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Opioid-sparing anesthesia with pre-induction dexmetedomidine in children undergoing strabismus surgery: a prospective comparative cohort study

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Keypoints

In this prospective comparative cohort of 167 children undergoing strabismus surgery, a protocol incorporating intravenous dexmedetomidine 0.3 μg/kg before induction and fentanyl 3 μg/kg was associated with favorable early postoperative outcomes compared with a conventional protocol using fentanyl 5 μg/kg.

Abstract

Introduction

Pediatric strabismus surgery is associated with the oculocardiac reflex (OCR), postoperative nausea and vomiting (PONV), emergence agitation (EA), and postoperative pain. Dexmedetomidine may facilitate an opioid-sparing anesthetic strategy and improve early postoperative recovery. This study evaluated perioperative outcomes associated with a low-dose pre-induction dexmedetomidine-containing regimen in children undergoing strabismus surgery.

Materials and Methods

This prospective comparative cohort study included 167 children aged 2–16 years undergoing elective strabismus surgery at Azerbaijan Medical University between 2022 and 2026. The control group (n=117) received propofol, sevoflurane, and fentanyl 5 μg/kg. The dexmedetomidine group (n=50) received intravenous dexmedetomidine 0.3 μg/kg before induction, together with propofol, sevoflurane, and fentanyl 3 μg/kg. OCR was defined as a ≥20% decrease in heart rate from the pre-manipulation baseline during extraocular muscle traction. PONV, EA, and rescue postoperative analgesia were prospectively recorded.

Results

OCR occurred in 75/117 patients (64.1%) in the control group and 30/50 (60.0%) in the dexmedetomidine group (p=0.727). PONV was documented in 100/117 control patients (85.5%) and in 0/50 dexmedetomidine patients (p<0.001). EA was documented in 100/117 (85.5%) and 0/50 patients, respectively (p<0.001). Rescue postoperative analgesia was required in 100/117 control patients (85.5%) and in 0/50 dexmedetomidine patients (p<0.001). The dexmedetomidine-containing protocol used a 40% lower fentanyl dose (3 vs 5 μg/kg).

Conclusion

A regimen incorporating pre-induction dexmedetomidine 0.3 μg/kg and lower fentanyl exposure was associated with favorable early postoperative recovery in this cohort, whereas OCR incidence was similar between groups. Because dexmedetomidine administration and fentanyl reduction were components of the same non-randomized protocol, the independent contribution of each cannot be determined. Randomized studies using standardized recovery measures are warranted.

Keywords

dexmedetomidine; strabismus surgery; pediatric anesthesia; opioid-sparing anesthesia; oculocardiac reflex; emergence agitation; postoperative nausea and vomiting; fentanyl

Introduction

Strabismus surgery is a common pediatric ophthalmic procedure and presents specific challenges for the anesthesiologist. Traction or manipulation of the extraocular muscles may trigger the oculocardiac reflex (OCR), a trigemino-vagal response manifested predominantly by bradycardia. Its occurrence can be influenced by anesthetic technique, opioid administration, and the characteristics of extraocular muscle manipulation [1–3].

In addition to intraoperative OCR, pediatric strabismus surgery is associated with postoperative nausea and vomiting (PONV), emergence agitation (EA), and postoperative pain [4–8]. These complications may impair early recovery and increase the need for rescue medications.

Sevoflurane is widely used in pediatric anesthesia because of its rapid onset and recovery characteristics. However, rapid emergence after volatile anesthesia may be accompanied by EA. Opioids such as fentanyl provide effective perioperative analgesia but may contribute to nausea, vomiting, sedation, and respiratory adverse effects. Consequently, multimodal opioid-sparing strategies are increasingly relevant in pediatric anesthesia.

Dexmedetomidine is a highly selective α2-adrenergic receptor agonist with sedative, anxiolytic, sympatholytic, and analgesic-sparing properties. Randomized studies in pediatric strabismus surgery have reported reductions in EA, postoperative vomiting, pain, and analgesic requirements after dexmedetomidine administration [4–9]. Song et al. demonstrated reduced EA without an increase in OCR [5], whereas Li et al. evaluated doses of 0.3 and 0.5 μg/kg and found the clearest reductions in OCR and PONV with the 0.5 μg/kg regimen [4]. A systematic review and meta-analysis of nine randomized trials reported reductions in EA, PONV, postoperative pain, analgesic requirements, and OCR with dexmedetomidine [6].

The present study compared a conventional anesthetic regimen using propofol, sevoflurane, and fentanyl 5 μg/kg with a protocol incorporating intravenous dexmedetomidine 0.3 μg/kg before induction and fentanyl 3 μg/kg. The primary objective was to compare rescue postoperative analgesic requirements. Secondary objectives were to compare PONV, EA, and OCR.

Materials and Methods

Study Design and Setting

This prospective comparative cohort study included 167 children undergoing elective surgical correction of strabismus between 2022 and 2026 at the Department of Ophthalmology, Azerbaijan Medical University, Baku, Azerbaijan.

Study Population

Children aged 2–16 years undergoing elective strabismus surgery were included. All patients were classified as American Society of Anesthesiologists (ASA) physical status I. The control group comprised 117 patients and the dexmedetomidine group 50 patients. In the control group, 60 patients (51.3%) were boys and 57 (48.7%) were girls; in the dexmedetomidine group, 30 (60.0%) were boys and 20 (40.0%) were girls. Unilateral surgery was performed in 60/117 control patients (51.3%) and 35/50 dexmedetomidine patients (70.0%); bilateral surgery was performed in 57/117 (48.7%) and 15/50 (30.0%), respectively. Surgical duration was approximately 30–40 min and anesthesia duration approximately 35–45 min.

Anesthetic Protocol

All children underwent general anesthesia with standard perioperative monitoring. The control group received propofol, sevoflurane 1.5–2.0%, and fentanyl 5 μg/kg. The dexmedetomidine group received intravenous dexmedetomidine 0.3 μg/kg as a bolus before induction, followed by propofol, sevoflurane 1.5–2.0%, and fentanyl 3 μg/kg. Thus, the dexmedetomidine-containing protocol

incorporated a 40% lower protocol-defined fentanyl dose. Standard monitoring included continuous electrocardiography, heart rate, non-invasive arterial blood pressure, and peripheral oxygen saturation.

Oculocardiac Reflex Assessment

Heart rate was monitored continuously during extraocular muscle manipulation. Baseline heart rate was recorded before manipulation. OCR was prospectively defined as a decrease in heart rate of ≥20% from the pre-manipulation baseline occurring in temporal association with traction or manipulation of an extraocular muscle. When OCR occurred, extraocular muscle traction was temporarily interrupted and the patient's hemodynamic status was assessed.

Postoperative Assessment

Patients were assessed during early postoperative recovery for PONV, EA, and the requirement for rescue postoperative analgesia. PONV was recorded when nausea and/or vomiting was clinically documented. EA was recorded according to clinically evident agitation during recovery from anesthesia. Rescue postoperative analgesia was recorded when additional analgesic medication was required according to clinical assessment.

Outcomes

The primary outcome was the requirement for rescue postoperative analgesia. Secondary outcomes were the incidence of PONV, EA, and OCR, together with protocol-defined intraoperative fentanyl exposure.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Azerbaijan Medical University (Protocol No. 5, 2023). The study was conducted in accordance with the Declaration of Helsinki and applicable institutional requirements. Written informed consent was obtained from the parents or legal guardians of participating children.

Statistical Analysis

Categorical variables were summarized as numbers and percentages. Between-group comparisons were performed using the chi-square test or Fisher's exact test, as appropriate. Fisher's exact test was used for outcomes containing zero events in one group. A two-sided p-value <0.05 was considered statistically significant. Because unilateral versus bilateral surgery was unevenly distributed between groups, this baseline difference was considered a potential confounding factor when interpreting postoperative outcomes.

Results

Patient and Perioperative Characteristics

A total of 167 children were included: 117 in the control group and 50 in the dexmedetomidine group. Overall, the cohort comprised 90 boys and 77 girls. Sex distribution did not differ significantly between groups (p=0.301). Unilateral surgery was more frequent in the dexmedetomidine group (70.0% vs 51.3%), and the distribution of unilateral versus bilateral surgery differed between groups (p=0.025).

Characteristic	Control (n=117)	Dexmedetomidine (n=50)	p-value
Age, years	2–16	2–16	—
Male, n (%)	60 (51.3)	30 (60.0)	0.301
Female, n (%)	57 (48.7)	20 (40.0)	
ASA I, n (%)	117 (100)	50 (100)	—
Unilateral surgery, n (%)	60 (51.3)	35 (70.0)	0.025
Bilateral surgery, n (%)	57 (48.7)	15 (30.0)	
Surgical duration, min	30–40	30–40	—
Anesthesia duration, min	35–45	35–45	—
Sevoflurane, %	1.5–2.0	1.5–2.0	—
Fentanyl, µg/kg	5	3	Protocol-defined
Dexmedetomidine, µg/kg	—	0.3	Protocol-defined

Table 1. Patient and perioperative characteristics. Values are presented as n (%) or range, as appropriate. ASA, American Society of Anesthesiologists.

Oculocardiac Reflex

OCR occurred in 75 of 117 children (64.1%) in the control group and in 30 of 50 children (60.0%) in the dexmedetomidine group. The difference was not statistically significant (Fisher's exact p=0.727).

Postoperative Nausea and Vomiting

PONV was documented in 100 of 117 children (85.5%) in the control group and in none of the 50 children in the dexmedetomidine group (p<0.001).

Emergence Agitation

EA was documented in 100 of 117 children (85.5%) receiving the conventional regimen and in none of the 50 children receiving dexmedetomidine (p<0.001).

Rescue Postoperative Analgesia

Rescue postoperative analgesia was required in 100 of 117 control patients (85.5%) and in none of the 50 children receiving dexmedetomidine (p<0.001). This was observed despite the lower protocol-defined fentanyl dose of 3 μg/kg in the dexmedetomidine group compared with 5 μg/kg in controls.

Outcome	Control (n=117)	Dexmedetomidine (n=50)	p-value
OCR, n (%)	75 (64.1)	30 (60.0)	0.727
PONV, n (%)	100 (85.5)	0 (0)	<0.001
Emergence agitation, n (%)	100 (85.5)	0 (0)	<0.001
Rescue postoperative analgesia, n (%)	100 (85.5)	0 (0)	<0.001
Fentanyl dose, μg/kg	5	3	Protocol-defined

Table 2. Perioperative outcomes. OCR, oculocardiac reflex; PONV, postoperative nausea and vomiting.

Discussion

The principal finding of this prospective comparative cohort study was that an anesthetic protocol incorporating pre-induction dexmedetomidine 0.3 μg/kg and lower fentanyl exposure was associated with a favorable early postoperative recovery profile in children undergoing strabismus surgery. No rescue postoperative analgesia, PONV, or clinically documented EA was recorded among the 50 children managed with the dexmedetomidine-containing protocol, whereas OCR remained frequent and did not differ significantly between groups.

Opioid-Sparing Strategy and Postoperative Analgesia

The dexmedetomidine group received fentanyl 3 μg/kg compared with 5 μg/kg in controls, representing a 40% lower protocol-defined fentanyl dose.

Despite this difference, no child in the dexmedetomidine group required rescue postoperative analgesia.

Previous randomized studies and meta-analytic evidence support analgesic-sparing effects of dexmedetomidine in pediatric strabismus surgery [6,8,9].

Chiang et al. reported a significant reduction in additional analgesic requirements (RR 0.38, 95% CI 0.25–0.57) [6]. However, the fentanyl dose in our study was predetermined by protocol rather than titrated as an experimental outcome.

Therefore, the data do not establish that dexmedetomidine itself caused a 40% reduction in opioid requirement; rather, they show that the combined dexmedetomidine-containing regimen used lower fentanyl exposure and was associated with no documented rescue analgesia.

Emergence Agitation

No clinically documented EA occurred in the dexmedetomidine group, compared with an incidence of 85.5% in controls. Song et al. reported EA incidences of 60%, 48%, 44%, and 21% with placebo and dexmedetomidine 0.25, 0.5, and 1 μg/kg, respectively [5].

Kim et al. also reported a marked reduction in EA with low-dose dexmedetomidine during strabismus surgery [9]. In the meta-analysis by Chiang et al., dexmedetomidine reduced EA (RR 0.39, 95% CI 0.25–0.62) and severe EA (RR 0.27, 95% CI 0.17–0.43) [6].

The complete absence of clinically documented EA in our dexmedetomidine group is a particularly large effect and should be interpreted cautiously because EA was assessed clinically rather than with a validated Pediatric Anesthesia Emergence Delirium scale.

Postoperative Nausea and Vomiting

PONV was documented in 85.5% of controls and in none of the dexmedetomidine patients. Li et al. reported that dexmedetomidine 0.5 μg/kg reduced 24-h PONV from 32% with placebo to 10% [4]. Chen et al. also reported lower postoperative vomiting with dexmedetomidine than placebo [8]. The meta-analysis by Chiang et al. found a significant reduction in PONV (RR 0.33, 95% CI 0.21–0.54) [6]. The magnitude of the difference in our cohort is greater than that generally reported in randomized trials and should not be interpreted as evidence that dexmedetomidine completely prevents PONV. Dexmedetomidine exposure, lower fentanyl exposure, and other protocol-related factors may all have contributed, and their independent effects cannot be separated in this *study.*

Oculocardiac Reflex

OCR occurred in 64.1% of controls and 60.0% of dexmedetomidine patients (p=0.727). Song et al. reported essentially identical OCR incidences across placebo and dexmedetomidine doses of 0.25, 0.5, and 1 μg/kg (36%, 36%, 36%, and 37%, respectively) [5]. In contrast, Li et al. reported a reduction in OCR from 68% with placebo to 42% with dexmedetomidine 0.5 μg/kg [4], and the meta-analysis by Chiang et al. reported an overall reduction in OCR [6]. Differences in dose, anesthetic technique, opioid exposure, depth of anesthesia, extraocular muscles manipulated, and OCR definitions may contribute to variability between studies. Our findings suggest that the 0.3 μg/kg dexmedetomidine-containing protocol was not associated with a detectable reduction in OCR.

Clinical Implications

The findings support further evaluation of low-dose pre-induction dexmedetomidine as a component of multimodal anesthesia for pediatric strabismus surgery. In this cohort, the main observed differences concerned early postoperative recovery rather than prevention of OCR. These findings are hypothesis-generating rather than proof of a dexmedetomidine-specific causal effect.

Strengths and Limitations

Strengths include the prospective design, inclusion of 167 pediatric patients, predefined anesthetic protocols, and assessment of several clinically relevant strabismus-specific outcomes. Important limitations include the single-center non-randomized design, unequal group sizes, and the significant imbalance in unilateral versus bilateral procedures. Dexmedetomidine administration and fentanyl reduction occurred simultaneously, preventing separation of their independent effects. EA was assessed clinically rather than with a validated PAED scale, and postoperative analgesia was assessed according to rescue medication rather than a standardized age-appropriate pain scale. The postoperative observation interval was not analyzed as a time-to-event endpoint. Finally, the zero-event findings for PONV, EA, and rescue analgesia in the dexmedetomidine group are stronger than most published randomized evidence and require cautious interpretation and external confirmation.

Conclusion

In this prospective comparative cohort of 167 children undergoing strabismus surgery, a protocol incorporating intravenous dexmedetomidine 0.3 μg/kg before induction and fentanyl 3 μg/kg was associated with favorable early postoperative outcomes compared with a conventional protocol using fentanyl 5 μg/kg. No PONV, clinically documented EA, or rescue postoperative analgesic use was recorded in the dexmedetomidine group, whereas OCR incidence was similar between groups. Because the study was non-randomized and dexmedetomidine administration coincided with lower fentanyl exposure, causal attribution to dexmedetomidine alone is not possible. Randomized controlled studies using standardized pain, agitation, and PONV assessments are warranted.

Declarations

Ethics approval and consent to participate: The study was approved by the Ethics Committee of Azerbaijan Medical University (Protocol No. 5, 2023). Written informed consent was obtained from the parents or legal guardians of participating children.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: G.I. contributed to patient evaluation, ophthalmologic management, data acquisition, and review of the manuscript.

References

1. Hahnenkamp K, Hönemann CW, Fischer LG, Durieux ME, Muehlendyck H, Braun U. Effect of different anaesthetic regimes on the oculocardiac reflex during paediatric strabismus surgery. Paediatr Anaesth. 2000;10(6):601–608. doi:10.1111/j.1460-9592.2000.00588.x.
2. Oh AY, Yun MJ, Kim HJ, Kim HS. Comparison of desflurane with sevoflurane for the incidence of oculocardiac reflex in children undergoing strabismus surgery. Br J Anaesth. 2007;99(2):262–265. doi:10.1093/bja/aem145.
3. Chung CJ, Lee JM, Choi SR, Lee SC, Lee JH. Effect of remifentanil on oculocardiac reflex in paediatric strabismus surgery. Acta Anaesthesiol Scand. 2008;52(9):1273–1277. doi:10.1111/j.1399-6576.2008.01745.x.
4. Li S, Liu T, Xia J, Jia J, Li W. Effect of dexmedetomidine on prevention of postoperative nausea and vomiting in pediatric strabismus surgery: a randomized controlled study. BMC Ophthalmol. 2020;20(1):86. doi:10.1186/s12886-020-01359-3.
5. Song IA, Seo KS, Oh AY, Baik JS, Kim JH, Hwang JW, Jeon YT. Dexmedetomidine injection during strabismus surgery reduces emergence agitation without increasing the oculocardiac reflex in children: a randomized controlled trial. PLoS One. 2016;11(9):e0162785. doi:10.1371/journal.pone.0162785.
6. Chiang FW, Chang JL, Hsu SC, Hsu KY, Chu KCW, Huang CJ, et al. Dexmedetomidine use in pediatric strabismus surgery: a systematic review and meta-analysis. PLoS One. 2020;15(10):e0240553. doi:10.1371/journal.pone.0240553.
7. Tramèr MR, Sansonetti A, Fuchs-Buder T, Rifat K. Oculocardiac reflex and postoperative vomiting in paediatric strabismus surgery: a randomised controlled trial comparing four anaesthetic techniques. Acta Anaesthesiol Scand. 1998;42(1):117–123. doi:10.1111/j.1399-6576.1998.tb05091.x.
8. Chen JY, Jia JE, Liu TJ, Qin MJ, Li WX. Comparison of the effects of dexmedetomidine, ketamine, and placebo on emergence agitation after strabismus surgery in children. Can J Anaesth. 2013;60(4):385–392. doi:10.1007/s12630-013-9886-x.
9. Kim J, Kim SY, Lee JH, Kang YR, Koo BN. Low-dose dexmedetomidine reduces emergence agitation after desflurane anaesthesia in children undergoing strabismus surgery. Yonsei Med J. 2014;55(2):508–516. doi:10.3349/ymj.2014.55.2.508.
10. Mizrak A, Erbagci I, Arici T, Avci N, Ganidagli S, Oner U. Dexmedetomidine use during strabismus surgery in agitated children. Med Princ Pract. 2011;20(5):427–432. doi:10.1159/000324554.

2. Tobias JD. Clinical experience with remimazolam in pediatric anesthesiology: An educational focused review. Paediatr Anaesth. 2024;34(11):1095-1106.
3. Rex DK, Bhandari R, Desta T, et al. A phase III study evaluating the efficacy and safety of remimazolam (CNS 7056) compared with placebo and midazolam in patients undergoing colonoscopy. Gastrointest Endosc. 2018;88(3):427-437.e6
4. Pastis NJ, Yarmus LB, Schippers F, et al. Safety and efficacy of remimazolam compared with placebo and midazolam for moderate sedation during bronchoscopy. Chest. 2019;155(1):137-146.
5. Doi M, Morita K, Takeda J, Sakamoto A, Yamakage M, Suzuki T. Efficacy and safety of remimazolam versus propofol for general anesthesia: A multicenter, single-blind, randomized, parallel-group, phase IIb/III trial. J Anesth. 2020;34(4):543-553.
6. Kimoto Y, Hirano T, Kuratani N, Cavanaugh D, Mason KP. Remimazolam as an adjunct to general anesthesia in children: Adverse events and outcomes in a large cohort of 418 cases. J Clin Med. 2023;12(12):3930.
7. Hirano T, Kimoto Y, Kuratani N, Cavanaugh D, Mason KP. Remimazolam for pediatric procedural sedation: Results of an institutional pilot program. J Clin Med. 2023;12(18):5937.
8. Gao YQ, Ihmsen H, Hu ZY, et al. Pharmacokinetics of remimazolam after intravenous infusion in anaesthetised children. Br J Anaesth. 2023;131(5):914-920.