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Comparative Study between General Anaesthesia and Thoracic Segmental Spinal Anaesthesia for Laparoscopic Cholecystectomy- A Prospective Randomised Open Label Study At A Tertiary Care Hospital

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Abstract

Background: Laparoscopic cholecystectomy is preferred for its minimally invasive benefits, like less pain and quicker recovery. However, managing anaesthesia can be complex due to the effects of pneumoperitoneum. While GA is standard, TSSA offers a promising alternative for patients with comorbidities. This study compares GA and TSSA using isobaric ropivacaine with dexmedetomidine to assess patient outcomes.

Methods: This study was conducted at Government Medical College, Jammu, India, from August 1, 2023, to July 31, 2024, involving 90 ASA patients aged 18–60 undergoing elective laparoscopic cholecystectomy. They were divided into Group T (n=45, TSSA with 0.75% ropivacaine + 10 µg dexmedetomidine) and Group G (n=45, GA). Data on demographics, hemodynamic, postoperative pain (VAS), satisfaction scores, and discharge times were collected. Statistical analysis included t-tests, Mann-Whitney U tests, and chi-square tests, with $P < 0.05$ considered significant.

Results: Demographic characteristics were similar (age: 34.67 ± 11.9 vs. 38.73 ± 11.29 years, P = 0.103595). Surgical duration was comparable (67.3 ± 8.79 vs. 68.6 ± 10.05 min, $P > 0.253$). Group T had higher rates of hypotension (20% vs. 2%, $P < 0.005$) and bradycardia (18% vs. 2%, $P < 0.005$), as well as greater fluid needs (2317.03 ± 465.06 vs. 1455.18 ± 295.62 mL, $P < 0.0001$). Postoperative VAS scores were lower in Group T (1.98 ± 1.34 vs. 2.93 ± 1.9 at 4h, P = 0.007794), with higher patient satisfaction (3.91 ± 1.15 vs. 3.49 ± 1.09, P = 0.03321), while surgeon satisfaction favoured GA (3.07 ± 0.61 vs. 3.87 ± 0.83, P = 0.00321).

Conclusion: TSSA outperforms GA in laparoscopic cholecystectomy, offering better pain control, higher patient satisfaction, and faster discharge, while maintaining manageable hemodynamic effects. It is safe for patients with respiratory issues like COPD and deserves further research for broader application.

Keywords: Laparoscopic Cholecystectomy, Thoracic Segmental Spinal Anaesthesia, General Anaesthesia

Introduction

Laparoscopic cholecystectomy is the preferred method for gallbladder removal due to its minimally invasive approach, resulting in less pain, shorter hospital stays, and quicker recovery [1,2]. These benefits are due to

minimal tissue trauma and reduced inflammatory mediators that activate pain pathways [3]. However, anaesthesia management is challenging because pneumoperitoneum and positioning can cause hemodynamic and respiratory changes [4]. General anaesthesia (GA) with endotracheal intubation is commonly used, providing stability and enabling day-care procedures through agents like propofol and sevoflurane. Despite its advantages, GA can cause stress responses and hemodynamic fluctuations, requiring good cardiorespiratory fitness.

In recent years, regional anaesthesia, particularly spinal anaesthesia, has gained attention as an alternative, especially for patients with significant comorbidities or those at high risk for GA, such as those with cardiorespiratory issues or difficult airways. Spinal anaesthesia offers advantages like faster recovery, effective postoperative pain control, no airway manipulation, reduced PONV, shorter hospital stays, and cost-effectiveness [5]. However, concerns such as hypotension (up to 20.5% incidence) and referred shoulder pain (25–43% incidence) due to subdiaphragmatic irritation from pneumoperitoneum have limited its widespread adoption [5]. These issues can be mitigated by preloading patients, minimizing head tilt, reducing intra-abdominal pressure to 8–10 mmHg, and using vasopressors.

Thoracic segmental spinal anaesthesia (TSSA) is an emerging regional technique that may serve as a viable alternative to GA for laparoscopic surgeries. Unlike conventional spinal anaesthesia, TSSA involves dura puncture at higher lumbar or thoracic levels, using lower doses of local anaesthetics like ropivacaine, levobupivacaine, or bupivacaine to achieve a true segmental blockade. This minimizes lower extremity blockade and venodilation, reducing intraoperative hemodynamic changes [6]. Anatomical studies using MRI have confirmed a greater depth of the posterior subarachnoid space in the thoracic region, reducing the risk of spinal cord injury during TSSA [7]. Additionally, the use of adjuvants like dexmedetomidine, a selective α2-adrenergic receptor agonist, enhances the efficacy of TSSA by prolonging sensory and motor blockade, reducing postoperative analgesic requirements, and attenuating stress responses without significant respiratory depression [8,9].

Given the evolving landscape of anaesthetic techniques for laparoscopic cholecystectomy, this study aims to compare the efficacy of GA versus TSSA using isobaric ropivacaine 0.75% with dexmedetomidine as an adjuvant. By evaluating outcomes such as hemodynamic stability, postoperative pain control, recovery time, and PONV, this research seeks to provide evidence to guide anaesthetic choices for optimizing patient outcomes in laparoscopic surgery.

Methodology

Study Design and Setting

This prospective, randomized study was conducted at the Department of Anaesthesiology and Critical Care, Government Medical College, Jammu, India, from August 1, 2023, to July 31, 2024, after Institutional Ethical Committee approval and informed consent.

Study Population

Ninety patients (ASA I–II, aged 18–60 years, either sex) scheduled for elective laparoscopic cholecystectomy were randomized into two groups (n=45 each) using an even-and-odd number method.

Inclusion Criteria

- Age 18–60 years, ASA I–II, elective laparoscopic cholecystectomy.

Exclusion Criteria

- ASA III–IV, refusal of spinal anaesthesia, contraindications (e.g., bleeding disorders, local infection), active choledocholithiasis, pancreatitis, cholangitis, BMI > 35 kg/m², drug allergies, cardiac diseases, procedures > 120 minutes.

Pre-Anaesthetic Evaluation

A pre-anaesthetic check-up included history, physical examination, and investigations (complete blood count, serology, coagulation, liver/kidney function, blood sugar, urine, ECG, chest X-ray). Demographic data (age, sex, weight, height, BMI) were recorded.

Pre-Anaesthetic Preparation

Patients were kept NPO for 8 hours and received tablet alprazolam 0.25 mg at bedtime. An IV line was secured, and premedication with glycopyrrolate 0.2 mg IM and pantoprazole 40 mg IV was given 30 minutes prior.

Patient Groups

- Group G (n=45): General anesthesia (GA) per institutional protocol.
- Group T (n=45): Thoracic segmental spinal anesthesia (TSSA) at T9–T10 with 27G Quincke's needle, using 1.5 mL 0.75% isobaric ropivacaine + 0.5 mL (10 µg) dexmedetomidine (total 2 mL).

Anaesthetic Technique

Monitors (NIBP, pulse oximeter, ECG) recorded baseline HR, NIBP, and SpO2. All patients received ondansetron 4 mg IV, midazolam 1 mg IV, and Ringer's lactate (15 mL/kg) preload.

- **Group G:** GA with standard induction and maintenance.
- **Group T:** TSSA administered in sitting position, followed by supine repositioning and oxygen at 5 L/min via nasal prongs. Sensory and motor blocks were assessed every 2 minutes until T4–T10 block was achieved, using pinprick and Modified Bromage Scale.

Modified Bromage Scale

- 0: Free leg/foot movement (0%).
- 1: Knee flexion, free foot movement (33%).
- 2: No knee flexion, free foot movement (66%).
- 3: No leg/foot movement (100%).

Surgery started after adequate block. Discomfort or shoulder pain in Group T was managed with midazolam/fentanyl. Bradycardia (HR < 60 bpm) and hypotension (MBP < 20% baseline or SBP < 90 mmHg) were treated with atropine (0.3 mg) and mephentermine (6 mg), respectively.

Postoperative Assessment

Vitals, sensory, and motor block were monitored every 15 minutes in recovery until regression. Pain was assessed via Visual Analogue Scale (VAS: 0–2 no/slight pain, 2–5 mild, 5–7 moderate, 7–9 severe, 10 worst). Rescue analgesia (diclofenac 75 mg or tramadol 1–2 mg/kg) was given at VAS > 3.

Outcome Measures

The primary objectives include evaluating satisfaction scores, awarding 1 point each for patients without postoperative pain, awareness, PONV, urinary retention, and headache/backache (up to 5 points), and for surgeons with adequate relaxation, no intraoperative movement, no conversion to general anesthesia, no side effects, and timely discharge (up to 5 points). The study also compares hemodynamic parameters (HR, NIBP, SpO2) and records the time from surgery to discharge.

Secondary objectives involve monitoring intraoperative and postoperative complications and assessing analgesia duration by tracking when rescue analgesia is needed (VAS > 3).

Statistical Analysis

Sample size (45 per group) was calculated using G*Power (α = 0.05, power = 80%, 10% error). Data were analysed with t-tests or Mann-Whitney U tests for continuous outcomes and chi-square tests for categorical outcomes. P < 0.05 was significant.

Results

This study compared thoracic segmental spinal anesthesia (Group T, n = 45) with general anesthesia (Group G, n = 45) in 90 patients undergoing elective laparoscopic cholecystectomy.

The demographic characteristics of the 90 patients were comparable, with no significant differences across key parameters. In Group T, there were 25 males and 20 females (56% vs. 44%), and in Group G, 20 males and 25 females (44% vs. 56%), with a chi-square value of 0.291841 and a P-value of 0.499. Age ranged from 18 to 60 years, with a mean of 34.67 ± 11.9 years in Group T and 38.73 ± 11.29 years in Group G (P = 0.103595). Weight means were 58.6 ± 5.75 kg in Group T and 60.62 ± 5.9 kg in Group G (P = 0.097298). Height means were 155.58 ± 4.46 cm for Group T and 156.04 ± 4.64 cm for Group G (P = 0.092968), while BMI means were 19.98 ± 0.75 kg/m² and 20.16 ± 0.73 kg/m² (P = 0.0281229), with no statistically significant differences. All procedures were completed laparoscopically, although two patients (4.4%) in Group T required conversion to general anaesthesia, indicating baseline comparability of the groups.

The mean duration of surgery was 67.3 ± 8.79 minutes in Group T and 68.6 ± 10.05 minutes in Group G, with no statistically significant difference (P > 0.253).

Table 1: Characteristics of Thoracic Spinal Anesthesia (n=45)

Parameter	No. of Patients	%	Time to Full Motor Regression (min)	Mean ± SD
Paresthesia from Spinal Needle				
Absent	43	96%		
Present	2	4%		
Total	45		Range: 140–180	157.8 ± 14.90
Sensory Block Upper Level Before Surgery			Lower Level of Sensory Block Before Surgery	
T2	10	22%	L1	25
T3	35	78%	L2	15
Total	45		L3	5
Upper Level of Sensory Block After Surgery			Lower Level of Sensory Block After Surgery	
T3	10	22%	T12	25
T4	30	67%	L1	15
T5	5	11%	L2	5
Total	45		Total	40

Bromage Grade Before Surgery			Bromage Grade After Surgery	
0	30	67%	0	40
1	10	22%	1	5
2	5	11%	Total	45
Total	45			

In Group T, paresthesia during spinal needle insertion occurred in 2 patients (4.4%), with an effective sensory block (upper T2–T3 to lower L1–L3) achieved within 10 minutes in all patients. Time to full motor block regression was 157.8 minutes (range: 140–180) (Table 1).

Table 2: Intraoperative Data

Parameter	Group T (n=45)	Group G (n=45)	Significance
Use of Medication			
Mephentermine (Yes, n, %)	9 (20%)	1 (2%)	FEp = 0.015
Atropine (Yes, n, %)	8 (18%)	1 (2%)	FEp = 0.0300
Crystalloid (mL)			
Range	1500–3000	1000–2000	t = 8.423968
Mean ± SD	2317.03 ± 465.06	1455.18 ± 295.62	P < 0.0001
Intraoperative Side Effects			
Nausea and Vomiting (Yes, n, %)	2 (4%)	0 (0%)	FEp = 0.487
Headache (Yes, n, %)	1 (2%)	0 (0%)	FEp = 0.549
Shoulder Pain (Yes, n, %)	10 (22%)	0 (0%)	FEp = 0.002

Intraoperative hemodynamic changes, fluid needs, and side effects are summarized in Table 4. Group T showed significant reductions in both systolic and diastolic blood pressure and lower heart rates compared to Group G ($P < 0.005$). Hypotension occurred in 20% of Group T versus 2% in Group G, and bradycardia was noted in 18% of Group T compared to 2% in Group G (both $P < 0.005$). Shoulder discomfort was reported by 22% of Group T, with fewer reports of headaches (2%) and nausea/vomiting (4%). No respiratory depression was observed (SpO2 97–98%). Group T required significantly more crystalloid fluids (2317.03 ± 465.06 mL) than Group G (1455.18 ± 295.62 mL, $P < 0.0001$).

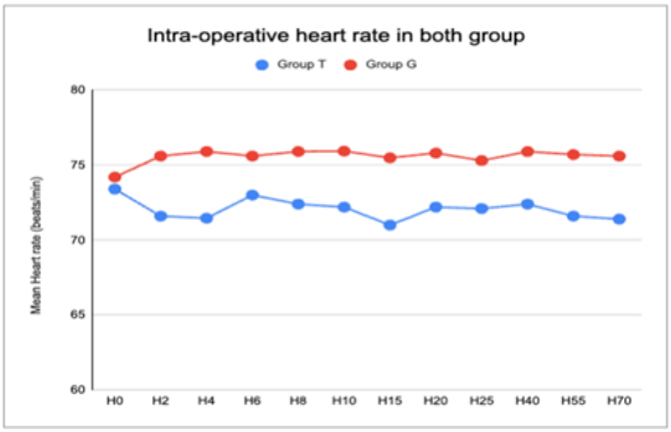

Figure 1: Bar Diagram of Intraoperative Heart Rate

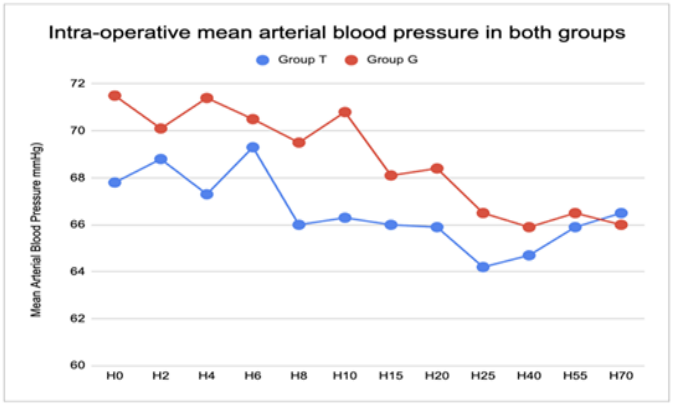

Figure 2: Bar Diagram of Intraoperative Mean Arterial Pressure

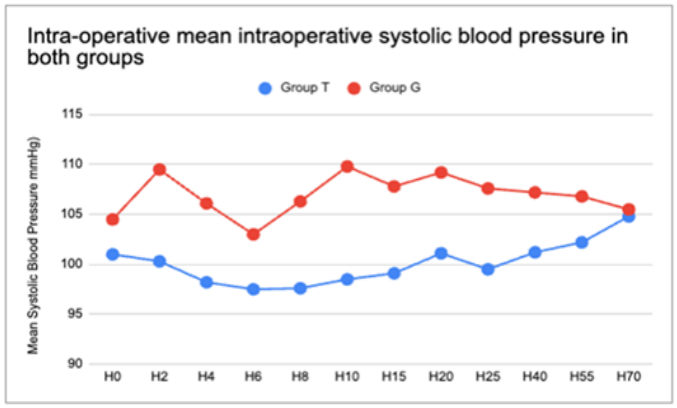

Figure 3: Bar Diagram of Intraoperative Systolic Blood Pressure

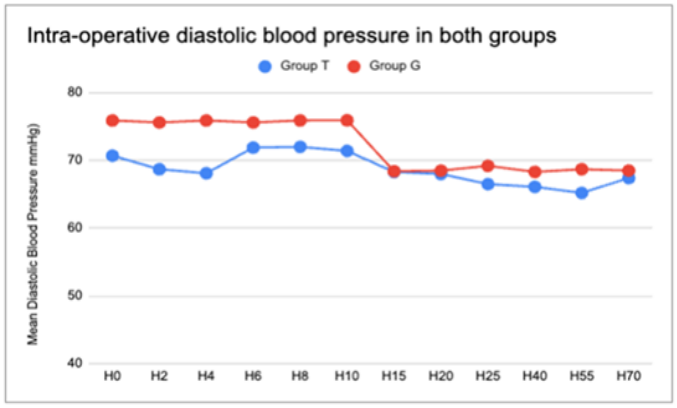

Figure 4: Bar Diagram of Intraoperative Diastolic Blood Pressure

Figures 1–4 depict intraoperative hemodynamic changes. Heart rate (Figure 1) was significantly lower in Group T at multiple intervals ($P < 0.05$). Mean arterial pressure (Figure 2) showed significant differences at 0, 4, 8, and 10 minutes ($P < 0.05$). Systolic blood pressure (Figure 3) was significantly lower in Group T at 2, 6, 8, 10, 15, 20, 25, and 40 minutes ($P < 0.05$). Diastolic blood pressure (Figure 4) was significantly lower in Group T at 0, 2, 4, 6, 8, 10, 25, and 55 minutes ($P < 0.05$).

Table 3: Postoperative VAS and Satisfaction Scores

Parameter	Group T (n=45)	Group G (n=45)	Significance
Postoperative VAS			
After 4 h			
Range	0–4	0–6	t = 2.723
Mean ± SD	1.98 ± 1.34	2.93 ± 1.9	P = 0.007794
After 8 h			
Range	0–5	0–6	t = 1.662354
Mean ± SD	2.51 ± 1.63	2.82 ± 2.08	P = 0.00043
After 12 h			
Range	0–5	0–6	t = 2.35575
Mean ± SD	2.33 ± 1.7	3.27 ± 2	P = 0.000207

After 24 h			
Range	0–2	0–5	t = 5.88205
Mean ± SD	0.91 ± 0.84	2.56 ± 1.65	P = 0.0003*
Patient Satisfaction			
Range	2–5	2–5	t = 2.16353
Mean ± SD	3.91 ± 1.15	3.49 ± 1.09	P = 0.03321
Surgeon Satisfaction			
Range	2–4	3–5	t = 2.015368
Mean ± SD	3.07 ± 0.61	3.87 ± 0.83	P = 0.00321
Discharge Time (min)			
Mean ± SD	33.5 ± 7.43	40.0 ± 4.69	P < 0.0001

In our study, Postoperative VAS scores (Table-5) were significantly lower in Group T at 4, 8, 12, and 24 hours (means: 1.98, 2.51, 2.33, 0.91) compared to Group G (means: 2.93, 2.82, 3.27, 2.56) ($P < 0.05$). Patient satisfaction was higher in Group T (mean: 3.91) than in Group G (mean: 3.49, $P < 0.05$), while surgeon satisfaction was lower in Group T (mean: 3.07) than in Group G (mean: 3.87, $P < 0.05$). Discharge time was significantly shorter in Group T (mean: 33.5 ± 7.43 minutes) compared to Group G (mean: 40.0 ± 4.69 minutes, $P < 0.0001$).

Discussion

This study compared thoracic segmental spinal anaesthesia (TSSA) with general anaesthesia (GA) for laparoscopic cholecystectomy, highlighting TSSA's potential as an effective alternative. TSSA reduces the surgical stress response by avoiding airway instrumentation, a finding supported by Tovaras G et al. (2006), who reported a lower incidence of deep vein thrombosis (DVT) and reduced physiological stress due to minimal tissue trauma [10]. This aligns with the minimally invasive nature of laparoscopic surgery, which limits the release of inflammatory mediators such as histamine and bradykinin, as noted in Miller's Anesthesia (2020) [11]. Despite concerns about inadequate ventilation from thoracic nerve block, the diaphragm's cervical innervation (C3–C5) ensures adequate inspiration, with expiration being a passive process, consistent with Ellakany M (2011) [6]. However, forceful expiration and coughing, driven by anterior abdominal wall muscles innervated by thoracic nerves, were compromised, a trade-off that did not significantly impact patient outcomes in this study.

Demographic data showed no significant differences between groups in age (34.67 ± 11.9 years in Group T vs. 38.73 ± 11.29 years in Group G, $P = 0.103595$), gender, weight, height, or BMI (Table 1), ensuring a balanced comparison. The mean surgical duration was comparable (67.3 ± 8.79 min in Group T vs. 68.6 ± 10.05 min in Group G, $P > 0.253$), indicating that anesthesia technique did not influence operative time. This consistency supports the feasibility of TSSA in routine practice, as noted by van Zundert AA et al. (2006), who emphasized its applicability in healthy patients [13].

Hemodynamic parameters revealed significant differences favouring TSSA. Group T exhibited lower

heart rates (e.g., 73.4 at 0 min vs. 74.2 in Group G, P = 0.041) and blood pressures (e.g., systolic 101.0 mmHg vs. 104.5 mmHg at 0 min, P > 0.05, but significant post-6 min, P < 0.05), reflecting reduced sympathetic activation. Hypotension occurred in 9 patients (20%) in Group T versus 1 (2%) in Group G, and bradycardia in 8 (18%) versus 1 (2%), both managed with atropine (0.6 mg) and mephentermine (6 mg). These findings align with Ellakany M (2013), who reported significant but controllable hemodynamic changes in TSSA, with 40% of patients requiring ephedrine or atropine [12]. Singhal G et al. (2023) also noted manageable hypotension (16%) and bradycardia (3%) with atropine, while Critchley LA et al. (1993) observed a 29% increase in mean arterial pressure under GA due to pneumoperitoneum, a response mitigated by TSSA [14-15]. Gupta A et al. (2011) similarly reported transient hypotension in 8 patients, effectively treated with mephentermine, supporting the manageability of TSSA-related cardiovascular changes[16]. TSSA characteristics included a 4.4% paraesthesia incidence during needle insertion, resolving with needle adjustment, with no permanent neurological deficits, consistent with Imbelloni et al. (2010)'s 6.6% rate [17]. Sensory block onset (T2–T3 to L1–L2 within 5–12 min) and regression (160.9 min) mirrored Ellakany M (2013)'s 15-min onset and 160-min regression, and Singhal G et al. (2023)'s 5-min median onset and 90-min regression[12,14]. Motor block was modest (66% Bromage 0 post-surgery), likely due to low-dose ropivacaine, reducing hypotension and enabling early ambulation, thus lowering DVT and infection risks, a benefit noted by Tovaras G et al. (2006) [10].

Postoperative pain, assessed by VAS, was significantly lower in Group T (e.g., 1.98 at 4h vs. 2.93 in Group G, P = 0.007794), supporting Goel et al. (2022)'s findings of lower VAS up to 6 hours with TSSA, and Ellakany M (2013)'s similar observations. This enhanced analgesia likely contributed to Group T's higher patient satisfaction (3.91 vs. 3.49, P = 0.03321), though surgeon satisfaction was lower (3.07 vs. 3.87, P = 0.00321), possibly due to TSSA's technical demands, as noted by Ellakany M (2013) and Yi JW et al. (2009) [12,18,19].

Intraoperative shoulder pain (22%) in Group T, linked to diaphragmatic irritation from pneumoperitoneum (van Zundert AA et al., 2006), was managed with midazolam and fentanyl, with 4.4% needing GA conversion—lower than Vincenzi et al. (2023)'s 10–55%. Nausea and vomiting (4.4%) were minimal, compared to Goel et al. (2022)'s 11–26.7% and Mahasivabhattau SS et al. (2023)'s 8% shoulder pain. Discharge was shorter in Group T (33.5 ± 7.43 vs. 40.0 ± 4.69 min, P < 0.0001), highlighting the benefits of TSSA in recovery, cost, and reduced PONV, as noted by Mahasivabhattau SS et al. (2023) [13,20,21].

It was observed that TSSA offers a viable alternative to GA for laparoscopic cholecystectomy, with superior patient satisfaction, reduced pain, and faster discharge, despite manageable hemodynamic challenges. Further studies in older or comorbid patients are warranted to optimize its application.

Conclusion

The study demonstrates the superiority of thoracic segmental spinal anaesthesia (TSSA) over general anaesthesia (GA) for laparoscopic cholecystectomy, as evidenced by better postoperative pain control (lower VAS scores in Group T), shorter discharge time, and higher patient satisfaction. TSSA proved safe for patients with impaired organ function, particularly those with respiratory comorbidities like COPD. Despite increased hemodynamic changes (hypotension in 20% and bradycardia in 18% of Group T vs. 2% each in

Group G), these were easily managed with mephentermine and atropine, posing no significant risk.

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