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# Reinforcement of spinal anesthesia by epidural injection of saline: a comparison of hyperbaric and isobaric tetracaine

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**Abstract:**
*Purpose.* An epidural injection of saline was reported to extend spinal anesthesia because of a volume effect. The aim of this study was to evaluate the influence of the baricity of spinal local anesthetics upon the extension of spinal anesthesia by epidural injection of saline.
*Methods.* Forty patients undergoing elective lower-limb surgery were randomly allocated to four groups of 10 patients each. Group A received no epidural injection after the spinal administration of hyperbaric tetracaine (dissolved in 10% glucose). Group B received an epidural injection of 8 ml of physiological saline 20 min after spinal hyperbaric tetracaine. Group C received no epidural injection after spinal isobaric tetracaine (dissolved in physiological saline). Group D received an epidural injection of 8 ml of saline 20 min after spinal isobaric tetracaine. The level of analgesia was examined by the pinprick method at 5-min intervals.
*Results.* The levels of analgesia 20 min after spinal anesthesia were significantly higher in hyperbaric groups than in isobaric groups [T5 (T2–L2) vs. T7 (T3–12)]. After epidural injection of saline, the levels of analgesia in groups B and D were significantly higher than in groups A and C. The segmental increases after epidural saline injection were 2 (0–3) in group B and 2 (1–7) in group D. Sensation in the sacral area remained 20 min after spinal block in one patient in group D; however, it disappeared after epidural saline injection.
*Conclusion.* In this study, 8 ml of epidural saline extended spinal analgesia. However, there was no difference between the augmenting effect in isobaric and hyperbaric spinal anesthesia. We conclude that the reinforcement of spinal anesthesia by epidural injection of saline is not affected by the baricity of the spinal anesthetic solution used.

**Key words:** Combined spinal-epidural anesthesia, Tetracaine, Baricity

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## Introduction

Combined spinal–epidural (CSE) anesthesia has become a popular technique, especially for gynecological and orthopedic lower-limb surgery. Epidural injection of physiological saline through an epidural catheter after spinal anesthesia results in rapid spread of the analgesic level [1]. The mechanism of this action is thought to be the epidural volume effect. Takiguchi et al. [2], using myelography, demonstrated that the diameter of the subarachnoid space decreased to less than 25% of its original value after injection of 20 ml of saline.

In clinical situations, spinal anesthesia with isobaric or hypobaric anesthetic solution is useful for retention of the lateral position to safeguard patients with hemilateral lower limb wounds. However, it is not known whether the density of local anesthetic solution that are related to the height of spinal anesthesia [3] affect this volume effect. We hypothesized that there was a difference between hyperbaric and isobaric local anesthetics in the distribution within the subarachnoid space, and that this difference would influence the reinforcement of spinal anesthesia by epidural injection of saline. This study was designed to evaluate the effect of epidural injection of saline on the extension of spinal anesthesia with hyperbaric or isobaric tetracaine.

## Materials and methods

We studied 40 patients, ASA physical status I or II, who were undergoing elective lower-limb surgery under CSE. The investigation was approved by the research committee of Takikawa Municipal Hospital, and informed consent was obtained from all patients.

Midazolam (2.5–3.5 mg) was administered intramuscularly 1 h before the institution of regional anesthesia. With the patient in a lateral position, an 18-gauge Touhy needle (Portex, Kent, UK) was introduced into

the epidural space at the L3–4 interspace, using the loss of resistance to less than 0.5 ml saline. Through the epidural needle, a long, 25-gauge Whitacre spinal needle (Portex) was introduced into the subarachnoid space. After confirmation of free flow of cerebrospinal fluid (CSF), 12 mg of 0.5% tetracaine was administered into the subarachnoid space at room temperature (22°–25°C). The spinal needle was removed, and an epidural catheter (Portex) was inserted rostrally 5 cm into the epidural space. After the Touhy needle had been withdrawn, the patient rested in a supine position, and the level of analgesia was examined by the pinprick method at 5-min intervals.

The 40 patients were randomly allocated to four groups of 10 by a random number table. Group A (hyperbaric–no injection) received no epidural injection after the subarachnoid administration of hyperbaric tetracaine (dissolved in 10% glucose). Group B (hyperbaric–saline injection) received an epidural injection of 8 ml of physiological saline 20 min after the subarachnoid administration of hyperbaric tetracaine. Group C (isobaric–no injection) received no epidural injection after the subarachnoid administration of isobaric tetracaine (dissolved in physiological saline). Group D (isobaric–saline injection) received an epidural injection of 8 ml of saline 20 min after the subarachnoid administration of isobaric tetracaine.

Data on patient characteristics and times from injection to the maximum level of analgesia are expressed as means ± SD or, in the case of analgesic levels, as medians (range). Statistical analysis was performed by Student's t test and the Mann-Whitney U test as appropriate. $P < 0.05$ was considered statistically significant.

## Results

There were no significant differences among the four groups in age, height, or weight (Table 1).

The levels of analgesia 20 min after spinal anesthesia were significantly higher in the hyperbaric groups [T5 (T2–L2)] than in the isobaric groups [T7 (T3–12)] ($P < 0.05$). The levels of analgesia after spinal anesthesia are shown graphically in Fig. 1. Epidural injection of saline resulted in significant increases in the maximum level of analgesia in groups B and D. Data on the maximum analgesic levels and times from injection to maximum analgesic level are shown in Table 2. The time taken to

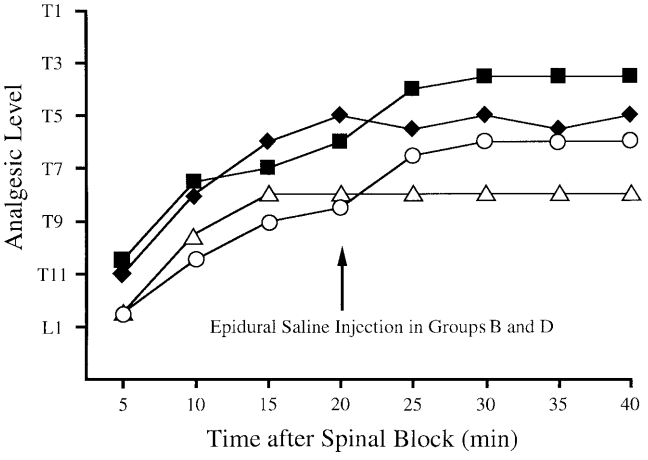


**Fig. 1.** Changes in analgesic levels (median) following spinal anesthesia in groups A (*filled diamonds*), B (*filled squares*), C (*open triangles*), and D (*open circles*). The *arrow* at the bottom indicates the point at which epidural saline injection was done in groups B and D

**Table 1.** Clinical characteristics of patients

| Characteristic | Group A ($n = 10$) | Group B ($n = 10$) | Group C ($n = 10$) | Group D ($n = 10$) |
|---|---|---|---|---|
| Age (yr) | 54.2 ± 20.4 | 52.7 ± 15.0 | 60.4 ± 10.2 | 45.8 ± 16.2 |
| Height (cm) | 156.0 ± 7.8 | 157.3 ± 10.7 | 156.2 ± 10.3 | 159.3 ± 9.2 |
| Weight (kg) | 57.1 ± 6.1 | 61.1 ± 10.9 | 56.3 ± 10.9 | 59.6 ± 9.0 |

Values are means ± SD. There were no significant differences between groups

**Table 2.** Maximum analgesic levels and onset time

| Level | Group A ($n = 10$) | Group B ($n = 10$) | Group C ($n = 10$) | Group D ($n = 10$) |
|---|---|---|---|---|
| Level 20 min after spinal block | T5.5 (T2–L2) | T6 (T4–T11) | T8 (T5–12) | T8.5 (T3–L12) |
| Maximum level | T5.5 (T2–L2) | T3.5 (T1–8) | T8 (T4–11) | T6 (T2–10) |
| | | * | | |
| Onset time (min) | 15.5 ± 3.7 | 26.5 ± 3.4 | 21.0 ± 7.4 | 26.5 ± 2.4 |
| | | | NS | |
| Segmental increase | | 2 (0–3) | | 2 (1–7) |

Values are medians (range) or means ± SD. The onset time is the time from subarachnoid injection to maximum level of analgesia. The segmental increase is given after epidural injection of saline in groups B and D. *$P < 0.05$. NS, not statistically significant

reach maximum analgesic level in group A was significantly shorter than in group C ($P < 0.05$). Groups B and D were similar in the segmental increases after epidural saline injection, 2 (0–3) and 2 (1–7), respectively.

In one patient of group D, analgesia was produced from L5 to T10 20 min after spinal anesthesia. In contrast, the lower levels of analgesia reached the sacral area in the other 39 patients at that time. Five minutes after epidural saline injection, the analgesia of the former patient was extended from S to T8.

## Discussion

Combined spinal and epidural anesthesia has been used for various surgical operations in recent years. Epidural injection of local anesthetics after spinal anesthesia produces rapid extension of analgesia [4,5]. Previously, the mechanism was thought to be the diffusion of local anesthetics from the epidural space to the subarachnoid space. However, Blumgart et al. [1] showed there was no significant difference between saline and bupivacaine in the extension of the sensory block level when they were injected into the epidural space 5 min after spinal anesthesia. They insisted that volume expansion within the lumbar epidural space by local anesthetics or any other fluid caused a decrease in CSF volume in the lumbar subarachnoid space and provoked a rostral shift of subarachnoid anesthetic within the CSF. Recently, Takiguchi et al. [2] demonstrated a shift of the contrast medium within the lumbar subarachnoid space to the rostral side after epidural saline injection using myelography. Thus, the mechanism of the extension of spinal anesthesia after epidural injection is now considered to be the "volume effect" [1,2,6].

It is not clear whether the baricity of subarachnoid local anesthetics affects the degree of increase in analgesic level by the volume effect. It was presumed that a hyperbaric solution within the subarachnoid space of a patient in the supine position sinks along the dorsal side of the vertebral canal, whereas an isobaric solution is distributed in all directions from the injected point. When 10 ml of saline was injected through the epidural catheter, the diameter of the subarachnoid space decreased to less than 25% of its original diameter [2]. The isobaric solution may have diffused more easily than the hyperbaric solution within the CSF, because the uniformity is a characteristic of the isobaric solution. In our study, the analgesic levels increased two segments in group B (hyperbaric–saline injection) and group D (isobaric–saline injection) after the injection of 8 ml of saline through the epidural catheter, a result similar to the results of previous studies [2,6]. Contrary to our expectation, there was no significant difference between the two groups regarding the reinforcement of spinal anesthesia. This study demonstrated that the baricity of the tetracaine solution did not affect the increase in analgesic levels after epidural saline injection. It would seem that the cephalad shift of CSF containing local anesthetic is unaffected by the difference in baricity. However, this assumption remains unsubstantiated.

In this series of 20 patients undergoing isobaric spinal anesthesia, one patient still had sensation in the sacral area 20 min after spinal anesthesia. After epidural saline injection, the analgesia extended in a cephalad direction from T10 to T8 and in a caudal direction from L5 to S. This result suggests that the shift of CSF due to a decrease in the diameter of the subarachnoid space occurred not only in the cephalad direction but also in the caudal direction. Spinal anesthesia with isobaric or hypobaric anesthetic solution is considered useful for the patient with hemilateral lower-limb injury. However, in some cases under isobaric or hypobaric spinal anesthesia, a lack of analgesia in the sacral area is experienced. Epidural saline injection could extend the analgesia in such a situation without additional local anesthetics.

Combined spinal–epidural anesthesia has the advantages of both spinal and epidural anesthesia. The advantages of spinal anesthesia are rapid onset and high intensity of analgesia. Epidural anesthesia has easy controllability of the analgesic level and is useful for postoperative pain relief. Furthermore, if the anesthetic level with spinal anesthesia is insufficient for the operation, epidural anesthesia can produce additional anesthesia. It was demonstrated that epidural saline injection extended spinal anesthesia by two or three segments in a cephalad direction and may also extend it in a caudal direction. This technique may be useful for raising a slightly insufficient level of analgesia without the need for increasing total local anesthetics or using repeated spinal anesthesia.

In conclusion, epidural injection of 8 ml of saline 20 min after spinal anesthesia increases the analgesic level. We found that the baricity of the tetracaine solution did not affect the increase in analgesic levels after epidural saline injection. Further studies are needed to investigate the distribution of local anesthetics within the CSF following epidural injection.

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