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ORIGINAL ARTICLE

Association of heart rate and oculocardiac reflex (OCR) during strabismus surgery in children.

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ABSTRACT… Objective: To determine the relationship between the baseline heart rate and the occurrence of the oculocardiac reflex in pediatric strabismus surgery using horizontal extraocular muscles. **Study Design:** Observational study. **Setting:** Mughal Eye Hospital, Lahore, Pakistan. **Period:** January-July 2024. **Methods:** Fifty children aged 3-12 years old who had elective surgery on strabismus (either esotropia or exotropia) were included. The baseline heart rate was used to classify patients as low (70-90bpm) and high (91-120bpm). All the surgeries were done under a standardised general anesthesia with intraoperative follow-up. The OCR was characterized as a 20 percent or more decrease in heart rate at baseline with extraocular muscle traction. Data were also analyzed with SPSS version 26, and associations were determined with the Chi-square test, and p was taken as significant ($p < 0.05$). **Results:** The mean age of participants was 7.6 ± 2.4 years, and the overall incidence of OCR was 58%. OCR occurred in 78.6% of patients with a low baseline heart rate and 31.8% of those with a high baseline heart rate, showing a statistically significant association ($p = 0.001$). OCR was more frequent during medial rectus surgery (35.7%) than lateral rectus (22.7%), though this difference was not statistically significant ($p = 0.320$). All OCR episodes were transient and managed successfully with cessation of traction and deepening of anesthesia. **Conclusion:** Children with lower baseline heart rates are significantly more prone to developing the oculocardiac reflex during strabismus surgery. Preoperative assessment of heart rate can thus serve as a simple yet valuable predictor for identifying high-risk patients and enhancing intraoperative preparedness.

Key words: Anesthesia, Baseline Heart Rate, Oculocardiac Reflex, Pediatric Ophthalmology, Strabismus Surgery.

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INTRODUCTION

A common ophthalmic procedure in children, strabismus surgery is often done to correct ocular misalignment and avoid long-term visual impairment and psychological effects.[1] However, after manipulating the extraocular muscles, the oculocardiac reflex (OCR), a trigeminovagal response marked by bradycardia or arrhythmia, is significantly linked to this surgery. Half Afferent signals from the trigeminal nerve's ophthalmic branch and efferent vagal stimulation mediate the OCR, which lowers heart rate and can cause anywhere from mild bradycardia to potentially fatal asystole.[2,3]

According to the definition and monitoring criteria employed, the incidence of OCR during pediatric strabismus surgery varies greatly, ranging from 14% to 90%.[3-5] A number of variables, such as patient age, anesthetic technique, depth of anesthesia, extraocular muscle manipulation type and sequence, and use of premedication or anticholinergic agents, affect the incidence and severity of OCR.[6-8] Younger children are especially vulnerable, and OCR is frequently linked to the first muscle operated on.[4,5] The incidence and magnitude of OCR have been demonstrated to be modulated by the depth of anesthesia and the selection of anesthetic agents, such as propofol, desflurane, or sevoflurane. Preventive measures have been studied with varying degrees of success, including the application of benzodiazepines, muscle relaxants, sub-Tenon block, intraoperative monitoring protocols, etc.[8-10]

Due to the unpredictability and the likelihood of severe cardiac complications, OCR remains one of the intraoperative priorities despite the ongoing improvements in perioperative care; further studies are needed to identify the correlation between the dynamics of heart rates and OCR presence in

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children who undergo strabismus operations.[2,11,12]

The discussion of the association between changes in heart rate and OCR will be essential to the development of effective management and prevention strategies, given the high prevalence and clinical significance of OCR during pediatric strabismus surgery. This paper seeks to explain this relationship in order to ensure that children have safer surgical experiences.

METHODS

This retrospective observational study was conducted to see whether there would be any relationship between baseline heart rate and the occurrence of the oculocardiac reflex (OCR) during strabismus surgery in pediatric patients. The study was carried out at Mughal Eye Hospital, Lahore, Pakistan after getting approval from ethical committee (Ref No. 0508/Admin/MEHT/RS), over an interval of seven months, continuing from January 2024 through July 2024. Fifty children, aged between three and twelve years at the time of the study, underwent elective strabismus surgeries, that is, esotropia or exotropia surgeries for horizontal extraocular muscles (medial or lateral rectus) during the operative period. To maintain homogeneous and healthy population features, prior to this study, children who had systemic illnesses, known cardiac abnormalities, previous ocular surgeries, and/or contraindications to general anesthesia were removed from the population sample.

Ethical approval for this study was obtained from the Institutional Review Board of Mughal Eye Hospital, and all procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the parents or guardians of all participants after explaining the study purpose, procedures, and potential risks.

All procedures were carried out by skilled ophthalmic surgeons under established general anesthesia guidelines. The goal of anesthetic management was to keep the depth of anesthesia constant throughout all cases. Continuous electrocardiography (ECG), pulse oximetry, and non-invasive blood pressure monitoring were all part of the intraoperative monitoring. During traction on the medial or lateral rectus, the first horizontal muscle operated on, the oculocardiac reflex was evaluated. A 20% or greater drop in heart rate from the baseline value obtained just prior to muscle traction was considered the OCR. When OCR happened, the surgeon immediately relaxed the muscle traction and, in accordance with accepted clinical practice, deepened the anesthesia.

ECG or pulse oximetry was used to measure the baseline heart rate prior to surgery while the patient was relaxed and at rest. Patients were split into two groups according to baseline measurements: those with a low baseline heart rate (70–90 beats per minute, or bpm) and those with a high baseline heart rate (91–120 bpm). A structured proforma was used to gather data on the patient's age, sex, type of strabismus (esotropia or exotropia), muscle operated (lateral or medial rectus), baseline heart rate, and presence or absence of OCR.

All data analyses were performed using SPSS version 26. Continuous variables were shown in mean ± standard deviation (SD), whereas categorical variables were expressed in frequency and percentage. The association between baseline heart rate groups and the occurrence of OCR was analyzed using the Chi-square test, and any p-value found to be less than 0.05 was considered statistically significant.

RESULTS

Fifty pediatric patients undergoing horizontal strabismus surgery were studied to identify the correlation between baseline heart rate and OCR incidence. The participants' mean age was 7.6 ± 2.4 years, with slightly more males (56%) than females (44%). Esotropia was most common (54%), and the medial rectus was operated more often (56%) than the lateral rectus (44%). The mean baseline heart rate was 92.4 ± 12.1 bpm.

The overall rate of OCR during surgery was 58% (29 of 50 patients). When stratified by baseline heart rate categories, OCR was present in 78.6% (22 of 28) of children with a low baseline heart rate (70–90 bpm) and 31.8% (7 of 22) with a high baseline heart rate (91–120 bpm). This difference was statistically

significant (p = 0.001), indicating that children with lower resting heart rates were significantly more likely to experience OCR during extraocular muscle traction.

TABLE-I

Demographic and Clinical Characteristics of the Study Population (n = 50)

Variable	Mean ± SD / n (%)
Age (years)	7.6 ± 2.4
Sex (Male/Female)	28 (56%) / 22 (44%)
Type of Strabismus	
• Esotropia	27 (54%)
• Exotropia	23 (46%)
Muscle Operated	
• Medial Rectus	28 (56%)
• Lateral Rectus	22 (44%)
Baseline Heart Rate (bpm)	92.4 ± 12.1

TABLE-II

Association between baseline heart rate and occurrence of oculocardiac reflex (OCR)

Baseline Heart Rate Group	n	OCR Present (%)	OCR Absent (%)	P-Value
Low HR (70–90 bpm)	28	22(78.6)	6(21.4)	0.001
High HR (91–120 bpm)	22	7(31.8)	15(68.2)	
Total	50	29(58)	21(42)	

TABLE-III

Relationship between the type of muscle operated and OCR occurrence

Muscle Operated	Total (n)	OCR Present n (%)	OCR Absent n (%)	P-Value
Medial Rectus	28	10 (35.7%)	18 (64.3%)	0.320
Lateral Rectus	22	5 (22.7%)	17 (77.3%)	
Total	50	15 (30%)	35 (70%)	

Regarding the type of muscle operated, OCR was observed in 35.7% of medial rectus and 22.7% of lateral rectus cases; however, this difference was not statistically significant (p = 0.320). All OCR episodes were transient and resolved promptly with cessation of traction and deepening of anesthesia.

Overall, these findings indicate that a lower baseline heart rate is significantly associated with an increased risk of OCR during pediatric strabismus surgery, while the specific horizontal muscle manipulated does not independently affect OCR occurrence.

DISCUSSION

The current research examined the relationship between preoperative heart rate and OCR incidence during strabismus surgery in children. We found that OCR was experienced in 58% of patients, with a much greater rate among children with lower baseline heart rate (78.6%) compared to those with higher baseline heart rate (31.8%). Although OCR occurred more often during medial rectus traction (35.7%) than lateral (22.7%), this difference was not statistically significant. All episodes were transient and well controlled by cessation of traction and deepening of anesthesia.

These observations are in tandem with variable incidence of OCR that has been mentioned in past literature, ranging between 14-90 percent based on methodology, type of anesthesia, and the criterion of monitoring.

Our findings are consistent with those of Ha et al., who reported a comparable 30% incidence of the oculocardiac reflex (OCR) during pediatric strabismus surgery. At the traction of the muscle, the adrenergic phase, and the cutting of the muscle, the difference in the drop in HR in patients with OCR was substantially less than that in patients without OCR (all, $p<0.01$). In this investigation, we measured the maximal recovered HR after traction of the extraocular muscle (EOM), and it, interestingly enough, did not completely recover until cutting of the EOM, while in surgery for patients with OCR. The mean percentage of decreased HR compared to baseline HR was 10% at the cutting of the EOM in patients with OCR. We hypothesized that once OCR was initially entered, it would be comparably difficult for HR to return to baseline HR at all points during surgery. Therefore, it might be crucial for the surgeon to monitor the occurrence of OCR at the

first traction of the EOM.[3]

Again, a different study has also examined the neurophysiological processes involved in OCR and the importance of increased vagal discharge after trigeminal stimulation. Such mechanisms define the reason why the children with a more sympathetic tone during the baseline can have a more prominent reflexive vagal response, which leads to the increased risk of OCR.2.

We also find similar results to those of other researchers who reported that among the baseline physiological parameters, heart rate and age are good predictors of the occurrence of OCR.[9] In addition, Karaman et al.[7] and Yi and Jee[6] found that the depth of anesthesia and anesthetic agent choice moderate OCR incidence. In particular, light anesthesia is likely to enhance vagal sensitivity and, therefore, children are more prone to more and worse episodes of OCR.

It was also found in the current study that medial rectus traction induced OCR more frequently than lateral rectus traction, but this difference was not found to be significant. Investigations also report the same tendency, and they found a greater rate of OCR when surgery is performed on the medial rectus, perhaps because of the more easily injured sensory fibers and the one being nearer to the ophthalmic branch of the trigeminal nerve.[4,6]

The importance of anesthetic depth and the selection of drugs used in OCR modulation has been studied widely. As Oh et al. 8 and Choi et al. 10 discovered, sevoflurane was more effective in suppressing the reflex than desflurane and isoflurane. Such results are in concert with our protocol of ensuring standardized sevoflurane anesthesia, which could have helped in the moderate incidence rate of OCR (30%) in the cohort. Similarly, it was shown that OCR reduction was achieved through bispectral index (BIS)-guided anesthesia through ensuring optimal anesthetic depth and avoiding vagal fluctuations.[13]

Anticholinergic agents have also been used prophylactically. Zhao et al.[11] compared Glycopyrrolate with atropine and observed that both of them were similar in OCR prevention, but glycopyrrolate had fewer side effects. OCR episodes in our study were temporary and could be controlled by stopping traction and further deepening anesthesia without the need for pharmacologic support, which is in line with the recommendations of prior literature.[10,14]

In the comparison of our results with Klikic and Gulec[15], we discussed a similar age group of pediatrics. They were anesthetized with sevoflurane, yet they had a significantly greater rate of observed OCR (62.3%) than we (30%). This might be because of their future surveillance methodology and the small size of the cohort that enabled them to detect less severe cases. Although their research established that OCR happened more often during manipulation of the first extraocular muscle irrespective of the type, our findings revealed a moderate relationship between increased initial heart rate and the occurrence of OCR.

We also found that OCR was more frequent during medial rectus traction (35.7%) than lateral rectus (22.7%), but this was not statistically significant. This is in line with the findings of Kim et al., who found a considerably higher incidence of OCR under medial rectus traction ($p = 0.009$) among 73 pediatric patients.[16] The overall OCR incidence was considerably higher in their report (74%), which can be explained by the differences in anesthetic technique, definition thresholds (any decrease in heart rate), and characteristics of the patient population.

The existing findings underline the value of the predictive nature of the preoperative baseline heart rate as a non-invasive, simple form of risk stratification. Children with a resting heart rate of more than 90 beats per minute are to be considered at risk of OCR and thus are to be monitored and be ready for intervention. This useful predictor supports recent reviews that highlight customized perioperative care as a means of improving safety in pediatric ophthalmic surgery.

Our findings establish baseline heart rate as a straightforward, non-invasive, and clinically significant predictor of OCR risk, contributing new information to the body of existing literature. In

pediatric strabismus surgery, this parameter may help direct customized anesthetic management when combined with proven preventive measures. Despite the fact that our study offers insightful information, generalizability may be limited by its retrospective design and small sample size. More thorough knowledge of OCR pathophysiology and improved preventive measures may be possible with future multicentric prospective studies that include autonomic function testing and heart rate variability analysis.

CONCLUSION

This study found a strong relationship between lower baseline heart rate and the incidence of the oculocardiac reflex during pediatric strabismus surgery. Children with a baseline heart rate of ≤90 bpm were significantly more likely to develop OCR compared to those with higher heart rates. Although the type of muscle operated was not significantly associated, medial rectus traction showed a slightly higher frequency. All OCR cases were brief and managed effectively with prompt intervention. These findings emphasize the importance of preoperative heart rate measurement as a simple, non-invasive risk factor that can help improve intraoperative safety and preparedness in pediatric ocular surgery.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Zunaira Mubarik:** Collecting sample size.
2	**Seema Qayyum:** Supervision.
3	**Fiza Azhar:** Literature writing.
4	**Amna Mehmud:** Data entry.
5	**Hira Awais:** Data analysis.