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Thoracic Segmental Spinal Anesthesia Versus General Anesthesia for Laparoscopic Cholecystectomy: A Comparative Study

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Abstract

Background: Laparoscopic cholecystectomy (LC) is traditionally performed under general anesthesia (GA), which ensures airway protection and optimal surgical conditions. However, GA is associated with notable drawbacks including hemodynamic fluctuations, delayed recovery, and increased postoperative discomfort. Thoracic segmental spinal anesthesia (TSSA) has emerged as a potential alternative, offering improved intraoperative stability and postoperative outcomes. ***Objective:*** To compare the intraoperative hemodynamic responses, perioperative complications, postoperative pain, and recovery profile between thoracic segmental spinal anesthesia and general anesthesia in patients undergoing elective laparoscopic cholecystectomy. ***Materials And Methods:*** This prospective, comparative observational study was conducted in the Ad-Din Akij Medical College Hospital, Khulna, during over 18 months from January'2023 to June 2024 and included 90 ASA I–II patients aged 25–55 years undergoing elective LC. Patients were randomized into two equal groups: Group a (TSSA) received 1.75 ml of 0.5% isobaric levobupivacaine with 25 µg fentanyl intrathecally at T9–T10; Group B (GA) received standard general anesthesia. Intraoperative heart rate and mean arterial pressure (MAP) were recorded at regular intervals. Postoperative outcomes included VAS pain scores, time to first analgesic, time to ambulation, and incidence of complications. ***Results:*** Baseline demographics were comparable between groups. Group A demonstrated significantly lower intraoperative heart rates and higher MAP values from 5 minutes after incision to the end of surgery ($p<0.01$). Postoperative VAS scores were significantly lower in Group A at 1, 3, and 6 hours ($p<0.05$). Time to first analgesic was longer (3.4±1.1 vs. 2.2±0.9 hours) and time to ambulation shorter (3.3±1.0 vs. 5.1±1.4 hours) in Group A ($p=0.001$). Perioperative complications were similar and not statistically significant between groups. ***Conclusion:*** TSSA is a safe and effective alternative to GA for laparoscopic cholecystectomy, offering superior intraoperative hemodynamic stability, better early postoperative analgesia, and faster recovery without increasing perioperative complications.

Keywords: Laparoscopic cholecystectomy, Thoracic segmental spinal anaesthesia, General anaesthesia.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the standard surgical procedure for symptomatic gallstone disease, most commonly performed under general anesthesia (GA) [1]. GA provides airway control, muscle relaxation, and optimal surgical conditions, making it the conventional choice for LC [2]. However, GA is associated with drawbacks including greater hemodynamic variations, postoperative nausea and vomiting, respiratory complications, prolonged recovery, and sometimes inadequate postoperative pain control [3, 4].

Thoracic segmental spinal anesthesia (TSSA) is defined as the selective blockade of only the required dermatomes necessary for the surgical procedure using a low dose of local anesthetic [5]. Emerging evidence suggests that TSSA offers improved perioperative hemodynamic stability and reduced postoperative complications compared to GA in LC patients [6]. Studies have demonstrated that TSSA preserves respiratory function, minimizes systemic drug exposure, and may facilitate faster recovery and better analgesic outcomes [7, 8].

Despite these advantages, the adoption of TSSA for LC remains limited due to concerns regarding

potential hemodynamic instability, the technical difficulty of thoracic neuraxial blockade, and limited anesthesiologist experience with this technique [9, 10]. Furthermore, comparative data on the safety, efficacy, and clinical outcomes of TSSA versus GA in laparoscopic cholecystectomy remain scarce.

This study aims to compare thoracic segmental spinal anesthesia and general anesthesia in patients undergoing laparoscopic cholecystectomy, with a focus on intraoperative hemodynamic stability, postoperative pain management, recovery profile, and incidence of complications.

MATERIALS AND METHODS

This prospective, comparative observational study was conducted in the Department of Anesthesiology at Ad-Din Akij Medical College Hospital, Khulna during over 18 months from January'2023 to June 2024. A total of 90 patients aged 25 to 55 years, weighing 50 to 85 kg, and classified as ASA physical status I or II, scheduled for elective laparoscopic cholecystectomy, were enrolled after obtaining informed consent. Patients with contraindications to spinal anesthesia, ASA grade III or IV, or who refused consent were excluded. Patients were divided into two groups of 45 each. Group a received thoracic segmental spinal anesthesia (TSSA) at the T9-T10 interspace with 1.75 ml of 0.5% isobaric levobupivacaine plus 0.25 ml fentanyl (25 µg). Group B underwent general anesthesia (GA) induced with fentanyl, propofol, and vecuronium, maintained with oxygen, nitrous oxide, and sevoflurane. Hemodynamic parameters including heart rate, blood pressure, Spo_2 and ECG were monitored at regular intervals intraoperative. Postoperative assessments included pain scores using the Visual Analogue Scale (VAS), incidence of nausea, vomiting, shivering, time to first analgesic request, need for oxygen supplementation, and time to ambulation. Data were analyzed using unpaired t-tests and Fisher's exact test, with $p<0.05$ considered statistically significant.

RESULTS

Table 1: Demographic characteristics of the study patients (n=90)

Demographic characteristics	Group A (n=45)		Group B (n=45)		*P* value
	Mean	±SD	Mean	±SD	
Age (years)	41.9	±8.3	40.6	±9.1	[a]0.481[ns]
BMI (kg/m^2)	24.1	±1.4	24.3	±1.6	[a]0.530[ns]
Sex					
Male	20	44.4	22	48.9	[b]0.673[ns]
Female	25	55.6	23	51.1	
ASA grade					
I	32	71.1	35	77.8	[b]0.468[ns]
II	13	28.9	10	22.2	

ns= not significant; [a]P value reached from unpaired t-test; [b]P value reached from chi square test
Group A = Thoracic Segmental Spinal Anesthesia
Group B= General Anesthesia

Table 1 presents the baseline demographic characteristics of the study participants (n=90), divided equally into two groups: Group A (Thoracic Segmental Spinal Anesthesia) and Group B (General Anesthesia). The mean age and BMI were comparable between the two groups, with no statistically significant differences (p=0.481 and p=0.530, respectively). The distribution of sex and ASA physical status grades was also similar between the groups, with no significant variation (p>0.05). Overall, both groups were demographically well-matched, indicating comparability in baseline characteristics.

Table 2: Intra-operative hemodynamic parameters in different follow up (n=90)

	Group A (n=45)	Group B (n=45)	*P* value
	Mean±SD	Mean±SD	
Heart rate (beat/min)			
Pre-operative	79.5±5.8	79.3±6.2	0.875[ns]
At 5 min after start surgery	76.1±6.3	82.5±6.6	0.001[s]
At 15 min after start surgery	75.5±5.7	83.0±6.5	0.001[s]
At 30 min after start surgery	76.0±6.1	82.8±6.7	0.001[s]
At 45 min after start surgery	76.1±6.0	81.6±6.5	0.001[s]
End surgery	77.4±6.5	81.5±6.4	0.003[s]
MAP (mmHg)			
Pre-operative	93.7±4.8	92.8±4.8	0.736[ns]
At 5 min after start surgery	89.8±5.3	84.6±5.5	0.001[s]

At 15 min after start surgery	88.4±4.9	82.1±5.6	0.001[s]
At 30 min after start surgery	89.1±5.2	82.4±5.3	0.001[s]
At 45 min after start surgery	90.9±5.8	84.9±5.2	0.001[s]
End surgery	91.4±5.0	87.1±4.9	0.001[s]

s= significant, ns= not significant; [a]P value reached from unpaired t-test

Table 2 compares the intra-operative heart rate and mean arterial pressure (MAP) between patients receiving Thoracic Segmental Spinal Anesthesia (Group A) and those under General Anesthesia (Group B) at multiple time intervals during surgery. The pre-operative heart rate and MAP values were comparable between the two groups, with no statistically significant differences (p>0.05).

Notably, from 5 minutes after the start of surgery through to the end, Group A demonstrated significantly lower heart rates and consistently higher MAP values than Group B, with all p-values <0.01, indicating statistical significance. These results highlight a more stable intra-operative hemodynamic profile in patients managed with thoracic segmental spinal anesthesia, suggesting its potential advantage in maintaining cardiovascular stability during surgery.

Table 3: Per-operative complications of the study patients (n=90)

Per-operative complications	Group A (n=45)		Group B (n=45)		*P* value
	n	%	n	%	
Nausea and vomiting	3	6.7	5	11.1	0.357[ns]
Headache	1	2.2	3	6.7	0.308[ns]
Abdominal pain	0	0.0	1	2.2	0.500[ns]

ns= not significant; P value reached from chi square test

Table 3 summarizes the per-operative complications observed in both groups of the study (Group A: Thoracic Segmental Spinal Anesthesia, Group B: General Anesthesia). The most commonly reported complications were nausea and vomiting, occurring in 6.7% of patients in Group A and 11.1% in Group B, though this difference was not statistically significant (p=0.357). Headache was noted in 2.2% of Group A and 6.7% of Group B patients (p=0.308), while abdominal pain was reported only in one patient (2.2%) from Group B and none from Group A (p=0.500). Overall, there were no statistically significant differences in per-operative complications between the two groups, indicating that both an aesthetic techniques were generally well tolerated.

Table 4: Postoperative visual analogue score of the study patients (n=90)

VAS score	Group A (n=45)		Group B (n=45)		*P* value
	Mean	±SD	Mean	±SD	
1 hour	2.1	±0.9	2.8	±1.1	0.001[s]
3 hours	2.7	±1.1	3.2	±1.0	0.026[s]
6 hours	3.2	±1.0	3.6	±0.9	0.049[s]

s= significant; P value reached from unpaired t-test

Table 4 presents the comparison of postoperative pain scores using the Visual Analogue Scale (VAS) between Group A (Thoracic Segmental Spinal Anesthesia) and Group B (General Anesthesia) at different time intervals. At 1 hour postoperatively, Group A reported a significantly lower mean VAS score (2.1 ± 0.9) compared to Group B (2.8 ± 1.1), with a p-value of 0.001. This trend continued at 3 hours (Group A: 2.7 ± 1.1 vs. Group B: 3.2 ± 1.0; p=0.026) and at 6 hours (Group A: 3.2 ± 1.0 vs. Group B: 3.6 ± 0.9; p=0.049), with all differences being statistically significant.

These findings suggest that patients in the thoracic segmental spinal anesthesia group experienced significantly lower postoperative pain during the early recovery period compared to those who received general anesthesia.

Table 5: Time to first analgesic requirement and ambulation of the study patients (n=90)

	Group A (n=45)		Group B (n=45)		*P* value
	Mean	±SD	Mean	±SD	
Time to first analgesic (hrs)	3.4	±1.1	2.2	±0.9	0.001[s]
Time to ambulation (hrs)	3.3	±1.0	5.1	±1.4	0.001[s]

s= significant; P value reached from unpaired t-test

Table 5 compares the mean time to first analgesic requirement and time to ambulation between Group A (Thoracic Segmental Spinal Anesthesia) and Group B (General Anesthesia).

Patients in Group A required their first dose of analgesia significantly later (mean: 3.4 ± 1.1 hours) compared to those in Group B (mean: 2.2 ± 0.9 hours), with a p-value of 0.001, indicating a statistically significant difference. Similarly, time to ambulation was significantly shorter in Group A (3.3 ± 1.0 hours) than in Group B (5.1 ± 1.4 hours), also with a p-value of 0.001.

These results indicate that thoracic segmental spinal anesthesia is associated with prolonged postoperative analgesia and earlier mobilization compared to general anesthesia, highlighting its advantages in enhancing recovery.

DISCUSSION

In our study, both groups (TSSA and GA) were comparable in terms of age, sex, BMI, and ASA physical status, with no statistically significant differences ($p>0.05$). This indicates appropriate group matching and eliminates demographic bias in interpreting outcomes.

Our findings are consistent with several previous studies. Kar *et al.,* [11] reported similar baseline characteristics between the two anaesthesia groups, confirming group comparability. Likewise, Mahasivabhattu *et al.,* [3] and Kumar *et al.,* [12] also demonstrated no significant differences in age, gender, BMI, or ASA grading among their study populations. This comparability strengthens the validity of further intra- and postoperative outcome comparisons.

Patients under TSSA (Group A) maintained significantly lower heart rates and more stable MAP values throughout the intraoperative period compared to those under GA (Group B), with p-values <0.01 at all-time intervals post-induction. This aligns with Kar *et al.,* [11] who reported significantly more stable intraoperative heart rate and blood pressure in the TSSA group. Gunaydın *et al.,* [13] also found TSSA to be superior in maintaining hemodynamic stability during laparoscopic cholecystectomy. Kumar *et al.,* [12] further confirmed that TSSA leads to fewer MAP and HR fluctuations compared to GA. The stable autonomic response in TSSA likely contributes to reduced surgical stress and may enhance overall safety during surgery.

In our study, per-operative complications such as nausea, vomiting, headache, and abdominal pain were not significantly different between the two groups. Nausea and vomiting were slightly more common in the GA group (11.1%) compared to the TSSA group (6.7%), but the difference was not statistically significant (p=0.357). This observation is in line with Kar *et al.,* [11] who found no significant difference in nausea and vomiting between TSSA and GA groups. However, Mahasivabhattu *et al.,* [3] reported a higher incidence of PONV in the GA group, with no cases observed under TSSA. Similarly, Kumar *et al.,* [12] reported significantly lower rates of nausea and vomiting in the TSSA group (9.4%) versus GA (29.6%). Though not statistically significant in our study, these findings suggest a potential trend toward fewer per-operative complications with TSSA.

The postoperative VAS scores at 1, 3, and 6 hours were significantly lower in the TSSA group than in the GA group ($p<0.05$), indicating better pain control in patients receiving thoracic segmental spinal anaesthesia. Kar *et al.,* [11] also observed significantly reduced pain scores in the TSSA group at early postoperative hours, supporting our findings. Mahasivabhattu *et al.,* [3] noted similar outcomes, with consistently lower VAS scores in the spinal anaesthesia group during the initial 6 hours postoperatively. In addition, Soliman HM found that VAS scores remained lower in TSSA patients even up to 24 hours post-surgery [14]. These results highlight the superior analgesic benefit of TSSA in the immediate postoperative period.

Group A (TSSA) patients required their first dose of analgesia significantly later and ambulated earlier compared to Group B (GA), with both outcomes showing $p<0.001$. These findings reflect the prolonged analgesic effect and enhanced postoperative recovery associated with TSSA.

Kar *et al.,* [11] reported similar findings, with delayed need for analgesia and earlier ambulation in the TSSA group, contributing to faster discharge readiness. Mahasivabhattu *et al.,* [3] also documented longer durations before the first analgesic request and shorter ambulation time in TSSA patients. These advantages are crucial in laparoscopic day-care surgeries, where rapid recovery and minimal postoperative discomfort are priorities.

CONCLUSION

Thoracic segmental spinal anaesthesia provides more stable intra-operative hemodynamics, with lower heart rates and higher mean arterial pressure compared to general anaesthesia. It is equally well tolerated in terms of perioperative complications. Additionally, it offers better postoperative pain control, delayed need for analgesics, and faster ambulation, supporting its benefits in improving surgical recovery and cardiovascular stability.

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