IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 01 Ver. IV January. (2018), PP 59-62
www.iosrjournals.org

Laparoscopic Cholecystectomy Under Low Thoracic Combined Spinal Epidural Anaesthesia: A Comparative Study Between Isobaric And Hyperbaric Bupivacaine

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Abstract
Background: *Thoracic spinal anaesthesia has proven its efficacy over general anaesthesia as a routine anaesthetic technique for laparoscopic surgeries. This study aimed to compare the block characteristics of isobaric and hyperbaric bupivacaine in thoracic spinal epidural anaesthesia for laparoscopic cholecystectomies.*
Materials And Methods: *The study included 60 ASA I and II patients undergoing elective laparoscopic cholecystectomy, divided randomly into two equal groups. Both the groups were given thoracic combined spinal epidural anaesthesia (CSE) at the T9-T10 / T10-T11 interspace using 1.5 ml of isobaric bupivacaine 0.5% (5 mg/ml) + 25µg (0.5 ml) of fentanyl in group I and 1.5 ml of hyperbaric bupivacaine 0.5% (5 mg/ml) + 25µg (0.5 ml) of fentanyl in group H.*
Results: *The onset of analgesia was comparable in both the groups. In contrast to the longer time taken to reach T4(7.8 min) by hyperbaric bupivacaine which also showed longer motor(220min) than sensory block(117min); isobaric bupivacaine showed lesser time to reach T4(2min) and a shorter duration of motor block (90 min) than the sensory block(160min).*
Conclusion: *By providing a sensory block of longer duration than the motor block isobaric bupivacaine is reflected in a better indication for upper abdominal laparoscopic surgeries.*
Keywords: *Baricity**,** hyperbaric bupivacaine, isobaric bupivacaine, laparoscopic cholecystectomy**,** thoracic combined spinal epidural anaesthesia*.

Date of Submission: 18-12-2017 Date of acceptance: 06-01-2018

I. Introduction

Thoracic spinal anaesthesia has come a long way since its introduction by Jonnesco in 1909. Initially used in patients with severe lung disease who could not tolerate general anaesthesia [1]. It was eventually demonstrated to be an effective anaesthetic technique in healthy patients for laparoscopic cholecystectomies with significant post operative benefits [2]. Studies have shown thoracic spinal anaesthesia to provide satisfactory operating conditions and shorter latency of the block with excellent haemodynamic stability for laparoscopic cholecystectomies. Many studies in the past have compared solutions of different baricities in lumbar spinal anaesthesia [3,4] but very few such studies are present for thoracic spinal anaesthesia. Also thoracic subarachnoid space is anatomically different from lumbar thecal space as shown by Hogan QH et al [5]. Hence the aim of this study was to compare the quality of anaesthesia as well as the sensory and motor block characteristics during thoracic combined spinal epidural anaesthesia of a patient group undergoing laparoscopic cholecystectomy with isobaric bupivacaine to those of another patient group treated with hyperbaric bupivacaine.

II. Materials and methods

After obtaining approval from the institutional ethics committee written consent was obtained from all 60 patients scheduled for elective laparoscopic cholecystectomy. Inclusion criteria were ASA 1and 2 patients aged between 18-65 years with normal coagulation status. Patients belonging to ASA status 3 and 4, acute cholecystitis, acute pancreatitis, severe cardiovascular/renal disability and BMI >30 kg/m^2 were excluded from the study. They were divided randomly by computer generated numbers into two equal groups. Patients were kept fasting six hours prior to surgery and premedicated with tablet alprax 0.25 mg, pantoprazole 40 mg and domperidone 10 mg on the night prior to surgery. Patients were informed about CSE in detail and assured that

any anxiety, discomfort or pain during surgery would be dealt with by intravenous medication and about the probability of conversion to GA, if needed.

After securing an 18 gauge IV cannula every patient received pre-loading with Ringer lactate 10 ml/kg over 30 minutes and premedication with Ondansetron 0.1 mg/kg and Ranitidine Hydrochloride 50 mg intravenously. All routine monitoring namely, non invasive blood pressure (NIBP), pulse oximetry (SpO2), end tidal Carbon dioxide (ETCO2) and electrocardiogram(ECG) was started. Inj. Midazolam 1mg i.v. was given to the patient just prior to the start of the procedure in order to allay the anxiety and apprehension.

In both the groups: group I and group H, CSE was performed with the patient in the sitting position. Under all aseptic precautions using portex combined spinal/epidural minipack with lock pencil point spinal needle, combined spinal epidural (CSE) block was administered either at the T9-T10/T10-T11 interspace using a 18 gauge Tuohy needle and a mid-line approach. In case of group I, 1.5ml (7.5mg) of isobaric preservative free bupivacaine 0.5% (5 mg/ml) + 0.5 ml (25µg) of Fentanyl was injected into the subarachnoid space using 27 gauge pencilpoint whitacre spinal needle and then the spinal needle was removed. In case of group H, 1.5ml (7.5mg) of 0.5% hyperbaric bupivacaine (5mg/ml) and 0.5ml (25µg) fentanyl was given into the subarachnoid space. The epidural catheter was then threaded into place keeping the hub cephalad and fixed at 4 cm within the epidural space. Immediately, the patient was turned to the supine position with a 10 -20 degrees head down tilt. Oxygen at four to five litres/minute was given to the patient by the face mask. Diverting type EtCO2 monitoring system was used, using nasal prongs applied inside the face mask. Onset of sensory block was assessed every 2 minutes bilaterally (upper and lower levels) in midclavicular line till there was no sensation to pinprick with hypodermic needle. Onset of motor block was assessed every two minutes till complete motor block (grade 3) was achieved and graded according to modified Bromage scale. The time to reach T4 dermatome sensory block, peak sensory block height, the lowest segment blocked and the maximum motor block achieved was recorded before surgery. Once the desired sensory block (minimum block T4-T12 as assessed by pinprick) was achieved, surgery was commenced. In both the groups if the sensory block was found inadequate after 15 minutes an attempt to extend the block with 4-8ml saline epidural topup was made.

After visualization of the abdominal cavity, lidocaine 1% 10 ml was sprayed under the right side of diaphragm. Intraoperative parameters (heart rate, SBP, DBP, MAP, SpO_2, respiratory rate and $ETCO_2$) were recorded in all patients every two minutes for first ten minutes, every five minutes for next fifteen minutes and every ten minutes thereafter till the completion of surgical procedure.

Intraoperative anxiety was treated with Midazolam 1 mg intravenous boluses upto total 5mg , any referred shoulder pain inspite of lidocaine instillation *with* reassurance and Fentanyl 25µg intravenous boluses upto total 100µg , hypotension (decrease in mean arterial pressure more than 20 % from baseline value) with fluid bolus 10 ml/kg ringer lactate or Mephentermine 6 mg boluses upto total 30mg and bradycardia (heart rate below 20% of baseline) with atropine 10 µg /kg intravenously.The surgical technique involved two major modifications-Using lower levels of intra-abdominal pressure upto maximum of 10 mm Hg and providing minimal right up tilt to the table to minimise diaphragmatic irritation. The patients were monitored in PACU till sensory level regressed two dermatomes below the peak block height.

Duration of the sensory block was taken as the time from the onset of sensory block at T4 dermatome to the time when the sensory block regresses to T12 dermatome and duration of motor block as the time from the previous recorded motor block till the patient regained the ability to raise extended legs.

Criteria for conversion to GA were –inadequate sensory level even after 15 minutes of an attempt to extend the block with epidural topup and if patient or the surgeon was uncomfortable with regional anaesthesia at any stage of the procedure.

Post operatively epidural analgesia top-up was given when VRS score > 3 with 0.125 % Bupivacaine 5 ml. Epidural catheter was removed the next morning after surgery. The patients were discharged 24 hours after the procedure after excluding post operative complications and neurological sequelae.

III. Statistical Analysis

The non parametric data was compared using Chi-square test and Mann- whitney U test. Parametric data was analysed using student t test using SPSS 16.0 software.

IV. Results

A total of 60 patients were enrolled in the study and no patient was excluded. No difference was observed between the groups with respect to gender, age, height and weight [TABLE 1].

The onset of analgesia was fast and similar among the two solutions – 2min (TABLE 2). The peak block height achieved was higher (T2 –T3) with isobaric bupivacaine than with hyperbaric solution (T3 –T4) (p value - <0.0001). Epidural top up was required in 2 patients in hyperbaric group for the extension of the level of block. Time to reach peak block height was significantly lesser in isobaric group (4min) than in hyperbaric group (8 min).Similarly time taken to reach T4 was 7.8 min in hyperbaric group which was significantly longer

than in isobaric group (2 min). Lowest segment blocked ranged from L3 –L4 in isobaric group and S1 – S2 in hyperbaric group. Maximum motor block achieved was bromage 1 in 15 patients in isobaric group and bromage 3 in 22 patients in hyperbaric group (p value - <0.0001). Time to reach the maximum motor blockade was significantly longer in isobaric group (6.8 min) than hyperbaric group (2.13 min) [TABLE 2]. The duration of motor block was significantly higher with hyperbaric (220 min) vs 90 min in isobaric whereas the duration of sensory block was significantly higher with the isobaric solution (160 min) vs 117 min for hyperbaric with significant inverse correlation (value - $P < 0.001$) [TABLE 2].

V. Tables

Table 1- Demographics

	Hyperbaric bupivacaine	Isobaric bupivacaine	P value
age	46.33	45.30	0.724
Weight	71.83	69.81	0.457
ASA(1/2)	18/12	17/13	0.634
Sex(F/M)	17/13	15/15	0.342

Table 2- Block characteristics

	Hyperbaric group	Isobaric group	P value
Onset of sensory block(min)	2.07	2.13	0.562
Onset of motor block(min)	2.07	4.00	<0.0001
Time to T4 (min)	7.80	2.00	<0.0001
Peak block height(T2/T3/T4)	2/9/19	15/12/3	<0.0001
Time to peak block height(min)	8.00	4.00	<0.0001
Max motor block (B1 /B2/B3)	0/8/22	15/9/6	<0.0001
Time to max motor block(min)	2.13	6.80	<0.0001
Sensory block duration(min)	117.07	160.10	<0.0001
Motor block duration (min)	220.47	90.33	<0.0001

VI. Discussion

Thoracic spinal anaesthesia has been demonstrated to be safer than the lumbar approach. Imbelloni et al [6] showed that at the thoracic level the distance between the dura and spinal cord is more than that at the lumbar level. Lee et al [7] suggested that this margin of safety is further augumented by the sitting position of the patient which increases the posterior separation of the duramater and spinal cord. Thus in our study thoracic CSE was performed in the sitting position and the tenth interspace was chosen as it lies in the center of the surgical field as shown by Zundert et al [8].

The time period of onset of analgesia with the isobaric solution was the same as with the hyperbaric solution. Our results are similar to a study by Imbelloni et al [10] who evaluated thoracic spinal anaesthesia in patients undergoing different laparoscopic surgeries. This can be explained by the lower amount of CSF in the chest region in relation to the lumbar segment as shown by Hogan et al [5]. They also showed that thoracic roots are thinner compared to segments above and below this level [9]. Thus, there is less anaesthetic dilution per segmental unit of distance from the site of injection, and the roots are easily blocked due to their small size, both factors predicting efficient blockade of these segments.

Hyperbaric bupivacaine achieved lower peak block height than isobaric bupivacaine.This can be explained by the fact that we administered the block in the sitting position after which the patient was laid supine. Hyperbaric drug being heavier than CSF tends to settle down in the spinal column under the influence of gravity till the patient is made supine. After the patient lies down, the curvatures of the spinal column affect the drug distribution before the drug finally becomes fixed. In the supine position, lumbar lordosis produces "splitting" of the local anaesthetic solution with some portion flowing caudad toward the sacrum and the remainder flowing cephalad into the thoracic kyphosis. The cephalad extent of the block then depends on what fraction of the injected drug flows cephalad. This explains our observation where a fraction of the hyperbaric drug had already flown caudad under gravity in the sitting position and the rest produced a block in the mid

thoracic region after patient was made supine. This sitting position of patient at the time of intrathecal procedure helps to limit the cephalad spread of local anaesthetic.The same phenomenon also explains the longer time taken by the hyperbaric drug to reach the desired T4 level.

On the other hand isobaric drug being of approximately the same density as CSF behaves differently. Because of its minimal gravitation to the dependent regions of the spinal cord in the sitting position there is a greater proportion of the drug available to move cephalad when the patient is made supine. Also as suggested by Fettes et al [11], clinically isobaric drug begins to behave slightly hypobaric when it reaches the CSF and its temperature becomes 37C within a short period of time.This explains the higher peak block height achieved and a shorter time to reach T4.

The hyperbaric drug was shown to produce a higher grade of motor block and a more caudad extent of the sensory block than isobaric drug. This can again be explained by difference in baricity.In the sitting position hyperbaric drug being heavier than CSF tends to immediately settle to the lower segments of the spinal cord thus blocking the lumbosacral plexus and producing dense motor and sensory block of the lower extremities.On the other hand isobaric drug distribution is minimally affected by gravity so it shows a segmental nature of the block with lesser grade of motor block in the lower extremities and a sensory block ending in the more cephalad segments than hyperbaric bupivacaine.

In our study isobaric bupivacaine gave a longer duration of sensory than motor block whereas hyperbaric bupivacaine gave a longer motor block than sensory. Our results are in direct contradiction to those of Imbelloni et al [12] who found hyperbaric bupivacaine to produce a longer sensory block in orthopaedic surgeries. This should be viewed in light of the end points chosen to determine the duration of block. Regression upto T12 was chosen as the end point for analgesia in our study as opposed to the complete regression of sensory block chosen by them because in upper abdominal surgery patient complains of pain as soon the level regresses below T12. This means the end of analgesia for the patient even if the segments below T12 may still be anaesthetised. Hyperbaric bupivacaine due to its greater spread to the dependent segments under gravity leaves lesser drug molecules to anaesthetise upper abdominal segments causing them to recover earlier than isobaric bupivacaine. Similarly the motor block ends when the patient gains the ability to ambulate. This is better provided by the segmental block of isobaric drug than the dense lumbosacral block achieved with hyperbaric bupivacaine. Thus isobaric bupivacaine is reflected in a better indication for upper abdominal surgeries.

VII. Conclusion

Isobaric bupivacaine by providing a longer sensory than motor block is better for use in thoracic combined spinal epidural anaesthesia for laparoscopic cholecystectomies.

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*Loveleen Kour. "Laparoscopic Cholecystectomy Under Low Thoracic Combined Spinal Epidural Anaesthesia: A Comparative Study Between Isobaric And Hyperbaric Bupivacaine." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 17, no. 01, 2018, pp. 59–62.