Positive Pressure

BY HARRY B. GRABOW, MD; STEPHEN B. LICHTENSTEIN, MD; AND GRAHAM BARRETT, MD

Surgeons occasionally encounter a poorly defined entity known as *positive pressure*. Three experts share their thoughts about this challenging intraoperative condition, which can complicate cataract surgery.

HARRY B. GRABOW, MD

Fortunately, positive IOP during small-incision cataract surgery is rare. Positive pressure can be categorized as two major types: positive anterior pressure and positive posterior pressure. The former is characterized by excessive deepening of the anterior chamber with elevated IOP and is often confirmed by tactile tension during surgery. If the procedure is performed under topical anesthesia, the patient may report the sudden onset of pain caused by the rapid posterior stretching of the iris root and ciliary apparatus as well as high IOP. If the patient is fixating on the microscope's light, he may report a dimming of the light or a loss of image clarity.

Positive anterior pressure can occur early in the procedure, during either hydrodissection or the introduction of the phaco tip with the initiation of irrigation. If it occurs during hydrodissection, the condition may be associated with the use of a retentive-dispersive viscoelastic and with iris prolapse. To alleviate the problem, the surgeon can aspirate some of the viscoelastic through the sideport, thereby reducing the anterior chamber volume and pressure, and sweep the prolapsed iris back into the anterior chamber. The phaco tip may then be introduced "dry" without irrigation and with the bottle slightly lowered. Next, the surgeon may insert the sideport instrument before depressing the pedal to initiate irrigation, which provides an exit port for the viscoelastic and BSS. To prevent this form of positive anterior pressure in cases in which a retentive-dispersive viscoelastic is desirable (eg, a brunescent nucleus, a shallow anterior chamber as in hyperopia, or the presence of guttata/Fuchs' dystrophy), the surgeon may create the capsulorhexis and perform hydrodissection under a cohesive viscoelastic. Slight posterior pressure on the posterior lip of the incision with the shaft of the cannula will allow viscoelastic and BSS to escape without dragging and prolapsing iris, thus avoiding positive anterior pressure. Just prior to introducing the phaco tip, the surgeon may inject a more protective, retentive-dispersive viscoelastic anteriorly under the dome of the cornea.

Positive anterior pressure may occur upon the introduction of the phaco tip and the initiation of irrigation, particularly if the incision is tight (which will reduce outflow) and if the infusion bottle is high. The condition is also more likely in large, myopic eyes and in young patients. The same phenomenon can occur during I/A of cortex and has the added sign of a deep, concave posterior capsule. In either situation, zonular integrity can be jeopardized if the patient has a pre-existing tendency toward zonuloparesis, such as in cases of pseudoexfoliation, Marfan's syndrome, posttraumatic eyes, and eyes that have undergone pars plana vitrectomy.

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By allowing egress of viscoelastic and BSS with the introduction of the second instrument through the sideport incision, the surgeon can prevent excessive anterior segment volume and pressure. Doing so prior to inserting the phaco tip or commencing irrigation may prevent a sudden rise in pressure in cases in which such an increase is expected. If positive anterior pressure occurs at this point, despite lowering the bottle, it may be necessary to enlarge the incision slightly to allow proper outflow. Additionally, a retentive-dispersive viscoelastic agent may block the outflow of irrigation fluid through the existing incisions and thereby cause positive anterior pressure.

A shallowing of the chamber can also signify positive pressure, positive posterior pressure, or "negative" anterior pressure (a pressure of zero due to excessive outflow or insufficient inflow). Shallowing associated with positive posterior pressure may be due to external ocular compression, posterior direction syndrome, or choroidal effusion/hemorrhage. The first can be relatively benign. Its causes include pressure from the lid speculum, tight lids, overinflation of the retrobulbar space from injected anesthesia, and retrobulbar hemorrhage. All of these causes are detectable and correctable before surgery begins. Other predisposing conditions to positive pressure include obesity, chronic obstructive pulmonary disease,

high blood pressure, and a Valsalva maneuver.

Posterior direction syndrome is thought to arise when irrigation fluid dissects posteriorly through the zonule or through an opening in the posterior capsule. The fluid becomes trapped behind the vitreous, which is pushed forward. An intact capsule can become convex, push the iris forward, shallow the chamber, close the incision, and raise the IOP to an extremely high level. Continued irrigation in an attempt to deepen the anterior chamber worsens the problem. The surgeon should stop irrigation, inject a retentive viscoelastic through the sideport, if possible, and then remove the handpiece. It may be advisable to aspirate 0.3 to 0.5 mL of liquid vitreous through the pars plana, 3 mm posterior to the limbus, with a 23- or 25-gauge needle. This step usually allows the injection of more viscoelastic, particularly over an area of suspected zonulodialysis, and continuation of phacoemulsification with very low-flow I/A (Dr. Robert Osher's "slow-motion phaco").

The most serious cause of positive posterior pressure is choroidal effusion/hemorrhage. Fortunately, studies have shown that the incidence of acute intraoperative suprachoroidal hemorrhage is extremely low in small-incision surgery.[1-3] One of the first signs of this complication is a loss of the typical, complete red reflex. Positive posterior pressure then occurs with a forward movement of the lens-iris diaphragm. Subsequently, the surgeon may inject a retentive viscoelastic through the sideport, remove the phaco tip, and immediately tamponade the incision with either a cotton-tipped applicator or even a finger. Continuous pressure on the incision should raise the IOP and help to tamponade the bleeding posteriorly. In this situation, vitreous tap or posterior sclerotomy are not recommended, because they can allow continuous bleeding; a posterior sclerotomy may be necessary, however, to allow closure of the incision and repositing of prolapsed iris. The surgeon may need to maintain pressure on the incision for up to 15 minutes and may decide to abort the remainder of the procedure. It may be advisable to begin intravenous mannitol, an oral or intramuscular carbonic anhydrase inhibitor, and topical treatment of the IOP and inflammation. Secondary surgical intervention should not take place for 7 to 14 days to allow the bleeding to stop and clot formation to begin to be absorbed. The goal is to prevent an expulsive choroidal hemorrhage, which usually will not occur unless a large incision was made for removing a brunescent nucleus or for implanting a PMMA IOL. In these settings, two or three sutures (preferably 9–0 nylon) should be preplaced prior to extending the incision and looped aside as "safety sutures" in case rapid closure of the longer incision becomes necessary.

Aside from the obvious benefits of small incisions, perhaps one of the greatest is the significant reduction in the incidence of positive posterior pressure and the associated acute intraoperative suprachoroidal hemorrhage and expulsive choroidal hemorrhage syndromes. The development of small-incision cataract removal by Charles Kelman, MD, and the creation of small-incision IOLs by Thomas Mazzocco, MD, not only led to better refractive results, but they also greatly reduced the incidence of intra- and postoperative complications.

STEPHEN B. LICHTENSTEIN, MD

Positive pressure can occur in any patient if the surgeon is not vigilant, particularly in high-risk cases. Some eyes have a lens-iris diaphragm that is more susceptible to pressure changes. They include eyes with pseudoexfoliation, those that are *status post* vitrectomy, and those that have dense, longstanding, nuclear sclerotic cataracts, as well as patients with a history of trauma or high axial myopia. Carefully monitor the initial instillation of viscoelastic to ensure that little gets under the subincisional iris. This problem alone can cause positive pressure and force infusion through the zonule at the start of phacoemulsification when the outward flow of fluid is blocked. If excessive deepening of the chamber with viscoelastic occurs, depressurize the chamber by applying pressure to the posterior lip of the incision before initiating infusion.

Be aware that the chamber can deepen during hydrodissection due to the instillation of too much fluid, even if the cannula is correctly positioned. If you observe a trampoline effect in the chamber during any of the preliminary phaco steps, lower the infusion bottle before entering the chamber. If iris prolapse occurs at any point, reposition the iris. There is almost always a "head of pressure" that can be decompressed from a second incision or by inserting a spatula over the iris into the primary incision and applying posterior pressure. During phacoemulsification, discontinue the infusion and apply posterior pressure with the phaco handpiece before removing the instrument. Always reform the chamber with viscoelastic to rule out a posterior-segment cause (infusion misdirection or a subchoroidal hemorrhage). Altered chamber fluidics with asymmetric shallowing or lenticular particles in the anterior vitreous suggest subclinical aqueous misdirection. My advice is, "when in doubt, pull out." Assess the situation before a little problem becomes big.

I believe that some eyes are at higher risk for positive pressure but that most of those encountered are iatrogenic, resulting from a small aberration of technique that starts a cascade of events. In a case of true positive pressure, in which the eye does not reform with viscoelastic and indirect ophthalmoscopy shows a progressive darkening of the red reflex, I would close the eye as soon as possible and watch the patient closely in conjunction with a

retinal specialist during the next week or so. If the chamber does reform, I would slowly proceed with lower fluidics. If I am able to complete cataract surgery, but the pressure makes it impossible to deepen the chamber and/or reposition the iris and create a normotensive eye, I would perform a small pars plana vitrectomy. This patient would have received 50 mg of intravenous mannitol push 15 to 20 minutes earlier when I first became concerned.

GRAHAM BARRETT, MD

Unwanted pressure describes a range of situations in which it is difficult to maintain a stable pressure and volume in the anterior chamber during cataract surgery. Although commonly attributed to positive vitreous pressure, raised pressure in the posterior segment is a relatively uncommon cause. Nevertheless, it is important to identify such situations, which can occur due to misdirection of the infusion fluid into the vitreous, choroidal effusions, and, rarely, a choroidal hemorrhage.

Extrinsic situations that raise pressure in the posterior segment and may cause shallowing of the anterior chamber include a retrobulbar hemorrhage or anatomical factors, including a shallow orbit and small palpebral fissure. Younger patients tend to have a more elastic sclera that may collapse with a consequent rise in vitreous pressure. Small hyperopic eyes with shallow anterior chambers also may be associated with difficulty in maintaining a stable anterior chamber during surgery.

In all of these circumstances, the pressure in the anterior chamber should remain higher than the vitreous pressure to avoid shallowing of the anterior chamber. The surgeon can only maintain positive pressure by ensuring that the infusion of fluid is equal to or, preferably, greater than that lost from the eye due to wound leakage and aspiration. The failure to ensure a positive fluid balance is a far more common cause of chamber instability than any of the situations described earlier. Excessive wound leakage, crimping of the infusion tubing, and inappropriate vacuum/flow settings or bottle heights are all common situations leading to chamber instability and pressure during surgery.

Chamber instability often becomes evident at the time of occlusion break, when nuclear fragments are aspirated due to rapid flow. Improved phaco technology has helped to address this complication, termed *postocclusion surge*. Newer phaco machines can monitor vacuum levels in the aspiration line and are better able to regulate pump speed. Also of benefit are a reduced incision size and decreased wound leakage, thanks to new phaco needles and power modulations that decrease the chance of thermal injury.

I had almost forgotten the potential difficulty of maintaining chamber volume and pressure until I began performing bimanual phacoemulsification approximately 6 months ago. The infusion capacity of the irrigation cannula is simply not of the same magnitude as that of the coaxial phaco needle and sleeve. Excessive wound leakage can also occur, and the correct incision size for the bare phaco needle and irrigation cannula is critical. The surgeon must counteract the reduced infusion rate by raising the infusion bottle extremely high (between 110 and 120 cm of water). The resultant increase in anterior chamber pressure tends to cause further wound leakage. The surgeon must carefully avoid an aspiration flow rate that exceeds the infusion rate, or significant variations in chamber pressure and chamber instability will result. Ophthalmologists therefore tend to use lower flow and vacuum settings with bimanual versus coaxial phacoemulsification, and the former also requires pulse or burst modulation to avoid thermal damage.

I find that many surgeons transitioning to bimanual microincisional phacoemulsification are using Dr. Osher's technique of slow-motion phacoemulsification. The issues of anterior chamber pressure and stability require new attention, because the fluid dynamics of bimanual phacoemulsification are more finely balanced than with the coaxial technique. ■

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