Clinical Study

Comparison of Intrathecal Use of Isobaric and Hyperbaric Bupivacaine during Lower Abdomen Surgery

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Received 9 September 2013; Revised 17 December 2013; Accepted 31 December 2013; Published 5 February 2014

Academic Editor: Necati Gökmen

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Objective. The ideal local anesthetic solution for intrathecal use has rapid onset and reliable duration, with less incidence of adverse events. This study was aiming to compare the onset of anesthesia and duration of action of isobaric and hyperbaric bupivacaine for subarachnoid block (SAB). **Methods.** Sixty patients who underwent lower abdominal, hips, and lower extremity surgeries were randomized into two groups. Group I received 20 mg of 0.5% isobaric bupivacaine, while Group H received 20 mg of 0.5% hyperbaric bupivacaine. Injection was made intrathecally in midline position at L3-4 interspace in sitting position. **Results.** The onset of analgesia and motor blocks with isobaric was faster when compared to hyperbaric bupivacaine (4.8 ± 2.2 versus 7.5 ± 2.2 minutes and 4.1 ± 2.1 versus 6.4 ± 2.4 minutes, resp., $P < 0.001$). The duration of sensory and motor blocks was longer in isobaric when compared to hyperbaric bupivacaine (276 ± 30 versus 163 ± 22 minutes and 266 ± 32 versus 163 ± 24 minutes, $P < 0.001$). In both groups, hemodynamic changes were not clinically relevant, and the adverse effects were comparable. **Conclusion.** Isobaric produced more rapid onset and longer duration when compared to hyperbaric bupivacaine.

1. Introduction

Bupivacaine is a local anesthetic that is largely used for spinal anesthesia, mainly as a hyperbaric or plain solution [1–3]. Controversy exists regarding the predictability of the levels of analgesia achieved with isobaric solution when compared to hyperbaric [4–6]. Virtually local anesthetics used for spinal anesthesia are mostly available as hyperbaric solutions and it is well established that the addition of dextrose to increase the specific gravity of the solutions alters the anesthetic profiles [1, 3, 7, 8].

Position of the patient and baricity or density of the local anesthetic solution injected as determinants of distribution are so closely related that one cannot be discussed without the other [5]. The sitting position is frequently used for induction of spinal anesthesia. Hyperbaric solutions, under the influence of gravity, would be expected to spread caudally, whereas isobaric solutions would be expected to distribute rostrally [2, 9, 10].

Density varies inversely with temperature. The actual change in density with temperature cannot be predicted with

different solutions. The temperature of local anaesthetic rapidly equilibrates with the core temperature of the CSF ($37\text{--}38^\circ\text{C}$). In order to determine accurately the baricity that dictates the spread of local anaesthetic, the density of CSF and the density of the local anaesthetic must be measured at $37\text{--}38^\circ\text{C}$ [8].

Even though hyperbaric and isobaric solutions have been extensively studied until now, the comparison of these two solutions from the same manufacturer without any adjuvant for SAB is not yet reported. This study aimed to compare the onset of anesthesia and duration of action of isobaric and hyperbaric bupivacaine 0.5% for SAB.

2. Patients and Methods

The university medical ethical committee approved this study. 60 patients with ASA I and II, undergoing elective lower abdominal surgeries with the estimation in duration of no longer than 120 minutes were enrolled. Exclusion criteria included patient's refusal to participate in the study,

coagulopathy, anticoagulation therapy, presence of cutaneous infection at the site of the planned puncture, or systemic infection, untreated hypovolemia, progressive cardiomyopathy > class III, chronic renal failure receiving hemodialysis, peripheral neuropathy, autonomic dysfunction, history of lumbar surgery making needle puncture impossible, grossly deformed vertebral column, increased intra-abdominal girth secondary to an expanding tumor, a mass or ascites, pregnancy, and allergy to local anesthetics. Drop-out was made when the surgery was more than 120 minutes and severe hemodynamic instability, total spinal, allergic reaction, failed block, and the conversion to general anesthesia took place.

Preoperatively, physical examinations and supportive investigations (i.e., routine laboratory, ECG, and chest X-ray) were made one day prior to surgery. Patients were randomized with sealed envelope method into two groups; Group I received isobaric bupivacaine, while Group H received hyperbaric bupivacaine. Neither anesthesiologist performing SAB or collecting perioperative and postoperative data nor the patients were aware of the used solution.

After monitoring, preanesthetic hydration which consisted of 10 mL/kg of a crystalloid solution was infused over 20–30 min via a 18-gauge cannula. After injection of local anesthesia, fluids were administered on the basis of changes in arterial pressure and urinary output. Blood loss was replaced with a crystalloid solution on a 3:1 basis until estimated or measured hematocrit reached 35%; further losses were replaced by blood.

Soon after proper sterility and disinfection procedure, SAB was performed using midline approach in the sitting position, in the L3-4 interspace with 25 G Quincke spinal needle (B-Braun, Melsungen, Germany) with the tip heading toward the head (cephalad). A clear-constant flow of cerebrospinal fluid (CSF) leakage from spinal needle indicated a correct position of needle tip in the subarachnoid space. In all patients, 20 mg (4 mL) of either 0.5% isobaric or hyperbaric bupivacaine solution (Buvanest, Kalbe Farma, Jakarta, Indonesia) was injected without barbotage in the speed of 0.2 mL/sec. Immediately after the injection, the patients were turned back to the horizontal supine position and a pillow was placed under the head for the rest of the study.

Analgesia, defined as the loss of sharp sensation to pin prick with the blunt tip of a Sherwood B400 27-gauge short needle at midclavicular line beginning from the feet in a cephalad direction bilaterally, was assessed every 2 min during preparation for surgery until the onset of surgery. The onset of analgesia is defined as the time to achieve the highest sensory block. Postoperative recordings were made every 5 min until discharge from the recovery unit and then every 15 min until regression of sensory block to L1.

Motor blockade of the lower limbs was assessed on the Bromage scale: 0 = no paralysis (full flexion of the knees and feet), 1 = inability to raise extended leg (just able to move knees), 2 = inability to flex knees (able to move feet only), 3 = inability to flex ankle joint (unable to move the knees or feet). The onset of motor blockade is defined as the time to achieve Bromage 3. The first assessments were made 5 minutes after the patient was placed in the supine position. All subsequent assessments were made at 5-minute intervals.

TABLE 1: Demographic data.

	Group I	Group H	P
Age (years)	38 ± 14	38 ± 9	0.90
Sex (male/female)	18/9	17/10	0.32
Weight (kg)	57 ± 8	60 ± 6	0.20
Height (cm)	158 ± 7	159 ± 6	0.63
SAP (mmHg)	131 ± 11	128 ± 10	0.21
DAP (mmHg)	79 ± 9	81 ± 7	0.47
MAP (mmHg)	97 ± 9	97 ± 6	0.95
ASA (I/II)	16/1	18/9	0.30

Mean ± SD. Group I: isobaric; Group H: hyperbaric; SAP: systolic arterial pressure; MAP: mean arterial pressure; DAP: diastolic arterial pressure; ASA: preoperative status based on the American Society of Anesthesiologists.

Baseline measurements (arterial blood pressure, and heart rate) were measured noninvasively 5 minutes before intervention and continuously monitored during anesthesia. After performing spinal block, these parameters were recorded every 2 minutes in the first 10 min, every 5 min in the first hour and every 10 minutes until the patient moved to the recovery unit.

Hypotension was defined as a systolic arterial pressure of less than 100 mm Hg irrespective of the baseline preinduction arterial pressure or a decrease in systolic arterial pressure of more than 30% of the baseline value and was treated by increasing the rate of the infusion and the administration of 5 mg increments of ephedrine intravenously. No intravenous ephedrine was given until hypotension occurred. Bradycardia was defined as heart rate less than 50 beat/min and treated with intravenous atropine of 0.5 mg. Amounts of ephedrine and atropine use were recorded.

Data were analyzed using SPSS 20.0 software. Results were expressed as mean ± standard deviation (SD). Continuous variables analyzed with student *t*-test, while the chi-square test was used to compare discrete variables. A *P* < 0.05 were considered significant, and exact values are given when <0.001.

3. Results

Six patients were dropped out due to failed block and the duration of surgery being longer than 120 minutes. The remaining 54 patients (27 each groups) followed all the study procedure. Patients in both groups were comparable, as in the demographic data (Table 1). Surgery lasted for 83 ± 19 minutes in Group I and 77 ± 19 minutes in Group H (*P* = 0.23).

3.1. Sensory and Motor Blockade. The measured sensory blockade and motor blockade are the onset and duration (Table 2). The onset of sensory blockade was significantly shorter in Group I when compared to Group H (*P* < 0.001). Duration of sensory block was the time measured from the time of the highest block for the regression to the S2 dermatome, which is significantly longer in Group I compared to Group H (*P* < 0.001). The onset of motor block was also shorter in Group I than Group H (*P* < 0.001), while the duration of motor block, the time measured from

TABLE 2: Block characteristics.

	Group I	Group H	P
Onset (minutes)			
Sensory	4.8 ± 2.2	7.5 ± 2.2	<0.001
Motor	4.1 ± 2.1	6.4 ± 2.4	<0.001
Duration (minutes)			
Sensory	276 ± 30	163 ± 22	<0.001
Motor	266 ± 32	163 ± 24	<0.001

Mean ± SD. Group I: isobaric; Group H: hyperbaric.

TABLE 3: Level of dermatome block.

	Group I		Group H		P
	n	%	n	%	
Thoracal 4	5/27	18.5	1/27	3.7	0.08
Thoracal 5	2/27	7.4	1/27	3.7	0.55
Thoracal 6	7/27	25.9	1/27	3.7	0.02
Thoracal 7	6/27	22.2	4/27	14.8	0.48
Thoracal 8	5/27	18.5	7/27	25.9	0.51
Thoracal 9	1/27	3.7	7/27	25.9	0.02
Thoracal 10	1/27	3.7	6/27	22.2	0.04

Number of patients and its percentage. Group I: isobaric; Group H: hyperbaric.

the achievement of Bromage 3 until regression to Bromage 0, was longer in Group I when compared to Group H ($P < 0.001$).

Cephalad spread of sensory blockade, assessed by pinprick (Table 3), was higher with isobaric than hyperbaric solution. The highest level of dermatome block was in thoracal 4, while the lowest was in Th 10. More patients in Group I had sensory block at Th 4 than in Group H. The majority of blocks level was in thoracal 6 or 7 in Group I, while Group H produced lower blockade at Th 8 to Th 10.

3.2. Hemodynamic Changes. The changes in mean arterial pressure of the initial 4 mL injection of anesthetic solution are shown in Figure 1. There were several hypotensive events within 6 to 15 minutes after the injection of local anesthetic solution, which are comparable in both groups, and were not clinically significant.

3.3. Adverse Events. Hypotension occurred in more patients in Group I (18.5%) than Group H (11.1%), while the other adverse events (bradycardia and nausea) are comparable for both groups as shown in Table 4.

4. Discussion

This study showed that isobaric bupivacaine produced more rapid onset of anesthesia and longer duration of action when compared to hyperbaric bupivacaine. In our study, the only variable was baricity, since dose, volume, and concentration were kept constant and even both solutions are produced by the same manufacturer. The isobaric bupivacaine (Buvanest 0.5%) used in this study is an isotonic bupivacaine HCL 5 mg/mL, while the hyperbaric bupivacaine (Buvanest Spinal

FIGURE 1: Changes in mean arterial pressure. Dashed line, isobaric; solid line, hyperbaric.

TABLE 4: Adverse events.

	Group I		Group H		P
	n	%	n	%	
Hypotension	5/27	18.5	3/27	11.1	0.44
Bradycardia	1/27	3.7	1/27	3.7	1.00
Nausea	1/27	3.7	1/27	3.7	1.00

Number of patients and percentage. Group I: isobaric; Group H: hyperbaric.

0.5% Heavy) is an isotonic bupivacaine HCl 5 mg/mL and dextrose monohydrate 80 mg/mL.

Baricity influenced the distribution of local anesthetic solution in the CSF. It is defined as the ratio of density (mass/volume) of local anesthesia solution's density compared to CSF density in 37°C. Thus, baricity influences local anesthetic spread and block height since gravity causes hyperbaric solutions to flow downward in the CSF, whereas hypobaric solutions tend to rise. In contrast, gravity has no effect on the distribution of truly isobaric solution [1, 8, 11, 12].

In our study, isobaric showed more rapid onset of anesthesia and longer duration of action than hyperbaric. Another important finding is that there was a lower blockade with hyperbaric solutions, which is consistent with previous studies [2, 4, 6, 13, 14], while other studies also proposed that hyperbaric solutions may be more suitable to reach the higher thoracic dermatomes as opposed to their plain (i.e., isobaric) [5, 6]. However, only by comparing similar volumes and doses can this difference be accurately assessed. The reasons for this differential effect are speculative, but it could be explained by the properties of the two drugs in relation to gravity and the mass movement of CSF as a result of the postural changes [1, 13, 15]. Gravity will tend to keep the hyperbaric solution near the lowest point of the thoracic curve (T4/T5) in the supine position and to resist attempts to move it further in a cranial direction. This tendency could be further assisted by the viscosity of the hyperbaric solution, preventing it mixing with the CSF [1, 2, 5–16]. The plain solution, however, mixing freely with CSF, has neither gravitational nor viscous effect to constrain its movement within the displaced CSF. The contribution made towards spread of analgesia by the mass movement of CSF and whether the effects of gravity are in the same direction or not will determine if hyperbaric

solutions spread more than isobaric solutions. The traditional explanation that isobaric solutions are unaffected by posture, while hyperbaric solutions merely spread down into the hollow of the thoracic curve under the influence of gravity [2–8, 11, 13–18]. In our study, pregnant women were not included. This is due to the effect of abdominal mass (pregnancy) may compress the CSF area, also to this population have the lowest mean of CSF density [2, 8, 9, 15].

The dose of 20 mg used in our study was chosen because the comparison of isobaric and hyperbaric solutions from this manufacturer for SAB has never been done before. Furthermore, this dose is the basic dose to be used in our daily practice as an academic hospital, where the duration of surgery is unpredictable. While sitting position was performed during the induction of spinal anesthesia was also to clarify the effect of baricity of these solutions in the CSF. During sitting position, these solutions have more space to go further down following the gravity, when compared to lateral position where the area of spread is limited [5, 8, 10, 11, 13, 18, 19].

Hypotension and bradycardia are common side effects after SAB procedure, which is due to sympathetic blockade. This sympathetic blockade causes arterial vasodilatation, resulting in the decrease of systemic vascular resistance and venous pooling. Therefore, fluid loading is beneficial to prevent hypotension [3, 7]. The hemodynamic parameters in our study were changed within 6 to 15 minutes after the injection of local anesthesia. Although there were some hemodynamic changes in the two groups these changes were not clinically significant (reversible). Furthermore, the decrease of MAP was quickly resolved with fluid loading or ephedrine injection. Other adverse events were comparable in the two groups and well tolerated.

In conclusion, isobaric bupivacaine produced more rapid onset and longer duration compared to hyperbaric bupivacaine.

Conflict of Interests

The authors declare that they received no financial support and that they have no conflict of interests.

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