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Original Research Article

Comparative study of two thoracic segmental spinal anaesthesia techniques for laparoscopic cholecystectomy: low-dose hypobaric ropivacaine and isobaric ropivacaine at T10-11 intervertebral space vs. standard technique using isobaric levo bupivacaine at T8-T10 intervertebral space

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ABSTRACT

Background: Many prior studies have utilized thoracic or lumbar spinal anesthesia with isobaric/hyperbaric bupivacaine or Ropivacaine and opioids for laparoscopic cholecystectomy and have reported variable results. our study is centered around addressing the occurrence of intraoperative right shoulder pain and its potential impact on the need for conversion to general anesthesia.
Methods: This is a prospective comparative case series study in which 70 patients scheduled for elective laparoscopic cholecystectomy were. Patients in Group R received 1 ml (1 mg) of Hypobaric Ropivacaine 0.1% at T10-11 followed by 25 mcg fentanyl, and 5 mg Isobaric Ropivacaine 0.5% whereas patients in Group B received 1.5 ml (7.5 mg) Isobaric levo Bupivacaine 0.5% and 25 mcg fentanyl at T8-T10. Patients in both the groups were compared for incidence of shoulder tip pain and Hemodynamic stability.
Results: Both techniques achieved satisfactory anaesthesia quality, with similar results in surgical anaesthesia onset. Average surgical duration was 45-75 minutes with average of 60 mins with longer durations in two cases common to both the groups. In group R there was there was no bradycardia or hypotension recorded more than 10% of preinduction vitals. Whereas in group B 2 patients had bradycardia and hypotension more than 10% of preinduction vitals.
Conclusions: The T10-11 technique using low-dose (6 mg) hypobaric ropivacaine and isobaric Ropivacaine appears to be superior in terms of shoulder tip pain, and hemodynamic stability compared to the T8-T10 technique using isobaric levo-Bupivacaine alone in higher dose.

Keywords: Segmental spinal anaesthesia, Levo-Bupivacaine, Ropivacaine, Shoulder Tip Pain, Haemodynamic stability

INTRODUCTION

Unlike traditional spinal anaesthesia thoracic segmental spinal anaesthesia targets the specific thoracic dermatomes relevant to the surgical field, allowing for a more focused and tailored anaesthetic effect.[1] This technique offers several potential benefits, including improved hemodynamic stability, reduced risk of post-dural puncture headache, and minimal interference with respiratory mechanics. Moreover, it has the potential to

be a valuable alternative for patients with contraindications to general anaesthesia or those seeking to avoid its systemic effects.[2] The introduction of neuraxial anaesthesia (NA) in laparoscopic surgeries dates back to 2006 when a patient with severe chronic obstructive pulmonary disease, awaiting lung transplantation, underwent a laparoscopic cholecystectomy (LC) under combined spinal-epidural anaesthesia. Since then, numerous reports have confirmed the safety and feasibility of NA, including spinal, epidural, and combined techniques, in laparoscopic procedures.[3] Prospective randomized studies have directly compared spinal anaesthesia (SA) with general anaesthesia (GA) for LC, revealing compelling advantages. SA has been shown to significantly lower postoperative pain, nausea, and vomiting, making it an attractive option for elective laparoscopic procedures on low-risk patients; American Society of Anaesthesiologists (ASA) score 1 or 2. This approach enables faster patient recovery, early discharge, and consequently, reduced healthcare costs.[4] However, concerns surrounding potential cardiovascular and respiratory complications stemming from increased intra-abdominal pressure during pneumoperitoneum and the sympathetic blockade associated with SA, along with unfounded fears of spinal cord damage and the notable occurrence of intraoperative right shoulder pain, have constrained the routine use of SA in elective LC.[5] Specifically, intraoperative shoulder tip pain, experienced by 10–55% of patients, has been identified as a distressing issue. Although typically alleviated with opioid administration, this pain could lead to conversion to GA in up to 10% of cases across various series. [6]

Furthermore, the majority of literature reports on the application of SA in elective LC have centred around lumbar puncture techniques, with only isolated instances of thoracic puncture methods.[7] Throughout these studies, isobaric and/or hyperbaric bupivacaine have commonly been used as intrathecal local anaesthetics, accompanied by opioids as adjuvants. The former necessitates a Trendelenburg (head-down) position for optimal sensory block, which could further impact the cardiovascular, respiratory, and central nervous systems. The latter category of adjuvants carries the potential for adverse effects such as respiratory depression, nausea, vomiting, and urinary retention.[8] Levobupivacaine and ropivacaine, both long-acting, amide-type local anaesthetics, have been extensively studied for their use in spinal anaesthesia. Their reduced cardiac toxicity, compared to racemic bupivacaine, makes them particularly appealing for outpatient and ambulatory procedures like laparoscopic cholecystectomy. Levobupivacaine and ropivacaine share similar pharmacological characteristics, including a slow onset of action and prolonged duration of sensory and motor block. Their differential block of sodium channels, with ropivacaine having a slightly higher degree of selectivity, contributes to their safety profile by minimizing cardiac toxicity and central nervous system effects. This selectivity can be particularly advantageous in patients with preexisting cardiac conditions or other comorbidities.[9] Both levobupivacaine and ropivacaine have demonstrated a more favourable safety profile compared to bupivacaine, with a wider therapeutic window. Their reduced propensity for causing hemodynamic instability makes them suitable choices for laparoscopic cholecystectomy, where maintaining stable intraoperative hemodynamic is crucial.[10] This study assesses two techniques with varying drug combinations and intervertebral levels to identify potential advantages in anaesthesia quality, block characteristics, postoperative outcomes, and hemodynamic stability.

METHODS

This was a prospective comparative case series study in which 70 patients scheduled for elective laparoscopic cholecystectomy were included in this study on the basis of a predefined inclusion and exclusion criteria. The study was conducted in the department of anaesthesiology of a tertiary care medical institute and institutional ethical committee approved the study. The duration of study was 8 months from January 2023 August 2023. The sample size was calculated on the basis of pilot studies done on the subject of segmental spinal anesthesia assuming 90% power and 95% confidence interval, the sample size required was 31 patients per arm (total 62). Based on central limit theorem, sample size was determined to be enough if it was more than 31 thus, 35 patients were included in each group. Computer based randomization was used for randomization and anesthetists were blind to allocation information.

Group R: Thoracic Segmental Spinal Anaesthesia given at T10-11 intervertebral space using a 26 G Quincke needle and 1 ml (1 mg) of Hypobaric Ropivacaine 0.1% slowly over 30 seconds (prepared by warming Ropivacaine 0.2% to 37 degrees & adding equal volume of distilled water to make it 0.1%), followed by 25 mcg fentanyl, and 5 mg Isobaric Ropivacaine 0.5% injected separately via different syringes. Group B: Thoracic Segmental Spinal Anaesthesia given at T8-T10 intervertebral space using a 26 G Quincke needle and 1.5 ml (7.5 mg) Isobaric levo Bupivacaine 0.5% and 25 mcg fentanyl. In group R Patients were immediately made supine with 15 degrees reverse trendelenberg position after giving spinal Anaesthesia. In group B Patients were immediately made supine after giving spinal Anaesthesia.

Block Characteristics such as Sensory and motor block onset times and levels were recorded. Incidence of shoulder tip pain and its management was noted. Intensity of pain, requirement of analgesia and hemodynamic Stability were compared in both the groups. Instances of tingling sensations, discomfort, or pain due to the procedure, as well as any challenges encountered during the insertion of the needle into the spinal area, were recorded for each individual case. Following the administration of pneumoperitoneum,

patients were positioned supine with a slight upward tilt of approximately 15° (anti-Trendelenburg) and then further inclined to 25-30°, with a gentle rotation towards the patient's left side. This specific posture was maintained throughout the entire surgical procedure until the insufflation of carbon dioxide was halted. The extent of sensory numbness was assessed through pinprick tests. Once an effective sensory numbness was achieved, spanning from the supraclavicular region (C3-C4) to the lower abdomen (T11-T12), the surgery was permitted to commence. Throughout the surgery, all patients received oxygen via Venturi masks, with a FiO2 (fraction of inspired oxygen) ranging from 28% to 40%. An additional 500 mL of colloid solution was administered. Standard monitoring procedures were implemented for both hemodynamic and clinical parameters, including the extent of sensory numbness. In cases where a drop in mean arterial blood pressure of over 20% from the initial pre-anesthetic value was observed (hypotension), ephedrine boluses at a dosage of 6 mg were used for management. The laparoscopic cholecystectomy was executed using the conventional three or four-port method, and pneumoperitoneum was established through the open umbilical access. The intraperitoneal pressure was kept within the range of 8 to 10 mmHg. After the surgical procedure was completed, patients were transferred to the recovery area. They underwent monitoring for a minimum of 30 minutes before being moved to the Surgical Unit.

Incidents arising during surgery, particularly those associated with single-shot thoracic spinal anesthesia (STSA) such as right shoulder or abdominal pain, headaches, discomfort, nausea, anxiety, hypotension, hemodynamic alterations, or the requirement for a nasogastric tube, were meticulously recorded. Daily check-ins were conducted with all patients to assess the presence of nerve root injury (radiculopathy, back pain, cauda equina), complications involving the central nervous system (meningitis, spinal abscess, spinal hematoma), and occurrences of post-dural puncture headache (PDPH). During the outpatient follow-up, a week after the surgery, patients were prompted to rate their satisfaction level (high, moderate, low) with the procedure. The same query was posed to the lead surgeon following each surgical procedure. SPSS 21.0 was used for data analysis. Group comparison was made using independent sample t test for continuously distributed data, and Chi-square test for categorical data. Repeated observations were compared using paired t-test or repeated measures ANOVA as applicable p value less than 0.05 was taken as statistically significant.

Inclusion criteria

Inclusion criteria were; Patients undergoing elective laparoscopic cholecystectomy, ASA status I or II, Patients above 18 years of age and Patient who gave written informed consent to be part of the study.

Exclusion criteria

Exclusion criteria were; Patients who refused consent to be part of study, ASA status III or above, Cases in which spinal anaesthesia Is contraindicated (Bleeding diathesis and Local Infections), Uncontrolled diabetes or hypertension and psychiatric disorders.

RESULTS

There were 13 (37.14%) males and 22 (62.86%) females in group R and 23 (65.17%) females and 12 (34.29%) males in Group B.

Table 1: Gender, Age and ASA grades of cases in both the groups.

Parameters		Group R		Group B		P value
		N	%	N	%	
Gender	Males	13	37.14%	12	34.29%	1.00 Not significant
	Females	22	62.86	23	65.71	
	Total	35	100	35	100	
Age (years)	18-40	6	17.14	6	17.14	0.766 Not significant
	41-60	21	60.00	20	57.14	
	>60	8	22.86	9	25.71	
	Total	35	100.00	35	100.00	
	Mean Age = 45.86±14.12 years.			46.86±13.98		
ASA Grades	I	22	62.86	21	60.00	0.804 Not significant
	II	13	37.14	14	40.00	

There is an overall predominance of females in group R as well as Group B with an overall M:F ratio of being 1:0.55. The mean age of patients in group R was found to be 45.86±14.12 whereas Mean age of patients in Group B was found to be 46.86±13.98. The mean age of patients in both the groups was found to be comparable with no statistically significant difference. Both the groups were also found to be comparable in terms of ASA grades (Table 1).

Table 2: Comparison of sensory block time, post operative analgesia and mean time for rescue analgesia in both the groups.

Parameters	Group R	Group B	Results
Sensory Block at T6 (in minutes) at	3.30±0.46	3.40±0.54	0.4072 (Not Significant)
Sensory Block at T1 (in minutes) at	8.40±2.32	9.10±2.10	0.1901 (Not significant)
Post-operative Analgesia at T6 in minutes	135±18.98	140±20.12	0.2887 (Not significant)
Mean Time for Requirement of rescue analgesia (minutes)	310±34.21	315±38.46	0.5674 (Not significant)

Table 3: Comparison of adverse effects in both the cases.

Parameters	Group R		Group B		P value
	N	%	N	%	
No adverse effects	35	100.00	29	82.86	0.0248 Significant
Post operative nausea vomiting	0	0.00	1	2.86	
Shoulder tip pain	0	0.00	3	8.57	
Haemodynamic instability	0	0.00	2	5.71	
Conversion to general anaesthesia	0	0.00	0	0.00	
Urinary retention	0	0.00	0	0.00	
Total	35	100.00	35	100.00	

The analysis of mean sensory block time in Group R and Group B showed that the mean time for sensory block at T6 and T1 was found to be 3.30±0.46 and 8.40±2.32 in group R whereas it was 3.40±0.54 and 9.10±2.10 minutes in Group B.

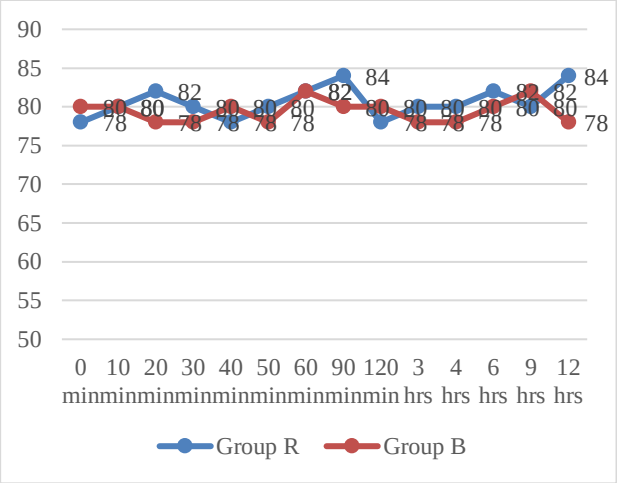

Figure 1: Comparison of mean heart rate in both the groups.

The mean time for sensory block at T6 and T1 were found to be comparable with no statistically significant difference (p>0.05). The mean time for sensory analgesia at C1 level in group R was 12 minutes whereas in group B it was not found. The mean time for sensory block at C3-4 level was 9.20 mins in group R and was 11.30 mins in group B. Similarly mean post operative analgesia at T6 was found to be 135±18.98 minutes in Group R and 140±20.12 in group B. Mean time for requirement of 1st dose of rescue analgesia was found to be 310±34.21 and 315±38.46. Mean time for rescue analgesia was found to be comparable in both the groups with no statistically significant difference (p>0.05) (Table 2). The analysis of the patients on the basis of haemodynamic stability showed that the mean heart rate, respiratory rate, systolic as well as diastolic blood pressures and Mean SPO2 levels were comparable in both the groups without any statistically significant difference (p>0.05) (Figure 1-5).

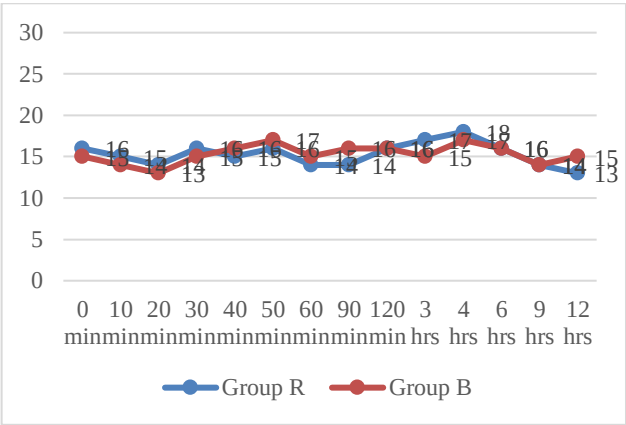

Figure 2: Comparison of mean respiratory rate in both the groups.

The comparison of adverse effects in both the groups showed that patients in Group R there was no patients with shoulder tip pain and vitals were stable in group R in all the patients throughout intraoperative as well as post operative period. In Group B 3 (8.57%) patients reported shoulder tip pain whereas 2 (5.71 %) patients had episode of bradycardia and hypotension and 1 (2.86%) developed post operative nausea and vomiting. No incidence of nausea or vomiting was present in group R. Conversion to general anaesthesia was not required in any of the groups. The adverse effects were more common in group

B as compared to group R and the difference was found to be statistically significant (p=0.0248) (Table 3).

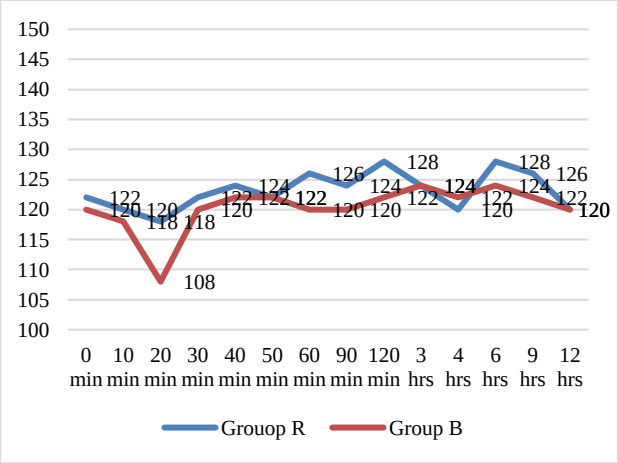

Figure 3: Comparison of mean systolic blood pressure in both the groups.

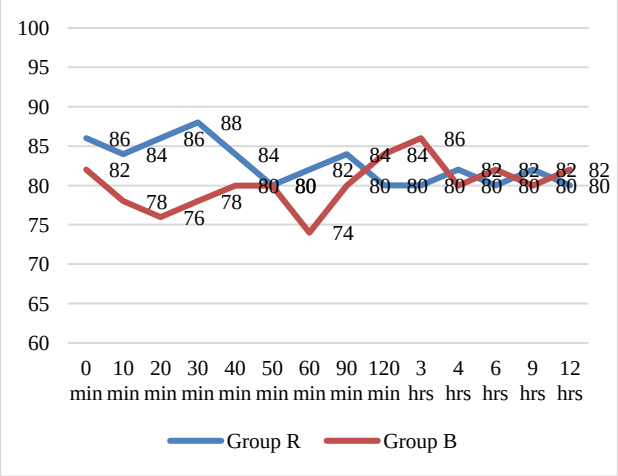

Figure 4: Comparison of mean diastolic blood pressure in both the groups.

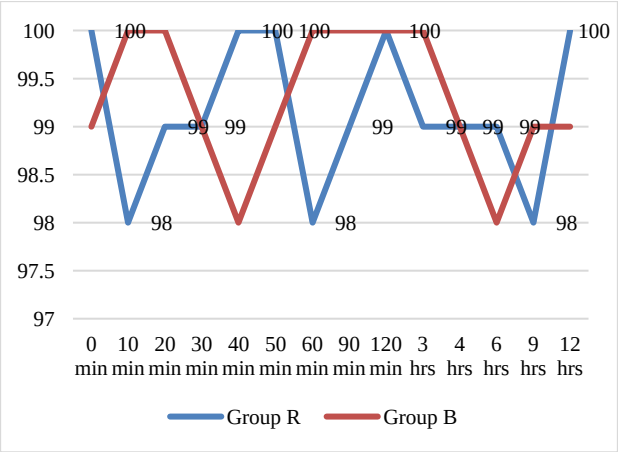

Figure 5: Comparison of mean SPO2 pressure in both the groups.

DISCUSSION

Over the past 15 years, various studies have explored the utilization of spinal anesthesia (SA) in laparoscopic cholecystectomy (LC).[11] Older reports predominantly focused on comorbid patients at high perioperative complication risk with GA. More recent research supports SA for low-risk patients (ASA 1-2) undergoing elective surgeries. Prospective randomized controlled trials involving low-risk patients scheduled for elective LC have highlighted multiple benefits of SA compared to GA.[12] These encompass improved perioperative pain management, decreased postoperative nausea and vomiting (PONV), accelerated patient recovery, smoother postoperative progress, and the potential for same-day discharge. These findings bolster the idea of LC evolving into a routine ambulatory procedure, ultimately reducing healthcare expenses and wait times.[13] The present study aimed to compare two different thoracic segmental spinal anesthsia techniques, namely low-dose hypobaric ropivacaine and isobaric ropivacaine at the T10-11 intervertebral space, with the standard technique using isobaric levobupivacaine at the T8-T10 intervertebral space in patients undergoing laparoscopic cholecystectomy. Specifically, our study focused on evaluating the incidence of shoulder tip pain, hemodynamic stability, sensory block time, postoperative analgesia, and adverse effects associated with these techniques. Our study observed a female predominance in both Group R (low-dose hypobaric ropivacaine and isobaric ropivacaine) and Group B (standard technique using isobaric levobupivacaine), with an overall male-to-female ratio of 1:0.55. The mean age of patients in both groups was comparable, indicating that age-related variations were unlikely to influence our results.

The analysis of sensory block time and postoperative analgesia revealed no statistically significant differences between the two groups. Sensory block initiation and duration at T6 and T1 dermatomes were similar. The mean time for sensory analgesia at C1 level in group R was 12 minutes whereas in group B it was not found. The mean time for sensory block at C3-4 level was 9.20 mins in group R and was 11.30 mins in group B .This suggests that both techniques provide adequate sensory block for laparoscopic cholecystectomy, but as group R achieved faster sensory analgesia at C3-4 level as compared to group B also group R provided sensory analgesia at C1 level which was not found in group B which probably contributed to no shoulder tip pain in group R with no significant variation in the time to first rescue analgesia. Kour et a conducted a study to compare the efficacy of levobupivacaine and bupivacaine in thoracic combined spinal epidural anaesthesia for laparoscopic cholecystectomies.[14] The authors found mean sensory block time to be more in bupivacaine group as compared to Ropivacaine group and the difference was found to be statistically significant ($p<0.05$). Similar longer duration of Bupivacaine group was also reported by the authors such as Kaur et al and Malinovsky et al.[15,16]

Our study found no significant differences in heart rate, respiratory rate, systolic and diastolic blood pressures, and mean SPO2 levels between the two groups. Though 2 patients in Group B had transient bradycardia and hypotension which may be due to slightly higher concentration &dosage used in group B as compared to group R. These findings suggest that both techniques can maintain hemodynamic stability effectively, ensuring the safety of patients undergoing laparoscopic cholecystectomy. Jaafar pour M et al conducted a study to determine the comparative effect of intrathecal hyperbaric bupivacaine vs. hyperbaric ropivacaine.[17] The study found haemodynamic in both the groups to be comparable with no statistically significant difference between the 2 groups with respect to haemodynamic parameters ($p>0.05$). Similar hemodynamic profile of ropivacaine and bupivacaine has also been reported by the authors such as Olapour et al and Bhat et al.[17,18] One of the key findings of our study was the difference in adverse effects between the two groups. Group R, which received low-dose hypobaric ropivacaine and isobaric ropivacaine, had no reported cases of shoulder tip pain, and patients maintained stable vital signs throughout the perioperative period. In contrast, Group B, which received standard isobaric levobupivacaine, experienced adverse effects, including shoulder tip pain (8.57%), bradycardia and hypotension (5.71%), and postoperative nausea and vomiting (2.86%). The statistical analysis showed that these differences were significant, with a p value of 0.0248. Similar adverse effect profile of bupivacaine was also reported by the authors such as Weiniger et al.[20]

CONCLUSION

The T10-11 intervertebral space technique using low-dose (6 mg) hypobaric ropivacaine and isobaric Ropivacaine offers potential advantages in terms of comparable block onset, comparable sensory block duration, reduced shoulder tip pain, and improved hemodynamic stability compared to the T8-T10 intervertebral space technique using isobaric levo Bupivacaine alone in higher dose (7.5 mg).

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Ethical approval: The study was approved by the Institutional Ethics Committee

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