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Features Of Anesthesiological Support for Operations in Extremely Low-Weight Newborns

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ABSTRACT

The presented work presents the results of a study of the features of anesthesiological support for surgical interventions in newborns with extremely low body weight. The analysis was based on prospective data collection at a multidisciplinary perinatal center.

Characteristic changes in hemodynamics and respiration were established, the effect of the anesthetics used on the stabilization of the child's condition in the perioperative period was revealed. The risks associated with temperature balance instability were identified, as well as the need for comprehensive monitoring to avoid the development of severe complications.

The results obtained allow optimizing anesthesia tactics, taking into account the individual characteristics of such patients, and can serve as the basis for improving clinical protocols

Keyword: *newborns with extremely low body weight, anesthesia, hemodynamics, complications, surgical interventions, perinatal center*

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1. INTRODUCTION

In modern neonatology, a special group of patients are children born with extremely low body weight. Such newborns have a body weight of less than 1000 g and often require urgent surgical interventions due to the presence of congenital developmental anomalies or severe pathological conditions. Surgical interventions performed in such children are associated with high risks, since prematurity and extremely low body weight form a special vulnerability of all body systems. The greatest difficulty is the anesthetic support of these operations, which should take into account the immaturity of the lungs, the instability of hemodynamics and the peculiarities of the pharmacokinetics of drugs.

The neonatology service has undergone significant changes in recent decades aimed at reducing mortality and disability in the group of deeply premature babies. Success in nursing babies with extremely low body weight increases the likelihood of a favorable outcome, which in turn requires the development of clear recommendations for anesthesiological tactics and the use of modern monitoring tools [3].

The list of common surgical interventions in extremely low-weight newborns includes operations on the abdominal organs with necrotizing enterocolitis, correction of heart defects, interventions on the central nervous system, and other manipulations requiring extensive or minor surgical assistance.

The combination of unstable hemodynamics, functional immaturity of the lungs and immaturity of the central nervous system in this category of children forms the prerequisites for severe intra- and postoperative complications. Characteristic risk factors include the rapid development of hypothermia, metabolic disorders, and high permeability of the blood - brain barrier and immaturity of enzymatic neutralization systems for drugs. Therefore, adequate anesthetic provision is not limited to the choice of optimal drugs for the induction and maintenance of anesthesia, but also includes strict monitoring of key vital signs, as well as active measures to warm up [1].

The safety of anesthesia in extremely low-weight newborns remains controversial due to the lack of a single universal approach, because various research groups note differences in the response to pharmacological agents and in the frequency of postoperative complications [10].

The accumulated clinical data allow us to conclude that a personalized approach is important when choosing anesthetic agents, dosages and the method of conducting the intraoperative period.

The purpose of this study was to analyze the key features of anesthetic provision and determine the factors affecting the outcomes of extremely low-weight newborns who underwent planned and emergency surgical interventions.

2. RESEARCH MATERIALS AND METHODS.

The study was conducted in a multidisciplinary perinatal center with intensive care units for newborns, an opera block, and a specialized neonatal surgery department. The patient recruitment period lasted from January 2020 to December 2024. The study included newborns with a confirmed birth weight of less than 1000 g who required surgical interventions for vital indications or as planned.

Consent to participate in the study was obtained from the parents or legal representatives of the child. Exclusion criteria provided for the presence of fatal malformations in the newborn, in which surgical treatment could not be shown. Also, children who underwent operations outside our center were not considered.

The main body of data included anamnestic information about pregnancy, diagnosed in intrauterine pathology and assessment of the state of the newborn according to the Apgar scale. Upon admission to the intensive care unit, hemodynamic parameters (heart rate, average blood pressure), oxygen saturation, and temperature status were recorded. Before surgery, laboratory parameters (hematocrit, hemoglobin, serum lactate) were taken into account and the presence of concomitant disorders (respiratory distress syndrome, sepsis, congenital malformations) was assessed.

The anesthetic manual was carried out in accordance with generally accepted protocols; however, in children with extremely low body weight, the dosage of drugs was selected individually under the control of vital functions. For induction, low doses of propofol were usually used, in some cases ketamine and fentanyl were used for severe hypotension.

Anesthesia was maintained by inhaled anesthetics (isoflurane, sevoflurane) in combination with opioids with the mandatory use of high-frequency artificial lung ventilation (if indicated). In the postoperative period, children remained in the intensive care unit under continuous monitoring of respiratory and circulatory parameters.

To assess the outcomes, the following indicators were taken into account: stability of hemodynamics during surgery, severity of pain syndrome (on a modified scale for newborns), frequency of hypothermia (body temperature less than 36.0 ° C), metabolic disorders (hypoglycemia, hyperkalemia), as well as features of the early postoperative period (the need for prolonged mechanical ventilation, signs of intracranial hemorrhages, infectious complications).

Statistical data processing was carried out using a software package that allows you to calculate average values and standard deviations. For comparative analysis of groups, parametric and non-parametric criteria were used depending on the distribution of variables. The significance of the differences was assessed at the level of statistical significance $p < 0.05$. All the information received was entered into a special database, where an individual anesthetic risk map was formed for each patient.

3. RESULTS AND DISCUSSIONS OF THE STUDY.

The total pool of studied patients was 62 newborns with a birth weight of 520 to 980 g. The average gestational age was 27.5 weeks, the range ranged from 24 to 30 weeks. Most of the children (41 patients) were born from multiple pregnancies or pregnancies complicated by intrauterine infections.

The Apgar score at the 1st minute of life in 35 children was on average 4 points, at the 5th minute - 6 points. Various types of operations were recorded: 28 cases of abdominal interventions (mainly resection of necrotic intestinal areas), 15 cardiac surgeries (correction of the hemodynamically significant open arterial duct), 9 neurosurgical interventions and 10 interventions on soft tissues (installation of drains and catheters).

For a more visual illustration of demographic and clinical characteristics, the first table has been formed, reflecting the averaged indicators of the studied sample.

Результаты и обсуждения исследования.

Table 1. Demographic and clinical characteristics of newborns

Indicator	Value (M ± SD)
Birth weight (g)	790 ± 88
Gestational age (wk)	27,5 ± 1,4
Apgar score in the 1st minute	4,1 ± 0,8
Apgar score at the 5th minute	6,2 ± 0,7
Heart rate before surgery	158 ± 12 bpm
Mean blood pressure	32 ± 5 mmHg St
Oxygen saturation	88 ± 4 %

According to the data obtained, the most vulnerable group was children with a gestational age of less than 27 weeks and a birth weight of up to 750 g. These newborns had a higher frequency of hemodynamic instability and pronounced fluctuations in body temperature during surgery, which is reflected in the monitoring results.

When analyzing the choice of drugs for induction, it was noted that propofol at low doses was most often used, which allowed maintaining the relative stability of hemodynamics. In conditions of severe hypotension, ketamine was preferred in combination with opioids. The use of sodium thiopental or other barbiturates was extremely limited due to the risk of cardiovascular depression [6].

The maintenance of anesthesia in most cases was performed by sevoflurane, which is associated with its less irritant effect on the respiratory tract and easier control of the depth of anesthesia. In some cases, the combined use of isoflurane and fentanyl was practiced. Table 2 presents the features of the selection of anesthetic drugs.

Table 2. Anesthetic frequency (% of total surgeries)

Medicine	Frequency,%
Propofol (induction)	63
Ketamine + fentanyl (induction)	22
Sodium thiopental (induction)	8
Sevoflurane (maintenance)	71

Isoflurane + fentanyl (maintenance)	18
Other combinations	3

In addition to the main diagnosis and concomitant disorders, the formation of the anesthesia strategy was influenced by the peculiarities of the child's condition immediately before the operation. The vast majority of patients were diagnosed with respiratory distress syndrome, which required mechanical ventilation, which complicated the choice of anesthetics and indicated the importance of respiratory support during surgery. The state of the cardiovascular system was also important: with a fixed heart rate of less than 140 beats/min and an average blood pressure below 30 mm Hg, the risk of using some agents for induction increased significantly [2].

Hemodynamic stability during surgery was monitored by continuous monitoring of ECG, blood pressure and saturation, and in some cases invasive monitoring of blood pressure was used through catheterization of the peripheral or umbilical artery. The analysis showed that fluctuations in average blood pressure during the operation were in the range of 28-40 mm Hg. Art. And most often the downward trend was observed after the introduction of the initial dose of anesthetic. In some cases, especially with combined anesthesia with drugs that have a vasodilating effect, additional administration of vasopressors was required to maintain adequate organ perfusion.

In the context of heat balance, the tendency to rapidly lose heat remained a significant problem. Almost all children had manifestations of hypothermia to one degree or another during surgery. To prevent hypothermia, various heating systems were used, including infrared lamps and warm solutions for infusions [9].

Despite these measures, the risk of lowering body temperature to 35-35.5 ° C remained high, especially when the operation lasted more than 90 minutes. Mean temperature changes are shown in the following graph, where the abscissa represents time intervals (every 15 minutes of surgery) and the ordinate represents mean body temperature (in ° C).

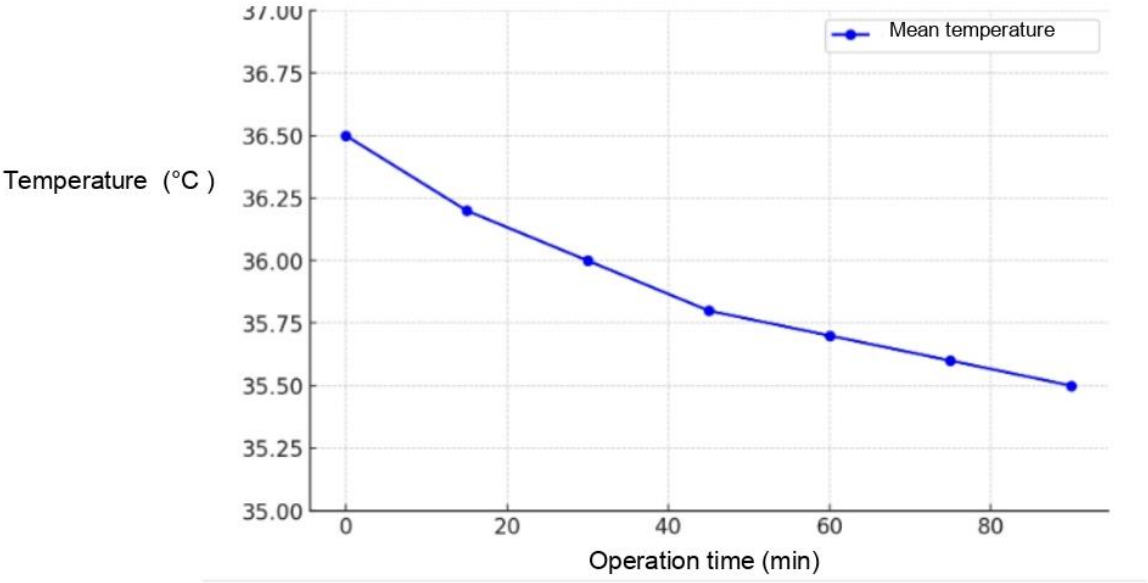

Figure 1 - Mean dynamics of body temperature during surgery

This trend emphasizes the need for constant control of heat balance and corrective measures in the intraoperative period, since hypothermia can provoke coagulation disorder and metabolic failures, increasing postoperative mortality.

When assessing early postoperative complications in 11 children (18% of the total), a further decrease in body temperature was noted in the first hours after surgery, which required additional correction in intensive care units.

In 9 newborns, episodes of severe hypoglycemia (blood glucose < 2.6 mmol/L) were observed, which was timely corrected with glucose infusion solutions.

In 7 cases (11%), signs of early septic complications occurred, confirmed by laboratory data, which led to an increase in the duration of stay in the intensive care unit.

The modified pain score for preterm infants during the first days after surgery showed a mean score of 3.2 ± 1.1, which is considered moderate pain. However, some children (14 patients) had high scale values exceeding 4 points, which required an increase in doses of analgesics.

Data on the intensity of pain syndrome in the first 24 hours after surgery suggest that intraoperative analgesia was often insufficient without adequate correction in the postoperative period. This is indicated by a comparison of data on the use of fentanyl and the need to transfer some patients to more intensive pain relief [5].

To demonstrate the association between anesthesia strategies and complication rates, a summary table was constructed showing how the selection of anesthetic agents influenced key outcomes (hypothermia, marked hypotension, need for vasopressors, and incidence of deep respiratory impairment).

Table 3. Relationship between choice of anesthetic tactics and underlying complications

Anesthesia tactics	Hypothermia,%	Hypotension,%	Vasopressors,%	Respiratory disorders,%
Propofol + sevoflurane	32	18	10	25
Ketamine + fentanyl + sevoflurane	40	10	15	22
Sodium thiopental + isoflurane + fentanyl	45	28	20	35
Combinations with additional drugs (rare)	50	30	25	40

The following important points are highlighted in the discussion of the presented data [3].

Firstly, children with extremely low body weight have a higher risk of complications than newborns of older gestational age.

Secondly, the choice of anesthetic tactics in conjunction with technical means and careful monitoring allows you to minimize negative consequences.

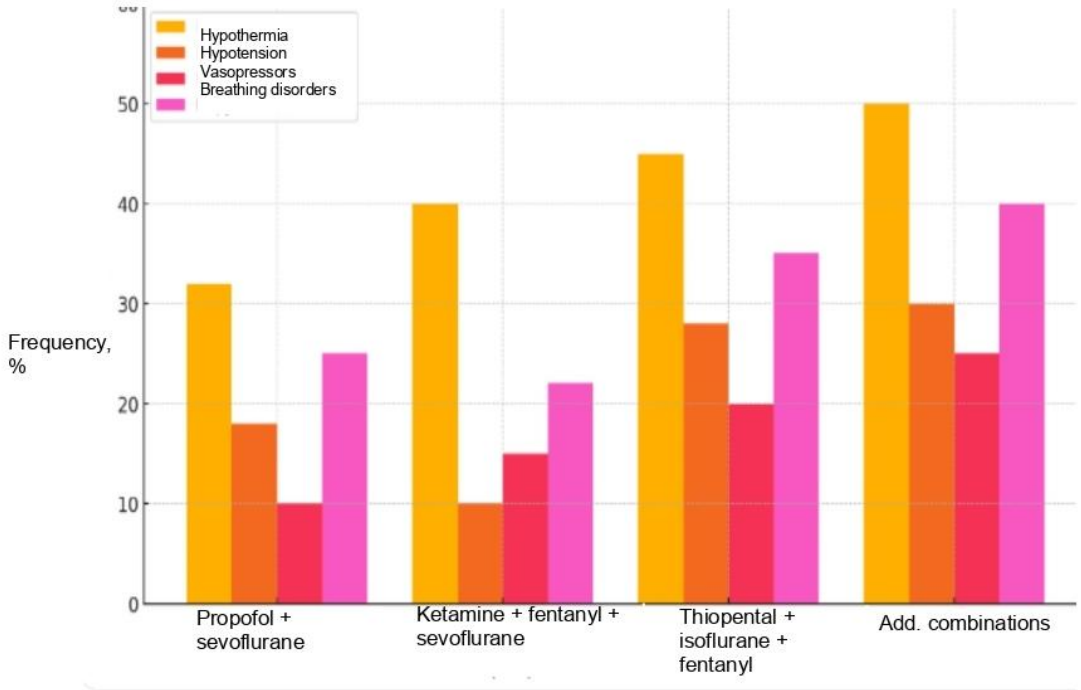

Figure 2 - Relationship between anesthesia choice and complication rate

The combination of propofol in low doses with the inhaled anesthetic sevoflurane looks safer than the use of barbiturates, although in cases with severe hypotension ketamine played a positive role in maintaining cardiac output [3].

The question of the duration of the operation turned out to be significant. With interventions exceeding 90 minutes, the risk of hypothermia and metabolic disorders increased, while short-term interventions (about 30-45 minutes) were relatively easier for newborns.

Transfusion of red blood cells and plasma during surgery was required in 34% of cases, primarily for the correction of anemia and impaired blood coagulation in necrotizing enterocolitis.

Observation of patients during the first week after surgery made it possible to assess the long-term consequences of anesthesia. There were 4 deaths (6.5%) within 7 days associated with severe septic infection and multiple organ failure, as well as 3 cases (5%) of severe intraventricular hemorrhages aggravated by the severity of the initial condition of the children. In other situations, a gradual improvement in indicators was noted, including the restoration of stable hemodynamics and respiratory status [10].

When comparing data with historical control, where higher doses of propofol and thiopental were used, a decrease in the incidence of complications by 10-15% was revealed, which emphasizes the importance of observing the principles of minimum necessary sedation and mild maintenance of anesthesia? An additional success factor was the active use of thermoregulation and precision monitoring systems in the intraoperative period [7].

Thus, the presented results indicate the effectiveness of individualized anesthetic tactics, taking into account the condition of the child and the specifics of the surgical intervention. Improved monitoring of vital functions and the use of modern anesthetics with a short half-life can increase the chances of a newborn for a favorable outcome. However, the complexity of this category of patients suggests the need for further studies with the inclusion of a larger sample, as well as a possible comparison of different anesthesia protocols and measures for the prevention of hypothermia.

4. CONCLUSIONS

The study revealed the key features of anesthesiological support for operations in newborns with extremely low body weight. The most significant aspect was the high frequency of hemodynamic instability, requiring the use of minimal but sufficient doses of anesthetics and, if necessary, vasopressor support. The most important condition was to maintain body temperature throughout the operation, since hypothermia develops rapidly in this category of newborns and leads to serious complications.

The optimal induction tactic in most cases was the use of propofol in combination with low doses of opioids or ketamine in the presence of severe hypotension. To maintain anesthesia, sevoflurane became preferable due to the controlled level of anesthesia and minimal negative effects on the lungs and cardiovascular system.

Timely correction of metabolic disorders (hypoglycemia, electrolyte failures) and prevention of septic complications largely determine the outcome of the intervention, which is confirmed by the relatively low (albeit unfavorable) mortality in the group of deeply premature patients. The findings highlight the need to further optimize anesthetic care, develop protocols that take into account not only the choice of drugs and thermoregulation tactics, but also the need for early postoperative rehabilitation with active monitoring of all vital systems.

The results of the work can be used in the practical activities of anesthesiologists-resuscitators and neonatologists, as well as in drawing up clinical recommendations for the management of extremely low body weight newborns who are to undergo surgical interventions. Improving research methods, introducing more accurate monitoring methods and developing neonatal surgery are necessary conditions for further reducing risks and increasing survival in this group of patients

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