Section: Anaesthesiology

Original Research Article

THORACIC SEGMENTAL SPINAL ANAESTHESIA VERSUS GENERAL ANAESTHESIA IN PATIENTS UNDERGOING LAPAROSCOPIC CHOLECYSTECTOMY: RANDOMIZED CONTROL TRIAL

Faizan Ahmad[1], Bhawna Singh[2], Mohd Khalik[3]

[1]*JR3, Department of Anaesthesiology, Rohilkhand Medical College and Hospital Bareilly, Uttar Pradesh, India*
[2]*Assistant Professor, Department of Anaesthesiology, Rohilkhand Medical College and Hospital Bareilly, Uttar Pradesh, India*
[3]*Professor Department of Anaesthesiology Rohilkhand Medical College and hospital Bareilly, Uttar Pradesh, India*

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Corresponding Author:
Dr. Faizan Ahmad,
JR3, Department of Anaesthesiology, Rohilkhand Medical College and Hospital Bareilly, Uttar Pradesh, India.
Email: faizanahmad00784@gmail.com

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ABSTRACT

Background: Laparoscopic cholecystectomy is the gold standard surgical treatment for symptomatic gallstone disease and other benign gallbladder pathologies. It has significantly reduced morbidity, shortened hospital stays, and improved patient outcomes compared to open cholecystectomy. The objective is to compare (Hemodynamic parameters and adverse effect) Thoracic segmental Spinal anaesthesia vs general anaesthesia in patients undergoing laparoscopic cholecystectomy.
Materials and Methods: The present study was conducted on 116 patients aged between 18 to 60 years group A received General Anaesthesia and Group B received Thoracic Segmental Spinal Anaesthesia.
Results: Hemodynamic stability is superior under TSSA compared to GA. Patients maintained higher systolic, diastolic, and mean arterial pressures throughout the surgery, demonstrating that the limited sympathetic blockade of TSSA prevents major cardiovascular depression. Incidence of adverse effects such as hypotension, bradycardia, and PONV is low and comparable between groups.
Conclusion: Thoracic segmental spinal anaesthesia emerges as a safe, efficient, and patient-friendly alternative to general anaesthesia for laparoscopic cholecystectomy in appropriately selected patients.
Keywords: Hemodynamic Parameters, Adverse Effect, Thoracic Segmental Spinal Anaesthesia, General Anaesthesia, Laparoscopic Cholecystectomy.

INTRODUCTION

Laparoscopic cholecystectomy, although minimally invasive, involves creation of pneumoperitoneum and manipulation of abdominal viscera, both of which can cause significant physiological stress. General anaesthesia, while effective, does not eliminate the risks of airway-related complications such as laryngospasm, aspiration, sore throat, and postoperative respiratory depression.[1] Moreover, volatile anaesthetics and opioid analgesics used in GA are associated with PONV, delayed bowel recovery, and opioid- related adverse effects.[2]
Thoracic segmental spinal anaesthesia, in contrast, provides excellent intraoperative analgesia by selectively blocking the relevant dermatomes without significant motor blockade or respiratory compromise.[3] Since the block is confined to the thoracic region, patients retain lower limb mobility and diaphragmatic function, which promotes spontaneous ventilation and reduces the risk of atelectasis or hypoxia. This makes TSSA particularly advantageous in patients with chronic obstructive pulmonary disease (COPD), asthma, or restrictive lung diseases where GA might exacerbate respiratory morbidity.[4]
Another important consideration is the role of TSSA in attenuating the stress response to surgery. Surgical stress causes a surge in catecholamines, cortisol, and inflammatory mediators, leading to hyperglycemia, immunosuppression, and delayed wound healing.[5] TSSA, by virtue of its pre-emptive

analgesia and sympathetic blockade, significantly blunts this neuroendocrine response, leading to better metabolic control and reduced intraoperative and postoperative complications.[6]

TSSA also facilitates a multimodal analgesic approach. The inclusion of intrathecal opioids such as fentanyl or sufentanil along with local anaesthetics enhances the analgesic effect without compromising hemodynamics. Less reliance on systemic analgesics results in lower risk of opioid side-effect such as constipation, urinary retention, and pruritus.[7] Early studies have shown that patients receiving TSSA mobilize earlier, have higher satisfaction scores, and are discharged sooner than those receiving GA.[8]

In rural or resource-limited healthcare settings, the cost-saving implications of TSSA cannot be overemphasized. Avoiding GA-related consumables (like volatile agents, laryngoscopes, and airway devices) reduces both the economic and logistical burdens on hospitals. Moreover, in situations where postoperative critical care beds are limited, the ability to conduct procedures under TSSA without the need for extensive postoperative monitoring offers significant operational advantages.[9]

Despite these promising benefits, the adoption of TSSA is often limited by concerns related to safety, particularly the perceived risk of spinal cord injury due to the proximity of the needle to the cord in the thoracic region. However, multiple anatomical and radiological studies have confirmed that with proper technique and by using fine- gauge needles, the risk of neurological complications remains exceedingly low.[10] Furthermore, real-time ultrasound guidance or the use of a midline approach with careful tactile feedback significantly enhances the safety of thoracic punctures.[11]

In summary, thoracic segmental spinal anaesthesia is emerging as a versatile, safe, and effective anaesthetic technique for laparoscopic cholecystectomy. It combines the physiological stability of regional anaesthesia with the rapid onset and effectiveness required for minimally invasive surgery. By comparing it directly with general anaesthesia in a randomized controlled setting, this study aims to provide strong evidence to support broader adoption of TSSA and contribute to the advancement of anaesthetic practice.

MATERIALS AND METHODS

This randomized controlled study was conducted in the Department of Anaesthesiology, Rohilkhand Medical College and Hospital, Bareilly. Patients scheduled for laparoscopic cholecystectomy were included in the study. The duration of the study was 1 year.

Inclusion Criteria:

- Age between 18 to 60 years
- ASA Grade I and II
- Provided informed and written consent
- Scheduled for elective laparoscopic cholecystectomy

Exclusion Criteria:

- Deranged coagulation profile
- Local infection at the site of needle insertion
- Known allergy to local anaesthetic
- Suspected difficult intubation
- Neuromuscular disorders
- Significant renal or hepatic dysfunction
- Breastfeeding patients
- Allergy or contraindication to drugs used for GA or neuromuscular block

Sample Size: A total of 116 patients were included which were statistically calculated by using Power and sample size Software12. The sample size calculated in each group was 58 10

- Alpha -5
- Power-70%
- Delta-14
- Sigma-30
- M=1
- Alpha-Type 1 error
- Delta - mean difference
- Sigma - standard deviation

Methodology

Randomization: Patients were randomly allocated into two groups using computer- generated random numbers.

- Group A: General Anaesthesia
- Group B: Thoracic Segmental Spinal Anaesthesia.

Preoperative Preparation: All patients were kept nil by mouth for 8 hours for solids and 2 hours for clear fluids. Pre-medication included oral tablet alprazolam 0.25 mg and ranitidine 150 mg given the night before and again at 6 AM on the day of surgery. Baseline heart rate, systolic and diastolic blood pressure were recorded. Intravenous access was secured with two wide-bore cannulas in the non-dominant hand.

Group A: General Anaesthesia: Monitoring included ECG, non-invasive blood pressure (NIBP), and pulse oximetry. Premedication was given with IV midazolam 0.02 mg/kg and IV butorphanol 0.02 mg/kg. Anaesthesia was induced with IV propofol 2 mg/kg, followed by IV vecuronium 0.1 mg/kg for muscle relaxation. After preoxygenation, tracheal intubation was performed using an appropriate-sized cuffed endotracheal tube.

Anaesthesia was maintained using isoflurane, nitrous oxide and oxygen (nitrous and oxygen in 60:40 ratio). Vecuronium 0.01 mg/kg was administered for continued muscle relaxation. $EtCO_2$ was maintained between 35–40 mm Hg using mechanical ventilation.

Vital parameters (heart rate, systolic and diastolic BP, MAP, SpO_2) were recorded every 3 minutes for the first 30 minutes, then every 5 minutes for the next 30 minutes, and every 15 minutes until the end of surgery.

At the end of the procedure, anaesthetic agents were discontinued, and muscle relaxation was reversed using IV neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. After confirming adequate spontaneous ventilation and airway reflexes, extubation was performed and patients were shifted to the postoperative ward.

In the postoperative period, IV fluids were continued for 6 hours. IV diclofenac 75 mg was administered for pain relief. Pain scores were recorded using the Visual Analogue Scale (VAS) at 6, 12, and 24 hours postoperatively. Adverse effects such as nausea, vomiting, shoulder tip pain, urinary retention, or neurological complications were documented.

Group B: Thoracic Segmental Spinal Anaesthesia

Monitoring was similar to Group A. An 18G IV cannula was inserted and patients were positioned in the sitting posture. Under strict aseptic precautions, thoracic spinal anaesthesia was administered at the T9–T10 interspace using a 25G Quincke needle. Once CSF flow was confirmed, 2 ml of 0.5% isobaric levobupivacaine (2 ml) combined with 0.5 ml of fentanyl (25 mcg) was injected intrathecally.

Patients were then placed in the supine position. The maximum sensory block level and number of segments anesthetized were noted, along with the time for 2-segment regression. Hemodynamic parameters (HR, BP, PR, SpO_2) were recorded every 3 minutes for the first 30 minutes, every 5 minutes for the next 30 minutes, and then every 15 minutes until the end of surgery.

Shoulder pain, shivering, chest discomfort, and nausea/vomiting were also monitored. IV midazolam and IV fentanyl were administered intraoperatively if required. Hypotension was treated with IV fluids and mephentermine (6 mg bolus), and bradycardia with IV atropine if necessary.

Postoperative Assessment: Pain was evaluated using VAS at 6, 12, and 24 hours postoperatively. Patients were assessed for complications including nausea, vomiting, shoulder pain and shivering. The duration of surgery, time to ambulation, and time to oral intake were recorded and compared between groups.

Statistical Analysis

- Data were entered in Microsoft Excel and analyzed using SPSS version 23.0.
- Descriptive statistics included means, standard deviations, and proportions.
- The appropriate statistical tests were applied based on data distribution.
- A p-value of <0.05 was considered statistically significant.

RESULTS

The present study was conducted on 116 patients aged between 18 to 60 years group A received General Anaesthesia and Group B received Thoracic Segmental Spinal Anaesthesia.

Following parameters were assessed: The age distribution between the general anaesthesia (GA) and thoracic segmental spinal anaesthesia (TSSA) groups shows both groups were comparable in terms of age, and any differences in outcomes between them are unlikely to be confounded by age variations.

In the general anaesthesia (GA) group, 16 participants (27.59%) were male and 42 participants (72.41%) were female. In the thoracic segmental spinal anaesthesia (TSSA) group, 19 participants (32.76%) were male and 39 participants (67.24%) were female. The difference in gender distribution between the two groups was not statistically significant ($p = 0.086$), indicating that both groups were comparable in terms of gender composition.

Weight categories show differing patterns: the general anaesthesia (GA) group had higher proportions in the 41–60 kg categories, while the thoracic segmental spinal anaesthesia (TSSA) group had more patients in the 61–70 and 71–80 kg categories. The provided p-value (1.39) seems no significant difference was intended, the distributions may still be unbalanced and weight should be mentioned in limitations or adjusted for if it influenced outcomes such as drug dosing or block spread.

In the general anaesthesia (GA) group, most participants (36.21%) were in the 146–150 cm range, followed by 32.76% in the 151–155 cm range. In contrast, in the thoracic segmental spinal anaesthesia (TSSA) group, the majority of participants (24.14%) had a height between 166–170 cm, followed by 22.41% each in the 151–155 cm and 161–165 cm ranges. A statistically significant difference was observed between the two groups ($p = 2.57$), indicating that the distribution of participants according to height was not comparable between the TSSA and GA groups.

Most patients were overweight or normal weight in both groups, with overweight classification notably higher in the thoracic segmental spinal anaesthesia (TSSA) group (55.17% vs 34.48%). The p-value (0.443) indicates no statistically significant difference in BMI categories between groups, suggesting BMI is reasonably balanced and unlikely to account for major between-group differences in outcomes.

ASA I and II patients were represented in both groups roughly similarly (GA: 53.45% ASA I; TSSA: 58.62% ASA I). The p-value (0.578) shows no significant difference in ASA physical status distribution, indicating comparable baseline operative risk between groups.

Table 1: ASA Grade Distribution among Study Groups

ASA Grade	Group GA (Freq.)	Group GA (%)	Group TSSA (Freq.)	Group TSSA (%)	p-value
I	31	53.45	34	58.62	0.578
II	27	46.55	24	41.38	
Total	58	100.00	58	100.00	

Table 2: Duration of Surgery among Study Groups

Duration of Surgery (min)	Group GA (Freq.)	Group GA (%)	Group TSSA (Freq.)	Group TSSA (%)	p-value
60	57	98.28	38	65.52	0.87
75	1	1.72	15	25.86	
90	0	0.001	2	3.45	
120	0	0.001	3	5.17	
Total	58	100.00	58	100.00	

Most procedures lasted about 60 minutes in both groups, though the thoracic segmental spinal anaesthesia (TSSA) group showed a larger spread with more cases in 75–120 minute than general anaesthesia (GA). The p-values reported suggest differences for longer durations (e.g., 90 and 120 min entries with p=0.001). Overall median/ modal duration appears similar (≈60 min). But the p-value (0.87) shows no statistically significant difference among both groups and hence both group can be comparable and is unlikely to bias group compression.

Table 3: Comparison of NPRS Scores Between TSSA and GA Groups

NPRS	GA Mean	GA SD	TSSA Mean	TSSA SD	p-value
1 hour	0.00	0.00	0.00	0.00	N.A.
2 hours	0.00	0.00	0.00	0.00	N.
3 hours	2.19	0.89	2.09	1.11	0.581
4 hours	4.05	0.74	3.69	0.96	0.024
5 hours	4.91	0.78	4.43	0.50	0.000
6 hours	5.79	0.74	5.59	0.50	0.081
12 hours	2.31	0.92	1.98	1.08	0.082
18 hours	1.64	0.95	1.86	1.05	0.231
24 hours	1.48	0.82	1.40	1.08	0.629

The comparison of NPRS (Numerical Pain Rating Scale) scores between general anaesthesia (GA) and thoracic segmental spinal anaesthesia (TSSA) groups shows that pain scores were comparable at initial timepoints (1 and 2 hours), with no significant difference observed. At 3 hours, mean pain scores were slightly higher in the GA group but statistically non-significant ($p > 0.05$). However, at 4 and 5 hours, pain scores were significantly higher in the GA group compared to the TSSA group ($p < 0.05$), indicating better postoperative analgesia under TSSA at later time intervals.

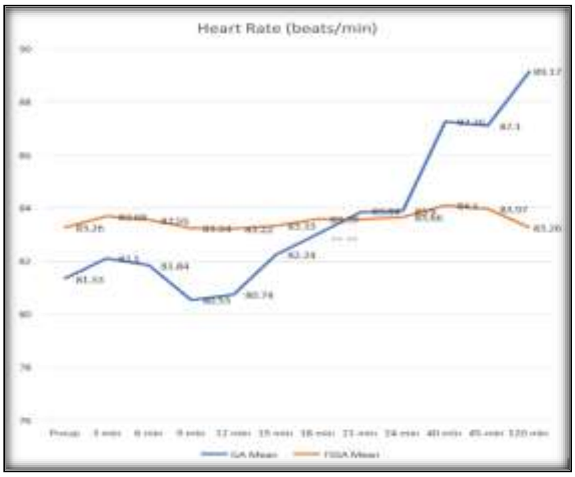

Figure 1: Comparison of Heart Rate (beats/min) between Groups

Initially Heart rate was comparable with p-value (<0.05) in both groups. Mean heart rates at most time points were similar between groups; early intraoperative intervals show small differences that are not statistically significant (p>0.05 for most early points). At later time points (40 and 45 min) the general anaesthesia (GA) group had slightly higher mean HR (87–89 bpm) compared with thoracic segmental spinal anaesthesia (TSSA) (≈84 bpm) and p-values at those times reached ~0.03, indicating a small but statistically significant increase in HR in the GA group during mid–late surgery. Clinically, these modest HR differences likely reflect hemodynamic responses to anesthetic technique and may be of limited physiological consequence.

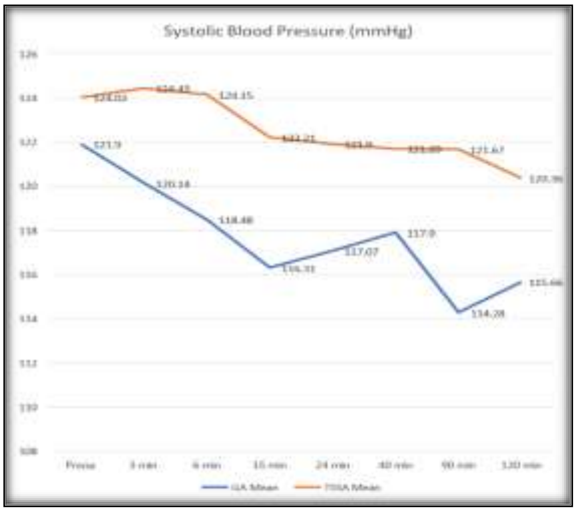

Figure 2: Comparison of Systolic Blood Pressure (mmHg) between Groups

Pre-operative difference in systolic blood pressure were statistically insignificant in both the group initially but then after induction fall in systolic blood pressure was noticed in general anaesthesia (GA) group at 3 minutes which was statistically significant (p-value 0.001). The GA group consistently showed lower mean SBP values (for example GA~114–120 mmHg vs TSSA ~120–124 mmHg), indicating that GA produced greater reductions in systolic pressure than TSSA in this cohort. This suggests that TSSA preserves systolic blood pressure better during laparoscopy.

Similarly pre-operative diastolic blood pressure data was comparable initially with p- value >0.05 i.e. 0.07 in both the groups but statistically significant difference noticed 15 mins onward when diastolic blood pressure started decreasing in both group but the fall in diastolic blood pressure was more in general anaesthesia (GA) group. These findings mirror the SBP results and support the interpretation that thoracic segmental spinal anaesthesia (TSSA) maintains higher diastolic pressures and overall less hypotensive effect than GA.

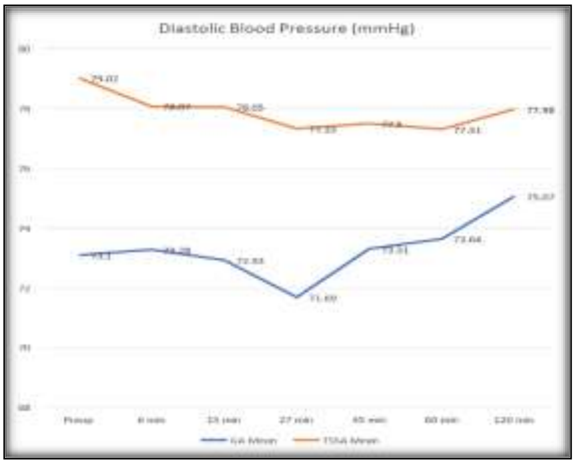

Figure 3: Comparison of Diastolic Blood Pressure (mmHg) between Groups

Mean arterial pressure (MAP) values were comparable initially in pre-operative period with p-value 0.2 which is >0.05. But significant differences were noticed intraoperatively on comparing both the group. (p = 0.001 at 15 mins and across measured intervals). The sustained difference in MAP indicates that thoracic segmental spinal anaesthesia (TSSA) provides more stable and higher perfusion pressures compared with general anaesthesia (GA) in this study, a finding that may be favourable in patients at risk of reduced organ perfusion.

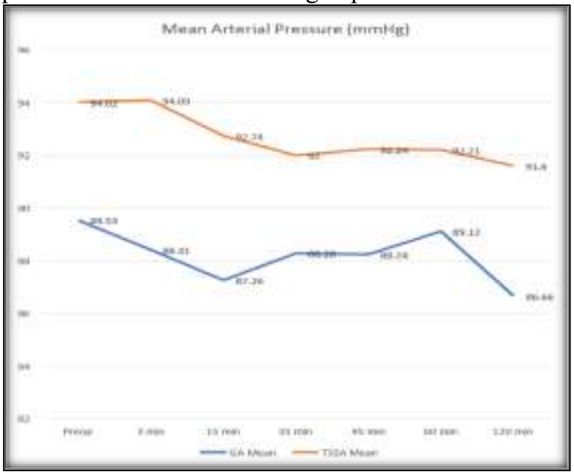

Figure 4: Comparison of Mean Arterial Pressure (mmHg) between Groups

SpO_2 remained well-maintained in both groups with means around 98–99% at all time points. Slightly higher mean SpO_2 was recorded in the thoracic segmental spinal anaesthesia (TSSA) group at several intraoperative points (p values approaching 0.07– 0.22), but absolute differences are clinically negligible; both groups maintained adequate oxygenation.

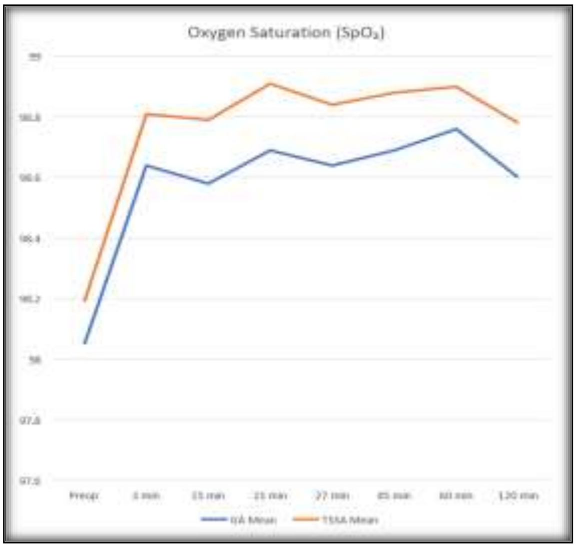

Figure 5: Comparison of Oxygen Saturation (SpO_2) between Groups

Table 4: Comparison Adverse Effects

Complications	GA (Freq.)	GA (%)	TSSA (Freq.)	TSSA (%)	p-value
Shivering	0	0.00	3	5.17	0.68
PONV	4	6.90	2	3.45	0.33
Shoulder Tip Pain	0	0	0	0	0
Chest Discomfort	0	0	0	0	0

The incidence of shivering was observed exclusively in the TSSA group (5.17%), whereas no cases were noted in the GA group; however, this difference was not statistically significant (p = 0.68). Postoperative nausea and vomiting (PONV) occurred slightly more often in the GA group (6.90%) compared to the TSSA group (3.45%), though this difference also failed to reach statistical significance (p = 0.33). Importantly, shoulder tip pain and chest discomfort were completely absent in both groups. Overall, none of the observed complications demonstrated statistically significant differences between GA and TSSA.

DISCUSSION

In our comparative study of thoracic segmental spinal anaesthesia v/s general anaesthesia in patients undergoing laparoscopic cholecystectomy conducted over 116 patients in two groups A:GA (58) and group B:TSSA (58). In terms of Hemodynamic parameters (Heart Rate, Systolic Blood Pressure, Diastolic Blood Pressure, Mean arterial Pressure), Mean duration of surgery, Post operative pain / VAS score, to compare an adverse effect (shoulder tip pain, nausea, vomiting, shivering, chest discomfort), Conversion into general anaesthesia.

Hemodynamic parameters: One of the consistent findings across the literature is that TSSA tends to preserve blood pressure and MAP better than GA in laparoscopic procedures, likely because TSSA produces a segmental sympathetic block (targeted dermatomes) rather than a widespread sympathetic depression or the systemic vasodilatory effects sometimes produced by GA agents and volatile anesthetics. Multiple studies and narrative reviews report smaller intraoperative blood pressure reductions, less vasopressor requirement, and more stable MAP in TSSA cohorts.[13]

In our study, intraoperative systolic, diastolic, and mean arterial pressures were better preserved in the thoracic segmental spinal anaesthesia group relative to the general anaesthesia group (multiple time points with $p \leq 0.001$) - a finding that matches the pattern seen in other comparative trials (e.g., Paliwal et al., Goel et al.). Clinically, maintaining MAP may be advantageous in patients; however, it is important to interpret the absolute differences (typically modest) in the context of overall clinical stability and the small rates of clinically significant hypotension observed in both arms.[14]

Respiratory function and oxygenation: A major theoretical advantage of TSSA is preservation of spontaneous ventilation and diaphragmatic function, thereby avoiding airway instrumentation and its sequelae (sore throat, aspiration risk, ventilator-associated atelectasis). In our study both groups maintained oxygenation in the normal range throughout; marginally better oxygenation values in the TSSA group reached statistical significance at some time points. These data are consistent with existing trials that show preserved oxygenation under TSSA in healthy patients and particularly favourable profiles in those with compromised respiratory function (e.g., COPD)—case reports and small series have documented successful emergency/urgent procedures under segmental thoracic neuraxial blocks in high-risk respiratory patients.[15]

In our study it was noted that careful monitoring is essential: pneumoperitoneum and shoulder up-tilt can impede ventilation even when diaphragmatic function is preserved, and intraoperative sedation/analgesic supplementation should be titrated to prevent hypoventilation. The literature frequently emphasizes strict selection criteria and readiness to convert to GA if respiratory compromise develops.13 Shatri & Singh, 2025 emphasizes that although TSSA generally preserves spontaneous ventilation and diaphragmatic movement, pneumoperitoneum can still impose respiratory strain. They highlight the importance of continuous monitoring, cautious sedation, and early recognition of respiratory compromise entirely consistent with our finding that pneumoperitoneum and head-up tilt may impair ventilation despite preserved diaphragm function. Like our study, they also stress the need for readiness to convert to GA if respiratory deterioration occurs.[13]

Postoperative nausea, vomiting, shoulder tip pain, and other adverse events: Our cohort showed low rates of PONV and shoulder tip pain in both groups with no significant differences. Many comparative studies report reduced PONV with TSSA (believed to result from lower systemic opioid usage and avoidance of volatile agents), although not all trials reach statistical significance — heterogeneity likely reflects differences in PONV prophylaxis protocols, intrathecal opioid dosing, and patient populations.16 Tiwari et al. also found that PONV rates under spinal anesthesia did not significantly differ from GA in many cases, despite a trend toward reduction. Their randomized trial demonstrated that while spinal anesthesia may lower PONV, the difference frequently fails to reach statistical significance exactly matching our observation of comparable PONV rates between groups. Thus, our findings align closely with the prospective results reported by Tiwari et al.[16]

CONCLUSION

From the results of the present study, the following conclusions can be drawn: Hemodynamic stability is superior under TSSA compared to GA. Patients maintained higher systolic, diastolic, and mean arterial pressures throughout the surgery, demonstrating that the limited sympathetic blockade of TSSA prevents major cardiovascular depression. Incidence of adverse effects such as hypotension, bradycardia, and PONV is low and comparable between groups. No neurological complications were observed, confirming the safety of the technique when performed under strict aseptic and anatomical precautions.

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