Optimization of pain management processes in pediatrics: the role of the anesthesiologist and pediatrician in providing effective therapy

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Abstract

The article is an in-depth analysis of modern approaches to pain management in pediatrics, focused on the role of the anesthesiologist and pediatrician in providing optimal therapy. As part of this study, the authors highlight various aspects of pain management, ranging from pharmacological methods to non-pharmacological techniques such as psychological support and procedural pain relief. Special attention is paid to an individual approach to each patient, taking into account his age, physiological characteristics, as well as chronic diseases or features of pathologies.

The authors analyze and compare existing standards and recommendations in the field of pain relief for children, discuss their applicability and effectiveness in a practical context. Practical tips and strategies for anesthesiologists and pediatricians aimed at optimizing the processes of anesthesia and improving the quality of medical care provided to children are presented. The authors present the problems faced by specialists in the field of anesthesia in children are also considered, and also suggests ways to overcome them through the development of innovative methods and techniques of anesthesia.

Keywords

Anesthesia, Pediatrics, Anesthesiologist, Quality of medical care, Effectiveness of therapy.

INTRODUCTION

Ensuring effective and safe pain management is one of the most important aspects of medical practice, especially in pediatrics, where children often have to deal with diseases and procedures accompanied by pain. Optimal pain management not only improves the quality of life of young patients, but also contributes to more successful treatment and recovery. In modern medical practice, various methods of anesthesia are widely used, from pharmacological to non-pharmacological, including both standard and innovative approaches.

Pediatric patients are more susceptible than adults to critical incidents related to anesthesia. Prospective observational multicenter studies have confirmed a relatively high incidence of severe critical events during anesthesia of surgical procedures[1].

The risk increases in newborns, children aged one to three years, as well as in those pediatric patients who have severe concomitant diseases. Studies of such cases emphasize the need to implement common protocols and guidelines in the field of anesthesia in pediatrics. During preanesthesia, doctors should give priority to patients and their families, who are highly interactive units. A thorough preoperative assessment includes a detailed medical history and a thorough physical examination to prevent serious complications and ensure that an individual anesthesia plan is prepared by a qualified pediatric team of anesthesiologists.

The aim of the work is to review modern strategies and methods of pain management in pediatrics with an emphasis on the role of the anesthesiologist and pediatrician in providing effective therapy. It is necessary to consider various aspects of pain management in children, starting from choosing the optimal method depending on the age and nature of pain, and ending...
with an analysis of the challenges faced by specialists in this field. It is also important to explore the proposed recommendations for improving pain management practices and improving the quality of medical care for children.

MATERIALS AND METHODS

In the process of preparing the work, an analysis of scientific literature and publications in the field of pediatrics, anesthesiology, anesthesia and pharmacology was carried out. The results of clinical studies on pain management methods in children, including randomized controlled trials (RCTs), observational studies and meta-analyses, were also studied and the opinions of leading specialists in the field of pediatrics and anesthesiology were analyzed to obtain expert opinions, recommendations and practical advice. In addition, official guidelines and standards of practice for pain management in pediatrics, such as the recommendations of the World Health Organization (WHO), as well as national associations of pediatricians and anesthesiologists, have been investigated. Statistical data on the prevalence of various diseases in children requiring anesthesia were analyzed, and an assessment of the effectiveness of the applied anesthesia methods based on statistical indicators and research results was studied.

RESULTS

According to available data, the incidence of perioperative mortality in the pediatric surgical population is low and is estimated at 0.1–1.2 per 100,000 anesthetics administered [2]. Perioperative mortality is the result of the interaction between concomitant diseases of patients and internal surgical risk (ISR). Intraoperative cardiopulmonary, endocrine and hemodynamic physiological reactions to surgical stimulation and tissue destruction are, among other factors, the main determinants of surgical risk [3]. In addition to mortality, the main indicator of the quality and safety of anesthesia, pediatric patients are at risk of morbidity, including, but not limited to, neurological decline, prolonged mechanical ventilation and unforeseen increased medical care. The identification of high-risk patients will ensure adequate case planning, the selection of qualified staff and the appropriate allocation of resources. It will also provide the family with objective, evidence-based counseling necessary to obtain informed consent for anesthesia [4].

Due to advances in medical therapy and the advent of modern extracorporeal cardiopulmonary support systems, patients with very complex medical problems are increasingly seeking surgical interventions and other procedures such as medical imaging.

The determinants of perioperative risk in children are complex and multifactorial. It is believed that perioperative morbidity is the result of an interaction between patient characteristics, concomitant diseases and ISR [5]. ISR represents a 30-day mortality risk for certain surgical procedures, regardless of concomitant diseases. It takes into account the perioperative physiological reactions of the cardiovascular, pulmonary, endocrine, coagulation and immune systems resulting from surgical tissue damage [6]. In addition, the complexity and duration of the operation have a direct impact on intraoperative hemodynamic changes caused by blood loss, fluctuations in central temperature, fluid displacement and mechanical changes in organs.

Most studies have identified respiratory complications as the main cause of severe adverse outcomes after sedation or general anesthesia in children. Severe respiratory critical events include laryngospasm, bronchospasm, stridor, and bronchial aspiration. A history of prematurity increases the relative risk of these respiratory complications by almost two times. However, although the most frequently reported incidents are related to the respiratory system (55%), cardiovascular events are the main causes of cardiac arrest [7].

Newborns and infants have a limited physiological reserve and are at greater risk of complications with general anesthesia, with premature newborns at the greatest risk. With an increase in the frequency of preterm birth, more and more premature newborns undergo complex surgical procedures at an early age and are at higher risk of perioperative critical events [8]. Despite medical advances in perioperative neonatal care over the past two decades, deeply premature infants are still at high risk of morbidity and mortality. Experts have found that hospital-acquired mortality in non-cardiac operations is five times higher in premature infants than in full-term newborns [9]. It was determined that premature newborns who underwent abdominal surgery during the first 2 months of life have a high risk of 30-day mortality, which increases significantly with the progression of prematurity. This can be explained by the fact that most premature newborns are more likely to have serious concomitant diseases such as necrotizing enterocolitis, sepsis, bron-
chopulmonary dysplasia (BPD) and severe intracranial hemorrhage, as well as dependence on a ventilator.

The unique physiology of newborns, a higher incidence of concomitant diseases such as extreme prematurity, congenital malformations or heart disease, immaturity of organ systems and an incomplete understanding of the pharmacology of the most commonly used anesthetics are among several factors that are believed to increase perioperative risk. In newborns, perioperative changes in physiological parameters such as blood pressure (hypotension/hypertension), oxygen saturation (hypoxemia/hyperoxia), carbon dioxide (hypocapnia/hypercapnia) and blood sugar (hypoglycemia/hyperglycemia) can significantly affect postoperative outcomes [10].

Postoperative apnea is another problem in extremely premature babies. This may be due to airway obstruction, respiratory arrest, or bradycardia. Postoperative apnea can still occur in the absence of a preoperative history of apnea. At the same time, early apnea usually occurs in the department after anesthesiological care, and later apnea occurs a few hours later in the ward.

It is known that general anesthesia (GA) reduces the tone of the muscles of the upper respiratory tract and can contribute to the development of apnea after anesthesia, even in the absence of a history of apnea, and can also induce or unmask violations of the ventilation control system. Identifying infants at risk of apnea before surgery can reduce postoperative morbidity and provide recommendations to clinicians regarding the optimal age for surgery, the type of anesthesia, as well as the duration and intensity of postoperative follow-up[11].

Heart defects and other birth defects cause an increase in the level of anesthetic risk in newborns, unlike older children and adults. Thanks to recent advances in pediatric cardiology, surgery, and intensive care, survival rates for patients with congenital heart defects have improved.

An intraoperative pulmonary hypertension (PH) crisis can be triggered by a number of mechanisms, including damaging stimuli (for example, intubation, airway clearance, extubation or surgical stimulation), discontinuation or interruption of pulmonary vasodilator therapy, or changes in intraoperative parameters. It is usually manifested by signs of insufficient cardiac output and decreased pulmonary blood flow, which is manifested by a sharp decrease in carbon dioxide concentration at the end of exhalation, bradycardia and cardiovascular collapse [12]. In the presence of an intracardiac right-to-left communication system, oxygen desaturation can be very rapid. In the case of an intraoperative PH crisis, the team should be aware of immediate interventions to prevent cardiovascular collapse, which include ventilation with 100% oxygen, bronchodilator therapy to mitigate hyperreactivity of the respiratory tract and bronchi, optimization of the depth of anesthesia with adequate analgesia and neuromuscular blockade, bolus injection of fluid against hypovolemia, ionotropic pancreatic support and reduction of afterload Pancreas with inhaled nitrogen oxide [13].

Thus, multidisciplinary perioperative preparation is crucial in patients with hypertension. Anesthesia should be performed in these children only if there is a serious clinical justification and if anesthesia is necessary, and it should be carried out with great caution to avoid accelerating the pulmonary hypertensive crisis. This is especially important because as the actual duration of the procedure increases, so does the risk of complications.

Children often seek elective surgery due to an active or recent upper respiratory tract infection (URTI). Viral invasion of the respiratory epithelium causes damage to the mucous membrane, activation of the smooth muscles of the respiratory tract and leads to increased sensitivity of the respiratory tract to the irritating effect of anesthetic gases. Respiratory infections also increase secretion, mismatch of ventilation and perfusion, increase final volumes and worsen diffusion capacity [14]. Anesthetics and airway manipulation can further endanger an already sensitized respiratory system and lead to respiratory distress. Careful preoperative optimization and perioperative monitoring are crucial to reduce perioperative respiratory side effects and reduce morbidity in this patient population.

Patients with respiratory diseases may seek surgery on the respiratory tract or respiratory system or other unrelated procedures. Respiratory complications during anesthesia may affect the upper and/or lower respiratory tract and have multiple clinical consequences [15]. It is believed that serious respiratory tract disorders usually occur during induction of anesthesia, withdrawal from anesthesia and in children with pre-existing respiratory tract disorders. These include bronchospasm, laryngospasm, respiratory retention, arterial desaturation, the need
for repeated intubation, bacterial pneumonia and unforeseen hospitalization. Under anesthesia, damage to the ciliary apparatus responsible for removing secretions from the trachea, combined with the presence of SARS and the action of anesthetics, are cumulative factors contributing to the development of respiratory adverse events. Failure to recognize and treat airway obstruction, especially in young children, can quickly lead to oxygen desaturation and cardiovascular failure [16].

Risk factors for severe clinical respiratory events include the presence of sensitized airways against the background of acute or chronic inflammation, prematurity, preoperative fever, signs of obstructive sleep apnea, surgical intervention on the respiratory tract and early age.

Postponing surgery in children with recent SARS remains controversial. The decision to cancel the operation should take into account the amount of discharge from the respiratory tract during acute illness, concomitant lung disease, the need for intubation and the place of surgical intervention, while the respiratory tract, chest and upper abdomen are places of surgical intervention with increased risk.

DISCUSSION

To reduce the risks of adverse surgical outcomes, the preoperative assessment of pediatric patients should include a thorough analysis of the medical history and birth history of the child, including prematurity and related complications [17].

A review of prior events during surgery or anesthesia should also be conducted, especially those related to respiratory or cardiac events. The family history should focus on complications of anesthesia, such as postoperative nausea and vomiting, malignant hyperthermia or blood clotting disorders, which may increase the risk of adverse events.

The preoperative assessment delves into the clinical and psychosocial factors that may affect the timing of surgery and aims to identify underlying conditions that require attention or treatment before surgery. During the preoperative examination, it is necessary to examine the medical, behavioral and social history of the patient and his family, previous complications associated with surgery or anesthesia, as well as any treatment methods. This preliminary assessment is based on an understanding of how anesthesia affects the normal physiology of children [18].

It is necessary to examine each phase of the child’s growth and any deviations from the typical stages of development. Cardiovascular, neuromuscular, respiratory, endocrine, and hematological factors should be taken into account to identify associated risks and send requests for clinical trials [19]. It is necessary to carefully collect a personal or family history of malignant hyperthermia, as well as risk factors for rare diseases.

The prevention of anaphylactic reactions primarily depends on documenting past reactions. Thus, during the consultation before anesthesia, it is necessary to collect a complete history of atopy and register any allergies to drugs, latex and cross-reactions to food. Allergies should be identified and documented.

Clinicians should examine the patient’s behavioral and social history and, if necessary, involve caregivers [20]. Gaining a comprehensive understanding of the patient’s psychosocial dynamics better informs the surgical team and prepares the child and family for the postoperative recovery period, which can be a vulnerable period, especially after more complex procedures.

It may be necessary to contact the perioperative team to determine treatment tactics on the day of surgery and whether to preventatively refuse to take any drugs due to potential interaction with anesthesia.

Important preoperative information plays a crucial role in preparing pediatric patients for surgery. Although children have not yet achieved legal independence, anesthesiologists should actively involve them in the decision-making process by offering explanations adapted to their clinical condition. It has been demonstrated that the benefits of providing clear preoperative information, possibly using visual aids or images, reduce anxiety in both children and their parents, mitigate negative behavior in children and increase postoperative satisfaction.

Preoperative planning in pediatrics involves many of the same steps as in adults, even if there are significant differences. First, there is a close relationship with parents and their role at every stage of the decision-making process. In addition to the traditional medical history and physical examination, attention should be paid to the overall development of the child and the presence of any syndromes [21].

The preoperative assessment helps the anesthesiologist to determine the appropriate anesthesia methods. Regional anesthesia becomes a viable option under appropriate circumstances, provided that
the patient has no special contraindications and when regional methods improve pain control [22]. The decision to use regional methods should be made on the basis of individual considerations, taking into account the risk-benefit ratio. Pediatric regional anesthesia is usually used when the patient is under deep anesthesia or under general anesthesia. Performing these methods in such conditions is considered safe and should be considered standard assistance.

Clinical assessment is a fundamental point in the proper perioperative management of a pediatric patient and should include a comprehensive assessment of the clinical status. The purpose of the assessment is to focus on identifying unrecognized conditions or analyzing the risk of already known diseases [23].

During a cardiovascular examination, sometimes noises or rhythm disturbances may be detected. Often, cardiovascular diseases associated with congenital heart defects occur during the first year of life. Such diseases, sometimes latent after birth, can occur during surgery, when hemodynamic changes caused by anesthetics, artificial ventilation and blood loss eventually unmask these heart defects. Echocardiography can help assess the function and movement of the heart, and a pediatric cardiologist should always examine patients with suspected congenital abnormalities in order to correctly stratify preoperative risks and optimize heart function before surgery.

An experienced pediatric cardiologist should always examine children with known congenital heart disease before anesthesia if a recent report is not available. It is necessary to inform the anesthesiological team about the previous operation to correct birth defects [24].

It is extremely important to always examine the lower respiratory tract with standard auscultation with a stethoscope, which can detect wheezing, wheezing, altered breathing sounds, stridor, wheezing or noises, as well as signs of neurologically altered breathing patterns. Respiratory rate is a sensitive marker of pulmonary problems. Symptoms such as nasal distension, retraction of the intercostals and pronounced use of auxiliary respiratory muscles indicate respiratory distress [25]. Upper respiratory tract infections (URTI), manifested by fever, wheezing or productive cough, are associated with an increased risk of perioperative respiratory adverse events. These conditions can often occur acutely and may not be obvious during the initial assessment of the possibility of using anesthesia. Therefore, it is extremely important to re-evaluate them in the near preoperative period, since they may require the cancellation of planned procedures. Such procedures should be rescheduled only after the resolution of an inflammatory or infectious condition.

During a physical examination, it is necessary to identify pre-existing conditions of malnutrition and dehydration in order to restore the physiological balance of the child, since preoperative malnutrition correlates with postoperative complications and increased hospital stay.

Physical examination is important when planning regional anesthesia. Skin infections near the site of local anesthetic administration serve as a contraindication to the use of regional techniques. Problems may arise in patients with pre-existing neurological diseases, congenital anatomical abnormalities (such as arthrogryposis or osteogenesis imperfecta), or in those who have previously undergone surgery (for example, spina bifida). In such cases, the anesthesiologist should anticipate potential problems in advance, preparing additional equipment or considering changing the site or methods of injection of a local anesthetic [26].

The most important aspect of a physical examination includes an assessment of the anatomy of the upper respiratory tract. Preoperative examination of the respiratory tract is aimed at identifying physical characteristics that may indicate potential problems with ventilation using a face mask or tracheal intubation. Certain signs, such as limited mouth opening, limited neck mobility, hypoplasia of the upper or lower jaw, should be considered as warning signs [27]. In the presence of malformations, conditions associated with a decrease in the malleability of the submandibular space or craniofacial syndromes, it is important to anticipate and carefully investigate the possibility of obstruction of the airway. Adequate training, including the provision of all necessary devices, is crucial to eliminate potential difficulties with airway obstruction in the operating room.

Ultrasound examinations are used to examine the respiratory tract of a child in order to determine internal anatomical features, predict the optimal size of the endotracheal tube and detect sublingual stenosis.

Preoperative assessment is aimed at identifying and optimizing conditions that increase perioperative morbidity and mortality. Preoperative anesthesia testing should only be required if it helps to stratify risk or determine perioperative management. The
decision on the appointment of preoperative examinations should be based on the patient's clinical history, concomitant diseases, the results of a physical examination and planned surgical intervention. According to the surgical risk scale, routine laboratory tests are not recommended for healthy children and adolescents who have undergone low- and very low-risk procedures. However, patients with concomitant diseases may benefit from targeted laboratory and imaging studies to assess clinical stability. Patients taking anticoagulants or antiplatelet agents require careful examination when planning methods of regional anesthesia.

Preoperative ECG, echocardiogram and cardiologist consultation are recommended for certain conditions and age groups, for example, if any of the following signs are detected: heart murmur of questionable interpretation, suspected congenital heart disease, severe scoliosis, bronchopulmonary dysplasia (BPD), or neuromuscular disease. Newborns and infants under the age of six months require special attention due to unknown conduction abnormalities such as long QT syndrome, Wolf-Parkinson-White syndrome and congenital heart defects [28].

Sick children are often subjected to ongoing serious treatment. Communication with the operational team is necessary to determine which medications should be continued or discontinued before surgery, especially given the potential interaction with anesthetic drugs.

Optimal glycemic control is required for diabetic patients who have undergone surgery. The anesthesiologist should receive specific information about patients undergoing insulin therapy, paying special attention to the insulin administration scheme and the type of insulin prescribed. The use of fast-acting insulin should be discontinued on the day of surgery, except in cases of hyperglycemia requiring correction. In the case of users of an insulin pump, it is important to document the last change of the pump location, discuss the plan of the operating field, place the pump insertion site away from the operating field and check the function and location of the pump before the procedure.

It is important to remember that children's lives are closely connected with their guardians. Facing a stressful event such as anesthesia and surgery can be both a traumatic experience and a moment of collective maturation. During the preoperative period, anesthesiologists should cooperate to help children and their parents cope with the situation and reduce anxiety levels. It requires a lot of skill and an emotional attitude.

Factors contributing to anxiety and emotional stress in parents and children include insufficient familiarity with the surgical environment, including medical equipment, insufficient preparation for painful procedures, and inadequate preoperative information. Older children may find it difficult to process and verbalize their fears and anxieties. Operating rooms, medical instruments, and even staff in surgical attire can cause fear. Because of all these problems, combined with fear of the unknown, children may react with nightmares, crying, or refusing to speak. This experience can also be overwhelming for parents.

At the same time, parents, trying to stay strong, may internally struggle with fears of complications, feelings of guilt for their inability to protect their child, or concerns about postoperative recovery.

Consideration of socio-cultural and economic factors is essential to improve the quality of family participation, and a well-defined strategy must be adopted. Recognizing the uniqueness of each child is of paramount importance, because what proves effective for one may not be suitable for another. It is extremely important to observe and understand the specific needs of each child. For example, some children can calmly discuss their feelings, while others prefer to engage in physical activities, such as drawing or playing.

Visual aids such as picture books, cartoons, or medical toys can be effective in helping a child visualize and process an upcoming event. Some centers and clinics offer courses or information sessions for parents on managing preoperative anxiety. These classes provide parents with valuable information and an opportunity to share experiences with other people who find themselves in similar situations. Improper emotional treatment can have both immediate consequences, such as complex induction of anesthesia, and long-term consequences. The emotional trauma may persist, affecting future doctor visits or procedures. On the contrary, effective treatment not only ensures a smoother anesthesia process, but can also establish trust in medical staff, reducing fear of future procedures. Thus, careful preoperative preparation of pediatric patients and their family members will reduce the risks of anesthesia or the occurrence of various pathologies associated with its use, and significantly
increase the effectiveness of surgical intervention and subsequent recovery of the child.

CONCLUSIONS

A pediatric anesthesiologist must have adequate clinical skills. He also needs to know how to interact with young patients and their parents, understand their fears and needs, and adapt his manner of speech and interaction. Anesthesia and the operating room environment are complex systems involving human-machine interaction and human-to-human interaction. Improved survival in congenital diseases, as well as the introduction of new surgical methods, have led to changes in the modern practice of pediatric anesthesia. A significant part of the patients admitted for surgery are premature newborns, as well as newborns with weight deficiency, having complex concomitant diseases and various congenital anomalies. Preoperative multidisciplinary care for a group of high-risk patients, identification of risk factors and perioperative optimization can potentially reduce postoperative mortality and improve postoperative outcomes.

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