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The effect of body position on hemodynamic parameters and bispectral index

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Surgical interventions routinely have a significant impact on haemodynamic parameters due to a combination of factors: stress, anaesthetics, specific surgical procedures and perioperative position. Monitoring the bispectral index (BIS) helps to adjust anaesthesia to maintain stable haemodynamic status, minimise consciousness and potentially reduce recovery time. Objective. To assess the effect of body position on haemodynamic parameters and bispectral index during upper limb surgery under general anaesthesia with propofol solution. Methods. A prospective randomised study involved 70 patients divided into two groups: I (n = 35) — operated on in a semi-sitting position (SSP); II (n = 35) — anaesthetised in a standard supine position. The average age of patients in group I was (43.06 ± 11.92), in group II — (40.25 ± 10.14) years. General anaesthesia was maintained with a 1% propofol solution depending on BIS monitoring indicators. To control the depth of sedation and adjust the propofol infusion, BIS monitoring COVIDEN was used. Results. Patients were comparable in terms of age, duration of surgery, and blood loss. When comparing haemodynamic values, the following changes were observed: a statistical difference in SBP (p < 0.001), DBP (p < 0.001), SAT (p < 0.001), slight tachycardia was observed compared to group II, but within the reference values (79.22 ± 9.76) beats per minute and (71.34 ± 7.77) beats per minute, respectively (p < 0.001). Reliable statistical values were obtained when calculating the dosage of 1% propofol solution; in group I, the average value was (4.87 ± 0.24) mg/kg/hour, while in group II it was (6.16 ± 0.49) mg/kg/hour (p < 0.001). Episodes of nausea and vomiting were observed in 12 patients in group I and in 5 patients in group II. The average time to spontaneous breathing recovery was longer in group I (p < 0.001), but no significant difference was found in the average time to extubation (p = 0.55). Conclusions. Anaesthesia monitoring using BIS allows to reduce the recovery time after awakening by reducing the total doses of anaesthetics administered. The infusion of anaesthetics depends not only on haemodynamic parameters but also on the perioperative body position.

Оперативні втручання зазвичай викликають значний вплив на гемодинамічні показники через поєднання таких чинників: стрес, анестетичні засоби, специфічні хірургічні процедури та періопераційне положення. Моніторинг біспектрактрального індексу (BIS) допомагає скоригувати анестезію для підтримки стабільного гемодинамічного статусу, мінімізації свідомості та потенційного скорочення часу відновлення. Мета. Оцінити вплив положення тіла на показники гемодинаміки та біспектрального індексу під час операції на верхніх кінцівках під загальною анестезією зі застосуванням розчину пропофолу. Методи. До проспективного рандомізованного дослідження залучено 70 хворих, розподілених на 2 групи: I (n = 35) — оперовані в напівсидячому положенні (НСП); II (n = 35) — анестезовані в стандартному положенні на спині. Середній вік хворих у I групі складав (43,06 ± 11,92), в II — (40,25 ± 10,14) років. Загальна анестезія підтримувалась розчином пропофолу 1 % залежно від показників BIS-моніторингу. Для контролю глибини седації та корекції інфузії пропофолу використовували BIS-моніторінг COVIDEN. Результати. Пацієнти були співставні за віком, тривалістю операції та крововтратою. Під час порівняння значень гемодинаміки виявлені такі зміни: статистична різниця в показниках СіАТ (p < 0,001), ДіАТ (p < 0,001), САТ (p < 0,001), спостерігається незначна тахікардія, порівняно з групою II, але в межах референтних значень (79,22 ± 9,76) уд. за хв та (71,34 ± 7,77) уд. за хв відповідно (p < 0,001). Достовірні статистичні значення отримано під час розрахунку дозування розчину пропофолу 1 %, в I групі середній показник складав (4,87 ± 0,24) мг/кг/год, тоді як в II — (6,16 ± 0,49) мг/кг/год (p < 0,001). Епізоди нудоти та блювання спостерігались у 12 хворих в I групі пацієнтів, та у 5 II групи. Середній час відновлення спонтанного дихання в I групі довший (p < 0,001), не було виявлено достовірної різниці в середньому часі екстубації (p = 0,55). Висновки. Моніторинг анестезії за допомогою BIS дозволяє скоротити час відновлення після пробудження, за рахунок зменшення введення загальних доз анестетиків. Їх інфузія залежить не лише від показників гемодинаміки, але і від періопераційного положення тіла. Ключові слова. Загальна анестезія, напівсидяче положення, гемодинаміка, BIS-моніторинг.

Keywords. General anaesthesia, BCP, haemodynamics, BIS monitoring

Introduction

Upper extremity surgery is performed in two main perioperative positions: semi-recumbent (SRP) and standard supine. Upper extremity surgery under general anesthesia requires controlled hypotension (to minimize blood loss and optimize the operating field). However, prolonged hypotension can lead to the development of neurological complications such as stroke, cerebral ischemia, and transient visual loss [1], as blood pressure is a target factor that affects organ perfusion. Hypoperfusion and organ dysfunction are correlated with each other depending on their severity, through the development of hypotension. Intraoperative hypotension is known to be associated with an increased risk of postoperative mortality [2], myocardial ischemia after noncardiac procedures [3], and acute renal failure [4]. SRP of the unanesthetized patient activates the sympathetic nervous system and thereby increases peripheral vascular resistance, which leads to a further increase in blood pressure. However, anesthetics inhibit the baroreceptor response, which is necessary to correct the effect of gravity on cerebral perfusion pressure, therefore, the main changes in hemodynamics occur precisely during the change in the position of the anesthetized patient [1]. One of the most widely used general anesthetics is propofol solution, which has a proven safety record of over 30 years [5]. Most inhalation anesthetics can cause peripheral vasodilation, but its mechanisms are different. Propofol acts by suppressing sympathetic tone, and not directly on the smooth muscles of peripheral vessels [6], therefore, the use of its solution contributes to better visualization of the surgical wound. The occurrence of a vasoplegic effect depends on the dosage, therefore, control of the depth of anesthesia is a critically important aspect of ensuring patient safety during surgical interventions. Traditional monitoring of depth of anesthesia is primarily determined by the patient's clinical signs and symptoms, such as changes in heart rate, blood pressure, and limb movements [7]. The bispectral index (BIS) represents a significant breakthrough in objectively assessing depth of anesthesia, providing valuable real-time feedback [8]. One important application of BIS monitoring is its role in preventing perioperative awakening, a psychologically traumatic event that is exacerbated by the patient's return to consciousness during surgery. In a systematic review, S. R. Lewis et al. found evidence that BIS-controlled anesthesia may reduce the risk of intraoperative awareness compared with standard practice without such monitoring [9]. The monitor processes real-time electroencephalogram data and calculates a numerical score (from 0 to 100) that reflects the degree of brain function suppression. Today, BIS monitoring is used to study the state of the central nervous system, the pharmacodynamic effect of anesthetics [10] and is the standard for monitoring intraoperative sleep levels.

Control of arterial hypotension is crucial during surgery. Hypotension is exacerbated by the use of anesthetics, perioperative body position, and blood loss.

Purpose: to analyze the influence of body position on hemodynamics and bispectral index indicators during surgical intervention on the upper extremities under general anesthesia with the use of propofol solution.

Material and methods

The study was performed at the State Institution "Professor M.I. Sytenko Institute of Spine and Joint Pathology of the NAMS of Ukraine". The study was approved by the local bioethics committee (Protocol No. 231 dated 05.20.2023) of the relevant institution in accordance with the ICH GCP amendment, the Helsinki Declaration of Human Rights and Biomedicine, as well as the current legislation of Ukraine. All involved patients were familiarized with the plan and conditions of the experiment and signed an informed consent.

The prospective randomized study included 70 patients, who were evenly distributed into 2 groups: I (n = 35) — surgical intervention was performed in the SRP; II (n = 35) — anesthetized patients in the standard supine position. The average age of patients in group I was (43.06 ± 11.92), in group II (40.25 ± 10.14) years. Patients with cardiac arrhythmias, angina pectoris, respiratory or hepatic failure, and a history of drug addiction were excluded from the analysis. Considering that BIS is a single number calculated on the basis of subparameters obtained from the electroencephalogram, several factors can change its value without affecting the depth of anesthesia (hypoglycemia, hypovolemia, cerebral ischemia) [11]; therefore, individuals with a history of traumatic brain injury and diabetes mellitus were also excluded. The physical status of the patient in the preoperative period was assessed according to the ASA (American Society of Anesthesiologists) scale, all of whom were classified as class I–II. The initial positioning of the patients in the two groups was in the standard position — lying on their backs. The day before, both groups were prescribed pregabalin 75 mg. Before induction, they received pantoprazole 40 mg, sibazone solution 10 mg. Induction included: propofol solution 1 % — 2 mg/kg, fentanyl solution 0.005 % — 0.2 mg, myoplegia during tracheal intubation was provided with suxamethonium solution 0.1 mg/kg, and subsequently myorelaxation was maintained with atracurium besylate solution at a dosage of 0.3 mg/kg. After airway prosthesis and transfer of the patient to artificial lung ventilation with the Drager Atlan A300 device, general anesthesia was maintained with propofol solution 1 % depending on BIS-monitoring indicators. 10 min after induction, patients in group I were transferred to the NSP, patients in group II remained in the supine position. Peripheral blood saturation (SpO_2), non-invasive systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean blood pressure (MBP) were determined by the Mediana YM 6000 monitor. The first measurement was performed immediately after venous access was established and then every 5 min. COVIDEN BIS monitoring was used to control the depth of sedation and correct the propofol infusion; the patient's depth of sedation should be from 40 to 60, an index below 40 corresponds to deep anesthesia, and BIS has a processing delay of 5–10 s [12]. The difference between the predicted and actual BIS was on average (30.09 ± 18.73) s. Given that CO_2 is a vasodilator and low levels are thought to cause cerebral vasoconstriction [13], affect neuroethology, structural histology, neuronal apoptosis, and cerebral edema [14], end-tidal carbon dioxide levels were measured continuously in both groups and were 35–45 mm Hg. The Aldrete system was used to assess the safety of transferring patients from the intensive care unit to the ward.

In the postoperative period, the presence of nausea and vomiting, the time of extubation and the restoration of spontaneous breathing were analyzed, the quality of which was assessed using the Quality of recovery 15 (QoR 15) scale 24 hours after the intervention.

Statistical analysis. The obtained data were analyzed using the IBM SPSS 9.0 software. The normal distribution of the samples was checked using the Kolmogorov-Smirnov test. The mean and standard deviation were calculated. Differences between groups of indicators were assessed using the Student's t-test.

Results

Analysis of primary indicators before perioperative change in body position. Patients in the two groups were comparable in age, duration of surgery and blood loss. The initial data are shown in Table. 1.

When studying the changes in hemodynamic parameters such as: SBP, DBP, pulse and BIS-monitoring values before induction, no significant difference was found, the initial data are shown in Table 2.

When analyzing the two groups after induction, no difference was found between them, a uniform decrease in SBP, DBP and BIS parameters was observed. Hemodynamic and BIS-monitoring data are presented in Table 3.

Analysis of hemodynamic and BIS-monitoring parameters after positioning. When comparing hemodynamic data after positioning patients

Table 1

Comparison of patient age, duration of surgery, and blood loss

Group	Age (years)	Blood loss (ml)	Duration (min)
I	43.06 ± 11.92	232.85 ± 51.71	112.97 ± 21.47
II	40.25 ± 10.14	226.34 ± 84.04	118.86 ± 20.53

Table 2

Comparison of initial hemodynamic parameters

Group	SBP (mm Hg)	DBP (mm Hg)	Pulse (beats per minute)	BIS
I	148.68 ± 24.30	88.8 ± 11.80	77.94 ± 11.80	97.08 ± 1.42
II	148.11 ± 15.71	93.6 ± 7.49	75.57 ± 11.00	95.78 ± 1.56

Table 3

Comparison of hemodynamic and BIS parameters after induction

Group	SBP (mm Hg)	DBP (mm Hg)	Pulse (beats per minute)	BIS
I	114.28 ± 11.00	73.6 ± 11.00	72.62 ± 11.06	47.05 ± 3.94
II	116.74 ± 11.15	76.08 ± 10.26	71.22 ± 10.30	45.2 ± 4.98

in the SRP and in the supine position, the following changes were found: the average SBP values were (98.28 ± 5.95) mm Hg, while in group II (105.74 ± 7.97) ($p < 0.001$), a significant decrease in DBP in group I — (63.37 ± 4.49) mm Hg ($p < 0.001$), SBP in group I was (75 ± 4.97) mm Hg, while in group II — (81 ± 5.67) mm Hg. There was a significant difference in pulse rates and slight tachycardia, compared with group II, but within the reference values (79.22 ± 9.76) beats per min and 71.34 ± 7.77, respectively ($p < 0.001$). No significant statistical changes were recorded in BIS values, namely in group I the average value was 46.37 ± 4.44, while in group II it was 45.54 ± 4.09 ($p = 0.42$). Significant statistical indicators were obtained when calculating the dosage of propofol solution, in group I the average values were (4.87 ± 0.24) mg/kg/h, while in group II (6.16 ± 0.49) mg/kg/h ($p < 0.001$). Changes in the obtained data are presented in Table 4.

Detection of complications after anesthesia. Episodes of nausea and vomiting were observed in 12 patients in group I and 5 in group II. The average time to restore spontaneous breathing in group I was (11.64 ± 3.82) min, while in group II it was 7.60 ± 2.36 ($p < 0.001$), the average time to extubation in group I was (16.61 ± 5.29) min, and in group II (16.05 ± 3.91) min, no significant difference was found between the groups ($p = 0.55$) (Table 5).

Diagnosis of the safety of transferring a patient from the intensive care unit to the department was performed using the Aldrete assessment system. The quality of recovery after surgery and anesthesia was assessed using the QoR 15 scale. The average value according to Aldrete and QoR 15 in group I was 9.25 ± 0.60 and 140.08 ± 6.17, respectively, in group II the average value according to Aldrete was 9.57 ± 0.60, while QoR 15 was (141.22 ± 8.35) points, no significant difference between the groups was found ($p > 0.001$) (Table 6).

Discussion

The study assessed the change in the dosage of propofol solution depending on the perioperative body position under the control of BIS monitoring during surgical interventions on the upper extremities. The results showed that in the SRP the dosage of propofol solution is significantly less than in the standard position, with the same hemodynamic effects and BIS indicators in the two groups.

Considering that controlled hypotension is the most effective method of stopping bleeding and achieving clear visibility of the surgical field [15],

Table 4

Comparison of changes in SBP, DBP, SAT, pulse, BIS and propofol solution dosage between groups after positioning

Group	SBP (mm Hg)	DBP (mm Hg)	MBP (mm Hg)	Pulse (beats per minute)	BIS	Dose of 1% propofol solution (mg/kg/h)
I	98.28 ± 5.95 *	63.37 ± 4.49 **	75 ± 4.97***	79.22 ± 9.76 °	46.37 ± 4.44 °°	4.87 ± 0.24 •
II	105.74 ± 7.97	69.2 ± 5.57	81 ± 5.67	71.34 ± 7.77	45.54 ± 4.09	6.16 ± 0.49

Notes: difference between groups I and II: * $p < 0.001$ — SBP; ** $p < 0.001$ — DBP; *** $p < 0.001$ — MBP; ° $p < 0.001$ — pulse; °° $p = 0.42$ — BIS indicators; • $p < 0.001$ — difference in the dosage of propofol solution between the groups.

Table 5

Complications in the postoperative period

Group	Nausea and vomiting (number of patients)	Time to return to spontaneous breathing (min)	Extubation time
I	12	11.64 ± 3.82 *	16.61 ± 5.29 **
II	5	7.60 ± 2.36	16.05 ± 3.91

Notes: * $p < 0.001$ — difference in time to restore spontaneous breathing; ** $p = 0.55$ — difference in time to extubation.

Table 6

Average score for assessing the safety of transferring a patient from the intensive care unit and the quality of recovery after surgery

Group	Aldrete Scale	QoR 15
I	9.25 ± 0.60 *	140.08 ± 6.17 **
II	9.57 ± 0.60	141.22 ± 8.35

Notes: * $p > 0.001$ — difference in Aldrete scale scores; ** $p > 0.001$ — difference in QoR 15 scores.

the pressure was maintained in both groups without statistical difference. The study performed by W. Yin et al. with the participation of 130 patients showed that in the case of using standard doses of propofol solution during shoulder arthroscopy, the time to restore spontaneous breathing was prolonged, but no difference was found in episodes of vomiting and nausea [16]. Another study took into account such disadvantages of propofol solution as the development of postoperative nausea and vomiting, although perioperative sedation with this solution does not affect this duration [17]. The time to recovery of spontaneous breathing was longer in the SRP group compared to patients in the standard position, and episodes of nausea and vomiting were observed in 4.2 % of cases.

One of the problems of anesthesia in the case of shoulder arthroscopy is the need for controlled hypotension to reduce intra-articular hemorrhage and thus provide adequate visualization for the surgeon.

T. Tantry et al. compared the efficacy and convenience of target-controlled infusion (TCI) of propofol and the inhaled agent sevoflurane in patients undergoing shoulder arthroscopy. Of the 34 patients, 17 received TCI propofol (target plasma concentration 3 μg/mL) and the same amount of sevoflurane (1.2–1.5 of the minimum alveolar concentration). Propofol TCI helped to achieve lower systolic and mean blood pressure, and the number of interventions required was also lower compared with the sevoflurane group [18].

T. M. Chokshi showed that the propofol group had better visualization of the surgical field. The target plasma concentration used was 3 μg/mL, which corresponds to a dosage of 8 mg/kg/h [19].

In a study by T. Sugiura on elbow surgery, balanced anesthesia was used, consisting of general anesthesia combined with brachial plexus block in the perioperative period under the control of electrocardiography, noninvasive blood pressure, SpO_2, end-tidal CO_2 tension and bispectral index. Propofol infusion was used with a target control infusion of 2 μg × ml^{-1} plasma concentration, corresponding to 6 mg/kg/h [20], and no hemodynamic instability was observed.

In the observation of N. Padhi et al., 9 episodes of hypotension were observed with propofol and no development of bradycardia, because hypotension can lead to increased use of vasoactive drugs and fluids that might otherwise be unnecessary [21].

S. A. Yildirim et al. noted that the development of arterial hypotension occurs due to dilation of veins or arteries, a decrease in cardiac output and systemic vascular resistance, and the manifestation of bradycardia, which is regulated by the antisympathetic effect of propofol [22].

However, M. Matsushima et al. showed that the decrease in heart rate caused by propofol cannot be completely explained by the effect of the central vagus nerve, i. e. this agent may also have a direct inhibitory effect on the sinoatrial node [23].

Conclusions

Monitoring anesthesia with BIS enables a reduction in recovery time following awakening, primarily due to the lower volume of general anesthetics administered and a potential decrease in side effects.

Infusion of anesthetics depends not only on hemodynamic parameters, but also on the perioperative body position. Positioning in a semi-sitting position under general anesthesia significantly prolongs the time of spontaneous breathing recovery, but at a dosage of 4.5 mg/kg/h does not affect the extubation time. SRP does not affect the duration of stay in the recovery room.

Conflict of interest. The author declares the absence of a conflict of interest.

Prospects for further research. This research facilitates enhanced perioperative monitoring and enables more efficient optimisation of patient recovery room stay durations.

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THE EFFECT OF BODY POSITION ON HEMODYNAMIC PARAMETERS AND BISPECTRAL INDEX

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