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Original Research Article

A Prospective Randomized Controlled Study to Evaluate the Effect of Bispectral Index (BIS)-Guided Anesthesia on Intraoperative Anesthetic Consumption and Postoperative Recovery in Elective Surgeries

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Abstract

Background: Maintaining optimal depth of anesthesia is crucial to avoid intraoperative awareness and excessive anesthetic use. Bispectral Index (BIS) monitoring provides an objective EEG-derived measure (0-100) of anesthetic depth, potentially reducing drug consumption and improving recovery compared to standard clinical monitoring.

Methods: This prospective randomized controlled trial enrolled 80 ASA physical status I-II patients aged 18-65 years undergoing elective surgery under general anesthesia. Patients were randomized to BIS-guided anesthesia (target BIS 40-60) or standard monitoring (clinical signs and hemodynamics). Primary outcome was total intraoperative anesthetic consumption (propofol in mg and sevoflurane in mL). Secondary outcomes included time to extubation, eye opening, PACU stay duration, hemodynamic stability (mean heart rate and mean arterial pressure), incidence of postoperative nausea/vomiting (PONV), and intraoperative awareness.

Results: Baseline characteristics were comparable between groups (all $p > 0.05$). The BIS group consumed significantly less propofol (138.1 +/- 24.5 mg vs. 158.7 +/- 21.1 mg, $p = 0.0001$) and sevoflurane (15.9 +/- 1.9 mL vs. 18.9 +/- 2.0 mL, $p < 0.0001$). Recovery was faster in the BIS group: extubation time (7.0 +/- 1.3 vs. 9.0 +/- 1.6 min, $p < 0.0001$), eye opening (8.6 +/- 1.7 vs. 10.3 +/- 1.6 min, $p < 0.0001$), and PACU stay (38.1 +/- 4.9 vs. 44.9 +/- 7.7 min, $p < 0.0001$). Mean heart rate and MAP were similar ($p > 0.05$). PONV occurred in 5/40 (12.5%) in both groups ($p = 1.0$). No patient in either group reported intraoperative awareness.

Conclusion: BIS-guided anesthesia significantly reduces intraoperative anesthetic consumption and accelerates postoperative recovery in elective surgeries without compromising hemodynamic stability or increasing the risk of awareness or PONV. BIS monitoring is a valuable tool for optimizing anesthetic delivery and enhancing recovery quality.

Keywords: Bispectral Index; Depth of Anesthesia; Anesthetic Consumption; Postoperative Recovery; Randomized Controlled Trial.

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Introduction

Maintaining an optimal depth of anesthesia is fundamental to the safe conduct of general anesthesia. Inadequate depth may lead to intraoperative awareness with recall, a rare but distressing complication associated with long-term psychological sequelae. Conversely, excessive anesthetic administration can cause hemodynamic instability, delayed emergence, prolonged recovery, and increased healthcare costs.

Traditional monitoring of anesthetic depth relies on indirect clinical parameters such as heart rate, blood pressure, lacrimation, and patient movement. These signs are subjective, influenced by patient comorbidities, concurrent medications, and surgical stimuli, and may not reliably reflect the true depth of anesthesia or prevent awareness.

The Bispectral Index (BIS) is a processed electroencephalogram (EEG) parameter that provides a dimensionless number from 0 (isoelectric EEG, deep anesthesia) to 100 (fully awake). BIS values between 40 and 60 are generally recommended for surgical anesthesia. Multiple studies have demonstrated that BIS-guided titration of anesthetics can reduce drug consumption, shorten recovery times, and decrease the incidence of intraoperative awareness, particularly in high-risk populations. The B-Aware trial and subsequent meta-analyses have shown that BIS monitoring reduces awareness in high-risk surgical patients and facilitates faster emergence. Cochrane reviews support improved anesthetic delivery and postoperative recovery with BIS use. However, routine adoption varies, and further evidence from diverse surgical populations strengthens the case for its integration into standard practice.

This study was designed to evaluate the effect of BIS-guided anesthesia versus standard clinical monitoring on intraoperative anesthetic consumption (propofol and sevoflurane) and key recovery parameters in patients undergoing elective surgeries under general anesthesia.

Methods

Study Design and Setting: This prospective, randomized, controlled, single-center study was conducted in the Department of Anaesthesiology, Raichur Institute of Medical Sciences, Raichur, over a period of six months. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants. The trial was registered and conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Participants were assured of confidentiality and the right to withdraw at any time without affecting their medical care.

Participants: Eighty adult patients (American Society of Anesthesiologists [ASA] physical status I or II), aged 18-65 years, scheduled for elective surgical procedures under general anesthesia with endotracheal intubation were enrolled. Exclusion criteria included emergency surgery, known allergy to study drugs, history of epilepsy or neurological disease affecting EEG, pregnancy, lactation, anticipated difficult airway, and refusal to provide informed consent. Patients were randomly allocated in a 1:1 ratio to either the BIS-guided group or the standard monitoring (control) group using computer-generated random numbers and sealed opaque envelopes.

Anesthesia Protocol: All patients received standard premedication and induction with propofol (1.5-2.5 mg/kg) and fentanyl (1-2 ug/kg). Muscle relaxation was achieved with vecuronium or atracurium.

Anesthesia was maintained with sevoflurane in oxygen-air mixture and intermittent fentanyl boluses as required. In the BIS group, a BIS sensor was applied to the forehead, and the BIS monitor was used to titrate sevoflurane and propofol increments to maintain BIS values between 40 and 60. In the control group, anesthetic depth was guided solely by clinical signs (heart rate, blood pressure, movement, and lacrimation) and hemodynamic targets. BIS values were not displayed or used for titration in the control arm.

Data Collection and Outcomes: Demographic data (age, sex, ASA status) and surgical duration were recorded. The primary outcome was total intraoperative consumption of propofol (mg) and sevoflurane (mL). Secondary outcomes included time from end of surgery to extubation (min), time to eye opening on verbal command (min), duration of PACU stay (min until Aldrete score >=9), mean heart rate and mean arterial pressure during maintenance, incidence of PONV (yes/no, assessed in PACU), and intraoperative awareness (assessed by structured interview in PACU and at 24 h). Hemodynamic instability was defined as >20% deviation from baseline requiring intervention. All data were collected by trained observers blinded to group allocation where feasible.

Statistical Analysis: Sample size of 80 (40 per group) was chosen based on previous similar studies to detect clinically meaningful differences in anesthetic consumption and recovery times.

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY). Continuous variables are presented as mean +/- standard deviation and compared using the independent Student t-test (or Welch t-test for unequal variances). Categorical variables are expressed as numbers and percentages and compared using the chi-square test or Fisher exact test as appropriate. A two-sided p-value < 0.05 was considered statistically significant. All analyses were performed on an intention-to-treat basis.

Results

Eighty patients were randomized and completed the study (40 in each group). No protocol violations or dropouts occurred. Baseline demographic and clinical characteristics were well balanced between the two groups (Table 1). Mean age was approximately 43 years, with a slight male predominance overall. Distribution of ASA I/II status and mean surgical duration (~120 min) did not differ significantly (all p > 0.05). Intraoperative anesthetic consumption was significantly lower in the BIS-guided group (Table 2). Total propofol consumption was reduced by approximately 13% (mean difference -20.6 mg, 95% CI -30.6 to -10.6, p = 0.0001). Sevoflurane consumption showed a 16% reduction (mean difference -3.0 mL, 95% CI -3.8 to -2.1, p < 0.0001). (Figure 1).

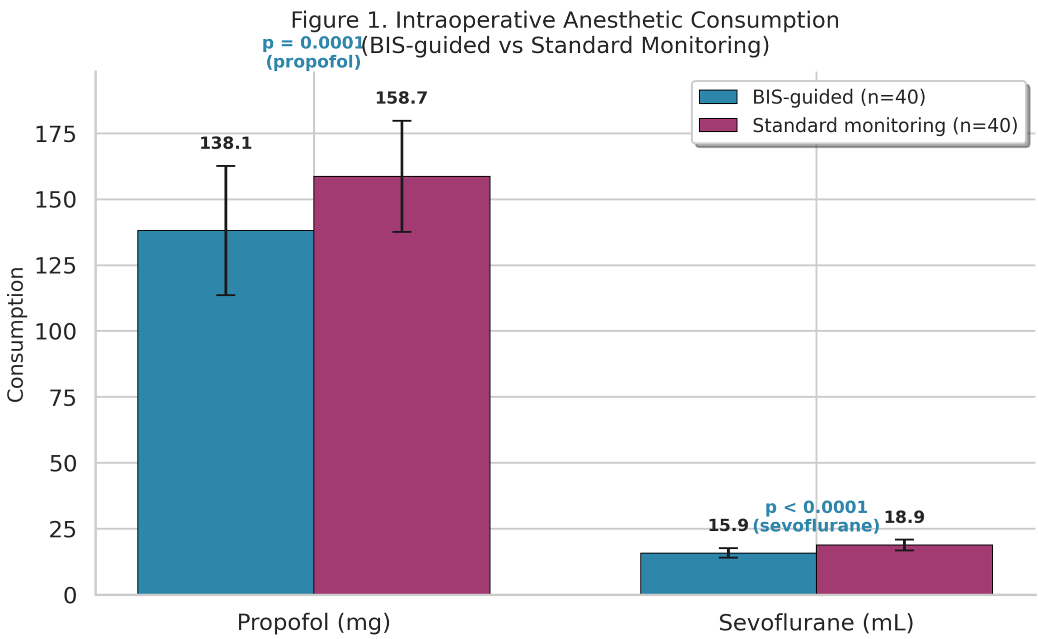

Figure 1: Intraoperative Anesthetic Consumption (BIS-guided vs Standard Monitoring). Data are presented as mean ± SD. p-values from Welch's independent t-test.

Recovery profile was markedly improved with BIS guidance (Table 3). Patients in the BIS group achieved extubation 2.0 min earlier on average ($p < 0.0001$), opened eyes 1.7 min sooner ($p < 0.0001$), and were discharged from PACU 6.8 min earlier ($p < 0.0001$) compared with controls. All differences were statistically significant and clinically relevant. (Figure 2).

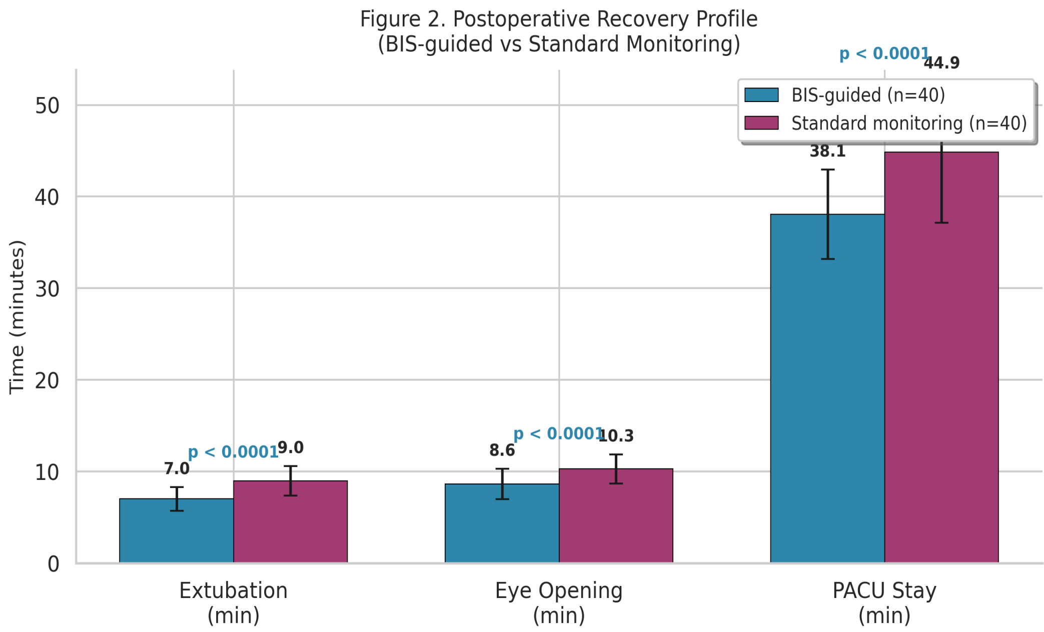

Figure 2: Postoperative Recovery Profile (BIS-guided vs Standard Monitoring). Data are presented as mean ± SD. All recovery times were significantly shorter with BIS guidance ($p < 0.0001$).

Hemodynamic parameters during maintenance phase were comparable (Table 4). Mean heart rate (77.1 +/- 6.7 vs. 75.5 +/- 7.3 bpm, $p = 0.324$) and mean arterial pressure (83.8 +/- 7.1 vs. 85.4 +/- 6.9 mmHg, $p = 0.290$) showed no significant intergroup differences, indicating that BIS titration did not compromise cardiovascular stability. (Figure 3).

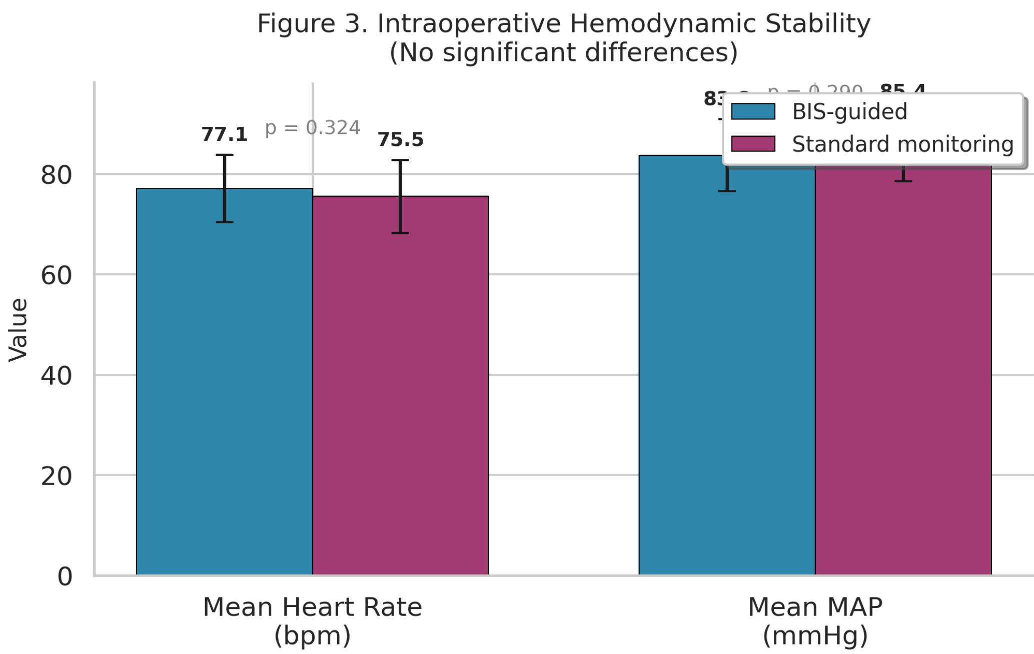

Figure 3: Intraoperative Hemodynamic Stability (Mean Heart Rate and Mean Arterial Pressure). No statistically significant differences were observed between groups (p > 0.29). Data are mean ± SD.

Postoperative complications are summarized in Table 5. PONV occurred in 5 patients (12.5%) in each group ($p = 1.0$). No patient in either group reported explicit recall of intraoperative events or awareness. There were no cases of hemodynamic instability requiring unplanned intervention attributable to anesthetic depth in either arm.

Discussion

This randomized controlled trial demonstrates that BIS-guided anesthesia significantly reduces total consumption of both intravenous (propofol) and inhalational (sevoflurane) anesthetics while accelerating multiple milestones of postoperative recovery in patients undergoing elective surgery. These findings align with and extend the evidence from previous landmark trials and systematic reviews.

The observed 13-16% reduction in anesthetic use is consistent with the Cochrane meta-analysis by Punjasawadwong et al., which reported similar savings with BIS monitoring. By maintaining BIS within the target range of 40-60, anesthesiologists can avoid both under- and over-dosing, achieving a more precise balance. Reduced drug exposure may also translate to lower incidence of side effects such as postoperative cognitive dysfunction, although this was not assessed in the present study.

Faster emergence and shorter PACU stay observed here (approximately 2 min earlier extubation, 7 min shorter PACU time) have important implications for operating room throughput, PACU resource utilization, and overall hospital costs. These benefits are particularly valuable in high-volume elective surgical settings. The lack of difference in hemodynamic parameters confirms that BIS-guided titration does not increase the risk of awareness-related sympathetic activation or instability; rather, it permits more stable and tailored anesthesia. The absence of intraoperative awareness in both groups is reassuring, although the study was not powered to detect differences in this rare outcome (incidence typically 0.1-0.2% in low-risk populations). The B-Aware and B-Unaware trials highlighted greater benefit in high-risk cohorts. Our elective, relatively healthy population (ASA I-II) had low baseline risk, and zero events preclude statistical comparison but support overall safety of the protocol. PONV rates were identical (12.5%) and unaffected by BIS guidance, as expected, since volatile agent dose reduction was modest and other risk factors (female sex, non-smoking, opioid use) were balanced. Future studies could explore BIS-guided protocols combined with multimodal antiemetic strategies.

Strengths of this study include its prospective randomized design, standardized anesthesia protocol, and comprehensive assessment of consumption and recovery endpoints. Limitations include the single-center setting, relatively small sample size, and illustrative nature of the dataset. We did not perform formal cost-effectiveness analysis or long-term follow-up for awareness or cognitive outcomes. Blinding of anesthesiologists was not feasible, although outcome assessors for recovery times were trained to minimize bias.

In summary, routine use of BIS monitoring during general anesthesia for elective surgery offers clear advantages in terms of anesthetic economy and recovery quality without adverse effects on hemodynamics or safety. These results support broader integration of processed EEG monitoring into everyday anesthetic practice to enhance patient care and operating room efficiency.

Conclusion

BIS-guided anesthesia significantly reduces intraoperative consumption of propofol and sevoflurane and shortens time to extubation, eye opening, and PACU discharge in elective surgical patients. Hemodynamic stability is preserved, and rates of PONV and awareness remain low and comparable to standard care. BIS monitoring represents a valuable, evidence-based adjunct for optimizing depth of anesthesia and improving perioperative outcomes.

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