Comparison of differential blockade during spinal anesthesia using isobaric *vs* hyperbaric lidocaine 2%

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Purpose: To compare the extent of the sensory, motor and sympathetic block produced by a single dose of 60 mg lidocaine at the same concentration (2%) and volume but at different baricity injected intraspinally.

Method: In a randomised double blind study, 40 ASA I - II patients were scheduled for elective surgery (orthopedic, urologic, peripheral vascular and lower digestive procedure). They were divided in two groups. Twenty patients received 60 mg lidocaine 2% in a hyperbaric solution and 20 received 60 mg lidocaine 2% in a isobaric solution. The levels of sensory (pinprick, ice) motor (Bromage scale) and sympathetic blockade (galvanometry, cutaneous blood flow, temperature) were measured at 0, 5, 10, 15, 20 and 30 min.

Results: There were no differences between the groups with regard to maximal height of sympathetic block, sensory level to pinprick: $T_5 \pm 2.4$ for isobaric group, $T_6 \pm 3.6$ for hyperbaric group or to cold: $T_3 \pm 2.3$ for isobaric group, $T_4 \pm 2.7$ for hyperbaric group. Hyperbaric lidocaine 2% produced a more pronounced sensory (pinprick, ice) and motor block on the dependant than on the non-dependant side.

Conclusion: The baricity of 60 mg lidocaine injected intraspinally in the lateral decubitus position did not influence the cephalad spread of sensory or sympathethic blockade. In the hyperbaric group, the dependent side showed a more pronounced sensory (pinprick, ice), and motor block.

Objectif : Comparer l'étendue du bloc sensitif, moteur et sympathique d'une dose de 60 mg de lidocaïne 2 % à baricité différente, administrée en injection intrarachidienne, en décubitus latéral.

Méthode : Quarante patients ASA I-II, dont l'opération était prévue, ont participé à une étude randomisée à double insu. Ils ont été répartis aléatoirement en deux groupes. Vingt patients ont reçu une anesthésie rachidienne avec 60 mg de lidocaïne isobare à 2 %, et 20 patients avec 60 mg de lidocaïne hyperbare à 2 %. Ont été mesurés sur une période de 30 min (0, 5, 10, 20, 30 min): l'expansion du bloc sympathique (galvanométrie, étude du flot vasculaire – Doppler - et prise de température aux extrémités), du bloc sensitif (aiguille et glace, côtés gauche et droit) ainsi que l'intensité du bloc moteur (gauche et droit). Une différence statistique de $P < 0{,}05$ était considérée significative.

Résultats : Nous n'avons trouvé aucune différence significative intergroupe de diffusion céphalique de la sensibilité au froid et à l'aiguille. Les variations de température, de flot vasculaire, et de résistance cutanée étaient également comparables. Le bloc moteur était complet en 15 min chez tous les patients du groupe isobare, tandis que quelques patients n'avaient qu'un bloc partiel à droite (côté non dépendant) dans le groupe hyperbare, et ce, après 30 min.

Conclusion : La baricité d'une solution de 60 mg de lidocaïne 2 % intrarachidienne n'influence pas le niveau céphalique sympathique, sensitif ou moteur en décubitus latéral. Cependant, un effet moteur plus marqué du côté déclive se dégage dans le groupe hyperbare.

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STUDIES on spinal anesthesia investigating the cephalic spread of hyperbaric *vs* isobaric bupivacaine or amethocaine solutions demonstrated that hyperbaric solutions produced more extensive cephalad spread than did isobaric solutions when injected in a lateral decubitus position.[1–4]

Nevertheless, recent studies using lidocaine solutions injected in the lateral decubitus position have produced controversial results. Toft *et al.* compared 80 mg isobaric lidocaine solution (2%, 4 ml) with 80 mg hyperbaric lidocaine solution (5%,1.3ml) and found no difference in the cephalic spread of the sensory or motor block.[5] Zundert *et al.* used 70 mg lidocaine and compared the extent of sensory and motor blockade.[6] Using large difference in volumes, concentrations and baricity between solutions, they found that as long as the dose remained constant, the level of spinal anesthesia was similar. Using a glass spine model placed in the vertical position, Lui *et al.* demonstrated that the hyperbaric solution extended lower than the injection site, whereas isobaric lidocaine diffused equally each side of the injected site.[7] Another study by Liu *et al.* comparing 50 mg lidocaine 1.5% isobaric with 50 mg lidocaine 1.5% hyperbaric showed that the block with the hyperbaric solution extended more cephalad than did the isobaric solution.[8]

Because of discrepancies between these results and our experience, we undertook a prospective randomized double blind study to compare the extent of the sympathetic, sensory, and motor block produced by a single dose of 60 mg lidocaine at the same concentration (2%) and volume, but at different baricity, injected intraspinally in the lateral decubitus position.

Methods

After approval of the project study by our Research and Ethics committee, written informed consent was obtained from all subjects.

Forty ASA I - II patients scheduled for orthopedic, peripheral vascular, urologic and lower surgery were recruited. Patients were randomly divided into two groups to receive either isobaric or hyperbaric lidocaine. Inclusion criteria were: age 18 - 70 yr, ASA I to II, weight 45 - 100 kg, height 165 - 180 cm. Exclusion criteria included: patient 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 intraabdominal girth secondary to an expanding tumour,a mass or ascites, allergy to local anesthetics, and failure of spinal anesthesia.

All patients were brought to a quiet preinduction room where the study was undertaken. Room temperature was kept at 20°C. Monitoring equipment including DINAMAP (Critikon Monitor 1846 SX) for simultaneous monitoring of blood pressure and hear rate, ECG (Textronic Monitor 414) and pulse oximetry (Ohmeda Biox 3740).

The patient received 2 $L \cdot min^{-1}$ oxygen by nasal cannulae. A volume preload of 10 $ml \cdot kg^{-1}$ Ringer's lactate was administered via a peripheral vein. Then the patient was positioned in the left lateral decubitus position for spinal anesthesia.

Technique

A combined spinal-epidural technique was used for surgical anesthesia.

After preparing the lumbar region, the skin was infiltrated with 3 ml lidocaine 1% with a needle# 25 at L_{2-3}. The epidural space was localized with a Tuohy #17 needle using loss of resistance technique with saline solution. Then, a Quincke needle # 27 with the bevel parallel to the dura mater fibres and turned toward the non-dependant (upright) side was introduced into the spinal space. All procedures were performed by the same anesthesiologist.

The isobaric lidocaine consisted of isobaric lidocaine 2% without preservative (ASTRA). The hyperbaric lidocaine 2%, prepared in our hospital pharmacy, consisted of a mixture of 1.2 ml lidocaine 5% with 1.35 ml dextrose 10% and 0.45 ml sterile water, giving a final concentration of lidocaine 2% and dextrose 7.5%. In each case, 3 ml, 60 mg lidocaine were injected over 10 sec with the patient in the left lateral position. An epidural catheter was introduced for two centimeters in the epidural space through the Tuohy needle which was then removed and the patient was returned to the supine position. These maneuvres were performed within one minute.

The anesthesiologist injecting the solution and the person making the assessment were blinded to the baricity of the solution injected.

A 20% decrease in blood pressure was treated with 5 mg ephedrine *iv* and a decrease in the heart rate of 20% with a similar decrease in blood pressure was treated with 0.4 mg atropine *iv*.

Measurements were made at the beginning of the procedure, and at 5, 10, 15, 20 and 30 min.

The level of the sympathetic blockade was studied with three methods.

1. Study of the cutaneous resistance with galvanometry (Grass Model 7E Polygram). An electrode for painful stimuli was placed in the left supra-clavicu-

lar region, while the other electrodes were located in the mid clavicular zone at the level of T_5, T_9 and on the iliac crest on the same side (right).

2. Vascular flow was evaluated with a Doppler apparatus (Transonic Doppler ALF21-P) on the right hand and right foot.

3. Temperature changes were monitored at the left thumb and left great toe (Mon-A-Therm Model 6510).

The sensory level was measured bilaterally using a needle for pain and ice cubes for cold perception. Motor block intensity was assessed bilaterally using a modified Bromage scale: Level I: complete block, Level II: block to the hip and knee, Level III: block to the hip, Level IV: no block.

Statistical analyses

Following assessment of normality and homoscedasticity, data were analyzed using analysis of variance for repeated measures applied to a 2 by 6 mixed model (2 groups and 6 time points). A third factor was added to the model to assess differences in measurements taken on the right and left sides of the body (Bromage scale sensory block level). The subject's height was introduced as a covariate for analyses dealing with block level. Multivariate ANOVA was used in case of lack of compound symmetry. Significant interactions were first partitioned in order to investigate group differences at each time point. Simple main effects were also calculated to study time variations within each of the two groups. Tukey's B method for multiple comparisons (comparisons of time points) was then used when significant partitions were encountered.

All analyses were considered significant at $P \leq .05$.

TABLE I Demographic data

	Hyperbaric	*Isobaric*	*P*
Sex:			
Women	7	8	0.74
Men	13	12	
ASA:			
I	15	16	0.70
II	5	4	
Age (median)	51.7 (54)	46.75 (45)	0.33
Weight (median)	70.8 (70.45)	76.13 (77.5)	0.20
Height (median)	1.69 (1.67)	1.70 (1.71)	0.62

Results

The demographic data of both groups were comparable for age, height, weight, sex and ASA staatus (Table I). One patient was excluded in the hyperbaric group because failure of anesthesia.

Hemodynamic variations, slowing of heart rate (HR) and decrease in mean blood pressure (MBP) were sustained throughout the study without any differences between the groups. (Figure 1)

Sympathetic block

Sympathetic blockade measured with galvanometry (cutaneous resistance), (Figure2), temperature, (Figure

TABLE II Results of anovas comparing effects of isobaric and hyperbaric solutions over time

Parameter	*Anesthetic X Time*		*Anesthetic X Side X Time (1)*		*Anesthetic X Side*		*Comment*
	P	*Effect size*	*P*	*Effect size*	*P*	*Effect size*	
Sensitive block (needle)	0.10	0.20	0.36	0.12	0.02	0.14	Left > Right, the difference being more pronounced in Hyper grp
Sensitive block (Ice)	0.50	0.10	0.82	0.04	0.04	0.12	Left > Right, the difference being more pronounced in Hyper grp
Heart rate	0.90	0.05	-	-			
Blood pressure	0.85	0.06	-	-			
Vascular flow (Doppler)	0.53	0.11	-	-			
Body temp (hand)	0.37	0.15	-	-			
Body temp (toe)	0.09	0.24	-	-			
Cutaneous resist (hand)	0.55	0.08	-	-			
Cutaneous resist (T_5)	0.73	0.06	-	-			
Cutaneous resist (T_9)	0.36	0.12	-	-			
Cutaneous resist (Iliac crest)	0.28	0.14	-	-			
Cutaneous resist (foot)	0.53	0.09	-	-			
Motor Block (Bromage)	0.52	0.09	0.05	0.23	-	-	Right side: Hyper > Iso at all times Left side: Hyper > Iso at T30 only

1. The model included a side effect only for a subset of parameters: sensitive (needle and ice) and motor block

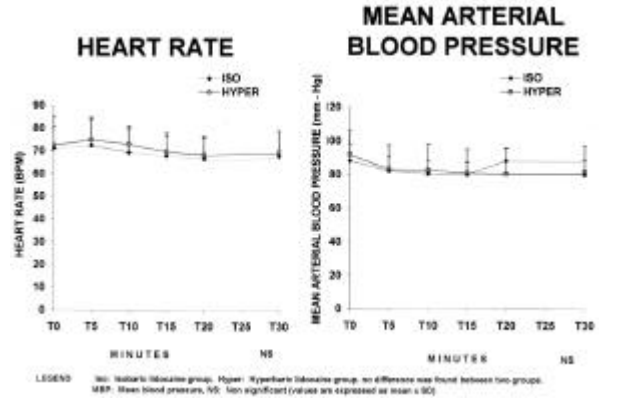
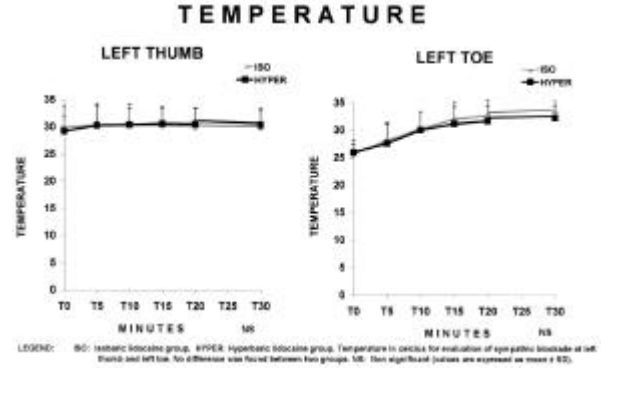


FIGURE 1



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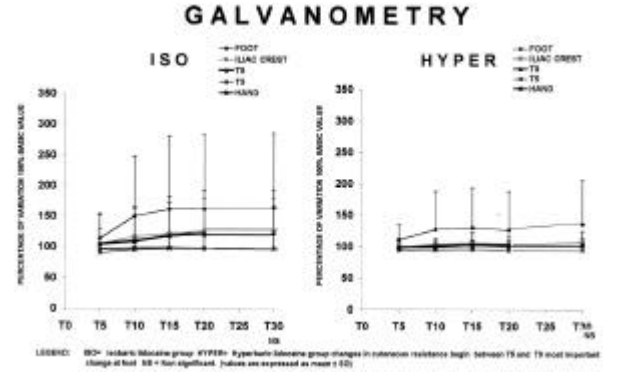

FIGURE 2

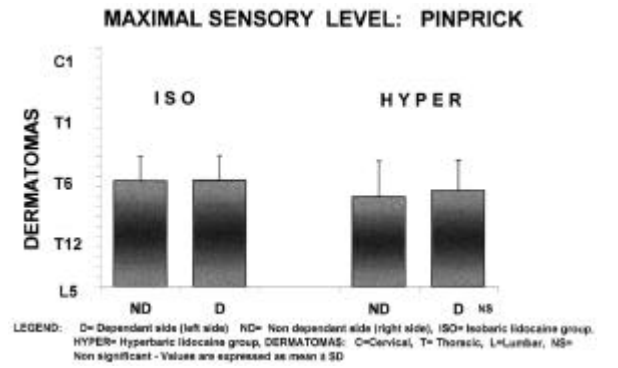

FIGURE 4

3), and vascular flow variation (Doppler): 4.15 ± 1.92 isobaric group *vs* 3.27 ± 2.26 hyperbaric group – *P*.0.53 showed no difference between isobaric *vs* hyperbaric group.

Sensory block

No difference in sensory block could be found during progress to maximal dermatome level of the blockade evaluated by pinprick (Figure 4), or ice (Figure 5).

Motor block

The degree of motor blockade was complete in 15 min in all patients in isobaric group while several patients in hyperbaric group achieved only a partial block at 30 min (dependant side effect)(*P*= 0.05). (Figure 6)

Left(dependent) vs right (non-dependent) side

We compared left *vs* right side (sensory and motor blockade) for each group. No difference could be found in the isobaric group (Figure 7) but differences were found in hyperbaric group for pinprick (*P*=0.005), ice (*P*=0.005) and motor block (*P*=0.001). (Figure 8)

Discussion

Several studies have demonstrated tha,t for an equal dose of bupivacaine, a hyperbaric (HB) formulation produces a greater cephalad spread of the sensory and sympathetic blockade, than an isobaric(IB) formulation, when injected in the lateral decubitus position. However, some recent similar studies using lidocaine as the anesthetic agent failed to find differences between the two groups. In these studies though, the injected volumes and concentrations were not kept constant.

The purpose of our study was to repeat these experiments with lidocaine, but keeping the volume and concentration the same, thus eliminating these confounding variables. The study was undertaken before

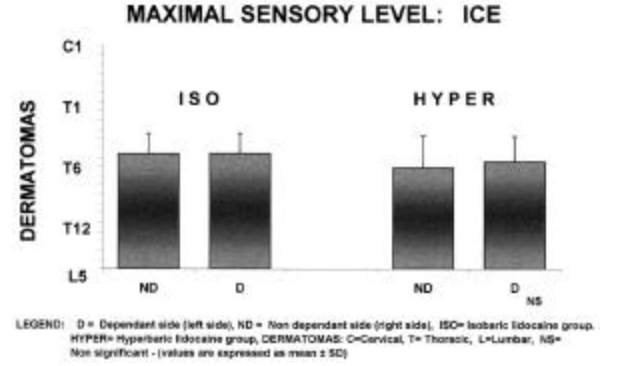

FIGURE 5

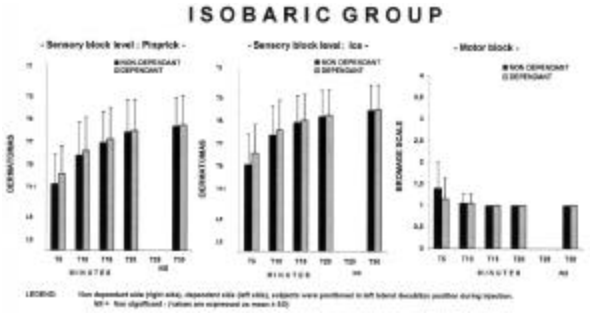

FIGURE 7

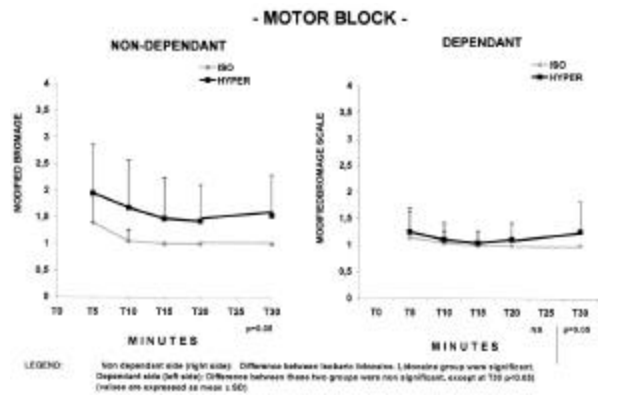

FIGURE 6

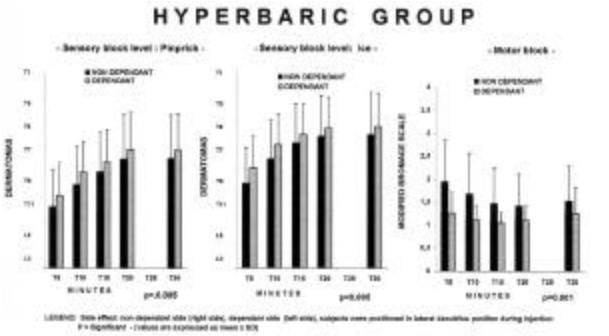

FIGURE 8

transient radicular irritation (TRI) became a concern with spinal lidocaine.

Cephalad spread was similar in both groups and was, thus, independent of baricity. We did notice, however, that even though the patients were in the lateral decubitus position for only one minute, the intensity of the block was greater on the dependent side.

In 1984, when injecting HB and IB bupivacaine in the sitting position, then placing the subject in a dorsal decubitus position, Bengtsson failed to find any difference in block spread.[9] In order to elucidate these findings Lui *et al.*,[7] compared HB with IB lidocaine in a glass spine model placed in the vertical position. With this model the HB solution was more concentrated at the lower end of the column, whereas the IB formulation tended to concentrate around the site of injection. They concluded that Bengtsson's findings were not only related to baricity, but also to the effect of the spinal curvature. However, the patients in Bengtsson's study were moved to the dorsal decubitus position two minutes after injection. Therefore, if Lui *et al.* had moved their model to the horizontal position after injection, their findings may have been different.

In 1990, Toft[5] published a study similar to that of Bengtsson, but with 80 mg of either 2% IB or 5% HB xylocaine. He found that concentration, volume, and baricity had no effect on the cephalad spread of the block. Other studies using bupivacaine[1–4] found that cephalad spread was greater by an average of two dermatomes when a HB formulation was used. Unlike Bengtsson's experiment, the subjects were injected in the lateral decubitus position and not the sitting position.

Zundert,[6] injected subjects in the lateral decubitus position with a constant dose of lidocaine (70 mg), but at different concentrations (0.5, 1, 2, 5, 10%), of which only the 10% was HB. He reported that baricity had no effect on cephalad spread, as long as the dose was kept constant. This suggested that there was

a difference between lidocaine and bupivacaine when injected in the lateral decubitus position.

In our study, the only variable was baricity, since dose, volume, and concentration were kept constant. We also studied the dependent and non-dependent sides separately, and found that although there was no difference between HB and IB when comparing the spread using an average of the two sides, there was greater sensory and motor blockade on the dependent side in the HB group despite the fact that the subjects were in the lateral decubitus position for only one minute.

A study by Liu,[8] appears to contradict our findings: eight volunteers were sequentially injected with 80 mg 1.5 % IB and HB lidocaine 80 mg, both with the same volume (3.3 ml) and done at the same speed.The injections were carried out in the lateral decubitus position, and the patients were then turned supine. They found a greater cephalad spread in the HB group. There are several differences in Liiu's study that could explain these findings. Measurement of sensory blockade was done only in the midline, and a 25G Whitacre needle was used, and directed cephalad during injection. Previous studies documented that a higher level of sensory blockade can be obtained when the Whitacre needle in the cephalad than in the caudad direction,[10] and larger needles produce higher blocks.[11] We used a 27 Quincke needle with the bevel turned upwards, and it has been shown that there is greater diffusion of injectate with a Quincke than with a Whitacre needle.[12] Thus, several technical factors can explain the greater cephalad spread in Liu's study, but it is not clear why were both solutions (HB and IB)were not affected to the same degree. At equal injection velocity the HB solution, with its greater density, would have greater kinetic energy, and thus go further cephalad.

In order to ascertain that the lack of difference between the two groups was not due to limited sample size, we conducted a power analysis based on observed results. As shown in Table II, most analyses comparing groups over time allowed identification of differences of only limited magnitude. In terms of effect size estimation, most of these differences fall in the "small" category (around .10), suggesting the absence of strong effects that could have been missed because of lack of power.[13] In fact, effect sizes in the .10 to .15 range could have been detected only with two groups of at least 130 subjects each. Thus, the available power for the detection of effects of this magnitude was low. However, when considering effects presenting higher clinical relevance as our study (effect sizes of .25 or higher), the available power was .76 with two groups of 20 subjects. Then it is unlikely that the result obtained in this study were a consequence of a type II error.

In conclusion, although baricity had an effect on the laterality of the block when the subjects were injected in the lateral decubitus position, it did not have any effect on the cephalic distribution of spinal lidocaine.

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