Classification of potential risk factors for trigeminocardiac reflex in craniomaxillofacial surgery

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Classification of Potential Risk Factors for Trigeminocardiac Reflex in Craniomaxillofacial Surgery

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Purpose: Trigeminocardiac reflex (TCR) in craniomaxillofacial surgery can lead to severely life-threatening situations. At least mild forms are probably much more common than the existing surgical literature suggests. Therefore, the aim of this presentation of cases and literature review was to evaluate the predisposing factors leading to a classification of risk factors for potential TCR and to give information concerning preventive measures and management procedures.

Patients and Methods: All surgery reports from the Department of Cranio-Maxillofacial and Oral Surgery in the University Hospital in Zurich between 2003 and 2008 were searched for severe intraoperative cardiovascular complications, and a literature review was performed for publications concerning asystole or bradycardia during maxillofacial surgical procedures.

Results: Three incidents were revealed in which severe bradycardia – in 2 cases followed by asystoly – had occurred. All incidents were successful managed.

Conclusion: All craniomaxillofacial surgeons involved in orbital surgery in general and in the treatment of midface fractures, eyelid surgery, and orthognathic procedures in particular should be aware of the possibility of the TCR and should be familiar with its prevention and therapy.
The surgeon is much more aware of most complications in maxillofacial surgery (eg, bleeding, infections, and injury of nearby structures) than the trigeminocardiac reflex (TCR), of which mild forms regularly appear in this field of surgery. In 1870, Kratschmer described the influence of reflexes on manipulation of the nasal mucosa. In 1908, the TCR was first described as an oculocardiac reflex. However, descriptions of the occurrence of the reflex during temporomandibular joint surgery and mandibular osteotomies emphasize that the maxillary and mandibular divisions can be involved as well as the ophthalmic branch of the trigeminal nerve. Besides this oculocardiac reflex, the oculo-respiratory reflex, which results in a reduction of respiratory rate and volume, has also been mentioned. Today, this phenomenon is well known and not just with regard to manipulation of the nasal mucosa.

The TCR is characterized by cardiac arrhythmia, ectopic beats, atrioventricular lock, bradycardia, syncope, vomiting, and asystole. This life-threatening condition has been documented during simple zygomatic arch elevations, repositioning of blow-out and maxillary fractures, orthognathic surgery, and nasoethmoidal fractures (Table 1). Although this complication occurs only rarely, every head and neck surgeon should be aware of this severe phenomenon.

Most authors agree that this reflex is rare, but Matarasso et al state that the oculocardiac reflex occurs in 25% of patients undergoing blepharoplasty. Precious and Skulsky reported the reflex in 1.6% of patients undergoing maxillofacial surgeries. The highest incidence (between 32% and 90%) has been described in strabismus surgery. For craniofacial surgery (Le Fort I osteotomy, midface fracture reduction, elevation of zygomatic fractures, and temporomandibular joint insufflation) an incidence of 1% to 2%, and for skull base surgery an incidence of 8% to 18%, have been reported.
Concerning these incidence rates, one must be aware that bradycardia during maxillofacial surgical procedures might happen much more frequently than is published. On the other hand, clinical features like nausea, vomiting, or bradycardia, particularly in children, can also be interpreted as commotio cerebri rather than being attributable to TCR. Therefore, no specific numbers concerning incidence can be given.

The aim of the present study was to evaluate severe events of the TCR during surgical procedures performed between 2003 and 2008 and to review the literature in order to provide information concerning incidence, predisposing factors, and, last but not least, development of a risk classification.

**Patients and Methods**

All surgery reports from the Department of Craniomaxillofacial and Oral Surgery in the University Hospital in Zurich between 2003 and 2008 were searched for severe intraoperative cardiovascular complications. Three other cases are presented, which showed either intra- or perioperative bradycardia and/or asystolia due to no other identifiable pathology than the described trigeminocardiac or oculocardiac reflex.

Electronic databases (Medline and Cochrane) were searched using a set of predetermined keywords. The search strategy was initially developed and implemented for PubMed but was revised appropriately to suit the other databases. A combination of free text terms with Boolean operators and truncation was used. No restriction was placed on the year or language of publication. The search strategy was devised in consultation with a senior librarian.

The citations retrieved from each database were exported into the EndNote bibliometric management software. Duplicates were discarded. The titles and
abstracts were screened, and the hard copies of all potentially relevant articles were retrieved. Their reference lists were manually searched for any related articles.

Case 1
A 66-year-old male patient, who, after tripping and falling down a short flight of stairs, suffered a displaced tripod fracture along with minimally dislocated further fractures of the facial skeleton and subdural hematoma, was referred to the emergency room. His medical history included type II diabetes and myocardial infarction and consecutive coronary artery stenting 10 years prior to presentation. He showed no signs or symptoms relating to cardiac dysfunction. Due to the subdural hematoma, operative treatment of the facial fractures was postponed for 10 days. The lateral facial fractures were then visualized by an intraoral approach under general anesthetic. On repositioning of the zygoma, the patient first became bradycardic and then asystolic for 23 seconds. The total event lasted for 2 minutes and 11 seconds. Cardiac massage was performed by the surgeon successfully in combination with ongoing ventilation and administration of 0.5mg Atropin IV and 1mg epinephrine IV through the anesthetist. Because the fracture was not stable, minimal plate fixation was performed. The patient was kept under close supervision 24 hours postoperatively, and regular checkups were performed during his time as an outpatient. He suffered no permanent damage of cardiac tissue as demonstrated by pre-, intra-, and postoperative electrocardiograms. No further cardiac pathology could be found.

Case 2
A 50-year-old male patient was referred to the Department of Craniomaxillofacial and Oral Surgery in the University Hospital in Zurich because of a massive fronto-basal,
mandible, and midface trauma from a car accident, including a contusion of the bulb and a foreign body in the right orbit next to other general injuries. His medical history included hypertonia and hypercholesterolemia, as well as myocardial infarction 3 years prior to presentation. He showed no signs or symptoms relating to cardiac dysfunction. After primary care the patient was transferred to our hospital for further treatment. On the patient’s arrival the mandible was provisionally treated and preparations were made for computer-assisted surgery 4 days later. Revision of the fronto-basal area was performed as well as reconstruction of both orbits and the right zygoma under navigation control (Fig 1).

During surgical manipulation of the severely fractured zygoma, a severe bradycardia occurred, followed by an asystoly. Immediately 0.5mg atropine IV was administered, and the surgical manipulation was stopped. After the episode totalling 120 seconds, the surgery was completed uneventfully.

About 72 hours after surgery, another event of bradycardia occurred, with the heart rate dropping to 36 bpm while the patient was still in the intensive care unit. After administration of 0.5mg atropine IV, the heart rate quickly normalized to 64 bpm. No further pathology was found to explain these incidents.

Case 3
A 74-year-old female patient was scheduled for extended tumor resection, including orbital extenteration and reconstruction of the soft tissue defect by radial forearm flap, due to T4 squamous cell carcinoma of the orbit. Her medical history did not include any known risks for TCR. Surgery was uneventful until the final manipulations at the optic nerve before the extenteration was done. Despite a prophylactic dose of 0.5 mg atropine IV before the actual extenteration, a bradycardia occurred down to 33 bpm. Without any further
measures except for pausing the surgical manipulations, the heart rate normalized to 70 bpm rhythm within 28 seconds. Further surgery and postoperative course were uneventful. No further pathology was found to explain this incident.

Discussion

Bradycardia or asystole is a known complication of zygomatic, blowout, and maxillary fractures. On presentation the patient suffers bradycardia or even asystole. Because most cases can be hypothesized to present during the actual accident, some cases of bradycardia during manipulation in orthognatic surgery or repositioning of lateral midface fractures have been reported. Besides the aforementioned risk during surgical procedures, delayed TCR within 48 hours after trauma has also been described.

The reflex responsible for this pathology is known under several synonyms, as follows: oculocardiac reflex (Achener-phenomenon), trigeminocardiac, or trigeminovagal reflex. The oculocardiac reflex is caused by traction of the extraocular muscles or compression of the eyeball, leading to a decrease in pulse rate by the efferent portion of the vagus nerve from the cardiovascular center of the medulla to the heart. This reflex is described not only in surgery of the zygomaticum, but also in mandible procedures. A significantly higher incidence has been reported in children, but it can be provoked in any patient even without pre-existing cardiac disease.

The neuronal signals of the afferent path of the TCR arch are transmitted by the sensory ends of the trigeminal nerve via gasserian ganglion. The afferent path runs along internuncial fibers in the reticular formation and merges with the efferent path in the nucleus of the vagus nerve, resulting in a chronotropic-inotropic response by a vagal stimulation of the cardiac branch of the vagus nerve in the myocardium (Fig. 2). Kayikcioglu et al mentioned that a minimum period of 15 to 20 seconds
of stimulation is necessary to elicit the reflex leading to at least 20% or more reduction in heart rate, or presence of arrhythmias.\textsuperscript{17}

Cha et al have described the critical period during the first few seconds after stimulation when bradycardia and cardiac depression are maximized.\textsuperscript{18} In addition to cardiac disease, hypoxemia and hypercapnia have both been identified as predisposing factors leading to an increased risk for TCR.

Concerning prevention, several points are important. Besides evaluation of at-risk patients (eg, children and patients with a medical history of cardiac disease) and high-risk surgeries (eg, strabismus), some authors suggested using ketamine for anesthetic induction to decrease the oculocardiac reflex in children undergoing strabismus surgery.\textsuperscript{19,20}

Table 2 presents a classification of several risk factors. The first case presented above would be a high-risk patient because of the previously described cardiac disease; the second patient would have a median risk due to the type of surgery and also would be high risk because of the previously described cardiac disease. The third case would be a high risk because of the type of surgery.

Allison et al. compared sevoflurane with halothane anesthesia for strabismus surgery in children and concluded that fewer dysrhythmias were observed in children receiving sevoflurane than in those receiving halothane because the baseline heart rate and respiratory rate are higher with sevoflurane, resulting in a less pronounced bradycardia on stimulation.\textsuperscript{3} In addition Yilmaz et al mentioned potent narcotic agents, such as sufentanil and alfentanil, and drugs, such as β-blockers or calcium channel blockers.\textsuperscript{14}

Another trigger point that has been described is rinsing with cold water (0 to 20°C) at the distribution of the ophthalmic division of the trigeminal nerve.\textsuperscript{21} Anticholinergic agents, such as atropine and glycopyrrolate, are the drugs of first
choice in cases of refractory bradycardia or asystole. However, besides the mentioned therapies, recognition of bradycardia is the first step in treatment.\textsuperscript{22}

Predisposing factors besides cardiac disease are hypoxia and hypercarbia, and use of opioids and \( \beta \)-blockers. Any of these factors should lead to an upgrade of the risk assessment according to Table 2. In the first case presented here, the patient had experienced myocardial infarction and consecutive coronary artery stenting 10 years before presentation; therefore, he was a high-risk patient.

On the other hand, TCR has been identified with a sudden onset of parasympathetic hypotension, apnea, or gastric hypermotility during stimulation of any of the sensory branches of the trigeminal nerve.\textsuperscript{23} Concerning therapy, in some cases stopping the surgery has resulted in recovery of a normal rhythm; in other cases, anticholinergic drugs and cardiac massage have been mentioned.

In every case of low and medium risk in the classification presented here, we recommend informing the anesthesiology team that they should be prepared for mobilization in case of adverse effects. Although TCR is rare in such cases, it presents a typical complication with a significant risk to the patient. We propose that information on TCR should be given as a part of any preoperative procedure.

In every high-risk case presented in the classification, we recommend a prophylactic administration of, eg, 0.5mg atropine IV, right before any surgical manipulation known to be risky for TCR. Preoperative information should be included as part of the informed consent in these cases.

**Acknowledgement**

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<table>
<thead>
<tr>
<th>Surgical procedure</th>
<th>Clinical feature</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>elevation of zygomatic arch fractures</td>
<td>bradycardia</td>
<td>Shearer Es et al, 1987</td>
</tr>
<tr>
<td></td>
<td>asystole</td>
<td>Bainton R et al, 1987</td>
</tr>
<tr>
<td></td>
<td>bradycardia</td>
<td>Loewinger J et al, 1987</td>
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<tr>
<td></td>
<td>bradycardia</td>
<td>Gillespie IA, 1988</td>
</tr>
<tr>
<td>Insufflation of TMJ during arthroscopy</td>
<td></td>
<td>Gomez TM et al, 1991</td>
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<tr>
<td>During orthognathic procedure of the mandible</td>
<td>asystole</td>
<td>Lang S et al, 1991</td>
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<td></td>
<td></td>
<td>Campbell R et al, 1994</td>
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<tr>
<td>Endoscopic transshenoidal surgery</td>
<td>asystole</td>
<td>Schaller B et al, 2008</td>
</tr>
<tr>
<td>Reposition of nasoethmoidal fractures</td>
<td></td>
<td>Baxandall ML et al, 1988</td>
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<td>blepharoplasty</td>
<td>asystole</td>
<td>Rippmann V et al, 2008</td>
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<tr>
<td>Intraorbital foreign body</td>
<td>bradycardia</td>
<td>Yilmaz T et al, 2006</td>
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<td>Periorbital laceration manipulation</td>
<td>asystole</td>
<td>Osborn TM et al, 2008</td>
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<td>Mesiodens removal</td>
<td>bradycardia</td>
<td>Webb MD et al, 2007</td>
</tr>
<tr>
<td>Midface disimpaction</td>
<td></td>
<td>Robideaux V, 1978</td>
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<tr>
<td>Use of mouth prop</td>
<td>asystole</td>
<td>Precious DS et al, 1990</td>
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Table 2: Classification of surgical risk factors

<table>
<thead>
<tr>
<th>Risk</th>
<th>Surgery</th>
<th>Prevention</th>
</tr>
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<tr>
<td>Low</td>
<td>insufflation of TMJ</td>
<td>°Informing the anesthetist directly before the time of the highest risk</td>
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<tr>
<td></td>
<td>LeFort-I-osteotomy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>elevation of zygomatic fractures</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>skull base surgery</td>
<td>°Informing the anesthetist directly before the time of the highest risk</td>
</tr>
<tr>
<td>High</td>
<td>ophthalmic surgery</td>
<td>°Informing the anesthetist directly before the time of the highest risk</td>
</tr>
<tr>
<td></td>
<td>strabismus surgery</td>
<td>°atropine and/or glycopyrrolate</td>
</tr>
<tr>
<td></td>
<td>exenteratio orbitae</td>
<td>°ketamine for anesthetic induction</td>
</tr>
<tr>
<td></td>
<td>orbital fractures in children</td>
<td></td>
</tr>
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<td></td>
<td>patients with cardiac disease</td>
<td></td>
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</tbody>
</table>
Fig. 1: Reconstruction of the right orbit under navigation – pointer on reconstructed floor.
Fig. 2: TCR pathway
References

1. Kratschmer F: Influences of reflexes of the nasal mucosa on breathing and circulatory. *Sber Akad Wis Wien* 1870;Abt. 2:147


