EFFECT OF BISPECTRAL INDEX (BIS) MONITORING ON POSTOPERATIVE RECOVERY AND SEVOFLURANE CONSUMPTION AMONG MORBIDLY OBESE PATIENTS UNDERGOING LAPAROSCOPIC GASTRIC BANDING*

OSAMA IBRAHEIM, AHAMAD ALSHAER, KHALID MAZEN ABDELAZEEM EL-DAWLATY, AHMED TURKISTANI, KHALED ALKATHERY, TARIQ AL-ZAHRANI, ABDULLAH AL-DOHAYAN AND AREEJ BUKHARI

Abstract

Early and uneventful postoperative recovery of morbidly obese patients remains a challenge for anesthesiologists. It could be valuable to titrate the administration of inhaled anesthetic, such as sevoflurane, in morbid obese patients, in order to shorten emergence using bispectral index (BIS) monitoring. It would be a great advantage if BIS permitted a more rapid recovery and less consumption in morbidly obese patients with a high cost inhaled agent. The aim of the study is to show whether the titration of sevoflurane based on the BIS monitoring would allow shortening of recovery time in morbidly obese patients and to evaluate whether BIS monitoring would contribute to reduce the amount of sevoflurane administered while providing an adequate anesthesia.

Patients and Methods: Thirty morbidly obese ASA I & II patients undergoing laparoscopic gastric banding (LAGB) procedures were

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From Departments of Anesthesia and Surgery.

* King Khalid University Hospital, King Saud University, Riyadh, Saudi Arabia.

Address for Correspondence: Osama Ibraheim (Assistant Professor of anesthesia, Assiut University, Egypt). Consultant in Department of Anesthesia & ICU, College of Medicine, King Saud University, E-mail: osamaibraheim@yahoo.com, Riyadh 11472, P.O. Box: 7805, Saudi Arabia.

studied. In the first group (15 patients), patients were anesthetized without the use of BIS (non BIS or control group), and sevoflurane being administered according to standard clinical practice (control group). In the second group (15 patients), sevoflurane was titrated to maintain a BIS value between 40 and 60 during surgery, and then 60-70 during 15 min prior to the end of surgery (BIS group). Recovery times were recorded. Time to extubation was also noted, as well as the time to achieve a modified Aldrete score of 9 were evaluated subsequently at 10-min intervals until 3 h after surgery by nurses who had no knowledge of the study. Sevoflurane consumption was calculated using the vaporizer weighing method.

Results: Awakening and extubation times were significantly shorter in the BIS group ($P < 0.05$). In the BIS (vs. non BIS) group, there were no significant differences observed in the time to obtain an Aldrete score of 9. The sevoflurane consumption and cost in the BIS group were lower than in the non BIS group ($P < 0.05$).

Conclusion: Bispectral index monitoring during anesthesia for morbidly obese patients provides statistically significant reduction in recovery times. It also has the added advantage in decreasing sevoflurane consumption.

Keywords: Bispectral index, Morbid Obesity, Sevoflurane consumption.

Introduction

Obesity is a leading cause of preventable death in the United States, resulting in >100,000 excess deaths per year[1] and an estimated annual cost of $ 70 billion, accounting for nearly 10% of national health care expenditures[2]. The numerical growth of the obese population has been matched by an increase in the number of obese patients requiring hospitalization, bariatric procedures and intensive care unit (ICU) care[3-4], this, in part, reflects the increasing prevalence of obesity in the world[5].

Morbid obesity has been identified as a risk factor for difficult mask

ventilation, difficult laryngoscopy[6-7], and more frequent perioperative respiratory events[8-9]. Traditionally, obesity has been seen as a physiologic state that magnifies the importance of the fat-blood solubility coefficient of the anesthetic in its relation to emergence and recovery, so early and uneventful postoperative recovery of morbidly obese patients remains a challenge for anesthesiologists.

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[11-12]. However, it could be even more valuable to titrate the administration of some inhaled anesthetic, such as sevoflurane, in morbid obese patients, the hypothesis being to shorten emergence from sevoflurane anesthesia by using BIS monitoring. It would be a great advantage if BIS permitted a more rapid recovery and less consumption in morbidly obese patients with a high cost inhaled agent. No studies have investigated the potential usefulness of BIS monitoring to guide the administration of sevoflurane in morbid obese patient.

In a randomized prospective controlled design, the present study evaluated and compared a BIS-monitored and a non-BIS-monitored anesthesia among morbidly obese patients undergoing laparoscopic gastric banding, to show whether the titration of sevoflurane, based on the BIS monitoring, would allow shortening of recovery time. 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.

Patients & Methods

After institutional Review Board approval, thirty morbidly obese (BMI >35 kg/m2), ASA I & II patients to undergo gastric banding procedures, were studied. Exclusion criteria consisted of renal, hepatic or neurological dysfunction or use of benzodiazepines, anticonvulsants, alcohol, opioids or other psychotropic drugs.

Patients were randomly assigned to two groups:

First group, (15 patients) were anesthetized without the use of BIS (non BIS or control group), and sevoflurane being administered according to standard clinical practice. The second group, (15 patients) sevoflurane was titrated to maintain a BIS value between 40 and 60 during surgery, and then 60-70 during 15 min prior to the end of surgery (BIS group).

Recovery times were defined from the end of surgery: Time to awakening (i.e, medications were dosed to ideal body weight; no sedative premedication was administered prior to surgery. Opening eyes on verbal command) was assessed at 1-min intervals in the operative room by the anesthetist. Time to extubation was also noted, as well as the time to achieve a modified Aldrete score of 9 were evaluated subsequently at 10-min intervals until 3 h after surgery by nurses who had no knowledge of the study.

Sevoflurane consumption was calculated using the vaporizer weighing method.

Table 1
Demographic data, Intraoperative and Post anesthetic data for the Non BIS Control and the BIS groups.

	Non BIS group (Control n = 15)	BIS group (n = 15)
Gender (M/F)	11/4	9/6
ASA (I & II)	10/5	8/7
Age (yr)	41.21 ± 5.07	39 ± 4.50
Weight (kg)	126.8 ± 12.4	124.8 ± 11.6
Height (Cm)	180.6 ± 8.3	176.6 ± 9.6
BMI (kg/m^2)	45.8 ± 7.5	43.2 ± 5.07
Total duration of anesthesia (min)	138.9 ± 13.8	136.6 ± 13.7
Mean intraoperative MAP (mmHg)	85.6 ± 3.7	83.7 ± 2.4
Mean intraoperative HR (beats/min)	66 ± 10	65 ± 9
Sevoflurane consumption (ml/h)	19.60 ± 3.94	15.66 ± 4.04 ml*
Recovery times (min)		
Awakening	8.66 ± 2.6	6.80 ± 2.14*
Extubation	11.80 ± 2.9	9.26 ± 2.01*
Aldrete score of 9	31. ± 4.81	29.8 ± 4.74

* Significance = $P < 0.05$.

Induction consisted of fentanyl 2 μg/kg, propofol 1.5 to 2.0 mg/kg, and succinylcholine 1.00 to 1.5 mg/kg. Bispectral index monitoring (BIS A-2000 software 2.21, Aspect Medical Systems, Newton, and Mass) was initiated at induction, and smoothing time was 30 seconds.

Standard monitoring (oxygen saturation [SpO2], electrocardiogram, end-tidal carbon dioxide [ETCO2], indirect or direct blood pressure (BP), and esophageal temperature probe) were used in all patients. Sevoflurane (2%) in 2 L/min fresh gas flow, mixed in air and oxygen, was administered to all patients for 5 min after endotracheal intubation and until skin incision, the concentrations were then changed every 5 min as follows:

- BIS Group: the anesthesiologist had access to the monitor and adjusted the concentration of sevoflurane to achieve a target BIS in the range 40-60.

- Non BIS (control group) the anesthesiologist adjusted the sevoflurane concentration purely according to the clinical signs.

During operation, the patients in both groups were observed for signs of inadequate anesthesia (Table 2). Significant hypotension or bradycardia was defined as 20% reduction of the baseline figures. Any instances of inadequate anesthesia were managed by increasing the concentration of sevoflurane.

Table 2

Criteria for inadequate anesthesia

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

Atracurium neuromuscular blockade was maintained to a single twitch of the train of four.

During the last 15 minutes of the case, the BIS value was gradually titrated to 60-70 by decreasing the inhaled anesthetic concentration. Intravenous fentanyl 100 μg was used approximately 15 minutes before the end of surgery to control early postoperative pain.

Just before skin closure and before application of surgical dressing, neuromuscular blockade was reversed with neostigmine (0.07 mg/kg) and glycopyrrolate (0.015 mg/kg). Fresh gas flows were increased to 10 L/min and the anesthetic was discontinued after application of dressing. Mechanical ventilation (10 mL/kg ideal body weight) was continued until the first spontaneous respiration began, followed by assisted manual ventilation.

A verbal command to open eyes was given every 10 seconds.

After a train-of-four ratio higher than 0.9, a 5-second head lift was performed and patients were extubated. Blinded study personnel recorded the time from discontinuation of the anesthetic gas to eye opening and extubation. After extubation, patients were transferred to the (PACU). In the PACU the time to achieve a modified Aldrete score of 9 was evaluated subsequently at 10-min intervals until 3 h after surgery by nurses who had no knowledge of the study.

Postoperative pain was evaluated at 5-min intervals using a 5-point verbal rating scale (0: no pain; 1: light pain; 2: moderate pain; 3: intense pain; 4: severe pain). Pain scores were treated with Ketoprofen 100 mg IM. At the time of discharge from the recovery room and 24 hours after surgery, patients were asked whether they dreamt or recalled any intraoperative events.

Sevoflurane Consumption

For determination of anesthetic consumption, the sevoflurane vaporizer was filled and weighed before induction. When anesthesia was complete, the vaporizer was disconnected and reweighed. This method has already been described by other authors[13-14]. Inhaled anesthetic consumption was expressed in g/min and assessed for each patient. Conversion from grams to milliliters was performed by using the specific weights of the volatile anesthetic (sevoflurane 1.52 g/mL). The mean value of each group was then established and the difference between the two means in ml/h. was established Results were statistically evaluated

using Student's t-test (significance $P < 0.05$).

Statistics

Data was collected statistically and analyzed using SPSS package (version 11.0, Washington). One-way repeated-measures analysis of variance (ANOVA) with post hoc Bonferroni correction was used to assess differences in mean between groups with respect of specific intraoperative events. The two-sample unpaired Student's t-tests were used to compare continuous variables: HR, MAP, duration of anesthesia, recovery times, and sevoflurane consumption. Data are expressed as mean values ± SD. P values <0.05 were considered statistically significant.

Results

Thirty morbidly obese patients were enrolled in this study and were equally divided into two groups (n = 15 each): Non-BIS group (Control) and BIS group (Table 1).

The two groups were similar in age, height, age, weight, BMI and duration of anesthesia. There were no statistical differences in intraoperative mean heart rate, mean blood pressure in either group.

- The time to awakening and extubation (time from end of operation to time of verbal command) was shorter in the BIS group:

  The Awakening time was 8.66 ± 2.69 min in the Non-BIS gr. (control), compared to 6.80 ± 2.14 min in the BIS gr., with $P < 0.05^{*}$.

  The Extubation time was 11.8 ± 2.9 min in the Non-BIS gr. (control), compared to 9.26 ± 2.01 min with in the 815 gr., with $P < 0.05^{*}$.

- No significant differences were observed in the time to obtain an Aldrete score of 9 in the BIS vs Non-BIS groups.

- The sevoflurane consumption and costs in the BIS group were lower than in the Non-BIS group. The mean ± SD for the consumption per hour of sevoflurane was 19.60 ± 3.94 ml liquid in the Non-BIS gr,

compared to 15.66 ± 4.04 ml liquid in the BIS gr., with $P < 0.05^{*}$.

* Significance = $P < 0.05$.

- There was no recall or dreaming reported by any patient in Recovery room or 24 hours after surgery in both groups. All patients were completely awake during the three postoperative hours without complications.

Discussion

The hypothesis adopted in the present study was that sevoflurane titration guided by BIS monitoring could be particularly useful at the end of surgery in order to adapt sevoflurane delivery to a higher BIS level and order to ensure a faster recovery. We demonstrated that the addition of BIS to standard monitoring was associated with a slight but significant decrease in sevoflurane consumption. Also, there was a significant difference in recovery times when comparing BIS guided and standard monitoring anesthesia. These results are comparable to those reported in other studies that assessed titration of propofol[15], desflurane or sevoflurane[16-17] by using BIS monitoring but not in morbidly obese patients. 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[11-18].

In the present study, the protocol was designed as a single blinded comparison of the anesthetic administration, as sevoflurane was titrated intraoperatively against objective measures such as BIS, HR, MAP, and patient movements.

Early recovery in the operative room (time to awakening and to extubation) was assessed by another anesthesia provider, that does not constitute an investigator associated bias. In addition, in the PACU, the nursing staff had no knowledge of the study. Furthermore, all anesthesia providers were anesthetists in our Department and had experience of more than 5 years in anesthesiology.

Bispectral index monitoring has been incorporated into studies comparing emergence and recovery profiles of desflurane and sevoflurane, mixed with nitrous, in elderly patients[19] and was incorporated into the study of De Baerdemaeker et al[20]. These studies all demonstrate that the time to recovery is shortened compared with previous non-BIS-guided studies where the dosage of desflurane or sevoflurane was based on MAC and hemodynamic response, whether mixed with nitrous oxide[21] or not[22].

We agree with the contention that a rapid emergence from anesthesia with minimal respiratory and cardiovascular adverse effects is important in MO patients who have a high prevalence of cardiovascular disease and are at risk for respiratory complications. White et al.[23] found that AEP and bispectral index (BIS) monitoring can decrease the end-tidal desflurane concentration during maintenance of anesthesia and discharge times after the end of anesthesia. During laparoscopic surgery, Recart et al.[24] found that AEP monitoring can reduce the desflurane requirement by 26%.

It has been shown that excessive costs can be minimized without compromising clinical outcome and patient satisfaction. Comparing anesthesia costs is not a trivial matter. Two studies published in 1999 investigated outpatients anesthetized with propofol and/or sevoflurane[25]: Tang and colleagues[26] focused on the total costs required to achieve complete patient satisfaction and found that propofol/propofol-N_2O were the cheapest kind of anesthesia, followed by propofol/sevoflurane – N_2O and sevoflurane/sevoflurane-N_2O. The present study showed that the use of BIS guided sevoflurane for the maintenance of anesthesia in morbidly obese patients was less expensive than maintenance of sevoflurane without BIS.

We have demonstrated that the addition of BIS to standard monitoring was associated with a slight, significant, decrease in sevoflurane consumption. Yll-Hankala and colleagues found that the sevoflurane saving was 40% in gynecological surgery patients who also received opioids[27]. Subsequently, other authors[28] using isoflurane found similar findings to those reported here. In that study, there was a 12%

saving in isoflurane consumption when using BIS which was explained as a result of the use of sufentanil and nitrous oxide[28].

Pavlin and colleagues found, in a study of junior residents who had differing durations of training, that a modest reduction of anesthetic use was associated with greater experience (13%)[29]. For junior residents, the difference in the concentrations of volatile anesthetic administered to the BIS and control groups was quite remarkable. There was not much difference in the case of residents whose experience was >1 yr. In our study, our anesthetist had at least 5 or more years experience. In evaluating the values of BIS and control groups, experience of anesthesia is an important factor.

Anesthesia costs during surgery constituted only 5.6% of the total hospital costs. Many opportunities may be found to reduce costs in operating suites[30-31].

A fast recovery is important after surgery. In our study, patient assessment in recovery was conducted by 'blinded' PACU nurses. There were significant differences in the 'time to open eyes on verbal command', the 'time to motor responds on verbal command' between BIS and control group while no difference in Aldrete's score. This is in accordance with Song and colleagues who found that the duration of stay in the recovery unit did not differ[11]; Guignard and colleagues also reported that the Aldrete's scores were also similar[28]. Pavlin and colleagues also reported that BIS monitoring did not influence the duration of recovery[29].

In conclusion, the recovery variables were shorter with BIS monitoring which in turn made significant savings in sevoflurane consumption and influenced the speed of recovery after laparoscopic gastric banding in morbidly obese patients.

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