ORIGINAL ARTICLE

Thoracic Segmental Spinal Anaesthesia for Laparoscopic Cholecystectomy: A Quasi-Experimental Study

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Abstract

Background: Laparoscopic surgery is normally performed under general anaesthesia but regional techniques have been emerging and found beneficial. This regional anaesthesia technique could be a potential alternative to GA. This technique also supports green anaesthesia by reducing use of volatile agents. The main objective of this study is to evaluate the effectiveness of thoracic segmental spinal anesthesia in laparoscopic cholecystectomy.

Methods: This is a nonrandomized clinical trial. Patients aging 18-50 years with American Society of Anesthesia (ASA) class I or II undergoing elective laparoscopic cholecystectomy were included. The patients were given thoracic segmental spinal anaesthesia at the level of T9-T10 with 1 mL (5 mg) of 0.5% isobaric bupivacaine and 0.25 mL (25 mcg) fentanyl. Adequacy of block was assessed by clinical examination. Their vital parameters (HR, BP, SpO_2) were recorded at regular interval. The satisfaction of both patients and surgeons were assessed by 5 points Likert scale.

Results: The average patient age was 41.9 ±4.9 years, with females comprising 20 (66.7%) and males 10 (33.3%). Most patients 18 (60%) were classified as ASA Class I, while 12 (40%) were Class II. Height, weight, and BMI showed moderate variability, indicating a relatively uniform group. Sensory blocks typically ranged from T4 to L2. Heart rate, SBP, DBP, and SpO2 were significantly affected during surgery, initially declining and later rising toward completion. The average duration of surgery was 40.2 ±6.4 minutes and duration of pneumoperitoneum was 29.6 ±5.5 minutes. The motor block lasted 67.3 ± 7 minutes, while sensory block was 100.1 ± 4.7 minutes. Postoperative pain was mild at 2 hours but reached its peak at 8 hours. The need for conversion to general anaesthesia was 2 (6.7%). However, perioperative complications such as bradycardia was 9 (30%), analgesic requirement was 6 (20%) and shoulder pain was 5 (16.7%). Both patients and surgeons reported high satisfaction, with a smaller group expressing neutrality or dissatisfaction.

Conclusions: Thoracic segmental spinal anaesthesia provides a reliable sensory and motor blockade and it could be an effective alternative technique for laparoscopic cholecystectomy surgery.

Keywords: Laparoscopy, Cholecystectomy, Spinal anaesthesia, Thoracic, Segmental

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Introduction

Laparoscopic cholecystectomy is usually performed under general anaesthesia but regional techniques have been emerging and found beneficial. General anaesthesia is associated with inadequate pain

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control, negative drug side effects, a higher stress response, a higher incidence of nausea and vomiting and increase length of hospitalization[1]. But the regional anaesthesia technique has several advantages over general anaesthesia. In particular, thoracic segmental spinal anaesthesia (TSSA) provides greater hemodynamic stability, better analgesia, with higher patient satisfaction, lesser incidence of nausea, vomiting, and reduced postanaesthesia care stay[2,3].

Although thoracic epidural anaesthesia, a commonly used regional anaesthesia technique, can be effective but it is also associated with a number of drawbacks, including a patchy sensory block, delayed onset of block, high cost and the possibility of local anaesthetic toxicity due to the large volume of local anaesthetic used[4]. Therefore, thoracic segmental spinal anaesthesia technique could be a potential alternative to general anaesthesia and thoracic epidural anaesthesia.

The term “segmental spinal anaesthesia” is frequently used interchangeably with thoracic spinal anaesthesia. However, in its true sense, thoracic segmental spinal anaesthesia refers to the selective blockade of specific dermatomes required for a particular surgical procedure using a minimal effective dose of local anaesthetic. Achieving this often involves performing a dural puncture at higher lumbar or thoracic levels, rather than the conventional approach below L1. Using lower doses of local anaesthetic increases the likelihood of achieving a precise segmental block[5].

Thoracic segmental spinal anaesthesia, using an extremely low dose of local anaesthetic, can selectively block the dermatomes necessary for the planned surgery. This approach preserves motor function in the legs, reducing patient anxiety and enhancing overall satisfaction[2,4,6].

Most studies in the literature on the use of spinal anaesthesia (SA) for elective laparoscopic cholecystectomy (LC) have focused on lumbar puncture, with only a few reporting on thoracic puncture. These studies commonly used isobaric and/or hyperbaric bupivacaine as the intrathecal local anaesthetic, often combined with opioids as adjuvants. Achieving an optimal sensory block with isobaric and/or hyperbaric bupivacaine typically requires the Trendelenburg (head-down) position, which may have adverse effects on the cardiovascular, respiratory and central nervous systems. Additionally, the use of opioids can lead to side effects such as respiratory depression, nausea, vomiting, and urinary retention[7,8].

Although recent studies have demonstrated the benefits of segmental thoracic spinal anaesthesia (STSA) in abdominal, urological, breast, and axillary surgeries[9], showing a safety profile comparable to that of lumbar anaesthesia (LA), only a few isolated reports in the literature have supported these findings in laparoscopic cholecystectomy (LC)[10]. However, no prior research has specifically explored alternative intrathecal local anaesthetics and adjuvants that could mitigate the limitations of currently used neuraxial anaesthesia (NA) techniques in laparoscopic cholecystectomy.

There are several benefits associated with administering the thoracic segmental spinal anaesthesia in the body. First, there is a limited caudal spread, meaning that no obstruction of the lower extremities. As a result, a greater area of the body does not experience venous dilatation, which may provide a protective buffer against unfavorable changes in blood pressure during surgery. Second, the dosage is extremely low, and the anaesthetic selectively blocks just specific nerve functions along a portion of the cord. Thirdly, the extent to which muscles can relax without depression of the central or peripheral respiratory or circulatory systems. Furthermore, the risk of cardiac arrest is significantly reduced[2,6,10,11].

However, there is significant debate going on regarding this practice around the world. The main concerns are fear of iatrogenic injury to the spinal cord, cephalad spread of local anaesthetic causing a complete spinal block and hemodynamic instability due to the blockade of cardioaccelerator sympathetic fibers[12].

STSA minimizes complications associated with general and epidural anaesthesia, hastens recovery and improves patient satisfaction. Therefore, this study aims to evaluate the efficacy of thoracic segmental spinal anaesthesia for laparoscopic cholecystectomy.

Materials and methods

This quasi-experimental study was conducted in the General Surgery operation theatre under supervision of the Department of Anaesthesia, Analgesia and Intensive Care Medicine, Bangladesh Medical University (BMU), Dhaka, from April 2024 to March 2025. The ethical permission of the study was obtained from the Institutional Review Board (IRB) of Bangladesh Medical University, Dhaka, Bangladesh. An informed written consent form was signed by all the participants before enrollment. The study recruited patients selected for laparoscopic cholecystectomy following the inclusion and exclusion criteria. The estimated sample size was 30 to accommodate potential dropouts and maintain statistical power.

Patients who underwent elective laparoscopic cholecystectomy aged above 18-50 years, irrespective of gender, with ASA class I & II and BMI (Body mass index) under 32 kg/m^2 were included in this study. Patients with a history of hypersensitivity to plain bupivacaine, infection at the site of block, history of coronary artery disease, psychiatric and neurological illness, coagulopathy, gallbladder empyema, spinal deformity, and block failure were excluded from this study.

Study Procedure

During the preoperative visit, patients were thoroughly counseled and explained about the anaesthetic plan, reassured that any pain, discomfort or anxiety would be effectively managed with medication or if necessary, conversion to general anaesthesia (GA). The surgical team was briefed about the planned anaesthesia approach, sensory blockade levels, hemodynamic management, side effects of neuraxial anaesthesia, and the protocol for conversion to GA.

Preoperative evaluations included history taking, physical examination and tests like ECG, chest X-ray etc. Airway, cardiovascular, and respiratory status were assessed. Patients were admitted the day before surgery and given premedications, including tablet Midazolam 5 mg to reduce anxiety and tablet Pantoprazole 40 mg to reduce gastric acidity and prevent aspiration. Patients were also advised to fast for 8 hours before surgery to minimize the risk of aspiration. Upon arrival in the preoperative room, an 18-gauge IV cannula was inserted (preferably in the left dorsal hand) for intravenous access, intravenous fluids were started to maintain hydration, and vital signs were recorded, including heart rate, blood pressure & SpO_2.

Patients were then positioned in a sitting posture with the neck flexed and lower back arched to optimize thoracic intervertebral space access. The T9-T10 insertion level was identified using anatomical landmarks. A line was drawn from the inferior scapular angle, where the T7 spinous process is situated, and counting downward from the T7 spinous process. The procedural site was disinfected with 0.5% chlorhexidine, allowed to dry, and covered with a sterile drape to maintain sterility. The puncture site was infiltrated with 2ml 1% lidocaine at the midline to minimize discomfort. Thoracic segmental spinal anaesthesia was administered at the T9-T10 level using the midline approach. A spinal needle was carefully advanced a few millimetres at a time at 45° through the ligamentum flavum until clear cerebrospinal fluid (CSF) was observed, confirming correct intrathecal placement. The following drug combination was injected intrathecally: 1 mL (5 mg) of 0.5% isoberic bupivacaine and 0.25 mL (25 mcg) fentanyl. Patients were immediately positioned in a supine posture to facilitate uniform spread of anaesthetic agents.

Sensory and motor blockade assessments were systematically performed. Sensory blockade levels were evaluated using cold and touch sensation tests. Motor blockade was assessed via the modified Bromage scale to ensure patient immobility during surgery. For successful spinal anaesthesia (minimum blockade from T4–T12 confirmed by cold and touch sensation), surgery proceeded using carbon dioxide insufflation (maximum pressure: 12 mmHg) for laparoscopic procedures.

Continuous monitoring and assessments were conducted throughout the procedure, including quality and adequacy of anaesthesia, need for supplemental sedation, hemodynamic changes such as tachycardia, bradycardia, hypotension, hypertension and any other complications like nausea, vomiting, or respiratory distress were monitored. The duration of surgery was also recorded.

Patients were given the option to watch the procedure on a monitor and reminded that conversion to GA remained an option if discomfort arose. Management of intraoperative discomfort and hemodynamic changes included treatment of anxiety with intravenous Midazolam 2 mg, pain management with intravenous Fentanyl 50 mcg, correction of hypotension with intravenous Ephedrine 5 mg as needed, with additional boluses administered as per response, treatment of bradycardia (HR < 50 bpm) with intravenous Atropine 0.6 mg, and fluid balance maintenance with judicious use of hartmann's solution to prevent hypovolemia.

Patients were converted to GA if an adequate sensory block was not achieved within 10 minutes after placement of thoracic segmental spinal anaesthesia. Criteria for conversion from TSSA to GA included:

1. Persistent patient anxiety despite sedation
2. Pain unrelieved by intravenous fentanyl 50 mcg/kg
3. Uncontrolled surgical bleeding requiring immediate open conversion.

Post-surgery, patients were monitored in the recovery room, where hemodynamics, Spo2, postoperative side effects nausea, vomiting, shoulder pain, urinary retention, or neurologic complaint and pain were evaluated. Pain was managed according to a stepwise protocol: first-line analgesia with intravenous Acetaminophen 1000 mg every 8 hours, second-line rescue analgesia with intramuscular Pethidine 1.5 mg/kg. Time required for sensory regression to baseline levels was recorded. Patient's and Surgeon's acceptance (using a Likert scale) were also documented. Early mobilization and deep breathing exercises were encouraged to prevent pulmonary complications.

Statistical analysis:

The data from the collection sheets were systematically organized, after which common themes were identified. The data were then analyzed and summarized based on the findings. Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) software, version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Qualitative data were expressed as percentages, while quantitative data were presented as mean ± standard deviation. A "P" value of less than 0.05 was considered statistically significant. The results were displayed using tables and figures.

Results

A total of thirty patients were included, selected based on predefined inclusion and exclusion criteria. The participants were admitted for laparoscopic cholecystectomy. The table I presents the distribution of patients based on various demographic and clinical characteristics. It includes the following parameters: age group, gender, BMI parameters and ASA classification. The overall mean age is 41.9 years, with a standard deviation of 4.9 years. The findings suggest a predominantly middle-aged study population with a fairly uniform age distribution. Out of the 30 patients, females represent the majority, comprising 66% while males account for the remaining 33.3%. The patients have an average weight of 54.3kg with a standard deviation of 10.3kg, indicating some variation. The mean BMI is 28.1kg/m² with a standard deviation of 3.4kg/m², suggesting that many patients are overweight or obese. Most patients 18 individuals (60%) belong to ASA Class I, while the remaining 12 individuals (40%) are classified as ASA Class II. This data highlights that most patients are in good health. The average duration of surgery was 40.2 minutes, with a standard deviation (SD) of 6.4 minutes. This indicates that most procedures were completed within a similar timeframe, though some lasted slightly longer or shorter.

The figure 1 presents Heart rate (HR), Systolic blood pressure (SBP), Mean arterial pressure (MAP), and Diastolic blood pressure (DBP) of patients during different time intervals. The heart rate gradually decreased from baseline at 75.2 bpm to 65.6 bpm at 30 minutes, then slightly raised at 40 and 50 minutes, maintained at 69.9 bpm at the end of surgery. Systolic blood pressure (SBP) decreased from 123.20 mmHg at baseline to a low of 113.2 mmHg at 10 minutes. After this initial decline, SBP maintained around 114–115 mmHg between 15 and 50 minutes. By the end of the surgery, SBP increased slightly to 118.5 mmHg, nearing the baseline value. The baseline mean arterial pressure (MAP) was 96.3 mmHg, representing the

Table I: Patient Demographics and Clinical Characteristics (n=30)

Parameter	Categories	Frequency and percentage (%)	Mean±SD
Age Group (years)	30-35	4 (13.3%)	33.5
	36-40	8 (26.7%)	38.5
	41-45	10 (33.3%)	43.7
	46-50	8 (26.7%)	47
	Total	30 (100%)	41.9 ± 4.9
Gender	Male	10 (33.3%)	
	Female	20 (66.7%)	
	Total	30 (100%)	
BMI	BMI (kg/m²)		28.1 ± 3.4
ASA Classification	Class I	18 (60%)	
	Class II	12 (40%)	
	Total	30 (100%)	
Duration of surgery			40.2 ± 6.4 minutes

Values are expressed as frequency and percentage (%) over column in total. Values are expressed as Mean±SD

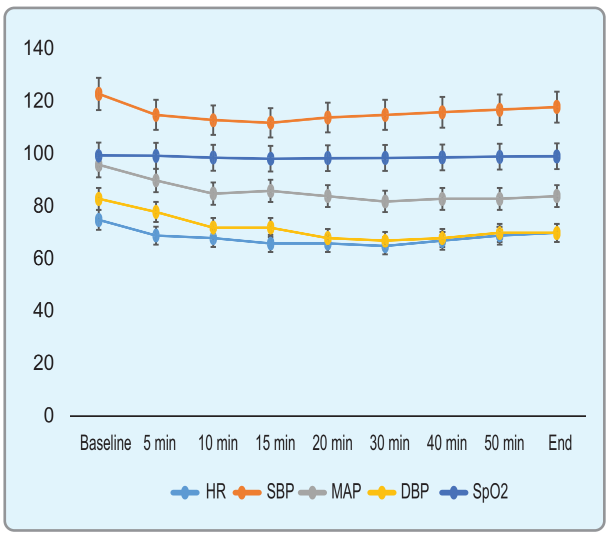

Figure 1: Heart rate (HR), Systolic blood pressure (SBP), Mean arterial pressure (MAP), Diastolic blood pressure (DBP) and Oxygen saturatuin (SpO_2) of patients during different time intervals

patients' hemodynamic status before the procedure. A noticeable and significant decline in MAP occurred during the first 15 minutes, decreasing from 96.3 mmHg at baseline to 82.2 mmHg at 30 minutes. After 20 minutes, MAP remained within the range of 83–85 mmHg throughout the remainder of the procedure. By the end of surgery, MAP slightly increased to 84.6 mmHg.

Oxygen saturation (SpO_2) levels remained consistently normal and stable throughout the surgical procedure, with a slight declined from 99.5% at baseline to a minimum of 98.3% at 15 minutes. SpO2 values were 99.2% by the end of the surgery, which was nearly equivalent to the baseline level.

Table II presents the distribution of sensory block levels among patients. At L1, the upper sensory block reached T3 in 2 patients (6.7%), T4 in 5 patients (16.7%), and T5 in 1 patient (3.3%), total 8 patients (26.7%). For L2, the upper block extended to T3 in 2 patients (6.7%), T4 in 9 patients (30%), and T5 in 6 patients (20%), making up 17 patients (56.7%). At L3, the upper sensory block reached T3 in 3 patients (10%), T4 in 1 patient (3.3%), and T5 in 1 patient (3.3%), summing up to 5 patients (16.7%).

In total, the sensory block extended to T3 in 7 patients (23.3%), T4 in 27 patients (50%), and T5 in 8 patients (26.7%), with an overall patient count of 30 (100%). Most patients achieved a sensory block between T3–T4 (73.3%), with L2 as the most common lower level (56.7%), indicating effective thoracic segmental spinal anaesthesia.

Motor blockade was assessed using the Modified Bromage Scale. Among the patients, 6 (20%) had

Table II: Cross table showing distribution of thoracic and lumbar segmental sensory blockage (n=30)

		Upper level of sensory block			Total
		T3	T4	T5	
Lower level of sensory block	L1	2 (6.7%)	5(16.7%)	1(3.3%)	8(26.7%)
	L2	2 (6.7%)	9 (30%)	6 (20%)	17(56.7%)
	L3	3(10%)	1 (3.3%)	1(3.3%)	5(16.7%)
Total	7 (23.3%)	15(50%)	8(26.7%)	30 (100%)	

Values are expressed as frequency and percentage (%) over the column in total.

Grade 0, indicating they were able to lift extended legs. The majority, 16 patients (53.3%), experienced a Grade 1 block, where they could not raise their extended legs but were able to bend their knees. Meanwhile, 8 patients (26.7%) had Grade 2 block, characterized by the inability to bend the knee while still being able to flex the ankle. (Table III).

Table III: Motor Blockade (Modified Bromage Scale, n=30)

Modified Bromage Scale	Frequency and percentage (%)
Grade 0	6 (20%)
Grade 1	16 (53.3%)
Grade 2	8 (26.7%)
Grade 3	0 (0%)

Values are expressed as frequency and percentage (%) over the column in total.

The mean duration of motor block is 67.3 minutes, with an SD of 7.0 minutes, indicating some variability in duration. The mean duration of sensory block is 100.1 minutes, with an SD of 4.7 minutes, suggesting a relatively consistent duration. Overall, the sensory block lasts longer than the motor block, with moderate variation in both durations.

Figure 2 presents the Visual Analog Scale (VAS) in 30 patients at various intervals. Pain was minimal at 2 hours post-surgery. It then increased, peaking at 8 hours, likely due to the diminishing effects of initial anaesthesia or analgesics. After 8 hours, the pain gradually subsided, possibly because of additional analgesic administration or the natural healing process.

Table IV presents adverse events observed in 30 patients during the intraoperative period. The most

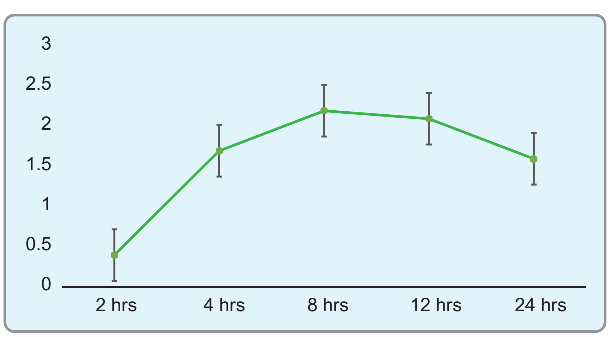

Figure 2: Visual analog scale during the postoperative period at different time intervals

common events were bradycardia (30%) and requirement for analgesia (20%), followed by shoulder pain (16.7%) and hypotension (13.3%). Other events, including respiratory discomfort (10%), abdominal pain (10%), Intraoperative nausea and vomiting (10%), and the requirement for sedation (13.3%), were less frequent. Conversion to general anaesthesia (GA) and hypertension were the least common, each occurring in 6.7% of cases.

Table IV: Adverse events during the perioperative period (n = 30)

Adverse events		Frequency and percentage (%)
Shoulder pain		5 (16.7%)
Abdominal pain		3 (10%5)
Bradycardia		9 (30%)
Hypotension		4 (13.3%)
Hypertension		2 (6.7%)
Respiratory discomfort		3 (10%)
Supplementation	Analgesia	6 (20%)
	Sedation	4 (13.3%)
Nausea and Vomiting		3 (10%)
Converted to general anaesthesia		2 (6.7%)

Values are expressed as frequency and percentage (%) over the column in total.

Table V reflects the surgeon's and patient's acceptance after surgery. Among the surgeons, the majority expressed positive feedback (70%), 60% agreed, and 10% strongly agreed with acceptance. A neutral stance was noted in 23.3%, while only 6.7% disagreed, and no one strongly disagreed. Among the patients, 56.7% (46.7% agree, 10% strongly agree) reported a positive experience. However, 33.3% remained neutral, while 10% (6.7% disagree, 3.3% strongly disagree) disagreed.

Table V: Frequency of acceptance of surgeons and patients

Acceptance level	Surgeon	Patient
Strongly disagree	0 (0%)	1 (3.3%)
Disagree	2 (6.7%)	2 (6.7)
Neutral	7 (23.3%)	10 (33.3%)
Agree	18 (60%)	14 (46.7%)
Strongly agree	3 (10%)	3 (10%)

Values are expressed as frequency and percentage (%) over the column in total.

Discussion

Regional anaesthesia for laparoscopic cholecystectomy has been demonstrated to be safe and effective, particularly in improving postoperative pain management[2-4]. However, it has not yet become the preferred anaesthetic technique for this procedure. Several factors may contribute to this. It is suggested that pneumoperitoneum leads to an increase in intra-abdominal pressure, which could potentially cause gastric content regurgitation. This risk necessitates the use of endotracheal intubation to prevent aspiration in such cases. Furthermore, the increased intra-abdominal pressure from pneumoperitoneum, combined with the head-up tilt commonly employed in upper abdominal laparoscopies, is thought to reduce venous return. Spinal anaesthesia itself induces peripheral vasodilation, raising concerns that performing a laparoscopic procedure under spinal anaesthesia might lead to hypotension. Moreover, the impact of CO pneumoperitoneum on intraoperative haemodynamics under spinal anaesthesia remains an area that is not well-studied[13].

But thoracic segmental spinal anaesthesia offers several benefits including a lower risk of respiratory and cardiac complications, greater suppression of the neuroendocrine stress response to surgery, and improved intraoperative and postoperative pain management. It also facilitates faster recovery of gastrointestinal function, reduces postoperative nausea and vomiting, promotes earlier ambulation and hospital discharge, lowers the incidence of deep vein thrombosis, and decreases overall costs. A major advantage of spinal anaesthesia is that it eliminates the need for airway instrumentation, thereby avoiding its associated complications[12].

In this study, we observed comparable patient demographics that were also consistent with the results of other studies[2,14]. The mean duration of surgery was 40.2 minutes, indicating a relatively short operative time. However, Paliwal et al. (2020)[15] reported a mean surgery duration of 36.12 minutes. This finding showed a slightly longer duration. This variation may be due to differences in surgical techniques, patient characteristics, or institutional practices. Both studies demonstrate comparable operative times, highlighting the efficiency of the procedure.

This study observed a fluctuation in hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), and oxygen saturation (SpO_2). These parameters exhibited a significant decrease during the first 30 minutes of the procedure, likely because of anaesthesia or pneumoperitoneum. Toward the conclusion of the surgery, a slight increase was observed, potentially due to the gradual waning of the sympathetic effect of TSSA and the cessation of pneumoperitoneum. In contrast, Ullah et al. (2022)[6] reported no significant changes in HR, SBP, DBP, MBP, or SpO_2, except at the end of the sixth hour during the postoperative period. El Moutaz et al. (2018)[16] noted significant hemodynamic fluctuations, including changes in HR and mean arterial pressure around the 30 to 35 minute mark, attributed to abdominal insufflation with CO_2, although SpO_2 remained stable in both groups. Van Zundert et al. (2007)[11] observed reductions in mean systolic and diastolic blood pressures as well as HR under segmental thoracic spinal anaesthesia during laparoscopic cholecystectomy, with oxygen saturation consistently maintained at 97%. Conversely, other studies demonstrated no clinically significant hemodynamic changes during the perioperative period[2,5].

Cardiovascular changes were minimal in this study due to the use of a lower dose of local anaesthetic, which required less of the drug to affect the spinal cord segment. Additionally, liberal fluid administration and conscious patients helped prevent central circulatory depression. In contrast, hypotension is a common side effect of conventional spinal anaesthesia, resulting from a decrease in systemic vascular resistance and central venous pressure caused by sympathetic block, vasodilation, and redistribution of blood to the extremities and splanchnic vascular bed. However, in segmental spinal anaesthesia, the sympathetic block is typically incomplete, allowing some preservation of sympathetic reflexes[17]. As a result, blood pressure, heart rate, and oxygen saturation remained within normal ranges throughout the procedure.

In this study, thoracic segmental spinal anaesthesia was administered at the thoracic 10th level. The upper sensory block most reached T4, observed in 50% of patients, followed by T5 in 26.7% and T3 in 23.3%. The most frequent sensory block distribution was T4-L2, observed in 9 patients (30%). Less common distributions included T3-L1 (2 patients, 6.7%) and T5-L3 (1 patient, 3.3%). In this study, Grade 1 motor block was the most common, observed in 16 patients (53.3%).

Mehta et al. (2016)[18] highlighted variability in peak sensory block levels among patients, with one achieving an upper block at T2, seven at T3, and the majority (22 patients) at T4. For lower sensory block levels, the distribution included L3 in 19 patients, L4 in six, L5 in two, and S1 in three. Motor blockade achieved was modified Bromage 1 (inability to raise extended legs can bend knee) in 15 patients, modified Bromage 2 (inability to bend knee/can flex ankle) in nine patients and modified Bromage 3 (complete paralysis/no movement) in six patients. Similarly, van Zundert et al. (2007)[11] demonstrated that effective sensory blocks were established within 15 minutes for all patients, with a median upper level at T3 (range T2–T4) and a median lower level at L3 (range L1–L5). These findings align with the outcomes of the current study. Achieving a sensory block up to T3 is crucial to prevent discomfort from surgical stimulation of the upper gastrointestinal tract. While some authors, such as Sinha et al. (2008)[19], have raised concerns about high spinal blocks reaching T2–T4 potentially causing myocardial depression and reduced venous return—further aggravated by pneumoperitoneum—these assertions lack substantive evidence. Additionally, El Moutaz et al. (2018)[16] reported that adequate sensory levels (T2–T4) were consistently achieved in both groups, with no significant differences between epidural and spinal anaesthesia regarding sensory block levels or Bromage scores.

Bradycardia was the most common adverse event observed in the study, affecting 30% of patients (9 individuals), indicating a significant incidence requiring careful perioperative monitoring. The need for additional analgesia was also a frequent concern, affecting 20% of patients (6 individuals), highlighting that a substantial proportion experienced perioperative discomfort requiring further pain management. The primary concerns centered on pain control, including abdominal and shoulder pain. Intraperative nausea or vomiting (NV) was observed in 10% of patients (3 individuals), emphasizing the need for effective antiemetic strategies in perioperative care. Respiratory discomfort and the need for additional sedation were also noted in 10% of patients (3 individuals). Hypotension affected 13.3% of patients (4 individuals), indicating a moderate incidence of hemodynamic instability. Hypertension and conversion to general anaesthesia (GA) were the least frequent, each affecting 6.7% of patients (2 individuals). Although hypertension and respiratory discomfort were relatively rare, they remain important issues requiring vigilant perioperative monitoring.

Gautam et al. (2024)[5] reported intraoperative hemodynamic changes, noting that hypotension occurred in three patients and was successfully managed with a single bolus of ephedrine. Bradycardia was observed in 3 patients (15%), while no cases of tachycardia were recorded. Chandra et al. (2023)[20] recorded adverse events in a larger cohort, reporting hypotension in 18% and bradycardia in 13% of 378 patients, all of whom responded well to single doses of vasopressors (ephedrine 5 mg) or atropine (0.6 mg). Intraoperative nausea (10%) and vomiting (2.5%) were also noted but were managed successfully with antiemetics. Shoulder pain was reported in 6% of patients, which was addressed with counseling. Kamal et al. (2025)[2] reported that 16% of patients experienced shoulder pain in their study.

Shoulder pain related to laparoscopy, primarily attributed to diaphragmatic irritation caused by CO, pneumoperitoneum, is a well-documented phenomenon[21]. In this study, shoulder pain was mild and manageable, affecting 16.7% of patients (5 individuals), none of whom required a change in anaesthetic technique. This aligns with other findings, such as Tiwari et al. (2013)[22], who reported a 3.6% conversion rate to GA during laparoscopic cholecystectomy (LC) under spinal anaesthesia (SA), which is comparable to rates reported by another study (0–2.8%)[19].

The incidence of intraoperative shoulder pain in this study (16.7%) was like the 25% reported by van Zundert et al. (2007)[11] and the 33% found by Mehta et al. (2016)[18] during LC under TSSA. However, Tzovaras et al. (2006)[23] reported a higher incidence of 43% in patients undergoing LC under lumbar SA. In patients undergoing LC under GA, shoulder pain is reported in 30–50% of cases.

This study found that, on average, the motor block, which leads to a loss of motor function (such as paralysis or weakness), lasts around 67.3 minutes. In comparison, the sensory block, responsible for the loss of sensation (e.g., numbness), lasts about 100.1 minutes on average, than the motor block. Mehta et al. (2016)[18] examined the feasibility of thoracic combined spinal-epidural anaesthesia for laparoscopic cholecystectomy and reported that sensory block regression occurred at an average of 137 minutes (to T12), and motor block regression to a modified Bromage score of 0 occurred at 159 minutes. These results differ from the findings of the current study.

Imbelloni (2014)[17] observed that the mean duration (SD) of motor block was 1 hour and 12 minutes with a 7.5 mg dose, while the sensory block lasted 2 hours and 44 minutes with the same dose. A significant positive correlation was found between the dose and the duration of sensory block (P-value < 0.0001, Rho = 0.6702).van Zundert et al. (2007)[11] reported that the first sign of sensory block regression appeared 75 minutes after injection, with the median upper level decreasing by two segments at 105 minutes, and complete recovery occurring at 176 minutes. These findings align with the current study.

Regarding the progression of postoperative pain, it was minimal 2 hours after surgery, but then increased, peaking at 8 hours, likely due to the diminishing effects of the initial anaesthesia or analgesics. After 8 hours, pain gradually decreased, which could be attributed to additional analgesic administration or the natural healing process. Imbelloni (2014)[17] noted that postoperative pain began 2 hours after the blockade, with pain scores increasing over the postoperative period. Pain scores were minimal and increased gradually but were easily manageable with treatment. Gautam et al. (2024)[5] found that the Visual Analogue Scale (VAS) scores were significantly lower at 2, 4, 8, and 12 hours postoperatively, indicating less pain intensity during recovery.

In our study, 70% of surgeons reported positive outcomes, reflecting overall satisfaction with the surgical results. Neutral responses were noted in 23% of cases, possibly due to varying individual perceptions or expectations, while only 6.7% expressed dissatisfaction, indicating that negative feedback was uncommon. Similarly, 56.7% (46.7% agree, 10% strongly agree) were satisfied with their surgical experience, suggesting a generally positive outcome. Neutral feedback was given by 33.3% of patients, potentially reflecting diverse expectations or perceptions of the results. Only 10% of patients reported dissatisfaction, and none strongly disagreed. In the study by Mehta et al. (2016)[18] on thoracic combined spinal epidural anaesthesia for laparoscopic cholecystectomy: 29 patients rated their satisfaction as excellent, with only one patient rating it as unsatisfactory. Surgeons highlighted excellent operative conditions and muscle relaxation, comparable to those under general anaesthesia, with all 30 surgeons scoring their satisfaction above 8. Similarly, Chandra et al. (2023)[20] found that 94% of patients were highly satisfied with thoracic spinal anaesthesia for laparoscopic cholecystectomy, citing comfort during the procedure and a quick recovery. A smaller number of patients reported average satisfaction, often linked to shoulder tip pain or nausea.

The above discussion suggests that thoracic segmental spinal anaesthesia (TSSA) is a viable and practical alternative to conventional anaesthesia for adult patients undergoing laparoscopic cholecystectomy. TSSA offers the benefits of fewer postoperative complications and higher patient satisfaction. It ensures effective sensory and motor block without any reported postoperative neurological complications. However, careful dose selection, drug administration and vigilant monitoring by the anaesthetist are essential for safe and effective application of TSSA.

Conclusion

It can be concluded that thoracic segmental spinal anaesthesia provides a reliable sensory and motor blockade. It could be an effective alternative technique for laparoscopic cholecystectomy surgery.

Declaration:

Ethics approval: The study was approved by the Institutional Review Board (IRB) of Bangladesh Medical University, Dhaka, Bangladesh (Registration No.BSMMU/2024/4926).

Author contributions

Conception and development of the idea: MNHN, DB, MSI
Writing: MNHN, MMK
Data analysis: MNHN, FK
Data collection: AHK, NM, FK
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