RESEARCH PAPER

Effect Of BIS-Guided Propofol Infusion Compared To Conventional Weight-Based Infusion On Hemodynamic Stability And Recovery Profile In General

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ABSTRACT

Background: Propofol is widely used for induction and maintenance of general anaesthesia, with dosing traditionally based on body weight. Bi-spectral Index (BIS)–guided infusion allows titration according to clinical depth of anaesthesia, potentially improving hemodynamic stability and recovery profile. This study aimed to compare BIS-guided propofol infusion with conventional weight-based infusion on hemodynamic stability and recovery in patients undergoing various surgical procedures.

Methods: In this prospective randomized study, 121 adult patients (ASA I–II), aged 18–65 years, undergoing elective OBG, general surgery, ENT and orthopedic procedures under general anaesthesia were enrolled. Patients were randomly assigned to a BIS-guided group (Group B, n = 61) or a conventional weight- based infusion group (Group C, n = 60). Propofol was administered for maintenance via either BIS-guided titration (target BIS 40–60) or standard weight-based rate (100–200 $\mu g \cdot kg^{-1} \cdot min^{-1}$). Clinical depth markers, hemodynamic parameters (heart rate, mean arterial pressure), total propofol consumption, and recovery profiles (Modified Aldrete Score at 5, 10, 20 min) were recorded.

Results: Baseline demographics including age, gender distribution, and ASA class were comparable ($p > 0.05$). Group B demonstrated significantly lower total propofol consumption ($p < 0.01$), more stable intraoperative haemodynamics (reduced episodes of hypotension, $p < 0.05$), and faster recovery (higher Aldrete scores at 10 min, $p < 0.01$) compared to Group C. Incidence of postoperative nausea and vomiting was lower in Group B ($p < 0.05$).

Conclusion: BIS-guided propofol infusion improves haemodynamic stability, reduces hypnotic drug requirement, and enhances early recovery compared with conventional weight-based infusion in general anaesthesia. BIS-guided dosing is recommended for tailored anaesthesia delivery in elective surgical patients.

Keywords: BIS-guided infusion, propofol, haemodynamic stability, recovery, Modified Aldrete Score, general anaesthesia.

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INTRODUCTION

General anaesthesia is a reversible pharmacological state characterized by unconsciousness, amnesia, analgesia, and immobility, allowing surgical procedures to be performed safely and humanely. The anaesthesiologist's primary objectives during maintenance of general anaesthesia include ensuring adequate depth of hypnosis, preserving haemodynamic stability, preventing awareness, minimizing drug-related adverse effects, and facilitating rapid postoperative recovery. Achieving these goals requires precise titration of anaesthetic agents to balance adequate hypnosis with physiological stability.

Propofol remains one of the most widely used intravenous hypnotic agents for both induction and maintenance of general anaesthesia, particularly in total intravenous anaesthesia (TIVA) techniques. Its popularity stems from favorable pharmacokinetic and pharmacodynamic properties, including rapid onset of action, short context-sensitive half-time, predictable recovery profile, antiemetic properties, and reduced postoperative cognitive dysfunction when compared to volatile agents [1,2]. Propofol exerts its hypnotic effect primarily through potentiation of gamma-aminobutyric acid (GABA) activity at the GABA- A receptor, leading to central nervous system depression.Conventionally, maintenance of anaesthesia with propofol is achieved through continuous infusion based on body weight, typically ranging from 100–200 $\mu g \cdot kg^{-1} \cdot min^{-1}$. While weight-based dosing provides a standardized approach, it does not account for interindividual variability in pharmacodynamics and pharmacokinetics. Factors such as age, gender, body composition, surgical stimulus intensity, comorbidities, and concomitant medications influence anaesthetic requirements. As a result, weight-based infusion may lead to periods of excessive anaesthetic depth or inadequate hypnosis. Excessive dosing can produce hypotension, bradycardia, delayed emergence, and increased drug consumption, whereas underdosing may increase the risk of intraoperative awareness and sympathetic stimulation [3].

Intraoperative hemodynamic instability remains a significant concern during general anaesthesia. Propofol is known to cause dose-dependent vasodilation, myocardial

depression, and blunting of sympathetic tone, often resulting in hypotension and bradycardia. These hemodynamic fluctuations are particularly relevant in ASA I and II patients undergoing elective surgeries, where maintaining physiological stability contributes to improved perioperative outcomes. Even transient episodes of hypotension have been associated with increased postoperative complications, including myocardial injury and acute kidney injury in susceptible individuals. Therefore, individualized titration of anaesthetic depth is critical to minimizing hemodynamic disturbances.

Traditional methods of assessing depth of anaesthesia rely on clinical signs such as heart rate, blood pressure, lacrimation, sweating, movement, and pupil size. However, these clinical markers are indirect and may not reliably reflect cortical activity. Autonomic responses can be influenced by analgesics, beta- blockers, or surgical stimulation, thereby reducing their sensitivity and specificity as indicators of hypnotic depth. Consequently, there has been a growing interest in objective monitoring tools that directly assess brain activity.

The Bi-spectral Index (BIS) monitor represents a significant advancement in depth-of-anaesthesia monitoring. BIS is derived from processed electroencephalographic (EEG) signals and generates a dimensionless number ranging from 0 (isoelectric EEG) to 100 (fully awake). Values between 40 and 60 are generally considered optimal for adequate general anaesthesia, correlating with a low probability of awareness while avoiding excessive hypnotic dosing [4–6]. By providing continuous real-time assessment of cerebral activity, BIS monitoring allows anaesthesiologists to titrate propofol infusion more precisely.

Several studies conducted over the past decade have evaluated the role of BIS- guided anaesthesia in improving perioperative outcomes. Evidence suggests that BIS-guided propofol administration may reduce total drug consumption, decrease incidence of hypotension, shorten recovery time, and lower the risk of intraoperative awareness compared with conventional dosing strategies [7–10]. However, findings across surgical populations have been inconsistent. Differences in study design, patient demographics, type of surgery, adjunct analgesic techniques, and anaesthetic protocols contribute to variability in reported outcomes. Furthermore, while many studies focus on specific surgical specialties, fewer have evaluated heterogeneous surgical populations encompassing obstetrics and gynaecology (OBG), general surgery, otorhinolaryngology (ENT), and orthopaedics within a single framework.

Haemodynamic stability during anaesthesia is commonly evaluated through monitoring of heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP). A deviation of more than 20% from baseline values is generally considered clinically significant. Maintenance of stable haemodynamics is associated with reduced perioperative morbidity, improved organ perfusion, and enhanced patient safety. By preventing excessive hypnotic depth, BIS-guided titration may theoretically reduce vasodilatory and myocardial depressant effects of propofol, thereby minimizing episodes of hypotension and bradycardia.

Another critical endpoint in modern anaesthesia practice is quality and speed of postoperative recovery. Rapid recovery enables early neurological assessment, facilitates fast-tracking in ambulatory settings, reduces PACU stay, and optimizes operating room turnover. The Modified Aldrete Score remains a validated and widely accepted tool for assessing readiness for discharge from the post-anaesthesia care unit (PACU). It evaluates five parameters: activity, respiration, circulation, consciousness, and oxygen saturation, each scored from 0 to 2, with a maximum score of 10. A score of 9 or above typically indicates suitability for PACU discharge [12–14]. Residual sedation due to excessive propofol dosing can delay attainment of adequate Aldrete scores, prolong PACU stay, and increase resource utilization [15].

In addition to recovery time, total anaesthetic consumption is an important economic and clinical parameter. Drug-sparing strategies contribute to cost reduction and may minimize adverse effects. BIS-guided protocols have been associated with reduced propofol requirements in some studies, suggesting improved titration efficiency. However, cost-effectiveness analyses must consider the additional expense of BIS electrodes and monitoring systems. Therefore, evaluation of clinical benefit in terms of haemodynamic stability and recovery profile is essential to justify routine implementation.

ASA physical status I and II patients represent a relatively healthy surgical cohort; nevertheless, anaesthetic-induced haemodynamic disturbances may still occur. Evaluating BIS-guided infusion in this population helps determine whether benefits extend beyond high-risk or elderly groups. Furthermore, inclusion of diverse surgical specialties such as OBG, general surgery, ENT, and orthopaedics enhances generalizability of findings and reflects real-world clinical practice.

Despite growing adoption of depth-of-anaesthesia monitoring, universal guidelines do not mandate BIS usage in all patients undergoing TIVA. Clinical judgment remains central to anaesthetic titration. Therefore, comparative studies examining objective EEG-based monitoring versus conventional weight-based dosing are crucial to establish evidence-based practice.

The present prospective randomized study aims to compare BIS-guided propofol infusion with conventional weight-based infusion in 121 adult patients undergoing elective surgeries under general anaesthesia. By evaluating haemodynamic parameters, clinical

depth markers, total propofol consumption, and recovery profile using the Modified Aldrete Score, this study seeks to provide comprehensive evidence regarding the clinical advantages of BIS-guided anaesthesia.

This investigation addresses an important clinical question: Does objective EEG-guided titration translate into meaningful improvements in haemodynamic stability and early recovery when compared with standard infusion techniques? Clarifying this relationship may influence routine anaesthesia practice, optimize drug delivery strategies, enhance patient safety, and improve perioperative outcomes across multiple surgical disciplines.

In an era emphasizing patient-centered care, enhanced recovery pathways, and cost-conscious resource utilization, individualized anaesthetic titration represents a critical advancement. By integrating objective monitoring with established clinical assessment, anaesthesiologists can move toward precision-based anaesthesia. This study therefore contributes to the evolving understanding of optimized propofol delivery in contemporary general anaesthesia practice.

METHODS

This prospective randomized controlled study was conducted in the Department of Anesthesiology of a tertiary care teaching hospital between January 2024 and December 2025 attached to Symbiosis Medical College for Women, Pune after institutional ethics committee approval and written informed consent.

Study Design and Population: A total of 121 adult patients (ASA I–II), aged 18– 65 years, scheduled for elective OBG, general surgery, ENT, and orthopedic procedures under general anaesthesia were enrolled. **Group Allocation:** Patients were randomly allocated using computer-generated randomization into: - Group B (BIS-guided group) – n = 61 - Group C (Conventional weight-based group) – n = 60 Allocation concealment was done using sealed opaque envelopes. **Inclusion Criteria:** Age 18–65 years - ASA I–II - Elective surgery under GA Expected duration 60–180 minutes. **Exclusion Criteria**: ASA III and above - Neurological disorders - Severe cardiac/hepatic disease - BMI > 35 kg/m² - Pregnancy (except elective OBG procedures) **Anaesthesia Protocol:** All patients received standard monitoring (ECG, NIBP, SpO_2, $ETCO_2$). **Induction:** - Propofol 2 mg/kg - Fentanyl 2 µg/kg - Vecuronium 0.1 mg/kg Maintenance: - **Group B:** Propofol infusion titrated to maintain BIS value 40–60. **Group C**: Propofol infusion at 100–200 $\mu g \cdot kg^{-1} \cdot min^{-1}$ adjusted by clinical signs. Ventilation was controlled to maintain $ETCO_2$ 35–40 mmHg. **Demographic Data** Collected were Age, Gender, BMI, ASA classification - Type and duration of surgery **Study Variables: Primary Outcome**: Intraoperative hemodynamic stability (HR, MAP deviations >20% from baseline). **Secondary Outcomes:** - Total propofol consumption (mg), Episodes of hypotension (MAP < 65 mmHg), Episodes of bradycardia (HR < 50 bpm), Modified Aldrete Score at 5, 10, and 20 minutes, Incidence of postoperative nausea and vomiting (PONV). **Statistical Analysis**: Data was analysed using SPSS v25. Continuous variables were expressed as mean ± SD and compared using Student's t-test. Categorical variables were analysed using Chi-square test. $p < 0.05$ was considered statistically significant.

RESULTS

1. Demographic Characteristics

Demographic Characteristics Both groups were statistically comparable with respect to baseline demographic variables and surgical characteristics, ensuring homogeneity and minimizing confounding bias. No significant difference was observed in age distribution, gender ratio, BMI, ASA status, or duration of surgery ($p > 0.05$). This confirms successful randomization.

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Table 1: Demographic and Baseline Characteristics

Variable	Group B (n-61)	Group C (n-60)	P value
Age in years	42.3± 11.4	41.8 ± 10.G	0.78
Gender (M/F)	32/3G	31/2G	0.G4
BMI (Kg.m2)	24.8±3.1	25.1±3.4	0.62
ASA I/II	36/25	34/26	0.81
Duration of Surgery (min)	112±28	10G±31	0.56

Interpretation: The absence of statistically significant differences confirms that outcome variations are attributable to the intervention rather than demographic imbalance.

2. Intraoperative Haemodynamic Parameters Haemodynamic stability was assessed by monitoring heart rate (HR) and mean arterial pressure (MAP) deviations greater than 20% from baseline. Group B exhibited significantly fewer episodes of hypotension and reduced MAP variability compared to Group C.

Table 2: Haemodynamic Events

Parameter	**Group B (n-61)**	**Group C (n-60)**	**P value**
Hypotension Episodes (%)	**14.7%**	**33.3%**	**0.02**
Bradycardia Episodes (%)	**8.1% (5 Patients)**	**15.0%-(G Patients)**	**0.0G**
MAP Variability (>20%)	**18.0%**	**36.7%**	**0.03**

Statistically significant Interpretation: BIS-guided titration resulted in significantly fewer hypotensive episodes and better MAP control. Bradycardia incidence was comparable between groups.

3. **Total Propofol Consumption** Total intraoperative propofol requirement was significantly lower in the BIS-guided group.

Table 3: Total Propofol Consumption

Parameter	Group B **(n-61)**	Group C **(n-60)**	P value
Total Propofol (mg)	786 ± 125	932 ± 148	**0.01**

Interpretation: BIS monitoring reduced propofol consumption by approximately 15–18%, indicating more precise titration and drug-sparing effect.

4. **Recovery Profile** (Modified Aldrete Score) Postoperative recovery was assessed at 5, 10, and 20 minutes in PACU using the Modified Aldrete Score.

Table 4: Modified Aldrete Scores (n-121)

Time after Extubating	Group B	Group C	P value
5 minutes	7.2 ± 0.8	6.9 ± 0.9	0.07
10 minutes	9.1 ± 0.6	8.3 ± 0.7	<0.01
20 minutes	9.8 ± 0.4	9.4 ± 0.5	0.01

Statistically significant Interpretation: Although early (5 min) recovery was comparable, Group B achieved significantly higher Aldrete scores at 10 and 20 minutes, indicating faster and smoother emergence.

5. **Postoperative Nausea and Vomiting (PONV)** The incidence of PONV was significantly lower in the BIS-guided group.

Table 5: Incidence of PONV

Parameter	Group B	Group C	P value
PONV (%)	**6.5% (4 Patients)**	**18.3% (11 Patients)**	**0.04**

Statistically significant Interpretation: Reduced propofol variability and optimized dosing in the BIS group likely contributed to decreased PONV incidence.

Summary of Key findings: Comparable baseline demographics - Significantly fewer hypotensive episodes in BIS group - Reduced propofol requirement - Faster attainment of Aldrete ≥ 9 - Lower PONV incidence These findings collectively support improved haemodynamic control and enhanced early recovery with BIS-guided propofol infusion.

DISCUSSION:

Discussion The present study evaluated the impact of Bispectral Index (BIS)- guided propofol infusion on intraoperative haemodynamics, total anaesthetic consumption, recovery profile, and postoperative nausea and vomiting (PONV). The findings clearly demonstrate that BIS guidance results in significantly fewer hypotensive episodes, reduced mean arterial pressure (MAP) variability, lower total propofol requirement, improved Modified Aldrete Scores at 10 and 20 minutes, and a reduced incidence of PONV. These findings collectively reinforce the clinical utility of objective depth-of-

anaesthesia monitoring in enhancing perioperative safety and recovery quality. ### Haemodynamic Stability In our study, Group B (BIS-guided) exhibited significantly fewer hypotensive episodes (14.7% vs 33.3%, p = 0.02) and reduced MAP variability (>20% deviation) compared to the conventional group. Excessive anaesthetic depth is a well-recognized contributor to intraoperative hypotension. By targeting an optimal BIS range, anaesthesiologists can avoid inadvertent overdosing of propofol, thereby minimizing vasodilation and myocardial depression. These findings align with Khurana et al. (2023) [9], who reported improved haemodynamic stability in general surgical patients receiving BIS-guided total intravenous anaesthesia (TIVA). Similarly, Lee et al. (2023) [11] emphasized that haemodynamic variability is independently associated with adverse postoperative outcomes, particularly in orthopaedic populations. Their findings underscore the importance of maintaining stable MAP during surgery, not merely preventing awareness. The reduced hypotension observed in our BIS group may therefore translate into improved end-organ perfusion, especially in vulnerable patient populations. Although our study excluded ASA III–IV patients, the haemodynamic benefit observed suggests potential advantages in higher-risk cohorts, warranting further investigation. ### Reduction in Propofol Consumption A significant reduction in total propofol consumption was observed in the BIS group (786 ± 125 mg vs 932 ± 148 mg, p < 0.01), representing approximately 15–18% drug savings. This finding supports the concept that clinical signs alone often lead to overestimation of anaesthetic requirement. Punjasawadwong et al. (2020) [4],
in their systematic review and meta-analysis, demonstrated that BIS monitoring reduces anaesthetic exposure and improves titration precision. Similarly, Cao et al. (2023) [6] reported reduced propofol consumption in ambulatory anaesthesia settings when BIS guidance was employed. Joshi et al. (2022) [8] further confirmed the drug-sparing effect of BIS-guided TIVA, attributing it to avoidance of unnecessarily deep hypnotic states. Reduced propofol consumption carries multiple clinical implications. Besides cost-effectiveness, it decreases cardiovascular depression and facilitates faster elimination, particularly relevant in short surgical procedures and ambulatory settings. In resource-limited environments, optimized drug utilization also contributes to economic sustainability. ### Recovery Profile and PACU Outcomes The Modified Aldrete Score was significantly higher in the BIS group at 10 and 20 minutes post-extubation, indicating faster recovery and smoother emergence. While early (5-minute) recovery was comparable, the divergence at later time points suggests that precise intraoperative titration influences emergence kinetics. Kim et al. (2024) [10] reported similar findings in ENT surgeries, where BIS-guided anaesthesia resulted in faster extubation and improved early recovery indices. Kapoor et al. (2021) [13] and Dey et al. (2024)
[15] also demonstrated improved PACU metrics, including shorter recovery times and earlier readiness for discharge, with depth-of-anaesthesia monitoring. The physiological basis for faster recovery likely relates to avoidance of drug accumulation and excessive central nervous system depression. Lower cumulative propofol doses reduce context-sensitive half- time and facilitate rapid restoration of consciousness and airway reflexes. ### Postoperative Nausea and Vomiting (PONV) The incidence of PONV was significantly lower in the BIS-guided group (6.5% vs 18.3%, p = 0.04). Although propofol itself has antiemetic properties, fluctuations in anaesthetic depth and haemodynamic instability may contribute to increased PONV. By maintaining stable hypnotic depth and minimizing overdosage, BIS guidance may indirectly reduce postoperative emetogenic triggers. This observation is consistent with broader literature indicating improved recovery quality with depth monitoring. Reduced anaesthetic exposure and smoother emergence likely contribute to lower autonomic disturbances and reduced emetic reflex activation. ### Prevention of Awareness and Titration Accuracy Myles et al. (2022) [5] confirmed that BIS targeting reduces awareness risk while improving anaesthetic titration. Although awareness was not specifically assessed in our study, maintaining BIS within recommended ranges ensures adequate hypnosis without unnecessary excess. The balance between preventing awareness and avoiding over-sedation is central to modern anaesthesia practice. Our findings suggest that BIS not only serves as a safeguard against intraoperative awareness but also optimizes pharmacodynamic precision. ### Mechanistic Considerations The observed benefits in our study can be mechanistically explained by: 1. Avoidance of excessive hypnotic depth 2. Reduced vasodilatory and myocardial depressant effects 3. Lower cumulative anaesthetic burden 4. Improved haemodynamic stability 5. Faster central nervous system recovery These mechanisms operate synergistically to enhance perioperative outcomes.

Limitations: Despite the encouraging findings, certain limitations must be acknowledged. The study was conducted in a single centre, potentially limiting generalizability. High-risk ASA III–IV patients were excluded, preventing extrapolation to critically ill populations. Long-term postoperative outcomes and cost-analysis were not evaluated. Furthermore, blinding of the anaesthesiologist was not feasible due to the nature of BIS monitoring. Future multicentre randomized trials including high-risk patients and long-term outcome measures would strengthen the evidence base.

CONCLUSION

The present study adds to the growing body of literature supporting BIS-guided anaesthesia. By significantly reducing hypotension, minimizing MAP variability, decreasing total propofol consumption, accelerating postoperative recovery, and lowering PONV incidence, BIS monitoring enhances both intraoperative safety and early postoperative quality of recovery. These findings support routine incorporation of depth-of-anaesthesia monitoring, particularly in TIVA- based protocols, to achieve precise titration and optimized patient outcomes. Certainly.

Limitations: Despite demonstrating significant clinical benefits of BIS-guided propofol infusion, the present study has several limitations that should be acknowledged. First, this was a single-centre study, which may limit the generalizability of the findings to other institutions with different patient populations, surgical practices, or anaesthetic protocols. Multicentre trials would provide broader external validity. Second, the study excluded high-risk patients (ASA III and IV). Therefore, the results cannot be extrapolated to patients with significant cardiovascular, respiratory, or systemic comorbidities. Since haemodynamic stability is particularly critical in such populations, future studies including high-risk cohorts are warranted. Third, blinding of the anaesthesiologist was not feasible due to the nature of BIS monitoring. This may introduce performance bias, as the treating anaesthesiologist was aware of group allocation. However, objective outcome measures such as propofol consumption, MAP variability, and Modified Aldrete Scores reduce the likelihood of substantial subjective bias. Fourth, long-term postoperative outcomes such as hospital stay duration, patient satisfaction scores, cognitive recovery, and cost-effectiveness analysis were not evaluated. Inclusion of these parameters would provide a more comprehensive understanding of the clinical and economic impact of BIS monitoring. Fifth, the sample size, though adequate to detect significant differences in primary outcomes, may not be powered sufficiently to evaluate rare adverse events such as intraoperative awareness. Finally, the study focused primarily on propofol-based anaesthesia. The findings may not be directly applicable to volatile anaesthetic techniques without further comparative research.

CONCLUSION BIS-guided propofol infusion provides: - Superior haemodynamic stability - Reduced propofol requirement - Faster early recovery - Lower incidence of PONV Routine BIS-guided titration may enhance precision anaesthesia delivery in elective surgical patients undergoing TIVA.

Author Contributions:

Author 1: Conceptualization of study design; formulation of research hypothesis; supervision of patient recruitment; intraoperative anaesthesia management; data interpretation; drafting and critical revision of the manuscript; final approval of the version to be published.

Author 2: Data collection and patient enrolment; intraoperative monitoring documentation; statistical analysis; preparation of tables and results section; literature review and referencing; contribution to manuscript drafting.

Author 3: Methodology design support; ethical approval coordination; data verification and validation; critical review of discussion and interpretation; editing for scientific accuracy; overall administrative oversight. All authors contributed substantially to the study conception, design, data acquisition, analysis, and manuscript preparation. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

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