**Case Report/Case Series**

**Intraocular Pressure Changes in Emergent Surgical Decompression of Orbital Compartment Syndrome**

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**IMPORTANCE** Orbital compartment syndrome is an acute rise in intraorbital volume resulting in increased intraorbital pressure and possible ischemic compromise of the optic nerve. Tonometric pressure measurement of intraocular pressure can aid surgeons in the diagnosis of this condition and in choosing the need to proceed with emergent surgical intervention. In addition, we present an unexpected cause of orbital compartment syndrome following routine frontal sinus irrigation.

**OBSERVATIONS** An emergent lateral canthotomy and cantholysis followed by endoscopic medial wall decompression were performed, with intraocular pressure measurements performed throughout the evolution of this successful, and vision sparing, set of procedures. The techniques and continuous improvements in intraocular pressure measurements are described.

**CONCLUSIONS AND RELEVANCE** There are only rare reports of the progression of intraocular pressure prior to, and concurrent with, surgical orbital decompression. While no absolute threshold for intraocular pressure exists for when surgical decompression should be performed, the decision of when and which decompression procedures to undertake should be based on clinical judgment and experience. Availability of tonometry in the operating room serves to measure response to management in these rare but challenging settings where intervention may be required to prevent irreversible visual loss.

O rbit compartment syndrome (OCS) is an ophthalmologic surgical emergency resulting from an acute rise in intraorbital volume and pressure. A number of conditions can cause OCS, including retrobulbar hemorrhage, orbital emphysema, orbital cellulitis, orbital edema, and foreign body entry into the orbital socket. A marked increase in the intraocular pressure (IOP) and subsequent compression of the optic nerve and associated vasculature can lead to rapid functional compromise and blindness. To prevent visual loss, rapid diagnosis and urgent performance of surgical decompression via lateral canthotomy and cantholysis, and/or endoscopic medial orbital decompression, are often required, although ultimately “pulling the trigger” on orbital decompression can be a challenging decision to undertake for most clinicians. Tonometric pressure measurements of IOP can be a helpful indicator in choosing to proceed with surgical intervention,\(^1\)\(^-\)\(^2\) although the objective benefit of each of these independent interventions has never previously been reported intraoperatively. Here, we tabulate our use of continuous IOP measurements recorded during emergent surgical decompression of OCS, which reveals the progressive decrement in IOP achieved through each individual interventional procedure.

**Report of a Case**

During endoscopic sinus surgery under general anesthesia, a middle-aged woman with chronic rhinosinusitis and focal areas of bone erosion in the paranasal sinuses (Figure, A, B) underwent routine irrigation of the left frontal recess and sinus outflow tract using a curved suction attached to a 20 cm\(^3\) saline syringe to clear purulent discharge from the endoscopic field. The patient demonstrated an immediate, unexpected left orbital swelling, which initially subsided over 7 to 8 minutes, with both eyes soft, and pupils equal, round, and reactive to light on examination. As the case resumed, approximately 4 minutes later, the left eye exhibited a second sequence of rapid, progressive, and now unremitting, edema, with the development of left-eye proptosis with chemosis. The rhinology and ophthalmology services were then immediately paged to the operating theater, while the primary surgery team obtained a tonometer for IOP readings (Table).

Twenty minutes after initial frontal irrigation and tonometer retrieval, an IOP of 50 mm Hg was measured in the affected eye, compared with 18 mm Hg in the contralateral (right)
A, Preoperative sinus computed tomographic (CT) scan reveals extensive left-sided pansinus mucosal thickening and supraorbital rim dehiscence from bone erosion (arrowhead). B, Preoperative magnetic resonance image of the left frontal sinus suggests absence of preexisting frontal sinus mucosal defects or depressions into the orbital vault at the site of bony dehiscence (arrowhead). C, Postoperative day 0 sinus CT status after external and endoscopic decompressions indicates cause of orbital compartment syndrome to be sizeable extraorbital fluid collection (asterisk) present within orbital vault despite now-normalized intraocular pressures. Postsurgical changes following medial orbital wall decompression with herniation of intraorbital fat through endoscopic surgical decompression site, are demonstrated (arrowhead).

**Discussion**

Acute OCS is a complication of rapid increased pressure within the orbital space. Typically, an IOP greater than 20 mm Hg is considered elevated, and an increased IOP may compress the optic nerve directly or cause compression of its vasculature. An enlarged blind spot on visual field testing, decreased color vision most notably red desaturation, and a RAPD are considered the most reliable clinical indicators of optic nerve compromise. Central retinal artery occlusion (CRAO) can be another mechanism of acute visual loss but proptosis and chemosis do not typically manifest in concert with isolated CRAO.

To protect against visual loss in the setting of a retrobulbar hemorrhage, it has been recommended that decompression of the affected orbit should be performed within 100 to 120 minutes of symptom onset. Hayreh and Weingeist performed 2 experimental studies on central retinal artery occlusion. In their study on aged monkeys, the retina was found to tolerate acute ischemia for up to 98 minutes with full recovery, but after 105 minutes the damage was considered irreversible. In contrast, in younger monkeys, there was a variable degree of damage in CRAO of 105 to 240 minutes. Total optic nerve atrophy occurred after 240 minutes. While not directly overlapping with OCS, these findings in CRAO are clearly relevant to understanding the sensitivity of timing to preserve optic nerve function.

Rapid diagnosis and treatment is necessary to avoid permanent blindness in OCS. Treatments are usually chosen...
based on degree of vision loss, pupillary examination, and tonometric pressure. Evidence suggests that proptosis is not a reliable prognostic factor of vision loss. In contrast, tonometric pressure may be the best predictive factor. Experimental studies of cadavers confirm the accuracy of IOP measurements with a tonometer in management of OCS. However, a consensus IOP on which to embark on surgical decompression remains controversial. Han et al compared the change in orbital pressure of the affected orbit with the normal contralateral orbit. They recommend orbital decompression in the presence of a tonometric pressure less than 20 mm Hg below the mean arterial pressure, a marked RAPD, or no retinal artery pulsation on ophthalmologic examination. Alternatively, others have suggested that an IOP greater than 40 mm Hg, as well as signs of optic nerve compression or CRAO, as indications for lateral canthotomy and cantholysis. Still other groups suggest an IOP greater 30 mm Hg as an indication for surgical intervention.

Imaging studies, such as CT and/or MRI scans, can be helpful to make an accurate diagnosis, but it is universally agreed that surgical decompression of the orbit should not be delayed on the basis of obtaining imaging. However, because of its availability and celerity, CT scan is the preferred imaging technique to identify the location and source of elevated orbital pressure. Interestingly, Oester et al compared the stretch angle between the patient’s eyes using axial CT images to predict poor visual outcome in patients with OCS.

Immediate lateral canthotomy and inferior cantholysis are recommended to prevent visual loss owing to optic nerve compression in OCS. The major goal of these external procedures is to allow anterior prolapse of the orbital contents to rapidly reduce the IOP and reestablish retinal arterial blood flow. The full-thickness incision should be made from the lateral canthus extending toward the orbital rim. Inferior (and occasionally superior) cantholysis is performed by releasing the crus of the lateral canthal tendon, resulting in complete lower eyelid laxity and mobility. It should be noted that the orbital contents and eyelid soft tissues are highly edematous and under tension in these emergent scenarios, such that reliable hand instrumentation (eg, heavy tonotomy scissors, DeBakey forceps), and, moreover, mental commitment as to the necessity of the procedure, are mandatory for achieving successful decompression.

Endoscopic orbital decompression is another surgical approach that can be used in the treatment of compressive optic neuropathy. In such cases, it is important to decompress the anterior and posterior aspects of the medial and inferior walls of the orbit. Studies have shown variable but significant reduction in IOP after decompression surgery. Onaran et al have, for example, reported increased IOP in Graves orbitopathy leading to compression of the vein and reduced venous outflow. In this study, a clinically significant reduction in IOP as well as a decrease in venous pressure were both observed following orbital decompression.

The ultimate, rare, and possibly unreported cause of OCS in this patient also deserves added attention. In hindsight, routine frontal sinus irrigation of saline through a narrow frontal recess or ostium in this patient, without adequate egress, produced entrapment and accumulation of fluid within the left frontal sinus and a breach along the “path of least resistance” through the tenuous mucosa overlying the supraorbital rim bony defect. This ultimately resulted in periorbital accumulation of fluid within the orbit, leading to a most unusual manifestation of OCS. The primary surgeon had noted the rim defect preoperatively on CT imaging, and an MRI scan prior to surgery confirmed an intact frontal sinus mucosal floor. Because the left frontal recess was challenging to dissect in this setting of florid sinus infection, saline irrigation was intentionally used to clear the endoscopic surgical field. Unfortunately, in this particular patient, the frontal outflow channel was too narrow to allow immediate outflow of saline irrigant from the frontal outflow tract once introduced at moderate pressure through a syringe from below.

Finally, past studies have reported tonometric measurements in cases of OCS preoperatively and postoperatively, but the objective benefit conferred by continuous, sequential measurements of IOP through the evolution of successful surgical decompression has, to our knowledge, not previously been reported. In this specific case, an approximate 60% overall reduction in IOPs was obtained within 30 minutes from the initiation of surgical decompression. Continuous tonometer measurements were conducted up to postoperative day 1, comparing the pressures of the affected eye with the contralateral eye as internal control. A supraorbital rim transconjunctival decompression to drain the extraorbital fluid intraoperatively may have also been entertained given the likely location of the extravasated fluid based on the defect (Figure, C). However, with the emergent scenario faced in this intraoperative emergency, after successful external decompression achieved through canthotomy and cantholysis, medial orbital decompression was next undertaken given (1) high levels of experience with this procedure for those physicians present, (2) the immediate availability of this equipment in the operating room, (3) the limited morbidity and high level of benefit of this adjunct procedure, and (4) lack of more precise information on the fluid collection size and depth at the time. A second external decompression approach may have been considered if the procedures described herein were unsuccessful in reducing the IOP, although without additional imaging, the effectiveness of this approach may have been suboptimal.

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Table. Continuous IOP Measurements During, and Following, Surgical Decompression

<table>
<thead>
<tr>
<th>Time Following Frontal Sinus Irrigation, min</th>
<th>IOP Measurements, mm Hg</th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>18</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>17</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>40, Following lateral canthotomy + cantholysis</td>
<td>17</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>60, Following medial orbital decompression</td>
<td>15</td>
<td>25</td>
<td></td>
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<tr>
<td>In PACU</td>
<td>15</td>
<td>25-30</td>
<td></td>
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<tr>
<td>Postoperative day 1</td>
<td>10</td>
<td>15</td>
<td></td>
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</tbody>
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Abbreviations: IOP, intraocular pressure; OD, right eye; OS, left eye; PACU, postanesthesia care unit.

* Unaffected.
Conclusions

Because some patients have more tenuous ocular vascular supply, it should be emphasized that there is no absolute threshold for IOP when surgical decompression should be performed—this remains a clinical judgment based on factors and circumstances that vary with each scenario. Similarly, the need to perform both external and endoscopic decompression is not well established, and although it was beneficial in this case, the decision of which decompression procedures to undertake should also be based on clinical judgment and experience. Finally, availability of tonometry in the operating room may assist the otolaryngology and ophthalmology surgical teams to predict and monitor cases in which OCS in a concern. It also serves to measure response to management in these rare but challenging settings where intervention may be required to prevent irreversible visual loss.

REFERENCES


