

COMPARISON OF HEMODYNAMIC CHANGES IN THORACIC SEGMENTAL SPINAL ANAESTHESIA AND GENERAL ANAESTHESIA FOR LAPAROSCOPIC CHOLECYSTECTOMY

¹Niraj Kumar, ¹Neeraj*, ²Sudama Prasad, ³Rakesh Kumar

¹Senior Resident, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India

²Professor & HOD, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India

³Assistant Professor, Department of Anesthesia & Critical Care, Patna Medical College & Hospital, Patna, Bihar, India

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ABSTRACT

Background

Laparoscopic cholecystectomy is the standard surgical procedure for symptomatic gallstone disease, typically performed under general anesthesia. Increasing evidence suggests that thoracic segmental spinal anesthesia (TSSA) improves perioperative hemodynamic stability and reduces postoperative complications. Therapeutically, comparing the physiological effects of both methods on intraoperative and postoperative hemodynamic measures is important.

Objective: to compare the hemodynamic effects of thoracic segmental spinal anesthesia to general anesthesia in laparoscopic cholecystectomy patients. Secondary outcomes include analgesic requirements, nausea/vomiting, and recovery profile.

Methods

A 13-month prospective, comparative research study at Patna Medical College & Hospital involved 107 adult patients undergoing elective laparoscopic cholecystectomy. Patients were randomly assigned to two groups: A (n=53) had thoracic segmental spinal anesthesia (TSSA), while B (n=54) received general anesthesia. At regular intervals, hemodynamic parameters like HR, MAP, and SpO₂ were recorded during and after the procedure. Analgesics, recovery time, and side effects like nausea and hypotension were recorded.

Results

Compared to GA, TSSA resulted in more stable hemodynamic parameters, with significantly reduced MAP and HR oscillations ($p < 0.05$). TSSA patients needed fewer intraoperative analgesics, recovered faster, and had less postoperative nausea and vomiting. TSSA had more hypotension early in surgery, but vasopressors controlled it. No high spinal block or neurological sequelae were observed.

Conclusion

Thoracic segmental spinal anesthesia offers a safe and effective alternative to general anesthesia for laparoscopic cholecystectomy, resulting in improved hemodynamic stability, reduced perioperative complications, and faster recovery. TSSA is beneficial for those at risk of general anesthesia.

Keywords: Thoracic spinal anaesthesia, General anaesthesia, Laparoscopic cholecystectomy, Hemodynamic changes, MAP, HR, Segmental block

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Corresponding Author: Neeraj*

Email: neerajgims@gmail.com

Senior Resident, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India

INTRODUCTION

Laparoscopic cholecystectomy has emerged as the benchmark approach for the surgical treatment of cholelithiasis, due to its minimally invasive characteristics, reduced hospital duration, and expedited postoperative recovery (Shroff & Thomas, 2021). This technique has conventionally been conducted under general anaesthesia (GA), which ensures optimal airway control, facilitates profound muscle relaxation, and permits meticulous management of carbon dioxide pneumoperitoneum. Nonetheless, general anaesthesia is linked to cardiac stress reactions, postoperative nausea

and vomiting (PONV), and extended recovery in predisposed individuals (Hamad & Abdelrahman, 2009; Lirk et al., 2015).

In recent years, alternative anesthetic approaches, such as segmental spinal anesthesia, especially at the thoracic level, have garnered interest as feasible possibilities for laparoscopic procedures. Thoracic segmental spinal anesthesia (TSSA) entails the injection of a low-dose local anaesthetic into the thoracic subarachnoid space, facilitating selective blockage of thoracic dermatomes while preserving function in the lower limbs (Karacaer et al., 2019; Mehta & Jain, 2018). It is thought to have numerous benefits, including more stable hemodynamic

profiles, enhanced perioperative analgesia, and reduced systemic adverse effects in comparison to general anaesthesia (Imbelloni et al., 2010).

The primary concern regarding the application of spinal anaesthesia at the thoracic level has traditionally been the potential for spinal cord injury. Numerous investigations have shown that the thoracic spinal cord is physically situated more anteriorly inside the vertebral canal, rendering midline and paramedian thoracic punctures reasonably safe when conducted by proficient anaesthesiologists (van Zundert & Paterson, 2006; Atallah et al., 2006). Consequently, thoracic segmental spinal anaesthesia is being utilized more frequently for urologic, gynecologic, and upper abdominal procedures

An essential element of anaesthetic management in laparoscopic procedures is the regulation of hemodynamic variations induced by pneumoperitoneum, reverse Trendelenburg positioning, and the autonomic reaction to surgical stimuli. These alterations are most evident under general anaesthesia, which inhibits baroreceptor reflexes and may result in significant variations in heart rate (HR) and mean arterial pressure (MAP) (Lirk et al., 2015; Girdhar & Mahajan, 2017). Thoracic segmental spinal anaesthesia, by specifically inhibiting sympathetic output at the surgical site, may yield a better physiologically balanced response.

This study aimed to compare the hemodynamic alterations linked to TSSA and GA in individuals undergoing elective laparoscopic cholecystectomy. The objective also encompassed the assessment of secondary outcomes, such as postoperative analgesic necessity, postoperative nausea and vomiting (PONV), and the overall recovery profile. This research aims to enhance the existing evidence for the broader implementation of spinal anaesthesia protocols in laparoscopic surgery by evaluating both approaches in a controlled clinical environment.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, comparative observational study carried out over 13 months in the Department of Anaesthesiology at Patna Medical College & Hospital. The study sought to assess and contrast the hemodynamic responses and perioperative outcomes of thoracic segmental spinal anaesthesia (TSSA) and general anaesthesia (GA) in patients undergoing elective laparoscopic cholecystectomy.

Sample Size and Group Allocation

The study included 107 adult patients, aged 18 to 60 years, scheduled for laparoscopic cholecystectomy. According to random assignment via a computer-generated table:

- **Group A (n = 53)** received thoracic segmental spinal anaesthesia.

- **Group B (n = 54)** received general anaesthesia.

Inclusion Criteria

- ASA Physical Status I or II
- Age between 18 and 60 years
- BMI <30 kg/m²
- Written informed consent obtained

Exclusion Criteria

- History of spinal deformities, coagulopathies, or neurologic disorders
- Contraindications to neuraxial blockade or general anaesthesia
- Emergency surgeries or conversion to open cholecystectomy
- Severe cardiopulmonary comorbidities (e.g., CHF, COPD)

Anaesthetic Technique

Group A: Thoracic Segmental Spinal Anaesthesia

- TSSA was performed at the T8–T10 interspace in the sitting position using a 26-G Quincke spinal needle under strict aseptic precautions.
- A combination of hyperbaric bupivacaine 0.5% (6–8 mg) and fentanyl (25 mcg) was administered intrathecally.
- Patients were placed in the supine and then reverse Trendelenburg position to achieve cephalad spread targeting T4–T12 dermatomes.
- Oxygen via face mask (4 L/min) was administered throughout the procedure.
- Sensory level was tested using cold and pinprick methods before starting surgery.

Group B: General Anaesthesia

- GA was induced with propofol (2 mg/kg), fentanyl (2 mcg/kg), and succinylcholine (1.5 mg/kg) for endotracheal intubation.
- Anaesthesia was maintained with sevoflurane, nitrous oxide, and atracurium.
- Patients were ventilated to maintain end-tidal CO₂ between 35–40 mmHg.
- Standard intraoperative monitoring was used.

Monitoring and Data Collection

All patients were monitored continuously using:

- ECG, NIBP, pulse oximetry (SpO₂), and capnography (in GA group)

- Hemodynamic parameters (HR, MAP, SpO₂) were recorded:
 - Baseline (pre-anaesthesia)
 - After induction
 - 5, 10, 15, 30, 45, and 60 minutes intraoperatively
 - Immediately postoperatively
 - At 30 minutes and 2 hours postoperatively

Additional parameters:

- Time to recovery (Aldrete score ≥ 9)
- Postoperative nausea and vomiting (PONV) incidence
- Analgesic requirement in the first 6 hours
- Any complications (e.g., hypotension, bradycardia, conversion to GA in TSSA group)

Outcome Measures

Primary Outcome

- Comparison of hemodynamic stability (HR and MAP changes) between groups.

Secondary Outcomes

- Postoperative analgesic consumption
- Incidence of PONV
- Recovery time
- Intraoperative or postoperative complications

Statistical Analysis

Data were input into Microsoft Excel and analyzed utilizing SPSS version 25. Continuous variables were presented as mean \pm standard deviation (SD) and analyzed using the Student's t-test. Categorical data were presented as frequencies and percentages and examined via the Chi-square test. A p-value less than 0.05 was deemed statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Patna Medical College & Hospital. All

participants gave written informed consent before enrolment.

RESULTS

One hundred seven patients scheduled for elective laparoscopic cholecystectomy participated in the trial, with 53 administered thoracic segmental spinal anesthesia (TSSA) and 54 receiving general anaesthesia (GA). The two groups were equivalent regarding age, sex, body mass index (BMI), and ASA physical status, with no statistically significant variations in baseline demographic data ($p > 0.05$).

Hemodynamic Trends

Heart Rate (HR)

The average heart rate exhibited more stability in the TSSA group during the procedure. At baseline, heart rate was comparable across the two groups (TSSA: 78 bpm versus GA: 80 bpm). Post-induction, the GA group exhibited a notable increase in heart rate, peaking at 100 bpm after 5 minutes, whereas the TSSA group experienced a slight decrease, reaching a minimum of 72 bpm at 15 minutes. The GA group exhibited a progressive drop over time while continuously maintaining higher levels compared to the TSSA group. The differences were statistically significant from induction to 30 minutes intraoperatively ($p < 0.01$).

Mean Arterial Pressure (MAP)

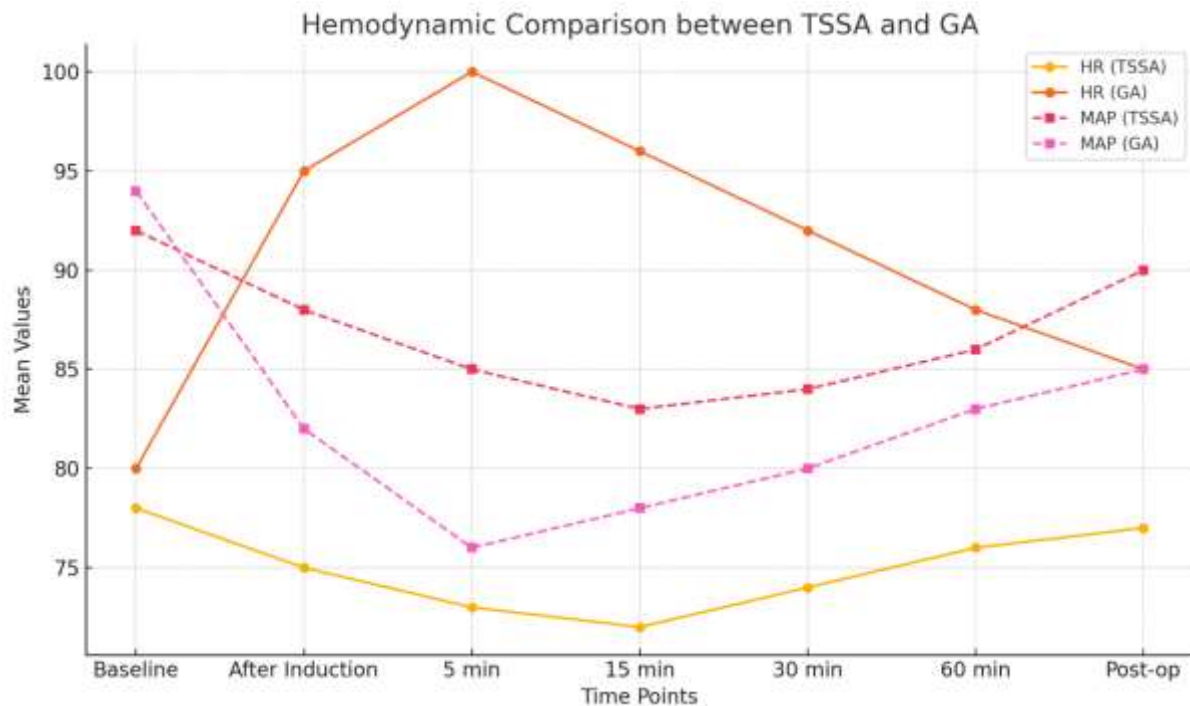
MAP exhibited greater consistency within the TSSA group. The GA group exhibited a more pronounced initial decrease in MAP post-induction (from 94 mmHg to 76 mmHg after 5 minutes), whereas the TSSA group encountered a less severe reduction (from 92 mmHg to 85 mmHg). MAP readings in the TSSA group progressively stabilized, but the GA group exhibited prolonged hypotension. At the 60-minute interval, MAP readings had approximated baseline levels in both cohorts. The disparities in MAP were statistically significant in the initial 30 minutes of operation ($p < 0.05$).

These trends are detailed in **Table 1** and illustrated in **Figure 1**, showing the hemodynamic advantage of TSSA during laparoscopic surgery.

Table 1: Hemodynamic Parameters at Various Time Points

Time Point	HR (TSSA)	HR (GA)	MAP (TSSA)	MAP (GA)
Baseline	78	80	92	94
After Induction	75	95	88	82
5 min	73	100	85	76
15 min	72	96	83	78
30 min	74	92	84	80
60 min	76	88	86	83
Post-op	77	85	90	85

Figure 1 shows the hemodynamic advantage of TSSA during laparoscopic surgery.



Postoperative Outcomes

- **Analgesic Requirement:** Patients in the TSSA group required significantly **less analgesia** during the first 6 hours postoperatively ($p < 0.01$), as the intrathecal fentanyl provided prolonged pain relief.
- **PONV Incidence:** Only 9.4% of patients in the TSSA group experienced postoperative nausea and vomiting, compared to **29.6%** in the GA group ($p < 0.05$).
- **Recovery Time:** Time to achieve an Aldrete score ≥ 9 was faster in the TSSA group (mean 12 ± 3 minutes) compared to the GA group (mean 23 ± 5 minutes), which was statistically significant ($p < 0.001$).
- **Complications:** The TSSA group had a few cases of transient hypotension (managed with ephedrine), but no serious adverse events such as high spinal block, respiratory distress, or neurologic sequelae were reported.

DISCUSSION

This study evaluated the hemodynamic effects and perioperative outcomes of thoracic segmental spinal anesthesia (TSSA) compared to general anesthesia (GA) in patients undergoing laparoscopic cholecystectomy. The results offer compelling evidence supporting TSSA as a safer and more stable alternative to GA, especially in

patients susceptible to heightened hemodynamic reactions or problems associated with general anesthetic drugs (Imbelloni et al., 2010; Girdhar & Mahajan, 2017). Our data revealed that patients undergoing TSSA exhibited markedly reduced variability in heart rate (HR) and mean arterial pressure (MAP) during the intraoperative phase. These findings corroborate earlier research by Imbelloni et al. (2010) and Karacaer et al. (2019), which indicated that segmental thoracic blocks, administered with low doses of local anesthetic, yield selective sympathetic blockade with limited cephalad dissemination and reduced systemic effects. This is particularly advantageous in laparoscopic procedures, where the establishment of pneumoperitoneum frequently triggers sympathetic activation and cardiovascular strain (Lirk et al., 2015).

Conversely, the GA group demonstrated a pronounced elevation in heart rate and a reduction in mean arterial pressure during induction, aligning with the anticipated hemodynamic response to laryngoscopy, intubation, and induction drugs such as propofol and neuromuscular blockers (Hamad & Abdelrahman, 2009). The sustained increase in heart rate during the intraoperative phase, despite analgesic and anesthetic administration, indicates a less advantageous autonomic equilibrium compared to the rather steady and regulated profile noted with TSSA.

The examination of postoperative outcomes revealed a distinct advantage for the TSSA group. Patients in this cohort had markedly decreased analgesic needs due to the

sustained action of intrathecal bupivacaine and fentanyl (Atallah et al., 2006; Mehta & Jain, 2018). The prevalence of postoperative nausea and vomiting (PONV) was reduced in the TSSA group, attributable to the exclusion of volatile agents and opioids commonly employed in general anesthesia (Shroff & Thomas, 2021). Moreover, recovery durations were reduced for TSSA patients, leading to expedited preparedness for PACU release and enhanced patient satisfaction (Karacaer et al., 2019; Hamad & Abdelrahman, 2009).

Although the TSSA approach presents concerns about possible neurological consequences, including high spinal block or spinal cord injury, none were detected in our investigation. Meticulous technique, appropriate patient selection, and the application of low-volume anesthetic solutions likely enhanced this safety profile. The risk remains theoretical when executed properly, and research indicates that the spinal cord is situated anteriorly within the thoracic vertebral canal, thus offering a secure margin for posterior dural puncture (van Zundert & Paterson, 2006; Mehta & Jain, 2018).

However, the limitations of this study encompass its single-center design, a relatively small sample size, and the lack of long-term follow-up to assess late complications or chronic pain outcomes. Furthermore, given that the treatments were elective, the safety of TSSA in emergencies or patients with cardiovascular problems requires further examination (Lirk et al., 2015; Girdhar & Mahajan, 2017).

In conclusion, our results support the expanding literature promoting thoracic spinal anesthesia as a feasible alternative to general anesthesia for specific laparoscopic procedures. It provides greater hemodynamic stability, improved analgesia, fewer adverse effects, and expedited postoperative recovery, rendering it a viable choice in contemporary anesthetic treatment.

CONCLUSION

This comparative study emphasizes the hemodynamic and therapeutic benefits of thoracic segmental spinal anesthesia (TSSA) compared to general anesthesia (GA) in patients having laparoscopic cholecystectomy. Patients in the TSSA group had more stable intraoperative heart rate and mean arterial pressure, diminished requirement for intraoperative and postoperative analgesia, reduced occurrence of postoperative nausea and vomiting, and expedited recovery durations relative to those in the GA group.

Although general anaesthesia remains the standard for numerous laparoscopic procedures, this study contributes to the increasing evidence that TSSA is a safe and effective alternative, especially for patients susceptible to complications from general anaesthetics or those necessitating improved hemodynamic control. The treatment, executed by proficient specialists, is linked to

few complications and ensures a high level of patient comfort and satisfaction.

Due to its simplicity, safety profile, and enhanced physiological advantages, TSSA should be regarded as a potential choice for certain patients undergoing laparoscopic cholecystectomy. Additional multicentric trials with bigger sample sizes and diverse patient groups are advised to corroborate these findings and endorse uniform methods for thoracic segmental spinal anesthesia in laparoscopic procedures.

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