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Determination Of Effects of Bispectral Index Monitoring on Sevoflurane Consumption in Patients Undergoing Elective Surgeries: A Prospective Observational Study

Dr. Sakshi Rathore[1], Dr. Prashant Kumar paikra[2], Dr. Madhumita G. Murthy[3], Dr. Bhavna Royzada[4] Dr. Dropadi choudhary[5], Dr. Sheetal Das[6]

[1]PG resident Chhattisgarh institute of medical sciences

[2]Assistant professor Chhattisgarh institute of medical sciences
[3]HOD Chhattisgarh institute of medical sciences
[4]Associate Professor Chhattisgarh institute of medical sciences
[5]PG resident Chhattisgarh institute of medical sciences
[6]Assistant professor Chhattisgarh institute of medical sciences

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Corresponding Author:

Dr. Sakshi Rathore
PG resident Chhattisgarh institute of medical sciences

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ABSTRACT

Background Bispectral Index (BIS) monitoring is an electroencephalography-based modality used to assess the depth of anaesthesia and guide titration of anaesthetic agents. BIS-guided anaesthesia may reduce volatile anaesthetic consumption, improve postoperative recovery, and minimize the risk of intraoperative awareness.
Aim To evaluate the effect of BIS monitoring on sevoflurane consumption and recovery profile in patients undergoing elective surgeries under general anaesthesia.
Materials and Methods This prospective observational study was conducted in the Department of Anaesthesiology at Chhattisgarh Institute of Medical Sciences, Bilaspur, among 70 patients aged 40–70 years belonging to ASA Grade I and II undergoing elective surgeries under general anaesthesia. Patients were randomly allocated into two groups: BIS group (n=35), where anaesthesia was guided using BIS monitoring along with standard ASA monitoring, and Control group (n=35), where only standard monitoring was used. Intraoperative haemodynamic parameters, minimum alveolar concentration (MAC), sevoflurane consumption, and recovery profile including time for eye opening, motor response, extubation, and Modified Aldrete Score were recorded and compared.
Results Baseline demographic and clinical characteristics were comparable between the groups. Haemodynamic parameters remained stable and clinically acceptable in both groups throughout surgery. Mean sevoflurane consumption was significantly lower in the BIS group compared to the Control group (13.58 ± 1.51 mL vs 23.5 ± 2.9 mL; $p < 0.001$). Recovery parameters were significantly improved in the BIS group, including shorter time for eye opening (5.24 ± 0.85 vs 8.80 ± 0.80 min), motor response (5.99 ± 0.75 vs 9.80 ± 0.90 min), and extubation (6.95 ± 0.83 vs 10.90 ± 0.90 min) ($p < 0.001$ for all). Modified Aldrete Score was significantly higher in the BIS group (9.70 ± 0.50 vs 9.00 ± 0.50; $p = 0.001$). No episodes of intraoperative awareness were reported in either group.
Conclusion BIS-guided anaesthesia significantly reduces sevoflurane consumption and facilitates faster postoperative recovery without compromising haemodynamic stability. BIS monitoring enables precise titration of anaesthetic depth and may improve perioperative safety and recovery outcomes.

Keywords*: Bispectral Index, BIS monitoring, Sevoflurane, General anaesthesia, Recovery profile, Volatile anaesthetic consumption, Modified Aldrete Score, Intraoperative awareness.*

INTRODUCTION

General anaesthesia is a pharmacologically induced, reversible state characterized by unconsciousness, amnesia, analgesia, and immobility, allowing surgical procedures to be performed safely and painlessly. Maintenance of an adequate depth of anaesthesia is a fundamental goal during general anaesthesia because insufficient hypnosis may result in intraoperative awareness, whereas excessive anaesthetic administration may lead to delayed recovery, prolonged extubation time, hemodynamic instability, and postoperative cognitive dysfunction. Among the various components of anaesthesia, unconsciousness and amnesia are particularly important because failure to achieve these may result in awareness with explicit recall, which is considered one of the most distressing complications of anaesthesia. Patients experiencing intraoperative awareness may subsequently develop anxiety, nightmares, sleep disturbances, depression, and post-traumatic stress disorder.[1,2]

Despite significant advances in anaesthetic drugs, delivery systems, and perioperative monitoring, awareness during general anaesthesia continues to remain a clinically important issue. The incidence of accidental awareness during general anaesthesia has been reported to range between 0.1% and 0.2% in the general surgical population, while the incidence may be considerably higher in high-risk groups such as elderly patients, trauma surgeries, cardiac surgeries, and patients receiving light anaesthesia.[2] One of the major reasons for this complication is the inability of conventional monitoring modalities to accurately assess the hypnotic component of anaesthesia. Traditionally, anaesthesiologists have relied upon haemodynamic parameters such as heart rate, blood pressure, lacrimation, sweating, tearing, and patient movement as indirect indicators of anaesthetic depth. However, these responses primarily reflect autonomic nervous system activity rather than cortical suppression responsible for consciousness and awareness.[3]Furthermore, haemodynamic responses can be significantly altered by several commonly used drugs such as opioids, beta-blockers, vasodilators, and neuromuscular blocking agents, making them unreliable indicators of hypnotic depth. In clinical practice, fear of intraoperative awareness often encourages the administration of higher concentrations of inhalational anaesthetic agents to ensure unconsciousness. Although this approach may reduce awareness, excessive anaesthetic dosing can prolong recovery, delay extubation, increase postoperative sedation, and contribute to postoperative cognitive dysfunction, especially in elderly patients and those with comorbidities.[4] Excessive use of volatile anaesthetics also increases overall anaesthetic cost and environmental burden.To overcome the limitations of conventional monitoring, various electroencephalography (EEG)-based technologies have been developed for direct assessment of cerebral cortical activity during anaesthesia. Among these modalities, the Bispectral Index (BIS) monitor is one of the most extensively studied and widely used devices for monitoring the depth of anaesthesia. BIS is a processed EEG parameter that converts complex electrical brain activity into a single dimensionless numerical value ranging from 0 to 100, where 100 represents the awake state and 0 indicates complete cortical electrical silence. A BIS value between 40 and 60 is generally considered optimal for maintenance of general anaesthesia and is associated with a low probability of intraoperative awareness.[1,3] BIS monitoring allows real-time titration of anaesthetic agents according to cortical activity, thereby enabling more individualized and precise administration of anaesthesia.Several studies have demonstrated that BIS-guided anaesthesia can reduce the consumption of intravenous and inhalational anaesthetic agents, facilitate faster recovery, improve extubation times, and reduce postoperative complications without compromising patient safety. However, despite these advantages, routine BIS monitoring is still not universally practiced, particularly in resource-limited settings where standard ASA monitoring remains the predominant method of assessing anaesthetic adequacy. In many institutions, volatile anaesthetic agents are titrated primarily according to haemodynamic parameters and minimum alveolar concentration (MAC), which may not accurately reflect the true hypnotic state of the patient.Sevoflurane is among the most commonly used inhalational anaesthetic agents due to its rapid onset, low airway irritation, favourable hemodynamic profile, and rapid recovery characteristics. However, the amount of sevoflurane administered during surgery may vary considerably depending on the monitoring strategy and the clinical judgement of the anaesthesiologist. BIS-guided administration of sevoflurane may potentially reduce unnecessary anaesthetic exposure while still maintaining adequate depth of anaesthesia and preventing awareness.Although several studies have evaluated the role of BIS monitoring, many have focused on specific surgical procedures, elderly patients, or selected populations, and some studies are limited by small sample sizes or non-randomized designs. Additionally, limited data are available from the Indian population regarding the impact of BIS-guided anaesthesia on sevoflurane consumption, recovery profile, and postoperative awareness. Therefore, the present study was undertaken to compare BIS-guided anaesthesia with standard ASA monitoring in patients undergoing surgery under general anaesthesia.

MATERIALS AND METHODS

The present study was a hospital-based prospective observational study conducted in the Department of Anaesthesiology, Major Operation Theatre, at Chhattisgarh Institute of Medical Sciences (CIMS), Bilaspur. The study was carried out after obtaining approval from the Institutional Scientific Research and Ethical Committee. The study continued until the desired sample size was achieved.The study included patients of either sex aged between 40 and 70 years belonging to the American Society of Anaesthesiologists (ASA) physical status Grade I and II who were scheduled for elective surgeries under general anaesthesia in the major operation theatre.A total of 70 patients were included in the study, with 35 patients in each group.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Patients providing valid informed consent.
- ASA Grade I and II patients.
- Age between 40 and 70 years.
- Duration of surgery up to 2 hours.

Exclusion Criteria
Patients with the following conditions were excluded from the study:
- Known allergy to drugs used during surgery.
- Psychiatric illness.
- Hyper-reactive airway disease.
- Altered renal or liver function tests.
- Cognitive impairment or Alzheimer's disease.
- Pregnancy.

Study Variables
Independent Variables
- Age
- Gender
- Body Mass Index (BMI)
- ASA physical status grade

Dependent Variables
The following parameters were monitored at preinduction (T0) and at regular intraoperative intervals (T1, T2, T3):
- Heart Rate (HR)
- Systolic Blood Pressure (SBP)
- Diastolic Blood Pressure (DBP)
- Mean Arterial Pressure (MAP)
- Respiratory Rate (RR)
- Oxygen Saturation (SpO_2)
- End-tidal Carbon Dioxide ($EtCO_2$)
- Bispectral Index (BIS)
- Minimum Alveolar Concentration (MAC)

Recovery profile parameters assessed included:
- Time for eye opening
- Time for motor response
- Time for extubation
- Modified Aldrete Score (MAS)
- Recall of intraoperative events

Materials and Equipment
The study utilized an anaesthesia workstation, multiparameter monitor, BIS monitor with disposable electrodes, laryngoscope with blades, endotracheal tubes, airway devices, anatomical face masks, $ETCO_2$ monitor, sevoflurane vaporizer, medical air compressor, intravenous fluids, anaesthetic and emergency drugs, central oxygen supply, and suction apparatus.

Methodology
All patients underwent detailed pre-anaesthetic evaluation prior to surgery. Written informed consent was obtained from each participant. Patients were kept nil per oral for at least 6 hours before surgery. After randomization, patients were allocated into two groups of 35 patients each:

BIS Group
Patients received general anaesthesia with sevoflurane along with BIS monitoring in addition to standard ASA monitoring. Recovery parameters were subsequently assessed.

Control Group
Patients received general anaesthesia with sevoflurane using standard ASA monitoring alone without BIS guidance.
All patients received intravenous diclofenac 75 mg infusion in the preoperative room. Upon arrival in the operating theatre, standard monitoring including non-invasive blood pressure (NIBP), electrocardiography (ECG), and pulse oximetry was initiated, and baseline parameters were recorded. Premedication consisted of injection ondansetron 4 mg IV, glycopyrrolate

0.2 mg IV, midazolam 0.02 mg/kg IV, and fentanyl 2 µg/kg IV.In patients belonging to the BIS group, BIS electrodes were applied over the forehead and temporal region before induction of anaesthesia. Preoxygenation was performed with 100% oxygen for 3 minutes at a flow rate of 8 L/min. Anaesthesia was induced using propofol 2 mg/kg IV, followed by lignocaine 1.5 mg/kg IV to attenuate the haemodynamic response to laryngoscopy and intubation. Endotracheal intubation was facilitated with succinylcholine 2 mg/kg IV.

Anaesthesia was maintained using a sevoflurane–oxygen–air mixture with FiO_2 of 0.4 through a closed breathing circuit with soda lime. Fresh gas flow was maintained at 6 L/min. Muscle relaxation was maintained using intermittent doses of vecuronium. In the control group, sevoflurane concentration was adjusted according to clinical parameters such as heart rate, blood pressure, and MAC values, whereas in the BIS group, sevoflurane concentration was titrated to maintain BIS values between 40 and 60.

Intraoperative hypertension was defined as blood pressure more than 25% above baseline and tachycardia as heart rate more than 20% above baseline. These were treated with fentanyl 25–50 µg IV along with vecuronium 0.02 mg/kg IV. Hypotension, defined as MAP less than 25% below baseline, was treated with mephentermine 6 mg IV bolus. Bradycardia, defined as heart rate below 50 beats/minute, was treated with atropine 0.6 mg IV.

Sevoflurane administration was continued until skin closure in both groups, and the time of discontinuation was recorded. Neuromuscular blockade was reversed using neostigmine 0.05 mg/kg IV and glycopyrrolate 0.02 mg/kg IV. Patients were extubated after fulfilling standard extubation criteria, and recovery parameters were recorded thereafter.
Patients undergoing surgery lasting more than 2 hours, those developing major intraoperative complications, or significant haemodynamic instability were excluded from the final analysis.

Monitoring and Outcome Assessment
All standard intraoperative parameters along with $EtCO_2$ and BIS values were recorded before induction (T0) and subsequently at 30-minute intervals after intubation until completion of surgery.
Intraoperative sevoflurane consumption was calculated using Dion's Equation:

$$\text{Sevoflurane Consumption} = \frac{PFTM}{2412d}$$

Where:

- P = Vaporizer dial concentration (%)
- F = Fresh gas flow (L/min)
- T = Duration for which concentration was maintained (minutes)
- M = Molecular weight of sevoflurane (200 g)
- d = Density of liquid sevoflurane (1.52 g/mL)

Recovery profile assessment included:

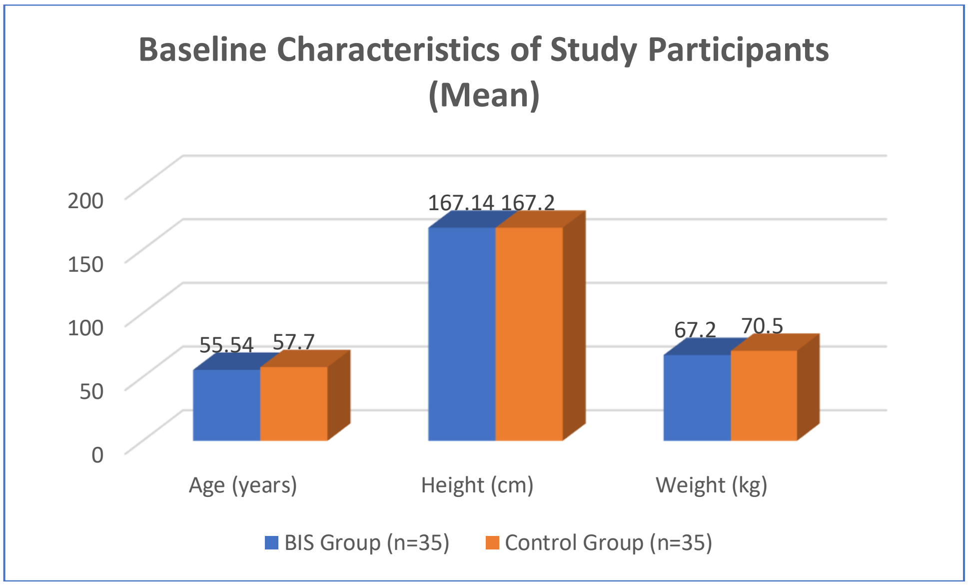
1. Time for eye opening (time from discontinuation of anaesthetic agent to eye opening on verbal command).
2. Time for motor response (time from discontinuation of anaesthetic agent to hand squeezing on verbal command).
3. Time for extubation (time from discontinuation of anaesthetic agent to extubation).
4. Modified Aldrete Score in the post-anaesthesia care unit.
5. Assessment of dream recall or awareness immediately after recovery room transfer and at 24 hours postoperatively by an independent observer not involved in the study.

Statistical Analysis
Data were entered into Microsoft Excel 2000 and analysed using SPSS software version 22.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Student's t-test was used for comparison of continuous variables between groups, whereas chi-square test was applied for categorical variables. A p-value less than 0.05 was considered statistically significant.

RESULTS
A total of 70 patients were included in the study, with 35 patients allocated to the BIS group and 35 patients to the Control group. Baseline characteristics were comparable between the two groups. The mean age was 55.54 ± 9.24 years in the BIS group and 57.70 ± 8.50 years in the Control group (p=0.995). Mean height and weight were also comparable between groups. ASA Grade I and II distribution was nearly equal, and Mallampati grading showed no statistically significant difference between the two groups, indicating baseline homogeneity (Table 1, Figure 1).

Table 1: Baseline Characteristics of Study Participants

Variable	BIS Group (n=35)	Control Group (n=35)	p-value
Age (years), Mean ± SD	55.54 ± 9.24	57.70 ± 8.50	0.995
Height (cm), Mean ± SD	167.14 ± 11.73	167.20 ± 10.70	0.992
Weight (kg), Mean ± SD	67.20 ± 14.01	70.50 ± 12.90	1.019
ASA Grade I, n (%)	17 (48.58%)	18 (51.42%)	0.811
ASA Grade II, n (%)	18 (51.42%)	17 (48.58%)	0.811
Mallampati Grade I, n (%)	22 (62.86%)	27 (77.14%)	0.192
Mallampati Grade II, n (%)	13 (37.14%)	8 (22.86%)	0.192



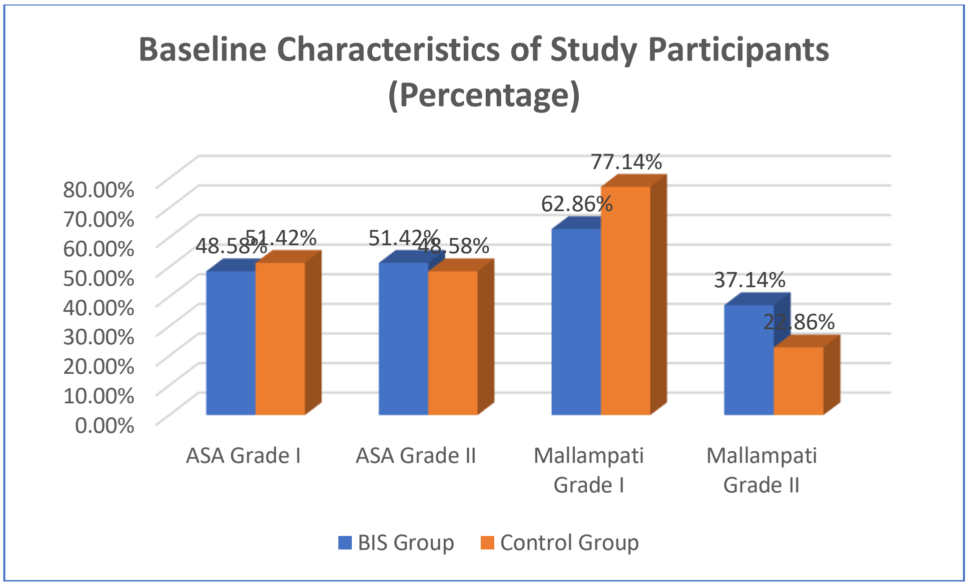


Figure 1 Baseline Characteristics of Study Participants

Intraoperative haemodynamic parameters remained largely stable and comparable between the groups. Heart rate showed a statistically significant difference only at T60, with values of 83.8 ± 4.4 bpm in the BIS group and 81.6 ± 4.6 bpm in the Control group (p=0.045). MAP was also significantly higher at T60 in the BIS group compared to the Control group (90.8 ± 5.6 vs 87.8 ± 5.7 mmHg, p=0.032). However, systolic blood pressure, diastolic blood pressure, SpO_2, and $EtCO_2$ showed no significant intergroup differences and remained within clinically acceptable limits (Table 2, Figure 2).

Table 2: Comparison of Intraoperative Haemodynamic Parameters

Parameter	Time Point	BIS Group Mean ± SD	Control Group Mean ± SD	p-value
Heart Rate	Preoperative	79.4 ± 11.0	77.3 ± 13.2	0.482
Heart Rate	T60	83.8 ± 4.4	81.6 ± 4.6	0.045

SBP	Preoperative	125.3 ± 9.4	125.3 ± 8.1	1.000
SBP	T60	117.0 ± 8.4	113.6 ± 9.3	0.115
DBP	Preoperative	74.7 ± 9.3	77.1 ± 8.3	0.259
DBP	T60	77.6 ± 6.9	74.9 ± 8.4	0.146
MAP	Preoperative	91.4 ± 6.2	93.1 ± 7.4	0.313
MAP	T60	90.8 ± 5.6	87.8 ± 5.7	0.032
SpO_2	Intraoperative	99.0 ± 0.0	99.0 ± 0.0	NA
$EtCO_2$	T60	34.6 ± 3.7	35.4 ± 3.5	0.321

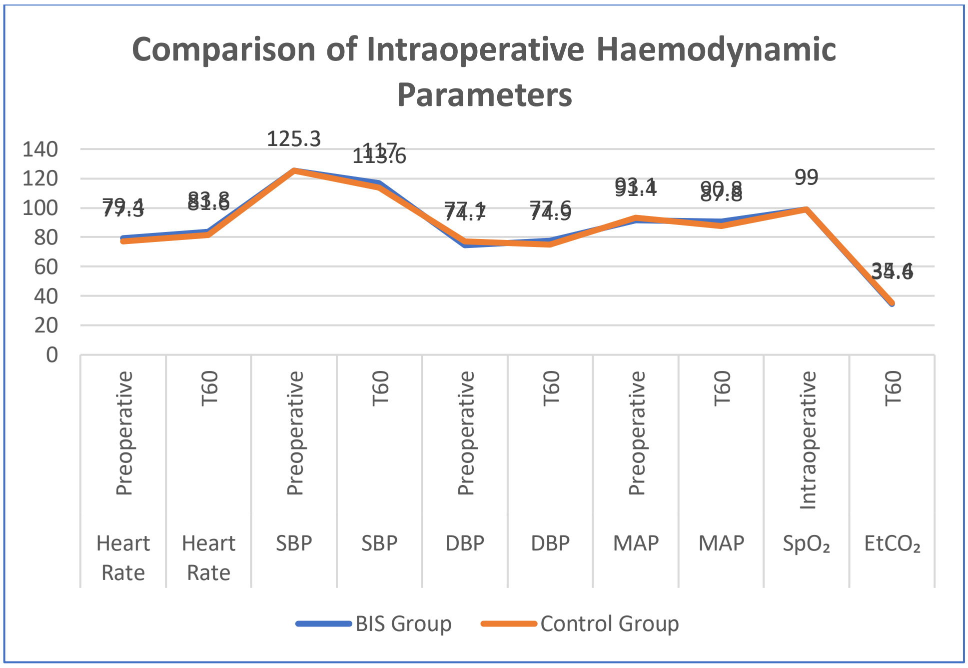


Figure 2 Comparison of Intraoperative Haemodynamic Parameters

MAC values were significantly lower in the BIS group at T10 and T90. At T10, the BIS group had a mean MAC of 0.6 ± 0.2 compared to 0.8 ± 0.2 in the Control group (p=0.001). Similarly, at T90, MAC was 0.6 ± 0.1 in the BIS group and 0.7 ± 0.1 in the Control group (p=0.003). BIS values in the BIS group were maintained within the recommended anaesthetic depth range during the intraoperative period, with mean values of 51.5 ± 6.7 at T10, 50.4 ± 5.6 at T30, 51.8 ± 5.4 at T60, and 50.1 ± 5.6 at T90 (Table 3).

Table 3: Comparison of MAC and BIS Values

Variable	Time Point	BIS Group Mean ± SD	Control Group Mean ± SD	p-value
MAC	T10	0.6 ± 0.2	0.8 ± 0.2	0.001
MAC	T30	0.7 ± 0.1	0.7 ± 0.1	0.472
MAC	T60	0.6 ± 0.1	0.6 ± 0.1	0.814
MAC	T90	0.6 ± 0.1	0.7 ± 0.1	0.003
MAC	T120	0.6 ± 0.1	0.6 ± 0.1	0.910
BIS Value	T0	96.0 ± 2.2	—	—
BIS Value	T10	51.5 ± 6.7	—	—
BIS Value	T30	50.4 ± 5.6	—	—
BIS Value	T60	51.8 ± 5.4	—	—
BIS Value	T90	50.1 ± 5.6	—	—
BIS Value	T120	58.2 ± 1.7	—	—

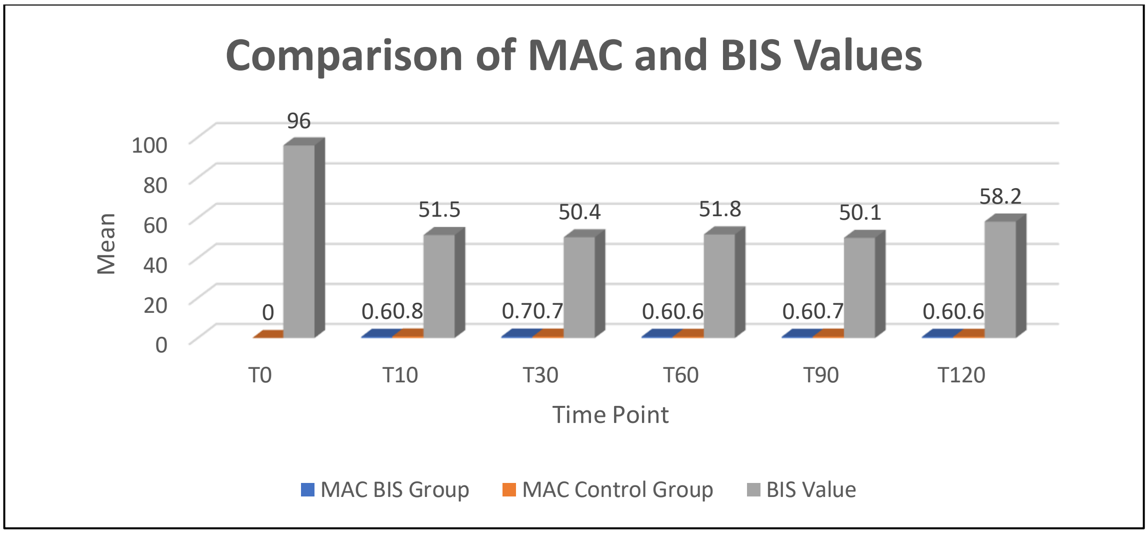


Figure 3: Comparison of MAC and BIS Values

Sevoflurane consumption was significantly lower in the BIS group compared to the Control group. The mean sevoflurane consumption was 13.58 ± 1.51 mL in the BIS group and 23.50 ± 2.90 mL in the Control group (p=0.001). Recovery parameters were also significantly better in the BIS group, with shorter time for eye opening (5.24 ± 0.85 vs 8.80 ± 0.80 min), motor response (5.99 ± 0.75 vs 9.80 ± 0.90 min), and extubation (6.95 ± 0.83 vs 10.90 ± 0.90 min). The Modified Aldrete Score was significantly higher in the BIS group than the Control group (9.70 ± 0.50 vs 9.00 ± 0.50, p=0.001), indicating better early postoperative recovery (Table 4).

Table 4: Comparison of Sevoflurane Consumption and Recovery Profile

Variable	BIS Group Mean ± SD	Control Group Mean ± SD	p-value	t-value
Sevoflurane consumption (mL)	13.58 ± 1.51	23.50 ± 2.90	0.001	17.954
Time for eye opening (min)	5.24 ± 0.85	8.80 ± 0.80	0.001	17.704
Time for motor response (min)	5.99 ± 0.75	9.80 ± 0.90	0.001	18.869
Time for extubation (min)	6.95 ± 0.83	10.90 ± 0.90	0.001	18.301
Modified Aldrete Score	9.70 ± 0.50	9.00 ± 0.50	0.001	5.570

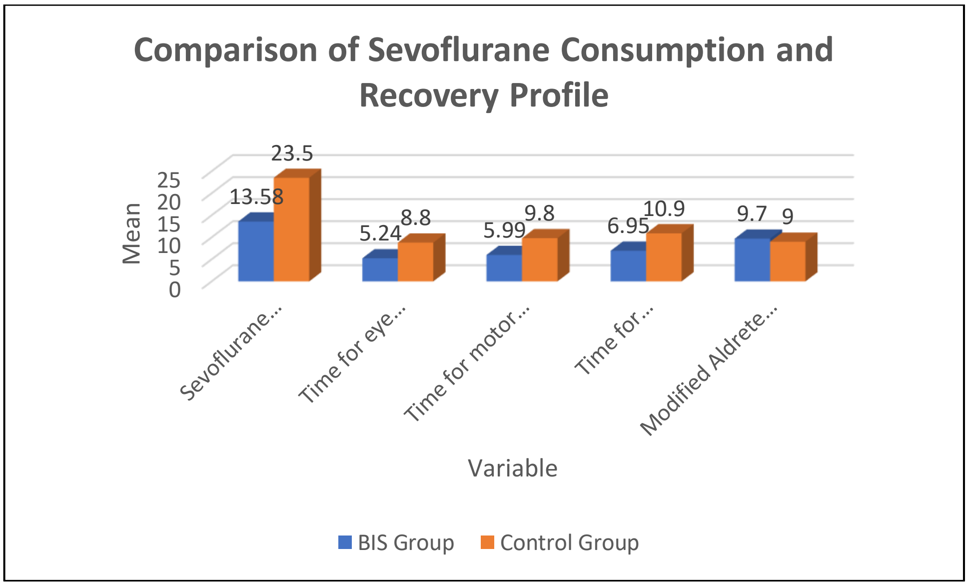


Figure **4: Comparison of Sevoflurane Consumption and Recovery Profile**

DISCUSSION

The present prospective observational study evaluated the effect of Bispectral Index (BIS) monitoring on sevoflurane consumption and recovery profile in patients undergoing elective surgeries under general anaesthesia. The findings demonstrated that BIS-guided anaesthesia significantly reduced sevoflurane consumption and improved postoperative recovery parameters without compromising haemodynamic stability.Baseline demographic characteristics including age, height, weight, ASA grade, and Mallampati grading were comparable between the two groups, minimizing confounding bias and validating intergroup comparisons. The mean age was 55.54 ± 9.24 years in the BIS group and 57.70 ± 8.50 years in the control group. ASA Grade I patients constituted 48.58% in the BIS group and 51.42% in the control group, whereas ASA Grade II patients constituted 51.42% and 48.58% respectively.Haemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, MAP, SpO_2, and $EtCO_2$ remained stable and clinically acceptable throughout surgery in both groups. Although statistically significant differences were observed at T60 for heart rate (83.8 ± 4.4 bpm vs 81.6 ± 4.6 bpm; p = 0.045) and MAP (90.8 ± 5.6 mmHg vs 87.8 ± 5.7 mmHg; p = 0.032), these were not clinically significant. Similar haemodynamic stability with BIS-guided anaesthesia was reported by Paventi et al.(2001)[5], Wong et al.(2002)[6], and Archana Nair et al.(2021)[7], all of whom observed reduced volatile anaesthetic consumption without cardiovascular compromise.In the present study, BIS values were maintained within the recommended range of 40–60 throughout maintenance of anaesthesia, confirming adequate hypnotic depth. MAC requirements were significantly lower in the BIS group at T10 (0.6 ± 0.2 vs 0.8 ± 0.2; p = 0.001) and T90 (0.6 ± 0.1 vs 0.7 ± 0.1; p = 0.003), demonstrating more precise titration of sevoflurane using EEG-guided monitoring.A major finding of the present study was the significant reduction in sevoflurane consumption in the BIS group (13.58 ± 1.51 mL) compared with the control group (23.5 ± 2.9 mL; p < 0.001). Paventi et al.(2001)[5] similarly demonstrated approximately 40% reduction in sevoflurane usage with BIS monitoring. Wong et al.2 reported reduced isoflurane consumption from 7.7 ± 3 mL to 5.6 ± 3 mL (p < 0.05), while Ibraheim et al.(2008)[8] also demonstrated significantly lower sevoflurane consumption in morbidly obese patients receiving BIS-guided anaesthesia. Archana Nair et al.3 reported reduced sevoflurane consumption in the BIS group (8.16 ± 1.17 mL vs 9.6 ± 2.66 mL; p = 0.019). Furthermore, Oliveira et al.(2017)[9] and the CODA trial by Chan et al.(2013)[10] confirmed significant reductions in volatile anaesthetic exposure with BIS monitoring. Punjasawadwong et al.(2014)[11] also demonstrated a pooled reduction of –0.24 MAC equivalents (p < 0.00001).Recovery parameters were significantly improved in the BIS group. Time for eye opening (5.24 ± 0.85 vs 8.80 ± 0.80 min), motor response (5.99 ± 0.75 vs 9.80 ± 0.90 min), and extubation (6.95 ± 0.83 vs 10.90 ± 0.90 min) were significantly shorter in the BIS group (p < 0.001 for all). Modified Aldrete Score was also significantly higher in the BIS group (9.70 ± 0.50 vs 9.00 ± 0.50; p = 0.001), indicating better early postoperative recovery. Similar findings were reported by Punjasawadwong et al.(2014)[11], Chiang et al.(2018)[12], Yu et al.(2018)[13], and Wong et al.(2002)[6], all demonstrating faster emergence and recovery with BIS-guided anaesthesia. Chan et al.(2013)[10] and Abdelzaam et al.(2020)[14] also reported significantly earlier PACU discharge in BIS-monitored patients.

No episodes of intraoperative awareness were observed in either group in the present study. However, BIS monitoring provided an additional safety margin by ensuring adequate hypnotic depth despite reduced sevoflurane administration. Punjasawadwong et al.7 reported a 35% relative reduction in awareness risk (RR 0.65; p = 0.02), while Gu Yichun et al.(2024)[15] demonstrated a significant reduction in awareness incidence with BIS-guided anaesthesia (RR 0.51; 95% CI: 0.36–0.74; p < 0.01). The present findings therefore support that BIS-guided lighter anaesthesia can reduce volatile anaesthetic exposure and improve recovery without compromising patient safety.

CONCLUSION

The present study demonstrated that BIS-guided anaesthesia significantly reduced sevoflurane consumption compared to conventional monitoring while maintaining adequate haemodynamic stability. Patients in the BIS group showed significantly faster recovery, including earlier eye opening, motor response, and extubation, along with better Modified Aldrete Scores. BIS monitoring enabled precise titration of anaesthetic depth by maintaining BIS values within the recommended range of 40–60, thereby avoiding excessive anaesthetic exposure. Thus, BIS-guided anaesthesia improves recovery profile, optimizes volatile anaesthetic usage, and enhances perioperative safety without increasing the risk of intraoperative awareness

LIMITATIONS

The present study was conducted at a single tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. Only patients undergoing elective surgeries of less than 2 hours duration and belonging to ASA Grade I and II were included; therefore, the results may not be applicable to high-risk patients or prolonged surgeries. In addition, long-term postoperative cognitive outcomes and cost-effectiveness analysis of BIS monitoring were not evaluated in the present study.

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