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Systematic Review

Trigeminal cardiac reflex in oral and maxillofacial surgery: a systematic review

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ABSTRACT

The trigeminocardiac reflex (TCR) is a brainstem reflex triggered by stimulation of the trigeminal nerve, resulting in sudden cardiovascular disturbances such as bradycardia, hypotension, arrhythmias, and, in severe cases, asystole or cardiac arrest. This systematic review evaluated the clinical characteristics, triggering factors, management strategies, and outcomes of TCR in oral and maxillofacial surgery. A systematic search was conducted according to PRISMA guidelines using PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar for studies published between 2009 and 2022. Eligible studies included case reports, case series, observational studies, and reviews involving TCR during oral and maxillofacial procedures. Ten studies met the inclusion criteria. TCR was most associated with orbital, maxillary, and zygomatic manipulation, including Le Fort I osteotomy and zygomatic fracture reduction. Clinical manifestations ranged from transient bradycardia and hypotension to severe arrhythmias and intraoperative asystole. In most cases, immediate cessation of surgical stimulation, anesthetic adjustment, and administration of atropine successfully reversed the reflex. Although severe complications were uncommon, isolated cases of cardiac arrest were reported. Early recognition, careful surgical manipulation, continuous intraoperative monitoring, and prompt management are essential to minimize morbidity and improve patient safety during maxillofacial surgery.

Keywords: Trigeminal cardiac reflex, Oculocardiac reflex, Oral and maxillofacial, Blowout fracture

INTRODUCTION

The relationship between the trigeminal nerve, principal cranial nerve responsible for facial sensory innervation, and cardiac reflex, essential autonomic mechanism involved in regulating heart rate and rhythm, has attracted considerable scientific attention.[1] Tarabanis et al described trigeminocardiac reflex (TCR) as phenomenon triggered during certain surgical procedures in which stimulation of the trigeminal nerve produces marked cardiovascular responses, including bradycardia and even asystole.[2] Similarly, Arora and Lee emphasized that close interaction between these neurological pathways highlights importance of understanding underlying mechanisms and precipitating factors of TCR, particularly during craniofacial procedures where manipulation near trigeminal nerve is common.[3]

The TCR is characterized by transient episodes of bradycardia, hypotension, or, in severe circumstances, cardiac arrest secondary to stimulation of the trigeminal nerve.[4] Although the exact pathophysiology remains unclear, several mechanisms have been proposed, including the release of neurotransmitters such as acetylcholine and the involvement of central neuronal integration pathways.[5]

According to Bohluli et al TCR may be precipitated by a variety of stimuli, particularly surgical manipulation involving the trigeminal nerve and maxillofacial procedures.[1] Maharaj et al further reported that

interventions such as Le Fort osteotomies, craniofacial reconstructive surgeries, and extraocular muscle manipulation may provoke the reflex.[6] In addition, study by Guedes et al demonstrated that factors including surgical complexity, patient-specific characteristics, and intraoperative vigilance significantly influence the likelihood of TCR occurrence.[5]

Although awareness of TCR in several surgical specialties has increased only recently, craniofacial procedures involving osteotomies and soft tissue manipulation within areas supplied by the ophthalmic, maxillary, and mandibular divisions of the trigeminal nerve have been recognized as potential triggers of the reflex. Moreover, advancements in skull base surgery have enabled surgical access to regions such as the cavernous sinus, cerebellopontine angle, and pituitary fossa, where TCR may occur during procedures including microvascular decompression of the trigeminal nerve and balloon-compression rhizotomy of the trigeminal ganglion.[7] While transient hemodynamic changes such as reductions in heart rate and blood pressure have been documented in these settings, they are generally reversible and rarely associated with major postoperative complications.

Furthermore, procedures such as Le Fort I osteotomy, which require surgical manipulation in close proximity to the trigeminal nerve, carry a notable risk for triggering TCR during craniofacial surgery.[6] The clinical implications of TCR in these operations underscore the necessity for meticulous intraoperative monitoring and careful surgical technique to minimize reflex activation. Bohluli et al suggested that preventive strategies, including controlled anesthetic management and atraumatic surgical handling, are essential in reducing TCR-related complications.[8] Likewise, Mhamunkar et al highlighted the importance of these preventive measures in enhancing patient safety and promoting favorable postoperative recovery following maxillofacial procedures.[9]

The objective of this systematic review was to evaluate the clinical characteristics, triggering factors, management strategies, and outcomes associated with TCR in oral and maxillofacial surgery, with emphasis on its clinical presentation, intraoperative management, and implications for patient safety.

METHODS

Study design

This systematic review was conducted to evaluate the occurrence, clinical manifestations, diagnosis, management strategies, and outcomes of TCR associated with orbital floor fractures. The review methodology was designed in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines to ensure a transparent and reproducible study selection process.

Focused research question

The review aimed to answer the following research question: What are the clinical characteristics, triggering factors, management approaches, and outcomes of TCR in oral and maxillofacial surgery?

Inclusion criteria

Studies were included if they met the following criteria: Reported cases of TCR associated with orbital floor fractures or orbital trauma, included human subjects of any age or sex, published as case reports, case series, retrospective studies, prospective studies, or observational studies, reported clinical manifestations consistent with TCR, including bradycardia, hypotension, arrhythmias, syncope, apnea, or cardiac arrest precipitated by trigeminal nerve stimulation and articles published in English were included in the study.

Exclusion criteria

Studies were excluded if they: Discussed TCR unrelated to orbital floor fractures, were review articles, conference abstracts without sufficient clinical data, editorials, letters without case details, or animal studies, included insufficient clinical information regarding diagnosis or management and were duplicate publications excluded from the study.

Information sources and search strategy

A comprehensive electronic literature search was performed using the following databases: PubMed/MEDLINE, Scopus, Web of Science and Google Scholar.

The search included all studies published between January 2009 and December 2022. Reference lists of included articles were also manually screened to identify additional relevant studies not captured during the database search.

The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords related to TCR and orbital floor fractures. The following search terms were used individually and in combination using Boolean operators (“AND” and “OR”): “Trigeminocardiac reflex”, “Oculocardiac reflex”, “Orbital floor fracture”, “Blowout fracture”, “Orbital trauma”, “Extraocular muscle entrapment”, “Bradycardia”, “Maxillofacial trauma”, “Orbital surgery”.

An example of the PubMed search strategy was as follows: (“trigeminocardiac reflex” OR “oculocardiac reflex”) AND (“orbital floor fracture” OR “blowout fracture” OR “orbital trauma”).

Study selection

All retrieved articles were imported into reference management software, and duplicate records were removed. Two independent reviewers screened titles and abstracts for eligibility. Full-text articles of potentially relevant studies were then assessed independently according to the predefined inclusion and exclusion criteria. Any disagreement between reviewers was resolved through discussion and consensus.

The study selection process was documented using a PRISMA flow diagram, detailing the number of identified, screened, excluded, and included studies.

Data extraction

Data extraction was performed independently by two reviewers using a standardized data collection form. The following variables were extracted from each study: Authors, study design, sample, surgical technique, aim of study, main findings, relevance.

Any discrepancies in data extraction were resolved by consensus between the reviewers.

Quality assessment

Given that most available evidence consisted primarily of case reports and case series, methodological quality assessment was conducted using the Joanna Briggs Institute (JBI) critical appraisal checklist for case reports and case series. Each study was evaluated for clarity of patient demographics, clinical history, diagnostic methods, intervention details, outcomes, and reporting quality.

Data synthesis

Due to the anticipated heterogeneity of study designs, patient characteristics, and reported outcomes, a qualitative narrative synthesis was performed rather than a meta-analysis. Findings were summarized descriptively with emphasis on clinical presentation, precipitating factors, management strategies, and patient outcomes associated with TCR in orbital floor fractures.

Ethical considerations

As this study was based exclusively on previously published literature and did not involve direct patient participation or identifiable patient data, ethical approval and informed consent were not required.

RESULTS

Study selection

The literature search identified 712 records from electronic databases and additional sources, including PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, and manual searching. After the removal of 198 duplicate records, 514 studies underwent title and abstract screening. Of these, 464 studies were excluded because they were irrelevant to the topic, unrelated to orbital floor fractures, or consisted of reviews and commentaries.

A total of 50 full-text articles were assessed for eligibility. After excluding studies with insufficient clinical data, unclear diagnosis of TCR, duplicate publications, or lack of relevance to orbital floor fractures, 10 studies met the inclusion criteria and were included in the qualitative synthesis. Due to heterogeneity in study design and outcome measures, meta-analysis was not performed.

Characteristics of included studies

The final analysis included 10 studies published between 2009 and 2022, comprising case reports, observational studies, literature reviews, and systematic reviews. The majority of evidence consisted of case reports and narrative reviews, with fewer prospective or higher-level evidence studies.

The included studies primarily evaluated the occurrence, pathophysiology, clinical manifestations, and management of TCR during maxillofacial and craniofacial procedures, including Le Fort I osteotomy, zygomatic fracture reduction, dental surgery, and other facial trauma interventions. Reported manifestations of TCR included bradycardia, hypotension, arrhythmias, and transient asystole, often triggered by manipulation of trigeminal nerve branches.

Several studies demonstrated that cessation of surgical stimulation resulted in immediate reversal of cardiovascular symptoms, emphasizing the importance of early recognition and prompt management. Severe outcomes such as intraoperative cardiac arrest and asystole were reported in isolated cases.

Risk of bias assessment

Most included studies demonstrated an overall moderate risk of bias, mainly because the evidence consisted predominantly of case reports and literature reviews, which have inherent methodological limitations. The lowest concern was observed in bias related to deviations from intended interventions, whereas missing data and selective reporting represented the most common sources of moderate bias. Therefore, findings regarding the TCR should be interpreted cautiously due to the limited availability of high-quality evidence.

Main findings

Across the included studies, the TCR was consistently associated with surgical stimulation of trigeminal nerve branches, resulting in acute cardiovascular responses. The

severity ranged from mild transient bradycardia to profound hypotension and asystole. Procedures involving orbital, zygomatic, and maxillary manipulation appeared particularly associated with TCR occurrence.

The available evidence suggests that prompt identification, cessation of surgical stimulation, anesthetic adjustment, and pharmacologic intervention when required are effective in reversing TCR manifestations and preventing serious complications.

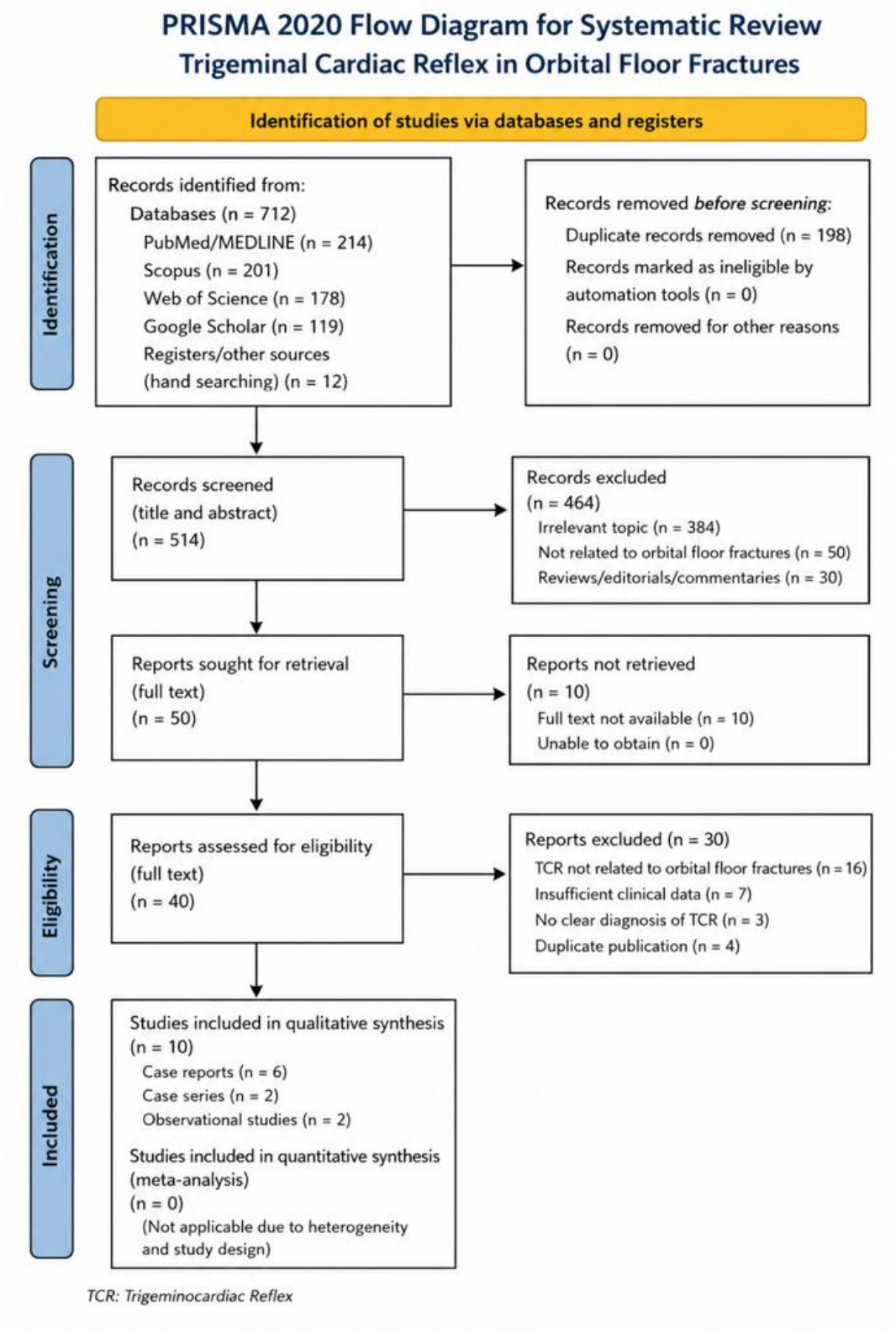


Figure 1: Study flowchart.

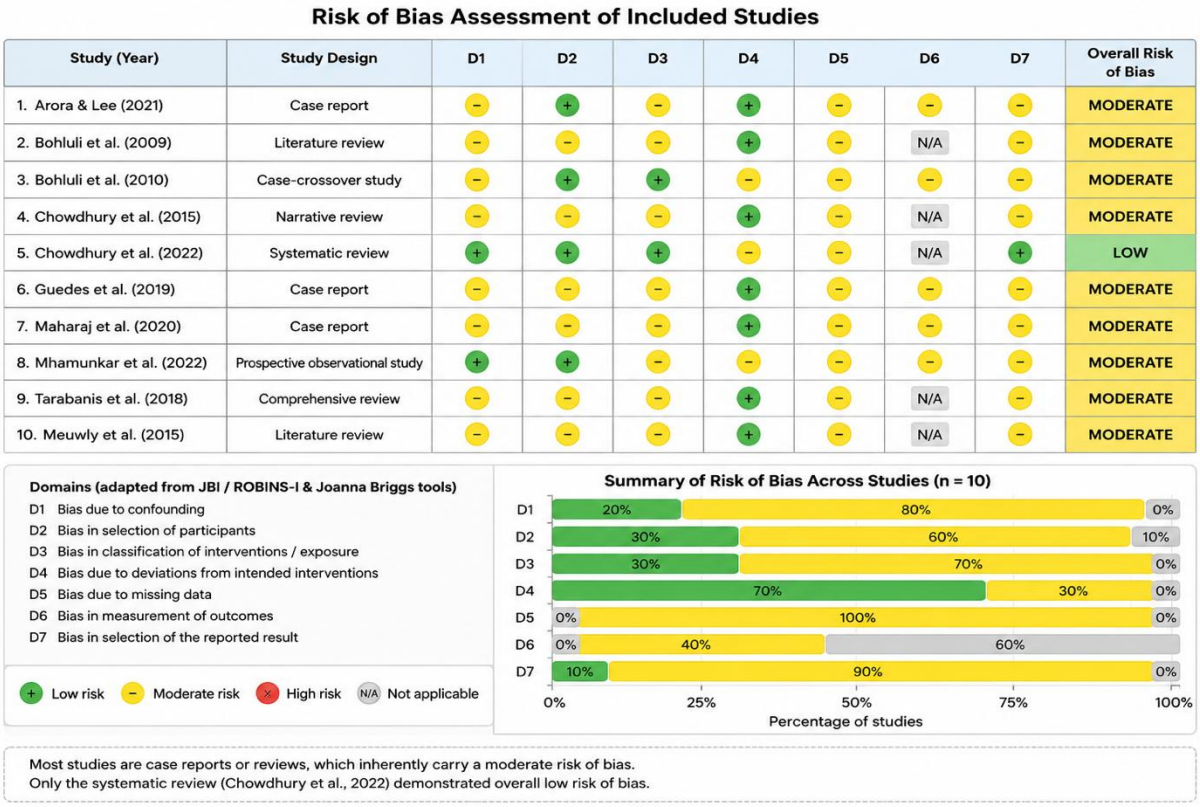


Figure 2: Risk of bias table.

Table 1: Characteristics and key findings of included studies on TCR.

Authors (year)	Study design	Population/ sample	Surgical technique/ setting	Aim of study	Main findings	Relevance
Bohluli et al (2009)[1]	Literature review	Published studies	Maxillofacial surgery	To review characteristics of TCR in oral and maxillofacial surgery	Described incidence, pathophysiology, risk factors, and management of TCR	Provides foundational understanding of TCR
Tarabanis et al (2018)[2]	Comprehensive literature review	Head and neck surgery reports	Head and neck surgery	To identify causes of intraoperative cardiac arrest	Recognized TCR as a significant contributor to sudden intraoperative cardiovascular collapse	Supports association between TCR and severe outcomes
Arora and Lee (2021)[3]	Case report	Single patient	Dental surgery	To report OCR/TCR during dental procedures	Reflex activation caused marked bradycardia that resolved after stimulus cessation	Demonstrates occurrence of reflex during oral procedures
Chowdhury et al (2015)[4]	Narrative review	Previous clinical studies	Neurosurgery / craniofacial surgery	To review physiology and clinical implications of TCR	Identified bradycardia, hypotension, arrhythmias, and asystole as common manifestations	Explains neurophysiology and clinical presentation of TCR
Guedes et al (2019)[5]	Case report	Single patient	Maxillofacial surgery	To report delayed postoperative TCR	Delayed TCR occurred postoperatively rather than intraoperatively	Indicates potential postoperative occurrence of TCR
Maharaj et al (2020)[6]	Case report	Single patient	Le Fort I osteotomy	To describe intraoperative asystole due to TCR	Severe trigeminovagal reflex caused transient cardiac arrest during surgery	Demonstrates potentially life-threatening complications

Continued.

Authors (year)	Study design	Population/ sample	Surgical technique/ setting	Aim of study	Main findings	Relevance
Meuwly et al (2015)[7]	Literature review	Published studies	General TCR	To reassess TCR definition and conceptual model	Proposed updated diagnostic definition emphasizing hemodynamic changes following trigeminal stimulation	Important for standardized diagnostic criteria
Bohluli et al (2010)[8]	Case-crossover study	Patients undergoing Le Fort I osteotomy	Orthognathic surgery	To investigate TCR during Le Fort I osteotomy	Significant reduction in heart rate observed during maxillary manipulation	Demonstrates TCR in orthognathic procedures
Mhamunkar et al (2022)[9]	Prospective observational study	Patients with zygomatic fractures	Facial trauma surgery	To evaluate TCR during zygomatic fracture reduction	Bradycardia and cardiovascular instability occurred during fracture manipulation	Relevant to trauma and orbital region surgery
Chowdhury et al (2022)[10]	Systematic review	Neurointerventional literature	Neurovascular procedures	To update evidence regarding brain-heart interactions in TCR	Reinforced importance of prevention, early recognition, and management strategies	Provides updated evidence on TCR mechanisms and prevention

*TCR=trigeminocardiac reflex; OCR=oculocardiac reflex.

DISCUSSION

The trigeminal nerve, a major cranial nerve responsible for facial sensation, together with the cardiac reflex, an essential autonomic mechanism regulating heart rate and rhythm, has attracted considerable attention in medical research.[1] The interaction between these systems can produce the TCR, a phenomenon characterized by marked cardiovascular responses-including bradycardia and asystole-following stimulation of the trigeminal nerve.[2] Understanding the mechanisms and triggers underlying TCR is particularly important in craniofacial surgery, where surgical manipulation frequently occurs in close proximity to branches of the trigeminal nerve.[3]

TCR is defined as a temporary episode of bradycardia, hypotension, or, in severe cases, cardiac arrest induced by trigeminal nerve stimulation.[4] Although the precise pathophysiology remains unclear, current evidence suggests involvement of neurotransmitter release, particularly acetylcholine, along with central neuronal integration pathways.[5,10] Multiple triggers for TCR have been reported, including cranial nerve manipulation-especially involving the trigeminal nerve-and a variety of maxillofacial procedures.[1,8] Surgical interventions such as Le Fort osteotomies, craniofacial reconstructions, and ocular muscle manipulation have all been linked to TCR occurrence.[6]

While awareness of TCR in other surgical specialties has increased only recently, craniofacial procedures involving the mandibular, maxillary, and ophthalmic branches of the trigeminal nerve have been consistently associated with reflex activation.[7] Advancements in skull base surgery have further expanded access to anatomical regions such as the cerebellopontine angle, cavernous sinus, and pituitary fossa, where TCR may be provoked during procedures including microvascular decompression of the trigeminal nerve and balloon-compression rhizotomy of the trigeminal ganglion.[7] Although these episodes often produce transient reductions in heart rate and blood pressure, they are generally reversible and rarely lead to significant postoperative complications.

Because craniofacial surgery carries a notable risk for inducing TCR, preventive measures are essential to reduce associated complications.[8,9] Careful anesthetic management and meticulous surgical technique remain key strategies for minimizing reflex occurrence and maintaining patient safety. Such measures include appropriate monitoring of anesthesia depth, stabilization of blood pressure and heart rate, and reducing unnecessary trigeminal nerve stimulation during procedures.[9] In some cases, anticholinergic agents such as atropine may be administered to counteract the parasympathetic effects associated with TCR.[8]

Effective prevention and management of TCR in craniofacial surgery require thorough understanding of the reflex and its clinical implications. Surgeons should remain alert to potential triggers and implement strategies to limit their effects. Furthermore, a multidisciplinary approach involving anesthesiologists, neurosurgeons, and craniofacial surgeons is crucial to ensure coordinated prevention and management of TCR during surgical interventions.[9] Arnold et al reported that profound bradycardia may occur in nearly 10% of strabismus surgeries when prophylactic anticholinergic agents are not administered; however, accurately predicting the occurrence of the oculocardiac reflex (OCR) remains challenging. Early awareness of this reflex, combined with vigilant anesthetic monitoring before extraocular muscle (EOM) manipulation, has made persistent adverse

outcomes associated with OCR exceptionally uncommon. Nevertheless, despite more than a century of clinical observation and research, the underlying physiological purpose of this occasionally dramatic cardiac response during ocular surgery remains poorly understood.[11] Schumacher et al reported that bradycardia frequently occurs during ophthalmologic examinations in extremely premature infants and tends to be more pronounced, develop more rapidly, and persist longer compared to the OCR observed during strabismus surgery.[12] According to Yoo et al patients experiencing maxillofacial trauma involving the orbital region are susceptible to developing the OCR, with younger individuals appearing to be more commonly affected. The orbital floor is frequently identified as the primary site of injury, while nausea and vomiting are among the most commonly reported clinical symptoms. Furthermore, the authors emphasized that OCR should not be considered a static phenomenon, as its presentation and severity may evolve throughout the patient's clinical course, as demonstrated in their reported case.[13] Patients undergoing ophthalmologic procedures remain at considerable risk of developing intraoperative arrhythmias associated with the OCR. Although this phenomenon has been widely documented in the literature, clear guidelines regarding the most effective surgical and anesthetic management strategies are still insufficient.[14] Dandekar et al compared vital signs and pain perception during phacoemulsification performed under peribulbar block versus topical anesthesia to evaluate the incidence of the OCR. The study concluded that OCR may occur with both anesthetic techniques during phacoemulsification, with no statistically significant difference observed between the two methods.[15] Blowout fractures involving the orbital floor may create a "trapdoor" effect, resulting in entrapment of the extraocular muscles. Inferior extraocular muscle entrapment typically presents with restricted upward gaze, and may also be accompanied by diplopia and exophthalmos. In uncommon cases, orbital fractures can trigger the OCR, characterized by the triad of bradycardia, syncope, and nausea. This study aimed to describe a patient with an orbital floor fracture who developed symptoms strongly suggestive of OCR following traumatic injury. While extraocular muscle entrapment necessitates prompt intervention to prevent ischemia and tissue necrosis, the occurrence of OCR requires urgent ophthalmologic assessment and management because of the potential risk of cardiac arrhythmias. Moreover, clinical signs may be absent or subtle, with impaired ocular motility sometimes representing the only detectable finding. This can be particularly challenging to evaluate in young or uncooperative children, highlighting the importance of maintaining a high degree of clinical suspicion to facilitate early diagnosis, timely treatment, and reduction of complications.[16] Fahling et al reported the presentation and management of the OCR in a 26-year-old male patient who developed retrobulbar hematoma and intraocular injury following a self-inflicted gunshot wound. The authors emphasized the importance of emergency physicians being familiar with OCR due to the frequent occurrence of craniofacial trauma and the potentially serious consequences that may arise if the condition is not promptly recognized and appropriately managed.[17]

CONCLUSION

The TCR is a clinically significant intraoperative complication that may occur during oral and maxillofacial surgical procedures involving manipulation of the trigeminal nerve and its branches. This systematic review demonstrated that TCR commonly presents as bradycardia, hypotension, arrhythmias, and, in severe cases, transient asystole or cardiac arrest. Procedures involving orbital, maxillary, mandibular, and zygomatic manipulation appear to carry a higher risk of reflex activation.

The reviewed studies consistently showed that early recognition and immediate cessation of surgical stimulation are critical for reversing the cardiovascular manifestations of TCR. Appropriate anesthetic management, continuous intraoperative monitoring, and pharmacologic intervention when necessary are also essential in preventing serious complications and ensuring patient safety. Preventive strategies such as meticulous surgical technique and close collaboration between surgeons and anesthesiologists play a major role in minimizing reflex occurrence.

Although awareness of TCR in oral and maxillofacial surgery has increased, the currently available evidence remains limited mainly to case reports and small observational studies. Therefore, further multicenter prospective studies are needed to better understand the pathophysiology, incidence, risk factors, and optimal management protocols associated with TCR in craniofacial and maxillofacial surgery.

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