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Research Article

COMPARISON OF TWO DIFFERENT DOSES OF HYPERBARIC BUPIVACAINE IN SEGMENTAL SPINAL ANESTHESIA FOR LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT

Objective: Thoracic segmental anesthesia, as opposed to general anesthesia (GA), is increasingly preferred by anesthesiologists for laparoscopic cholecystectomy in both sick and healthy patients because it provides favorable operating conditions, a faster block time, and better hemodynamic stability. This study compared the efficacy of two different dosages of hyperbaric bupivacaine administered during segmental spinal anesthesia.

Methods: In the current study, 54 American society of anesthesiologists Grade 1 and two patients undergoing elective laparoscopic cholecystectomy were randomly assigned to either Group A, which used 1.5 mL of hyperbaric bupivacaine mixed with 0.5 mL of fentanyl, or Group B, which used 2 mL of hyperbaric bupivacaine mixed with 0.5 mL of fentanyl. Primary objectives were to determine the onset and duration of the sensory and motor block, as well as height of sensory block. Determining the hemodynamic factors and complications were the secondary objectives. The mean, standard deviation, independent t test, Chi-square test, and p-value were used to calculate the data. $p<0.05$ was regarded as significant. Only some drugs were routinely given to the patient to manage their anxiety, discomfort, shoulder tip pain, etc., before, during, or after operation.

Results: Onset of analgesia occurred in 2.5 min for Group A and 2.2 min for Group B. The sensory and motor blocks in Group B lasted longer than in Group A, but the differences were not statistically significant. No patients in either group reported any neurological complications, and there were no discernible differences between the two groups' hemodynamic and respiratory dysfunctions. Despite some patients experiencing minor discomfort that was easily controlled by midazolam and ketamine in small doses, none of them required the conversion to GA. In two instances, Mephentermine was required to treat hypotension. In every patient, recovery went without a side effect.

Conclusion: According to this preliminary study, laparoscopic surgery on healthy people can be performed with segmental spinal anesthesia using low doses of bupivacaine that is just as effective as high doses and present fewer complications.

Keywords: Thoracic spinal anesthesia, Bupivacaine, Cholecystectomy, Hemodynamic parameter.

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INTRODUCTION

The gold standard procedure for cholecystectomy is laparoscopic surgery, which is normally carried out under general anesthesia (GA). GA is considered as safe anesthesia for laparoscopic surgery for most of the cases till now. Many anesthesiologists have experience conducting laparoscopic cholecystectomy and upper abdominal surgery under GA as well as under spinal anesthesia [1]. Single puncture spinal anesthesia can be an easier technique than GA because monitoring of patients under spinal anesthesia is easier than GA, particularly for patients who are thought to be at high risk while receiving GA. Although it is not frequently performed, the procedure has been demonstrated to be helpful in preserving hemodynamic stability and minimizing side effects related to GA [2]. In GA, complication of endotracheal intubations such as damage to teeth, oral cavity, failure of Intubation, sore throat, and aspirations, is absent in spinal anesthesia. Cost of spinal anesthesia is far less than GA. Nausea and vomiting are also less with spinal anesthesia.

Spinal anesthesia, such as thoracic segmental spinal anesthesia, may be more suitable in certain situations like patients with medical problems. Segmental spinal anesthesia of the lower thoracic was used in 1954 [3]. The information that there is substantially more space in the dorsal subarachnoid space at thoracic level, might lead to potential application in regional anesthesia [4]. The thoracic spinal puncture at T10 showed a rapid onset of action, regardless of baricity, decrease in the incidence of hypotension with faster recovery of the blockade, with low incidence of paresthesia and no spinal cord injuries in 636 patients [5]. If it was possible to limit anesthesia to the operative field and to use anesthetic agents in more diluted solutions and in smaller doses, certain undesirable effects of spinal anesthesia could also be avoided. In best of our knowledge not any single study to compared different doses of bupivacaine in laparoscopic cholecystectomy in thoracic segmental spinal anesthesia, so we decided to compare these doses to decrease side effects of higher dose at segmental level.

METHODS

After receiving written informed consent for the procedure and study, this prospective, randomized, double-blind controlled study was carried out on patients scheduled for laparoscopic cholecystectomy in the Department of Anaesthesia at the Chhindwara Institute of Medical Science from February 2022 to January 2023. American society of anesthesiologists physical status classes I or II, ages 20 to 60 of either sex and cholelithiasis were inclusion criteria; exclusion criteria included drug allergies, being pregnant or nursing, severe cardiac, pulmonary, and renal disease, and being unable to give informed consent.

Sample size calculation

According to a related study by Kaur *et al*., an estimated sample size was determined with a 90% confidence interval, 80% power, and a 0.05 alpha level, taking into account the time to onset, length of sensory, and motor blockage. Each group's determined sample size consisted of 25 patients. The patients were divided into two groups, each with 27 patients, using a computer-generated random number table using the sealed envelope procedure.

- Group A - Intrathecal hyperbaric bupivacaine 1.5 mL (7.5 mg) mixed with 0.5 mL (25 µg) of fentanyl.
- Group B - Intrathecal hyperbaric bupivacaine 2 mL (10 mg) mixed with 0.5 mL (25 µg) of fentanyl.

Before administering anesthesia, patients were shifted to the operating room and non-invasive monitors (NIBP, blood pressure, saturation by pulse oximetry, and $Etco_2$) and a peripheral venous cannula were secured. Patients were seated comfortably and under strict aseptic precaution a segmental spinal anesthesia was advocated in the 10th or 11th thoracic interspace using a 25 gauge spinal needle. After flow of clear cerebrospinal fluid (CSF), drugs according to study were injected which was prepared by another anesthesiologist not in the study team, then patient was turned to the supine position. The upper and lower levels of sensory (pinprick) motor (modified Bromage scale: 0 - able to lift extended legs, 1 - Just able to flex knees, full ankle movement, 2 - No knee movement, some ankle movement, and 3 - Complete paralysis) block were evaluated and recorded every minutes prior to surgery. Once the block was determined to be adequate (minimum block T4-T12 as determined by pinprick), the procedure began with intra-abdominal CO_2 pressure being kept between 10 and 12 mmHg.

The sensory block's onset time was the time between the injection and the complete absence of the pinprick reaction in both lower limbs. The duration of the sensory block is the period of time that passes between the onset of the first post-operative pain and the total sensory block (full absence of the pinprick response). Two dermatomes were seen as having regressed when the sensory level dropped from the thoracic dermatome 10 to the dermatome 12. The motor block was defined by Bromage as any type of paralysis, Bromage 3 (unable to move the knees or feet), and complete recovery, Bromage 0. (Full flexion of knee and feet).

As soon as spinal block was confirmed, injections of 0.3–0.5 mg/kg of midazolam and 1–2 mg/kg of ketamine were administered intravenously to relieve anxiety and induce sleep. Nasal oxygen was started at 5 L/minute. During surgery, the heart rate, blood pressure, and oxygen saturation were recorded every minute for the first 15 min and every 5 min thereafter. Patients were informed that if they expressed any dissatisfaction with the anesthetic, it might be changed to GA and offered the option of watching the process on a monitor. Mephentermine 30 mg intravenous boluses were administered if there was hypotension. Both drug intake and fluid balance were noted. The patients were urged to report any discomfort, pain in their shoulders or abdomen, nausea, vomiting, or itching during and after the operation.

Statistical analysis

Data were analyzed using computer software, SPSS version 24. Means, standard deviations, t-values, Chi-square, and p-values were computed; a p-value of 0.05 or less was considered significant at a 90% confidence level. For numerical values such as age, height, weight, onset of sensory and motor block, duration of stable sensory and motor block, and hemodynamic variables, the mean and standard deviation were compared between the two groups using an unpaired t-test. To determine whether there was a difference between the two groups for categorical variables, Pearson's Chi-square test was used.

RESULTS

The mean age, mean height, and mean weight were comparable in both the group, so there was no statistical difference between the groups in contrast to demographic variables (p>0.05). There was total 15 female and 12 male in Group A and 16 female and 11 male in Group B but no statistical significant difference between both the groups (Table 1).

The mean heart rate was similar before, during, and after induction of surgery. The average pulse rate in Group B decreased by more than 10% after 15 min of spinal anesthesia and returned to normal after 45 min. This decrease in pulse rate did not require any medical treatment. There was no discernible statistical difference between the groups (p>0.05) (Table 2).

There was no significant difference in mean arterial blood pressure between the groups. Although mean blood pressure was dropped in Group B patients after 15 min of surgery, this also not required any drug or physical intervention (p>0.05) (Table 3).

The mean time to onset of sensory and motor blocks did not significantly differ when compared between groups, but Group B showed quicker onset time may have been caused by the high medication dosage. Moreover, in Group B prolonged analgesia was statistically different from the other groups in terms of length, as well as two segments of regression in sensory block. However, as the surgery only lasted for roughly an hour, post-operative pain was the only benefit of this prolonged duration analgesia (Table 4).

Table 1: Demographic profile

Parameters	Group A	Group B	p-value
Age in years (Mean±SD)	40.1±12.3	38.53±9.29	0.764#
Height in cm (Mean±SD)	164±7.54	161.6±7.92	0.852#
Weight in kg (Mean±SD)	69.2±9.63	72.3±9.43	0.487#
Sex ratio (F: M)	15:12	16:11	0.563*

#Independent t test,*Chi-square test

Table 2: Mean pulse rate

Pulse rate	Group A (Mean±SD)	Group B (Mean±SD)	p-value Chi-square test
Preoperative	85.53±14.24	84.50±11.02	0.465
After induction	86.73±12.63	82.42±12.94	0.065
Start of surgery	84.18±22.55	78.69±11.70	0.056
15 min	85.13±16.11	74.90±18.5	0.057
30 min	85.10±14.46	82.67±19.62	0.265
45 min	84.11±17.54	79.58±18.69	0.168
60 min	86.10±13.55	84.29±16.23	0.327
75 min	85.18±10.48	80.45±17.43	0.448
90 min	84.16±16.56	82.13±17.45	0.364

Table 3: Mean arterial pressure

Arterial pressure	Group A (Mean±SD)	Group B (Mean±SD)	p-value Chi-square test
Pre-operative	99.43±7.38	98.53±5.60	0.057
After induction	94.50±5.39	96.62±4.64	0.675
Start of surgery	95.47±8.27	92.75±6.29	0.059
15 min	94.52±7.75	90.87±7.62	0.062
30 min	92.84±6.64	90.93±5.87	0.058
45 min	97.38±6.39	92.67±4.93	0.055
60 min	98.29±5.47	93.92±3.59	0.056
75 min	97.47±5.74	94.29±2.99	0.064
90 min	99.56±7.35	92.75±4.85	0.055

Table 4: Anesthetic effects of two doses of bupivacaine

Time (minutes)	Group A Mean±SD	Group B Mean±SD	Significance (p-value)
Onset of sensory block	2.5±1.68	2.21±1.72	0.698
Onset of motor block	6.13±1.86	5.02±1.15	0.903
Two segment regression of sensory block	148.80±9.25	165.06±7.51	0.685
Duration of analgesia	180.76±95.22	250.55±18.53	<0.05
Duration of surgery	60.33±10.96	62.26±09.35	>0.05

Side effects such as bradycardia, hypotension, and nausea were more in Group B than in Group A (p<0.05). In Group B hypotension found in two patient but mean blood pressure not decrease more than 25% compared with baseline than the Group A (p<0.05). Nausea was noted only one patient in Group B not any patient in Group A. shoulder tip pain and abdominal discomfort was occurred more in Group A patients but easily managed by additional sedation and was statistically insignificant. No additional side effects such as vomiting, pruritis, and respiratory depression were reported in these patients (Table 5).

DISCUSSION

For segmental spinal anesthesia to occur, it is necessary to deposit the anesthetic as close as possible to the innervations of the surgical site, but anesthesiologists are hesitant to perform spinal anesthesia above the termination of conus medullaris due to fear of injuring the spinal cord. However, thoracic spinal anesthesia has been demonstrated as a safe and effective method for various surgeries, including abdominal cancer surgeries, laparoscopic cholecystectomy, and breast cancer lumpectomies [6]. While spinal anesthesia is the method of choice for lower extremity operations, it is within the abdominal cavity that it becomes the ideal procedure, because it provides unprecedented relaxation of the abdominal muscles, abdominal silence and an almost complete absence of postoperative complications. The pressure of the pneumoperitoneum also needs to be controlled carefully during surgery to ensure adequate diaphragmatic excursion. Efforts have been made to reduce the dose of bupivacaine, using adjuvant, to achieve good quality sensory and motor block with the least possible dose, to minimize its respiratory and cardiovascular adverse effects.

It was very dreaded that puncturing the dura at the thoracic segment would cause neurological harm when we planned to inject the drug at T10-11 level. Yet, anatomical images created by MRI have demonstrated that in the thoracic region, spinal cord is relatively protected due to larger space at the subarachnoid plane and that space varies between 3 and 8 mm [7,8]. As a result of the absence of any neurological impairment, the findings of the current study also support previous studies in which there was not a single instance of neurological impairment when thoracic spinal puncture was advocated for numerous patients having a variety of surgical procedures [9].

In a study by Kour and Gupta, both groups were immediately placed in the supine position, demonstrating that the duration of the sensory block with hyperbaric bupivacaine was much longer than the motor block in comparison to isobaric bupivacaine. The hyperbaric solution is better because it provides a longer-lasting sensory blockade without the unpleasant motor blockade, even though the same dose of both solution [9]. The onset of sensory and motor block did not differ significantly between the two bupivacaine dosages. With the aid of these researches, we were able to show that, depending on the injection solution and drug baricity, the sensory block may be longer than the motor block. The results of our study also revealed that there was no discernible difference in the timing of the start of sensory and motor block between two different dosages of hyperbaric bupivacaine, even when fentanyl was added to them. As a result, administering a smaller dose is a more sensible option.

Table 5: Incidence of side effects

Side effects	Group A	Group B	p-value
Hypotension	0	2	0.28
Bradycardia	0	1	0.35
Nausea	0	1	0.36
Vomiting	0	0	0
Pruritis	0	0	0
Resp depression	0	0	0
Shoulder tip pain	2	1	0.45
Abdominal discomfort	0	0	0
Total	27	27	

The time of onset of analgesia with both the doses of bupivacaine was the same for both the groups. No group experienced a delay in the commencement of the procedure. In both groups, every patient reached the maximum amount of sensory block up to T4. An adequate and noninvasive assessment of the degree of local anesthetic dispersion in the CSF is provided by measuring the maximum level of sensory block (MLSB) through loss of sensation to pinprick or temperature. Based on the local anesthetics cephalad distribution in the CSF and its absorption by neural tissue, the MLSB is calculated. Less anesthetic dilution occurs per segment from the injection site due to the lower CSF concentration in the chest area compared to the lumbar segment. The concentration and potency of a given pharmacological dose in CSF are increased with lower dilution. Furthermore, it has been demonstrated that thoracic roots are thinner than lumbar and cervical roots. Because of this, they are vulnerable to quick and effective blockades. Managing intrathecal drug spread entails the ability to forecast the MLSB within acceptable limits in the individual patient by employing a specific approach. These outcomes are consistent with research comparing thoracic spinal anesthesia in patients following various procedures [10-12]. This demonstrates the close relationship between local anesthetic dose, volume, and concentration; any change in one causes changes in the other two, making it challenging to attribute one entity to intrathecal drug spread. However, in this study, there was no significant difference on MLSB attainment with either dose due to the small dosage differences, which was consistent with previous studies.

In the present study, the total duration of motor block was prolonged in group B but it was not statistically significant. Similarly in one previous study on comparison of two dosages of hyperbaric bupivacaine in patients with caesarian section found no clinically meaningful motor block but significant Intraoperative hemodynamic abnormalities [13]. In a different research by Mazy *et al*., when they compared the Thoracic Para vertebral block and Segmental thoracic spinal anesthesia (STSA) procedures for mastectomy, they found that the latter provided significant analgesia and a sufficient level of anesthesia with few complications. The STSA group's anesthesia required less fentanyl and was quicker, wider, and longer [14]. Muscle relaxation is therefore equivalent across the low and high dose groups during surgeries lasting roughly 90 min. Within 90 min, the low-dose group recovers from motor block substantially more quickly, enabling early ambulation.

According to a study by Alimian *et al*., there was higher incidence of nausea, hypotension, and a greater requirement for ephedrine when they raise the amount of bupivacaine. The hemodynamic variables (mean heart rate and mean blood pressure) did not significantly differ between the two groups in this investigation. The results of our investigation were comparable to those of a study by Kour and Gupta and Imbelloni *et al*., when they assessed the impact of drugs with different baricity and different dose on hemodynamic variables during thoracic combined spinal epidural anesthesia. In this study with 7.5 mg and 10 mg of hyperbaric bupivacaine, the cephalad spread was controlled by the position and was practically the same (T_{10}), resulting in a low incidence of hypotension and bradycardia. In this study, it is clear that lowering the spinal dose improves hemodynamic stability [9,15].

The time to two-segment regression did not differ significantly between the two groups either. The previous studies by Imbelloni *et al*. have reported a shorter two segment regression time and recovery of sensory blockade and a longer duration of motor blockade with low and conventional dose of bupivacaine. Thus, using a low dose and lower concentration of local anesthetic at each segment (mg/segment), it will be eliminated more quickly, enabling early two-segment regression and a return to early sensory and motor recovery. This will allow early ambulation, readiness for the home, and the avoidance of urinary retention [15].

In the current study, Group B experienced analgesia for longer period than Group A. Despite the fact that fentanyl was administered as an adjuvant in both groups, there was no clinically meaningful difference between them in terms of the length of analgesia because in Group A pain-free period was only 20 min shorter than Group B. The findings of this investigation were consistent with earlier research [5]. When Kalepalli and Metta *et al.* compared levobupivacaine with hyperbaric bupivacaine in various abdominal procedures, they found that the time for initial rescue analgesia and duration of analgesia was longer in the hyperbaric bupivacaine group irrespective of level and dose of drug [16,17].

Shoulder tip pain was a frequent adverse reaction to laparoscopic cholecystectomy both during and after the procedure. Along with Sarli *et al.*, we avoid excessive CO_2 pressure for pneumoperitoneum, as well as pretreatment with ketamine and avoiding excessive head-down tilts to prevent blood and other irritating fluids from dripping into the diaphragm. All of these steps serve to lessen this unpleasant effect in both the groups [18].

In contrast to earlier studies, no patients complained of abdominal discomfort or anxiety in this one. The majority of patients who experienced abdominal discomfort in a prior study after pneumoperitoneum did so while under epidural or combined epidural spinal anesthesia, possibly as a result of an inadequate block that could have resulted in a conversion to GA but due to adequate block no patient need conversion to GA in this study [19].

The result of paralyzing the primary expiratory muscles of the anterior abdominal wall was another potential problem covered in the earlier case report of Imbelloni *et al.* This would be anticipated to have little impact in a group of individuals without respiratory problems, and there were never any respiratory status worries in the group in question. Due to the utilization of the horizontal position and low gas pressure during abdominal insufflations, none of the patients in particular developed dyspnea. The administration of a low dose of bupivacaine may have contributed to a reduction in the severity of thoracic motor block. No patients in this study experienced paresthesia, as was the case in the earlier study [20]. After comprehensive literature research and a review of cervical myelography, those complications were more frequently linked to needle insertion with the neck extended rather than flexed. Hence, we suggested spinal anesthesia using a 25-gauge needle placed in neck flexion and inserted slowly and carefully.

Limitations

A bigger sample size might be more typical of the population overall than the 54 patients included in the current investigation. The sample size was determined to be adequate after the authors completed a power analysis. The effects of the block may differ significantly in other surgical procedures, hence post-operative pain and hemodynamic should be assessed to boost study transparency.

CONCLUSION

The beginning of the block is fast regardless of the solution used. Thoracic segmental spinal anesthesia provides excellent anesthesia for laparoscopic abdominal surgeries. In conclusion, this small study has provided preliminary evidence that segmental spinal anesthesia can be an effective anesthetic technique for routine laparoscopic surgery. No comparison has yet been made with other regional or general anesthetic technique for such surgery, but further careful evaluation of the method is appropriate.

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