Analgesic Dose-response Relation in Cervical Epidural Block

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The relationship between the age and the spread of analgesia from different epidural anesthetic doses was examined by studying analgesic dose responses in cervical epidural analgesia. Two different anesthetic doses (5 ml or 10 ml) of 2% mepivacaine were injected into the cervical epidural space at a constant pressure (80 mmHg) using an intravenous apparatus, and the spread of analgesia to pinprick was assessed. The significant correlation was found between the patient's age and the number of spinal segments blocked (5 ml:r=0.8498, $P<0.01$, 10 ml:r=0.5988, $P<0.01$). The inverse linear relationship was found between the patient's age and the segmental dose requirement (5 ml:r=−0.6754, $P<0.01$, 10 ml:r=−0.5784, $P<0.01$). Patients under 39 years of age showed a direct relationship between the dose injected and the number of spinal segments blocked, enabling prediction of the number of segments blocked with a given dose of local anesthetic. Doubling the epidural dose approximately doubled the number of spinal segments blocked. The analgesic dose-response relation in patients over 60 years of age differed from that in patients under 39 years of age and doubling the epidural dose did not double the number of spinal segments blocked. Progressively more extensive analgesia was obtained from a given dose of local anesthetic with advancing age. It was difficult to limit the extent of analgesia by injecting a smaller dose of local anesthetic in the elderly. (Key words: epidural analgesic dose-response relation, segmental dose requirement, cervical epidural analgesia)

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The widely accepted analgesic dose-response relation in lumbar epidural analgesia was originally reported by Bromage[1,2]. He assumed a direct dose-response relation[1] (double the epidural dose injected = double the number of spinal segments blocked), and a strong inverse linear relationship[2] between the age and the segmental dose requirement. The analgesic dose-response relation in cervical epidural analgesia and its relation to the age has received little attention. The present study was performed to evaluate the effect of age on the spread of cervical epidural analgesia from different anesthetic doses and to construct cervical epidural analgesic dose-response relation in younger and older subjects.

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Methods

Forty-five patients who required cervical epidural anesthesia for elective surgery were investigated using two different epidural anesthetic doses. Nineteen patients received 5 ml and twenty-five patients, 10 ml of 2% mepivacaine without epinephrine, respectively. The mean age of the patients was 48 years old, mean height 156 cm, and mean weight 53 kg. None had a history of neurologic disease or bleeding diathesis. Informed consent was obtained from each patient. Atropine (0.5 mg) was given in all patients intramuscularly 30 min prior to arrival in the operating room. The patient was placed in the right lateral position on a horizontal operating table. A 17-gauge Touhy needle with the bevel pointing cephalad was introduced via mid-line approach at the C7-Th1 interspace. The epidural space was identified using the dripping method[3]. After the entry of the needle point into the epidural space, the hub of the needle was connected through a three-way tap to an electromanometer (Yokokawa Hewlett Packard 78242A) calibrated in mmHg. When no drip back of cerebrospinal fluid or bood was noted, epidural injection of 2% mepivacaine without epinephrine was delivered at a constant pressure (80 mmHg) using an intravenous apparatus. An epidural catheter was inserted to 5 cm beyond the point of the needle and the patient was then turned to the supine position. Fifteen minutes after injection of the anesthetic, the distribution of analgesia was determined by pinprick using a segmental dermatome chart[4]. The spread of analgesia was expressed by the average numbers of analgesic segments on each side. A segmental dose requirement (SDR), that is, the number of milliliters of local anesthetic needed to block one spinal segment was calculated.

Results are expressed as mean ± SD. The relation between the spread of analgesia and the dose injected was recorded in each group using linear regression analysis. Statistical evaluation was performed using Student's t-test, and differences were considered to be significant when $P<0.05$.

Results

The significant correlation was found between the patient's age and the number of spinal segments blocked (5 ml : y = 0.2008x + 1.2823, r = 0.8494, $P<0.01$, 10 ml : y = 0.1330x + 9.0556, r = 0.5988, $P<0.01$) (fig. 1 and 2). Calculated SDR showed a inverse linear relationship with the patient's age (5 ml : y = −0.0095x + 0.9919, r = −0.6754, $P<0.01$, 10 ml : y = −0.0053x + 0.9315, r = −0.5784, $P<0.01$) (fig. 3 and 4).

In patients under 39 years of age, the numbers of spinal segments blocked remarkably varied with the volume injected.

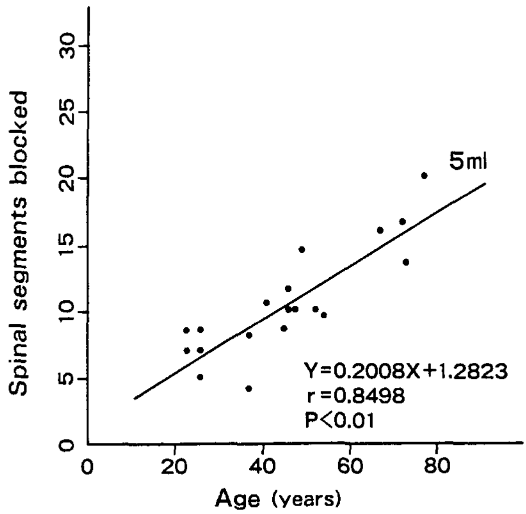

Fig. 1. Correlation between age and spinal segments blocked after injection of 5 ml of 2% mepivacaine.

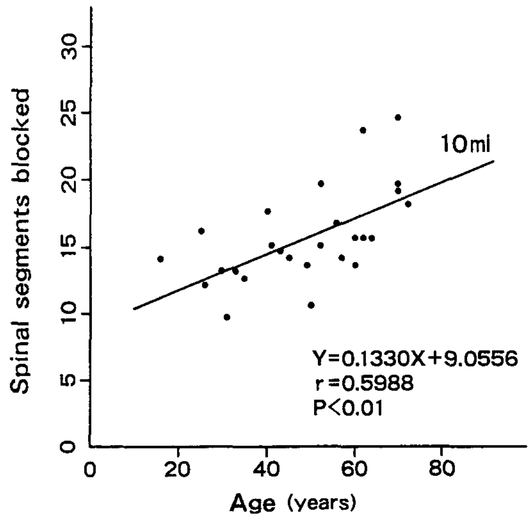

Fig. 2. Correlation between age and spinal segments blocked after injection of 10 ml of 2% mepivacaine.

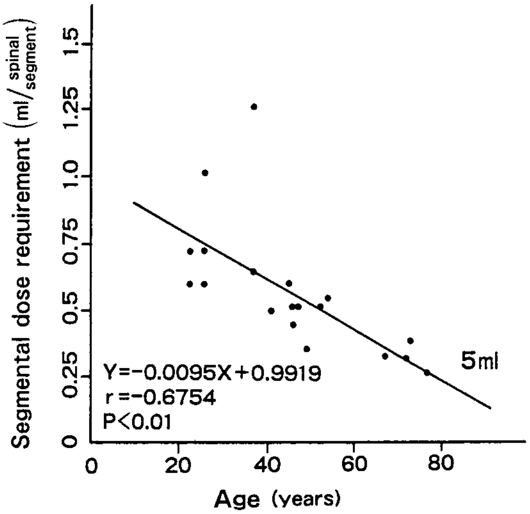

Fig. 3. Correlation between age and segmental dose requirement from 5 ml of 2% mepivacaine injected.

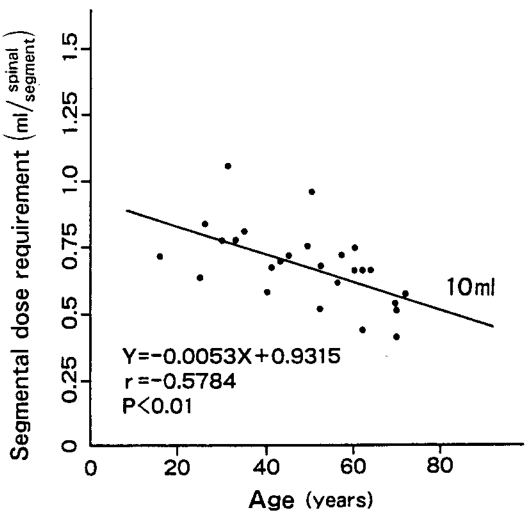

Fig. 4. Correlation between age and segmental dose requirement from 10 ml of 2% mepivacaine injected.

Epidural injection of 5 ml of 2% mepivacaine blocked 6.9 ± 1.7 spinal segments, while 10 ml of the same anesthetic solution blocked 12.9 ± 2.0 segments (fig. 5). Doubling the epidural dose approximetely doubled the number of spinal segments blocked. On the other hand, in patients over 60 years of age, there was no significant difference in the numbers of spinal segments blocked

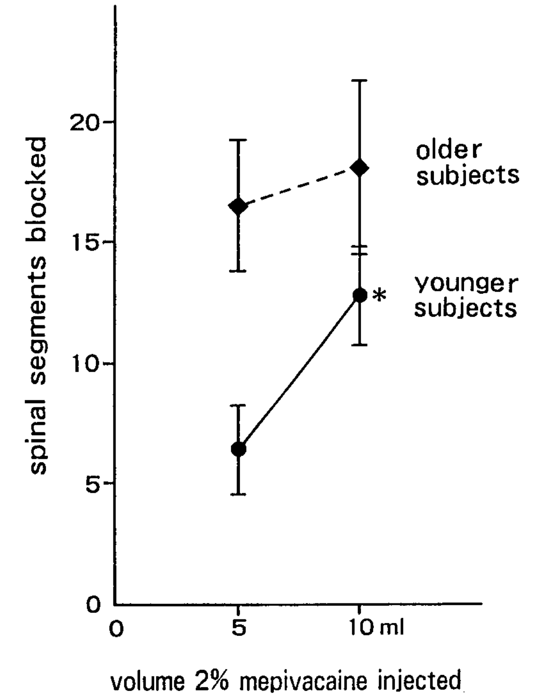

Fig. 5. Relationship between spinal segments blocked and volume of 2% mepivacaine injected in patients under 39 years of age (solid line) and over 60 years of age (interrupted line). *: $P<0.05$

from different epidural anesthetic doses. Epidural injection of 5 ml and 10 ml of 2% mepivacaine blocked 16.5 ± 2.3 and 18.3 ± 3.8 spinal segments, respectively (fig. 5). Doubling the epidural dose did not double the number of spinal segments blocked in the elderly.

In patients under 39 years of age, values for SDR did not vary with the volume injected. The averages of SDR in the 5 ml and 10 ml groups were 0.78 ± 0.25 ml and 0.79 ± 0.13 ml, respectively (fig. 6). By contrast, patients over 60 years of age showed no uniformity of results, and values for SDR varied from 0.31 ± 0.08 ml to 0.57 ± 0.11 ml, depending on the volume injected (fig. 6).

In patients under 39 years of age, there was no difference between the cephalad and caudad spread of analgesia following the injection of either 5 ml or 10 ml of local

Table 1. The cephalad and caudad spread of analgesia (spinal segments blocked) 15 min after injection of 2% mepivacaine without epinephrine.

age (yr.)	5 ml of mepivacaine		10 ml of mepivacaine	
	cephalad	caudad	cephalad	caudad
~ 39	2.5±1.9	4.4±1.9	6.7±0.6	6.1±1.9
40 ~ 59	5.2±1.0	5.4±2.0	5.9±0.9	9.1±2.3**
60 ~	5.3±2.0	11.1±1.3*	6.4±1.3	11.9±3.2**

*$P<0.05$, **$P<0.01$; The caudad spread was significantly greater than the cephalad spread.

anesthetic (table 1). On the other hand, the spread of analgesia to lower-thoracic level (T9–12) developed in patients over 60 years of age, irrespective of the dose injected. It was not possible to secure a high thoracic level reliably by injecting a smaller volume in these elderly patients, in whom 5 ml resulted in the spread of analgesia to the 9th thoracic dermatome or lower.

Discussion

Results of our study verified the decline in segmental dose requirements with age, but the dose-response relation was more complex than originally proposed[1,2].

Bromage[1,2] found a direct inverse linear relationship between the age and the segmental dose requirements in adult patients who required lumbar epidural anesthesia, and assumed that the epidural dose-response relation is directly linear and therefore, doubling the epidural dose would double the number of spinal segments blocked. However, Park et al.[5] investigated the effect of age on the level of lumbar epidural anesthesia from different anesthetic doses, and reported that epidural injection of 10 ml of 1.5% lidocaine with epinephrine blocked 15 spinal segments while 20 ml of the same anesthetic solution blocked 18 segments. With an epidural dose range of 10 to 20 ml, the level of anesthesia achieved had no direct linear relationship with epidural dose in any age. Same authors assumed that the number of spinal segments anesthetized was related to total epidural anesthetic dosage, but not in a linear manner and that doubling the epidural

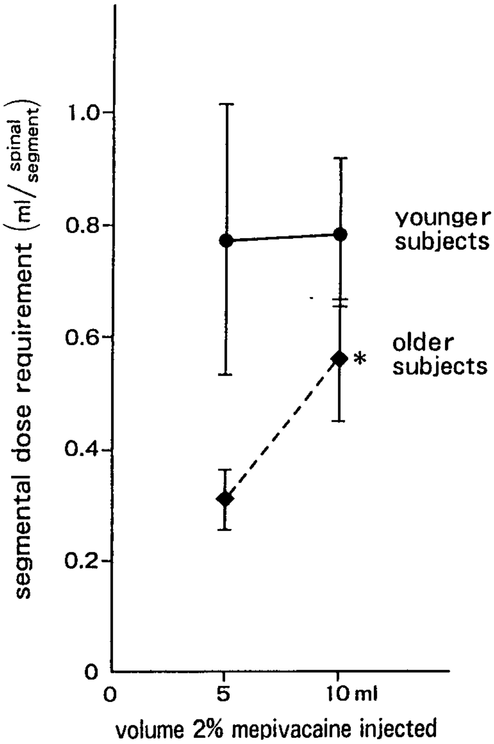

Fig. 6. Relationship between segmental dose requirement and volume of 2% mepivacaine injected in patients under 39 years of age (solid line) and over 60 years of age (interrupted line). *: $P<0.05$

anesthetic dose did not double the number of spinal segments anesthetized. Grundy et al.[6] also found the similar results that doubling the volume of 0.75% bupivacaine from 10 ml to 20 ml produced a 3–4 segment higher level of lumbar epidural anesthesia. In our patients under 39 years of age, with an epidural dose range of 5 to 10 ml, the spinal segments blocked had a direct linear relationship with epidural dose injected. To block 6.9 segments, 5 ml of 2% mepivacaine was necessary and to block 12.9 segments, 10 ml was necessary. It is enable to predict the number of segments blocked with a given dose of local anesthetic, because the SDR shows a uniformity of results from different epidural anesthetic doses. On the other hand, in the patients over 60 years of age, with an epidural dose range of 5 to 10 ml, a direct dose-response analogous to spinal segments blocked in younger patients was not seen. Epidural injection of 5 ml of 2% mepivacaine blocked 16.5 spinal segments, while 10 ml of the same anesthetic solution blocked 18.3 segments. Thus, doubling the epidural dose blocked only two rather than 16.5 additional spinal segments. Progressively more extensive analgesia was obtained from a given dose of local anesthetic with advancing age, and lower thoracic levels were usually ensured, irrespective of dose injected. Sharrock[7] found the results similar to ours that the lumbar epidural dose-response relation in the young differs from that in patients more than 50 years old.

It is not easy to explaine why the dose-response relation in young differs from that in the elderly. The anesthetic solution injected into the epidural space initially fills the epidural space where the pressure is negative, and additional volume builds up positive pressure in the epidural space, and spreads cephaladly, caudadly, and laterally in the epidural space. It not only fills the epidural space adjacent to the epidural needle but it also leaks out through the intervertebral foramina. While the volume of local anesthetic required to fill each segmental epidural space is relatively constant and limited, the volume that leaks out through the intervertebral foramina is unlimited and variable[5]. This variability depends on the patency of individual intervertebral foramen, the total volume of local anesthetic injected, and the epidural positive pressure produced by injecting of local anesthetic. Following epidural injection, radiopaque dye was seen in the paravertebral spaces of young, but not elderly, patients[8]. This finding suggests that with increasing age the intervertebral foramina are progressively occluded, preventing egress of local anesthetic. The volume that leaks out through a given intervertebral foramina is also positively related to the total volume of local anesthetic injected. Park et al.[5] suggested that increasing the volume of anesthetic solution will result in greater anesthetic leakage and consequently greater SDR calculated. We previously reported the relationship between the epidural pressure following the injection of local anesthetic and the spread of analgesia, and assumed that, the lower the epidural pressure during and following the injection of local anesthetic associated with higher age, the wider the spread of epidural analgesia[3]. The higher epidural compliance and lower epidural resistance would result in the smaller volume of anesthetic leakage from the epidural space and the wider spread of anesthetic in the epidural space.

On the other hand, Shanta[9] suggested that, with age, the dura becomes more permeable to local anesthetic owing to a progressive increase in size and number of arachinoid villi, providing a larger area through which local anesthetic can diffuse into the subarachnoid space. The wide spread of analgesia with small volumes in the elderly could result from a more dominant action within the subarachnoid space.

In conclusion, the spread of epidural analgesia achieved following the cervical epidural injection of either 5 or 10 ml of 2% mepivacaine without epinephrine showed a significant correlation with the age. The calculated SDR showed a inverse linear relationship with the age, but the relationship varied with increasing age. In younger patients, the number of spinal segments blocked was directly related to the total epidural anesthetic dosage, providing the predictability of the number of spinal segments blocked with the volume injected. In older patients, a direct dose-response relation in younger patients was not seen. Progressive more extensive analgesia was obtained from a smaller dose of local anesthetic in the elderly. Doubling the epidural anesthetic dose did not double the number of spinal segments blocked.

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