Original Research Article

Indian Journal of Anesthesia and Analgesia
2019;6(4) (Part - II): 1422-1427
DOI: http://dx.doi.org/10.21088/ijaa.2349.8471.6419.50

Study of the Effect of Different Temperatures on Quality of Subarachnoid Blockade using 0.5% Hyperbaric Bupivacaine for Infraumbilical Surgeries

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Abstract

Background: Factors affecting spread of local anaesthetic are baricity, position, volume injected, level of injection, concentration of local anesthetic, speed of injection, abdominal pressure (ascites, pregnancy) and other factors are density, viscosity and temperature of the local anaesthetics injected. Our study compares the effects on sensory and motor blockade when 0.5% hyperbaric bupivacaine is administered at various temperatures viz., 24°C, 37°C and 40°C intrathecally in patients coming for infraumbilical surgeries. *Methods:* In this study 90 patients, 30 in each group undergoing surgery below the umbilicus were randomly administered spinal anesthesia at 24°C (Group A), 37°C (Group B) and 40°C (Group C). Sensory blockade and two segment regression were assessed by pinprick and motor blockade with Bromage scale. *Results:* Study showed with increased temperature the cephalad spread of sensory dermatome was rapid and high. Drugs injected at room temperature (24°C) had slow onset of sensory and motor blockade (p<0.001). Two segment regression achieved from the maximum level also was rapid with increased temperature of the local anesthetic administered. *Conclusion:* The sensory and motor blockade is influenced by the temperature of the local anaesthetic that is administered following subarachnoid injection.

Keywords: Baricity; Density; Intrathecal; Viscosity; Warm hyperbaric bupivacaine.

How to cite this article:

Shobha Dhayalan, Asha Narayan Gowda, Raghavendra Rao. Study of the Effect of Different Temperatures on Quality of Subarachnoid Blockade using 0.5% Hyperbaric Bupivacaine for Infraumbilical Surgeries. Indian J Anesth Analg. 2019;6(4): 1422-1427.

Introduction

Spinal anesthesia involves the use of small amounts of local anaesthetic (LA) injected into subarachnoid space to produce reversible loss of sensation and motor function producing excellent operating conditions for infraumbilical surgeries. Apart from the factors like baricity, position, volume injected, concentration of LA and few other factors are density and viscosity of the LA which influences the distribution of sensory and motor blockade[1-6] where further density and viscosity is influenced by the temperature[7-10] of the LA. The onset of blockade, extent and two segment regression with warming of bupivacaine from room temperature 24°C to 37°C and 40°C was assessed.

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Received on 04.05.2019, **Accepted on** 08.06.2019

Methods

This was a prospective observational study conducted from Sep 2018 to Jan 2019 after obtaining approval from Institutional Ethical Committee and was registered under CTRI (CTRI/2018/09/015610). Inclusion criteria were ASA physical status I and II, age group of 18-60 years of either sex, posted for elective infraumbilical surgeries and were willing to participate in the study. Exclusion criteria were any contraindications for neuraxial blockade, allergic to LA, any coagulation disorder and localised infection over injection point. Randomization was performed with computer generated codes maintained in sequentially numbered, opaque envelopes into 3 equal groups. All patients were examined a day before surgery and were kept fasting overnight. Once the patients were shifted to the operating table standard ASA monitors were attached. Non-invasive parameters 5 lead electrocardiogram, systolic, diastolic and mean arterial pressure and pulse oximetry were documented. Intravenous access was secured and Ringer Lactate solution 10 ml/kg/hr was started when spinal anesthesia block was performed. With strict aseptic and universal precautions subarachnoid block was performed using 25/26 G Quincke Babcock spinal needle in L_3-L_4 space with patient in lateral position. The safety of the study drug with warming as per the study[11] was taken into consideration. Group A received 3ml of 0.5% hyperbaric bupivacaine at room temperature 24°C, Group B received the same volume at 37°C and Group C received 3 ml at 40°C where the ampules were kept in water bath at a particular temperature for particular time to raise the temperature of the solution inside the ampule. The investigator not involved in the study prepared the drug. The study drug was drawn in the syringe, with in 20 sec of retrieval drug was injected over 10-15 sec once free flow of CSF was obtained after dural puncture. This time was considered as zero time of the study and all measurements were recorded from this point, following which patients were made to lie supine. Sensory anesthesia was assessed by pinprick method using 25-G short bevelled needle at 1 min interval for first 10 min, 5 min interval for next 60 min during surgery after spinal anesthesia and then every 10 min interval until regression to L_1. Time of onset of sensory block- L_1 dermatome, time to achieve T_{10} level, highest ascent achieved and two segment regression from the highest level achieved were recorded. Motor block was assessed every minute for first 15 min, then at every 5 min until the resolution of the motor block using Bromage scale (Appendix). Time of onset of motor block (Bromage scale 2) and time required for maximum level of motor block was recorded. Haemodynamic variables were monitored according to the institutional protocol. The patients were shifted to the post anesthesia care unit following surgery where haemodynamic variables was documented and discharged to the ward once recovered from sensory and motor blockade. Drop in systolic blood pressure of >30% Inj Mephentermine 6 mg IV and drop in heart rate below 50 beats/min Inj Atropine 0.6 mg IV was administered. The incidence of any adverse effects such as shivering, nausea and vomiting was recorded and treated accordingly.

Results

There was no significant differences between the Groups in terms of demographic data (Table 1).

Demographic data are presented as mean SD. Analysis of variance (ANOVA) has been used to find the significance of study parameters between the groups. Chi-square /Fisher Exact test has been used to find the significance of study parameters on categorical scale between the groups.

Speed of onset of sensory and motor block was faster in Group C (40°C) and Group B (37°C) with maximum sensory level achieved. There was moderate decrease in heart rate and blood pressure in Group C necessitating intervention but was not statistically significant. Time for two segment regression from the highest dermatome achieved was faster in Group C and Group B when compared to Group A (24°C) (Table 2 and Graph 1-5).

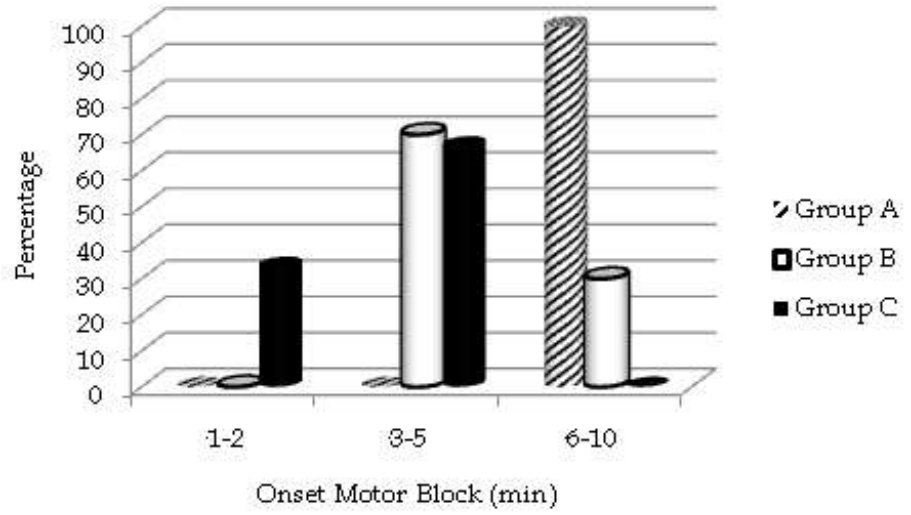
Table 1: Demographic characteristics

Characteristics	Group A (24°C)	Group B (37°C)	Group C (40°C)
No of patients	30	30	30
Age (yrs)	36	37	36
Sex (M:F)	20/10	18/12	17/13
Height (cm)	158	161	159
Weight (kg)	55	61	60

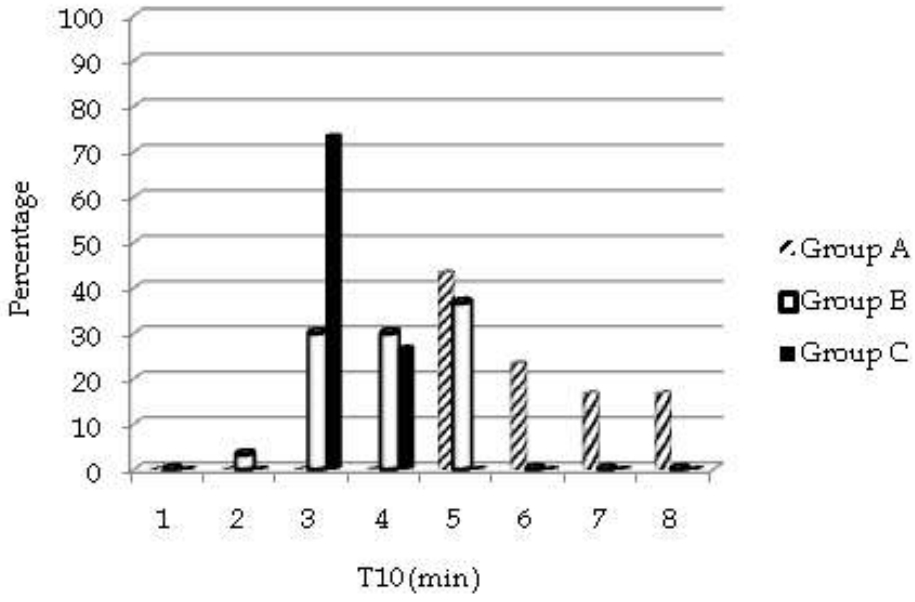
Data are Mean ± SD (Min-Max)

Table 2: Characteristics of Neural Block

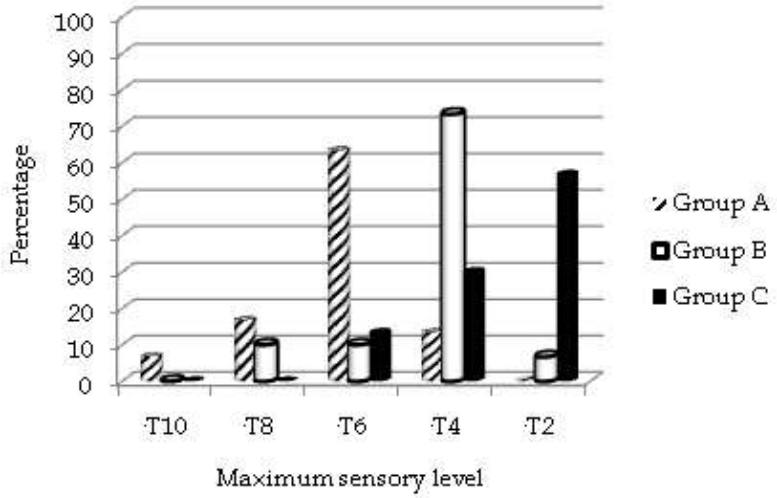
Minutes	Group A (24°C)	Group B (37°C)	Group C (40°C)	*p* value
Time for onset of sensory block (L1)	4.2 ± 0.8	2.6 ± 0.7	1.4 ± 0.5	<0.001
Time to reach T10 dermatome	6 ± 1	4 ± 0.9	3 ± 0.4	<0.001
Highest level of sensory block (MSL)	T6 (63%)	T4 (57%)	T2 (57%)	<0.001
Time for maximum level of sensory block (TMSL)	8 ± 1	6 ± 0.8	4 ± 0.8	<0.001
Time for onset of Motor block (B2)	7 ± 0.9	4 ± 0.8	3 ± 0.8	<0.001
Time for maximum level of motor block (TMMB)	8 ± 1	6 ± 0.8	4 ± 0.8	<0.001
Time for two segment regression (TSR)	103 ± 10	55 ± 8	51 ± 8	<0.001



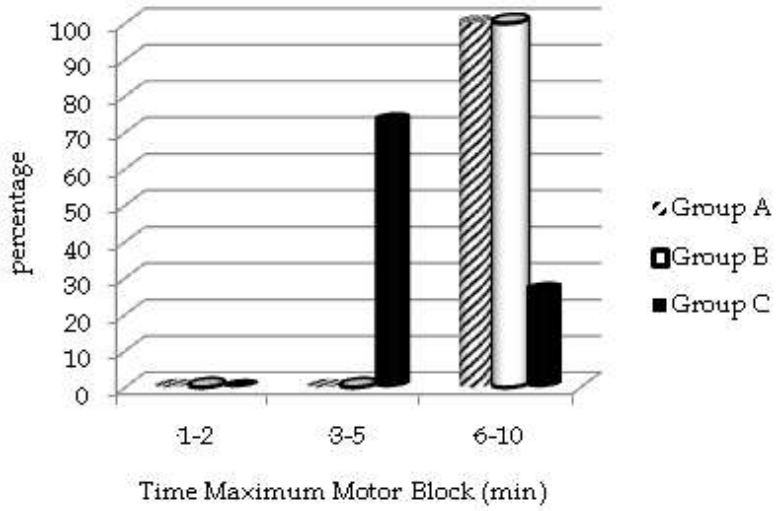
Graph 1: Onset of Motor Blockade (Bromage 2)



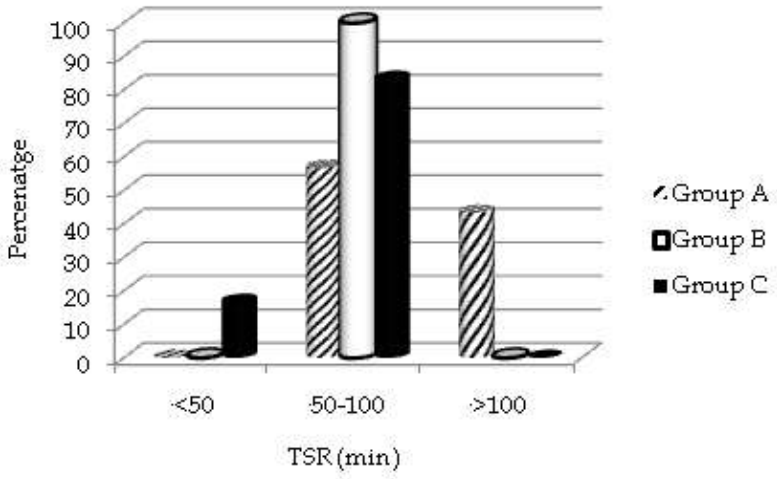
Graph 2: Time to reach T10 dermatome



Graph 3: Time to reach maximum sensory level



Graph 4: Time to reach maximum motor blockade



Graph 5: Time for two segment regression

Discussion

Large comparative studies and multiple prospective randomized control trials have reported with increase in temperature of bupivacaine there was faster onset of sensory blockade. In addition our study demonstrated when 0.5% hyperbaric bupivacaine was administered intrathecally at 24°C (room temperature) had slow onset of sensory blockade. At 37°C and 40°C when 0.5% hyperbaric bupivacaine was administered there was rapid onset of sensory and motor blockade. There was higher level of sensory block achieved. Regression of two segment from highest dermatome achieved also was faster with 37°C and 40°C compared to 24°C.

Miriam E Tucker[12] had failed spinal anesthesia in a group of 14 cases who underwent C-sections which was believed to be the result of exposure of the anaesthetic to lower temperatures. Due to which there will be significant clinical consequences like pain during surgery, repeat subarachanoid block or conversion to general anesthesia. The other contributing factors for failed neuraxial anesthesia like technical failure has to be identified and managed accordingly.

The density of LA is key determinant of LA distribution with in the subarachnoid space[13]. CSF density varies between 1.00028 to 1.00100 g/ml[14]. For every increase in temperature by 1°C between 23°C and 37°C the density of all plain solutions fall by 0.0003 mg/ml. Viscosity and density of the LA reduces with warming[15] and affects the distribution of spinal anesthesia. The time of onset of LA is related to the pka values which is between 7.8 and 9.1 when there will be a higher percentage of non-ionized free base which is close to the physiologic pH[16]. So a more rapid onset and higher level of sensory block is achieved[17,18].

Aria *et al*.[19] Showed increase in the fraction of unionized drug due to decrease in pka of LA solution when the temperature of the LA was increased which was demonstrated by increased uptake of LA by mammalian nerve with increased temperature.

Data from Higuchietal[20] proved strong relationship between CSF density and highest level of sensory block achieved.

Depending on thermodynamics, temperature serves to gauge the intensity of the thermal energy that is an actual energy of motion (kinetic energy) of the individual mobile particle matter. Higher level of sensory block achieved could be due to increased temperature with which molecular kinetic energy is increased and number of individual mobile particles increases.[21]

Limitations

Even though the waterbath was within the operating room the temperature of the ampule will drop once it is retrieved from the waterbath, so it was impossible to administer the drug exactly at 40°C or 37°C. The temperature of the injectate was not directly measured. In our research centre thermostatically controlled waterbath/incubator was not available. So precise temperature was not maintained. Waterbath which was used in our setup was relatively economical which can be used in low setup hospitals but precautions of contamination has to be taken.With precautions, prewarming of LA solutions is inherently safe. Using thermostatically controlled waterbath or intravenous solution warmer LA ampules may be warmed upto 43°C. Ensure that overheating is not allowed to occur[10]. Dry heating may prevent the risk of undetected contamination by water from heating in a water bath.

Conclusions

With increase in temperature of hyperbaric bupivacaine from 24°C to 37°C and 40°C for spinal anesthesia there is higher ascend of sensory block, rapid onset and faster regression of sensory and motor block. Warmed bupivacaine can be preferred in ambulatory surgery and in setups with high turnover rate of surgeries. With smaller dose we can achieve a high level of blockade so can reduce the dosage of the LA without much of change in haemodynamics which must be confirmed by further studies.

Source of support: Nil

Presentation at a meeting: Nil

Conflict of interest: None

Appendix: Bromage scale

Bromage 1- Free movement of legs and feet.

Bromage 2 - Just able to flex knee with free movement of the feet.

Bromage 3 - Unable to flex knees, but with free movement of the feet.

Bromage 4 - Unable to move the legs or feet.

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