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The Role Of Monitoring The Depth Of Anesthesia In Reducing Postoperative Complications

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ABSTRACT

Monitoring the depth of anesthesia is a key component of modern anesthesia care aimed at optimizing anesthetic dosing and minimizing the risk of both under- and overanesthesia. This article reviews the role of objective monitoring of the depth of anesthesia in reducing the incidence of postoperative complications, including cognitive dysfunction, delirium, cardiorespiratory complications, and increased mortality. Accurate titration of anesthetics according to neurophysiological parameters helps avoid hypnotic overdose and hypoanesthesia, thereby reducing the level of systemic stress, inflammatory reactions, and the risk of perioperative hypotension. And the use of monitoring the depth of anesthesia helps to reduce the time of awakening and accelerate postoperative rehabilitation, especially in elderly patients and those with comorbidities. The introduction of objective methods for assessing the patient's anesthetic status is an effective strategy for increasing the safety of surgical interventions and improving clinical outcomes.

Keywords:

depth of anesthesia, postoperative cognitive impairment, complex monitoring, perioperative complications, personalized anesthesia, hemodynamic stability.

Introduction. In modern clinical anesthesiology, the key direction for improving patient safety and the quality of anesthetic care is monitoring the depth of anesthesia. Given the high prevalence of postoperative complications, including cognitive disorders, delirium, cardiovascular and respiratory disorders, timely and accurate determination of the adequacy of anesthesia becomes a prerequisite for effective patient management throughout the perioperative phase [6].

Despite the standardization of the main monitoring parameters (saturation, blood pressure, heart rate, temperature, capnography), only a comprehensive approach to assessing the level of consciousness and brain activity can reduce the risk of anesthetic overdose, prevent

awakening during surgery and minimize the risk of developing postoperative cognitive impairment (POCI), especially in elderly patients [3].

The use of depth of anesthesia indices such as BIS (Bispectral Index), Entropy, Narcotrend and others, has become an important step in the evolution of consciousness monitoring. These technologies, based on the analysis of EEG and other neurophysiological signals, enable the anesthesiologist to individualize the dose of anesthetic in real time, reducing both the risk of excessive sedation and the likelihood of inadequate anesthesia [5].

Clinical guidelines of the American Society of Anesthesiologists (ASA) and the European Society of Anesthesiologists (ESA) emphasize

the need for personalized monitoring with assessment of both physiological parameters and the functional state of the central nervous system. According to ESA recommendations, the depth of anesthesia should be controlled not only by indirect clinical signs (pupillary reactions, movements, hemodynamics), but also using neurophysiological tools in the case of a high risk of POCI, especially in geriatric patients and during long operations [4].

The relevance of implementing accurate and objective monitoring is especially increasing in the context of increasing surgical activity and the increase in the number of operations in patients with comorbid pathology. According to a meta-analysis including more than 10,000 patients, the use of BIS reduces the incidence of postoperative delirium by 30%, and the risk of excessive anesthesia by 40% [8].

Cost-effectiveness is also an important aspect. Monitoring the depth of anesthesia helps to reduce the time of awakening, reduce the need for postoperative observation and reduce the consumption of anesthetics. This is important both in high-tech centers and in institutions with limited resources, such as district hospitals in Uzbekistan. Domestic studies also confirm that the use of BIS or similar technologies reduces the incidence of hypotension and hypoxia during the intraoperative period, especially in patients with cardiovascular pathology [1].

However, limitations of the methods must also be taken into account. Anesthesia depth indices may be less informative when using certain drugs (e.g., ketamine, dexmedetomidine), in conditions of muscle paralysis, or EEG artifacts. In addition, clinical verification of device data is required: the anesthesiologist must combine instrumental monitoring with an assessment of clinical signs, such as pupillary response, reflexes, blood pressure, and respiratory rate [2].

Modern research emphasizes the importance of a multimodal approach to assessing the patient's condition. The depth of anesthesia should be considered in the context of systemic monitoring, including oxygen saturation, capnography, body temperature, blood pressure, and heart rate, as well as clinical

data - muscle tone, motor responses, nausea, tremors, and agitation in the postoperative period [7].

Thus, monitoring the depth of anesthesia plays a key role in the prevention of postoperative complications, being an integral part of the strategy of safe anesthesia. Its implementation is especially important in the context of increasing surgical activity, aging population and comorbidity of patients. The results of domestic and international studies, as well as clinical recommendations of professional communities, confirm the need for routine use of depth monitoring technologies in anesthesiology practice. This article reviews existing approaches to monitoring the depth of anesthesia, analyzes their impact on postoperative outcomes and substantiates the importance of integrating these methods into the standards of anesthesia care in Uzbekistan.

The aim of the study: to study the role of comprehensive monitoring of the depth of anesthesia in reducing postoperative complications based on clinical and physiological indicators.

Materials and methods: The study was conducted at the Bukhara branch of the Republican Scientific Center for Emergency Medical Care (RSC EMC) during 2024–2025. The study included 50 patients who underwent elective and urgent surgeries under general anesthesia. The patients were distributed by gender: 28 men (56%) and 22 women (44%). The average age was 54.3 ± 12.6 years (range, 28–74 years). The most common comorbidities in the subjects were arterial hypertension (58%), type 2 diabetes mellitus (26%), and chronic obstructive pulmonary diseases (10%). A moderate positive correlation was established between the age of patients and the incidence of postoperative cognitive dysfunction ($r = 0.43$, $p < 0.05$).

All patients were conditionally divided into six main surgical groups most commonly encountered in practice:

- Abdominal surgeries (appendectomy , cholecystectomy) – 12 patients (24%);
- Urological interventions (transurethral resections, nephrectomies) – 9 patients (18%);

- Thoracic operations (drainage of the pleural cavity) - 7 patients (14%);
- Orthopedic interventions (endoprosthetics, osteosynthesis) - 8 patients (16%);
- Gynecological operations (hysterectomy, laparoscopy) - 6 patients (12%);
- ENT surgeries (tonsillectomy, septoplasty) - 8 patients (16%)

To assess the depth of anesthesia, a comprehensive monitoring was used, including:

- clinical characteristics of the patient (level of consciousness, behavioral reactions),
- hemodynamic parameters (blood pressure, heart rate),
- oxygen saturation (SpO₂),
- capnography (etCO₂),
- body temperature,
- presence and severity of reflexes (conjunctival, corneal),
- motor and vegetative reactions (sweating, tremor, pupillary reaction).

Each patient underwent preoperative assessment using the ASA (American Society of Surgeons) scale. Society of Anesthesiologists). Induction of anesthesia was performed using propofol and fentanyl, followed by maintenance of anesthesia with sevoflurane or total intravenous anesthesia (TIA). Real-time monitoring of parameters was performed throughout the operation and early postoperative period (first 24 hours). Cases of hypotension (BP<90/60 mmHg), bradycardia (HR<50 bpm), episodes of awakening during the procedure, as well as postoperative cognitive impairment, pain according to the visual analog scale (VAS) and delirium were recorded.

Research results

The analysis of 50 clinical cases showed that the use of complex monitoring of the depth of anesthesia significantly affects the frequency and severity of postoperative complications. During the observation, 11 episodes of hypotension (22%) and 6 cases of bradycardia (12%) were recorded in the intraoperative period, mainly in patients over 60 years old. Of these, only two cases required drug correction, which is probably due to early detection of

changes due to continuous monitoring of blood pressure and heart rate.

Saturation values (SpO₂) were within the normal range in most patients (94–99%), however, 5 patients (10%) had short-term episodes of decreased saturation to 90–92%, mainly in the group of thoracic and abdominal surgeries. Capnography proved to be highly informative in detecting hypoventilation: 6 patients had an increase in etCO₂ > 50 mm Hg, which allowed timely adaptation of mechanical ventilation parameters.

Temperature homeostasis monitoring showed that 18 patients (36%) had a decrease in body temperature below 36 °C, especially in the groups of long-term orthopedic and urological interventions. This required the active use of warming mats and intravenous heated solutions.

The most significant clinical effect was a decrease in the incidence of postoperative cognitive impairment. In the group of patients with comprehensive monitoring of the depth of anesthesia, cognitive dysfunction in the first day after surgery was observed only in 6 people (12%), while according to the literature, without monitoring this figure can reach 25–30% in people over 60 years of age. Most often, cognitive impairment was recorded after abdominal and orthopedic interventions (2 cases in each group), which is associated with the duration of operations and a greater need for anesthetics.

Analysis of subjective pain according to VAS in the first 6 hours after surgery showed that in the group with precise correction of the depth of anesthesia, the need for additional analgesia arose in 18 patients (36%). The average VAS score was 4.2 ± 1.1, which is an acceptable value in the early postoperative period. Among patients with hyperreaction (VAS > 6), an association with unstable depth of anesthesia (according to HR and DBP) was noted.

Postoperative delirium was recorded in 3 patients (6%), all over 65 years old and with concomitant arterial hypertension and cerebrovascular insufficiency. In two of them, the BIS indicator during the operation varied within 75–85, which could indicate insufficient

depth of sedation . Thus, the obtained data confirm that precise control of the level of anesthesia can reduce the risk of delirium and cognitive impairment.

Correlation analysis showed a statistically significant relationship between age and the severity of postoperative cognitive dysfunction ($r = 0.43$, $p < 0.05$), as well as between the duration of surgery and the decrease in body temperature ($r = 0.51$, $p < 0.01$).

Thus, the obtained results indicate a high diagnostic and prognostic value of complex monitoring of the depth of anesthesia. Its use allows for timely detection of deviations in physiological parameters, adaptation of anesthetic tactics and reduction of the incidence of early postoperative complications.

Discussion

The obtained results confirm the key role of complex monitoring of the depth of anesthesia in reducing the frequency of postoperative complications, which corresponds to modern international clinical guidelines and the results of large studies. Monitoring based on a set of clinical and physiological parameters (blood pressure, heart rate, SpO₂, capnography, body temperature, behavioral and vegetative reactions) allows timely response to changes in the patient's condition and avoidance of both insufficient and excessive anesthesia.

In the context of an aging population and high comorbidity among surgical patients, an individualized approach is of particular importance. Our study found a significant correlation between patient age and the incidence of postoperative cognitive dysfunction, which is consistent with the results of large clinical observations, according to which the risk of POI increases almost twofold in individuals over 65 years of age without control of the depth of sedation .

The informative value of capnography and continuous oxygen saturation monitoring within the framework of multilevel monitoring is also confirmed by the detection of early signs of hypoventilation and hypoxia in 10% of patients, including with stable blood pressure and heart rate. This emphasizes the importance of combined analysis of ventilation and

hemodynamic parameters, especially in patients with respiratory pathology or obesity.

Of particular interest is the finding that body temperature decreased in one third of patients, predominantly in the orthopaedic and urology groups. Intraoperative hypothermia contributes to increased recovery time and decreased efficiency of anesthetic metabolism, which may also impact cognitive function in the postoperative period. These observations are consistent with ASA and ESA recommendations for temperature monitoring as a critical parameter during prolonged operations.

In addition, the revealed relationship between unstable depth of anesthesia and severity of postoperative pain (VAS > 6) in some patients confirms that inadequate anesthesia can provoke both hyperreactivity of the nervous system and stress hyperactivation, which increases pain syndrome. This makes the issue of the role of BIS monitoring and other tools for objective assessment of anesthetic control in ensuring adequate analgesia relevant.

Of further interest is the fact that monitoring the depth of anesthesia was most effective in urgent interventions and in patients with baseline hemodynamic instability. It is in these clinical situations that reducing variability, achieving a stable anesthetic profile, and reducing anesthetic consumption can significantly impact treatment outcomes and length of stay in the department.

Thus, the results of the conducted study are fully consistent with modern international trends in anesthesiology, where special attention is paid to personalized and multiparametric monitoring. This is especially important in the context of the implementation of high-tech safety protocols and the reduction of postoperative complications - both in multidisciplinary clinics and in regional centers, such as the Bukhara branch of the Republican Scientific Center of Emergency Medicine.

Conclusion

The results of the study convincingly demonstrate that comprehensive monitoring of the depth of anesthesia, based on a combination of clinical signs and physiological parameters (BP, HR, SpO₂, capnography, temperature, behavioral and vegetative reactions),

significantly reduces the risk of postoperative complications. Particularly significant is the decrease in the frequency of cognitive disorders and delirium in older patients, which emphasizes the need for a personalized approach to monitoring anesthesia care. The use of multilevel monitoring allows for timely detection and correction of critical deviations, minimization of hypothermia, hypoxia and hemodynamic instability, as well as optimization of the use of anesthetics. The data obtained confirm that the introduction of protocols using technologies for assessing the depth of anesthesia (including BIS and analogues) in the practice of anesthesiology and resuscitation departments is advisable from both a clinical and economic point of view. The introduction of such approaches, especially in regional institutions, will improve the quality of anesthesia care, reduce the duration of postoperative rehabilitation and reduce the overall burden on the healthcare system.

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