Unplanned Vitrectomy Technique 2012

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Abstract

Anterior segment surgeons need to be familiar with techniques for dealing with posterior capsule and vitreous complications, either through unexpected vitreous prolapse during cataract surgery or when vitreous must be removed during the course of planned anterior segment reconstruction. This paper will help the surgeon and their team prepare a mental flow chart of maneuvers and a sequence of decisions prior to surgery to anticipate high-risk situations, recognize complications early, limit collateral damage, and promote optimal outcomes. Based on the literature, experience, and laboratory exploration this paper suggests a detailed strategy and details specific parameters and techniques for success.

Keywords

Vitrectomy, pars plana incision, particulate staining, dropped nucleus, vitreous traction, optic capture, trocar system

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Vitreous loss is inevitable. Given the volume of cataract surgery and the variety of pathology presented by the human eye, even in the best of hands there will be some rate of complications involving loss of the integrity of the capsular or zonular structure. Our obligation to our patients is to prevent vitreous loss where predictable, and minimize the impact of the consequences where possible.

Complications can be placed into three categories: a broken capsule or loss of zonular integrity with an intact vitreous face; vitreous prolapse (defined as vitreous within the confines of the anterior chamber); and vitreous loss through the incision. The likelihood of post-operative sequelae increases significantly with each of these categories, and motivates the surgeon to recognize and control damage at the earliest stage. The more vitreous traction we permit or cause, and the more we fail to prevent inflammation, the lower chance of an ideal outcome we offer our patient.

In the heat of the battle, we are least likely to be logical and analytical. It behooves us to prepare a flow chart of maneuvers and a sequence of decisions before entering a patient's eye. This paper will provide a framework to achieve an optimal result.

Prevention

"An ounce of prevention is worth a pound of cure". We heard it from our mothers as youngsters, and the adage remains valuable today in every endeavor. Each step of cataract surgery is built on the solid foundation of the prior maneuver. If we have misjudged the patient's ability to tolerate the choice of anesthesia (or the lack thereof), or our ability to communicate and work on a moving target, we have set the stage for disaster. I advocate always having a 'plan B', i.e., standby intravenous anesthesia or the wherewithal to initiate subtenons injection intraoperatively.

Wound construction is central to the maintenance of the chamber. Minimal leak through the main incision as well as the paracentesis results in a deep chamber and minimization of surge. An understanding of the fluidics and dynamics of the phacoemulsification machine employed is critical to be able to anticipate trouble and optimize the intraocular environment.

Recognize poor zonular integrity by the ease with which the anterior capsule can be perforated and the response to applied vectors of force during continuous circular capsulotomy (CCC). Be prepared with techniques to minimize zonular stress such as phaco chop. Have capsular tension rings and capsule expander hooks available. Extra-dispersive viscoelastic and compartmentalization over zonulolysis can save the day and prevent egress of vitreous around defects. Maintain a flat lens dome during capsulorhexis. The choice of a more viscous retentive viscoelastic in the settings of capsule elasticity, as in the pediatric cataract, or spherical lens morphology, as in the high hyperope, is helpful. Re-grasp the CCC edge frequently so the vector force is always in the right direction in case of sudden patient movement during creation of the CCC under topical anesthesia. Improve visualization of the lens capsule in hypermature cataracts by employing capsular dye.

Hydro-dissection and delineation are risky in the face of a very shallow anterior chamber and care must be taken to burp the bag as the fluid wave progresses to prevent tampenade of the CCC edge by the lens resulting in posterior capsule rupture secondary to bag over-inflation.

Adequate mobility of the lens material inside the bag must be established prior to initiating phaco to avoid stress on the zonules during the disassembly phase. Beware of capsular–cortical adhesions visible as discreet broad opacities that can lead to capsule rupture upon rotation if not gently lysed by hydro or visco-dissection.

During phacoemulsification keep the phaco tip in the 'safe zone' within the center of the pupil as much as possible and only use ultrasound to gain purchase on fragments in the periphery actually emulsifying in the safe zone only. Always place the non-dominant hand instrument (do not use sharp choppers) under the phaco tip to avoid contact with the posterior capsule in case of surge when emulsifying the last fragments.

The author recommends the use of a silicone sleeve for irrigation and aspiration to provide a good seal and therefore a controlled chamber while removing cortex. An open bag fornix cannot be achieved with a metal sleeve because the rigid tube permits leakage around it. During insertion of the intraocular lens (IOL) be certain the capsular bag is sufficiently concave to avoid snagging the posterior capsule and disinserting zonules.

Try to maintain positive pressure in the anterior segment at all times. This becomes especially valuable when patients 'Valsalva', as with unpredicted coughing. Do not withdraw the phaco tip: instead, have the assistant hold the forehead firmly down against the headrest, affix your hands to the patient's face, and stay in foot position two. In this way positive pressure will be maintained and the incidence of resultant negative consequence will approach zero.

Despite the application of these vigilant maneuvers, complications still occur. The Swedish National Cataract Registry notes 2.09 % of cataract surgery results in unplanned vitrectomy.

Early Recognition

The titer of suspicion must be high to appreciate the early signs of complication and allow optimum corrective action. Something as subtle as a bounce of the iris diaphragm, change in anterior chamber depth or a change in pupil size may be due to the sudden redistribution of fluid associated with a break in the posterior capsule. A momentary spidering of the posterior capsule deserves evaluation. A strangely clear area in capsule is nearly pathognomonic of a rent. Assuming that you have checked your phaco parameters and eliminated the possibility of a clog of the tip, loss of followability of lens material and phaco efficiency during phaco or irrigation and aspiration (I&A) is a reliable sign to suspect the presence of vitreous. It is vital that aspiration be discontinued as vitreous cannot be phacoed and potentially catastrophic traction will be transmitted to the retina. Tilting of the lens equator, loss of the ability to rotate the nucleus or a deepening of the anterior segment during emulsification are ominous signs of impending loss of lens material into the posterior segment and deserve immediate attention. Anything between the lips of the incision will prevent an internal seal from forming. In a well-constructed wound that fails to prove watertight, after irrigating the tunnel to eliminate debris, suspect an occult strand of vitreous insinuating itself invisibly and take steps to identify it. A peaked pupil or movements of the pupil edge with remote touch are classical signs not to be ignored.

Early Response

When we touch a hot stove our innate response is withdrawal. We must control that natural response to pull out of the eye upon the recognition of a complication. With the phaco tip between the lips of the wound we are controlling the intraocular environment. Upon recognition of a problem go to foot position one or zero but do not remove the phaco tip. Remove the non-dominant hand instrument from the paracentesis, which will not result in chamber instability. Instill viscoelastic (dispersive ideally) through the paracentesis between the posterior capsule and any remaining lens fragments until the anterior chamber is normal depth. Only then can the phaco tip be withdrawn from the eye without anterior chamber collapse. If the chamber is permitted to collapse in the presence of a tear in the capsule, since vitreous follows a gradient from high to low pressure, the tear will extend and the stage of complication may progress from rupture to vitreous prolapse or prolapse to vitreous loss.

Now, with the incision effectively closed and the situation static, it is time to assess the situation, inspect, relax, and think. Announce the delay to the operating room staff to avoid having the patient who may be on the cart in the next room prepped and draped prematurely. Remember, too, to relax yourself and your voice. Many times family is watching and patients are awake, alert and aware of what is going on and they deserve to feel you are in calm control of the situation.

Anesthesia

Without pain receptors, the vitreous cannot 'hurt.' If the patient is under topical and intracameral anesthesia, it is possible to complete the case without supplementation. If a pars plana incision is employed, or the wound needs to be significantly enlarged, give a subconjunctival bleb of lidocaine/epi over the intended site of sclerotomy.

Avoid re-introduction of intracameral anesthetic. There will be no permanent damage to the neuroretina but transient amaurosis can be disconcerting or even frightening to both patient and surgeon.

Mild intravenous sedation may be desirable to help the patient to co-operate or promote the faster passage of time during a prolonged case. Over-sedation may cause agitation and reduce co-operation so a calm voice (vocal local) and having an operating room team that can seamlessly prepare for a vitrectomy is most helpful in minimizing patient anxiety.

If these measures fail and the patient loses the ability to co-operate under topical anesthetic, akinesia may be required. A subtenons or parabulbar block is appropriate. First be sure that your incision is closed and that there is no concern about loss of chamber. A snip down to bare sclera and use of a Greenbaum or Masket cannula to create akinesia without injection is optimal, obviating the risk of retrobulbar hemorrhage.

Damage Control

Once the existing complication is recognized, the next step is to control the damage by compartmentalization with a dispersive viscoelastic. If the rent in the posterior capsule is central or paracentral, this must be converted to a circular capsulorhexis if at all possible. Even when the posterior tear appears round it still lacks resistance to extension unless it is converted. Insinuating a small amount of viscoelastic through the tear to push back the intact vitreous face is helpful. On high

magnification, grasp the edge of the tear with forceps, applying a centripetal vector (directed centrally), minimizing the size of the opening. If there is no visible edge it may be necessary to start off with a tiny cut made with an intraocular scissor. Accomplishing this challenging maneuver results in a stable tear and permits the use of an in-the-bag implantation after clean-up.

If nuclear fragments remain, they must be raised above the iris plane. In patients with small pupils, some pupil stretch, visco-mydriasis, intracameral preservative-free bisulfate-free epinephrine, or perhaps micro-sphincterotomy will be helpful. It is imperative to make the best effort to maintain the integrity of the CCC for implantation of the IOL. If it restricts a large fragment from forward movement it can be enlarged. Under viscoelastic control, a tangential cut is made and forceps used to enlarge the continuous tear to the minimum effective size. Next, maneuvers to dial, lift, cantilever, or float the nucleus or nuclear fragment with viscoelastic can be employed, making them accessible for removal. Be mindful of protecting the endothelium and iris with all maneuvers.

Now that the eye has been stabilized and the damage controlled, a plan must be formulated to complete the case for the optimal outcome.

To Phaco or Convert to Extracapsular Extraction

There are very strict conditions required for safely completing the removal of nuclear fragments with ultrasound in the setting of vitreous prolapse. It is essential there be no admixture of vitreous and lens material. As previously stated, vitreous will preferentially be attracted to the phaco port, displacing nucleus and preventing aspiration of lens material. More important than the resulting inefficiency is the certainty of placing traction on the vitreous transmitted to the retina, causing retinal tear and detachment. Unless vitreous can be isolated and compartmentalized away from lens fragments, the phaco hand piece should not be used to complete the removal of the nucleus.

The second condition, which must be satisfied, is the presence of a controlled area of capsule tear, covered by viscoelastic or a lens glide to minimize the risk of forcing nuclear fragments posterior or hydrating vitreous and thereby increasing prolapse. Miochol E (acetylcholine) can be used to bring the pupil down behind the fragment.

When the decision is made to phaco, a slow-motion technique should be employed, with low flow, moderate vacuum, and appropriate pulses of energy to promote followability and minimize chatter. Because this will take place in a viscoelastic filled environment, care must be taken to establish adequate flow avoiding wound burn.

If a stable capsular tear and compartmentalized vitreous are not the prevailing conditions, conversion to extracapsular extraction technique should be pursued. Choose the incision based on the size of the remaining fragments. If the fragment is judged to fit through an opening of four millimeters or less, the clear corneal incision (CCI) can be utilized. Any longer incision will require at least one suture, which will increase post-operative astigmatism and have a prolonged healing time. For this reason it is advisable to ascertain the CCI to be watertight and abandon it as though it were merely a super-paracentesis. Move superiorly and perform an adequate limbal or scleral tunnel incision appropriate to the fragment size. Do not express with external pressure in the method that is used in primary extracapsular surgery: that technique depends on an intact vitreous body and, in this case, would result in expression of vitreous along with the nucleus. Instead, remove the fragment with a cystotome used as a pick, forceps such as a Kansas forceps or a vectus—something to glide it out, preferably under a viscoelastic sandwich always mindful of the endothelial integrity.

Medically (and legally) the worst thing an anterior segment surgeon can do, tempting retinal damage, is fish through vitreous for nuclear fragments lost behind the iris. The phaco tip should not be placed in the posterior segment and attempts to irrigate fragments out of vitreous will meet with disaster. More controversial, posterior assisted levitation as described by Kelman in which a pars plana incision gives access to a spatula or sweep placed into the mid vitreous used to lift the errant nuclear fragment into the anterior chamber has been improved by Chang to use a Viscoat cannula through the pars and irrigating dispersive viscoelastic to raise the fragment. This technique is performed essentially blind and can create vitreous traction. Serious consideration should be given to the prudent choice of letting the vitreoretinal surgeon deal with the lost fragment in a subsequent surgery. Statistically, excellent outcomes are almost uniformly obtained when applied in a timely fashion. The cataract surgeon's job then is to finish the case with a clean anterior segment, a well-placed IOL, and a secure closure paving the way for the vitreoretinal surgeon if needed. Careful follow-up, honest communication with the patient and appropriate referral will almost uniformly lead to a happy result.

Vitrectomy Technique

A valuable tool whenever a broken hyaloid is suspected is triamcinolone acetonide (Triessence® from Alcon). The particles adhere to the vitreous and not to viscoelastic. Installation of this steroid diluted with balanced salt solution into the anterior chamber identifies vitreous prolapse like throwing a sheet over a ghost. Also, the drug has the therapeutic effect of reducing post-operative inflammation.

Although anterior vitrectomy can be performed through a clear corneal or a pars plana approach, there are some absolute criteria we must follow. Whichever incision we choose, the instruments should be biaxial, with the irrigation separated from the vitrector. As vitreous always follows a gradient from high to low pressure, if we want it to flow into the vitrector, irrigating at the tip will be counterproductive and fluid tends to displace the vitreous body, necessitating more to be removed. The goal is to preserve as much of the vitreous structure as possible while removing any strands that have prolapsed into the anterior segment. Irrigation should always be through the side-port incision to encourage vitreous to remain posteriorly and keep higher pressure in the front of the eye. Whether the incision is clear corneal or scleral it must snuggly fit the bare vitrector needle so vitreous cannot flow around it through a leaky incision. Default settings of irrigation in foot position 1, cutting in foot position 2, and then vacuum in foot position 3 must be confirmed to prevent followability and therefore traction. Always stay in foot position 2 (cutting) when moving the vitrector through vitreous to avoid inadvertent flow into the tip from causing traction. No actual vitreous removal will occur until foot position 3 is engaged. All machines have a manual override that switches the function of foot

position 2 and 3 so that vacuum can be applied without cutting to facilitate followability. This should only be employed when vitreous is no longer present as in the removal of residual cortex.

The cut rate should be at its highest setting available: 400–5,000 cuts per minute depending on the machine. The aspiration flow rate is kept low: 20 cc/minute for 20 g instrumentation; 15 cc/minute for 23 g. The lowest vacuum that provides removal of vitreous should be employed; usually 250 mmHg for 20 g and 350 mmHg for 23 g in a viscoelastic filled environment. I encourage this to be on a panel or fixed setting rather than linear since the surgeon can then be anywhere in foot position 3, even pedal to the metal, without allowing too much vacuum. The bottle is then balanced with vacuum to maintain a normotensive eye usually around 80 cm for a 23 g cannula or chamber maintainer.

If a clear corneal approach is employed, tilt the vitrector down below the posterior capsule in order to pull vitreous back to the posterior segment. Remove or amputate anterior posterior connections of any prolapsed vitreous. It can be difficult to fully amputate a flat sheet of vitreous or a strand to the incision that is adherent to the iris with this approach. There is a tendency to call more vitreous forward while trying to remove the vitreous that is already forward. Once we reach an end-point with the maneuver, the pressure is lowest in the anterior segment, which encourages vitreous to present again on subsequent maneuvers. For these reasons a corneal incision may not be the optimal choice though it is mandatory when there is no view available through the pupil and best when the surgeon isn't familiar with the pars plana approach.

The reasons for using a pars plana sclerotomy for vitrectomy are that it leaves the lowest pressure posteriorly, allowing subsequent maneuvers while minimizing re-presentation; it is the most efficient, because it calls the vitreous home; and it will not unzip the zonules when vitreous presents around the lens equator by calling more vitreous forward through the defect. Finally, the pars plana approach facilitates amputation of the vitreous within incisions. Although we were taught to use a sweep from the side-port incision to drag entrapped vitreous away, this actually creates more traction on the connection through the pupil rather than efficiently freeing the vitreous from incarceration in the wound. I strongly discourage this practice. The preferred technique is particulate identification and sharp cutting or, ideally, using a vitrector to amputate connections posteriorly at the pupil margin. Once the vitreous sheet either retracts to the posterior segment or is severed from the vitreous within the wound, it is safe to remove residual vitreous from the incision with a cellulose sponge. Sponges should never be used to remove vitreous that is still attached posteriorly because they absorb vitreous strands, causing traction, and upon contact with iris tissue cause inflammation. Anytime you touch a sponge to the incision have scissors ready in the other hand so that, should you discover vitreous, you can cut it without lifting or stretching the strands. Immediately cut off the vitreous at the plane of the sclera so that you do not pull it forward out of the wound. Then you may address the vitreous in the optimal manner.

The pars plana incision is made by measuring 3.5 mm behind the limbus in a quadrant (away from cilliary arteries, vessels, and muscle insertions) under a small fornix-based conjunctival flap; the microvitreoretinal (MVR) blade is inserted aiming toward the geometric center of the globe. Ideally it is visualized within the pupillary space, as is the vitrector that follows. Upon completion of the vitrectomy, the incision should be free of vitreous incarceration and, if a 20 g vitrector was employed, sutured with a double bite mattress stitch of 8-0 vicryl or the surgeon's preferred closure. If a 23 g trocar cannula system is to be used a true sutureless incision can be performed. The eye must be firm and intact with closed or sutured incisions. Pull the conjunctiva away from the site of puncture 3.5 mm back from the limbus and initiate a partial thickness scleral tunnel with the trocar parallel to the limbus. Travel 2 mm, then turn the device perpendicular to the sclera and puncture the sclera in the direction of the optic nerve, driving the cannula trocar system through the eye wall. Once the trocar is in place, remove the MVR blade and leave the seated cannula for the vitrector's insertion. If vitreous has been lost, you will not be able to close the incisions, even with sutures, so a direct MVR entry with suturing would be safest. Because the trocar cannula protrudes into the vitreous cavity, the vitrector probe never gets close to the retinal surface, as it does when inserted through a bare sclerotomy. This design provides a margin of safety upon entry and exit. As they become sharper and require less pressure for entry, trocars will become the entry of choice.

Cortex Removal

Once vitreous and lens particles are removed, cortex often remains. We must clean the capsular fornix thoroughly to avoid inflammation, a poor-quality view with fluffed cortex in the post-operative period, and ultimately to reduce the risk of cystoid macular edema (CME). The safest way to clean the capsular bag (albeit not the most efficient) is to empty it with a dry technique by expanding the chamber and the capsular fornix with cohesive viscoelastic, packing in the dispersive agent to cover the capsule or the zonular defect. Without irrigation use a 26 g cannula on a 5 ml syringe to suction out residual cortex. Replace the cohesive optical variable device (OVD) as needed to keep the capsular fornix expanded and the eye normotensive as cortex removal proceeds. This technique avoids the risk of displacing more vitreous with irrigation and inviting it forward, or pushing fragments to the back of the eye. Another way to remove residual cortex is via bimanual I&A. Some surgeons prefer this strategy because of its efficiency and it is safer than coaxial I&A because the separate aspiration can be kept fully occluded as cortex is stripped, while irrigation through the side-port paracentesis encourages vitreous to stay back. Although unlikely, if vitreous is encountered there will be a tractional event and so a safer approach is with the vitrector on irrigation/vacuum/cut. Cortex is removed in foot position 2 and should vitreous represent foot position 3 it can instantly relieve a tractional event. Regardless of the method, make sure to prevent the chamber from collapsing while removing instruments.

Inspection and Intraocular Lens Choice

Stop and inspect. Verify a clean bag and the absence of residual vitreous prolapse. Use an instrument to gently retract the pupil edge to look into the fornix. Be sure the pupil is round without a peak, which is pathognomonic of a residual vitreous strand adherent usually to the incision. The pupil should be constricted before the end of the case to verify symmetry. Be certain all incisions are sealable. Evaluate the intactness of the CCC and the extent of the posterior capsule tear and residual sulcus support.

A foldable IOL should be placed in the bag only if the posterior tear has been converted to a posterior continuous curvilinear capsulorhexis

(PCCC). No matter how round in appearance, an unconverted tear may extend with the least pressure. If the PCCC is 4–5 mm and centrally located, then we can place a three-piece lens in the bag and perform an optic capture through the PCCC into Berger's space. This is the ideal outcome. If these conditions are not present then, if the anterior CCC is intact, the foldable lens should have sulcus haptic placement with the optic captured through the anterior CCC into the bag. In the absence of any intact CCC, a sulcus-style IOL (only the Staar AQ series is ideal for the sulcus in the US) may be placed entirely in the sulcus if there is adequate posterior capsule support 180 degrees apart. If a standard three-piece sulcus implanted lens cannot be optic captured, consider suturing it to the iris. Plate haptic and one-piece acrylic lenses are not intended for the sulcus and can only appropriately be placed into an intact capsular bag.

A single-piece polymethyl methacrylate (PMMA) lens should ideally be used through a scleral or limbal wound because a larger than 4 mm size incision is required. In the absence of capsule support one could employ a sutured posterior chamber lens or an anterior chamber open loop lens according to surgeon preference. Consider reducing operative time and trauma after a difficult case by the choice of the anterior chamber lens with a peripheral iridectomy easily made with the vitrector on I/A/cut. When appropriately sized, they have not been associated with an increased risk of corneal decompensation or glaucoma. The author believes the glued scleral fixation method has not yet stood the test of time.

If the surgeon has been unable to clean the anterior chamber or there is significant edema and reduced view by the end of the case, and particularly if posterior loss of lens material is confirmed or suspected, leaving the eye temporarily aphakic may be the wisest option. A poorly placed lens or an unstable one can create increased inflammation and hamper a subsequent vitreoretinal surgery. Suture even a sutureless-style incision if a subsequent retinal surgery is anticipated.

Post-operative Care

Remember that there is a 14-fold increased risk of endophthalmitis with vitreous loss compared with lens extraction with an intact capsule. Therefore, I add one prophylactic oral dose of moxifloxacin immediately post-operatively as well as my usual off-label intracameral moxifloxacin. Both topical steroid and non-steroidal anti-inflammatory drugs (NSAIDs) should be used more aggressively as well. A pressure rise is also anticipated, especially in the setting of retained lens material. Be proactive with hypotensive medication

Conclusion

Effectively dealing with a crisis is, more often than not, a matter of having prepared for it. We must remain ever mindful of not causing intra-operative or allowing post-operative vitreous traction. The author hopes this paper will help the reader achieve the excellent visual results that are still obtainable in these challenging cases. ■