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CONCEPTS

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# Orbital compartment syndrome: Pearls and pitfalls for the emergency physician

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## Abstract

Orbital compartment syndrome (OCS) is a rare, vision-threatening diagnosis that requires rapid identification and immediate treatment for preservation of vision. Because of the time-sensitive nature of this condition, the emergency physician plays a critical role in the diagnosis and management of OCS, which is often caused by traumatic retrobulbar hemorrhage. In this review, we outline pearls and pitfalls for the identification and treatment of OCS, highlighting lateral canthotomy and inferior cantholysis (LCIC), a crucial skill for the emergency physician. We recommend adequate preparation for the diagnosis and procedure, early consultation to ophthalmology, clear and thorough documentation of the physical examination, avoidance of iatrogenic injury during LCIC, and complete division of the inferior canthal tendon. Emergency physicians should avoid failing to make the diagnosis of OCS, delaying definitive surgical treatment, overrelying on imaging, failing to decrease intraocular pressure, and failing to exclude globe rupture. The emergency physician should be appropriately trained to identify signs and symptoms of OCS and perform LCIC in a timely manner.

KEYWORDS

inferior cantholysis, intraocular pressure, lateral canthotomy, ocular trauma, ophthalmology, orbital compartment syndrome, retrobulbar hemorrhage

## 1 | INTRODUCTION

Orbital compartment syndrome (OCS) is a rare, vision-threatening diagnosis that requires quick identification and immediate treatment for preservation of vision.[1–4] As with other compartment syndromes, rapidly increasing and sustained high intraocular pressures (IOP) can result in devastating consequences. OCS causes ischemia of the optic nerve and retina. Although the exact duration of ischemia necessary to cause irreversible vision loss in humans is unknown and vision has been restored after prolonged ischemia, animal studies have shown that retinal ischemia lasting > 100 minutes can lead to irreversible vision loss.[5,6] This is confirmed by many clinical reports of permanently decreased vision following 1 to 2 hours of OCS.[7–9] Because of the time-sensitive nature of this condition, the emergency physician plays a critical role in the diagnosis and management of OCS.[10]

Most often, OCS is caused by retrobulbar hemorrhage secondary to facial trauma.[11] Retrobulbar hemorrhage can also occur after ophthalmologic or craniofacial surgery,[12] peribulbar or retrobulbar

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injections (eg, anesthetic), or orbital metastases of extraocular tumors. Non-hemorrhagic causes of OCS include prolonged prone positioning, facial/periocular burns, and massive fluid resuscitation following extensive thermal burns. There have even been documented cases of OCS caused by contrast extravasation during cerebral angiography,[13] tight hair-braiding,[14] and significant orbital emphysema secondary to orbital wall fracture and coughing, nose blowing, or sneezing.[15]

The diagnosis of OCS is primarily clinical, relying on the history of present illness and physical examination.[11,16] It is important to identify recent trauma, surgical procedures, or sinus disease. An evaluation of the past medical history should identify bleeding disorders, anticoagulant or antiplatelet use, oncological disease, systemic inflammatory conditions, and use of nonsteroidal anti-inflammatory drugs. Anticoagulation is an important risk factor in OCS and may be present in as many as 50% of cases.[16] Ask about the onset of symptoms, vision loss or color desaturation (especially red), diplopia (suggesting ophthalmoplegia), and pain (although only 15% of patients may have this complaint).[12]

The physical examination must be performed quickly and should evaluate for the following features of OCS:[11]

- Proptosis
- Ophthalmoplegia
- Decreased visual acuity
- Relative afferent pupillary defect (RAPD)
- Tense globe resistant to retropulsion
- Tight eyelids in partially retracted position (difficult to further open or close eyelids)
- Elevated IOP
- Papilledema, optic atrophy, cherry red macula, venous congestion, or central retinal artery pulsation seen on fundoscopy

In addition, it is important to perform as thorough an eye examination as possible,[11] including evaluation of the following:

- visual acuity,
- presence of double vision,
- fluorescein staining for corneal abnormalities, and
- signs of globe rupture (laceration of globe, misshapen pupil, enophthalmos, exposed uveal tissue, protruding intraocular contents, shallow or deep anterior chamber, and positive Seidel sign).[17]

Normal IOP is 8–21 mmHg. In cases of OCS, elevated IOP is essential to the diagnosis and may increase to 60 mmHg or higher.[18] Pressure > 30 mmHg requires emergent ophthalmology consultation and IOP > 40mmHg should prompt immediate therapy to decompress the orbit.[19] This typically is done by performing the lateral canthotomy and inferior cantholysis (LCIC) procedure. The lateral and medial canthal tendons anchor the eyelid tarsal plates to the orbital rim and prevent forward movement of the globe. LCIC decompresses the orbit and allows the globe to prolapse forward, relieving the increased IOP.

To perform the procedure, appropriate analgesia is first obtained with local anesthetic injected at the lateral canthus and topical anesthetic applied to the globe. A straight hemostat is used to crush the lateral canthus for 1 minute and ensure devascularization of the area. Using an iris scissors, the lateral canthus is cut to expose the inferior and superior canthal tendons. To prevent injury to the orbit or lateral rectus muscle, the instruments should point away from the eye and aim toward the lateral orbital rim. The lower eyelid is then lifted medially and anteriorly with forceps to tighten the inferior crus of the lateral canthal tendon; this makes it easier to identify the tendon by palpation with the scissors by moving the scissors over the tendon to "strum" it, as a guitar pick strums a guitar string. The inferior crus is then severed with the scissors. During this step, it is important to direct the scissors inferiorly. Once the procedure is completed, the globe may prolapse forward. IOP then should be measured to confirm that the elevated pressure has been relieved.

LCIC is an important skill in the emergency physician's toolbox. Dixon et al noted a 2.58 times greater likelihood of vision returning to baseline when LCIC was performed by emergency physicians compared to other physicians.[20] In a survey study, Edmunds et al found emergency physicians can accurately diagnose OCS and identify irreversible vision loss as a consequence of untreated retrobulbar hemorrhage, yet only a minority of them would actually perform LCIC.[10] Furthermore, > 90% of emergency physicians surveyed felt that they had a lack of training and that more education was required on the procedure. In this review, we identify some key pearls and pitfalls for the emergency physician in the identification and treatment of OCS.

## 2 | PEARLS AND PITFALLS

### 2.1 | Pearl #1 – Be prepared for OCS and LCIC

When OCS is diagnosed, LCIC must be performed rapidly, most often by the emergency physician before arrival of the ophthalmologist, in order to prevent long-term complications. Patients who have retinal ischemia for > 90–120 minutes are at high risk for permanent blindness. As such, the time of diagnosis is not the time to be first learning the procedure, its indications and contraindications, potential complications, and the necessary equipment. A recent survey study suggests that over 90% of emergency physicians feel inadequately trained in LCIC.[10] We recommend that emergency physicians prepare for this procedure well in advance in either cadaver,[21] animal, [22] or low-fidelity simulation models[23] (using a container, a ping-pong ball, rubber band, and tape) after reviewing the procedure highlights from textbooks, blogs, or videos easily found on the Internet:

- EM:RAP HD Video: "How to do a lateral canthotomy"[24]
- University of Iowa Health Care EyeRounds.org: "Lateral Canthotomy and Cantholysis"[25]
- First10EM.com: "Lateral Canthotomy–Procedure Guide"[26]
- Northwestern University EM Blog: "Canthotomy"[27]
- Larry Mellick: "Emergency Lateral Canthotomy and Cantholysis"[28]
- EyeGuru.org: "How to Perform a Lateral Canthotomy"[29]

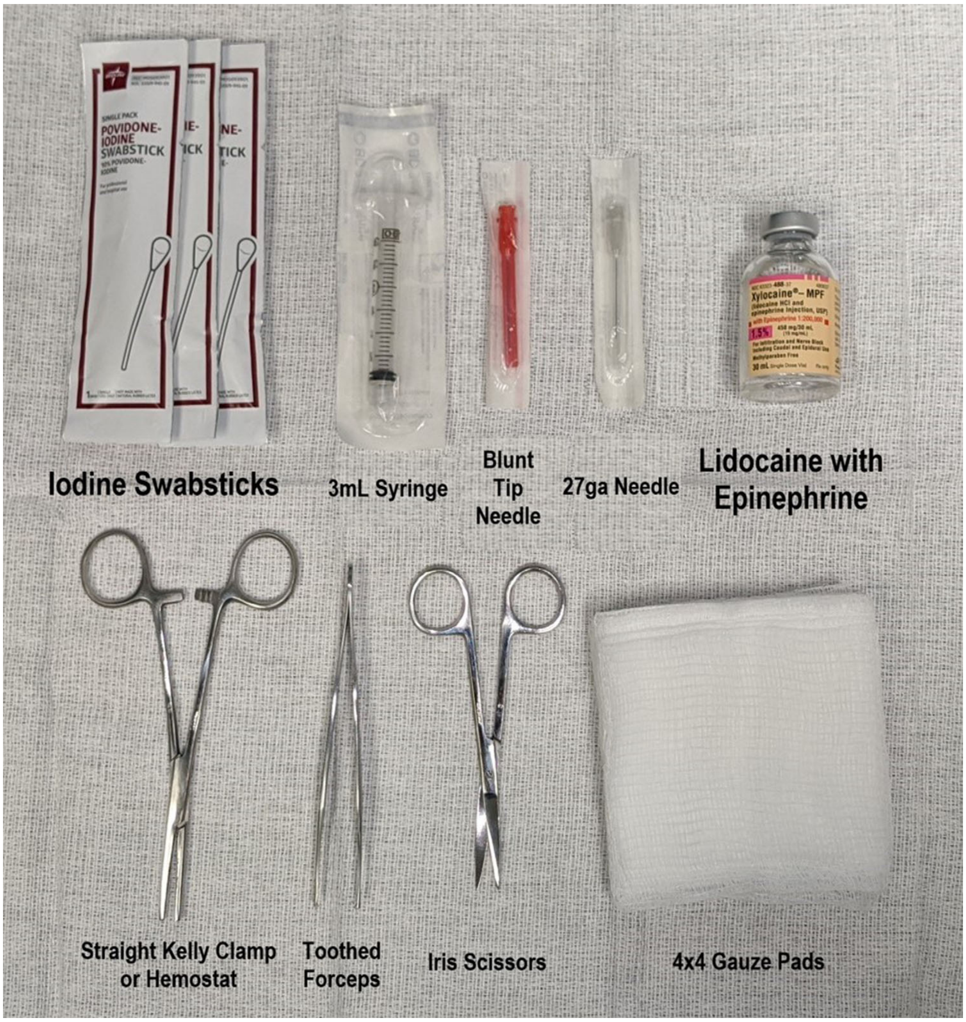


**FIGURE 1** Supplies necessary for lateral canthotomy and inferior cantholysis

- Roberts and Hedges' *Clinical Procedures in Emergency Medicine and Acute Care*, 7th ed.: "Technique: Lateral Canthotomy and Cantholysis," p. 1334[30]
- Rosen's *Emergency Medicine: Concepts and Clinical Practice*, 9th ed.: Fig. 61.13, p. 799[31]
- Tintinalli's *Emergency Medicine: A Comprehensive Study Guide*, 9th ed.: "Lateral Canthotomy," p. 1550[32]

We also recommend creating a kit with the necessary equipment (Figure 1) for rapid access to the appropriate tools.

## 2.2 | Pearl #2 – Consult ophthalmology early

In all cases of OCS or suspected OCS, early consultation to ophthalmology is essential. Because LCIC may incompletely relieve increased IOP or fail to improve vision loss, the patient may require definitive source control of hemorrhage, drainage of hematoma, medical treatments (such as mannitol or steroids), or other procedures to be performed by the ophthalmologist (eg, canthal cutdown, inferior orbital septal release, transcutaneous transseptal orbital decompression, inferior anterior orbitotomy, and others).[16] Additionally, there may be associated injuries requiring ophthalmologist involvement, such as hyphema, vitreous hemorrhage, or globe rupture.

Patients - also may have delayed manifestations of OCS after trauma. Christie et al reported an average time of manifestation of OCS symptoms of 20.5 hours after injury and 29.8 hours after surgery.[12] Ophthalmologists should be involved in the patient's inpatient care and outpatient follow-up to assist with prevention or treatment of complications. Fortunately, in many cases, no further surgical interventions are necessary other than lid repair for ectropion resulting from LCIC.

## 2.3 | Pearl #3 – Document the physical examination thoroughly

Meticulous documentation of a complete physical examination ensures effective communication to the rest of the team and the ophthalmologist. This not only allows the emergency physician to justify the decision to perform LCIC if needed but also assists the ophthalmologist during follow-up. An important item to document is the visual acuity using an eye chart. If the patient's vision is impaired, assess for the ability to count fingers, see hand movement, or in severe cases, perceive light. Although the RAPD (seen on swinging flashlight test) may have imperfect interobserver reliability,[33] it can be performed in patients with altered mentation. Even mild RAPD with initial constriction followed by minor dilation is abnormal.

Measure and document the IOP. For cases in which opening the lids completely to measure IOP is difficult (and when globe rupture is unlikely), use a transpalpebral tonopen (Diaton) if available or palpate and assess firmness and resistance of the globe to retropulsion. Cases of OCS will feel "hard as a rock." If it can be done in a timely fashion, perform and document a fundoscopic examination, preferably using a retinal camera if available.[34,35] The ophthalmologist will use the initial documented physical examination to monitor for improvement in symptoms during the patient's hospital course.

It is imperative to repeat and to document the IOP and visual acuity after performing LCIC. The decrease in IOP should be immediate, whereas improvements in visual acuity could take hours. Repeat measurements of IOP may be necessary because the IOP reduction following LCIC may be short lived in the setting of continued hemorrhage.[36]

## 2.4 | Pearl #4 – Take care to avoid iatrogenic injury during the procedure

Most patients with traumatic OCS have chemosis and large subconjunctival hemorrhage, massive lid edema and ecchymosis, and a proptotic globe, making LCIC a challenging procedure. There often is little space to insert instruments at the lateral canthus and extreme caution must be taken to avoid iatrogenic injury. Although the most devastating complication of LCIC is globe rupture, the procedure can also rarely cause excessive bleeding, infection, damage to the lacrimal gland or artery, damage to the lateral rectus muscle, and ptosis from levator aponeurosis injury.[37,38]

Consider procedural sedation, in addition to local intradermal and topical ophthalmic anesthesia, to minimize patient discomfort and movement. A Morgan lens can be used as a shield to protect the globe[39]; however, insertion can be challenging in patients who have significant edema and ecchymosis. Lacrimal gland and levator aponeurosis injury can be avoided during superior cantholysis by lifting the upper lid and making a superoposterior incision avoiding deep penetration. Bleeding might be diminished by use of lidocaine with epinephrine, but more so by crimping the canthal tendon with hemostats for 1 minute. Finally, aseptic technique is crucial, and empiric systemic antibiotics can also be used to prevent infections.

## 2.5 | Pearl #5 – Ensure complete division of the inferior canthal tendon

Lateral canthotomy alone is typically insufficient to adequately treat OCS[40,41] and may decrease IOP by ≈ 14 mmHg in comparison to 30 mmHg with cantholysis.[41] The lateral canthotomy is performed to provide access to the inferior canthal tendon. This tendon must be severed to allow the globe to move anteriorly. Upon proper inferior cantholysis, the lower lid should fall away from the lid margin.[9] Frequently, bleeding and edema can make it challenging to identify the canthal tendon. Again, locate the tendon by strumming it with the tip of the scissors.

## 2.6 | Pitfall #1 – Failure to make OCS diagnosis and appropriately perform orbital decompression

Have a high level of suspicion for OCS in any patient with facial trauma or recent orbital/cranial surgery. Loss of vision may be a late sign, so perform a thorough eye examination and measure the IOP early. Although there is no consensus on the number of symptoms that must be present to diagnose OCS, a larger number of symptoms predicts worse outcomes.[12] Typically, if the IOP is > 40 mmHg and the patient has RAPD, LCIC is likely needed. Erickson et al suggest a 3-part decision tool to predict the need for LCIC that includes relative proptosis, "tight" eyelids that are difficult to open with finger pressure, and presence of a RAPD in the traumatized eye.[42]

Conversely, it must be noted that the vast majority of patients with facial trauma or recent surgery will not need LCIC. In the absence of elevation of IOP, tight eyelids, and RAPD, LCIC is not indicated.

## 2.7 | Pitfall #2 – Delaying definitive surgical treatment for any reason

As a vision-saving procedure, LCIC should be performed as soon as possible. Delays in treatment of OCS are likely to result in permanent vision loss. When symptoms of OCS are present, the procedure should not be postponed until after a discussion with the ophthalmologist or the patient's health care decision-maker. If the patient can participate in his or her own care, the procedure should be explained quickly and performed immediately.

When the diagnosis of OCS is certain, the procedure should also not be delayed just to obtain computed tomography (CT) or ultrasound imaging. If signs or symptoms are not definitive but concerning for OCS, then imaging should be performed expeditiously, with the awareness that findings other than globe rupture might not change the treatment.

Do not wait for worsening visual acuity, which can be a late sign of OCS. Christie et al found reduced visual acuity in only 45% of cases.[12] Even in the absence of significant vision changes, immediate LCIC is advised when elevated IOP, tense globe, and proptosis are present.

On the other hand, delayed presentation after traumatic injury should not prevent the emergency physician from performing the procedure. It is better to perform LCIC to give the patient the best chance of regaining normal eye function. Although patients treated > 2 hours after injury have poorer reported outcomes, Dixon et al found that 73% of OCS cases had returned to baseline vision even with LCIC delayed

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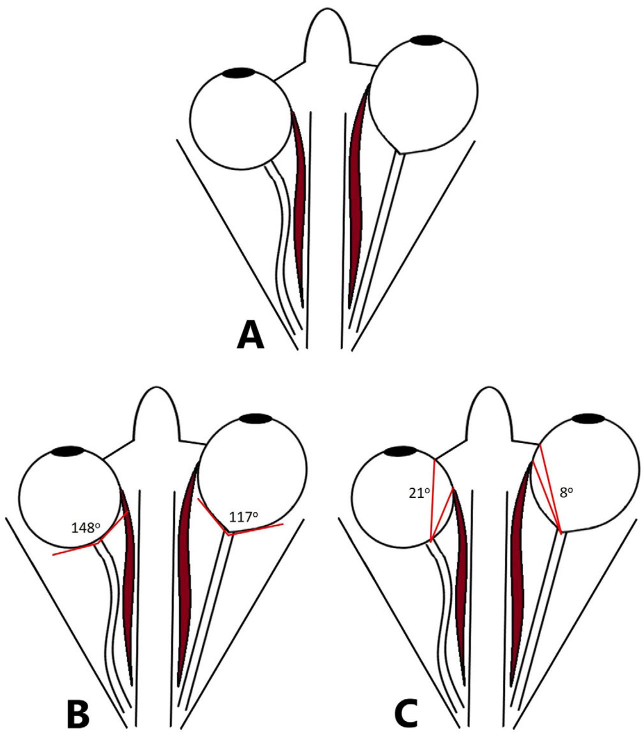


**FIGURE 2** (A) Graphic representation of computed tomography (CT) orbit at the level of the superior orbital fissure. The proptotic eye is abnormal. Medial rectus muscle is shown in the images. (B) Posterior globe angle as described by Dalley et al. Value < 120 degrees is associated with variable recovery of vision. (C) Stretch angle as described by Oester et al; stretch angle is defined as the angle created by 2 intersecting lines: 1 from the medial rectus insertion to the optic nerve and the second from the nasal sclera to the optic nerve. When the difference between stretch angles for the 2 eyes is calculated, larger values are associated with vision loss

beyond 1 hour after arrival.[20] Furthermore, Bailey et al determined that 60% had improvement in vision with LCIC beyond 3 hours.[4] There are reports of vision recovery after delayed decompression,[4,20,43–47] even up to 5 days.[48]

## 2.8 | Pitfall #3 – Overreliance on imaging

Computed tomography of the orbit can be useful in identifying fractures, proptosis, and the presence or absence of retrobulbar hemorrhage.[49] Demonstration of proptosis and retrobulbar hemorrhage are supportive of the diagnosis but non-specific and do not predict poor outcome.[42,50] The confirmatory findings of OCS on CT are tenting of the globe (Figure 2B), with a posterior globe angle <120°, and stretch angle difference (Figure 2C; larger values are associated with vision loss).[50,51] Neither finding will typically be noted in a radiology report, so it may be necessary to review CT images yourself and look for a globe that is not circular at the optic nerve insertion (Figure 3A). However, CT scan should not delay LCIC when there is high clinical suspicion for OCS based on examination findings; the procedure should be performed before CT to decrease retinal ischemia time.

Similarly, bedside ultrasound, which may be faster than CT imaging, should not delay the LCIC procedure. Focus on identifying the "guitar pick" sign[52] (Figure 3B; the ultrasound equivalent of globe tenting seen on CT scan) and retrobulbar hemorrhage. Although ultrasound has high sensitivity for retrobulbar hemorrhage, it is not essential for OCS diagnosis.[53] A recent cadaveric study by Carlin et al showed that emergency physicians at a variety of training levels can correctly identify retrobulbar hematoma with 87% sensitivity and 88% specificity.[54] Furthermore, globe rupture may or may not be detected by ultrasound.[55] Although more challenging to perform for most emergency physicians, retinal ischemia can also be diagnosed with color flow doppler and pulsed wave doppler. These modes have been shown to demonstrate decreased blood flow in central retinal vein and artery occlusion[56–58]; however, more research is needed to determine the role of color flow and pulsed wave doppler in OCS and traumatic retrobulbar hemorrhage.

Findings commonly seen on ultrasound could explain vision changes but should not dissuade the clinician from performing LCIC in the setting of high suspicion for OCS. Ultrasound may be considered after decompression of the orbit to evaluate for other conditions such as retinal detachment, vitreous detachment, or vitreous hemorrhage.[59]

## 2.9 | Pitfall #4 – Failure to decrease IOP

Because the primary objective of LCIC is to treat OCS, reduce IOP, and improve retinal perfusion, IOP should be measured immediately after performing the procedure. LCIC does not always adequately decrease IOP.[47] If it is still elevated, then superior cantholysis can be performed. Take caution with this procedure because of the associated increased risk of globe rupture and lacrimal gland injury. If IOP is still elevated, medical management (mannitol, acetazolamide, high-dose methylprednisolone), although not very effective, can be considered.[37,60] Despite these interventions, if the IOP is still elevated, the patient will need further surgical procedures performed by the ophthalmologist in the operating room.

## 2.10 | Pitfall #5 – Failure to exclude globe rupture

Both OCS and globe rupture can cause monocular vision loss following trauma, and retrobulbar hemorrhage can occur with either condition. Yet, globe rupture is the only relative contraindication to LCIC because of the high risk of hemorrhage, infection, and further iatrogenic damage. Fortunately, this pathology is rare except in combat victims,[61] and LCIC has been performed for OCS in the setting of globe rupture.

When suspected, globe rupture is clinically apparent in some cases, often diagnosed by the presence of a visible laceration to the cornea or sclera, circumferential subconjunctival hemorrhage, a shallow or deep anterior chamber, protrusion of intraocular contents, positive Seidel sign, or a misshapen pupil.[17] In other cases, the diagnosis is not obvious and can be difficult to identify without CT or ultrasound imaging. Although tonometry is classically contraindicated, gentle IOP

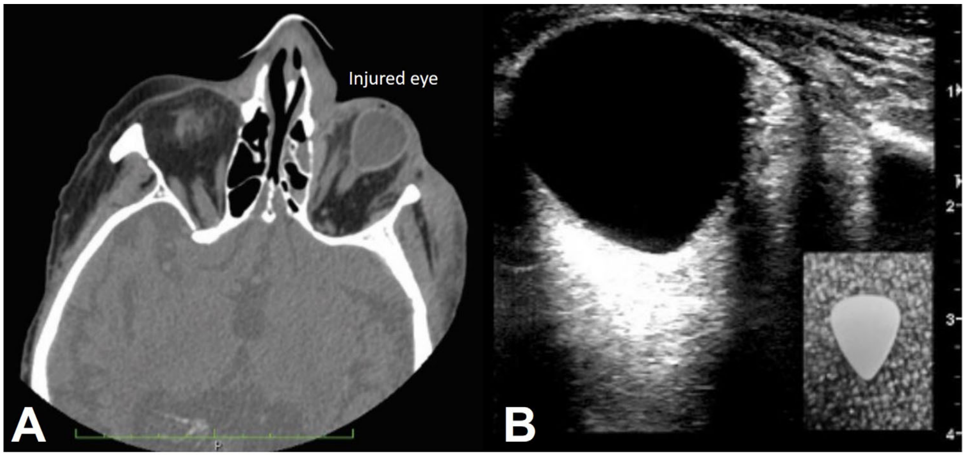


**FIGURE 3** (A) Computed tomography (CT) scan demonstrating globe tenting and (B) ultrasound images demonstrating "guitar pick sign." Images taken from Theoret et al with permission from the corresponding author

measurement with a tonopen, iCare, or Diaton device may be safe; although elevated IOP may be present in the setting of globe rupture with OCS, a low IOP suggests globe rupture alone without OCS. Similarly, ocular ultrasound is considered relatively contraindicated, despite minimal change in IOP,[62] and the use of a plastic shield may further diminish any increases in IOP.[63] In a clinical review based on 8 cases of globe rupture, ultrasound had 100% sensitivity and 99% specificity,[64] whereas an animal model reported 79% sensitivity and 51% specificity.[63] In situations where globe rupture is considered, CT imaging would be reasonable because it has sensitivity of 76%–87% and specificity of 85%–97% for anterior globe rupture when read by experienced radiologists and neuroradiologists.[65,66] When OCS is clinically obvious (IOP >40 mmHg, tight lids and RAPD) and rupture is unlikely, the clinician might best opt to perform LCIC rather than wait for imaging.

## 3 | CONCLUSION

OCS is a vision-threatening condition that requires prompt recognition and emergent decompression with LCIC. The emergency physician should be appropriately trained to identify signs and symptoms of OCS and perform LCIC in a timely manner.

### CONFLICT OF INTEREST

None

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