The Effect of BIS Usage on Anaesthetic Agent Consumption, Haemodynamics and Recovery Time in Supratentorial Mass Surgery

İclal Karaca¹, Fatma Eren Akçıl², Özlem Korkmaz Dilmen², Güniz Meyancı Köksal², Yusuf Tunalı²

¹Department of Anaesthesiology and Reanimation, Ege University Faculty of Medicine, İzmir, Turkey

²Department of Anaesthesiology and Reanimation, İstanbul University Cerrahpaşa Faculty of Medicine, İstanbul, Turkey

Objective: In this study, we aimed to compare Bispectral Index (BIS) monitoring with the conventional anaesthesia approach based on haemodynamic changes in terms of anaesthetic agent consumption, haemodynamic recordings, recovery time and cost.

Methods: This study was performed in 82 patients, aged 20 to 60 years, who were operated for supratentorial mass and were graded ASA I or II. Cases were randomly divided into two equal groups. In the standard control group haemodynamic parameters were used to determine depth of anaesthesia and in the BIS group, BIS monitoring was applied. In the BIS group the BIS values were kept between 40 and 60; in the control group haemodynamic changes within the range of +/-20% of initial values were controlled using appropriate anaesthetic practice. Haemodynamic parameters, awakening conditions and drug usage were recorded.

Results: The difference between the two groups in terms of timing of eye opening and initial spontaneous breath was not statistically significant. The 'Aldrete' score at the 20th postoperative minute for the BIS group was significantly higher than the score calculated for the control group ($p<0.05$). Rocuronium consumption ($\text{mg kg}^{-1} \text{hr}^{-1}$) was significantly lower in the BIS group than the control group ($p<0.05$). Although a statistically significant difference ($p<0.05$) was found between the two groups in terms of initial heart rate and SpO_2 values, there was no clinically significant difference in other haemodynamic parameters.

Conclusion: Although using BIS monitoring to evaluate depth of anaesthesia does not bring much benefit versus the use of haemodynamic parameters, it may be beneficial for selected surgeries such as awake craniotomy, for patients with a history of awareness and in haemodynamically unstable patients.

Key Words: BIS monitoring, depth of anaesthesia, haemodynamics, neurosurgery

Introduction

The main targets of anaesthesia are providing hypnosis, analgesia, and neuromuscular blockade and prevention of reflex responses. Currently, hypnotic level during anaesthesia is mainly monitored by haemodynamic responses and measurement of minimum alveolar concentration (MAC) of the inspired and expired inhalation anaesthetics. However, this application mostly supplants the true needs of the patient. While anaesthesia providing a superficial hypnosis state can be applied in a patient with fluid deficit, anaesthesia providing a deeper hypnosis can be applied in a hypertensive patient. Bispectral Index (BIS) derived from electroencephalography (EEG) measurements is used in determining anaesthesia depth and assessing the levels of sedation, hypnosis and consciousness.

In the present study, we aimed to compare conventional anaesthesia based on haemodynamic parameters and BIS guided anaesthesia based on haemodynamic parameters and BIS changes with in terms of anaesthetic agent consumption, hemodynamic parameters, recovery time and cost in patients undergoing surgery for supratentorial mass lesion.

Methods

This study was performed on 82 American Society of Anaesthesiologists (ASA) I-II patients aged between 20 and 60 years undergoing elective surgery for supratentorial mass lesions under general anaesthesia in the brain surgery operating rooms of Cerrahpaşa Medical Faculty after approval of İstanbul University Cerrahpaşa Medical Faculty Ethics committee. The study was commenced after signed informed consents were obtained from the patients. The patients with cardiac failure,

renal failure, anaemia, ischemic heart disease, liver disease, gastrointestinal system disease, diabetes mellitus, hypothalamic-pituitary gland disorders, diuretic use, hypoalbuminemia, hyperglycaemia, electrolyte imbalance and alcohol consumption were excluded from the study. The patients who required hormone replacement therapy, those in pregnancy and lactation period and a psychiatric condition that would interfere with consent were also not included in the study.

The cases were randomly divided into two groups as BIS group monitored by BIS (Group BIS) and standard group monitored by haemodynamic parameters (Group Standard Control) in terms of anaesthesia depth.

Before the surgery, heart rate (HR), non-invasive arterial pressure (NIAP) and peripheral oxygen saturation (SpO_2) monitoring was performed in the preparation room, and the first measurements were recorded (Dräger Infinity Kappa, PA, USA) and the patients were premedicated using 30-50 $\mu\text{g kg}^{-1}$ midazolam (Demizolam 5 mg ampule DEM drug Kadıköy, Turkey). In the operating room HR, ST analysis, NIAP, SpO_2 , neuromuscular transmission (NMT) monitoring (ADU, AS/3, Datex Ohmeda GE Healthcare, Finland) were performed. Closed envelope method was used for randomization. In the BIS group, BIS electrodes were placed and

calibrated (BIS Quatro, Aspect Medical Systems, Massachusetts, USA). Vecuronium (Blok-L 10 mg lyophilized flacon, Mustafa Nevzat drug Industry Limited Company Gayrettepe, İstanbul, Turkey) (0.1 mg kg^{-1}) was used as the neuromuscular blocker (NMB) in order to facilitate intubation during anaesthesia induction in both groups. Standard anaesthesia group received 2 mg kg^{-1} of propofol (Propofol ampule 1% Propofol Fresenius Kabi, Hamburg, Germany), while BIS group received an initial dose of 1 mg kg^{-1} of propofol and 20 mg additional doses until BIS was below 60, and remifentanyl (Ultiva 2 mg/5 mL, Glaxo Smith Kline, Middlesex, United Kingdom) ($0.15 \text{ microgram kg}^{-1} \text{ min}^{-1}$) infusion was started. The time to reach a train-of-four (TOF) ratio of 0% in the neuromuscular transmission monitor was recorded. In the control group, anaesthesia was maintained with propofol infusion, started at a dose of $8 \text{ mg kg}^{-1} \text{ hr}^{-1}$ and decreased by $2 \text{ mg kg}^{-1} \text{ hr}^{-1}$ at 10 minute intervals, remifentanyl infusion ($0.1 \text{ microgram kg}^{-1} \text{ min}^{-1}$), and rocuronium (Esmeron amp 10 mg mL⁻¹ Merck Sharp & Dohme, Whitehouse Station, USA) was ($0.2\text{-}0.3 \text{ mg kg}^{-1} \text{ hour}^{-1}$) infusion. In the BIS group, propofol infusion was initiated at a rate of $8 \text{ mg kg}^{-1} \text{ hr}^{-1}$ and was continued in 40 mg doses to maintain BIS between 40 and 60. Anaesthetic management protocols of the study groups are presented in Table 1 and 2:

Haemodynamic parameters (HR, SAP, DAP, MAP), BIS, end-tidal CO_2 (ETCO_2) and SpO_2 values were recorded before and after induction, after intubation, during skull pin placement (or during positioning in patients who were not applied skull pins), during brain manipulation, bleeding control and skin closure and after extubation. Rocuronium infusion was discontinued 30 minutes before the surgery ended, and propofol and remifentanyl infusions were discontinued at the last skin sutures. Total dose of remifentanyl (μg), rocuronium (mg) and propofol (mg), and the required amounts of remifentanyl ($\mu\text{g kg}^{-1} \text{ min}^{-1}$), rocuronium ($\text{mg kg}^{-1} \text{ hour}^{-1}$) and propofol ($\text{mg kg}^{-1} \text{ hour}^{-1}$) adjusted per kilogram were recorded in both groups. The time to spontaneous breathing (TSB), and the time to eye opening (TEO) after intervention were also recorded. The patients were extubated and trans-

Table 1. Anaesthetic management protocol of the standard control group monitored by perioperative haemodynamic changes

Hemodynamic parameters	Intervention
20% increase in MAP and/or HR	Propofol and remifentanyl infusion is increased and the cause is evaluated. Rocuronium and antihypertensive drugs may be added
Stable	No change was made
20% decrease in MAP and/or HR	Initially propofol, thereafter remifentanyl infusion is decreased. If no results can be achieved in 10 minutes, MAP may be increased by fluid resuscitation and/or ephedrine use
MAP: mean arterial pressure; HR: heart rate	

Table 2. Anaesthetic management protocol of the BIS group monitored by perioperative changes in haemodynamic parameters and BIS

Hemodynamic parameters	BIS	Application
Increased MAP and HR	>60	Propofol and remifentanyl infusion are increased and the cause is sought
Stable	>60	Propofol infusion is increased
Decreased/unstable MAP	>60	Remifentanyl infusion is decreased, and propofol infusion is increased
Increased MAP and HR	40-60	Remifentanyl infusion is increased/rocuronium and antihypertensive drugs may be added
Stable	40-60	No change was made
Increased MAP and HR	<40	Propofol infusion is decreased, remifentanyl infusion is increased; an antihypertensive agent may be added
Decreased/unstable MAP	40-60	MAP is increased by fluid resuscitation and/or ephedrine use, remifentanyl infusion is decreased
Stable	<40	Propofol and remifentanyl infusion is decreased
Decreased/unstable MAP	<40	MAP is increased by fluid resuscitation and/or ephedrine use, remifentanyl and propofol infusion is decreased
MAP: mean arterial pressure; HR: heart rate		

ferred to the postoperative recovery unit or intensive care unit when they regain consciousness, adequate depth and rate of breathing, and stable cardiovascular findings. The patients' haemodynamic parameters and SpO₂ values were recorded 10 minutes, and "modified Aldrete" scores were recorded 20 minutes after arrival to the postoperative recovery unit or intensive care unit (1). The patients' awareness during surgery was questioned asking "the last event they recalled about the surgery". Intraoperative fluid balance and bleeding amount were calculated by dividing to body mass index (BMI). Among patients who were transferred to the postoperative recovery unit, those with a Modified Aldrete score ≥ 9 were transferred to the ward. Patients who were taken to the intensive care unit were followed-up for at least one night and transferred to the ward according to their general condition.

Statistical analysis

Statistical Package for Social Sciences (SPSS) for Windows 13.0 program was used for the statistical analysis of study data. Descriptive statistics were presented as mean, and standard deviation, normal distribution of the data was tested using "Kolmogorov-Smirnov" test. In this evaluation, $p > 0.05$ was considered as normal distribution, and inter-group comparisons of continuous variables was performed using t test, and discrete variables were compared using Chi square test. Intra-group multiple comparisons were performed using repeated measures "ANOVA", and "Bonferroni" test was used as "post hoc" test. The results were presented within 95% confidence interval and the significance level was accepted as $p < 0.05$.

Results

The distribution of cases according to surgical diagnosis and age, gender, weight, height, body mass index and ASA grades of the groups were similar (Table 3 and 4). There was also no difference between the groups regarding TOF values in the induction period, and fluid balance, bleeding amount, and total amounts of propofol, remifentanyl and rocuronium use. There was no difference between the groups in terms of the values obtained by dividing the perioperative fluid balance and bleeding amount by BMI (Table 5). Duration of surgery, time to eye opening and spontaneous breathing were similar in the groups, however, modified Aldrete score at 20 minutes was statistically significantly higher in the BIS group than that in the standard anaesthesia group (Table 5). There was no significant difference between the groups in terms of additional propofol, remifentanyl and rocuronium (mg kg⁻¹ hour⁻¹) use according to weight and time (Table 6). HR values of the control group at baseline and after induction were significantly higher than that of the BIS group ($p = 0.025$, $p = 0.04$). There was no statistically significant difference between the groups regarding the SAP, DAP and MAP values measured at any period. There was a statistically significant increase in SpO₂ values except those at the 2nd and 9th periods. ETCO₂

Table 3. Distribution of cases according to surgical diagnosis

Groups	Tumour (n) (%)	Aneurism (n) (%)	Pituitary Adenoma (n) (%)
Group BIS (n=41)	19 (46)	14 (34)	8 (20)
Group STD (n=41)	27 (66)	7 (17)	7 (17)

Table 4. Comparison of age, weight, height, body mass index (BMI), gender and American Society of Anaesthesiologists (ASA) scores between the two groups

	Group	N	Mean	Std. deviation	p
Age (years)	BIS	41	48.83	14.729	0.686
	STD	41	48.17	15.778	
Weight (kg)	BIS	41	74.61	12.934	0.541
	STD	41	74.02	11.282	
Height (cm)	BIS	41	168.78	7.112	0.411
	STD	41	166.05	9.211	
BMI (kg/m ²)	BIS	41	26.212	4.3193	0.357
	STD	41	27.102	4.3269	
ASA	BIS	41	1.46	0.505	0.825
	STD	41	1.49	0.506	
Gender (N=M/F)	BIS	41=24/17			0.185
	STD	41=18/23			

"Chi square test" was used in the analysis of data in this table.

Table 5. Comparison of body mass index (BMI) related fluid balance, bleeding amount, surgery duration, time to eye opening (TEO), time to spontaneous breathing (TSB) and "modified Aldrete" scores (MAS) at 20 minutes

mL/BMI	Group	N	Mean	Std. deviation	p
Fluid balance (mL kg ⁻¹)	BIS	41	50.57	20.95	0.281
	STD	41	42.69	22.47	
Bleeding (mL kg ⁻¹)	BIS	41	11.11	10.34	0.433
	STD	41	7.96	6.61	
Intervention duration (min)	BIS	41	271.46	90.237	0.542
	STD	41	262.32	102.787	
TEO (sec)	BIS	41	153.76	169.960	0.704
	STD	41	106.90	126.069	
TSB (sec)	BIS	41	58.46	67.145	0.343
	STD	41	62.61	107.262	
MAS	BIS	41	8.76	0.943	0.003*
	STD	41	8.32	0.687	

"Chi square test" was used in the analysis of data in this table

*: $p < 0.05$

values of the BIS group at 5th, 6th and 7th period were significantly high. Mean BIS values in this group was 93.54 ± 6.55 at baseline, 52.32 ± 11.92 at maintenance and 81.10 ± 11.15 at awakening (Figure 1).

Table 6. Propofol ($\text{mg kg}^{-1} \text{ hour}^{-1}$), rocuronium ($\text{mg kg}^{-1} \text{ hour}^{-1}$) and remifentanyl ($\mu\text{g kg}^{-1} \text{ min}^{-1}$) requirements of the groups

	Group	N	Mean	Std. Deviation	p
Propofol $\text{mg kg}^{-1} \text{ hour}^{-1}$	BIS	41	4.80	1.030	0.373
	STD	41	4.07	2.25	
Remifentanyl $\mu\text{g kg}^{-1} \text{ min}^{-1}$	BIS	41	0.11	0.04	0.474
	STD	41	0.12	0.06	
Rocuronium $\text{mg kg}^{-1} \text{ hour}^{-1}$	BIS	41	0.26	0.05	0.328
	STD	41	0.31	0.10	

"Chi square test" was used in the analysis of data in this table

Figure 1. The change in BIS values according to time in the BIS group
1: Before induction, 2: Induction, 3: After intubation, 4: At the beginning of surgery, 5: Brain manipulation, 6: Bleeding control, 7: Skin closure, 8: After extubation

Discussion

Nowadays, many of the anaesthetists adjust the doses of pharmacological agents by monitoring haemodynamic responses and by measuring minimum alveolar concentrations of inspired and expired inhalation anaesthetics. However, these findings do not realistically reflect the hypnotic component of anaesthesia. Therefore, complications such as hypotension and delayed awakening may develop by deep hypnosis, and awareness may occur by superficial anaesthesia (2).

In our study, we divided patients undergoing supratentorial surgery into two groups. Requirement of anaesthetic drugs was monitored by standard hemodynamic findings in one patient group, and by BIS in the other. We compared anaesthetic drug consumption, haemodynamic responses and recovery time between the two groups.

Based on the results of previous prospective studies, considering that a BIS index of 40-60 during general anaesthesia provides an adequate hypnotic effect, we maintained the target BIS level as 40-60 in the maintenance period. In our study, the mean BIS values at baseline, maintenance and awakening periods were $93.54 (\pm 6.55)$, $52.32 (\pm 11.92)$, and $81.10 (\pm 11.15)$, respectively.

There are various studies in the literature comparing BIS and haemodynamic based anaesthesia practices (3-9). According to the results of these studies, while propofol use in BIS group range between 2.9 and $8.0 \text{ mg kg}^{-1} \text{ hour}^{-1}$, it varies between 4.9 and $11.9 \text{ mg kg}^{-1} \text{ hour}^{-1}$ in the control group. It has been reported that the amount of propofol use is lower in BIS group (3-9). We, in our study, found that propofol use was higher in the BIS group than that in the control group. However, the difference between the groups was not statistically significant. We consider that this situation is basically due to method discrepancies. While only propofol had been used to correct the haemodynamic changes in these studies, we used both propofol and remifentanyl.

In our study, TSB was shorter and TEO was longer (2.6 min) in the BIS group in comparison to that in the control group (1.8 min), but the differences between the groups were not statistically significant.

Anez and colleagues (3), and Kreuer and colleagues (9) found shorter TEO in the BIS group than that of the control group. In the literature, while TEO of the BIS group ranges between 3.4 and 8.1 min, it is between 8.1 and 10.9 min in the control groups. Method differences might explain the different results we obtained.

Provisio studies report a shorter recovery time in BIS groups (4-9). Although we did not evaluate the recovery time in our study, we determined that BIS group achieved statistically significantly higher MAS values during the same duration and this finding is also consistent with the literature.

Studies using remifentanyl reported no difference between BIS and control groups; as a matter of fact they found almost the same values in the two groups (4, 10). In our study, similar to those studies, we could not detect any difference between the groups in terms of remifentanyl use.

In our study, as a NMB we preferred to use vecuronium in induction and rocuronium in maintenance. Total consumed rocuronium amount was lower in the BIS group (90.24 mg) in comparison to that in the control group (98.90 mg), however this difference was not significantly different. When consumption rates ($\text{mg/hour per kilogram}$) of the two groups were compared, it was found that BIS group ($0.264 \text{ mg kg}^{-1} \text{ hour}^{-1}$) had a lower consumption rate than the control group ($0.3098 \text{ mg kg}^{-1} \text{ hour}^{-1}$), but this difference was also not statistically significant.

Song et al. (11) evaluated the consumed mivacurium dose in patients using desflurane and sevoflurane under the guidance of BIS and clinical findings. They reported that mivacurium use was significantly increased in sevoflurane and desflurane subgroups, where BIS monitoring is used. In our review of the literature, we could not detect any study using NMB infusion. We determined that NMB infusion was greater in the control group. This result suggests that the concern of patient motion was in the forefront in patients not monitored by BIS.

We observed no incidence of intraoperative awareness. Myles et al. (12) in their study on 2463 patients compared the effects of standard anaesthesia with BIS on intraoperative awareness. They reported that BIS use decrease the incidence of awareness. However, even this study, performed on a large number of patients could only detect 13 patients who experienced awareness. Muralidhar and colleagues (6) also compared the effects of standard anaesthesia practice with BIS on intraoperative awareness, and chose the target BIS value as 45-55. They found no incidence of awareness in their study. We think that our findings are also consistent with the literature, and inclusion of a greater number of patients will help clarify this subject.

Whether suitable conditions for intubation were developed by neuromuscular blockade was tested by TOF monitoring. The time to reach a TOF ratio of 0 after vecuronium (0.1 mg g^{-1}) application was recorded. While it was 157.5 sec in the BIS group, it was 137.46 sec in the control group. Statistically, there was no difference between the groups ($p>0.05$).

Among studies on BIS, very few of them compare intraoperative haemodynamic variables. Some of them are experimental, some of them are performed on a small number of patients and some only evaluate the intubation period (13-15). We observed that the heart rates of the control patients in the 1st and 2nd period were statistically significantly higher than that of the BIS patients. This difference was not observed in the maintenance and awakening periods. We suggest that the difference observed at baseline was random, and the difference observed after induction is the continuing effect of the difference detected at baseline. Additionally, we observe that these differences are not clinically significant.

Bithal et al. (14) performed a study in patients undergoing cervical surgery using skull pins, and compared the haemodynamic and bispectral index changes following skull pin attachment with and without local anaesthetic infiltration (with 0.9% NaCl) of the scalp. They reported that BIS, HR and MAP were significantly increased in the normal saline group than that in the local anaesthetic group. As we used local anaesthetics during pin attachment, we did not observe significant differences between the groups in terms of haemodynamic variables.

An important subject of research in BIS studies is the effect of BIS on total cost. We also calculated the total cost of drugs and BIS at the end of our study. In the literature there are two studies evaluating the total drug cost, and they reported lower costs in the BIS group in comparison to that of the control group.

Mayer and colleagues (16) found that propofol cost was 5.8 ± 11.4 cents $\text{kg}^{-1} \text{ hour}^{-1}$ in the BIS group, and 7.5 ± 1.6 cents $\text{kg}^{-1} \text{ hour}^{-1}$ in the control group ($p<0.05$).

Paventi and colleagues (17) estimated sevoflurane cost as 0.699 and 0.984 euro $\text{min}^{-1} 70 \text{ kg}^{-1}$ in the BIS and control

groups, respectively, and reported that BIS monitoring was 14.01 euro/patient, accordingly.

Neither of the studies offers a complete efficacy/cost analysis for BIS monitoring and neither of them carries a decisive nature.

The cost of propofol used in our study (Propofol Fresenius 1%) was $0.1 \text{ TL kg}^{-1} \text{ hour}^{-1}$ in the BIS group, and $0.09 \text{ TL kg}^{-1} \text{ hour}^{-1}$ in the control group.

Remifentanyl (Ultiva, 2 mg/5 mL) cost was found to be approximately $0.001 \text{ TL kg}^{-1} \text{ min}^{-1}$ in both groups.

Rocuronium cost (Esmeron amp 10 mg mL^{-1}) was $0.16 \text{ TL kg}^{-1} \text{ hour}^{-1}$ in the BIS group and $0.2 \text{ TL kg}^{-1} \text{ hour}^{-1}$ in the control group.

The cost of BIS monitoring according to Social Security Institution government price list is 11.86 TL in our country.

Therefore, it is difficult to say that there is a significant difference between BIS and control groups in terms of total patient cost. We think that the most important factor in BIS choice is indication. BIS should be used without considering the cost especially in awake craniotomy surgeries, in patients with a previous history of intraoperative awareness, or in surgeries having a high risk of awareness such as open heart surgeries and caesarean section.

We have the opinion that using a test for the evaluation of patient awareness would be appropriate and increasing the number of cases would allow a more definitive evaluation.

Conclusion

In the present study, we compared BIS- and haemodynamic-guided anaesthesia in terms of drug consumption, haemodynamic variables and awakening quality in patients undergoing supratentorial surgery. Our results suggest that BIS use does not provide a selective advantage in this regard. BIS use may be more essential in selected surgeries like awake craniotomy and in patient groups with a history of intraoperative awareness and high haemodynamic risk. In addition, we think that introducing BIS use in anaesthesia practice is important in terms of learning in research and education hospitals.

Ethics Committee Approval: Ethics committee approval for this study was received from the ethics committee of İstanbul University Cerrahpaşa School of Medicine.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - Y.T., İ.K.; Design - Y.T.; Supervision - Y.T., Ö.K.D., F.E.A.; Funding - İ.K., Y.T.; Materials - İ.K.; Data Collection and/or Processing - İ.K.; Analysis and/or Interpre-

tation - İ.K., Y.T., G.M.K., Ö.K.D., F.E.A.; Literature Review - İ.K.; Writer - İ.K., Y.T.; Critical Review - G.M.K., Ö.K.D., F.E.A.; Other - İ.K., Y.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Turkish Society of Anesthesiology and Reanimation (TARD) Anesthesia Practice Guidelines Postanesthetic care. November 2005; 5.
2. Mahla ME. Electroencephalogram in the OR. *Seminars in Anesthesia* 1997; 16: 3-13. [\[CrossRef\]](#)
3. Anez C, Papaceit J, Sala JM, Fuentes A, Rull M. The effect of encephalogram bispectral index monitoring during total intravenous anesthesia with propofol in outpatient surgery. *Rev Esp Anesthesiol Reanim* 2001; 48: 264-9.
4. Gan TJ, Glass PS, Windsor A, Payne F, Rosow C, Sebel P, et al. Bispectral index monitoring allows faster emergence and improved recovery from propofol, alfentanil, and nitrous oxide anesthesia. BIS Utility Study Group. *Anesthesiology* 1997; 87: 808-15. [\[CrossRef\]](#)
5. Masuda T, Yamada H, Takada K, Sagata Y, Yamaguchi M, Tomiyama Y, et al. Bispectral index monitoring is useful to reduce total amount of propofol and to obtain immediate recovery after propofol anesthesia. *Masui* 2002; 51: 394-9.
6. Muralidhar K, Banakal S, Murthy K, Garg R, Rani GR, Dinesh R. Bispectral index-guided anaesthesia for off-pump coronary artery bypass grafting. *Ann Card Anaesth* 2008; 11: 105-10. [\[CrossRef\]](#)
7. Struys MM, De Smet T, Versichelen LF, Van De Velde S, Van den Broecke R, Mortier EP. Comparison of closed-loop controlled administration of propofol using Bispectral Index as the controlled variable versus "standard practice" controlled administration. *Anesthesiology* 2001; 1: 6-17. [\[CrossRef\]](#)
8. Tufano R, Palomba R, Lambiasi G, Giurleo LG. The utility of bispectral index monitoring in general anesthesia. *Minerva Anesthesiol* 2000; 66: 389-93.
9. Kreuer S, Biedler A, Larsen R, Altmann S, Wilhelm W. Narcotrend monitoring allows faster emergence and a reduction of drug consumption in propofol-remifentanyl anesthesia. *Anesthesiology* 2003; 99: 34-41. [\[CrossRef\]](#)
10. Bruhn J, Kreuer S, Bischoff P, Kessler P, Schmidt GN, Grzesiak A, et al. Bispectral index and A-line AAI index as guidance for desflurane-remifentanyl anaesthesia compared with a standard practice group: a multicentre study. *Br J Anaesth* 2005; 94: 63-9. [\[CrossRef\]](#)
11. Song D, van Vlymen J, White PF. Is the bispectral index useful in predicting fast-track eligibility after ambulatory anesthesia with propofol and desflurane? *Anesth Analg* 1998; 87: 1245-8. [\[CrossRef\]](#)
12. Myles PS, Leslie K, McNeil J, Forbes A, Chan MT. Bispectral index monitoring to prevent awareness during anaesthesia: the BAware randomised controlled trial. *Lancet* 2004; 363: 1757-63. [\[CrossRef\]](#)
13. Bae JY, Choi DY, Woo CH, Kwak IS, Mun SH, Kim KM. The BIS and hemodynamic changes in major burn patients according to a slow infusion of propofol for induction. *Korean J Anesthesiol* 2011; 60: 161-6. [\[CrossRef\]](#)
14. Bithal PK, Pandia MP, Chouhan RS, Sharma D, Bhagat H, Dash HH, et al. Hemodynamic and bispectral index changes following skull pin attachment with and without local anesthetic infiltration of the scalp. *J Anesth* 2007; 21: 442-4. [\[CrossRef\]](#)
15. Guignard B, Menigaux C, Dupont X, Fletcher D, Chauvin M. The effect of remifentanyl on the bispectral index change and hemodynamic responses after orotracheal intubation. *Anesth Analg* 2000; 90: 161-7. [\[CrossRef\]](#)
16. Mayer J, Boldt J, Schellhaass A, Hiller B, Suttner SW. Bispectral index-guided general anesthesia in combination with thoracic epidural analgesia reduces recovery time in fast-track colon surgery. *Anesth Analg* 2007; 104: 1145-9. [\[CrossRef\]](#)
17. Paventi S, Santevecchi A, Metta E, Annetta MG, Perilli V, Sol-lazzi L, et al. Bispectral index monitoring in sevoflurane and remifentanyl anesthesia. Analysis of drugs management and immediate recovery. *Minerva Anesthesiol* 2001; 67: 435-9.