spread more easily to the higher thoracic segments. It has been found that hyperbaric amethocaine (tetracaine) [1] and cinchocaine (dibucaine) [2] injected into the midlumbar subarachnoid space spread to higher levels in adolescents than in adults. This suggests that the flatter thoracic curvature observed in supine adolescents is a likely reason for the higher levels of spinal anaesthesia with hyperbaric solutions in these teenagers.

Unlike hyperbaric anaesthetic solutions, isobaric anaesthetic solutions injected into the midlumbar subarachnoid space spread independently of the influence of gravity [9] and stay in the vicinity of the puncture site. In addition, hypobaric anaesthetic solutions tend to rise to the top of the lumbar lordotic curve [10]. Thoracic kyphotic curvature is therefore expected to have little effect on the spread of isobaric or hypobaric solutions. King and Wooten [11] compared spinal anaesthesia with isobaric amethocaine in adolescent and adult patients and found no difference in spread between the groups. The difference in thoracic kyphotic curvature between the adolescent and adult may not affect the spread of spinal anaesthesia with isobaric solutions.

In addition to the anatomical configuration of the spinal column, the level of termination of the spinal cord and volume of cerebrospinal fluid (CSF) is thought to influence the spread of anaesthetic solutions within the subarachnoid space in the adolescent [1]. It is well known that in young children the spinal cord is close to the sacral canal, and that as they grow, the end of the cord retracts cephalad relative to the spinal canal. In this study we failed to demonstrate any difference in the level of termination of the spinal cord between the adolescent and adult groups. The end of the spinal cord is expected to assume its adult position before 13–17 yr of age. In addition, our sagittal MR images provided no information on the volume of CSF below the termination of the spinal cord. Further studies, including quantitative axial MR images [12], are needed to clarify this issue.

This study was performed on subjects of Japanese origin. The results of this study can be applied directly only to people of the same race and within the age, height and weight range of the subjects in this study. Our volunteers were all of relatively small stature and weight compared with European or North American subjects. It is therefore possible that different results might be encountered in these populations.

Although in adolescents there is a very wide range of height and weight values compared with adult populations, we failed to demonstrate any differences between the two groups in height, weight or body mass index. This probably reflected a type 2 error, because the numbers studied were small. In addition, we failed to show any differences between males and females. However, the results of this study indicated a greater angle of decline in females, which is consistent with the larger buttocks of females. This difference was consistent with the results of our previous study [6]; however, it would be necessary to study a substantially larger population to confirm possible differences.

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References