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The effect of depth of anesthesia on the incidence of early postoperative complications during surgery in the beach chair position

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Objective: To investigate the effect of BIS-controlled anesthesia depth on hemodynamic changes and early postoperative complications during shoulder surgery in the BCP. Methods. The prospective study involved 50 patients who underwent shoulder surgery in the BCP. Group I (n = 25) — patients whose BIS values were maintained intraoperatively within the range of 40–48, Group II (n = 25) — patients whose BIS monitoring values were maintained at the level of 49–57. Intraoperative BIS fluctuations beyond the range of 40–60 were not allowed in patients of both groups. The average age of patients in the I group was 43.2 ± 12.5 years, in the II group — 41.8 ± 10.2 years. After induction of propofol/fentanyl in a standard dosage, tracheal intubation, the patient was transferred to the BCP. For postoperative pain relief, patients received paracetamol and non-steroidal anti-inflammatory drugs without the use of narcotic analgesics. BIS monitoring with COVIDEN was used to control the depth of sedation. The Mini-mental state examination (MMSE) scale and the number linking test were used to assess cognitive impairment 24 hours before surgery and 2 days after surgery. Pain was assessed using a visual analogue scale (VAS). Results. Haemodynamic parameters were assessed before induction, after induction, and 20 minutes after positioning. Patients in group I had a significantly higher pulse rate (79.04 ± 7.51 vs. 72.76 ± 9.46 mm Hg, p < 0.05). No significant changes in MMSE and number binding test were found when comparing pre- and postoperative indicators. Significant differences in the intensity of pain syndrome were found between the groups: 3.72 ± 1.06 vs. 5.11 ± 0.90 points on the first day after surgery (p < 0.001). In group 1, 12.0 % of patients experienced postoperative nausea and vomiting on day 1, compared to 20.0 % in group 2. The time of extubation showed a significant difference between groups 1 and 2: 19.08 ± 2.87 versus 15.30 ± 2.55 points (p < 0.001). Conclusions. Maintaining the level of sedation under BIS monitoring at 49–57 in patients during surgery in NSP conditions is accompanied by less postoperative pain and a lower incidence of PONV.

Мета. Дослідити вплив глибини анестезії під контролем BIS на зміни гемодинаміки та ранні післяопераційні ускладнення під час проведення оперативних втручань на плечі в напівсидячому положенні (НСП). Методи. До проспективного дослідження було залучено 50 пацієнтів, яким виконувалась операція на плечовому суглобі в НСП. Група I (n = 25) — особи, яким інтраопераційно підтримували показники BIS у межах 40–48, група II (n =25) — хворі, показники BIS-моніторингу яких підтримували на рівні 49–57. У пацієнтів обох груп не допускалося інтраопераційних коливань BIS за межі 40–60. Середній вік у I групі складав (43,2 ± 12,5) років, у II — 41,8 ± 10,2. Після проведення індукції пропофол/фентанілу в стандартному дозуванні, інтубації трахеї хворий переводився у НСП. Для післяопераційного знеболення пацієнти отримали парацетамол і нестероїдні протизапальні препарати без використання наркотичних анальгетиків. Із метою контролю глибини седації використовували BIS-моніторінг COVIDEN. Для оцінки когнітивних порушень застосовували шкалу Mini-mental state examination (MMSE) і тест зв'язування чисел (ТЗЧ) за 24 год до оперативного втручання та на 2-гу добу після. Біль визначали за візуальною аналоговою шкалою (ВАШ). Результати. Показники гемодинаміки оцінювали до та після індукції та через 20 хв після позиціонування. Пацієнти групи I мали достовірно частіший пульс (79,04 ± 7,51 проти (72,76 ± 9,46) уд./хв, p < 0,05). Достовірних змін MMSE і ТЗЧ під час порівняння перед- та після операції виявлено не було. Відмінності в інтенсивності больового синдрому виявлені між групами: 3,72 ± 1,06 проти (5,11 ± 0,90) балів на 1-шу добу після втручання (p < 0,001). У групі I — в 12,0 та в II — 20,0 % на 1-шу добу спостерігалась післяопераційна нудота та блювання. Час екстубації мав достовірну різницю між групами: 19,08 ± 2,87 проти (15,30 ± 2,55) балів (p < 0,001). Висновки. Підтримання рівня седації під контролем BIS-моніторингу на рівні 49–57 у пацієнтів під час операції в умовах НСП супроводжується меншим післяопераційним больовим синдромом і нижчою частотою ПОНБ. Ключові слова. Напівсидяче положення, BIS-моніторинг, когнітивні дисфункції, післяопераційна нудота та блювання.

Keywords. Semi-sitting position, BIS monitoring, cognitive dysfunction, postoperative nausea and vomiting

Introduction

Accurately determining the depth of sedation remains a constant challenge for anesthesiologists. Excessively deep anesthesia can cause hemodynamic changes, while overly shallow sedation carries the risk of awakening during surgery [1]. Awakening during anesthesia is a serious complication that can have long-term psychological consequences, such as anxiety and post-traumatic stress disorder. Traditional monitoring of sedation depth is mostly assessed through clinical signs and symptoms of the patient: changes in heart rate, blood pressure, pupil size, and eye or limb movements [2]. The Bispectral Index (BIS) monitoring system was introduced in the United States in 1994 and approved by the FDA in 1996 to measure the level of consciousness using algorithmic analysis of electroencephalograms (EEG) during general anesthesia. BIS monitoring is a technology used in anesthesia to assess the level of consciousness and the hypnotic effect of anesthetic agents. It helps reduce intraoperative awakening incidents and provides an objective and accurate method for tracking the depth of anesthesia, which is a key component of some Enhanced Recovery After Surgery (ERAS) recommendations [3]. By quantitatively determining excitatory or inhibitory states of the cerebral cortex using power and frequency analysis in the EEG, BIS provides a numerical value corresponding to a specific level of consciousness that reflects the functional state of the cortex. This enables continuous non-invasive monitoring of anesthesia depth throughout the entire perioperative period, aligning with ERAS goals to optimize patient recovery, minimize complications, and accelerate recovery.

A multicenter study [4] has shown that the depth of anesthesia can influence postoperative complications. When comparing target BIS levels of 50 and 35, it was found that the quality of sedation did not affect the one-year mortality rate, but deeper anesthesia was associated with a higher risk of hemodynamic disturbances. Similar data regarding operations in a semi-sitting position (SSP) have not been found, although such a position could create a risk of brain hypoperfusion even with minor hemodynamic disturbances. Earlier reports have indicated that BIS values depend on intraoperative positioning and are significantly lower in the semi-sitting position compared to the lying position [5], although the mechanism of this phenomenon remains unclear. Given this, it is relevant to determine the safe level of BIS in the semi-sitting position.

Objective: To investigate the effect of BIS-controlled anesthesia depth on hemodynamic changes and early postoperative complications during shoulder joint surgeries in the semi-sitting position.

Materials and Methods

The study was conducted at the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine and was approved by the local Bioethics Committee (Protocol No. 231, dated 20 May 2023) of the relevant institution in accordance with the ICH GCP guidelines, the Helsinki Declaration of Human Rights and Biomedicine, and current Ukrainian legislation. All patients involved were informed about the plan and conditions of the study and provided both written and oral consent.

The prospective study involved 50 patients who underwent shoulder joint surgery (arthroscopic rotator cuff repair) in a SSP. The patients were divided into two groups: Group I ($n = 25$) consisted of individuals in whom intraoperatively BIS values were maintained within the range of 40–48, and Group II ($n = 25$) consisted of patients whose BIS index was maintained between 49–57. In both groups, intraoperative BIS fluctuations were not allowed outside the range of 40–60. The mean age of patients in Group I was (43.2 ± 12.5) years, and in Group II, it was (41.8 ± 10.2). Inclusion criteria: age 18–65 years, ASA I–II, undergoing shoulder joint surgery in SSP. Exclusion criteria: history of central nervous system diseases, gastroesophageal reflux disease, post-cholecystectomy syndrome (as these conditions increase the risk of postoperative nausea and vomiting (PONV) [6]).

After ensuring venous access, both groups received a volumetric load of 12 ml/kg [7]. Anesthesia induction was performed with a 1 % propofol solution at a dose of 2 mg/kg and fentanyl at a dose of 100 mcg. Myoplegia for tracheal intubation was induced with succinylcholine at a dose of 0.1 mg/kg, followed by maintenance of muscle relaxation with atracurium besilate at a dose of 0.3 mg/kg. General anesthesia was maintained with a 1 % propofol solution according to the BIS-monitoring parameters. Postoperative analgesia was provided with paracetamol and non-steroidal anti-inflammatory drugs without the use of narcotic analgesics. For the prevention of PONV, all patients received ondansetron 4 mg and dexamethasone 4 mg [8].

Mechanical ventilation was provided using the Drager Atlan A300 ventilator, and peripheral blood saturation (SpO2), non-invasive systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were monitored using the Mediana YM 6000 monitor. BIS monitoring COVIDEN was used to control the depth of sedation and adjust the propofol infusion. According to the manufacturer, the BIS system has a processing delay of 5–10 seconds [9]. Considering that CO_2 is a vasodilator and that a low level of carbon dioxide is thought to cause cerebral vasoconstriction [10], continuous monitoring of end-tidal CO2 concentration was performed in both groups, and the values were maintained within the range of 35–45 mm Hg.

To assess potential early cognitive impairment, the Mini-Mental State Examination (MMSE) and the number connection test (NCT) were used: assessments were conducted 24 hours before surgery and on the second postoperative day. Pain was assessed using the visual analog scale (VAS). In the postoperative period, the frequency of nausea and vomiting, extubation time, and the recovery of spontaneous breathing were analyzed.

The statistical analysis of the obtained data was performed using IBM SPSS version 9.0 software. The normality of the distribution of the samples was tested using the Kolmogorov–Smirnov test. Mean values and standard deviations were calculated. Comparisons of parameters between the groups were made using the Student's t-test.

Results

Hemodynamic indicators were assessed before and after induction and intubation, as well as 20 minutes after positioning. As expected, there were no differences in values between the groups during the first and second stages. However, at the third stage, 20 minutes after positioning, and against the backdrop of preloading, no differences in blood pressure between the groups were observed (Table 1). At the same time, patients with more superficial anesthesia (Group I) had a significantly higher pulse rate (79.04 ± 7.51 vs. 72.76 ± 9.46 beats per minute, $p < 0.05$).

Cognitive function was evaluated 24 hours before surgery and two days after. No significant changes in MMSE scores or in the number connection test were found when comparing preoperative and postoperative values (Table 2).

Pain assessment was conducted on the 1st and 2nd postoperative days using the Visual Analog Scale. Statistically significant differences were found in the intensity of pain between patients in Group I and Group II: 3.72 ± 1.06 vs. 5.11 ± 0.90 points on the first postoperative day ($p < 0.001$). On the 2nd postoperative day, no significant differences were observed (Table 3).

Postoperative nausea and vomiting were observed in 5 patients (12.0 %) in Group I and 3 patients (20.0 %) in Group II on the first postoperative day. On the second day after surgery, no instances of postoperative nausea or vomiting were recorded in any patient.

Recovery of adequate spontaneous breathing was considered to occur when CO_2 levels were maintained below 50 mm Hg. Extubation was performed when the BIS level reached 85. The time to extubation showed a significant difference between Group I and Group II: 19.08 ± 2.87 minutes vs. 15.30 ± 2.55 minutes ($p < 0.001$) (Table 5).

Discussion

This study examined how anesthesia depth, measured by BIS, affects peripheral hemodynamics,

Table 1

Hemodynamic changes in patients of the studied groups, M ± SD

Group	SBP, mmHg	DBP, mmHg	MAP, mmHg	Pulse, bpm
I	Initial level			
	126.32 ± 8.57	83.88 ± 7.65	95.7 ± 7.82	78.96 ± 10.87
	After induction			
	98.72 ± 9.96	65.12 ± 10.48	73.86 ± 3.75	74.76 ± 7.73
	20 Minutes after positioning			
	97.6 ± 5.38	63.92 ± 2.88	74.25 ± 3.48	79.04 ± 7.51
II	Initial level			
	125.84 ± 12.25	85.88 ± 10.67	97.73 ± 5.34	74.84 ± 10.57
	After induction			
	103.69 ± 12.54	69.38 ± 9.20	75.32 ± 4.42	81.30 ± 10.69
	20 Minutes after positioning			
	98.07 ± 5.57	64.69 ± 2.72	75.58 ± 4.84	72.76 ± 9.46

Table 2

Dynamics of cognitive functions in the patients of the study groups, M ± SD

Group	MMSE, score	TCT, sec
I	24 hours before surgery	
	27.92 ± 1.15	65.96 ± 18.50
	2 days after surgery	
	28.28 ± 2.33	65.84 ± 22.62
II	24 hours before surgery	
	27.65 ± 1.12	71.73 ± 7.65
	2 days after surgery	
	27.88 ± 0.99	72.92 ± 12.51

Table 3

Study of pain syndrome levels in patients, M ± SD

Group	VAS (score)	
	Day 1	Day 2
I	3.72 ± 1.06	2.92 ± 1.28
II	5.11 ± 0.90 *	3.5 ± 0.86

Note: * $p < 0.001$ — differences in pain syndrome scores between Group I and Group II on the first postoperative day.

Table 5

Study of differences in recovery time of spontaneous breathing and extubation in patients

Group	Spontaneous breathing recovery, min	Extubation, min
I	10.36 ± 1.95	19.08 ± 2.87 *
II	9.03 ± 1.86	15.30 ± 2.55

Note: * $p < 0.001$ - differences in extubation time between groups.

neuropsychological status, pain perception, and postoperative recovery quality after shoulder surgery under general anesthesia. Our findings showed that with deeper sedation (BIS 40–48), as compared to superficial sedation (BIS 49–57), there were no significant changes in hemodynamic parameters, which is particularly important for surgeries in the SSP. Patients with deeper sedation reported less intense pain and fewer episodes of nausea and vomiting.

In studies by Y. Gu et al., postoperative nausea and vomiting were analyzed, and it was found that in the group where BIS monitoring was used during anesthesia (1,556 patients), there was no reduction in the incidence of postoperative nausea and vomiting compared to the group where standard clinical monitoring was used (1,645 patients) [11]. Similarly, in a study of 247 patients by J.L. Vance et al., no statistical differences were found between the depth of anesthesia under BIS control, the length of stay in the intensive care unit, or the overall duration of hospitalization [12]. A recent meta-analysis of 26 randomized controlled trials, involving 10,743 patients, showed that based on depth of anesthesia monitoring, deeper sedation was associated with lower pain scores during the first hour after surgery, but with a higher incidence of postoperative delirium [13]. Another meta-analysis of 15 studies with 5,392 participants demonstrated that aiming for a relatively high BIS level was associated with a reduction in postoperative dementia and cognitive dysfunction, but no significant differences were found in terms of hospital length of stay or mortality [14].

In a study involving 50 patients aged 18–60 years, it was found that BIS-guided anesthesia promotes earlier extubation and reduces the consumption of anesthetics [15].

Conclusions

Comparison of deeper anesthesia (BIS 49–57) with more superficial anesthesia (BIS 40–48) in patients undergoing shoulder joint surgery in the SSP showed that the former is associated with less postoperative pain and a lower frequency of PONV, without leading to significant changes in intraoperative hemodynamics, which is especially important for surgeries performed in the SSP.

The level of anesthesia depth based on BIS parameters does not affect the detection of cognitive disorders in the early postoperative period.

Conflict of Interest. The authors declare no conflict of interest.

Prospects for Future Research. The obtained data allow for the optimization of anesthesiological management of patients under BIS monitoring, contributing to the reduction of complication rates.

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THE EFFECT OF DEPTH OF ANESTHESIA ON THE INCIDENCE OF EARLY POSTOPERATIVE COMPLICATIONS DURING SURGERY IN THE BEACH CHAIR POSITION

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