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Trendelenburg position with hip flexion as a rescue strategy to increase spinal anaesthetic level after spinal block†

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Background. When the level achieved by a spinal anaesthetic is too low to perform surgery, patients are usually placed in the Trendelenburg position. However, cephalad spread of the hyperbaric spinal anaesthetics may be limited by the lumbar lordosis. The Trendelenburg position with the lumbar lordosis flattened by hip flexion was evaluated as a method to extend the analgesic level after the administration of hyperbaric local anaesthetic.

Methods. When the pinprick block level was lower than T10 5 min after intrathecal injection of hyperbaric bupivacaine (13 mg), patients were recruited to the study and randomly allocated to one of the two positions: the Trendelenburg position with hip flexion (hip flexion group, $n=20$) and the Trendelenburg position without hip flexion (control group, $n=20$). Each assigned position was maintained for 5 min and then patients were returned to the horizontal supine position. Spinal block level was assessed by pinprick, cold sensation, and modified Bromage scale at intervals for the following 150 min.

Results. The maximum level of pinprick and cold sensory block [median (range)] was higher in the hip flexion group [T4 (T8–C6) and T3 (T6–C2)] compared with the control group [T7 (T12–T4) and T5 (T11–T3)] ($P<0.001$). The maximum motor blockade median (range) was not different between the two groups being 3 (3–3) in the hip flexion group *vs* 3 (0–3) in the control group.

Conclusions. When the level of spinal anaesthesia is lower than required, flexion of the hips in the Trendelenburg position may be useful as a strategy attempt to increase the level of the block.

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During spinal anaesthesia, the lumbar lordosis may affect the spread of intrathecally-administered hyperbaric local anaesthetics. Hyperbaric local anaesthetics administered at interspaces lower than L3–4 may result in a lower-than-anticipated spinal block level owing to pooling of drug in the sacral region. When the spinal block level is not high enough to perform surgery, the Trendelenburg position is used to extend the level of the block. However, if cephalad spread of hyperbaric local anaesthetics is limited by the lumbar lordosis, Trendelenburg positioning may be less effective.

Although Trendelenberg positioning does not ensure spread of a local aneasthetic into the thoracic region,[1] the analgesic level was reported to be higher in the Trendelenburg position compared with the horizontal supine position.[2 3] Contrary to a unimodal distribution of the maximal spinal block level without lumbar lordosis, lumbar lordosis seems to cause a bimodal distribution by dividing the injected drug between the sacral and thoracic regions.[4 5]

Because the lumbar lordosis can be flattened by hip flexion,[4–6] we hypothesized that with hip flexion the Trendelenburg position would be more effective for

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increasing spinal block level. This study was performed to assess if the Trendelenburg position with hip flexion is effective as a strategy attempt to extend the level of spinal anaesthesia when necessary.

Methods

The study was approved by the Hospital Ethics Committee (Seoul National University Hospital, Seoul), and written informed consent was obtained from patients before surgery. Forty-nine male patients with the American Society of Anesthesiologists physical status I were enrolled. They were scheduled for lower extremity fracture fixation, lower extremity mass excision, varicocelectomy, and inguinal herniorrhaphy under spinal anaesthesia without premedication. The ECG and non-invasive blood pressure readings were monitored during anaesthesia and surgery. An 18-gauge i.v. catheter was placed and approximately 500 ml of lactated Ringer's solution was rapidly infused before spinal anaesthesia. All spinal punctures were performed by one anaesthetist (J.-T.K) using a Quincke-type 25-gauge spinal needle (Hakko Co. Ltd, Chikuma, Japan) at the L4–5 interspace with the patient sitting. After confirming free flow of cerebrospinal fluid, 2.6 ml (13 mg) of 0.5% heavy bupivacaine (Marcaine®; AstraZeneca, Södertälje, Sweden) was injected over approximately 20 s without barbotage. Immediately after withdrawing the needle, the patient was gently returned to the horizontal supine position.

Patients with a pinprick block level of T10 or higher 5 min after the intrathecal injection were excluded from this study. If the pinprick block level was lower than T10, the patients were randomly allocated to one of the two groups according to a computer-generated sequence until 20 patients were assigned to each group: the Trendelenburg position with flexion of the hips and knees (the hip flexion group) and the Trendelenburg position without flexion of both joints (the control group). Control group patients lay supine with their legs straight and the operating table was tilted 15° head down. Hip flexion group patients were placed in the same degree of head down tilt, but with the hips and knees flexed and the hips slightly external rotated. The patients were asked to flex the hips as much as possible without straining while two assistants helped the patients to maintain flexion of the hips and knees. The Trendelenburg position was maintained for 5 min in each group. Five minutes after Trendelenburg positioning, all patients were returned to the horizontal supine position with the legs straight. The surgery was started when the pinprick block level was confirmed to be at least two dermatomes higher than the surgical field.

Sensory and motor blockade were assessed with 21-gauge needle, alcohol sponge, and using the modified Bromage scale (0=being no block, 1=inability to raise the extended legs, 2=inability to flex the knee, 3=inability to flex the ankle) every 5 min for the first 30 min after intrathecal injection, then every 10 min until the pinprick block level regressed to T10, and then every 30 min until 150 min had elapsed. Spinal blockade were assessed by the first anaesthetist (J.-T.K) from 5 min after intrathecal injection to the time that patients were returned from the Trendelenburg position to the horizontal supine position, and thereafter were checked by the second anaesthetist (S.-H.K) blinded to the patient grouping. Before this study, it had been confirmed that the interobserver variation in assessing spinal block levels was less than 5% between the two anaesthetists. The time to the maximum pinprick and motor block and the regression time to T10 were also recorded.

Mean arterial pressure and heart rate were recorded every 5 min for 30 min after intrathecal injection and monitored throughout the surgery. Atropine 0.5 mg was administered i.v. when heart rate was lower than 45 beats min^{-1} and, if the systolic arterial pressure decreased to less than 90 mm Hg, 10 mg of ephedrine was administered i.v. Enquiry was made for back pain and postdural puncture headache twice a day for the first two postoperative days.

For the purpose of statistical analyses, each dermatomal level was scored in sequence starting at S5=1, such that S1=5, L1=10, T8=15, T3=20, and C6=25. Statistical analyses were performed using SPSS version 12.0 (SPSS Inc., Chicago, USA). On the basis of the results of a pilot study, approximately 19 patients per group were required to detect a difference of three levels in anaesthesia to pinprick using the Mann–Whitney *U*-test with an α error of 0.05 and a β error of 0.2. Therefore, we allocated 20 patients per group in this study. The haemodynamic variables were compared by repeated measures analysis of variance (ANOVA) and Tukey test, and any differences between groups were compared by two-way repeated measures ANOVA. Sensory and motor block was analysed using Mann–Whitney *U*-test. The incidences of grade 3 motor blockade, full motor function recovery, and ephedrine or atropine requirements were analysed by Fisher's exact test. Data are expressed as mean (SD) or median (range). A P-value<0.05 was considered statistically significant.

Results

Of 49 recruited patients, nine patients were excluded: six because analgesic level was T10 or higher 5 min after spinal block; one because of failed spinal block; and two (inguinal hernia and ankle fracture) in the control group because general anaesthesia was required during surgery owing to surgical or tourniquet pain. One of the patients in the hip flexion group was returned to the horizontal supine position during Trendelenburg positioning because he complained of dyspnoea and his spinal block level

exceeded T4. This patient was not excluded. Therefore, 20 patients were finally included in each group. The two groups were comparable with respect to age, height, and weight. The median (range) age in the hip flexion group was 21 (18–28) yr and that in the control group 21.5 (19–32) yr. The mean (SD) heights in these two groups were 175.4 (5.7) cm and 174.4 (4.7) cm, respectively, and the mean (SD) weights 71.9 (7.1) kg and 70 (5.3) kg, respectively. The types of surgery were evenly distributed between the two groups.

Five minutes after intrathecal injection, median (range) pinprick block level was comparable between the groups [L5 (S4–T12) in the hip flexion group and L5 (S5–L1) in the control group, $P=0.53$]. However, pinprick block level in the hip flexion group was higher than that of the control group 10 min after intrathecal injection and remained at a higher level throughout the study ($P<0.05$). The maximal median (range) pinprick block level was higher in the hip flexion group than in the control group [T4 (T8–C6) versus T7 (T12–T4), $P<0.001$] (Fig. 1). The mean (SD) time for maximal spread of pinprick block was 28 (10) min in the hip flexion group and 21 (5) min in the control group ($P<0.01$). The mean (SD) regression time of pinprick block to T10 was 102 (19) min in the hip flexion group ($n=20$) and 55 (25) min in the control group ($n=17$; three patients were excluded because the peak level of analgesia had been lower than T10) ($P<0.001$).

No difference in the median (range) cold sensory block level was observed between the two groups 5 min after intrathecal injection [L3 (S2–T5) in the hip flexion group and L3 (S1–T8) in the control group, $P=0.80$]. However, cold sensory block level of the hip flexion group became higher than that of the control group 10 min after intrathecal injection and remained higher throughout the study ($P<0.05$). The median (range) maximum cold sensory block level was higher in the hip flexion group than in the control group [T3 (T6–C2) *vs* T5 (T11–T3), $P<0.01$] (Fig. 1).

There was no difference between the two groups in the median (range) maximum motor blockade [3 (3–3) *vs* 3 (0–3)] and in the mean (SD) time to maximum motor blockade [12 (4) *vs* 15 (10) min]. Nine patients in the hip flexion group and 15 patients in the control group recovered full motor function within the 150 min study period.

Unlike the control group, mean arterial pressure and heart rate were decreased in the hip flexion group ($P=0.003$ and $P<0.001$, ANOVA for repeated measures) (Figs 2 and 3). In the hip flexion group, ephedrine was administered in four patients and atropine injected in one patient. In the control group, one patient was managed with i.v. administration of atropine. There was no case of lower back pain or postdural puncture headache in the postoperative period.

Discussion

Miyabe and Namiki[2] found that the cephalad spread of analgesia after intrathecal injection of 2–3 ml of 0.5% heavy tetracaine was higher in the Trendelenburg position than in the horizontal position. To the contrary, Sinclair and colleagues[1] observed that the spinal block level could not be significantly increased by the Trendelenburg position after intrathecal injection of 3 ml of 0.5% heavy bupivacaine compared with the horizontal position. These inconsistent results may be explained by varying degrees of cephalad spread of anaesthetics beyond the lumbar lordosis during the Trendelenburg position. In our study, the

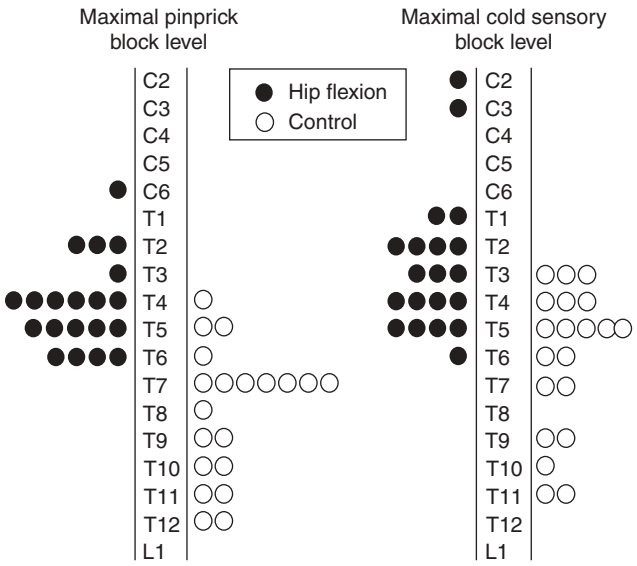

Fig 1 Distribution of maximal pinprick and cold sensory block levels in the two groups. Both pinprick and cold sensory blockades extend more cephalad in the hip flexion group than in the control group ($P<0.001$ for pinprick block and $P<0.01$ for cold sensory block).

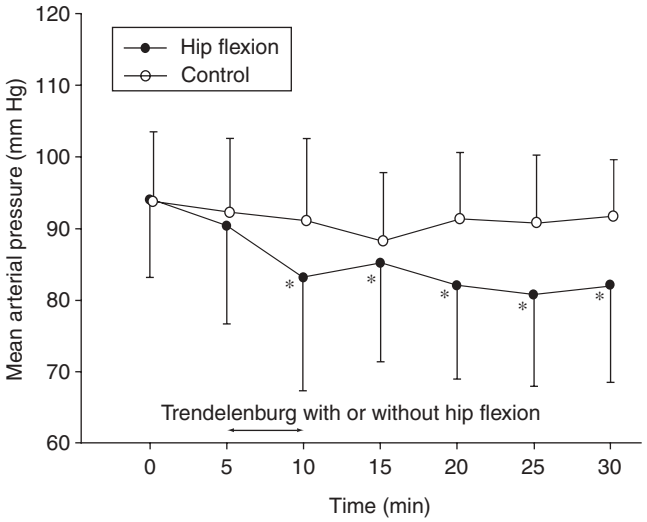

Fig 2 Changes in mean arterial pressure in the two study groups. The error bars represent standard deviations. The *y*-axis is truncated. $^{*}P<0.05$ compared with baseline value of the hip flexion group.

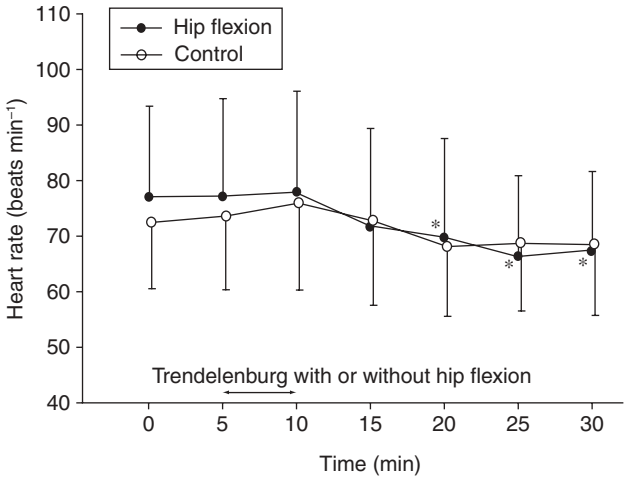

Fig 3 Changes in heart rate. The error bars represent standard deviations. The *y*-axis is truncated. $^{*}P<0.05$ compared with baseline value of the hip flexion group.

influence of the Trendelenburg position was augmented by flattening the lumbar lordosis.

The peak of lumbar lordosis is located at L4 vertebra or L3–4 intervertebral space.[7] Clinically, selecting the L4–5 or L5–S1 interspace for spinal puncture may result in inadvertent low analgesic level, which may be explained by sacral pooling of anaesthetics. During continuous spinal anaesthesia, positioning of the catheter in the sacral region or injection of hyperbaric solution with the catheter tip oriented caudad may result in pooling of the hyperbaric anaesthetic solutions caudad to the peak of lumbar lordosis.[8–11] In our study, we simulated sacral pooling by injecting local anaesthetics caudad to the peak of lumbar lordosis, which is known to be associated with lower spinal block level. Therefore, spinal block was performed at L4–5 interspace in the sitting position.

Hip flexion can reduce the curvature of lumbar lordosis.[4] Because lumbar lordosis cannot be fully flattened even with hip flexion by 90°,[6] the patients were asked to flex their hips beyond 90°.

Acute increases in the intra-abdominal pressure has been known to have less effect on spread of anaesthetics than chronic increases.[12] However, abdominal compression, possibly associated with epidural vein engorgement, has been shown to decrease cerebrospinal fluid volume resulting in high sensory block level.[13–15] Although hip flexion does not seem to be associated with significant increase in intra-abdominal pressure, every care was taken not to compress the abdomen by slightly rotating the hips externally with the patient's thighs supported.

We could not find any statistical difference in motor blockade between the two groups, but all patients in the hip flexion group and 16 patients in the control group showed a grade 3 motor blockade. However, only nine patients in the hip flexion group, but 15 patients in the control group, did attain full recovery of motor function 150 min after intrathecal injection.

In our study, the hip flexion group had a tendency towards a higher incidence of hypotension and bradycardia, which can be explained by the higher spinal block level. It suggests that the Trendelenburg position with hip flexion can result in greater risk of haemodynamic problems due to higher spinal block.

It has been reported that spinal block level is increased by position change even 60 min after injection of local anaesthetics.[16 17] However, the influence of body position on the spread of local anaesthetics decreases with time after intrathecal injection. Therefore, earlier decision to place the patients in the Trendelenburg position with the hips flexed would be more effective for elevating spinal block level.

There are some limitations to this study. First, because data were obtained only from young healthy Asian male patients with normal body build, it may not be appropriate to extrapolate our results into other patient groups. Second, the simulated pooling of local anaesthetics in the sacral region may not resemble the real clinical situation. Nevertheless, Trendelenburg positioning with hip flexion could be a potential rescue measure to overcome the impending low spinal anaesthesia level.

In conclusion, when the spinal block level is expected to be lower than required a few minutes after intrathecal injection, the block level may be extended cephalad more efficiently and reliably by the Trendelenburg position with hip flexion when compared with the conventional Trendelenburg position.

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