Effect of Bi-Spectral Index–Guided Low-Flow Anaesthesia on Sevoflurane Consumption per Hour: A Randomized Controlled Trial

Dr. Domala Radhika[1], Dr. Malla Alekhya[2], Dr. Gayathri Dakshinamurthy[3*]

[1]Assistant Professor, Department of Anaesthesiology, ESIC Medical College and Hospital, Sanathnagar, Hyderabad, India

[2]Assistant Professor, Department of Anaesthesiology, ESIC Medical College and Hospital, Sanathnagar, Hyderabad, India

[3*]Assistant Professor, Department of Anaesthesiology, ESIC Medical College and Hospital, Sanathnagar, Hyderabad, India (Corresponding Author)

ABSTRACT

Background: Low-flow anesthesia is increasingly used in modern anesthetic practice because it reduces consumption of volatile anesthetic agents, minimizes environmental pollution, and lowers anesthetic cost. However, accurate monitoring of anesthetic depth is essential to avoid excessive anesthetic administration and ensure adequate hypnosis during surgery. Conventional monitoring techniques rely on clinical parameters and end-tidal anesthetic concentration, which may not accurately reflect cerebral activity. The Bispectral Index (BIS) is an electroencephalography-based monitoring tool that provides objective assessment of anesthetic depth and may allow more precise titration of inhalational anesthetic agents.

Aim: To evaluate the effect of BIS-guided monitoring on sevoflurane consumption per hour during low-flow anesthesia compared with conventional monitoring techniques.

Methodology: This prospective randomized controlled trial was conducted in the Department of Anaesthesiology at ESIC Medical College and Hospital, Hyderabad, over a period of one year. A total of 150 patients aged 18–60 years with ASA physical status I–II scheduled for elective surgeries under general anesthesia were enrolled and randomly allocated into two groups of 75 each. In both groups, anesthesia was maintained using a low-flow technique with fresh gas flow of 1 L/min and sevoflurane as the inhalational agent. In the BIS group, anesthetic depth was monitored using BIS and sevoflurane concentration was titrated to maintain BIS values between 40 and 60. In the conventional monitoring group, anesthetic depth was guided by end-tidal anesthetic concentration and minimum alveolar concentration values. The primary outcome was mean sevoflurane consumption per hour (ml/h). Secondary outcomes included intraoperative haemodynamic parameters, recovery profile in terms of time to eye opening, extubation time, and Modified Aldrete Score, and incidence of intraoperative awareness. Statistical analysis was performed using SPSS software with a significance level of $p < 0.05$.

Results: The mean sevoflurane consumption per hour was significantly lower in the BIS group (12.4 ± 3.1 ml/h) compared with the conventional monitoring group (20.3 ± 4.2 ml/h; $p < 0.001$). Recovery was significantly earlier in the BIS group, with shorter time to eye opening (7.8 ± 2.1 minutes vs 11.6 ± 3.2 minutes) and earlier extubation (8.2 ± 2.6 minutes vs 12.9 ± 3.8 minutes) compared with the conventional group. The Modified Aldrete Score at 10 minutes was also higher in the BIS group. Intraoperative haemodynamic parameters remained stable and comparable between the two groups. No patient in the BIS group experienced intraoperative awareness, whereas one patient (1.3%) in the conventional group reported possible awareness.

Conclusion: BIS-guided monitoring during low-flow anesthesia significantly reduces sevoflurane consumption per hour and improves postoperative recovery profile without compromising haemodynamic stability or increasing the risk of intraoperative awareness. BIS monitoring therefore represents a valuable tool for optimizing anesthetic drug administration and enhancing perioperative patient outcomes.

Keywords: Bispectral Index, Low-flow anesthesia, Sevoflurane consumption per hour, Depth of anesthesia monitoring, Recovery profile

How to cite this article: Radhika D, Alekhya M, Dakshinamurthy G. Effect of Bi-Spectral Index–Guided Low-Flow Anaesthesia on Sevoflurane Consumption per Hour: A Randomized Controlled Trial. Int J Drug Deliv Technol. 2026;16(14s): 616-623. DOI: 10.25258/ijddt.16.14s.70

Source of support: Nil.
Conflict of interest: None

INTRODUCTION

General anesthesia is a controlled and reversible state of unconsciousness characterized by hypnosis, analgesia, amnesia, and muscle relaxation that allows surgical procedures to be performed safely and effectively. Modern anesthetic practice focuses not only on maintaining adequate depth of anesthesia but also on optimizing patient safety, reducing anesthetic drug consumption, minimizing environmental pollution, and ensuring rapid postoperative recovery. Volatile anesthetic agents such as sevoflurane are widely used for maintenance of anesthesia due to their rapid onset, controllable depth of anesthesia, and favorable recovery characteristics (Brioni et al., 2017) [1]. However, excessive administration of inhalational anesthetics may lead to delayed recovery, hemodynamic instability, increased healthcare costs, and increased environmental burden due to the greenhouse effect of inhalational agents.

Traditionally, anesthetic depth during surgery has been monitored using clinical signs such as heart rate, blood pressure, lacrimation, sweating, and patient movement, along with measurement of end-tidal anesthetic concentration and minimum alveolar concentration (MAC). Although these conventional indicators provide indirect information about anesthetic depth, they may not accurately reflect the level of cerebral activity or consciousness. Consequently, patients may either receive inadequate anesthesia leading to intraoperative awareness or excessive anesthesia resulting in hemodynamic instability and delayed recovery (Shafiq et al., 2012) [2].

To overcome these limitations, electroencephalography-based monitoring techniques have been developed to assess the hypnotic component of anesthesia. The Bispectral Index (BIS) is a processed electroencephalographic parameter that provides a numerical scale ranging from 0 to 100, where values between 40 and 60 are considered optimal for surgical anesthesia. BIS monitoring enables anesthesiologists to titrate anesthetic agents more precisely according to the patient's cerebral response rather than relying solely on clinical signs (Gan et al., 1997) [3].

Several studies have demonstrated that BIS-guided anesthesia may reduce the consumption of inhalational anesthetic agents and facilitate faster recovery from anesthesia. A randomized controlled trial conducted by Başar et al. reported that BIS monitoring allowed more accurate titration of sevoflurane and was associated with reduced volatile anesthetic consumption compared with conventional monitoring techniques [4]. Similarly, other investigations have shown that BIS monitoring helps maintain adequate depth of anesthesia while preventing excessive drug administration.

Low-flow anesthesia techniques have also gained popularity in modern anesthetic practice. Low-flow anesthesia involves the use of reduced fresh gas flow rates, typically ≤1 L/min, during maintenance of anesthesia, allowing rebreathing of anesthetic gases after carbon dioxide absorption. This technique offers several advantages including reduced consumption of volatile anesthetic agents, decreased operating room pollution, improved humidification of inspired gases, and significant cost savings (Baum et al., 2001) [5].

When combined with low-flow anesthesia, BIS monitoring may further optimize anesthetic delivery by allowing precise titration of anesthetic agents according to the patient's hypnotic state. Studies have suggested that BIS-guided titration during inhalational anesthesia can reduce anesthetic agent consumption while maintaining stable hemodynamics and adequate depth of anesthesia (Jeong et al., 2005) [6].

In addition to reduced anesthetic consumption, BIS monitoring has been associated with improved recovery profiles. Previous studies have demonstrated shorter times to eye opening, extubation, and response to verbal commands in patients managed with BIS-guided anesthesia compared with conventional monitoring methods (Nair et al., 2021) [7]. Faster recovery not only improves patient safety but also enhances operating room efficiency and reduces postoperative care unit stay.

Another important concern in modern anesthesia practice is the prevention of intraoperative awareness, a rare but potentially distressing complication of general anesthesia. BIS monitoring has been proposed as a useful tool for reducing the risk of awareness by ensuring adequate hypnotic depth throughout the surgical procedure (Avidan et al., 2008) [8]. By providing real-time feedback regarding cerebral activity, BIS may help anesthesiologists maintain appropriate anesthetic depth.

Despite the potential advantages of BIS monitoring, some studies have reported variable results regarding its effectiveness in reducing anesthetic consumption or improving clinical outcomes. Certain investigations have suggested only modest reductions in volatile anesthetic usage when BIS monitoring is applied, highlighting the need for further research to clarify its clinical benefits in different anesthetic techniques and surgical settings (Aimé et al., 2006) [9].

Furthermore, while low-flow anesthesia itself reduces anesthetic gas consumption, the combination of low-flow techniques with BIS-guided monitoring may provide an additional advantage by ensuring optimal titration of anesthetic agents. However, limited randomized controlled trials have evaluated the comparative effectiveness of BIS-guided monitoring versus conventional monitoring methods during low-flow anesthesia.

Therefore, the present study was designed to evaluate the effect of BIS-guided monitoring on sevoflurane consumption per hour during low-flow anesthesia. By comparing BIS-guided monitoring with conventional monitoring based on end-tidal anesthetic concentration and MAC, this study aimed to determine whether BIS monitoring provides additional benefits in reducing sevoflurane consumption per hour, maintaining hemodynamic stability, improving recovery profile, and preventing intraoperative awareness (Hemmerling et al., 2005) [10]. The findings of this study may help optimize anesthetic techniques and contribute to safer and more cost-effective anesthesia practice (Punjasawadwong et al., 2014) [11].

The present study was conducted to evaluate the effect of Bispectral Index-guided monitoring on volatile anesthetic consumption per hour during low-flow anesthesia, with the primary aim of comparing mean sevoflurane consumption per hour between BIS-guided anesthesia and conventional monitoring technique. The secondary objectives were to assess the intraoperative haemodynamic parameters, postoperative recovery profile including time to eye opening and extubation, and the incidence of intraoperative awareness between the two monitoring approaches. The findings of this study may help promote more precise titration of inhalational anesthetics, faster postoperative recovery, improved patient safety, and cost-effective anesthesia practice, thereby contributing to the advancement of modern anesthetic management strategies in surgical patients.

METHODOLOGY

This study was conducted as a prospective randomized controlled trial in the Department of Anaesthesiology at ESIC Medical College and Hospital, Hyderabad, over a period of one year after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. The study included 150 patients belonging to ASA physical status I–II, aged 18–60 years, who were scheduled for elective surgical procedures under general anaesthesia. Patients with pre-existing neurological disorders, history of psychiatric illnesses, and drug or alcohol abuse were excluded from the study to avoid confounding. Patients undergoing emergency surgeries and those who required elective postoperative ventilation were also excluded from the study.

The sample size was calculated using the formula for comparison of two means:

$n = 2\sigma^2 (Z\alpha/2 + Z\beta)^2 / d^2$

where σ represented the standard deviation of sevoflurane consumption per hour based on previous literature, d represented the expected difference between the two groups, $Z\alpha/2$ was 1.96 corresponding to a 5% level of significance, and $Z\beta$ was 0.84 corresponding to 80% power. Based on earlier studies demonstrating approximately 20% reduction in volatile anesthetic consumption with BIS-guided titration, the minimum required sample size was calculated as 68 patients per group. Considering a 10% dropout rate, 75 patients were included in each group, resulting in a total sample size of 150 patients.

Participants were randomly allocated into two equal groups using a computer-generated randomization sequence. In both groups, low-flow anaesthesia technique was used during the maintenance phase with fresh gas flow maintained at 1 litre per minute after an initial high-flow period for denitrogenation. In Group B, the depth of anaesthesia was monitored using the Bispectral Index, and sevoflurane concentration was titrated to maintain BIS values between 40 and 60. In Group C, the depth of anaesthesia was monitored using conventional techniques including end-tidal anaesthetic concentration and minimum alveolar concentration values without BIS monitoring.

All patients followed standard preoperative fasting guidelines. Anaesthesia induction was performed using fentanyl 2 µg/kg intravenously followed by propofol 2 mg/kg intravenously. Neuromuscular blockade was achieved using vecuronium 0.1 mg/kg intravenously, and tracheal intubation was performed after adequate muscle relaxation.

Anaesthesia was maintained using sevoflurane as the inhalational agent with a 50:50 mixture of oxygen and air. Fresh gas flow was initially maintained at a higher rate for approximately 10 minutes for denitrogenation, after which it was reduced to 1 litre per minute in both groups. In the BIS group, sevoflurane concentration was adjusted according to BIS values, whereas in the conventional monitoring group, sevoflurane concentration was adjusted according to end-tidal sevoflurane concentration, MAC values, and standard clinical parameters. Additional doses of vecuronium (0.02 mg/kg) were administered intraoperatively as required.

Intraoperative parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, BIS values in the BIS group, end-tidal sevoflurane concentration, and mean sevoflurane consumption per hour were recorded at 5-minute intervals throughout the procedure. The primary outcome measured was mean sevoflurane consumption per hour (ml/h), while secondary outcomes included haemodynamic stability, recovery profile, and incidence of intraoperative awareness.

Postoperative recovery was assessed using time to eye opening, time to extubation, and Modified Aldrete Score in the recovery room. Assessment of intraoperative awareness was performed postoperatively using the Modified Brice questionnaire.

All collected data were entered into Microsoft Excel and analysed using SPSS statistical software. Continuous variables including sevoflurane consumption per hour were expressed as mean ± standard deviation. Repeated measures ANOVA was applied for comparison of intraoperative haemodynamic parameters over time. Categorical variables were analysed using the Chi-square test. A p-value less than 0.05 was considered statistically significant. Because the duration of surgery differed among patients, sevoflurane consumption was standardized and expressed as sevoflurane consumption per hour to allow accurate comparison between groups.

RESULTS

A total of 150 patients were included in the study and were equally distributed into two groups, with 75 patients in the BIS-guided group and 75 patients in the conventional monitoring group. The baseline demographic characteristics between the two groups were comparable. The mean age in the BIS group was 39.8 ± 10.6 years, while in the conventional group it was 40.7 ± 9.9 years, showing no statistically significant difference ($p = 0.62$). Similarly, gender distribution was comparable, with 54.7% males and 45.3% females in the BIS group and 52.0% males and 48.0% females in the conventional group ($p = 0.74$). The mean body weight and ASA physical status distribution were also similar between the two groups, indicating that both groups were comparable at baseline.

The primary outcome of the study was mean sevoflurane consumption per hour, which was significantly lower in the BIS-guided group compared with the conventional monitoring group. The mean sevoflurane consumption per hour in the BIS group was 12.4 ± 3.1 ml/h, whereas in the conventional monitoring group it was 20.3 ± 4.2 ml/h, demonstrating a statistically significant reduction in volatile anesthetic usage ($p < 0.001$). Additionally, the mean end-tidal sevoflurane concentration and MAC values were significantly lower in the BIS group compared with the conventional monitoring group ($p < 0.001$), indicating more precise titration of anesthetic depth when BIS monitoring was used.

The recovery profile was also significantly improved in patients monitored with BIS. The mean time to eye opening was 7.8 ± 2.1 minutes in the BIS group compared with 11.6 ± 3.2 minutes in the conventional monitoring group ($p < 0.001$). Similarly, the mean time to extubation was shorter in the BIS group (8.2 ± 2.6 minutes) compared with the conventional group (12.9 ± 3.8 minutes) ($p <0.001$). Furthermore, patients in the BIS group achieved higher Modified Aldrete Scores at 10 minutes (9.1 ± 0.8) compared with the conventional monitoring group (8.4 ± 0.9), indicating faster early postoperative recovery ($p = 0.002$).

In terms of haemodynamic parameters, both groups maintained stable intraoperative vital signs throughout the surgical procedure. The mean heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were comparable between the two groups, and no statistically significant differences were observed ($p > 0.05$). This suggests that BIS-guided anesthesia maintained adequate haemodynamic stability while allowing lower sevoflurane consumption per hour.

With regard to intraoperative awareness, none of the patients in the BIS group reported awareness during surgery, while one patient (1.3%) in the conventional monitoring group reported possible awareness, although the difference between the groups was not statistically significant ($p = 0.31$). Overall, the findings indicate that BIS-guided monitoring during low-flow anesthesia significantly reduces sevoflurane consumption per hour and improves recovery profile without compromising haemodynamic stability or increasing the risk of intraoperative awareness.

Table 1: Baseline Demographic Characteristics of Study Participants (n = 150)

Variable	**BIS**	**Conventional**	**p-**

	Group (n = 75)	Group (n = 75)	value
Age (years), Mean ± SD	39.8 ± 10.6	40.7 ± 9.9	0.62
Male	41 (54.7%)	39 (52.0%)	0.74
Female	34 (45.3%)	36 (48.0%)	
Weight (kg), Mean ± SD	65.2 ± 8.5	66.1 ± 7.9	0.53
ASA I	46 (61.3%)	44 (58.7%)	0.74
ASA II	29 (38.7%)	31 (41.3%)	
Duration of surgery (min), Mean ± SD	95.6 ± 20.4	97.3 ± 21.1	0.66

Table 2: Comparison of Sevoflurane Consumption per Hour Between Groups (Primary Outcome)

Variable	**BIS Group (n = 75) Mean ± SD**	**Conventional Group (n = 75) Mean ± SD**	**p-value**
Mean sevoflurane consumption per hour (ml/h)	12.4 ± 3.1	20.3 ± 4.2	<0.001*
End-tidal sevoflurane (%)	1.4 ± 0.3	2.1 ± 0.4	<0.001*
MAC value	0.72 ± 0.10	1.05 ± 0.14	<0.001*

Table 3: Comparison of Recovery Profile Between Groups

Recovery Parameter	**BIS Group Mean ± SD**	**Conventional Group Mean ± SD**	**p-value**
Time to eye opening (min)	7.8 ± 2.1	11.6 ± 3.2	<0.001*
Time to extubation (min)	8.2 ± 2.6	12.9 ± 3.8	<0.001*
Modified Aldrete Score at 10 min	9.1 ± 0.8	8.4 ± 0.9	0.002*

Table 4: Comparison of Haemodynamic Stability and Intraoperative Awareness

Parameter	**BIS Group (n = 75)**	**Conventional Group (n = 75)**	**p-value**
Mean Heart Rate (beats/min)	78.4 ± 8.1	80.2 ± 7.9	0.21
Mean Systolic BP (mmHg)	118.6 ± 10.4	120.1 ± 11.2	0.37
Mean Diastolic BP (mmHg)	74.2 ± 7.6	75.5 ± 8.0	0.34
Mean Arterial Pressure (mmHg)	88.9 ± 6.5	90.1 ± 6.8	0.28
Intraoperative Awareness	0 (0%)	1 (1.3%)	0.31

Figure 1: Comparison of sevoflurane consumption per hour between groups

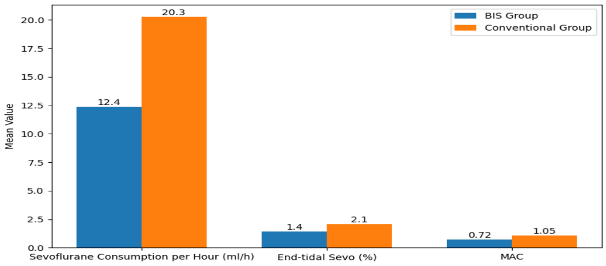


Figure 2: Comparison of recovery profile between groups

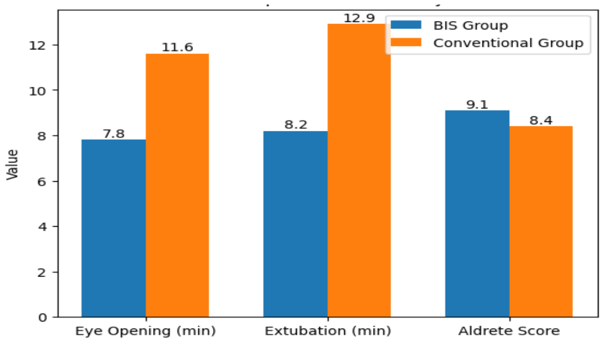
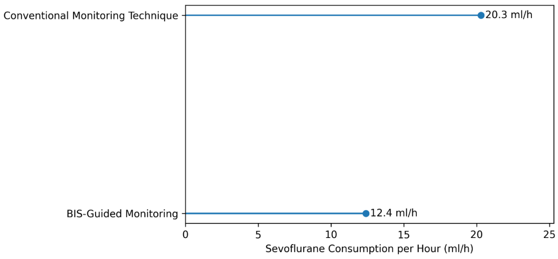


Figure 3: Effect of BIS-guided monitoring on sevoflurane consumption per hour



DISCUSSION

The present randomized controlled trial evaluated the effect of BIS-guided monitoring on sevoflurane consumption per hour during low-flow anesthesia. In this study, the mean sevoflurane consumption per hour in the BIS group was 12.4 ± 3.1 ml/h compared with 20.3 ± 4.2 ml/h in the conventional monitoring group, demonstrating a statistically significant reduction in volatile anesthetic usage ($p < 0.001$). These findings indicate that BIS-guided anesthesia allows more accurate titration of anesthetic depth and avoids excessive administration of volatile agents.

A randomized clinical trial conducted by Başar et al. evaluated the effect of BIS monitoring on sevoflurane anesthesia in patients undergoing abdominal surgery. The study reported that BIS-guided anesthesia resulted in reduced sevoflurane consumption and improved recovery profile, as anesthetic concentration was titrated to maintain BIS values between 40 and 60. Their findings demonstrated that BIS monitoring helps optimize anesthetic drug delivery during surgery [12].

Similarly, Aimé et al. reported that BIS-guided anesthesia reduced sevoflurane consumption compared with conventional monitoring techniques, indicating that EEG-based monitoring allows more accurate control of anesthetic depth and prevents unnecessary anesthetic administration [13]. These findings are comparable with this study, where BIS monitoring significantly reduced sevoflurane consumption per hour.

Another study by Yli-Hankala et al. evaluated BIS monitoring during sevoflurane and propofol anesthesia and reported that BIS guidance could reduce anesthetic consumption while also improving early recovery after anesthesia [14]. The reduction in anesthetic usage observed in the present study is consistent with these findings, suggesting that BIS monitoring can help optimize anesthetic dosing.

In addition to reduced anesthetic consumption, the present study demonstrated significantly faster recovery in the BIS group, where the time to eye opening was 7.8 ± 2.1 minutes compared with 11.6 ± 3.2 minutes in the conventional group, and the time to extubation was 8.2 ± 2.6 minutes compared with 12.9 ± 3.8 minutes. Similar findings were reported by Chaudhuri et al., who observed that BIS monitoring resulted in earlier extubation and improved recovery characteristics compared with end-tidal anesthetic gas monitoring [15].

A study comparing BIS monitoring with end-tidal anesthetic gas monitoring also reported that BIS-guided anesthesia significantly improved recovery parameters, including shorter extubation time and earlier postoperative responsiveness [16]. These results support the observation in this study that BIS-guided anesthesia may facilitate faster postoperative recovery by preventing excessive anesthetic exposure.

Regarding haemodynamic parameters, this study found that heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were comparable between the two groups ($p > 0.05$), indicating that BIS-guided titration of sevoflurane maintained adequate haemodynamic stability despite reduced sevoflurane consumption per hour. Similar findings were reported in previous clinical trials where BIS monitoring maintained stable haemodynamic parameters while reducing anesthetic drug requirements [17].

Another important aspect evaluated in the present study was intraoperative awareness. No patient in the BIS group experienced awareness, whereas one patient (1.3%) in the conventional monitoring group reported possible awareness. Although the difference was not statistically significant, several studies have suggested that BIS monitoring may help reduce the risk of intraoperative awareness by maintaining adequate hypnotic depth throughout the surgical procedure [18].

Large observational data evaluating BIS-guided anesthesia have also demonstrated a significant reduction in volatile anesthetic consumption in clinical practice. A real-world analysis involving thousands of anesthesia records reported that hourly sevoflurane consumption was significantly lower in BIS-guided anesthesia compared with standard monitoring techniques, confirming the economic and clinical advantages of BIS monitoring [19].

Overall, the findings of the present study are consistent with existing literature demonstrating that BIS-guided anesthesia during low-flow techniques significantly reduces sevoflurane consumption per hour, improves recovery profile, and maintains haemodynamic stability without increasing the risk of intraoperative awareness. These results support the use of BIS monitoring as an effective tool for optimizing anesthetic drug administration and improving perioperative outcomes.

CONCLUSION

The present randomized controlled trial demonstrated that BIS-guided monitoring during low-flow anesthesia significantly reduced sevoflurane consumption per hour compared with conventional monitoring techniques based on end-tidal anesthetic concentration and MAC. The mean sevoflurane consumption per hour in the BIS group was 12.4 ± 3.1 ml/h, which was significantly lower than the 20.3 ± 4.2 ml/h observed in the conventional monitoring group. In addition to reduced sevoflurane consumption per hour, BIS monitoring was associated with a faster recovery profile, as evidenced by shorter times to eye opening and extubation, along with higher Modified Aldrete Scores in the early postoperative period. Importantly, BIS-guided anesthesia maintained stable intraoperative haemodynamic parameters, and no cases of intraoperative awareness were reported in the BIS group. These findings suggest that BIS-guided anesthesia allows more precise titration of volatile anesthetics during low-flow anesthesia, resulting in improved efficiency, faster recovery, and potential reduction in anesthetic costs without compromising patient safety.

LIMITATIONS OF THE STUDY

Despite the significant findings, this study has several limitations. First, the study was conducted at a single tertiary care centre, which may limit the generalizability of the results to other healthcare settings. Second, the sample size of 150 patients, although adequate for statistical analysis, may not fully represent the variability in anesthetic requirements across different surgical populations. Third, the study included only ASA physical status I–II patients undergoing elective surgeries, and therefore the results may not be directly applicable to high-risk patients or emergency surgical procedures. Additionally, intraoperative awareness was assessed using the Modified Brice questionnaire, which relies on patient recall and may not detect all subtle awareness events. Finally, the study focused mainly on sevoflurane consumption per hour and recovery parameters, while other potential benefits of BIS monitoring such as long-term cognitive outcomes or environmental impact of anesthetic gases were not evaluated.

RECOMMENDATIONS

Based on the findings of this study, BIS-guided monitoring should be considered as a useful adjunct during low-flow anesthesia for optimizing anesthetic drug administration. Routine use of BIS monitoring may help anesthesiologists achieve more precise control of anesthetic depth, reduce sevoflurane consumption per hour, and enhance postoperative recovery. Future studies with larger sample sizes and multicentre designs are recommended to validate these findings in diverse surgical populations and clinical settings. Further research may also evaluate the cost-effectiveness of BIS monitoring, its role in high-risk surgical patients, and its potential impact on long-term postoperative outcomes and environmental sustainability in anesthesia practice.

REFERENCES

1. Brioni JD, Varughese S, Ahmed R, Bein B. Sevoflurane: a clinical review of inhalation anesthesia. J Anesth. 2017;31(2):281–290. doi:10.1007/s00540-016-2290-x
2. Shafiq F, Khan FA. Monitoring depth of anesthesia using bispectral index and MAC. J Anaesthesiol Clin Pharmacol. 2012;28(4):544–547. doi:10.4103/0970-9185.101939
3. Gan TJ, Glass PSA, Windsor A, Payne F, Rosow C, Sebel P, et al. Bispectral index monitoring allows faster emergence and improved recovery from anesthesia. Anesthesiology. 1997;87(4):808–815. doi:10.1097/00000542-199710000-00014
4. Başar H, Ozcan S, Buyukkocak U, Akpinar S, Apan A. Effect of bispectral index monitoring on sevoflurane consumption and recovery profiles. Eur J Anaesthesiol. 2003;20(5):396–400. doi:10.1017/S0265021503000622
5. Baum JA, Aitkenhead AR. Low-flow anaesthesia. Anaesth Analg. 2001;93(4):833–834. doi:10.1097/00000539-200110000-00001
6. Jeong SW, Lee HG, Kim WM, Yoon MH. Effect of bispectral index monitoring on anesthetic use during sevoflurane anesthesia. Korean J Anesthesiol. 2005;49(6):782–787. doi:10.4097/kjae.2005.49.6.782
7. Nair A, Saini S, Radhakrishnan M. Effect of BIS monitoring on sevoflurane consumption and recovery profile. Ain-Shams J Anesthesiol. 2021;13:54. doi:10.1186/s42077-021-00169-8
8. Avidan MS, Zhang L, Burnside BA, Finkel KJ, Searleman AC, Selvidge JA, et al. Anesthesia awareness and the bispectral index. N Engl J Med. 2008;358(11):1097–1108. doi:10.1056/NEJMoa0707361
9. Aimé I, Verroust N, Masson-Lefoll C, Taylor G, Laloë PA, Liu N, et al. Does monitoring bispectral index reduce sevoflurane consumption during anesthesia? Anesth Analg. 2006;102(1):152–158. doi:10.1213/01.ANE.0000181288.07570.A4

10. Hemmerling TM, Olivier JF, Basile F, Prieto I, Bracco D. Bispectral index-guided anesthesia reduces volatile anesthetic consumption. Anesth Analg. 2005;100(6):1733–1738. doi:10.1213/01.ANE.0000153014.74287.A3
11. Punjasawadwong Y, Phongchiewboon A, Bunchungmongkol N. Bispectral index monitoring for improving anesthetic delivery and postoperative recovery. Cochrane Database Syst Rev. 2014;(6):CD003843. doi:10.1002/14651858.CD003843.pub3
12. Yli-Hankala A, Vakkuri A, Annila P. EEG bispectral index monitoring in sevoflurane or propofol anesthesia. Anesth Analg. 1999;88(3):671–675. doi:10.1097/00000539-199903000-00037
13. Chaudhuri S, Sethi P, Sharma R. Comparison of recovery times using BIS versus end-tidal anesthetic gas monitoring during sevoflurane anesthesia. Indian J Anaesth. 2022;66(4):291–297. doi:10.4103/ija.ija_1030_21
14. Kumar N, Singh P, Sharma V. Role of bispectral index monitoring versus end-tidal anesthetic gas concentration in predicting extubation time. Int J Pharm Clin Res. 2022;14(4):147–152.
15. Poon YY, Chang HC, Chiang MH, Wu SC. Real-world evidence for reduction of volatile anesthetic consumption with BIS-guided anesthesia. Sci Rep. 2020;10:14554. doi:10.1038/s41598-020-71535-7