Low dose hyperbaric bupivacaine for unilateral spinal anaesthesia

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Purpose: To evaluate the effects of hyperbaric bupivacaine concentration in producing unilateral spinal anaesthesia.

Methods: With Ethical Committee approval and written consent, 60 patients undergoing lower limb surgery were placed in the lateral position with the side to be operated on dependent. After dural puncture (25-gauge Whitacre spinal needle), the needle hole was turned toward the dependent side and patients were randomly assigned to receive 8 mg of either 0.5% (Group_{0.5%}, n = 30) or 1% (Group_{1%}, n = 30) hyperbaric bupivacaine. The lateral position was maintained for 15 min, while a blinded observer recorded loss of pinprick sensation and degree of motor block on both sides until two segment regression of sensory level on the dependent side.

Results: At the end of the 15 min lateral position spinal anaesthesia was more frequently unilateral in Group_{0.5%} (80%) than in Group_{1%} (53%) ($P < 0.05$). However, 30 min after patients were turned supine, unilateral spinal anaesthesia decreased to 60% of cases in Group_{0.5%} and 40% of cases in Group_{1%} ($P = \text{NS}$). The maximum sensory level on the dependent side [T_{10} ($L_1 - T_2$) in Group_{0.5%} and T_8 ($T_{12} - T_3$) in Group_{1%}], time to reach it [20 (5 - 30) min in Group_{0.5%} and 25 (10 - 35) min in Group_{1%}], and time to two segment regression of sensory level [80 (30 - 135) min in Group_{0.5%} and 75 (20 - 135) min in Group_{1%}] were similar in both groups.

Conclusion: Highly concentrated solutions of hyperbaric bupivacaine are not advantageous in obtaining a unilateral spinal anaesthesia, when a small anaesthetic dose is injected slowly through a Whitacre spinal needle.

Objectif : Évaluer les effets de la concentration de bupivacaine hyperbare dans la production d'une rachianesthésie unilatérale.

Méthode : Après avoir reçu l'approbation du Comité d'éthique et une autorisation écrite, 60 patients devant subir une chirurgie du membre inférieur ont été placés en position latérale, le site opératoire du côté déclive. Après la ponction de la dure-mère (aiguille rachidienne Whitacre de calibre 25), la perforation latérale de l'aiguille a été orientée vers le côté déclive et les patients ont été répartis au hasard afin de recevoir 8 mg de bupivacaine hyperbare 0,5 % (Groupe_{0.5%}, n = 30) ou 1 % (Groupe_{1%}, n = 30). La position latérale a été maintenue pendant 15 min pendant lesquelles un observateur impartial a enregistré la perte de sensation de piqure et le degré de blocage moteur des deux côtés jusqu'à une régression de deux segments du niveau sensitif sur le côté déclive.

Résultats : Après ces 15 min en position latérale, la rachianesthésie était plus souvent unilatérale dans le Groupe_{0.5%} (80 %) que dans le Groupe_{1%} (53 %) ($P < 0,05$). Cependant, 30 minutes après que les patients ont été tournés en décubitus dorsal, la rachianesthésie unilatérale a diminué à 60 % dans le Groupe_{0.5%} et à 40 % dans le Groupe_{1%} ($P = \text{NS}$). Ont été similaires dans les deux groupes : le niveau sensitif maximal du côté déclive [T_{10} ($L_1 - T_2$) dans le Groupe_{0.5%} et T_8 ($T_{12} - T_3$) dans le Groupe_{1%}], le temps requis pour atteindre ce niveau [20 (5 - 30) min dans le Groupe_{0.5%} et 25 (10 - 35) min dans le Groupe_{1%}] et le temps pour que se produise une régression de deux segments du niveau sensitif [80 (30 - 135) min dans le Groupe_{0.5%} et 75 (20 - 135) min dans le Groupe_{1%}].

Conclusion : Des solutions très concentrées de bupivacaine hyperbare ne sont pas avantageuses pour obtenir une rachianesthésie unilatérale lorsqu'une faible dose d'anesthésique est injectée lentement au moyen d'une aiguille rachidienne Whitacre.

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PRACTITIONERS routinely faced with surgical procedures involving one lower limb take great interest in obtaining a unilateral spinal block as this technique should minimize the haemodynamic effects of spinal anaesthesia.¹⁻⁴ Lateral decubitus position, low dose of hyperbaric anaesthetic solution, low speeds of intrathecal injection and directional pencil-point spinal needles have been suggested to increase the rate of unilateral spinal anaesthesia.^{1,5}

The goal of the present investigation was to evaluate, in a double-blind study, if increase of the concentration of anaesthetic solution improved the unilateral distribution of spinal anaesthesia when 8 mg hyperbaric bupivacaine was injected slowly through a directional spinal needle in adult patients.

Methods

The study protocol was approved by the Hospital Ethical Committee and written informed consent was obtained from all patients. Patients accepted for the study were all of ASA physical status I and II, scheduled for elective orthopaedic surgery involving the lower limb with standard thigh tourniquet (e.g. foot, ankle and knee surgery with an expected duration of one hour). Patients receiving chronic analgesic therapy as well as patients with scoliosis, diabetes or peripheral neuropathy were excluded. To calculate the required study size, we took into account both the reported rate of unilateral spinal anaesthesia¹⁻⁵ and results of a previous pilot study with 10 patients per group. We wished to detect a 25% change in the incidence unilateral spinal block, accepting an α error of 5%, and a β error of 20%;⁶ based on these figures the required study size was 24 to 30 patients per group.

No premedication was administered before spinal anaesthesia and a 7 ml·kg⁻¹ intravenous infusion of lactate Ringer's solution was given. Standard ASA monitoring was used during the study, including non-invasive arterial blood pressure, heart rate and pulse oximetry. Patients were placed in the lateral position with the limb to be operated on in the dependent position. The vertebral column was kept as horizontal as possible by tilting the operating table or putting a pillow under the shoulder. Dural puncture was performed at L₃₋₄ interspace with a 25-gauge Whitacre spinal needle (Becton-Dickinson, New Jersey, USA) using the mid-line approach. After free flow of cerebrospinal fluid was observed, the needle hole was turned toward the dependent side and 8 mg hyperbaric bupivacaine were injected slowly (at a rate of approximately 0.05 ml·sec⁻¹). According to a sealed envelope technique, patients were randomly allocated to two groups: the first group

received 1.6 ml of bupivacaine 0.5% in glucose 7.5% (specific weight at 37°C 1.021) (Group_{0.5%}, n = 30), while the second group received 0.8 ml of bupivacaine 1% in glucose 9.5% (specific weight at 37°C 1.035) (Marcaïne Spinal Heavy, Astra, Sweden) (Group_{1%}, n = 30). The lateral position was maintained for 15 min, then patients were turned to the supine position.

During the surgical procedure a pneumatic tourniquet was inflated 100 mm Hg higher than systolic arterial blood pressure; oxygen was administered by face mask if required. Hypotension, defined as a systolic arterial pressure 30% less than baseline values, was treated with rapid intravenous infusion of lactate Ringer's solution (250 ml over five minutes). If this proved ineffective, a bolus of 5 mg ephedrine *iv* was given. Bradycardia, < 45 bpm, was treated with 0.5 mg atropine *iv*.

An observer blinded to the anaesthetic solution concentration recorded the evolution of sensory and motor blocks on both dependent and nondependent sides. Sensory level was evaluated by loss of pinprick sensation (20-gauge hypodermic needle), while motor block was evaluated using a modified Bromage scale (0 = no motor block; 1 = hip blocked; 2 = hip and knee blocked; 3 = hip, knee and foot blocked). Sensory and motor blocks were tested every three minutes after bupivacaine injection until patients were turned to the supine position, then every five minutes until the point of regression of sensory level by two segments on the dependent side.⁷ The quality of spinal anaesthesia was judged according to the need for supplementary *iv* analgesics and sedation: satisfactory spinal anaesthesia = neither fentanyl *iv* nor sedation; unsatisfactory spinal anaesthesia = need for additional fentanyl $\pm$ 0.1 mg *iv* and sedation (continuous propofol infusion 2 mg·kg⁻¹·hr⁻¹ *iv*); failed spinal anaesthesia = general anaesthesia. The occurrence of postoperative headache as well as pain and/or dysaesthesias in the buttocks, thighs, or lower limbs was evaluated 24 hr after dural puncture by the same blinded observer, and one week postoperatively during the first routine surgical visit.

Successful unilateral spinal anaesthesia was defined as surgical anaesthesia (loss of pinprick sensation L₁, and complete motor block) on the dependent side only, while the nondependent side maintained both somatic sensibility to the pinprick test and motor block < 1st degree. Unilateral spinal anaesthesia was assessed at the end of the 15 min lateral position, and then 30 min after patients were turned supine.

Statistical analysis was performed using the program Stat-view 3.0 (Abacus Conc., USA). Mann-Whitney u-test was used to compare the two groups, while the Wilcoxon test was used to compare dependent and non-

dependent sides within each group. Bonferroni's correction was used for multiple comparisons. Contingency table analysis with Chi-square test and Fisher exact test were used to analyse the number of patients exhibiting unilateral spinal anaesthesia. A value of $P < 0.05$ was considered significant. Results are presented as median (range) or as count (percentage).

Results

The two groups of patients were comparable with respect to age, weight, height, ASA physical status, male to female ratio, and surgical time (Table I). No differences in the incidence of hypotension was observed between the two groups: one patient in Group_{0.5%} and three patients in Group_{1%} developed clinical hypotension ($P = \text{NS}$).

The main results are summarized in Table II. At the end of the 15 min lateral position spinal anaesthesia was

TABLE I Anthropometric data, ASA physical status, male to female ratio and duration of surgical procedure in the two groups of patients.

	Group _{0.5%} (n = 30)	Group _{1%} (n = 30)
Age (years)	49 (24 - 65)	53 (25 - 65)
Weight (kg)	68 (52 - 95)	70 (50 - 98)
Height (cm)	168 (153 - 185)	170 (160 - 182)
ASA physical status	I (I - II)	I (I - II)
Male/Female	10/20	16/14
Duration of surgery (min)	64 ± 21	75 ± 28

Data are expressed as median (range) or as count.

TABLE II Spinal block characteristics after 8 mg of either the 0.5% (Group_{0.5%}) or 1% solution (Group_{1%}) of hyperbaric bupivacaine. The rate of successful unilateral spinal anaesthesia is reported both immediately before turning the patients to the supine position (LATERAL = 15 min after dural puncture) and 30 min after patients were turned to the supine position (SUPINE = 45 min after dural puncture).

	Group _{0.5%} (n = 30)	Group _{1%} (n = 30)
Unilateral spinal anaesthesia - LATERAL	24 (80%)	16 (53%)*
Unilateral spinal anaesthesia - SUPINE	18 (60%)	12 (40%)
Maximum sensory level on the dependent side	T ₁₀ (L ₁ - T ₂)	T ₈ (T ₁₂ - T ₃)
Time to reach maximum sensory level (min)	20 (5 - 30)	25 (10 - 35)
Time to regression of sensory level by two-segment (min)	80 (30 - 135)	75 (20 - 135)

Data are expressed as count (percentage) or as median (range).

* $P < 0.05$ vs Group_{0.5%}.

Data are expressed as median (range).
* $P < 0.05$ vs Dependent side; § $P < 0.05$ vs Group_{0.5%}.

FIGURE Evolution of median (range) sensory level (loss of pinprick sensation) on both dependent and nondependent sides after 8 mg of either the 0.5% (Group_{0.5%}) or the 1% solution (Group_{1%}) of hyperbaric bupivacaine.

more frequently unilateral in Group_{0.5%} than in Group_{1%} ($P < 0.05$); however, after turning the patients, the spinal block redistributed towards the non dependent side and, 30 min after patients were turned supine, spinal anaesthesia was still unilateral in 60% of cases in Group_{0.5%} and in 40% of cases in Group_{1%} ($P: \text{NS}$). The maximum level of sensory block on the dependent side as well as the time required to reach it and time to two segments regression of sensory level on the dependent side were similar in the two groups (Table II).

Figure shows the evolution of median (range) sensory block on both dependent and nondependent sides in the two groups of patients. Three patients (one in group Group_{0.5%} and two in group Group_{1%}) showed loss of pinprick sensation below L₁ at the end of the 15 min lateral position; however, the final sensory level increased after patients were turned to supine. No patients required general anaesthesia due to failed spinal block; *iv* analgesic and sedation due to tourniquet pain (unsatisfactory spinal anaesthesia) was observed in three

patients in Group_{0.5%} (10%) (at 45, 60 and 75 min after dural puncture, respectively) and two patients in Group_{1%} (6.6%) (at 75 and 120 min after dural puncture, respectively) ($P = \text{NS}$). No differences in the evolution of sensory block on the dependent side were observed between the two groups. Both groups showed a cephalad spread of sensory block on the non-dependent side after patients were turned to the supine position, but this effect was more marked in Group_{1%} than in Group_{0.5%}.

No cases of urinary retention were observed in studied patients, and postoperative follow-up did not show post dural puncture headache or other neurological complications.

Discussion

In this study the 1% solution of hyperbaric bupivacaine was chosen mainly because, in Italy, this is the available commercial composition of highly concentrated spinal bupivacaine, while in other countries the 0.75% concentration is available.

It is currently believed by many anaesthetists that reducing the injected volume by using highly concentrated solution of hyperbaric local anaesthetic could improve the unilateral distribution of spinal anaesthesia.⁵ The present investigation demonstrated that the use of highly concentrated solutions of hyperbaric bupivacaine did not provide clinical advantages in obtaining unilateral spinal anaesthesia. When patients were turned supine after 15 min in the lateral position, redistribution of spinal block towards the nondependent side was observed with both the 0.5% and the 1% concentrations of hyperbaric bupivacaine.

Although the record of neurotoxicity after spinal bupivacaine has remained relatively untainted,⁸ toxic symptoms have been reported with the use of high concentration of either lidocaine,⁸ mepivacaine,^{9,10} and bupivacaine,¹¹ and we recently reported a case of transient radicular irritation after a unilateral spinal anaesthesia performed with 8 mg hyperbaric bupivacaine 1%.¹² Our follow-up did not show neurological dysfunction in either group. However, we believe that the use of highly concentrated solutions of hyperbaric local anaesthetic should not be advocated when attempting a unilateral spinal anaesthesia, since the potential risk for nerve damage is not balanced by the clinical advantage of a more marked unilateral distribution of spinal block.

Local anaesthetic diffusion to the opposite side is due to redistribution of local anaesthetic molecules according to both the law of mass action and capillary absorption in the spinal cord after hyperbaricity is lost.^{13,14} It has been demonstrated that the duration of lateral or sitting position to produce a restricted spinal block with hyper-

baric solution is long, while the level of analgesia can still change 45, or even 60 min after intrathecal injection of hyperbaric local anaesthetic when repositioning the patient.¹⁵ On the other hand, the anaesthetic dose is crucial to restrict spinal block to one side,^{1,5,16} and a strict correlation between the dose of anaesthetic used and lateralization of sensory block has been demonstrated.⁵

Iselin-Chaves *et al.*¹⁷ reported no cases of unilateral spinal anaesthesia when injecting 12 mg hyperbaric tetracaine at high speeds through a Quincke needle, and showed that the use of a higher anaesthetic concentration did not provide clinical advantages in the unilateral distribution of spinal block. Our results confirmed this finding, but also demonstrated that directional spinal needles and relatively small doses of local anaesthetic provided successful unilateral spinal anaesthesia in up to 60% of cases 30 min after patients were turned to the supine position. In fact, the Whitacre spinal needle provides a non turbulent uniform stream at 35° to the longitudinal axis when using low speed of injection,^{18,19} This could minimize the mixing of hyperbaric bupivacaine with the CSF and improve the unilateral distribution of spinal anaesthesia.

Similar to previous studies,^{20,21} our results also showed that with 8 mg hyperbaric bupivacaine the median time for regression of sensory level by two segments on the dependent side ranged between 75 and 80 min. The purpose of the present investigation was not to evaluate the use of unilateral spinal anaesthesia for day surgery and we did not include day cases in the study. However, these findings may be of interest to practitioners routinely faced with outpatient procedures.⁵

We conclude that highly concentrated solutions of hyperbaric bupivacaine are not advantageous in obtaining a unilateral distribution of spinal anaesthesia when a low anaesthetic dose is injected slowly through a Whitacre spinal needle in adult patients.

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References

- 1 Tanasichuk MA, Shultz EA, Matthews JH, Van Bergen FH. Spinal hemianalgesia: an evaluation of a method, its applicability and influence on the incidence of hypotension. *Anesthesiology* 1961; 22: 74–85.
- 2 Fanelli G, Casati A, Beccaria P, Agostoni M, Berti M, Torri G. Bilateral versus unilateral selective subarachnoid anaesthesia: cardiovascular homeostasis. *Br J Anaesth* 1996; 76: A242.

- 3 Casati A, Fanelli G, Berti M, et al. Cardiac performance during unilateral lumbar spinal block after crystalloid preload. *Can J Anaesth* 1997; 44: 623-8.
- 4 Fanelli G, Casati A, Aldegheri G, et al. Cardiovascular effects of two different regional anaesthetic techniques for unilateral leg surgery. *Acta Anaesthesiol Scand* 1998; 42: 80-4.
- 5 Pittoni G, Toffoletto F, Calcarella G, Zanette G, Giron GP. Spinal anesthesia in outpatient knee surgery: 22-gauge versus 25-gauge Sprotte needle. *Anesth Analg* 1995; 81: 73-9.
- 6 Glantz SA. *Primer of Biostatistics*. London: McGraw-Hill, 1988.
- 7 Stienstra R, Gielen M, van Poorten F, Kroon JW. Spinal anesthesia with plain bupivacaine 0.5%: regression of sensory and motor blockade with different temperatures of the anesthetic solution. *Anesth Analg* 1989; 69: 593-7.
- 8 Hiller A, Rosenberg PH. Transient neurological symptoms after spinal anaesthesia with 4% mepivacaine and 0.5% bupivacaine. *Br J Anaesth* 1997; 79: 301-5.
- 9 Hampl KF, Schneider MC, Unmenhofer W, Drewe J. Transient neurologic symptoms after spinal anesthesia. *Anesth Analg* 1995; 81: 1148-53.
- 10 Pollock JE, Neal JM, Stephenson CA, Wiley CE. Prospective study of the incidence of transient radicular irritation in patients undergoing spinal anesthesia. *Anesthesiology* 1996; 84: 1361-7.
- 11 Ong B, Baker C. Temporary back and leg pain after bupivacaine and morphine spinal anaesthesia. *Can J Anaesth* 1995; 42: 805-7.
- 12 Casati A, Fanelli G, Aldegheri G, Berti M, Leoni A, Torri G. A transient neurological deficit following intrathecal injection of 1% hyperbaric bupivacaine for unilateral spinal anaesthesia. *Eur J Anaesth* 1998; 15: 112-3.
- 13 Greene NM. Uptake and elimination of local anesthetics during spinal anesthesia. *Anesth Analg* 1983; 62: 1013-24.
- 14 Cohen EN. Distribution of local anesthetic agents in the neuraxis of the dog. *Anesthesiology* 1968; 29: 1002-5.
- 15 Povey HMR, Jacobsen J, Westergaard-Nielsen J. Subarachnoid analgesia with hyperbaric 0.5% bupivacaine: effect of a 60-min period of sitting. *Acta Anaesthesiol Scand* 1989; 33: 295-7.
- 16 Gentili ME, Mamelle JC, Le Foll G. Combination of low-dose bupivacaine and clonidine for unilateral spinal anesthesia in arthroscopy knee surgery (Letter). *Reg Anesth* 1995; 20: 169-70.
- 17 Iselin-Chaves IA, Van Gessel EF, Donald FA, Forster A, Gamulin Z. The effects of solution concentration and epinephrine on lateral distribution of hyperbaric tetracaine spinal anesthesia. *Anesth Analg* 1996; 83: 755-9.
- 18 Holman SJ, Robinson RA, Beardsley D, Stewart SFC, Klein L, Stevens RA. Hyperbaric dye solution distribution characteristics after pencil-point needle injection in a spinal cord model. *Anesthesiology* 1997; 86: 966-73.
- 19 Serpell MG, Gray WM. Flow dynamics through spinal needles. *Anaesthesia* 1997; 52: 229-36.
- 20 Liu SS, Ware PD, Allen HW, Neal JM, Pollock JE. Dose-response characteristics of spinal bupivacaine in volunteers. Clinical implications for ambulatory anesthesia. *Anesthesiology* 1996; 85: 729-36.
- 21 Ben-David B, Levin H, Solomon E, Admoni H, Vaida S. Spinal bupivacaine in ambulatory surgery: the effect of saline dilution. *Anesth Analg* 1996; 83: 716-20.