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## Anesthesia for ophthalmic surgery in children (review)

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### Abstract

The literature review is devoted to the analysis of the applied anesthesia techniques in ophthalmic surgical interventions in children from the point of view of the drugs used and the methods of anesthesia. In the preparation of the material, the databases Cyberleninka, PubMed, Medline were used with targeted searches based on the keywords: propofol, sevoflurane, paracetamol, regional anesthesia, ophthalmology, children. The depth of search by the date of publication of works was not limited, the emphasis was on publications of the last 10 years. The purpose of the review was to assess the breadth of application of various methods of anesthesia (general anesthesia and regional blockade), anesthesia drugs (sevoflurane, propofol, paracetamol, local anesthetics) in ophthalmosurgery in children.

**Keywords:** anesthesia, ophthalmic surgery, children

### Introduction

The active development of eye microsurgery within the last decade, undoubtedly, requires improvement of anesthetic support in such interventions. The specifics of anesthesia in the pediatric eye surgery is based on solution of such problems as sufficient sedation, effective intra- and postoperative analgesia, prevention of adverse reflex reactions (oculocardiac, laryngeal), relief of postoperative nausea and vomiting (PONV), and prevention of post-anesthesia agitation<sup>[1-12]</sup>.

### Ketamine and propofol as components of general anesthesia in pediatric eye surgery

Various authors consider that low doses of ketamine permit to improve the intraoperative status, reduce the risk of the oculocardiac reflex (OCR) and do not require the use of atropine for OCR prevention<sup>[13, 14]</sup>.

Ketamine anesthesia with obligatory premedication with atropine and seduxen has been considered a method of choice in pediatric eye surgery for a long time.<sup>[15-17]</sup> However, this option did not completely meet the requirements set by surgeons, who tried to avoid postoperative agitation, nausea and vomiting, i.e. factors that can elevate the intraocular pressure and, therefore, spoil the results of the surgical intervention<sup>[18]</sup>. This problem could be partially solved by the use of a combination of ketamine and propofol, which provide a fast and smooth induction of anesthesia<sup>[19-22]</sup> with a dose-dependent cardio-respiratory effect related to suppression of the sympathetic nervous system and produce a vagotonic and bronchodilating effect<sup>[8, 19, 23-25]</sup>; at that, the exact dosing of the drug permits to avoid possible hypoventilation<sup>[26]</sup>; and the patient recovers within a short period of time following a single dose.

Beletsky A. V. *et al.* (2015) describe propofol as a drug that meets all requirements to an anesthetic support in eye surgery. The authors note that propofol does not elevate the intraocular pressure; general anesthesia is induced quickly as it has been predicted; the anesthesia is stable with subsequent quick and smooth recovery of consciousness and somatic functions without straining efforts and vomiting. A combined anesthesia with propofol permits to arrange the most adequate conditions for the surgery, minimize adverse effects of its elements and ensure the specific tasks of the anesthesiological support in eye surgery<sup>[27]</sup>. Complete characteristics of propofol was by Sorokin E. Yu. (2014)<sup>[28]</sup> and Dmitriev D. V. (2014)<sup>[29]</sup>; they indicated both positive and negative characteristics of the drug, as well as the ability of the drug to reduce intraocular pressure, which is important in eye surgery. Many colleagues show their interest in a combined anesthesia with propofol and ketamine or fentanyl, indicating that this combination allows to maintain spontaneous

breathing, reduce the time of recovery, provide a gradual recovery from anesthesia without excitation, and reduce the need for antiemetic agents [30]. Whereas ketamine has the most pronounced damaging effect on the mental status, according to Elkin I. O. (2006), the combined anesthesia with propofol damages the mental status by sedation. Therefore, the combination of ketamine-propofol is more favorable [31].

Singh Bajwa (2010) studied advantages of total intravenous anesthesia (TVA) and found that at the time of anesthesia induction, the combination of propofol-fentanyl led to significant bradycardia and a marked decrease in systolic and diastolic pressure as compared to the combination of propofol-ketamine, however, in the maintenance phase, both combinations demonstrated stable hemodynamic parameters [32]. Wilhelm S. (1996), studied propofol in combination with sufentanil in children with surgical correction of strabismus and noted a high risk of bradycardia and oculocardiac reflex, but the risk of postoperative nausea and vomiting was not high [22]. Hahnenkamp K. (2000) studied ketamine, sevoflurane, propofol, midazolam and halothane in eye surgery and found that ketamine demonstrated the lowest hemodynamic changes and the risk of an oculocardiac reflex [33]. However, the study of St. Pierre M. (2002) has shown that the combination of propofol-ketamine has a longer post-anesthesia recovery; at that PONV is not reduced in comparison with the propofol-opioid combination [34]. Bröking K. (2011) recommends induction of anesthesia using ketamine and midazolam and notes that propofol and remifentanyl lead to an increased risk of oculocardiac reflex. [35]. However, Lili X. (2012) studied propofol in combination with sufentanil and remifentanyl and did not note undesirable complications in the form of oculocardiac, oculopulmonary and oculogastral reflexes during and after the surgery [36].

Choi S. R. (2009) presented a broad study on the use of ketamine in combination with sevoflurane, desflurane, propofol, remifentanyl, and midazolam during anesthesia in eye surgeries. In all cases, no premedication was carried out. To ensure airway patency, a laryngeal mask was used. The author comes to the conclusion that a combination of ketamine-propofol and ketamine-remifentanyl and midazolam-propofol and midazolam-remifentanyl often lead to oculocardiac reflex [37]. Трапир М. R. (1997) [21] indicates the high frequency of symptoms of oculocardiac reflex after the use of propofol (1444 cases of bradycardia). In their studies I. E. Skobeido (2004) and D. Yu. Ignatenko (2016) with co-authors compared propofol and opioid anesthesia with a combined anesthesia implying the use of sub-tenon or retrobulbar blockade in combination with intravenous administration of propofol. The authors point to negative aspects of administration of fentanyl which is manifested in respiratory depression, increased the duration of post-anesthesia recovery; and earlier recovery of consciousness and spontaneous respiration was noted in patients who underwent regional anesthesia [38, 39]. A.D.Dubok demonstrates the advantages of multicomponent anesthesia based on the use of inhalation sevoflurane anesthesia and intravenous anesthesia with propofol in combination with retrobulbar anesthesia (2011). The author reasons that the combination of general anesthesia with retrobulbar block in surgeries for strabismus eliminates oculogastral and oculocardiac reflexes and provides effective intra- and postoperative analgesia creating a

favorable psychological background both in children and their parents [40].

### **The use of sevoflurane in inhalation anesthesia for pediatric eye surgery**

Sevoflurane, an inhalation anesthetic, is one of drugs of choice for anesthesia in eye surgery, which is the most widely used drug in pediatrics. The drug is characterized by dose-dependent respiratory depression, with minimal effect on the cardiovascular system, allows to carry out highly controlled inhalation anesthesia with instant induction and rapid recovery, contributing to a rapid postoperative recovery of the patient. Sevoflurane has a more favorable cardiac profile compared to other halogen-containing inhalation anesthetics (halothane, isoflurane, desflurane) [41]. It reduces the brain metabolism, adapting it to ischemia [42]; it is characterized by a dose-dependent increase in intracranial pressure and a slight increase in cerebral blood flow in normocapnia [43]. Positive characteristics of inhalation anesthesia, including the use of sevoflurane, include the ability to perform anesthesia by low- and minimum-flow methods, providing more favorable conditions in the respiratory circuit, as well as good cost-effectiveness [44, 45].

However, the serious disadvantages of sevoflurane, which are crucial for patients after eye surgery, include post-anesthesia agitation, expressed in behavioral and psycho-emotional instability, especially in young children (up to 6 years). Study by Ignatenko D. Yu. (2009), has demonstrated that the agitation after sevoflurane administration occurs in 45% of cases and is typical for children aged from 1 to 5 years. The recovery was accompanied by motor hyperactivity (crying, negativism towards parents and medical staff). The author indicated that the use of midazolam as a premedication, as well as conduction anesthesia before the surgery, resulted in achieving the adequate postoperative analgesia reducing the incidence of the agitation syndrome at a recovery rate of 5% of cases [46]. In turn, Costi D. (2014), while emphasizing the basic problem of sevoflurane, also indicated behavioral disorders or manifestations of delirium after its application and recommends to apply a multimodal approach in order to reduce the agitation, using propofol, halothane, dexmedetomidine, clonidine, opioids (fentanyl), and ketamine [19]. Van Hoff S. L. (2015) offers to administer propofol for reduction of agitation after sevoflurane application, at the end of the surgical intervention [47]. Egorov V. M. and Elkin I. O. (2012) say that sevoflurane provides the greatest preservation of mental functions, like dornicum and propofol [48].

At present, sevoflurane is a drug of choice from a wide range of inhalation anesthetics in pediatric ophthalmic anesthesia that provides rapid induction of anesthesia and rapid recovery, without significant negative hemodynamic effects, with minor effects on intracranial and intraocular pressures. However, despite many important and positive characteristics of the drug, it has a significant negative effect, i.e. the post-anesthesia agitation, whose frequency and severity can be reduced by propofol.

### **Paracetamol as a component of analgesia in general anesthesia in pediatric eye surgery**

A significant number of papers devoted to anesthesia in eye surgery dwell on the issues of a combined use of non-

opioid analgesics; and in the pediatric practice they most often discuss paracetamol, which has a relatively strong analgesic effect and is permitted for use in all age categories [49–51]. The analgesic effect of the drug occurs within 5–10 minutes after the start of infusion and reaches its maximum within 1 hour; the peak analgesic effect is achieved within 4–6 hours. According to Zakharenko G. and Goncharuk V. (2016), there is enough evidence related to the clinical use of intravenous paracetamol (in the form of monotherapy or as a component of multimodal anesthesia) [52]. According to Macintyre P. E. (2010), the analgesic effect of paracetamol is equal to 30 mg of ketorol, 75 mg of diclofenac, 10 mg of metamizole and morphine [20].

Paracetamol is widely used as a non-opioid analgesic for the treatment of acute and early postoperative pain [53]. Savustyanenko A.V. (2014), analyzed their five-year experience (2005–2010) in the use of intravenous paracetamol and data of Macario, Royal (2011) [54] and demonstrated the scale of its surgical application, including the strabismus surgery [49]. Intraoperative intravenous administration of paracetamol (15mg/kg) does not lead to the development of postoperative nausea and vomiting within 24 hours after surgery; and its effectiveness is greater, if the drug is used for prevention before surgery or intraoperatively as compared to its introduction to relieve pain. Preoperative intravenous administration of paracetamol is comparable to the effect of analgesia after surgery [55–57], which is explained by processes of prevention of central and peripheral sensitization [53]. While treating patients with glaucoma, authors found that paracetamol reduced intraocular pressure [58].

Undoubtedly, conclusions can be made on the positive role of paracetamol as an effective analgesic in intraoperative anesthesia of eye surgery and postoperative analgesia in children, but it is also clear that the drug is used as a co-analgesic in most cases, providing a reduction in the dosage of opioid analgesics during general anesthesia.

### Regional blockades as a component of combined anesthesia in pediatric eye surgery

Almost most requirements to arranging conditions for eye surgery can be met by the use of regional blockades, which include: retrobulbar, parabolbar, perilimbal, epibulbar, sub-tenon, epibulbar-intrachamber anaesthesia, wing-orbital block (WOB) and drip (instillation) anesthesia [8, 9]. For example, sub-tenon anesthesia in combination with postoperative administration of NSAIDs and serotonin receptor antagonists significantly reduces pain, as well as prevents the risk of postoperative nausea and vomiting in children with surgical treatment of strabismus, due to a more complete interruption of afferent impulses from the area of eye surgery [59]. There is no doubt that retrobulbar anesthesia provides a deeper suppression of sensitivity and akinesia, allows to stabilize the eyeball during the surgery, but unfortunately, the risk of complications is very high [60]. Since the autonomic innervation of the eye is comes from two nodes, the ciliary and pterygopalatine [61], it is advisable to affect the two ganglia simultaneously. Prokop'ev M. A. (2011) indicates pterygopalatine ganglion as an anatomical and physiological structure that is important for eye surgery, noting that the blockade of the pterygopalatine ganglion provides the denervation of the nerve structures related to the eye, orbit, and periorbital tissue [9, 62]. In adult eye surgery, as well as in the treatment

of post-concussion ocular hypertension, a wing-orbital blockade (zygomatic access to the pterygopalatine fossa) is used [63].

A lot of research is devoted to the use of WOB in glaucoma, although Vaisblat S.N. (1962) noted the positive effect of the blockade of the pterygopalatine ganglion for the treatment of patients with glaucoma [64]. Tatarinov N. *et al.* (2009) and Zelentsov S. N. *et al.* (2014) noted that the blockade of the pterygopalatine fossa is one of the components of patient's antinociceptive protection in surgery [61, 65], in which it is possible to operate on the ciliary and pterygopalatine vegetative nodes simultaneously. Prokop'ev M. A. *et al.* (2011) emphasize that the more selective the blockade is, the more effective it is. With such a blockade, drug deposition is formed, the effect of which is softer, and the effect lasts longer. They indicate that this technique is useful in a number of operations, including vitreous surgeries and dacryocystorhinotomy, and to relieve a glaucoma episode [62].

Vaisblat S. N. (1962) describes several methods of the pterygopalatine blockade through different accesses [64], indicating that pterygopalatine fossa but not round foramen should be the injection site for anesthesia of the maxillary nerve. This route is easily accessible and accurate, and the passage of a needle in the palatine pathway, through the pterygopalatine canal, along the vessels and nerves embedded in it does not have any adverse consequences, because their hydraulic removal takes place by a slowly introduced a local anesthetic. The technique is successfully used in adult rhinosurgery [66, 67]. Malamed S. F. pays attention to the positive results of the anesthesia. The use of the technique ensures success and a low level of complications. In 90% of cases, this anesthesia is determined as adequate by the authors [25]. However, Hawkins J. M. *et al.* (1998) found that in the case of a higher fornix of the oral cavity, greater palatine foramen is located closer to the dentition; and in the case of a lower fornix, it is closer to the midline [68]. While performing palatine anesthesia in children, McDonald R. E. (2003) notes that an imaginary line should be drawn from the gingival margin of the last molar to the midline in order to determine the direction of the needle. The needle should be moved distally, placing the syringe on the opposite side. [69].

It is always necessary to determine the volume of injected local anesthetic (LA) during regional block in eye surgery due to a constant risk of diplopia that occurs when the LA penetrates into the orbit through the inferior orbital fissure [22, 70]. Coronado G. C. A. (2008) confirms the likelihood of penetration of the local anesthetic into the orbit through the inferior orbital fissure during the palatine blockade. Based on the anatomical position and average volume of the pterygopalatine fossa, he determines the maximum amount of anesthetic (1.2 ml), which can be deposited in it [71]. The following characteristics of the local anesthetics are important in ensuring the effectiveness and safety of regional blockades: analgesic potential, latent period, effect duration, and toxicity [72]. Currently, ropivacaine is actively used in the pediatric practice due to the most pronounced positive pharmacological properties among all local anesthetics. The duration of its effect depends on the route of administration and dose, and is from 4 to 10 hours. It is low-toxic; the latent period is 10–15 minutes; the maximum single dose is 250 mg; the daily dose is 800 mg, which, according to Prokopiev M. *et al.* (2011), is more

than enough for eye surgeries [62]. Wang *et al.* (2001) noted that ropivacaine is a long-acting local anesthetic with a high cardiovascular safety potential, a significant sensory/motor differential block and a shorter half-life (tS), and with a less accumulation potential than that of bupivacaine. However, high safety of ropivacaine is its most important feature as compared to bupivacaine when taken in equal doses, manifested in lower cardiovascular toxicity than that of bupivacaine in relation to the direct myocardial depression. [73]. Bachinin E. *et al.* (2017) recommend to use ropivacaine 0.75% alone or in the combination with lidocaine as a LA in the surgical treatment of glaucoma. They claim that the effectiveness of anesthesia is due to the rapid sensory block (due to the action of lidocaine) and prolonged postoperative anesthesia (due to the action of ropivacaine) [74]. Regional blockades in eye surgery have been and are still used not only by anesthesiologists but also by ophthalmic surgeons due to its attractive efficacy, relative safety and development of new safer local anesthetics [75-81].

### Conclusion

Despite the active use of regional anesthesia in eye surgery, there are very few papers devoted to its use in children. In particular, there are almost only a few works on the application of the blockade of the infraorbital nerve and palatine anesthesia; and there is no data on the volume of the LA used in ophthalmic surgery to ensure the effective blockade in children. We also could not find any relevant information about the combination of different blockades to achieve the desired result of anesthesia and specific technologies that contribute to the directed spread of the injected local anesthetic in the eye area in children. In the available literature, we did not find data on the choice of the most optimal options for anesthesia in eye surgeries from the standpoint of their effectiveness, safety, comfort for the child and his parents, and economic feasibility. There is no doubt that this can and should be the subject of further research.

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