NON-INVASIVE ELECTROENCEPHALOGRAM-BASED ANESTHESIOLOGICAL MONITORING IN GERIATRIC PATIENTS IN THE ENT-SURGERY

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ABSTRACT

BACKGROUND: *Demographic ageing of the society and the growing demand for medical service among the elderly citizens require perfecting the anesthesiology approaches.* ***AIM:*** *Evaluation of the efficiency of using various types of electroencephalography-based monitoring when performing general anesthesia in the settings of ENT-surgery in geriatric patients.* ***METHODS:*** *The randomized study included 99 patients (70–85 years old, ASA III–IV) who underwent surgery under general anesthesia for ENT pathology. The patients were distributed into three groups: Group A (n=33) — anesthesia controlled by CONOX — monitoring, Group B (n=33) — no cerebral monitoring, Group C (n=33) — controlled by BIS monitoring. The controlled parameters included the dosage of the medicinal products (Propofol, Fentanyl, Sevoflurane), the hemodynamics, the rates of intraoperative awakenings, postoperative nausea and vomiting, the need for additional pain medications and the parameters of the cognitive functions before and after surgery.* ***RESULTS:*** *The Propofol dosage in Group B was higher than in Groups A and C (p=0.016 and p=0.012 respectively). The concentration of Sevoflurane in Group C was lower (p=0.016), than in Groups A and B. Hemodynamic disorders and postoperative nausea/vomiting were more often observed in group B. Intraoperative awakenings were reported in 3% of the patients in Group A, in 9% for Group B and in 6% patients in Group C. Additional pain management was required in 39% of the patients in Groups A and B along with 42% in Group C, no statistical difference was found between the groups. Cognitive functions were better preserved in Group A with the duration of general anesthesia being more than 120 minutes (p=0.044).* ***CONCLUSION:*** *Anesthesiology monitoring based on electroencephalogram parameters, optimizing the dosages of the medicinal agents, decreases the rates of hemodynamic disorders, of intraoperative awakenings and of postoperative nausea and vomiting. Combined with the clinical monitoring of the electroencephalogram parameters, this accelerates rehabilitation and improves the surgery outcomes. The optimization of the dosage of opioids with controlling the anesthesia depth index (the Nociception Index, qNOX) positively affects the postoperative cognitive status of the patients.*

Keywords: *anesthesia; anesthesiology monitoring; ENT; geriatry.*

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BACKGROUND

In parallel with the development of anesthesiology, a necessity has appeared to control the efficiency of general anesthesia components (syncope or hypnosis, analgesia, neurovegetative block and myorelaxation), for both the insufficient anesthesia level, resulting in subconscious sensation of pain or anesthesia awareness, and the excessive anesthesia depth can serve as the predictors of negative consequences with increasing the neurotoxic effects of anesthetic drugs, which is especially important among the aged and elderly patients [1–3]. Inadequate level of sedation and analgesia in such patients can act as an inductor of the onset and further progression of encephalopathy. Multiple research works have correlated the development of postoperative delirium and postoperative cognitive dysfunctions with excessive sedation depth, with its duration being more than 120 minutes and with the age of the patients — older than 65 years [4–6]. Besides, possible effects of

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НЕИНВАЗИВНЫЙ АНЕСТЕЗИОЛОГИЧЕСКИЙ МОНИТОРИНГ НА ОСНОВЕ ЭЛЕКТРОЭНЦЕФАЛОГРАММЫ У ГЕРИАТРИЧЕСКИХ ПАЦИЕНТОВ В ЛОР-ХИРУРГИИ

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АННОТАЦИЯ

Обоснование. *Демографическое старение общества и растущая потребность в медицинском обслуживании пожилых граждан требуют усовершенствования анестезиологических подходов.* ***Цель исследования*** *— оценить эффективность применения различных видов мониторинга на основе электроэнцефалографии при проведении общей анестезии в ЛОР-хирургии у пациентов гериатрического профиля.* ***Методы.*** *В рандомизированное исследование включены 99 пациентов (70–85 лет, ASA III–IV), прооперированных в условиях общей анестезии по поводу ЛОР-патологии. Пациенты разделены на три группы: группа А (n=33) — анестезия под контролем монитора CONOX, группа В (n=33) — без церебрального мониторинга, группа С (n=33) — под контролем монитора BIS. Оценивались дозировки препаратов (пропофол, фентанил, севофлуран), гемодинамика, частота интраоперационных пробуждений, послеоперационная тошнота и рвота, потребность в дополнительном обезболивании и когнитивные функции до и после операции.* ***Результаты.*** *Доза пропофола в группе В была выше, чем в группах А и С (p=0,016 и p=0,012 соответственно). Концентрация севофлурана в группе С была ниже (p=0,016), чем в группах А и В. Гемодинамические нарушения и послеоперационная тошнота и рвота наблюдались чаще в группе В. Интраоперационные пробуждения отмечены у 3% пациентов группы А, у 9% — группы В, у 6% — группы С. Дополнительное обезболивание потребовалось 39% пациентов групп А и В, 42% — группы С без статистической разницы между группами. Когнитивные функции лучше сохранялись в группе А при длительности общей анестезии более 120 минут (p=0,044).* ***Заключение.*** *Анестезиологический мониторинг на основе электроэнцефалограммы, оптимизируя дозировку препаратов, снижает частоту гемодинамических нарушений, интраоперационных пробуждений и послеоперационных тошноты и рвоты. В сочетании с клиническим мониторингом электроэнцефалограммы ускоряются восстановление и улучшаются исходы операции. Оптимизация дозировки опиоидов под контролем индекса глубины анальгезии (qNOX) положительно влияет на послеоперационный когнитивный статус пациентов.*

Ключевые слова: *анестезия; анестезиологический мониторинг; ЛОР; гериатрия.*

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anesthesia were shown with regard to the manifestation and progression of the Alzheimer's disease [3].

Due to the advances in the methods of obtaining and processing the electroencephalography (EEG) signals, from 1990s, the set of tools available to anesthesiologists was supplemented with the methods to evaluate the anesthesia depth in the real time mode during surgical interventions [7]. The widely known methods of additional monitoring in anesthesiology include the EEG bispectral index (BIS) — the parameter that measures the sedation depth [8, 9]. The CONOX monitor (Fresenius-Kabi, Germany), along with the sedation depth index (quantitative consciousness index, qCON), using the frontal electroencephalography / electromyography data, also calculates the quantitative nociception index (qNOX) using the neuronal network to calculate the power ratios for various EEG frequencies (adaptive neuro-fuzzy inference system, ANFIS) and

the suppression splashes [10–12]. Both indexes — qCON and qNOX — can reflect the EEG changes in response to pain stimuli, though the qNOX reaction is more dynamic than qCON. This is due to the fact that the increase of qNOX is a consequence of developing EEG changes directly from pain stimulation, while the increase of qCON is resulted by the secondary effect of pain stimulation. The calculations of qCON and qNOX can be affected by the use of muscle relaxants [12].

Research aim — to evaluate the efficiency of various types of electroencephalography-based monitoring upon performing the general anesthesia in the settings of ENT-surgery among the geriatric patients.

METHODS

Research design

A single-centre open-label prospective randomized controlled research was arranged.

Several results of the present research were published earlier and were describing the intraoperative monitoring of sedation depth and analgesia in patients older than 70 years in the settings of ENT-surgery. The present article is the continuation of previously performed research work with the inclusion of Group C (the use of BIS-monitoring) and with summarizing the results for all the three research groups [13].

Conformity Criteria

Inclusion criteria: age from 70 years and older; patients operated due to the presence of ENT-diseases.

Non-inclusion criteria: psychiatric and neurological diseases (including chronic alcoholism or drug abuse); significant decrease in the cognitive functions (MMSE scores ≤24).

Exclusion criteria: the use of artificial ventilation during the postoperative period.

Research facilities

The research was carried out within the premises of the Federal State Budgetary Institution "National Medical Research Center for Otorhinolaryngology" of the Federal Medical-Biological Agency (FSBI NMRCO of the Russian Federal Medical-Biological Agency).

Research Duration

From January 2021 until June 2024.

Medical Procedure Description

The research included 99 patients aged 70–85 years with a grade III–IV physical status according to the surgical-anesthesiological risk scale from the American Society of Anesthesiologists (ASA) and undergoing ENT surgeries. All the patients were receiving general combined anesthesia using the endotracheal method. Intravenous induction of anesthesia — consequential administrations of Fentanyl (1–2 μg/kg) and Propofol (0.60–1.90 mg/kg). Tracheal intubation after relaxation with Rocuronium bromide (0.6–0.8 mg/kg), maintaining relaxation with the fractional dosages of 0.2–0.4 mg/kg. All the patients were receiving anesthesia with Sevoflurane using the low-flow method with the flow of air-oxygen mixture at a rate of 1 l/min. The oxygen concentration in the air mixture is 30–50%.

In all the groups, the evaluation of minute pulmonary ventilation, the respiratory capacity, the concentration of Sevoflurane and the partial pressure of carbon dioxide upon inhaling and exhaling was carried out using the anesthesia machines manufactured by General Electric (USA): GE Care Station 620, GE AVANCE CS 2, GE DATEX-OHMEDA.

The patients were divided into three groups. In Group A (n=33), general anesthesia was carried out with the controls by means of the CONOX monitor; patients of Group B (n=33) were not controlled by cerebral monitoring; patients from Group C (n=33) were receiving general anesthesia with the BIS monitoring (BIS VISTA manufactured by Medtronic, USA). All the patients were undergoing standard intraoperative monitoring (non-invasive measurements of blood pressure, heart rate, respiration rate and blood hemoglobin saturation with oxygen).

For the evaluation of the cognitive status, all the patients underwent the MMSE test (mini-mental state examination) [14]. The testing was carried out twice within 24 h — before surgery and in 24 hours after surgery. In Group A, the anesthesia tactics was based on analyzing the qCON and qNOX indexes.

After the induction of anesthesia and tracheal intubation, Sevoflurane inhalations were beginning from the concentration of 5–8% by vol. with a background of moderate hyperventilation ($etCO_2$ 30–34 mmHg). Upon achieving the minimal alveolar concentration (MAC) of 1.0, normoventilation was initiated ($etCO_2$ 34–42 mmHg), with the beginning of surgical intervention taking place with a background of decreasing the Sevoflurane concentration to 1.0–1.5% by vol. and with the MAC reduced to 0.7–0.8 (15–20 minutes after the induction with further correction of the concentration of the anesthetic agent, if necessary). Fentanyl was fractionally administered with portions of 1 μg/kg (once every 15–20 minutes). Constant registration was set for the qCON and qNOX

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indexes (every 15 minutes). During surgery, the qCON value was maintained at the level of 40–60. When the values were dropping below <40, the Sevoflurane concentration was also decreased, while in cases of elevation above >60, the concentration was increased, maintaining the qNOX value at the level of 40–60. If the qNOX index was increasing above 60, the patient was additionally receiving 1 μg/kg of Fentanyl.

In Group B, analgesia was provided by Fentanyl calculated as 1–2 μg/kg every 30–35 minutes, additional administrations of Fentanyl and/or changes in the Sevoflurane concentration in the inhaled air mixture were regulated empirically with analyzing the hemodynamic parameters (decreased or increased mean blood pressure and/or heart rate by more than 20% comparing to the baseline), the half-elimination time of the medicinal products and the intensity of the pain stimuli (depending on the stage of surgery).

In Group C, similar to Group A, the dosages of the anesthetic agents (Propofol and Sevoflurane) were adjusted based on the BIS levels. The Fentanyl dosage was taken empirically, just like in Group B. During the course of the surgery, the BIS levels were maintained at the level of 40–60. If the levels were dropping below 40, the concentration of Sevoflurane was decreased, if the levels were exceeding 60 — increased.

For the evaluation of the postoperative pain, Pain Visual Analogue Scale (VAS) was used, according to which, the score under 4 cm was classified as weak, 4–7 cm — moderate, ≥7 cm — severe pain [15]. The presence of postoperative delirium (confused consciousness) in patients was evaluated using the CAM-ICU scale (Confusion Assessment Method for Intensive Care Unit) [16].

Research outcomes

After surgery, the analyzed parameters included the total consumption of Propofol, Sevoflurane and Fentanyl; the intraoperative hemodynamical profile (blood pressure, heart rate); the cases of postoperative delirium; the rate of initial manifestations of intraoperative awakening (initial vegetative changes expressed as the acceleration of pulse, developing spontaneous respiratory movements and elevation of airway pressure were considered as being the initial manifestations of intraoperative awakening, in all the cases theses manifestations lasted for 1–3 minutes, during the postoperative period, all the patients had no memories of intraoperative awakening) as well as postoperative nausea and vomiting.

Subgroup analysis

The subgroup analysis was based on the duration of general anesthesia (<120 or >120 minutes).

Methods for registrations of outcomes

We have used the medical records and the protocols of anesthesiology aid along with the parameters recorded by CONOX and BIS monitors.

Ethical review

The conduct of the research was approved by the local Ethics Committee of the Federal State Budgetary Institution “NMRCO” of the Russian Federal Medical-Biological Agency (protocol No. 4/23, dated 27.11.2023).

Statistical analysis

Taking into consideration the research aim, the correlation between the intraoperative dosages of hypnotic and narcotic medications and the levels of sedation depth (BIS) or the depth of sedation and analgesia (CONOX), in order to calculate the sample size, we have used the significance level of 0.05 to avoid the type I error (alpha level, bilateral), and the level 0.20 to avoid the type II error (beta), using the Spearman’s correlation coefficient of 0.5. Thus, each group needed to contain not less than 32 patients [17, 18].

The statistical processing of the research results was carried out using the SPSS software (version 26, IBM, USA). For the purpose of defining the correctness of sample distributions, the Kolmogorov–Smirnov non-parametric test was used. Data were provided as absolute values (rates in percentages) or medians with the 25th and 75th percentile (Me [25%; 75%]) depending on the type of data. The analysis of differences between the groups was done using the Mann-Whitney method or the chi-square test and the Fisher’s exact test, depending on the data. The dynamic analysis of intragroup data differences was carried out using the Wilcoxon test. The correlation analysis was conducted using the Spearman’s test (rho). The direction (direct or reverse) and the strength of correlational relationships were determined by the coefficient level: in case of rho >0, the relation was considered direct, while the rho <0 was considered reverse. The strength of the relation (rho) was evaluated as weak if the value was <0.3, as moderate — if the value was 0.3≤ rho ≤0.7 and as strong for the levels of >0.7. The statistically significant level was stated for the *p* value being <0.05.

RESULTS

Research sample (participants)

The patients of three research groups did not differ in terms of clinical-demographic characteristics, the severity of surgical interventions and concomitant diseases also did not statistically differ (p >0.05). The perioperative evaluation of the patient's cognitive status (MMSE) between the groups before and after surgery did not differ (p >0.05).

Main research outcomes

Monitoring the analgesia depth (in group A) has allowed for administering lesser dosages of Fentanyl boluses (0.5–1 μg/kg every 15–20 minutes instead of 1–2 μg/kg every 30–35 minutes in Groups B and C), though more frequent (every 15–20 minutes) depending on the analgesia level, not causing any sudden changes in the hemodynamic parameters. The use of BIS in Group C has allowed for decreasing the total Sevoflurane dosage. The dosages of Propofol in Group B (where empirical calculation was used) were higher than in group A, and higher than in Group C (table 1).

The difference in the number of cases of hemodynamic disorders (p=0.240), postoperative nausea and vomiting (p=0.538), initial manifestations of intraoperative awakening (p=0.587), postoperative delirium (p=0.771) and postoperative pain (p=0.959) between Groups A, B and C was insignificant (Fig. 1).

The rate of postoperative nausea and vomiting was 18% in Group B, 9% — in Group A, 12% — in Group C, which, according to the correlation analysis data, was related to the duration of the surgical intervention [(rho)=0.472; p=0.001)], to the usage of insufficient dosages of Fentanyl

Table 1

The comparison of the dosages of the anesthetic agents and opioid analgesics between groups, Me [25%; 75%]

Drug	Group			*p*			
	A (CONOX) (*n*=33)	B (control) (*n*=33)	C (BIS) (*n*=33)	A/B	B/C	A/C	A/B/C
Propofol, mg/kg	1.6 [1.30; 1.77]	1.76 [1.54; 1.90]	0.71 [0.62; 1.14]	**0.016**	**0.012**	0.325	0.129
Fentanyl, μg/kg	1.92 [1.62; 3.13]	2.21 [1.35; 3.71]	2.07 [1.71; 2.38]	0.672	0.439	0.428	0.444
Sevoflurane, MAC	1 [1; 1]	1 [1; 1]	1 [0.80; 1.07]	0.539	0.135	0.067	**0.016**

Note. Semi-bold font indicates statistically significant parameters (p <0.05).

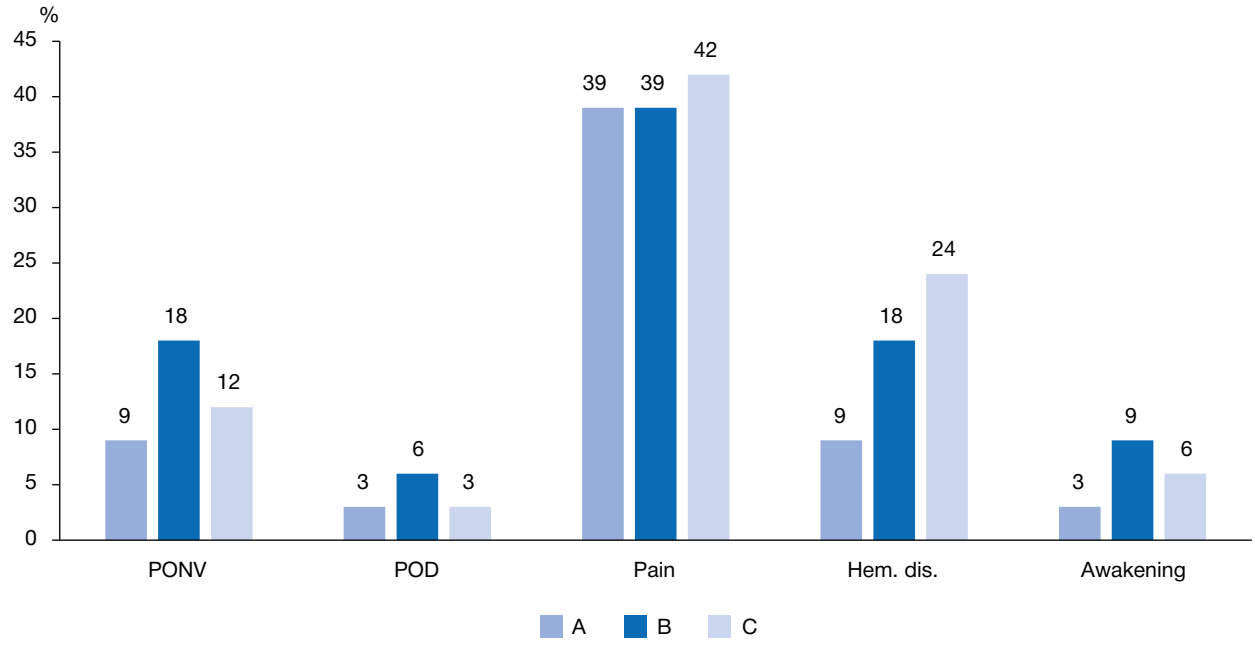

Fig. 1. The adverse effects in the peri-operational period. A, B, C — study groups; PONV — postoperative nausea and vomiting; POD — postoperative delirium; Pain — postoperative pain; Hem. Dis. — hemodynamic disorders; Awakening — initial manifestations of intraoperative awakening.

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[(rho)=-0.259; p=0.010)] and to the presence of postoperative pain [(rho)=0.411; p=0.001)].

Postoperative delirium, expressed as mild short-term disorders, has resolved with no special therapy within several hours after surgical intervention. The rates of developing postoperative delirium did not statistically differ between the groups (p >0.05) and it was showing weak correlation to the duration of surgery [(rho)=0.249; p=0.013)] or intraoperative variability of blood pressure [(rho)=0.302; p=0.002)].

Additional research outcomes

When analyzing the duration of anesthesia, it was found that Fentanyl dosage with the duration of anesthesia being <120 minutes was higher than for the duration of >120 minutes (table 2).

The MMSE cognitive status parameters after surgery were higher in Group A for the duration of surgery being >120 minutes and with lesser Fentanyl dosages, respectively (table 3); in Groups B and C, the MMSE parameters after surgery did not differ depending on the duration of general anesthesia (p=0.679 and p=0.255 respectively), though the Fentanyl dosages were different (p=0.002 and p=0.024 respectively).

The comparison of the dosages of anesthetics and analgesics inside each group depending on the duration of anesthesia has shown that Fentanyl dosages for higher duration of general anesthesia (>120 minutes) were less than in cases when general anesthesia lasted <120 minutes (table 4). In Group A, Propofol dosage was higher for long-term general anesthesia (>120 minutes), than in cases of general anesthesia lasting <120 minutes (see table 4). The Sevoflurane concentration did not differ between the groups depending on the duration of general anesthesia.

In Group A, the qNOX5 index (the parameter of analgesia depth during extubation and right after extubation) was higher for the anesthesia duration being >120 minutes comparing to the duration of <120 minutes (93.5 and 92 respectively; p=0.004), which is probably, related to relatively high dosages of Fentanyl when the surgery duration was <120 minutes. Other noted findings include a moderate positive correlation between the duration of anesthesia and the qNOX5 [(rho)=0.501; p=0.003)] along with mild negative correlation between the Fentanyl dosages and the qNOX5 [(rho)=-0.385; p=0.027)].

Undesirable phenomena

No undesirable phenomena were reported as related to using the sedation and analgesia depth monitors (CONOX) and the sedation depth monitors (BIS).

DISCUSSION

In the current anesthesiology practice, the EEG-based anesthesia monitoring methods are being used quite widely, of which, the most conventional is the BIS sedation depth monitoring [9], however, a very promising option is the possibility of monitoring not only the sedation level, but also the analgesia level. The

Table 2

The use of anesthetic agents and opioid analgesics in the groups depending on anesthesia duration, Me [25%; 75%]

Parameter	Duration, minutes		*p*
	<120	>120	
Number patients, *n* (%)	59 (59.6)	40 (40.4)	-
Propofol, mg/kg	1.36 [0.76; 1.71]	1.60 [1.03; 1.83]	0.095
Fentanyl, μg/kg per hour	2.56 [1.87; 3.75]	1.75 [1.22; 2.08]	**0.001**
Sevoflurane, MAC	1 [1; 1]	1 [0.8; 1.0]	0.276

Note. Semi-bold font indicates statistically significant parameters (p <0.05).

Table 3

The dependence of the cognitive functions on the duration of general anesthesia and dosages of opioid analgesics in Group A, Me [25%; 75%]

Parameter	Duration, minutes		*p*
	<120	>120	
Fentanyl, μg/kg per hour	2.85 [1.75; 3.56]	1.70 [1.06; 1.86]	**0.001**
MMSE after surgery	27 [27; 27]	28 [27; 29]	**0.044**

Note. Semi-bold font indicates statistically significant parameters (p <0.05).

Table 4

The use of anesthetic agents and opioid analgesics in study groups depending on anesthesia duration, Me [25%; 75%]

Parameter	Duration, minutes		*p*
	≤120	>120	
Group A			
Number of patients, *n* (%)	21 (63.6)	12 (36.4)	-
Propofol, mg/kg	1.57 [1.13; 1.68]	1.76 [1.5; 1.84]	**0.013**
Fentanyl, μg/kg per hour	2.85 [1.75; 3.56]	1.70 [1.06; 1.86]	**0.001**
Sevoflurane, MAC	1 [1; 1]	1 [0.8; 1.0]	0.058
Group B			
Number of patients, *n* (%)	19 (57.6)	14 (42.4)	-
Propofol, mg/kg	1.76 [1.40; 1.84]	1.80 [1.68; 2.00]	0.114
Fentanyl, μg/kg per hour	3.52 [1.87; 4.22]	1.59 [1.11; 2.37]	**0.002**
Sevoflurane, MAC	1 [1; 1]	1 [0.8; 1.0]	0.212
Group C			
Number of patients, *n* (%)	19 (57.6)	14 (42.4)	-
Propofol, mg/kg	0.71 [0.62; 0.97]	0.72 [0.62; 1.28]	0.815
Fentanyl, μg/kg per hour	2.22 [1.98; 2.81]	1.88 [1.55; 2.09]	**0.024**
Sevoflurane, MAC	1 [0.80; 1]	1 [0.8; 1.16]	0.304

Note. Semi-bold font indicates statistically significant parameters ($p < 0.05$).

use of extended monitoring of anesthesia depth is of special importance among the high risk group patients, which, certainly, include geriatric patients.

During the course of our research, the usage of CONOX and BIS monitors has allowed for decreasing the dosage of Propofol required for anesthesia induction (in mg/kg) in Groups A and C comparing to the dosages in the control group B (see table 1). Taking into consideration that the hypotensive effect of Propofol is dose-dependent, optimizing its dosages helps to stabilize the hemodynamics in the patient, decreasing the rates and the severity of perioperative complications, including the neurological ones [19]. Arterial hypotension often develops during the induction or in case of low intensity pain stimulus (the vegetative component of pain reaction in the organism) depending on the surgery stage, while the blood pressure increase or heart rate increase usually occurring during intubation or extubation, as well as upon untimely administration of the analgesic agent [20–22], which was more often observed in Groups B and C. The hemodynamic parameters in Group A were more stable comparing to two other research groups. This result, on the one hand, provides the justification for using auxiliary methods of EEG-based anesthesiology monitoring, on the other hand — the insufficiency of controlling only the sedation depth without monitoring the analgesia level, which was discussed in previous research works [23–25].

Due to monitoring the sedation depth in Group C (BIS), Sevoflurane concentration during the MAC was lower comparing to other research groups (see table 1), however, this was not enough for decreasing the rates of hemodynamic disorders [9, 26].

The Fentanyl dosages in cases of longer duration of general anesthesia (>120 minutes) were less than in cases of shorter general anesthesia (<120 minutes) (see table 2), which is apparently related to the pharmacokinetics of the medicinal product in the said categories of patients. Upon multiple administrations of Fentanyl, some kind of plateau was formed in terms of its concentration in tissues and blood, which was specifically decreasing the demand for additional dosages, which could eventually and positively affect the cognitive status of the patients from Group A, in which the CONOX monitor, besides sedation depth, has allowed for controlling also the analgesia level [27]. The medical literature contains data on the benefits of uninterrupted administrations of analgesics (for example, via the infusion pump with adjusting the infusion rate, if necessary) comparing to bolus administrations [28].

In Group A, the MMSE cognitive status parameters after surgery were higher with the surgery duration

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of >120 minutes (with lesser Fentanyl dosages, respectively). This phenomenon is not conflicting with the theory about the neurotoxicity of anesthetic agents, especially in elderly and aged patients [1–3]. In Group A, the qNOX5 index (analgesia level at the moment of extubation) was also higher for the general anesthesia duration being >120 minutes, where the Fentanyl dosage was lower, which indicates lesser residual concentration of Fentanyl in such patients, which shortens the time of their restoration.

The initial manifestations of intraoperative awakening in our research, followed by vegetative symptoms, such as hypertension, tachycardia, developing single spontaneous respiratory movements without remembering anything occurring during the anesthesia in the postoperative period (which, most probably, was the sign of the transition from the stage of mild surgical anesthesia grade III-2 to the stage of superficial anesthesia grade III-1) were reported (in a descending order) in Groups B, C and A. With this, the attempts to obtain deeper narcosis took 1–3 minutes [17].

Hypotension during surgery is a risk factor for postoperative delirium. According to our data, postoperative delirium has correlated to the impaired hemodynamics [(rho)=0.358; p=0.001)]. The decrease of cerebral circulation as a result of hypotension is considered a significant risk factor for postoperative delirium, especially if it is following the course of surgical intervention for a long period of time [29, 30]. Intraoperative pain is also the risk factor for developing cognitive dysfunctions, for the areas of the brain that participate in pain perception and in the cognitive functions, are interconnected [30]. The rates of postoperative nausea and vomiting may depend on the duration of the surgical intervention (in our research (rho)=0.472; p=0.001) and on using excessive /insufficient dosages of sedative and narcotic medications, as well as on the excessive anesthesia depth [31].

Research limitations

The limitations of this research were resulting from several important factors. First of all, the research was conducted in a single medical center with a limited number of participants, which limits the representativity of data and hampers its extrapolation. The use of a single research facility and the limited patient sample do not allow for ruling out the effects of local factors.

Secondly, the absence of validating the results in other medical institutions decreases the versatility of the conclusions, which is important for the practical application of the obtained data. Besides, the limited follow-up period and the absence of follow-up data complicates the evaluation of the long-term effects of using the EEG-based anesthesiology monitors, especially in patients with peri-operational adverse effects.

Thus, despite the significance of the obtained data, the said limitations embound the justification and summarizing of results.

CONCLUSION

The implementation of non-invasive anesthesiology monitoring of sedation and analgesia depth based on EEG parameters in geriatric patients within the settings of ENT-surgery allows for more precise optimizing the dosing of sedative and narcotic medications, which promotes to decreasing the rate and the severity of hemodynamic disorders, to decreasing the rates of intraoperative awakenings and postoperative complications when comparing to using the sedation depth monitors. Combined with conventional clinical monitoring, EEG-monitoring accelerates the recovery after anesthesia and improves the outcomes of surgical interventions. Besides, the optimization of the dosing of opioid analgesics with controlling the analgesia depth index (qNOX) favorably affects the cognitive functions among geriatric patients during the postoperative period. Nevertheless, EEG-based anesthesiology monitoring methods are only the valuable addition to the traditional clinical-instrumental monitoring, but they do not replace it.

ADDITIONAL INFORMATION

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