Original Article

Effects of bispectral index monitoring on isoflurane consumption and recovery profiles for anesthesia in an elderly asian population

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Abstract

Background: Age related limited physiological reserves and associated co-morbidities in elderly patients require careful titration of inhalational anesthetic agents to minimize their side effects. The use of Bispectral index (BIS) monitoring may be helpful in this regard. The objectives of this study were to evaluate the effect of BIS monitoring on Isoflurane consumption during maintenance and recovery profile at the end of anesthesia. This Quasi experimental study was conducted for a 1 year period at the main operating units of a tertiary care hospital.

Materials and Methods: Total 60 patients of age 60 years and above were enrolled in either standard practice (SP) or (BIS) group. In the SP group, the anesthesia depth was maintained as a routine clinical practice, while in BIS group it was maintained by monitoring the BIS score between 45 and 55. Standard anesthesia care was provided to all of the patients. Data including demographics, isoflurane consumption, hemodynamic variables and recovery profiles were recorded in both groups.

Results: The mean isoflurane consumption was lower (P = 0.001) in the BIS group. The time to eye opening, extubation and ready to shift was shorter (P = 0.0001) in BIS group. The patients in BIS group had higher Post anesthesia recovery score (P = 0.0001) than the SP group.

Conclusion: The use of BIS in an elderly Asian population resulted in 40% reduction of isoflurane usage. The patients having BIS monitoring awoke earlier and had better recovery profiles at the end of anesthesia.

Key words: Bispectral index monitoring, elderly population, isoflurane, recovery

Introduction

The advancement in medical science and availability of health care facilities has increased the numbers of elderly patients requiring anesthesia for surgical intervention. It is generally agreed that the term "elderly" is applied to the period of life starting sometime after 60 years, and is characterized by a progressive aging process that continues until the end of life[1]

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The patients in this age group are usually suffering from a broad spectrum of diseases leading to the marked limitation in physiological reserves and associated end organ damage[2] All these conditions make them vulnerable for getting adverse events in the peri-operative period[3]

Isoflurane is a commonly used inhalational anesthetic agent to maintain the depth of anesthesia (DOA). Its requirement as measured by minimum alveolar concentration (MAC), decreases with the advancement of age,[4] and thus, requires careful administration and monitoring. Its excessive usage in elderly patients may cause significant morbidity because of hypotension, tachycardia and delay in recovery. The Bispectral index (BIS) monitoring may be useful for titration of volatile anesthetic agents more precisely than what is possible by usual clinical parameters.[5]

The Bispectral Index is a derived electro-encephalographic parameter that has been extensively validated as the monitor for the DOA.[6] BIS has got scoring ranges from 0-100 that correlate with the degree of hypnosis. In patients who are conscious and awake, the score lies between 90-100, while the complete cortical suppression lead to BIS value of 0 and the values between 44-60 have been recommended for general anesthesia.[7] The monitoring has shown convincing evidence in preventing unnecessary exposure to higher concentrations of anesthetic agents leading to faster emergence, quick turnover and shorter recovery time in post anesthesia care unit[8] The purpose of doing this study was to evaluate the effect of BIS monitoring on isoflurane usage during the maintenance and recovery profile at the end of anesthesia in the elderly population.

Materials and Methods

This Quasi-experimental study was conducted at main operating theatres of a tertiary care hospital, for a period of one year, that is, from January to December 2008. The clearance from the hospital ethical review committee and informed consent from all the patients was also taken. Patients with age of 60 years or above, and American Society of Anesthesiologists' (ASA) physical status I or II, with no significant end organ damage, requiring general anesthesia with endotracheal intubation and controlled mode ventilation, were included in the study. The gynecological and general surgical procedures, which were expected to last for 2-6 hours, were selected for the study purpose. Patients with history of any psychiatric illness, alcohol abusers, altered mentation, and those requiring head, neck or laparoscopic surgeries were excluded from the study. The surgical procedures associated with anticipated major blood losses or fluid shifts were also excluded. The sample size calculated was of 60 patients on the basis of study done by Wong *et al.* in the elderly western population.[8] After power analysis, it was suggested that 28 patients in each group would be adequate to detect a 20% reduction in time to get orientation after discontinuation of the anesthesia.

After convenient sampling, patients were randomly allocated to either Standard practice group (SP Group) or Bispectral index group (BIS Group) Sixty slips of paper were taken. Thirty were labeled as SP group and rest of the thirty as BIS group. These slips were placed in an envelope and taken out for every patient before the start of procedure. The consultant anesthetist supervised all the cases. All patients had premedication with midazolam 3.75 mg orally an hour prior to the surgery. Routine standard monitoring in the form of pulse oximetery, electrocardiogram, end tidal carbon dioxide and non-invasive blood pressure was instituted in both the groups. The spectrophotometer analysis of inspired and expired composition of the gases and Isoflurane was also employed. The Datex Ohmeda monitor (Type DL CC 15.03, Compton Drive Beaverton, Oregon, USA) was used to monitor these parameters. Patients in the BIS Group had continuous assessment of BIS monitoring by applying BIS sensors (Aspect Medical System Inc. Newton, MA, USA) to the forehead and temple regions before the induction of anesthesia. BIS value was recorded by Aspect Electroencephalography (EEG) monitor (Model A-2000)

After pre-oxygenation with 100% oxygen, general anesthesia was induced in groups with propofol 1.5- 2.0 mg/ kg, fentanyl 1 mcg/kg and atracurium 0.5 mg/kg of body weight. Endotracheal intubation was performed after three minutes of giving the muscle relaxant. All patients were mechanically ventilated to keep end tidal carbon dioxide of 32-35 mmHg. Maintenance of anesthesia was done with 40% oxygen and 60% nitrous oxide with total flow of 2.5 liters monitored via float indicator on the constant pressure variable orifice flow-meter. Isoflurane was delivered through TEC 4 vaporizer by regulating its concentration through the dial setting in percentage and by monitoring the MAC value on the anesthesia monitor. Intermittent bolus of atracurium 10 mg intravenously was delivered to keep at least 1-2 twitch using train of four stimuli as guided by the nerve stimulator. The isoflurane was used in all the patients to maintain adequate DOA. In the SP Group, it was titrated at the discretion of the primary anesthetist by monitoring the routine clinical parameters like heart rate, blood pressure and end tidal vapor concentration in the form of MAC. On the other hand, in the BIS Group, isoflurane delivery was aided by keeping the BIS value between the numerical value of 45-55.

Intraoperative hypertension was defined as blood pressure greater than 25% of base line, and tachycardia as heart rate greater than 90/minute. The standard protocol for treating the intraoperative hypertension was used, that is by adjusting DOA along with the boluses of fentanyl 25-50 ug or muscle relaxant depending upon the situation, and the judgment of primary anesthetist. Intraoperative hypotension defined as blood pressure less than 25% of base line, was treated with boluses of ephedrine 5 mg or phenylephrine 50-100 ug. Bradycardia (defined as heart rate less than 25% of base line), was treated with glycopyrolate 0.2 mg in both the groups.

Patient's demographic data and other relevant information were recorded. Hemodynamic variables including systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and BIS score were recorded at 10 minutes interval till the discontinuation of Isoflurane. For the data collection purpose, all the parameters were started to be logged after declaring the patient ready for surgery, because that was supposed to be the maximum time during which the patients recovered from hemodynamic response to induction and intubation. Measurement of intraoperative isoflurane consumption in milliliters was started at the same time. The parameters included for this measurement were recorded as described by Dion and as given below:[9]

"Usage of Isoflurane (ml) = Dialed concentration x Fresh gas flow x Duration at that concentration x Molecular weight divided by 2412 x Density"

Mean consumption of isoflurane in milliliters during the procedure was calculated. Isoflurane was continued till the closure of skin incision in both the groups. The patients in both the groups were extubated when they were fulfilling the subjective and objective criteria for extubation. That is following the command, they had an intact gag, tidal volume of at least 6 ml/kg body weight, and T1/T4 ratio of more than 0.7 on the nerve stimulator. Neuromuscular blockade was reversed with glycopyrrolate 0.5 mg and neostigmine 2 mg. Nitrous oxide was discontinued after giving the reversal agent. The time of discontinuation of isoflurane was noted. From this point, the time taken by the patient for eye opening on verbal command for extubation and becoming ready for the shifting to the recovery room was recorded in both the groups. All patients were considered for shifting to the recovery room, when they had stable hemodynamics and were not requiring any support to maintain their airway. Finally, at the arrival in recovery room, immediate post anesthesia recovery score (PAR) score was also recorded in all the patients. The PAR scoring system includes the assessment of airway, ventilation, color of the patient, awareness and the assessment of movement. The total score is 10 and a patient with a score greater than 8 can be discharged safely. The postoperative pain management was left at the discretion of primary anesthetist.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 10. Data variables including age, weight, height, systolic, diastolic blood pressure, heart rate, isoflurane consumption and PAR score were expressed as mean ± Standard Deviation (SD). Student's t - test (unpaired) and Chi Square tests were applied to compare different variables between the SP Group and BIS Group, respectively. *P* value of less than 0.05 was considered as significant.

Results

Total 60 patients were enrolled in the study. Patients in both the study groups were successfully followed till the end of study period. There was no statistically significant difference in the demographic data between the two groups [Table 1]. Hypertension and diabetes mellitus were common associated diseases in the study patients; however, the difference in their frequency was not significant amongst the groups ($P = 0.9$) The mean duration of surgery was 152.33 ± 29 minutes in the SP group versus 154.46 ± 35.6 minutes in the BIS group ($P = 0.80$) There was no significant difference in HR, SBP and DBP during the maintenance of anesthesia between the two groups ($P = 0.1$) The mean isoflurane usage in SP group was 10.6 ± 2.5 ml and 6.10 ± 2.3 ml in BIS group [Figure 1] The difference was statistically significant with *P* value of 0.001. Regarding recovery profiles there was significant difference in time to eye opening in SP versus BIS group (10.1 ± 3.0 min versus 6.96 ± 2.1 minutes) with *P* value of 0.0001. The time taken to extubate the patients was higher in the SP as compared to BIS group (11.23 ± 3.1 vs. 7.83 ± 2.6 minutes) with *P* value of 0.0001. Similarly, the time taken by the patients to become ready for the shifting to recovery room was also higher in the SP group as compared to BIS group (13.0 ± 2.1 minutes versus 9.40 ± 2.2 minutes) with *P* value of 0.0001 [Figure 2].The mean PAR score at arrival in recovery room was 7.7 in SP group versus 9.1 in BIS group, showing a significant difference with a *P* value of less than 0.0001.

Discussion

The DOA is usually assessed by monitoring the clinical

Table 1: Comparison of demographic data between the groups expressed as mean with standard deviation (SD) as seen in the study

Variables	Group		*p* value
	SP (n = 30)	BIS (n = 30)	
Age (years)	62.80 ± 3.14	64.00 ± 4.68	0.248
Weight (kg)	64.24 ± 13.73	66.37 ± 12.49	0.534
Height (cm)	157.78 ± 7.43	158.38 ± 9.88	0.791
BMI (kg/m2)	26.66 ± 3.46	26.46 +3.49	0.831
Sex (Male\Female)	8\22	8\22	> 0.999

Where, BIS = Bispectral index; SP = Standard practice

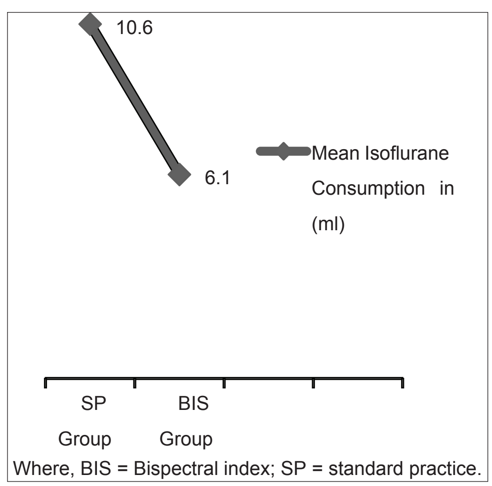

Figure 1: Mean Isoflurane consumption (ml) between the groups as seen in the study Where, BIS = Bispectral index; SP = standard practice

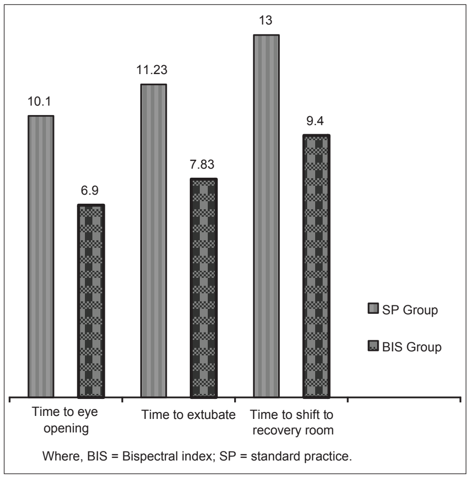

Figure 2: Comparison of recovery profiles (in minutes) between the SP and BIS group as seen in the study Where, BIS = Bispectral index; SP = standard practice. Source of Funding: Post Graduate Medical Education Committee, Aga Khan University, Karachi, Pakistan

parameter during anesthesia. These clinical parameters become unreliable in term of the exact titration of anesthetic agents.[10] The monitoring of inhalational anesthetic concentration in the form of MAC value is also a part of the routine anesthesia practice. It provides a method to monitor the continuous brain concentration of volatile anesthetics after equilibration between the alveolus, blood and brain concentration. The BIS index is a numerically processed, clinically-validated EEG parameter that measures the effects of anesthesia and sedation on brain.[11] According to the manufacturer of BIS, this monitoring may act as an additional vital sign that allows the clinicians to deliver anesthesia according to the patient need, and to assess and respond appropriately to a patient's clinical condition during surgery. Over all it may be helpful in maintaining adequate DOA. A study by Katoh *et al.*[4] examining the effect of increased age on the BIS index showed that the BIS index was a better predictor of depth of sedation than the end-tidal sevoflurane concentration.

The study done by Wong *et al.*[8] in elderly western population undergoing elective hip or knee replacement, showed 30% reduction in isoflurane usage in the BIS group. Similarly, the results of prospective randomized controlled study conducted by Song[12] in young females undergoing gynecological surgery on outpatient basis, showed that BIS monitoring reduced sevoflurane and desflurane usage by 30–38%. The results of our study were also consistent with these studies, indicating that BIS monitoring may be used successfully to titrate isoflurane in elderly patients as evidenced by 40% reduction in isoflurane consumption in the BIS group. The major difference between our study and these studies is the selected population and the type of surgical procedures. The hemodynamic variables including SBP, DBP and HR during the maintenance of anesthesia did not show any statistically significant difference between the two groups in our study. It indicated adequate DOA in spite of significant reduction of the isoflurane usage in the BIS group.

As already described, the elderly patients may have an altered response to the anesthetic intervention because of the age related deterioration of physiological reserves. This may impact in the form of delayed recovery at the end of anesthesia. BIS monitoring may be helpful in attaining faster recovery at the end of anesthesia. This is because of the titrated use of isoflurane. We also need to consider the fact that our elderly population may have got a different physiological status, lifestyle and habitual characteristics in comparison to the western population, where most of the studies were conducted. We were anticipating the much better role of this monitoring in our aged population. In this study, BIS monitoring was associated with 31% reduction in the time to eye opening.

The time to extubation was also decreased to 30%, and the time taken by the patients to become ready for the shifting to recovery room was also reduced by the same. In comparison to this, Johansen *et al.*[13] reported 37% reduction in time to extubation after emergence from anesthesia, while the operation theatre exit time was decreased to 24% when BIS monitoring was used to monitor DOA. They maintained the DOA in BIS group by keeping the BIS score between 50 and 65, which was higher than our targeted BIS, score. Plavin *et al.*[14] showed 11% faster recovery and discharge in patients when BIS monitoring was used to guide the anesthesia depth.

The PAR score was used for monitoring and discharge of patients from the recovery room in our study. The time to achieve PAR score greater than 9 at the time of arrival to post-anesthesia care unit (PACU) was faster, and statistically significant in the BIS group. This may be because of the titrated use of isoflurane in BIS group, which ultimately lead to early awakening and returning of orientation in these patients. The study conducted by Gan *et al.*[15] in 300 adult patients undergoing general anesthesia showed significant difference in orientation at the time of arrival in PACU in patients monitored by BIS, hence, these patients became eligible for the discharge sooner than the non BIS group. The elderly patients in the Wong's study also showed statistically significant reduction in time to achieve the Aldrete score of 9 in the BIS group.

The study of Plavin[14] on 1580 patients showed no convincing effect of BIS monitoring on the recovery profiles after anesthesia. The major difference in the study conducted by Plavin and our study is the non-standardization of anesthetic technique in the Plavin's study. Similarly the results of Zohar *et al.*[16] in the elderly out-patients showed no difference in sevoflurane consumption, and recovery profiles between the BIS and the non BIS group.

The technique involved in their protocol was maintenance of spontaneous ventilation using a laryngeal mask airway, which was different from the technique used in our protocol.

There were a few limitations in our study. The study was not blinded at all. For the study purpose, the primary investigator worked with the anesthetist who was responsible for the case. The primary investigator recorded all observations. The second limitation is the variation in the type of surgical procedures between the patients in both the groups. Its impact may be in the form of variation in the DOA requirement for the particular procedure, leading to the difference in anesthetic consumption. Time management for the different observations would be the same if the standard surgical procedure was considered. Different authors have also measured the postoperative cognitive dysfunctions and incidences of awareness in their work; however, this was not our objective and requires a large sample size for finding such rare incidences.

The cost of getting BIS monitor and BIS electrodes is a major hindrance in developing countries for the provision of this monitoring. For the study purpose, our patients did not have to bear any additional charges, as the expenses were executed by the grant. The cost of using this monitoring involves the cost of purchasing the monitor, and the cost of the single use of a BIS electrode. Implementation of this monitoring may however reduce the overall cost by reduction in the inhalational agent usage and help with better recovery profiles and earlier discharge. However, this requires further confirmation by a large multicenter trial employing a bigger sample size.

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