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EFFECTIVENESS OF BISPECTRAL INDEX (BIS) MONITORING ON POSTOPERATIVE RECOVERY AND SEVOFLURANE CONSUMPTION AMONG MORBIDLY OBESE PATIENTS UNDERGOING LAPAROSCOPIC BARIATRIC SURGERY

[1]Dr Anshuman Dutta, [2]Dr Aditi Dugaya, [3]Dr Deepak Gupta

[1,2]Senior Resident, [3]Assistant Professor; Department of Anesthesia, Government Medical College, Ratlam

Abstract

Introduction: In India, obesity rates are rising, posing significant challenges for anesthesiologists managing morbidly obese patients. Due to differences in how these patients process drugs, dosing anesthetic medications can be complicated compared to those with normal BMI. Achieving early and smooth postoperative recovery in morbidly obese patients is a significant challenge for anesthesiologists. Titrating the administration of inhaled anesthetics like sevoflurane using bispectral index (BIS) monitoring may be beneficial in these patients to speed up emergence and reduce anesthetic consumption. This study aims to determine if BIS-guided titration of sevoflurane can shorten recovery time and decrease sevoflurane usage while maintaining adequate anesthesia in morbidly obese patients undergoing surgery.

Material & Methods: After obtaining IEC approval, this study was conducted on 60 morbidly obese ASA I & II patients undergoing laparoscopic surgical procedures. The patients were divided into two groups: a control group (30 patients) and a BIS group (30 patients). In the control group, sevoflurane was administered according to standard clinical practice without BIS monitoring. In the BIS group, sevoflurane was titrated to maintain a BIS value between 40-60 during surgery and 60-70 for 15 minutes before surgery ended. Recovery times were recorded, including extubation time and the time to reach a modified Aldrete score of 9, evaluated at 10-minute intervals for up to 3 hours post-surgery by blinded nurses. Sevoflurane consumption was calculated using the vaporizer weighing method**.**

Results: Patients in the BIS group had statistically significant shorter awakening and extubation times compared to those in the non-BIS group. ($P<0.05$) Although there was no notable difference between the two groups regarding the time required to achieve an Aldrete score of 9, the BIS group demonstrated lower sevoflurane consumption and reduced as compared to the non-BIS group. ($P<0.05$)

Conclusion: Monitoring anesthesia in morbidly obese patients using the Bispectral Index results in a statistically significant reduction in recovery times. This method also provides the added advantage of decreasing sevoflurane consumption, making it a more efficient option during surgical procedures.

Keywords: Morbid Obesity, Bispectral index, Sevoflurane

INTRODUCTION

Obesity poses significant challenges for anesthesiologists, as it is often accompanied by comorbid conditions such as hypertension, diabetes, and accelerated atherosclerosis. [1] Morbidly obese patients face various anesthesia-related concerns, including difficulties in positioning, mask ventilation, intubation, and a higher frequency of perioperative respiratory and cardiovascular events. Additionally, altered pharmacokinetics and pharmacodynamics in these patients can lead to delayed awakening and recovery from general anesthesia. [2,3]

Electroencephalographic monitors, such as the bispectral index (BIS), have demonstrated improved titration of anesthetic drugs during general anesthesia. [4,5] BIS monitoring has been shown to optimize anesthesia levels, leading to potentially faster awakening, reduced recovery time, and decreased anesthetic drug consumption. [5] BIS monitoring could significantly benefit morbidly obese patients by facilitating rapid emergence, early extubation, and quicker postoperative recovery from general anesthesia. [6]

Bispectral index (BIS) monitoring is beneficial in reducing the total amount of anesthetic used, thereby decreasing emergence and recovery times. Its potential is particularly significant in morbidly obese patients, where titrating anesthetics like sevoflurane could lead to faster recovery and reduced anesthetic consumption, especially given the high cost of sevoflurane. [7] However, no studies have yet explored the specific benefits of using BIS to guide sevoflurane administration in this patient group.

This randomized comparative study aimed to examine the impact of combining conventional monitoring with BIS monitoring on awakening time, extubation time, and postoperative recovery in morbidly obese patients undergoing laparoscopic bariatric surgery. These patients were administered sevoflurane as an inhalational anaesthetic during the maintenance of anesthesia. The study compared the effectiveness of conventional monitoring, which included heart rate, arterial blood pressure, electrocardiogram, oxygen saturation, temperature, end-tidal carbon dioxide, and urine output, with the additional use of BIS monitoring to determine its effects on anesthesia management. The secondary objective is the to show whether BIS monitoring would contribute to reduction of the amount of sevoflurane administered while at the same two providing an adequate anesthesia.

MATERIAL & METHODS

After institutional Review Board approval, 60 morbidly obese (BMI >35 kg/m^2), ASA I & II patients posted for laparoscopic bariatric procedures were enrolled to participate in the study. Patients satisfying the inclusion criteria were enrolled after obtaining a written informed consent. Confidentiality of the data was maintained.

Inclusion Criteria:

- Morbidly obese patients electively scheduled for laparoscopic bariatric surgery
- Adult patients of either gender aged 20-50 years and
- ASA Grade I & II patients.
- BMI >35 kg/m^2
- Patients who consented for the study.

Exclusion Criteria

- All patients with history of renal, hepatic or neurological dysfunction
- Patients with history of use of benzodiazepines, anticonvulsants, alcohol, opioids or other psychotropic drugs.
- Non consenting patients.

Methodology

All patients meeting the inclusion criteria were randomly assigned into two groups of 30 each using an odd-even method. Group I, the non-BIS (control) group, received standard sevoflurane anesthesia without BIS monitoring. Group II, the BIS group, had their sevoflurane titrated to maintain a BIS value between 40 and 60 during surgery and between 60 and 70 for the last 15 minutes before the end of the procedure.

Recovery times were defined from the end of surgery and included the following metrics: Time to awakening, measured by the patient's ability to open their eyes in response to verbal commands, was assessed at 1-minute intervals by the anesthetist. Time to extubation and the time to achieve a modified Aldrete score of 9 were recorded by nurses at 10-minute intervals until 3 hours after surgery. The nurses conducting these evaluations were unaware of the study's specifics. Medications were dosed based on the patient's ideal body weight, and no sedative premedication was administered prior to surgery.

All patients, considered to have full stomachs, were premedicated with oral pantoprazole 40 mg the night before and metoclopramide 10 mg one hour prior to surgery, along with sips of water. On the surgery day, baseline vitals were recorded in the preoperative room. Patients were preloaded with 1 liter of Ringer's lactate and preoxygenated for 3 minutes with 100% oxygen. Induction included intravenous xylocaine 1.5 mg/kg, fentanyl 2 µg/kg, propofol 1.5-2 mg/kg, and rocuronium 0.9 mg/kg for tracheal intubation and neuromuscular blockade.

Anesthesia maintenance involved 40% oxygen mixed with air to maintain an end-tidal carbon dioxide concentration of 35-40 mmHg. Conventional monitoring was performed with pulse oximetry (SpO_2), non-invasive blood pressure (BP), electrocardiogram, end-tidal carbon dioxide ($EtCO_2$), and a nasopharyngeal temperature probe. In the BIS group, Bispectral index monitoring (BIS A-2000 software 2.21, Aspect Medical Systems, Newton, and Mass) was started at induction with a smoothing time of 30 seconds, and desflurane was administered at 6% in 2 liters/minute fresh gas flow. Sevoflurane at a concentration of 2% with a fresh gas flow of 2 L/min, mixed in air and oxygen, was administered to all patients for 5 minutes following endotracheal intubation and up until the skin incision. Following this initial period, the concentrations were adjusted every 5 minutes as needed.

- **BIS Group:** The anesthesiologist monitored the BIS value and adjusted the concentration of sevoflurane to keep the BIS value between 40 and 60 for optimal anesthesia. (N=30)
- **Non-BIS (Control) Group:** The anesthesiologist relied solely on clinical signs and standard monitoring parameters to adjust the concentration of sevoflurane, without any input from the BIS monitor. (N=30)

Sevoflurane consumption was calculated using the vaporizer weighing method.

During the operation, patients in both groups were closely monitored for signs of inadequate anesthesia, as outlined in Table 1. Significant hypotension or bradycardia was characterized by a 20% reduction from the baseline figures. In cases where inadequate anesthesia was detected, the concentration of sevoflurane was increased to manage the situation effectively.

Hypertension: blood pressure	20% increase from baseline
Relative tachycardia: heart rate	90 beats min/L
Somatic	movement, grimacing, eye opening, coughing

Table 1. Criteria for inadequate anesthesia

Atracurium was used to maintain neuromuscular blockade, ensuring a single twitch response in the train-of-four stimulation. In the last 15 minutes of surgery, the BIS value was gradually adjusted to between 60 and 70 by reducing the inhaled anesthetic concentration. Approximately 15 minutes before the end of the procedure, 100 µg of intravenous fentanyl was administered to manage early postoperative pain.

Before the skin was closed and the surgical dressing applied, the neuromuscular blockade was reversed with neostigmine at a dose of 0.07 mg/kg and glycopyrrolate at 0.015 mg/kg. After applying the dressing, fresh gas flows were increased to 10 L/min, and the anesthetic was stopped. Mechanical ventilation, set at 10 mL/kg based on ideal body weight, continued until the first spontaneous breath was noted, followed by assisted manual ventilation.

The anesthesiologist gave verbal commands every 10 seconds for the patient to open their eyes. Once the train-of-four ratio exceeded 0.9, a head lift lasting five seconds was performed to ensure adequate recovery from anesthesia, after which patients were extubated.

The time from stopping the anesthetic to eye-opening and extubation was recorded by blinded study personnel. After extubation, patients were transferred to the Post-Anesthesia Care Unit (PACU), where nurses, unaware of the study's specifics, assessed the time required to reach a modified Aldrete score of ≥9 at 10-minute intervals for up to three hours post-surgery.

Postoperative pain was assessed every five minutes using a verbal rating scale ranging from 0 to 4, where 0 indicated no pain, and 4 indicated severe pain. Pain scores were managed with 100 mg of Ketoprofen administered intramuscularly. Upon discharge from the recovery room and again 24 hours post-surgery, patients were questioned about any dreams or recollection of intraoperative events.

Sevoflurane Consumption

To measure anesthetic consumption, the sevoflurane vaporizer was filled and weighed before induction. After the anesthesia concluded, the vaporizer was disconnected and weighed again. Anesthetic consumption was calculated in grams per minute and recorded for each patient. The conversion from grams to milliliters was accomplished using the specific gravity of sevoflurane, which is 1.52 g/mL. Subsequently, the average consumption for each group was calculated, and the difference in consumption between the two groups was expressed in mL/h. The results were statistically analyzed using Student's t-test, with a significance level of $P < 0.05$.

Statistical Analysis

Raw data was collected statistically and entered on Microsoft excel sheet 10.0 and analyzed using SPSS software 22.0 version. For variables with a normal distribution, the data were presented as Mean ± SD. For variables that were not normally distributed, the data were expressed as the median with an interquartile range. Categorical variables were represented as percentages or proportions. To compare normally distributed continuous variables, either an independent sample t-test or ANOVA was utilized, depending on the number of groups. For non-normally distributed continuous variables, comparisons were made using the Mann-Whitney U Test or the Kruskal-

Wallis H Test. Categorical variables were compared using either the Chi-Square Test or Fisher's Exact Test, based on the sample size. Continuous variables such as heart rate (HR), mean arterial pressure (MAP), duration of anesthesia, recovery times, and sevoflurane consumption were compared using two-sample unpaired Student's t-tests. A p-value of less than 0.05 was regarded as statistically significant.

RESULTS

In this study, sixty morbidly obese patients were included and divided equally into two groups, each containing 30 participants: the non-BIS group (Control) and the BIS group. Both groups were comparable in terms of age, height, weight, BMI, and duration of anesthesia. Additionally, there were no statistical differences observed in the intraoperative mean heart rate and mean blood pressure between the groups.

Awakening and Extubation Times: The time to awakening and extubation (from the end of the operation to the time of following a verbal command) was significantly shorter for patients in the BIS group:

- **Awakening Time:** Non-BIS group: 8.64 ± 2.4 minutes; BIS group: 6.76 ± 2.11 minutes (P < 0.05*).
- **Extubation Time:** Non-BIS group: 11.74 ± 2.4 minutes; BIS group: 9.24 ± 2.10 minutes (P < 0.05*).

Aldrete Score: There was statistically significant difference between the BIS and Non-BIS groups in the time taken to achieve an Aldrete score of ≥9 i.e., 40.80 ± 3.86 and 31.60 ± 3.86: P<0.05.

Sevoflurane Consumption: The BIS group used significantly less sevoflurane per hour compared to the non-BIS group, resulting in lower costs i.e., 15.66 ± 4.04 ml and 19.60 ± 3.94 ml, respectively. (P < 0.05*).

Postoperative Observations: No patients in either group reported recall or dreaming during their stay in the recovery room or 24 hours post-surgery. All patients were fully awake and free of complications during the three-hour postoperative period.

	Non-BIS group (Control n = 30)	**BIS group (n = 30)**	**P value**
Gender (M/F)	22/8	18/12	---
ASA (I & II)	29/10	16/14	---
Age (yr)	40.2 ± 5.12	38.9 ± 4.51	**>0.05**
Weight (kg)	125.84 ± 11.8	123.8 ± 11.5	**>0.05**
Height (Cm)	181.2 ± 8.2	176.8 ± 9.7	**>0.05**
BMI (kg/m^2)	44.8 ± 7.2	43.5 ± 5.17	**>0.05**
Total duration of anesthesia (min)	138.9 ± 13.8	136.6 ± 13.7	**>0.05**
Mean intraoperative MAP (mmHg)	85.5 ± 3.5	83.8 ± 2.5	**>0.05**
Mean intraoperative HR (beats/min)	67 ± 11	66 ± 10	**>0.05**
Sevoflurane consumption (ml/h)	19.58 ± 3.84 ml	15.64 ± 4.14 ml*	**<0.05**
Recovery times (min)			
Awakening	8.64 ± 2.4	6.76 ± 2.11*	**<0.05**
Extubation	11.74 ± 2.4	9.24 ± 2.10*	**<0.05**
Aldrete score of ≥9	40.80 ± 3.86	31.60 ± 3.86	**<0.05**

* Significance = P < 0.05.

Table 2 Demographic data, Intraoperative and Post anesthetic data for the Non-BIS Control and the BIS groups.

DISCUSSION

Our study found no significant differences in intraoperative mean Mean Blood Pressure (MBP) and Heart Rate (HR) between the BIS and Non-BIS groups at any point during the procedure. However, there was a statistically significant difference in awakening time, extubation time, and the time taken to achieve a modified Aldrete score of ≥9.

The results of this study demonstrate that the use of Bispectral Index (BIS) monitoring can lead to a quicker postoperative recovery for morbidly obese patients undergoing laparoscopic sleeve gastrectomy. These findings align with other studies evaluating the titration of anesthetics done by Liu N et al. [8], Gan TJ et al. [9], Yli Hankala et al. [10], Song D et al. who used propofol, desflurane or sevoflurane by using BIS monitoring but not in morbidly obese patients. Song et al. [8] concluded that BIS monitoring helps reduce intraoperative anesthetic consumption and shortens emergence and recovery times. Heavner et al. [11] found that BIS monitoring improved recovery profiles in elderly patients undergoing anesthesia with desflurane and nitrous oxide. Burrow N et al. [12] observed that BIS monitoring was beneficial in reducing anesthetic requirements during craniotomy. It can be inferred that Bispectral index monitoring allows reduction in the total amount of anesthetic that patients are exposed to and appears to decrease time for emergence and recovery. [7-15]

Although the use of cerebral monitors like BIS (bispectral index) to reduce intraoperative anesthetic consumption and improve recovery has raised concerns about potential negative effects from increased autonomic activity, our study did not find significant changes in intraoperative hemodynamic variables.

The study was designed as a single-blinded comparison of anesthetic administration, with sevoflurane titrated based on BIS, heart rate (HR), mean arterial pressure (MAP), and patient movements. Recovery times, including awakening and extubation, were assessed by an independent anesthesia provider to avoid investigator bias, and the nursing staff in the PACU were unaware of the study details. All anesthesia providers involved had over five years of experience.

Previous studies, such as those by De Baerdemaeker et al. [16] and White et al. [17], have shown that BIS monitoring can shorten recovery times compared to non-BIS-guided methods. For instance, BIS monitoring has been incorporated in studies comparing desflurane and sevoflurane, demonstrating reduced recovery times and decreased anesthetic requirements.

Comparing anesthesia costs, BIS-guided sevoflurane use was found to be less expensive than standard sevoflurane administration. Research by Tang et al. [18] indicated that propofol-based anesthesia was the most cost-effective, but our study showed that BIS-guided sevoflurane reduced costs compared to traditional sevoflurane use.

Further studies have demonstrated substantial savings in sevoflurane consumption with BIS monitoring. For example, Yll-Hankala et al. [19] reported a 40% reduction in sevoflurane use in gynecological surgery patients receiving opioids. Similarly, a study using isoflurane found a 12% reduction in consumption with BIS monitoring.

Experience level also plays a role; more experienced anesthetists, such as those in our study with over five years of experience, tend to achieve greater reductions in anesthetic use with BIS monitoring.

Anesthesia costs account for only 5.6% of total hospital expenses, and opportunities exist to reduce costs further in operating rooms. Fast recovery post-surgery is crucial. In our study, recovery times were assessed by blinded PACU nurses. We found significant differences in the time to open eyes on verbal command and the time to motor response between the BIS and control groups, although Aldrete scores were similar in both groups. This aligns with studies by Song et al.[7], Guignard et al.[20], and Pavlin et al.[21], which reported that BIS monitoring did not significantly affect recovery duration or Aldrete scores.

In conclusion, BIS monitoring resulted in shorter recovery times and reduced sevoflurane consumption, leading to cost savings and improved recovery speed in morbidly obese patients undergoing laparoscopic bariatric surgery.

However, our study has some limitations: it did not include pediatric patients, lacked blinding, and was limited to an age range of 25-50 years.

CONCLUSION

The use of bispectral index (BIS) monitoring effectively reduced awakening and extubation times, leading to earlier postoperative recovery in morbidly obese patients undergoing elective laparoscopic sleeve gastrectomy, without negatively impacting hemodynamics.

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