INDONESIAN JOURNAL OF ANESTHESIOLOGY AND REANIMATION
Volume 7 (1), January 2025 : 12-21

Original Research Article

BISPECTRAL INDEX VERSUS MINIMUM ALVEOLAR CONCENTRATION GUIDED ANESTHESIA FOR ASSESSMENT OF INTRAOPERATIVE AWARENESS IN PATIENTS UNDERGOING LAPARASCOPIC ABDOMINAL SURGERY

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ABSTRACT

Introduction: Intraoperative awareness with explicit recall (AWR) occurs when an individual retains memory of intraoperative events after completion of anesthesia. It is an unpleasant feeling feared by both the patients and the anesthetists. **Objective:** This research aims to compare Bispectral Index (BIS) versus Minimum Alveolar Concentration (MAC) guided anesthesia for assessment of intra-operative awareness in patients undergoing laparoscopic abdominal surgery. **Methods:** This research is a prospective comparison involving 100 patients divided into two groups of 50 patients each. Group M (MAC): Desflurane concentration was maintained at a MAC value of 1. The BIS monitor was not to be applied to this group of patients at the time of induction, but in Group B (BIS), the BIS electrode was applied on the forehead immediately before induction. Hemodynamic parameters including heart rate and mean arterial blood pressure were recorded. After the surgery, the patients were interviewed using the Modified Brice Awareness Questionnaire and Michigan Awareness Classification score for assessment of intra-operative awareness or consciousness at two intervals: in the post-anesthesia care unit and 48 hours after surgery. **Results:** Demographic data were comparable between groups M and B. No significant differences in the hemodynamic parameters, which include heart rate and mean arterial blood pressure (MAP) between the M group and the B group (p value>0.05). The patient's awareness was compared based on a modified Brice awareness questionnaire. The distribution of awareness was comparable between groups M and B (0% vs. 4% respectively) (p value=0.495). The distribution of Michigan awareness classification scores was comparable between groups M and B. Class 0 (no awareness) was 98% vs. 96% respectively, and Class 1(isolated auditory perception) of 2% vs. 4% respectively with (p value=1). **Conclusion:** This research found that BIS-guided anesthesia works just as well as MAC-guided anesthesia at keeping patients from waking up and keeping an eye on changes in their blood pressure while they are under general anesthesia for laparoscopic abdominal surgery.

Keywords: Awareness; Bispectral Index; Blood Pressure; Heart Rate; Mean Arterial Pressure; Minimum Alveolar Concentration

ABSTRAK

Pendahuluan: Kesadaran intraoperatif dengan ingatan eksplisit (AWR) terjadi ketika setelah selesainya anestesi, seseorang mengingat kembali kejadian intraoperatif. Kejadian ini merupakan perasaan tidak menyenangkan yang ditakuti oleh pasien maupun ahli anestesi. **Tujuan:** Penelitian ini bertujuan untuk membandingkan indeks bispektral (BIS) versus konsentrasi alveolar minimum (MAC) berdasarkan panduan anestesia untuk penilaian kesadaran intraoperatif pada pasien yang menjalani operasi laparoskopi abdomen. **Metode:** Penelitian ini adalah penelitian komparatif prospektif yang melibatkan 100 pasien dibagi menjadi 2 kelompok yang masing-masing terdiri dari 50 pasien. Kelompok M (MAC): Konsentrasi desflurane dipertahankan pada nilai MAC 1. Monitor BIS tidak diterapkan pada kelompok pasien ini pada saat induksi dan Kelompok B (BIS): Pada kelompok ini elektroda BIS diterapkan pada dahi tepat sebelum induksi. Parameter hemodinamik (denyut jantung dan tekanan darah arteri rata-rata) juga dicatat. Setelah pembedahan, pasien diwawancarai menggunakan Kuesioner Kesadaran Brice yang dimodifikasi dan skor Klasifikasi Kesadaran Michigan untuk penilaian kesadaran intra-operatif pada dua interval: di unit perawatan pasca-anestesi dan 48 jam setelah pembedahan. **Hasil:** Data

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demografi dibandingkan antara kelompok M dan B. Tidak ada perbedaan signifikan dalam parameter hemodinamik yang mencakup denyut jantung dan tekanan darah arteri rata-rata antara kelompok M dan kelompok B (nilai p> 0,05). Kesadaran pasien dibandingkan berdasarkan kuesioner kesadaran brice yang dimodifikasi. Distribusi kesadaran dibandingkan antara kelompok M dan B. (Masing-masing 0% vs 4%) (nilai p = 0,495). Distribusi skor klasifikasi kesadaran Michigan dibandingkan antara kelompok M dan B. Kelas 0 (Tidak ada kesadaran) masing-masing 98% vs 96%, Kelas 1 (Persepsi pendengaran terisolasi) masing-masing 2% vs 4% dengan (nilai p = 1). **Kesimpulan:** Penelitian ini menyimpulkan bahwa anestesi yang dipandu BIS sama efektifnya dengan anestesi yang dipandu MAC dalam mencegah kesadaran dan mengelola perubahan hemodinamik selama pasien menjalani operasi perut laparoskopi dengan anestesi umum.

Kata kunci: Kesadaran; Indeks bispektral; Tekanan darah; Denyut jantung; Tekanan arteri rata-rata; Konsentrasi alveolar minimum

Article info: Received: July 10, 2024; Received: August 6, 2024; Accepted: November 25, 2024; Published: January 30, 2025

INTRODUCTION

Laparoscopic surgeries are widely accepted and performed due to several advantages such as decreased postoperative pain, early ambulation, shorter hospital stay, cosmetically small incision, and more cost-effectiveness. There are three elements of balanced anesthesia namely amnesia, analgesia, and areflexia, which must always be considered while providing general anesthesia to patients (1).

The element of amnesia should be addressed carefully while anesthetizing any patient. A multitude of surgical patients apprehendto the possibility of immobility, being awake, or being in pain due to inadequate anesthesia during the surgery (2). This inadequacy results in patients having awareness during anesthesia. Intraoperative awareness with explicit recall (AWR) occurs when an individual recalls intraoperative events after completion of anesthesia. It is an unpleasant feeling feared by the patients and the anesthetists, equally. It is an important cause of post-traumatic stress disorder (PTSD) for the patients following surgery and an important medico-legal liability for the anesthesiologist. Therefore, it is important to maintain adequate depth of anesthesia during the surgery (3).

General anesthetic agents suppress cortical activity; and disrupt the connectivity of cortical areas and subcortical–cortical connections in a dose-dependent manner.

Some processing of information occurs in lighter planes of anesthesia also, even though the patients are apparently adequately anesthetized. The overall incidence of intraoperative awareness with explicit recall is approximately 0.2%-2%, but maybe >40% in some high-risk surgical patients like those with caesarean section, multiple trauma, hemodynamic instability, and cardiac surgery (4,5).

Depth of anesthesia refers to the progressive depression of the central nervous system and a decreased response to noxious stimuli. Adequate depth of anesthesia is achieved when the concentration of agents is sufficient to ensure both patient comfort and successful surgery. There are various somatic and clinical parameters, and devices available for anesthetists to monitor the depth of anesthesia. The two main methods frequently used are bispectral index (BIS) and minimum alveolar concentration (MAC). MAC relates to the concentration of the inhalational anesthetic agent to a single, clinically relevant endpoint of general anesthesia. It is defined as the minimum alveolar concentration of inhaled anesthetics required to prevent response in

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50% of the subjects to a painful stimulus. When the MAC is approximately 0.3, 50% of the subjects do not respond to verbal commands (MAC awake), and maintaining the MAC more than 0.7 is said to reduce the incidence of AWR. It is thought that the end-tidal inhaled anesthetic partial pressure shows the partial pressure in the alveoli, which in turn shows the partial pressure of the anesthetic agent at the effect site, like the brain. This makes MAC reliable and useful. Thus, with the ease of measurement of the end-tidal anesthetic gas, MAC is considered a standard metric for comparing the potency of inhalational anesthetic agents (6,7).

The Bispectral Index (BIS) is a complicated number that is made up of different EEG features, such as frequency domain, time domain, and higher-order spectral features. Based on extensive clinical data, it correlates with behavioral assessments of hypnosis and sedation, regardless of the anesthetic or sedative agent used. The BIS score ranges from 0 to 100, with a target range of 40–60 recommended to prevent awareness; it also provides a reliable prediction of consciousness levels and responsiveness (8–10). This research aims to compare Bispectral Index (BIS) versus Minimum Alveolar Concentration (MAC) guided anesthesia for assessment of intraoperative awareness in patients undergoing laparoscopic abdominal surgery.

METHODS

Research Design and Sample Size

This prospective, randomized, and comparative research was performed at the Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, with approval from the institutional ethical committee on October 22nd, 2019 with the certificate number TP(MD/MS)08/2019)/IEC/ABVIMS/RMLH/ 672/19. The research was conducted between November 1st, 2019 and March 31st, 2021. The sample size calculation was based on the research of Alkaissi A. et al. (11) which found no cases of awareness in the BIS-guided group and 4 cases (13.8%) in the control group. Based on these figures, a minimum sample size of 49 patients per group was calculated to achieve 80% power with a 5% significance level. Thus, a total of 100 patients were included, with 50 patients in each group.

Research Participants

A hundred patients were randomly divided into two groups of 50 patients each by computer-generated random sampling. The research included 100 patients classified as American Society of Anesthesiologists (ASA) grade I and II, aged 18 to 60 years, of either sex, undergoing laparoscopic abdominal surgery. Exclusion criteria were refusal of consent, allergy to research drugs, psychosis or memory impairment, and a history of brain injury.

Research Procedures

Written and informed consent was obtained from all patients. After a thorough preoperative evaluation and investigation, patients who met the inclusion criteria were included in the research. The night before surgery, all patients received premedication with a 0.25 mg tablet of alprazolam and a 150 mg tablet of ranitidine. Upon entering the operating room, routine monitoring was initiated, including a 5-lead electrocardiogram (ECG), pulse oximetry, and non-invasive blood pressure (NIBP) measurement. Baseline vital signs, such as heart rate, systolic, diastolic, mean blood pressure, and ECG rhythm, were recorded. An 18G cannula was inserted into the dorsum of the left hand, and intravenous fluid infusion was started. Patients were then

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randomly assigned to two groups using computer-generated random numbers. Group M (MAC): Desflurane concentration was maintained at a MAC value 1. BIS monitor was not to be applied to this group of patients at the time of induction and Group B (BIS): In this group, the BIS electrode was applied on the forehead just before induction. Depth of anesthesia was BIS guided, and a BIS value of 40-60 was targeted. Desflurane concentration was titrated to keep the BIS value between the target range.

Patients received Inj. Midazolam 0.03 mg/kg and Inj. Fentanyl 2 µg/kg intravenously. Anesthesia was induced with Inj. Propofol 2 mg/kg intravenously, and 0.1 mg/kg Vecuronium bromide was given intravenously after facemask ventilation was established. Patients were ventilated with 50% oxygen, 50% nitrous oxide, and an inhalational anesthetic agent (desflurane). Intubation was carried out after 3 minutes with an appropriately sized cuffed endotracheal tube. Target end-tidal CO2 was maintained between 32-36 mm Hg. Post intubation, patients were maintained on a gas flow of 1.5 L/min (50% nitrous oxide and 50% oxygen) and an inhalational agent (desflurane). Intraoperatively, desflurane concentration was titrated as per the group chosen. Injection of Vecuronium bromide 0.01 mg/kg was given every 30 minutes. The inhalational agent was stopped at the end of skin closure and fresh gas flows were increased to 8 L/min. All patients received paracetamol 1gram intravenously 30 minutes before completion of surgery. At the completion of the surgery, neuromuscular blockade was reversed using neostigmine (0.05-0.07 mg/kg) and glycopyrrolate (0.01-0.02 mg/kg).

Intraoperative hypotension (mean arterial pressure (MAP) < 65 mmHg or less than 20% of baseline) was treated with 6 mg boluses of mephentramine, while intraoperative hypertension (MAP > 90 mmHg or more than 20% of baseline) was treated by giving intravenous nitroglycerine (0.5 -5 mcg/Kg/min). When blood pressure was not controlled after nitroglycerine, the patient was excluded from the research.

Table 1. Modified Brice Awareness Questionnaire (12)

Question asked	Immediate postoperative period	Day 2
What was the last thing you remember before going to sleep?		
What was the first thing you remember after waking up?		
Do you remember anything between going to sleep and waking up?	Yes/No	Yes/No
Did you have any dreams while you were asleep for surgery?	Yes/No	Yes/No
Were your dreams disturbing to you?	Yes/No	Yes/No
What was the worst thing about your surgery?		
Awareness		
Yes	**No**	
• If the event recalled was confirmed by the attending personnel present in the OT or investigators are convinced that the memory was real. • Unable to recall any event but memories could have been related to intra-operative events. • The answer is yes to any of the questions asked in the above interview.	• No reported awareness • The answer is no to the questions asked in the above interview.	

After the surgery, the patients were interviewed using the Modified Brice Awareness Questionnaire (12) and Michigan Awareness Classification score (13) for assessment of intraoperative awareness at two intervals: in the post-anesthesia care unit and

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48 hours after surgery. Based on the answers given, the patients were divided as having awareness or no awareness (Table 1 and Table 2).

Table 2. Michigan Awareness Classification Score (13)

Michigan awareness classification score	
Class 0	No awareness
Class I	Isolated auditory perception
Class II	Tactile perception
Class III	Pain
Class IV	Paralysis
Class V	Paralysis and Pain

The primary objective of this research was to compare the incidence of intraoperative awareness between MAC-guided and BIS-guided anesthesia. The secondary objective was to compare hemodynamic parameters, specifically heart rate and mean arterial blood pressure, in both groups.

Statistical Analysis

In the statistical analysis, categorical variables were expressed as numbers and percentages, while continuous variables were reported as mean ± SD or median. The Kolmogorov-Smirnov test was used to assess normality, and non-parametric tests were applied if normality was not met. Quantitative variables were compared between the two groups using the unpaired t-test or Mann-Whitney test, depending on the data distribution. Qualitative variables were analyzed using the chi-square test or Fisher's exact test. A p-value of <0.05 was considered statistically significant. Data were entered into an MS Excel spreadsheet, and analysis was conducted using SPSS version 21.0.

RESULT AND DISCUSSION

A total of 100 patients were included in the research. The distribution of gender was comparable between groups M and B (female: 60% vs. 50% respectively; male: 40% vs. 50% respectively) (p-value = 0.315). The distribution of ASA grade was comparable between groups M and B (Grade I: 46% vs. 48%, respectively; Grade II: 54% vs. 52%, respectively) (p-value = 0.841). The mean age was 38.86 ± 10.6 years and 36.34 ± 9.66 years in groups M and B, respectively, and the difference was not significant between the two groups in terms of age. The distribution of age was comparable between the two groups (p = 0.217) (Table 3).

Table 3. Comparison of Demographic Characteristics between Group M and B.

Variable	Group M (n=50)	Group B (n=50)	Total	p-value
Age (years)				
Mean ± SD	38.86 ± 10.6	36.34 ± 9.66	37.6 ± 10.17	0.217*
Gender				
Female	30 (60%)	25 (50%)	55 (55%)	0.315**
Male	20 (40%)	25 (50%)	45 (45%)	
ASA grade				
I	23 (46.00%)	24 (48.00%)	47 (47.00%)	0.841**
II	27 (54.00%)	26 (52.00%)	53 (53.00%)	

* Based on the independent t-test, significant if *p*-value < 0.05
** Based on the chi-square test, significant if *p*-value < 0.05

The patient's awareness was compared based on a modified Brice awareness questionnaire. The distribution of awareness was comparable between groups M and B (0% vs. 4%, respectively) (p-value = 0.495). The distribution of Michigan awareness classification score was comparable between group M and B. Class 0 (no awareness) 98% vs 96%, respectively, Class 1(isolated auditory

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perception) 2% vs. 4% respectively with (p-value = 1) (Table 4 and Table 5).

Table 4. Comparison of the Modified Brice Awareness Questionnaire between Groups M and B

Awareness	Group M (n=50)	Group B (n=50)	Total	p-value
No	50 (100%)	48 (96%)	98 (98%)	0.495*
Yes	0 (0%)	2 (4%)	2 (2%)	
Total	50 (100%)	50 (100%)	100 (100%)	

* Based on Fisher's exact test, significant if *p*-value<0.05

No significant difference was seen in heart rate (bpm) at baseline (p = 0.084), 10 minutes after intubation (p = 0.894), at skin incision (p = 0.144), at end of port placement (p = 0.098), 15 minutes after port placement (p = 0.63), 30 minutes after port placement (p = 0.974), 60 minutes after port placement (p = 0.775), at end of skin closure (p value = 0.106), 10 minutes after extubation (p = 0.244) between group M and B.

Table 5. Comparison of Michigan Awareness Classification Score between Groups M and B

Michigan Awareness Classification Score	Group M (n=50)	Group B (n=50)	Total	p-value
Class 0 {no awareness}	49 (98%)	48 (96%)	97 (97%)	1*
Class 1 {isolated auditory perception}	1 (2%)	2 (4%)	3 (3%)	
Total	50 (100%)	50 (100%)	100 (100%)	

* Based on Fisher's exact test, significant if *p*-value < 0.05

Mean ± SD of heart rate (bpm) of group M at baseline was 86.52 ± 7.66, 10 minutes after intubation was 83.8 ± 10.27, at skin incision was 78.52 ± 9.23, at end of port placement was 77.94 ± 10.4, 15 minutes after port placement, it was 77.6 ± 7.43, 30 minutes after port placement, it was 77.38 ± 7.21, 60 minutes after port placement was 78.24 ± 8.01, at the end of skin closure was 79.38 ± 8.78, 10 minutes after extubation was 82.96 ± 7.65.

Table 6. Comparison of Heart Rate between Group M and B.

Heart Rate (beats per minute)	Group M	Group B	Total	p-value
Baseline				
Mean ± SD	86.52 ± 7.66	89 ± 6.51	87.76 ± 7.18	0.084*
10 minutes after intubation				
Mean ± SD	83.8 ± 10.27	84.08 ± 10.72	83.94 ± 10.45	0.894*
At skin incision				
Mean ± SD	78.52 ± 9.23	82.16 ± 14.82	80.34 ± 12.42	0.144*
At the end of port placement				
Mean ± SD	77.94 ± 10.4	81.82 ± 12.71	79.88 ± 11.72	0.098*
15 minutes after port placement				
Mean ± SD	77.6 ± 7.43	76.68 ± 11.2	77.14 ± 9.47	0.630*
30 minutes after port placement				
Mean ± SD	77.38 ± 7.21	77.44 ± 10.57	77.41 ± 9	0.974*
60 minutes after port placement				
Mean ± SD	78.24 ± 8.01	77.52 ± 9.3	77.9 ± 8.57	0.775*
At the end of skin closure				
Mean ± SD	79.38 ± 8.78	82.64 ± 11.08	81.01 ± 10.08	0.106*
10 minutes after extubation				
Mean ± SD	82.96 ± 7.65	84.98 ± 9.49	83.97 ± 8.64	0.244*

* Based on the Independent t-tes, significant if *p*-value<0.05

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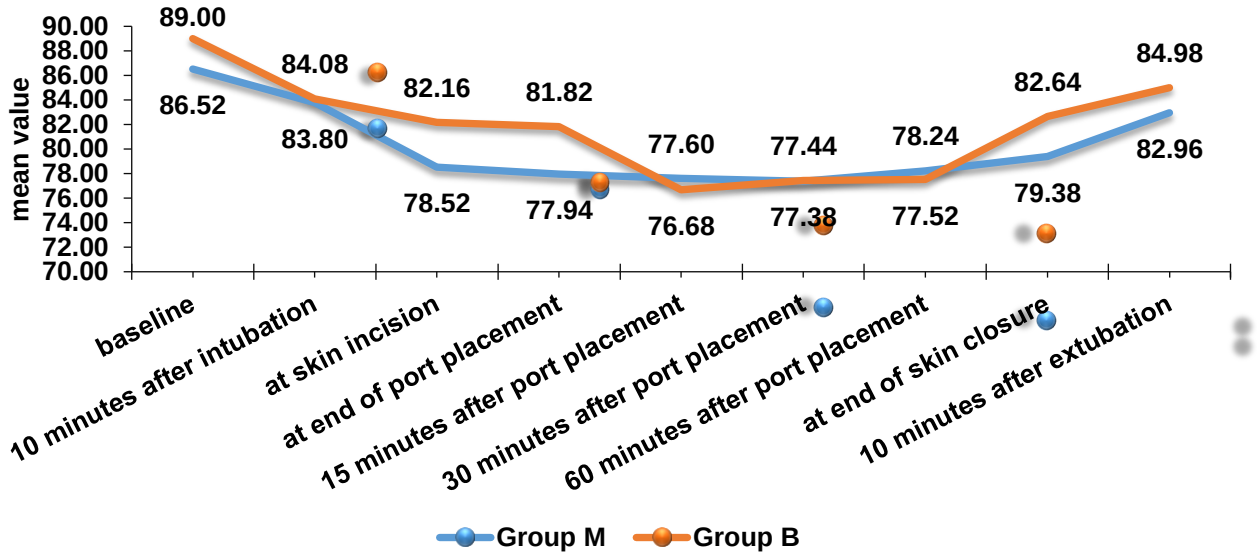

Figure 1. Comparison of The Trend of Heart Rate (Beats per Minute) at Different Time Intervals between Groups M and B.

Mean ± SD of heart rate (bpm) of group B at baseline was 89 ± 6.51, 10 minutes after intubation was 84.08 ± 10.72, at skin incision was 82.16 ± 14.82, at the end of port placement was 81.82 ± 12.71, 15 minutes after port placement was 76.68 ± 11.2, 30 minutes after port placement was 77.44 ± 10.57, 60 minutes after port placement was 77.52 ± 9.3, at end of skin closure was 82.64 ± 11.08, 10 minutes after extubation was 84.98 ± 9. (Table 6) (Figure 1).

No statistically significant difference was seen in mean arterial pressure(mmHg) at baseline (p value = 0.156), at end of port placement (p value = 0.677), 15 minutes after port placement (p value = 0.15), 30 minutes after port placement (p value = 0.654), 60 minutes after port placement (p value = 0.062), at end of skin closure (p value = 0.264), 10 minutes after extubation (p value = 0.626) between group M and B (Table 7) (Figure 2).

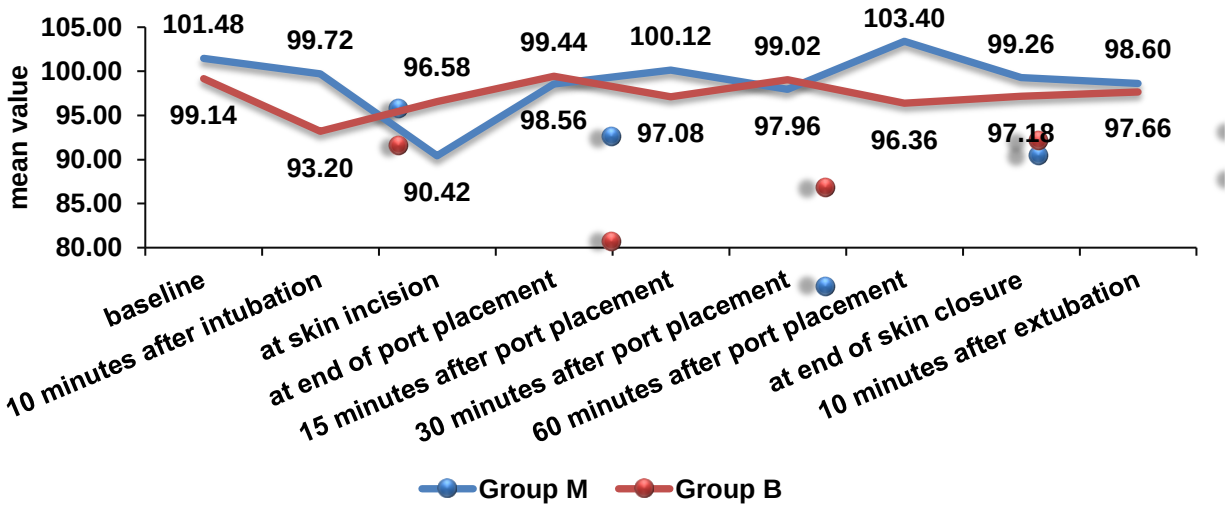

Figure 2. Comparison of The Trend of Mean Arterial Pressure (mmHg) at Different Time Intervals between Groups M and B.

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Intraoperative awareness can be a major source of post-traumatic stress disorder and cognitive dysfunction in the patients which has important medico-legal implications for the anesthesiologist.

In this research, the two groups were comparable with respect to age (P = 0.217), gender distribution (P = 0.315), and ASA physical status (P = 0.841), and no statistical difference was found between Group M and Group B. The demographic variables of age, gender, ASA grade, or type of laparoscopic surgery did not influence the incidence of intraoperative AWR nor did it affect the hemodynamic stability during the surgery. This research results of the demographic profile are in concordance with the previous research conducted by Wang J. et al. (14) and Mozafari H. et al. (15).

In this research, we observed that the incidences of intraoperative awareness in Group M and Group B were comparable with only 1 case of awareness in Group M and 2 cases of awareness in Group B (P = 1). The AWR was assessed using the Michigan Awareness Classification score. Similarly, based on the Modified Brice Awareness Questionnaire incidence of awareness in MAC and BIS-guided maintenance of anesthesia were 0% & 4%, respectively with two cases of definite intraoperative awareness reported, both being in BIS monitored group and no cases of definite or possible awareness in the MAC monitored group (p = 0.495).

The both observations are consistence with Chen Y et al. (16) which proved that the incidence rates of intra-operative anesthesia awareness were 0.62% and 0.31% in the BIS and MAC groups, respectively, and concluded that intraoperative awareness was comparable between MAC and BIS groups. The observations relating to intraoperative awareness in this research are also corroborated by the research conducted by Shanks AM et al. (17) which did not detect a difference in the incidence of definite awareness or recovery variables between monitoring protocols based on either MAC values or BIS values.

Table 7. Comparison of Mean Arterial Blood Pressure between Group M and B

Mean Arterial Pressure(mm Hg)	Group M	Group B	Total	p-value
Baseline				
Mean ± SD	101.48 ± 8.11	99.14 ± 8.27	100.31 ± 8.23	0.156*
10 minutes after intubation				
Mean ± SD	99.72 ± 10.96	93.2 ± 10.12	96.46 ± 11	0.003*
At skin incision				
Mean ± SD	90.42 ± 10.68	96.58 ± 12.99	93.5 ± 12.23	0.011*
At the end of port placement				
Mean ± SD	98.56 ± 9.78	99.44 ± 11.25	99 ± 10.49	0.677*
15 minutes after port placement				
Mean ± SD	100.12 ± 9.83	97.08 ± 11.08	98.6 ± 10.53	0.15*
30 minutes after port placement				
Mean ± SD	97.96 ± 12.51	99.02 ± 11.05	98.49 ± 11.75	0.654*
60 minutes after port placement				
Mean ± SD	103.4 ± 12.84	96.36 ± 12.25	100.11 ± 12.92	0.062*
At the end of skin closure				
Mean ± SD	99.26 ± 9.33	97.18 ± 9.2	98.22 ± 9.28	0.264*
10 minutes after extubation				
Mean ± SD	98.6 ± 8.81	97.66 ± 10.37	98.13 ± 9.59	0.626*

* Based on the Independent t-test, significant if *p*-value<0.05

The incidence of awareness was 0.12% in MAC monitored groups and 0.08% in BIS-monitored groups. In this research results are supported by the trial conducted by Mozafari H et al. (15) which showed that the overall incidence of AWR was not statistically significant in the BIS and routine monitored groups. In this research, observations were also

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supported by research conducted by Wang J et al. (14) which showed that the end-tidal anesthetic gas concentration can be used for reducing the incidence of intraoperative awareness with explicit recall. The incidence of intra-operative awareness in the MAC group was comparable to the routine monitoring group, and not statistically significant in the MAC and routine monitored groups.

This research states that there were no significant differences in the hemodynamic parameters which include heart rate and mean arterial pressure between the M group and the B group before induction, during maintenance of anesthesia and post anesthesia care unit (p value > 0.05). These results and observations are consistence with the research conducted by Mozafari H. et al. (15) who found that hemodynamic changes were not dependent on the type of technology used for monitoring the depth of anesthesia during abdominal surgeries.

The research's limitations include a small sample size and short duration, as well as recruitment exclusively from a single tertiary care hospital. To enhance precision and applicability, broader participation from multiple tertiary care hospitals would strengthen the findings. Larger sample sizes and extended research durations are necessary to yield more robust findings.

CONCLUSION

There are no significant differences in the comparison of bispectral index versus minimum alveolar concentration guided anesthesia for assessment of intraoperative awareness in patients undergoing laparoscopic abdominal surgery. Further research could explore other factors or methods to improve the assessment of intraoperative awareness during anesthesia.

Acknowledgment

The authors would like to express their gratitude to the Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Mannohar Lohia Hospital, New Delhi, India. The authors also extend thanks to all the patients who participated in this research.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this article.

Funding

The authors declared that this research has received no financial support.

Authors' Contributions

All authors have contributed to all processes in this research.

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