The Intrathecal Spread of Hyperbaric Dibucaine in Adolescents

Yoshihiro HIRABAYASHI and Reiju SHIMIZU

We investigated the spread of spinal anesthesia with hyperbaric dibucaine in 20 adolescents aged 9–18 yr and 20 adults aged 23–53 yr. No significant difference was found between the two groups with regard to height, whereas a statistical significant was found between the two groups with regard to weight. Spinal anesthesia was conducted with Neo-Percamin S® injected at the L3–L4 interspace through a 25-gauge spinal needle. Injected volumes of the anesthetic solution were calculated from the patients' height at 0.01 $\mathrm{ml \cdot cm^{-1}}$. In adolescents, 1.6 ± 0.1 ml (mean ± SD) of the anesthetic solution produced 19.4 ± 1.5 spinal segments blocked. In adults, 1.6 ± 0.1 ml of the solution produced 13.4 ± 1.6 spinal segments blocked. A high spinal anesthesia above T5 was achieved in 17 (85%) patients in adolescents, whereas such a high level of spinal anesthesia was not experienced in adults. These results suggest that the hyperbaric dibucaine solution for spinal anesthesia in adolescents may have a tendency to produce an unexpectedly extensive spread of anesthesia. (Key words: spinal anesthesia, dibucaine)

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The endogenous and exogenous factors influencing the spread of spinal anesthesia have been thoroughly reviewed by Greene[1]. Although many investigators have reported doses of drugs for spinal anesthesia in infants and children under 13 yr of age[2–6] and in adults[7–15], controlled studies of the influence of the dose on the level of spinal anesthesia in adolescents have been lacking. We experienced several instances during which intrathecal hyperbaric dibucaine solution led to unexpected high spinal anesthesia in adolescents. In Japan, many medicolegal suits associated with spinal anesthesia especially in adolescents have been conducted[16]. It is postulated that the poor outcome of intraoperative cardiac arrest related to high spinal anesthesia may be attributable to the degree of sympathetic blockade produced by high spinal anesthesia[17].

In this study, we investigated the spread of spinal anesthesia with hyperbaric dibucaine solution in adolescents, and compared to that in adults.

Methods

The spread of spinal anesthesia performed for minor surgical procedures was investgated in 20 adolescents aged 9–18 yr, and in 20 adults aged 23–53 yr. Informed consent was obtained from each patient or the parents, and

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Table 1. Patient's characteristics, volume of anesthetic solution, spinal segments blocked, and segmental dose requirement

	Adolescents (n=20)	Adults (n=20)	Difference
Age (yr)	13.9 ± 2.4	36.9 ± 9.1	$P < 0.001$*
Height (cm)	158 ± 9	162 ± 8	NS
Weight (kg)	52 ± 11	58 ± 7	$P < 0.05$*
Volume of Anesthetic (ml) Solution	1.6 ± 0.1	1.6 ± 0.1	NS
Spinal Segments Blocked	19.4 ± 1.5	13.3 ± 1.6	$P < 0.001$**
Segmental Dose Requirement (ml·segment^{-1})	0.082 ± 0.009	0.124 ± 0.019	$P < 0.001$*

Values are mean ± SD. NS: not significant
*Student *t*-test, **Mann-Whitney U test

the study was approved by the Hospital Ethics Committee. All patients (ASA physical status I or II) were devoid of known neurological or spinal disease and had no contraindications to spinal anesthesia.

Premedication was not prescribed. Routine monitoring consisted of electrocardiograph, noninvasive blood pressure measurement and pulse oximetry. Lactated Ringer's solution, 200–300 ml, was infused before induction of spinal anesthesia. The patients were placed in the lateral decubitus position. Under aseptic conditions, lumbar puncture was performed at the L3–L4 interspace with a 25-gauge spinal needle via a mid-line approach. The correct position of the needle was confirmed by aspiration and reinjection of 0.1 ml of cerebrospinal fluid (CSF) before and after the administration of the drug. The patients received the commercially prepared hyperbaric dibucaine solution (Neo-Percamin S®, Teikoku Chemical Co., Ltd., Japan) which consists of 0.24% dibucaine, 0.12% T-caine*, and 9.5% glucose. Injected volumes of the solution were calculated from the patients' height at 0.01 ml·cm^{-1}. All injections were performed by the same anesthesiologist at a rate of approximately 0.1 ml·sec^{-1}. Immediately after the spinal injection, the patients were turned to the supine horizontal position. The level of sensory analgesia was determined by using the pinprick method 10 min after completion of the injection. If there was a difference in height of block between the left and right sides, the mean value was used for analysis. Segmental dose requirement was calculated by dividing a volume of the injected solution (ml) by the number of spinal segments blocked. All surgical procedures were performed under appropriate spinal anesthesia without complications.

All data were expressed as mean ± SD. Student's unpaired *t*-test was used

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**p-butylaminobenzoyldiethylaminoethanol hydrochloride*

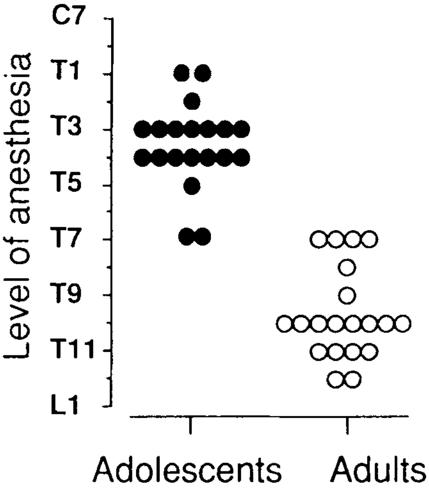

Fig. 1. Distribution of levels of anesthesia: adolescents (closed circle, n=20); adults (open circle, n=20).

to determine the statistical significance for parametric data; Mann-Whitney U test was used, for non-parametric data. $P < 0.05$ was considered to be significant.

Results

The patient's characteristics, volume of the injected anesthetic solution, the number of spinal segments blocked, and segmental dose requirement are summarized in table 1. No significant difference was found between the two groups with regard to height, whereas a statistical significant was found between the two groups with regard to weight ($P < 0.05$). A significant difference in number of spinal segments blocked was found between adolescents and adults ($P < 0.001$). Although the volumes of the injected anesthetic solution were similar between adolescents and adults, the upper level of anesthesia was significantly higher in adolescents than in adults. A high spinal anesthesia above T5 was achieved in 17 (85%) patients in adolescents, whereas such a high level of spinal anesthesia was not experienced in adults (fig. 1). In order to clarify the difference in height and weight between groups, levels of anesthesia were plotted against height (fig. 2) and weight (fig. 3). The segmental dose requirements were significantly smaller in adolescents than in adults (fig. 4).

Discussion

Although the volumes of the injected anesthetic solution were similar between adolescents and adults, the upper level of anesthesia was significantly higher in adolescents than in adults. Our results suggest that hyperbaric dibucaine solution for spinal anesthesia in adolescents may have a tendency to produce an unexpectedly extensive spread of anesthesia.

For adults, the dose of drugs for spinal anesthesia has been calculated according to height of the patient and/or desired levels of anesthesia[14–15]. For infants and small children, body weight has been clinically used[2–6]. Unfortunately there was no report concerning doses of drugs for spinal anesthesia in adolescents. If the dose is determined by using the above-mentioned methods in adolescents, overdose will occur because of a large standard deviation for weight. In our study, 60–70% of the dose of hyperbaric dibucaine used routinely in adults produced sensory block to T3–4 level in almost all patients in adolescents.

There are no reliable explanations for the reason why more extensive level of anesthesia is achieved by a smaller dose of hyperbaric dibucaine in adolescents. The lower end of the cord at birth is at the L3 level and assumes its adult position at the L1–2 junction at the end of the second decade of life[18]. The volume of CSF below termination of the cord may be smaller in adolescents than in adults.

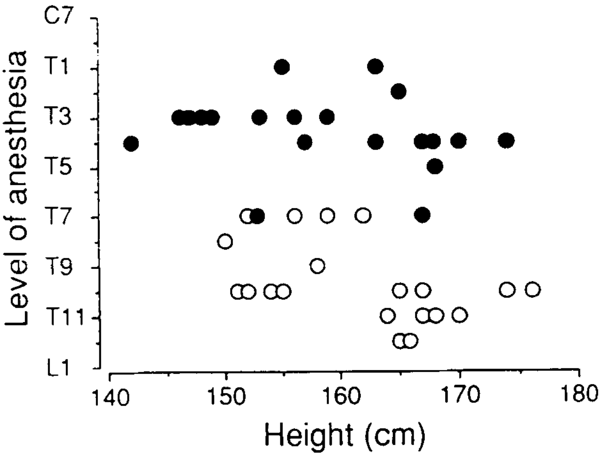

Fig. 2. Relationship between level of anesthesia and height: adolescents (closed circle, n=20); adults (open circle, n=20).

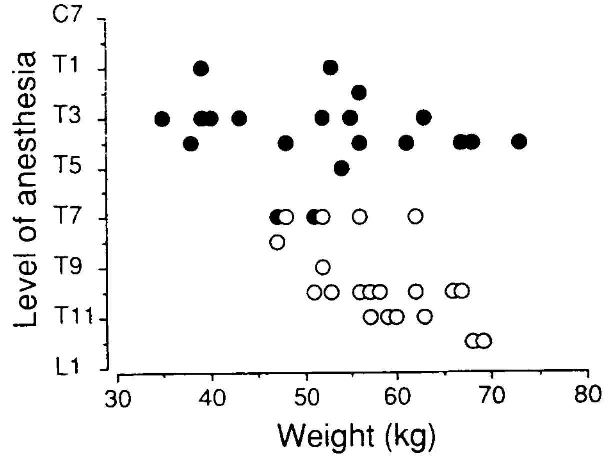

Fig. 3. Relationship between level of anesthesia and weight (right): adolescents (closed circle, n=20); adults (open circle, n=20).

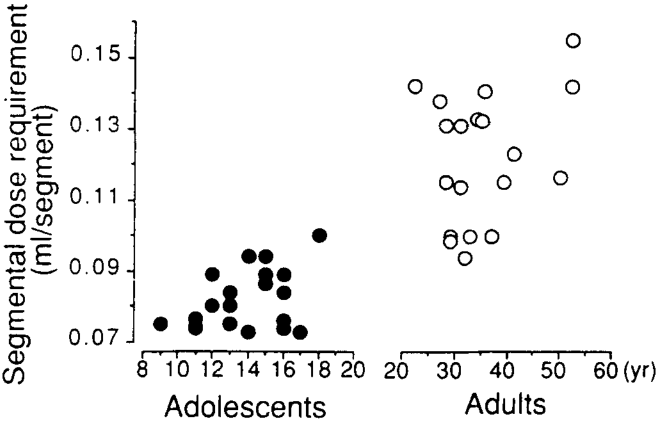

Fig. 4. Relationship between segmental dose requirement and age: adolescents (closed circle, n=20); adults (open circle, n=20).

The diameter of the spinal cord may be also an important factor which determines the volumes of spinal CSF above the termination of the cord. The differential growth between longitudinal direction and centrifugal direction of the spinal canal during adolescence[19] may decrease the volume of spinal CSF above the termination of the cord. Therefore, adolescents may have the smaller volume of spinal CSF for their height and weight. A volume of the injected anesthetic solution into the smaller spinal CSF produces the wider spread of the anesthetic solution. However, no data on the effect of aging on the volume of spinal CSF are available. This inference requires further studies.

Anatomical configuration of the spinal column may significantly affect distribution of spinal anesthetics, the spread of which is governed by gravity. Because of the physiological spinal curvature a hyperbaric solution tends to reach the third to sixth thoracic segments if adult patients lie supine. In adolescents, elimination of the thoracic lordotic curve may occur because of prematurity and pliability of the spinal column and may consequently enhance the cephalad spread of hyperbaric solutions[1].

There are a few controlled studies that deal with the relationship between the age and the spread of spinal anesthesia with hyperbaric solution. With subarachnoid administration of hyperbaric tetracaine[10,11], mepivacaine[10], and bupivacaine[10,13] no effects of aging on spread of analgesia have been observed in adults. As with hyperbaric bupivacaine, only one report mentioned a moderate correlation between the level of analgesia and the age[12]. The age-related differences in spread of spinal anesthesia with hyperbaric solution in adults are so small as to be found no clinical significance. However, our results suggest that spinal anesthesia with hyperbaric solution in adolescents leads to unexpected high spinal anesthesia. In adolescents volume of hyperbaric solution should not be determined arbitrarily on the basis of height and weight, because the effect of aging on segmental dose requirement in adolescents is different from that in adults.

In summary, Our results suggest that hyperbaric dibucaine solution for spinal anesthesia in adolescents may have a tendency to produce an unexpectedly extensive spread of anesthesia. Further investigations will be needed in order to elucidate the reason why an unexpectedly extensive anesthesia is achieved in adolescents. In adolescents a high block should be anticipated so that problems of hypotension and respiratory embarrassment can be treated speedily. Practically, strict vigilance is very important during spinal anesthesia especially in adolescents.

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