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The association between surgical technique and oculocardiac reflex in pediatric strabismus surgery: an observational study

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Abstract

Background and objectives: The most common cause of oculocardiac reflex (OCR) is traction of the extraocular muscles. Therefore, strabismus surgery is highly risk for the development of this complication. This study aimed to investigate whether an association exists between the occurrence of OCR and the type of extraocular muscle manipulated during strabismus in a pediatric population.

Methods: A total of 53 pediatric patients who were operated for strabismus under sevoflurane anesthesia were enrolled in this prospective study. The association between surgical techniques and the occurrence of OCR was investigated.

Results: This study included 30 (56.6%) males and 23 (43.4%) females, with a mean age of 8.4 years. Overall, 83 eyes with 93 extraocular muscles were operated. Surgery was performed most frequently on the medial (44.6%) and lateral (36.1%) recti. OCR occurred in 33 (62.3%) patients. OCR was found to be significantly higher in the first operated muscle compared with the second muscle, regardless of muscle type, as identified in the statistical analysis based on the sequence of the operated muscles.

Conclusions: The manipulation of the first extraocular muscle has a higher risk of OCR in the pediatric population undergoing two-muscle surgery for strabismus.

KEYWORDS

Anesthesia; Oculocardiac reflex; Pediatrics; Sevoflurane; Strabismus

Introduction

Strabismus surgery is among the most common ophthalmic procedures in the pediatric population and involves surgical manipulation in one or more extraocular muscles that provide eyeball movement.[1] In addition, strabismus surgery has a low complication rate. However, a decrease in heart rate (HR), defined as oculocardiac reflex (OCR), is often encountered during this surgery.[2] The most common cause of OCR is the traction of the extraocular muscles, although it may occur as a result of any ocular intervention (e.g., direct pressure on the eyeball, retrobulbar injection, or orbital apex surgery).[3,4] Therefore, compared with other ocular operations, strabismus surgery is highly associated with this complication.

The incidence of OCR in strabismus surgery has been reported to reach 90%.[5,6] The risk of developing OCR is higher in children than in adults. Pediatric patients are also more susceptible to the harmful consequences of this reflex, due to higher dependence on HR to maintain cardiac output. None of the various methods proposed to reduce the incidence of OCR, such as premedication with anticholinergics, was found to be effective in preventing this reflex.[3,5] Thus, determining the potential association between OCR and surgical techniques, together with sufficient knowledge of pathophysiology and clinical aspects of OCR, is important for the preventive or therapeutic approaches.

This study aimed to investigate the possible relationship between the occurrence of OCR and the type of extraocular muscle manipulated during strabismus surgery in pediatric patients.

Methods

General data

This prospective observational study was conducted in a tertiary hospital. Following the approval of the Local Ethics Committee (number 03; 22 October 2019), pediatric patients aged 2 - 18 years who underwent elective strabismus surgery at the Osmangazi University Hospital were enrolled in this prospective study. The parents were preoperatively informed about the study, and informed consent was obtained. The

patients' age and gender, American Society of Anesthesiologist (ASA) physical status, Mallampati score, coexisting diseases, procedural data, anesthetic medications, and perioperative complications were recorded. Exclusion criteria were age less than 2 years old, ASA physical status of 3 – 4, the presence of any significant hepatic, renal, cardiac, or respiratory disease, the presence of developmental or mental delay, and allergy to the drugs involved in the study.

Anesthesia management

The fasting time was at least 8 hours before surgery. No premedication was given to the patients. Anesthesia was administered via a face mask with inhalation of sevoflurane (8%, 5%, and 3%) in 4 L min⁻¹ oxygen (50%) and nitrous oxide (50%) after standard monitoring, including 5-lead electrocardiogram, pulse oximetry, noninvasive blood pressure, and inspiratory–expiratory gas concentrations. Venous access was established after adequate loss of consciousness, and airway control was provided by laryngeal mask airway (LMA) along with intravenous administrations of remifentanyl (0.5-1 µg kg⁻¹), lidocaine (0.5 mg kg⁻¹), and propofol (3-4 mg kg⁻¹). The patients received sevoflurane (with age-corrected 1-1.5 minimum alveolar concentration) in 4 L min⁻¹ nitrous oxide (50%) and oxygen (50%) to maintain anesthesia. Weight-appropriate continuous intravenous fluids (0.9% NaCl) were given to the patients during the procedure. HR, mean arterial pressure, oxygen saturation, and end-tidal carbon dioxide were monitored continuously during the surgery. The HRs before and after the traction of extraocular muscle were also recorded. OCR was defined as either a 20% decrease in HR following extraocular muscle traction or the presence of dysrhythmia. The surgeon was warned by the anesthesiologist to stop the traction if the OCR lasted for more than 5 seconds and to wait until the HR returned to its normal cardiac rhythm. Atropine (0.01 mg kg⁻¹) was intravenously administered when a persistent OCR or rapid drop in HR < 60 min⁻¹ was observed. The surgeon continued the operation after the values were within normal limits.

Surgery

All operations were performed by the same surgical team using standard techniques. The conjunctival tissue was separated with a smooth incision, and the extraocular muscle was reached following tenon dissection. The type of strabismus, sliding angle, and history of eye surgery were taken into consideration before selecting the type of

surgery. One or more of the five main extraocular muscles (medial rectus, lateral rectus, inferior oblique, inferior rectus, and superior rectus) were operated depending on the type of strabismus. All patients in the study underwent weakening (regression) surgery for extraocular muscles.

Statistical evaluation

A power analysis based on previous articles[2,3,5] showed that a sample size of 48 patients was required to achieve a 80% power with a 5% significance level to evaluate the differences between the groups with or without OCR. The standard version of the Statistical Package for the Social Sciences (SPSS 23.0 software) was used for statistical analysis. Descriptive data were presented as number (percentage) and mean \pm SD (minimum-maximum) for categorical and continuous variables, respectively. The differences between the groups were evaluated using Chi-square, Mann-Whitney *U*, and Fisher's exact tests. A *p*-value < 0.05 was accepted as the level of significance.

Results

Fifty-three [30 (56.6%) males and 23 (43.4%) females] pediatric patients with a mean age of 8.4 (3-18) years were included in this study. The patients were preoperatively classified into ASA 1 (45, 84.9%) and ASA 2 (8, 15.1%). All patients underwent strabismus surgery, including 16 (30.2%) right, 7 (13.2%) left, and 30 (56.6%) bilateral eyes.

OCR occurred in 33 (62.3%) patients during the surgery. The basic characteristics and surgical data of the patients with and without OCR were compared (Table 1). Age, gender, weight, ASA physical status, duration of anesthesia and surgery, and mean HR were similar between the patients with and without OCR ($p > 0.05$).

Overall, 83 eyes with 93 extraocular muscles were operated, including 91 (97.8%) weakening (recession) and 2 (2.2%) strengthening (resection) procedures. No reoperation procedures were included in this study; all eyes were operated for the first time. Surgery was most frequently performed on the medial (44.6%) and lateral (36.1%) recti. No significant difference was observed in the type of muscle operated between the two groups ($p = 0.706$). The mean number of operated muscles was also statistically similar between the groups ($p = 0.883$).

Overall, 18 (34%) and 31 (58.5%) patients underwent one and two-muscle surgery, respectively. No significant difference in the occurrence of OCR was found

between these groups ($p = 0.768$). OCR was detected in 17 of the 31 patients with two-muscle surgery, of which 15 occurred following the traction of the first extraocular muscle. In the analysis based on the sequence of the operated muscles, regardless of the type, the incidence of OCR was found to be significantly higher in the first than in the second operated extraocular muscle ($p < 0.01$, Fig. 1).

Discussion

The present study showed that the incidence of OCR in patients undergoing two-muscle surgery was higher in the manipulation of the first than in the second extraocular muscle, regardless of muscle type. We also demonstrated that the first operated extraocular muscle was strongly associated with the risk of OCR, similar to the studies by Ha et al. and Lai et al.[3,4] However, the occurrence of OCR in the first manipulated muscle did not significantly increase the risk of OCR in subsequently treated muscles. This may be explained by an unknown counter-regulatory mechanism that requires the adaptation of a subsequent stimulus, increased attention of the anesthesia team, and more careful surgical manipulations.

OCR is an entity caused by the stimulation of the trigeminal nerve afferently and the activation of the vagus nerve efferently, thus resulting in bradycardia by reducing the sinoatrial node impulses.[4] This phenomenon is a variant of the trigeminocardiac reflex characterized by hemodynamic disturbances, respiratory changes and gastric hypermotility. Trigemino-cardiac reflex can be triggered by direct stimulation of the trigeminal nerve along its course, from the central nuclear complex to the terminal branches. This reflex is classified into two main subtypes, central and peripheral (nasopharyngeal, maxillomandibulocardiac, and OCR), according to the sensory territory stimulated.[7,8] Although the most common presentation of OCR is sinus bradycardia, various detrimental presentations, such as coronary artery spasm, asystole, or cardiac arrest, have been reported to date.[9,10] In this study, all clinical manifestations were in the form of sinus bradycardia except one case of ventricular extrasystole, and most of these were mild and corrected by terminating the manipulation.

The incidence of OCR in strabismus surgery has been reported to range from 14% to 90%, depending on the different ratios of HR drop used in the studies.[5,6,11] OCR is usually defined as at least a 20% decrease in heart rate or a new arrhythmia following eyeball compression or traction of extraocular muscles.[12] This study also

used this definition of OCR and 62.3% incidence was observed, which is consistent with the literature.[5,6]

Several risk factors including female gender, underlying cardiovascular disease, and type of anesthesia are associated with OCR.[4,13] No significant difference in gender was observed in the cohort of the present study, consistent with the previous studies.[2,3] The most frequently associated risk factor for the occurrence of OCR is the various triggering stimuli, and the traction of the extraocular muscles during surgery is the most common.[3] Therefore, strabismus surgery is associated with a higher risk of OCR.

Few studies examining the relationship between strabismus surgery and OCR exist in the literature.[1-4,14,15] However, some methodological differences are evident between the present study and most of those works. First, some studies have been conducted on patients who had undergone not only strabismus surgery but also any ophthalmic surgery. Second, most of those studies did not have a specific age distribution (e.g. pediatrics, adults, or geriatrics). However, in routine practice, OCR is most commonly observed in the pediatric population undergoing strabismus surgery. Therefore, the current study differs from other studies as it was conducted in this special group.

Conflicting results regarding the association between surgical techniques in strabismus surgery and the occurrence of OCR are noted in previous studies. Aletaha et al. found that weakening operations, without any statistically significance, had a higher risk of eliciting the OCR compared with strengthening procedures.[2] Conversely, Ha et al. showed that OCR was more prevalent in resection surgery.[3] No statistical evaluation between the type of surgeries could be conducted in the present study because all patients, except two with resection of extraocular muscle, underwent weakening operations. It should be stated here that the primary factor for the OCR is the traction to the extraocular muscles rather than the type of surgery. The relationship between the operated muscle and the development of OCR was also investigated in the previous studies. Some studies showed that the traction of the medial rectus muscle was associated with a higher risk of OCR compared to the other extraocular muscles, whereas others reported opposite results.[3,4,13,14,16] The majority of the operated extraocular muscles were medial and lateral recti in this study, which is similar to other published works. However, no association exists between the development of OCR and the specific type of extraocular muscle manipulated. Thus, the discrepancies in the

results between the studies may be related to the heterogeneity of the studied populations and the different anesthetic medications.

Several limitations of the present study should be noted. First, the study was conducted in a single center, which may limit the generalization of the results. Second, the relatively small number of patient groups may make it difficult to interpret subgroup findings. However, its prospective nature, the absence of any premedication that may affect the occurrence of OCR, and the standard anesthetic and surgical protocols are the strengths of this study.

In conclusion, the manipulation of the first extraocular muscle may have a higher risk of OCR in the pediatric population undergoing two-muscle strabismus surgery. OCR remains an important concern for anesthesiologists and surgeons in this group of patients because of the high incidence and potential catastrophic clinical consequences (e.g. severe arrhythmias or cardiac arrest). Therefore, interaction between the surgeon and the anesthesiologist is of great importance for the safe management of patients during surgery, particularly during the manipulation of the first muscle.

Conflict of interest

The authors declare no conflict of interest

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Figure 1 The occurrence of oculocardiac reflex according to the sequence of operated muscle in patients undergoing two-muscle surgery (n = 31). Chi-square test was used to evaluate the difference in oculocardiac reflex between the groups ($p < 0.01$).

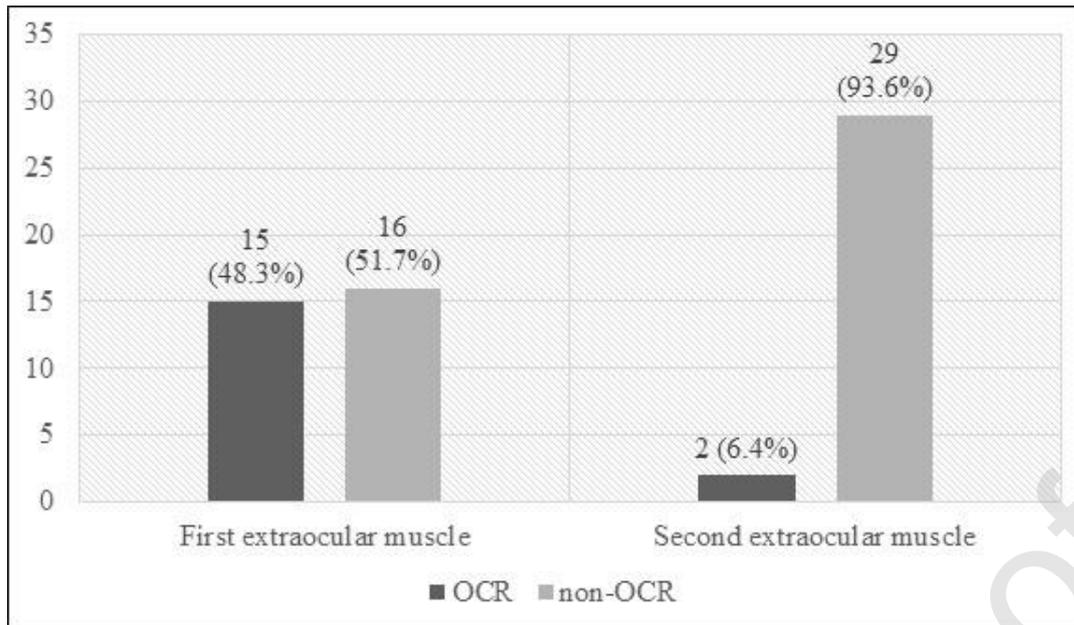


Table 1 Comparison of baseline and surgical characteristics between the two groups.

Characteristics	OCR group (n = 33)	Non-OCR group (n = 20)	<i>p</i>
Age (y)	9.03 ± 4.7 (3-18)	7.6 ± 4.2 (3-17)	0.289
Weight (kg)	31.5 ± 17.2 (11-67)	27.6 ± 15.3 (13-73)	0.508
Gender (Female/Male)	16 (48.4%)/17 (51.6%)	7 (35%)/13 (65%)	0.400
ASA (ASA 1/ASA 2)	30 (90.9%)/3 (9.1%)	15 (75%)/5 (25%)	0.137
Laterality			0.779
Unilateral	15 (45.4%)	8 (40%)	
Bilateral	18 (54.6%)	12 (60%)	
Operated muscle			0.706
Medial rectus	22	18	
Lateral rectus	21	15	
Inferior oblique	11	3	
Inferior rectus	1	1	
Superior rectus	1	0	
Duration of procedure (min)	48.1 ± 12.4 (30-69)	49.6 ± 17.1 (20-85)	0.725
Duration of anesthesia (min)	55.2 ± 14.7 (35-85)	55.4 ± 16.5 (25-90)	0.807
Baseline HR (beat/min)	99.1 ± 18.5 (66-132)	104.4 ± 16.7 (63-128)	0.247
Number of operated muscle	1.8 ± 0.8 (1-4)	1.7 ± 0.4(1-4)	0.883

y, year; kg, kilogram; min, minute.

Data are presented as mean ± SD for age, weight, duration of the procedure, duration of anesthesia, and baseline HR; n (%) for other variables.

Chi-square test, Mann-Whitney *U* test, and Fisher's exact test were used to evaluate the differences between the groups.