Section: Anaesthesia

Original Research Article

COMPARISON OF RECOVERY PROFILES OF PROPOFOL AND SEVOFLURANE FOLLOWING BISPECTRAL INDEX TITRATED ANAESTHESIA IN PATIENTS UNDERGOING LAPAROSCOPIC SURGERIES

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ABSTRACT

BIS-guided titration of anesthetics whether volatile or intravenous enhances recovery quality and reduces drug consumption and cognitive dysfunction. Although propofol and sevoflurane are both well-established agents for general anaesthesia, their comparative performance in laparoscopic surgeries when titrated using BIS remains underexplored. This study aimed to compare the recovery profiles of patients anesthetized with propofol and sevoflurane following Bispectral Index (BIS) titrated anaesthesia in patients undergoing laparoscopic surgery. Ninety patients were randomly allocated into two groups. Group P (n=45) received propofol infusion and Group S (n=45) received sevoflurane for maintenance. The primary outcome of this study was to compare the time taken for patients to open their eyes. Secondary outcomes were time to spontaneous ventilation, time to hand squeezing, time taken for patients to respond to verbal commands, time to airway device removal, time required for patients to pronounce their name, time it took to achieve a modified Aldrete Score of 9 or higher. perioperative changes in haemodynamic parameters and other postoperative complications will be noted.The time to eye opening was 99 seconds (82–222) in Group P and 130 seconds (89–210) in Group S ($p = 0.594$). All secondary outcome parameters showed non-significant p-values ($p > 0.05$), suggesting that the recovery times from anaesthesia were clinically comparable between the two groups.This study demonstrates that both propofol and sevoflurane are safe and effective agents for maintenance of anaesthesia during laparoscopic cholecystectomy when titrated using BIS monitoring.

INTRODUCTION

The past few decades have witnessed as shift in surgical practice with the increasing preference for laparoscopic procedures due to numerous advantages, including reduced postoperative pain, shorter hospital stays, decreased incidence of wound infections, and earlier return to daily activities.[1] Among the critical components of perioperative management in laparoscopic surgeries is the choice of anaesthetic agent. An ideal anaesthetic technique should not only provide a smooth induction and maintenance of anaesthesia but also facilitate rapid emergence, minimize postoperative complications and early discharge. [2,3]

Propofol is the most widely used intravenous induction agent due to its favourable pharmacological properties—rapid onset, short duration of action, smooth induction, and quick emergence,[4] Sevoflurane, on the other hand, is a modern volatile anaesthetic agent with a low blood-gas partition coefficient, which enables quick equilibration between alveolar gas and blood, resulting in faster induction and emergence.[5]

BIS monitoring facilitates individualized titration of anaesthetic agents, preventing excessive dosing and thereby contributing to reduced anaesthetic consumption, faster emergence, and shorter PACU stay.[6] Meta-analyses have confirmed that BIS-guided titration of anaesthetics—whether volatile or intravenous—enhances recovery quality and reduces drug consumption and cognitive dysfunction.[7]

Although propofol and sevoflurane are both well-established agents for general anaesthesia, their

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comparative performance in laparoscopic surgeries when titrated using BIS remains underexplored. Given the current emphasis on Enhanced Recovery After Surgery (ERAS) protocols, it is essential to identify anaesthetic regimens that offer rapid emergence, stable hemodynamics, minimal side effects, and faster turnover.

This study is therefore designed to compare the recovery profiles of propofol and sevoflurane in patients undergoing elective laparoscopic surgeries under BIS-guided anaesthesia.

MATERIALS AND METHODS

After Institutional ethical committee approval and registration with the clinical trials registry, the study was conducted at a tertiary care centre between December July 2024 to September 2025 in agreement with the principles of the World Medical Association Declaration of Helsinki, 1975, revised in 2013. Confidentiality of all patients were maintained.

All patients provided written informed consent to participate in the study and to allow their data to be used for research and educational use. This randomized study included 90 patients of either sex, aged 18-65 years, belonging to ASA physical status I or II and scheduled for elective laparoscopic procedures under general anaesthesia. Patients were excluded if they refused participation, had known allergies to propofol or sevoflurane, had obesity (BMI > 30 kg/m²), or were scheduled for surgeries lasting more than 2 hours. [Figure1]

Patients were assessed a day prior to surgery in the pre-anaesthetic clinic. A detailed clinical history was obtained, and general, systemic, and airway examinations were performed. Routine haematological and biochemical investigations were carried out as required. Patients were kept fasting as per standard guidelines. Pre-medication with tablet alprazolam (0.25 mg) at bedtime was given. Demographic and vital parameters were recorded on the day of surgery.

Standard anaesthesia monitoring was performed for all patients. An appropriately sized peripheral IV cannula was secured. The BIS sensor was applied to the forehead according to standard anatomical landmarks, Signal quality was assessed to confirm appropriate electrode contact and acquisition of reliable BIS values. All patients were pre-medicated with IV fentanyl (2 mcg/kg) and preoxygenated with 100% oxygen for 3 minutes. Induction was achieved with IV propofol (2-2.5 mg/kg) and IV vecuronium (0.1 mg/kg), followed by the insertion of an appropriate size supraglottic device or endotracheal tube (ETT). Two distinct anaesthetic protocols were followed for the groups:

Group P (n=45): received propofol infusion at 3–12 mg/kg/hour along with a 50:50 oxygen-air mixture.

Group S (n=45): received sevoflurane at 1–3% concentration along with the same oxygen-air mixture.

Additional vecuronium was administered at 0.01 mg/kg as required. Anaesthesia depth was monitored using BIS, targeting a range of 40–60. Propofol infusion and sevoflurane concentrations were titrated accordingly: increased if BIS exceeded 60 and decreased if it fell below 40.

Haemodynamic parameters (heart rate, mean arterial pressure) were recorded at various intervals: preoperatively, during and after induction, at intubation, and every 15 minutes intraoperatively, fifteen minutes prior to the conclusion of surgery, anaesthetic agents were gradually reduced. Reversal of neuromuscular blockade was achieved with IV glycopyrrolate (0.01 mg/kg) and IV neostigmine (0.05 mg/kg), followed by airway device removal. During emergence, the following parameters were recorded from the time of cessation of anaesthetic agents: time to spontaneous ventilation time to eye opening time to hand squeezing time to respond to verbal commands, time to airway device removal, time to pronounce name, time to achieve a modified Aldrete Score ≥ 9 Postoperative complications such as laryngospasm, bronchospasm, postoperative nausea and vomiting, agitation, headache, sore throat, and hoarseness were recorded until discharge from the recovery room.

The sample size was calculated using the formula given by Snedecor & Cochran (1989),[8] based on the study by Pandya et al. (2021),[9] which reported the mean time to eye opening in the two groups as follows: 9.88 minutes in group P and 5.65 minutes in group S. Assuming 80% power and 95% confidence interval minimum calculated sample size was 42. The calculated sample size was approximately 45 patients per group (total 90 patients) to accommodate possible dropouts.

The data obtained in this prospective randomized controlled study by SPSS version 25. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation for normally distributed data and as median with interquartile range for non-normally distributed data. Intergroup comparisons of categorical variables were performed using the Chi-square test, and Fisher's exact test was applied when expected cell counts were small. Continuous variables between the two independent groups were compared using the Mann–Whitney U test, as most variables did not follow a normal distribution. Hemodynamic parameters (heart rate and mean arterial pressure) and bispectral index values measured at multiple perioperative time points were analysed using point-wise intergroup comparisons with the Mann–Whitney U test, along with within-group comparisons against baseline values. All statistical tests were two-tailed, and a p-value of <0.05 was considered statistically significant.

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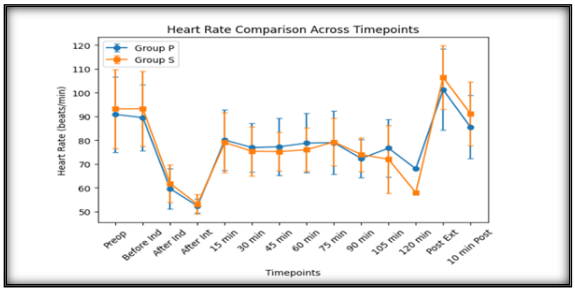
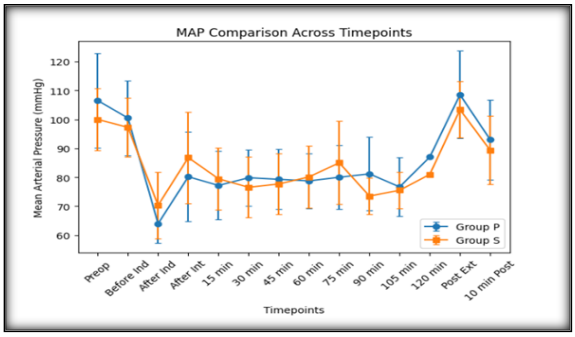
RESULTS

A total of 96 patients were enrolled in the study, of which 90 were included in the final data analysis. No exclusions occurred post randomization. The groups were comparable, showing no significant differences in age, weight, height, sex distribution and duration of surgery and anaesthesia [Table 1].

Table 1: Baseline demographic variables

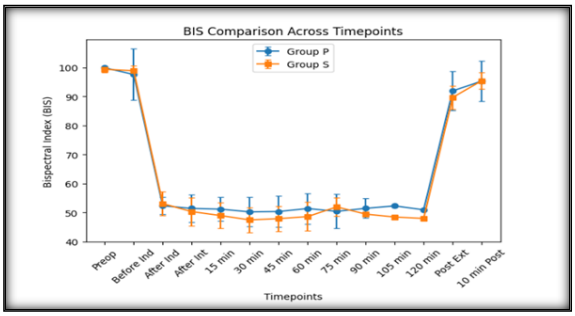
Demographic variable	Group P	Group S	P value
Age (years)	38.56+/-9.74	41.09+/-11.08	0.49
Sex (M:F)	9:36	13:32	0.46
Weight (kg)	62.16+/-8.78	62.36+/-7.97	0.96
Height (cm)	161.47+/-6.75	163.27+/-8.45	0.42
BMI (kg/m2)	23.68+/- 2.4	23.45+/-2.23	0.77
ASA (I:II)	29:16	28:17	0.97
Duration of surgery (minutes)	43.62+/-13.04	42.95+/-12.14	0.98
Duration of anaesthesia (minutes)	51.24+/-19.41	50.40+/-12.78	0.33





The heart rate (HR) pattern and MAP in both groups followed a similar trend throughout the perioperative period, showing an initial decrease after induction, stabilization during surgery, and a transient rise during emergence. However, at 105 minutes, Group P exhibited a slightly higher HR compared to Group S (76.67 ± 12.01 vs. 72.00 ± 14.14), which was statistically significant Preoperatively, Group P had a slightly higher MAP (106.51 ± 16.39 mmHg) compared to Group S (99.98 ± 10.77 mmHg), and this difference was statistically significant (p = 0.0021). After induction, a marked reduction in MAP was observed in both groups, more pronounced in Group P (63.98 ± 6.73 mmHg) than in Group S (70.33 ± 11.47 mmHg), showing a significant difference (p = 0.0003). After induction, a marked reduction in MAP was observed in both groups, more pronounced in Group P (63.98 ± 6.73 mmHg) than in Group S (70.33 ± 11.47 mmHg), showing a significant difference (p = 0.0003). [Figure 1,2]

The bispectral index (BIS) values in both groups showed a consistent pattern of decline following induction and intubation, indicating an appropriate depth of anaesthesia, followed by a gradual rise toward baseline during emergence. intraoperative period, BIS remained within the optimal range of 40–60 in both groups. However, Group S showed significantly lower BIS values at 15, 30, and 45 minutes (p = 0.0156, 0.0092, and 0.0245, respectively), suggesting a slightly deeper plane of anaesthesia during this phase. [Figure 3]



The comparison of recovery parameters between Group P and Group S demonstrated that both groups had similar recovery profiles, with no statistically significant differences observed in any of the assessed criteria. The median time to spontaneous ventilation showed p = 0.856, Similarly, the time to eye opening showed p = 0.594, while the time to hand squeezing had p = 0.490. The ability to follow verbal commands had p = 0.399. Removal of the airway device showed p = 0.307. All parameters showed non-significant p-values (p > 0.05), suggesting that the recovery times from anaesthesia were clinically comparable between the two groups [Table 2].

Table 2: Recovery criteria

Parameter	Group P (n = 45)	Group S (n = 45)	p-value
Time to Spontaneous Ventilation	80 (57 – 202) sec	108 (59 – 144) sec	0.856
Time to Eye Opening	99 (82 – 222) sec	130 (89 – 210) sec	0.594
Time to Hand Squeezing	119 (98 – 245) sec	152 (110 – 235) sec	0.490

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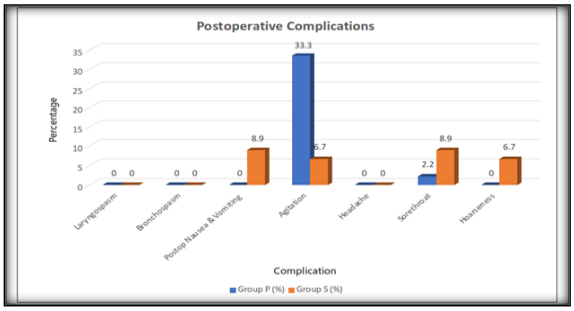
Time to Follow Verbal Commands	140 (112 – 270) sec	172 (122 – 250) sec	0.399
Time to Removal of Airway Device	165 (129 – 288) sec	190 (135 – 262) sec	0.307
Time to Pronouncing Name	175 (144 – 314) sec	215 (155 – 307) sec	0.197

Most postoperative complications were comparable and mild in both groups, agitation was significantly higher in Group P(p = 0.003) suggesting better postoperative calmness and emergence profile in Group S. [Figure 4].



DISCUSSION

In the present study baseline demographic variables, intraoperative hemodynamic parameters, BIS trends, recovery endpoints, and postoperative complications were systematically recorded and compared between the two groups. The groups were comparable, showing no significant differences in age, weight, height, sex distribution and duration of surgery The heart rate (HR) pattern and MAP in both groups followed a similar trend throughout the perioperative period, showing an initial decrease after induction, stabilization during surgery, and a transient rise during emergence.

In the present study, heart rate (HR) demonstrated a consistent perioperative trend in both Group P (propofol) and Group S (sevoflurane). Preoperatively, HR was comparable between the two groups (90.84 ± 15.86 beats/min in Group P vs. 93.16 ± 16.64 beats/min in Group S; p = 0.113). Following induction, HR decreased significantly within both groups to 59.67 ± 8.42 beats/min in Group P and 61.82 ± 7.93 beats/min in Group S (p = 0.1048). After intubation, HR further declined and remained comparable (52.38 ± 2.93 vs. 53.11 ± 4.09 beats/min; p = 0.5930). During the intraoperative period (15–90 minutes), HR remained stable without statistically significant intergroup differences (p > 0.05 at all timepoints). At 105 minutes, HR was significantly higher in Group P (76.67 ± 12.01 beats/min) compared to Group S (72.00 ± 14.14 beats/min; p = 0.0468). Post-extubation, HR increased in both groups (101.24 ± 17.05 vs. 106.38 ± 13.32 beats/min; p = 0.1352), with a significant difference at 10 minutes post-extubation (85.56 ± 13.23 vs. 91.18 ± 13.43 beats/min; p = 0.0373).

Comparable findings were reported by Khare et al. (2016),[11] who observed baseline HR values of approximately 88–92 beats/min in both propofol and sevoflurane groups, with HR decreasing significantly after induction but showing no statistically significant intergroup difference at any intraoperative timepoint (p > 0.05). Similarly, Shah et al. (2011),[12] reported a reduction in mean HR during maintenance anesthesia compared to baseline in both groups, with a greater fall in the propofol group, yet no episode of severe bradycardia requiring intervention. In a large observational study by Johansen et al. (2000),[13] involving 1,552 patients, HR remained clinically stable when BIS values were maintained between 50 and 65, and no significant HR instability was reported during maintenance or emergence.

In the present study, mean arterial pressure (MAP) showed significant perioperative variation within both groups. Preoperatively, MAP was significantly higher in Group P (106.51 ± 16.39 mmHg) compared to Group S (99.98 ± 10.77 mmHg; p = 0.0021). Following induction, MAP decreased markedly in both groups, with a greater reduction in Group P (63.98 ± 6.73 mmHg) than in Group S (70.33 ± 11.47 mmHg; p = 0.0003). After intubation, MAP increased due to sympathetic stimulation, with higher values in Group S (86.80 ± 15.74 mmHg) compared to Group P (80.18 ± 15.45 mmHg; p = 0.0323). During the intraoperative maintenance phase (15–90 minutes), MAP remained stable and comparable between groups (p > 0.05). Post-extubation, MAP increased significantly in both groups, with higher values in Group P (108.53 ± 15.12 mmHg) compared to Group S (103.36 ± 9.76 mmHg; p = 0.0168).

Orhon et al. (2013),[14] reported mean MAP values between 75–85 mmHg during maintenance anesthesia in both groups, with no statistically significant intergroup difference (p > 0.05). Somvanshi et al. (2015),[10] similarly demonstrated that MAP remained within ±15% of baseline in both propofol and sevoflurane groups throughout surgery. Further corroboration comes from Pandya et al. (2021),[9] who reported comparable MAP values between groups during BIS-guided anesthesia, and from Shu et al. (2024),[15] where MAP remained clinically stable despite differences in HR and vasopressor requirements.

In the present study, BIS values in both groups followed the expected anesthetic depth trajectory. Preoperatively, BIS was marginally but significantly higher in Group P (99.91 ± 0.36) compared to Group S (99.40 ± 1.03; p = 0.0015), though both reflected full wakefulness. After induction, BIS decreased sharply to 52.38 ± 2.93 in Group P and 53.11 ± 4.09 in Group S (p = 0.5930), confirming equivalent hypnotic depth. During early maintenance, Group S exhibited significantly lower BIS values at 15 minutes (49.00 ± 4.39 vs 51.22 ± 4.16; p = 0.0156), 30 minutes (47.49 ± 4.37 vs 50.27 ± 5.07; p = 0.0092), and 45 minutes (47.93 ± 4.30 vs 50.40 ± 5.33; p = 0.0245). Post-extubation, BIS

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increased more rapidly in Group P (91.93 ± 6.68) than Group S (89.69 ± 4.00; p = 0.0004), while by 10 minutes post-extubation BIS values were comparable (95.33 ± 7.02 vs 95.44 ± 2.91; p = 0.2545.

Somvanshi et al. (2015) also reported comparable BIS scores between groups (mean BIS 48–54; p > 0.05) during maintenance, reinforcing that BIS-guided titration equalizes hypnotic depth irrespective of anesthetic agent. Pandya et al. (2021),[9]maintained BIS strictly between 40–60 in both groups and reported no statistically significant difference in BIS values at any intraoperative time point, consistent with the present findings. Shu et al. (2024),[15] similarly targeted BIS 40–60 and reported equivalent BIS control in both groups, despite differences in opioid requirement and recovery characteristics.

In the present study, recovery times were clinically comparable between the two groups. The median time to spontaneous ventilation was 80 seconds (57–202) in Group P and 108 seconds (59–144) in Group S (p = 0.856). Eye opening occurred at 99 seconds (82–222) in Group P and 130 seconds (89–210) in Group S (p = 0.594). Similarly, no statistically significant differences were observed for hand squeezing (119 vs 152 seconds; p = 0.490), response to verbal commands (140 vs 172 seconds; p = 0.399), airway removal (165 vs 190 seconds; p = 0.307), or pronouncing one's name (175 vs 215 seconds; p = 0.197).

Pandya et al. (2021),[9] also reported longer emergence times in both propofol and sevoflurane groups compared to the present study, which may be explained by the use of glycopyrrolate (0.004 mg/kg) and higher doses of midazolam (0.1 mg/kg). Nevertheless, they found significantly shorter times to spontaneous ventilation, eye opening, extubation, stating name, and achieving an Aldrete score ≥9 in the sevoflurane group as compared to propofol (all p < 0.05). In contrast, Singh et al. (2013),[4] reported findings consistent with the present study, demonstrating no significant difference in eye opening time (7.5 ± 1.6 vs 6.9 ± 1.7 minutes; p > 0.05) or extubation time (10.7 ± 2.3 vs 10.3 ± 2.0 minutes; p > 0.05), likely due to the use of lower doses of midazolam (0.025 mg/kg) as premedication.

Postoperative complications were minimal in both groups in our study. Postoperative nausea and vomiting (PONV) occurred in 0% of patients in Group P and 8.9% in Group S (p = 0.117). Sore throat was reported in 2.2% of Group P and 8.9% of Group S (p = 0.361), while hoarseness was observed only in Group S (6.7%; p = 0.242). Notably, emergence agitation was significantly more frequent in Group P, occurring in 33.3% of patients compared to 6.7% in Group S (p = 0.003).

These findings are consistent with previous studies. Pandya et al. (2021),[9] reported sore throat in two patients in the sevoflurane group and none in the propofol group. Shinn et al. (2011),[16] demonstrated significantly lower PONV with propofol, with reduced RINVR scores at one hour postoperatively. Orhon et al. (2013),[14] The significantly higher incidence of agitation observed in the propofol group likely reflects a more abrupt emergence as seen by rapid rise of BIS values in the propofol group, possibly due to rapid redistribution and clearance of propofol from the circulation, whereas sevoflurane provides a comparatively smoother recovery profile.

CONCLUSION

This study demonstrates that both propofol and sevoflurane are safe and effective agents for maintenance of anaesthesia during laparoscopic cholecystectomy when titrated using BIS monitoring. Propofol offered the advantage of a lower incidence of postoperative nausea and vomiting, but at the expense of significantly higher postoperative agitation. Sevoflurane was associated with a trend toward minor airway symptoms and postoperative nausea but provided slightly smoother BIS-guided emergence.

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