

Ultrasonic Biomicrocopy or UBM – high frequency ultrasound

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Section and subsection titles (time)

Introduction (0 to 1:30)

Ultrasonic Biomicrocopy or UBM is a useful diagnostic tool with diverse clinical applications for visualizing subtle detail in the anterior segment. When paired with the Clearscan® cover, a single use “balloon” appearing accessory, the anterior segment, lesions side of the eye, the lid, as well as lachrymal anatomy are readily examined. The FDA certified Clearscan® makes the old *gel and shell* technique obsolete and overcomes limitations related to sterility, comfort and safety. The UBM is invaluable in the glaucoma patient where imaging the angle, scleral spur and structures behind the iris such as the ciliary body give information that can lead to better treatment decisions. Inspection of these posterior structures are not possible with coherent light technology. Consider the UBM for sulcus-to-sulcus measurements for the implantable contact lens as well as for determining the presence of synechia, cysts, clefts, retinoschisis and melanomas that have invaded the ciliary body.

Use of the ClearScan: fill technique with a sealed probe and methods of optimizing internal bag pressure (1:30 to 6:50)

There are two types of UBM probes. The sealed unit is filled with oil, versus an open probe that must be filled with distilled water prior to use. Each of these units requires a different fill method when using the Clearscan® cover. Peer reviewed literature shows the sterile/sanitized Clearscan® cover, which is pressurized, to be safer than an open shell, prevents accidental probe contact with the cornea, and being more comfortable than the open shell technique. Further, it is an FDA certified device. With the 25 MHz sealed transducer, the probe body has a parting line, in other words two pieces of plastic joined together which must be sealed to prevent leakage of water from the Clearscan® cover. A simple flexible sheath is available that stretches over the

probe body covering the parting line. The sheath is tubular and it fits tightly over this parting line at the lower aspect of the transducer. The no cost sheath is durable and will last 6 months or a year if not longer. When using the Clearscan® cover with a sealed probe, the bag can be filled with either tap or distilled water to the bottom of the Clearscan® ivory ring, with the clear silicone seal facing upwards. Sterile water is preferred in case there is any spillage. In addition to providing a water-bath separation between the cornea or the side of the eye and the probe tip, upon transducer insertion the bag is now pressurized minimizing the likelihood of the probe making direct contact with the eye. Note the Clearscan® cover is a sterile or sanitized unit intended for single use. Prior to use a line is drawn on the side of the Clearscan® with a Magic Marker permitting accurate alignment with the white line on the probe. This is important to identify image orientation. It is important to know that whatever structure the white line faces appears on the right hand side of the display screen. In other words when examining the right eye, if the probe white line is directed at toward the nose, the right side of the screen will depict nasally located structures and the left side of the screen will show temporal structures.

Again, when filling the Clearscan® the silicone gasket is the insertion side and also functions as a release valve. This is critical when adjusting internal bag pressure, especially in the patient with low intraocular pressure. In summary, the proper fill technique for the sealed probe does not necessarily require distilled water, although sterile water is recommended, but the bag should be about 75% to 80% full. It is recommended to pour water slowly into the bag minimizing the formation of air bubbles. Align the white line on the side of the probe with the line on the Clearscan® cover. It just takes seconds to accomplish the fill and insertion steps. Appropriate bag pressure prevents denting of the cornea, an important point to remember because not every patient has the same intraocular pressure. Changing bag pressure can be accomplished in several ways. For correct probe insertion depth inspect the side of the filled Clearscan® that has been affixed onto the probe. A good starting point for your examination is when you can just see the white line peeking out from under the ivory collar. Creating a conical bullet shape to the bag end is optimal and an indicator of correct pressure.

Over-pressurizing will cause the tip to swell making the examination more difficult, especially if the lid fissures are narrow, and in patients with low intraocular pressure, cause corneal denting.

The over pressurized and distended probe tip will prevent a complete sulcus-to-sulcus view. Recall that the inner silicon ring functions as a relief valve. Another way pressure can be quickly reduced is by holding the filled Clearscan® firmly with one hand and sharply pushing the probe to one side. You readily see bag wrinkles after instantaneously expelling air from the bag, hence indicating a lowering of bag pressure. Also the probe body can be pulled up slightly from the bag collar increasing probe volume.

While under-pressurization may produce wrinkles or feathering on top of the cornea, generally this is just cosmetic and will not necessarily affect the visualization of the underlying ocular structures. However for aesthetic purposes “feathering” can be eliminated by slightly sliding the Clearscan® upward or pushing the probe deeper into the bag thereby increasing pressure.

Fill technique with an open probe (6:51 to 7:52)

This 50 megahertz probe is the revised model and the white line has been moved upward so it is not necessary to mark the side of the Clearscan®. Note I am holding the Clearscan® in the crook of my left hand and adjacent in the same hand is the open probe with the marker facing out. I slowly add distilled water to both the Clearscan® and the probe. Quickly mate the two together. This is usually assembled over a paper towel or wastebasket in case water spills. If the bag appears bulbous and over pressurized, the conical bullet shape can be achieved after reducing pressure, by pushing the probe against the internal seal of the Clearscan® to expel water and air or unscrewing the set screw to release excess water. If necessary try pushing on the bag at the upper aspect near the ivory collar. Remember, the bag is sterile so avoid touching the tip. Once you have the optimal bag shape replace the set screw. Remember that the internal pressure of this bag has to be lower than the pressure of the eye. Wrinkles may be visible on the side of the bag, indicating low bag pressure, and required for a patient that has a low intraocular pressure of two or three millimeters of mercury. In normal patients feathering or wrinkling in the display on the surface of the cornea can be eliminated by slightly increasing pressure by pushing the probe more deeply into the bag. When performing a UBM examination with low IOP you will be adjusting ClearScan internal pressure by either varying the bag fill level, or probe insertion

depth, as well as pushing the probe against the silicone seal to release air and water, to find the optimal bag pressure for each individual patient.

When performing UBM examinations have the patient sitting up, in the same orientation that the eye care specialist would examine the patient. This should overcome problems in measurement accuracy since ocular structures such as the iris/anterior chamber may be subject to gravitational changes when the patient reclines.

Probe Orientation to Accurately Label Echograms – Faux Speculum Method to Open Lid Fissures and Sulcus-to-Sulcus Measurements (7:51 to 9:52)

Knowledge of *probe orientation* is necessary to correctly label your echograms. The white line on the side of the probe body indicates the direction of linear movement of a motorized nub. For examining angles in the glaucoma patient, the line should always point toward the cornea regardless of clock hour. The image captured on the screen will *always* show the sclera on the left side of the screen and the anterior chamber on the right. When performing a Sulcus-to-Sulcus measurement the probe line will face the nose for the right eye and the ear for the left eye. The resultant echogram will be in the same orientation as if you were directly viewing the patient's eye. Make sure that the Clearscan® is centered on the cornea and the bag pressure is adjusted to allow complete corneal coverage. Patient fixation is important in the sulcus-to-sulcus exam.

I use what is called a *faux speculum* to maximally open the fissures. In the hand holding the probe, curl your last three fingers like this, to pull down the lower lid. The thumb of the left hand pushes the upper lid up to the boney brow. *For sulcus-to-sulcus ultrasounds*, look carefully at the eye making sure it is centered and aim the conical-bullet Clearscan® tip at the center of the pupil. It takes just seconds to obtain a perfect sulcus-to-sulcus scan. The image itself is smooth on the corneal surface implying that the vector forces are even and spread evenly over the first surface of the cornea. One disadvantage of the open shell technique, aside from being uncomfortable, is “tenting” of the cornea due to excessive force of the open shell on the sclera,

bending the apex of the cornea, the thinnest part. “Tenting” affects the reliability of sulcus-to-sulcus measurements. This is eliminated with the Clearscan® cover technology.

Examining Angles and Identifying the Scleral Spur (9:54 to 13:06)

When examining angles, the probe line is directed to the cornea. To scan the temporal angle have the patient look slightly nasal (3:00 right eye). Continuing, when visualizing the inferior angle the patient looks superiorly slightly (12:00). For the nasal angle patient looks slightly temporal (9:00) and when examining the superior angle the patient looks slightly downward (6:00). When capturing this sonogram of the temporal angle, keep in mind several things. Make only micro movements up, down, left and right. The pupil is an important landmark that should appear in every angle and sulcus-to-sulcus echogram. Let’s study the inferior angle; the patient is directed to look slightly superior, following my finger used for fixation. The probe’s white line faces the cornea. Make small almost micro-movements when the probe is on the eye so that pupil appears on the screen. It only takes seconds to obtain an excellent echogram that is much more comfortable for the patient and easier on the examiner than the open shell technique because the bag is gently covering the sclera.

The sclera spur is the gateway to the anterior chamber and an indicator of whether the angle is open or closed, but often the spur is difficult to identify reliably. There is an acoustic discontinuity between the scleral and uveal tissue producing a dark line on the echogram. The spur is located somewhere on this line. Use the calipers, under tools, and measure one millimeter back from the transition interface between the cornea and sclera. Then draw a line straight down and where it intersects the scleral/uveal line is the approximate location of the scleral spur. In this patient the sclera spur angle is open completely normal. While the 25 megahertz probe might have somewhat reduced resolution it has the advantage of further penetration, an important benefit when trying identify the posterior capsule of the phacomorphic patient. Even with less resolution the examiner will not miss the presence of significant pathology.

At the end of UBM examination throw away the Clearscan® cover as the possibility of transferring of microorganisms from patient-to-patient is real. A study showed that this is potentially a problem. Thirty-four subjects had both eyes examined by UBM using the Clearscan® cover. Following ultrasound the tip of the Clearscan® was swabbed and sent to the pathology lab where 80% of 34 patients grew microorganisms associated with either endophthalmitis or keratitis.

B-scan Introduction and Probe Orientation

The B-scan ultrasonography is used primarily for vitreal, retinal and orbit examinations. In the diabetic patient, sound waves readily penetrate vitreous hemorrhage allowing a direct inspection of the retina or choroid to determine detachment. Membranes may be separated from detachments. Calcium in the nerve head, posterior vitreal detachments causing retinal tears, scleritis, foreign bodies and tumors are just a few entities that lend themselves to B-scan ultrasonography.

The B-scan probe is focused at the level of the retina. Generally, exams are performed through the eyelids. However, you trade 10% in reduced resolution for increased patient comfort and cooperation. If you are trying to detect subtle pathology such as a recent vitreous hemorrhage, endophthalmitis or to obtain accurate tumor measurements, the 10% resolution is not worth sacrificing and it is recommended that you examine directly on the eye.

Probe orientation is a confusing concept. There are transverse and longitudinal scans. Transverse scans across six clock hours whereas a longitudinal scan shows only a single clock hour, from the optic nerve to the ora. In contrast to the UBM where ocular structures adjacent to probe line appear on the right hand side of the screen, with B-scan the structures facing the probe marker appear at the top of the screen. So when looking at a patient (right eye – transverse scan) and the line is facing the nose, then the nasal aspect of the eye is at the top of the screen. The white line on the probe body indicates the direction of movement of a motorized nub that waggles back and forth. The nub moves in a lateral direction oriented with the white line on the side of the probe.

Lets try to clarify the difference between a transverse scan with transverse meaning across six clock hours in contrast to a longitudinal scan, an examination of a single clock hour. So if the patient is looking down (inferiorly) at 6:00 the probe is placed on the upper lid directing sound waves across the eye to the inferior part of the globe. When examining the right eye – transverse scan, if the probe marker line faces the nose, the internal nub is wagging between 3:00, 6:00 and 9:00. By shifting the probe further from the limbus, the same six clock hours can move from the level of the optic nerve to the equator and toward the ora. For a longitudinal scan the probe is turned 90 degrees with the probe line touching the limbus. Of course the probe nub is still wagging, but now it's only scanning a single clock hour. The probe marker always faces the cornea and sound waves are directed to the opposite side of the eye. For longitudinal scan inferiorly, the marker is placed on the upper lid with the marker line facing the cornea. The resultant scan will show a single clock hour, 6:00, with the optic nerve at the bottom of the screen and the ora at the top. Don't forget to use some type liquid interface between the lid or eye and the probe with one or two drops of viscous solution such as goniosol or Genteal.

Your first scan, regardless of diagnosis, should be a transverse scan to determine if the fovea is intact. The fovea, responsible for detailed vision, and translates to quality of life for the patient. The probe line faces the nose (right eye-transverse scan) and the transducer is close to the limbus with sound being directed to the optic nerve. When performed correctly, the nasal retina is at the top of the screen, a black "V" or the optic nerve is apparent and just on the other side of the nerve on the temporal retina is the fovea. Is the fovea, thickened or detached? With the patient looking down, cup your right fingers that are holding the probe and make micro movements. I steady the probe with two fingers of my left hand. Drape the transducer cord over your shoulder so it doesn't end up in the patient's face. With the patient is looking down make micro-movements. In this example with the nerve centered on the screen, the probe line faces the nose and remember structures adjacent to the line appear at the top of the screen. Nasal is at the top of the screen and the optic nerve right is the *echolucent* or black area and the temporal retina on the other side. Transverse scans covering six clock hours can be: 3:00 to 9:00 as well as 6:00 to 12:00 and 12:00 to 6:00. Retinal and choroidal layers can be identified individually, a subtle but

important distinction. With the patient still looking down I am switching from a transverse scan, to a longitudinal scan, along a single meridian. Note the probe line is at the superior limbus pointing toward cornea with the sound waves directed at 6:00. Have the patient look in the direction that you, the echographer, want to examine with the probe on the other side of the eye. Again with the longitudinal scan, the optic nerve is always at the bottom of the screen and the ora toward the top of the screen. We can readily visualize retinal and choroidal layers. As you are examining, keep in mind that increasing or decreasing gain or sensitivity depends on the pathology you are investigating. For recent vitreous hemorrhages, endophthalmitis or posterior vitreal detachments increase the gain. However if you're looking for a drusen or calcium of the nerve head you need to sharply reduce the gain.

10 megahertz B-scan and the Clearscan® cover for use in a sterile environment and for examinations of the anterior segment as well as the retina (15:41 to 18:10)

The Clearscan® can be used with a standard 10 megahertz probe with an adapter for both retinal and anterior segment ultrasounds. Some clinics and hospitals require that any instrument that touches the eye must be sterile. An ultrasound probe can not be sterilized, but since the Clearscan® is sterile or sanitized for single use, the transfer of micro-organism from patient-to-patient is minimized and ultrasounds can be performed in a sterile environment such the operating room. The front of the eye, the including the anterior chamber, can be visualized with a water filled Clearscan® attached to the B-scan probe, but of course without the detail of a high frequency UBM. However resolution is adequate to determine whether a melanoma has invaded the ciliary body. For a conventional B-scan of the back of the eye and orbit or an anterior segment examination the adaptor must first be affixed to the ultrasound probe.

After anesthetizing the eye with a topical anesthetic, align the adaptor marker with the line on the probe. Adaptors are available for the various Quantel probes. For an *anterior segment ultrasound* fill the bag with water and insert the probe about 1/4 of an inch into the bag until you can just see the white probe marker under the ivory collar of the Clearscan®. Again, if you needed to change pressures for better corneal coverage or to eliminate wrinkles, you can move the Clearscan®

collar forward or backwards or push the body probe sharply against the Clearscan[®] silicone seal to release air and water.

When conducting a *retinal examination* instead of filling the bag with water, just add a few of drops of a viscous gel such as goniosol to the inside bag surface and push the probe all the way to the bottom of the bag so that the probe tip is covered by the gel. In other words, the gel acts as an interface between the probe and the inner bag surface. Also place gel, such as Genteal on the outer surface of the bag and you are ready to begin your ultrasound examination.

ESI, Inc of Plymouth, MN, manufacturer of the Clearscan[®], makes adaptors for a wide variety of probes including the 10 megahertz transducer being used in this segment. With the bag filled and maintaining its conical-bullet shape, after adjusting the collar up and down the adaptor body and expelling air if necessary, we are going to scan the anterior segment. The image will not be as detailed as a 25 MHz or 50 MHz UBM, but 10 MHz is adequate to identify gross pathology without having to buy additional equipment. The adaptor with the Clearscan[®] affixed to it can be “burped” by pushing the probe against the silicone seal to obtain the appropriate conical bullet shape. With the patient fixating on my finger we readily see the cornea, the iris and the posterior capsule of the lens if the tip of the Clearscan[®] is directly centered on the cornea. The edge of the bag is rolling off the ocular plane and presents as a vertical line on the screen. If sterility is required, such as an examination in the operating room or by institutional requirements, transfer of micro-organisms are minimized by using the sterile Clearscan[®]. Anterior and posterior ultrasounds are possible with no artifact as the the Clearscan[®] bag material is acoustically invisible.

Demonstration of the Prager Shell for axial length measurements: Biometry/axial length measurement and how to attach/detach tubing (19:33 to 23:39)

The fixed immersion shell has essentially replaced the awkward two-handed open shell method of biometry. Clinically there is no difference between immersion biometry and coherent light methods of measuring axial length prior to cataract surgery. Fixed immersion makes it easier to

get on axis and obtain scans as an internal shelf positions the probe at the exact distance from the cornea as recommended by the manufacturer. A Prager Shell is the only FDA certified device. BSS will be infused through sterile tubing to create a water bath between the cornea and the probe tip. This tubing is for single use to prevent transfer of microorganism to other patients. Tubing is available with check valve so that there is no reflux of BSS back into the bottle. This is a cost saving feature because a small BSS bottle is adequate for 3 to 5 patients. After each measurement don't forget to soak the shell with probe attached in alcohol for at least 5 or 10 minutes to kill any residual bugs and discard the tubing.

Attaching the tubing to the Luer fitting on the side of the shell is very straight forward. The outer ring of the Luer fitting tightens by turning to the right. Removing the used tubing requires a counter clock wise twist of the outer ring and it is important to pull it back slightly to engage a set of teeth on the end of the tubing then continue twisting.

methodology

Patient cooperation is paramount. Begin by applying topical anesthetic to each eye. A detailed explanation to the patient aids in creating a successful outcome resulting. Obviously if you just insert the shell in an uninformed patient you will create a nervous individual who is reluctant to cooperate. Before I insert the immersion shell, I might lightly put my thumb over the upper eyelid, if it flutters I'll leave my thumb in place for 15 to 20 seconds until the tremors disappear.

Note that the tubing, attached to the shell faces the ear, in other words it is always on the temporal side of the face. On the left side it's going to face the left ear and on the right side the right ear. As a biometrist I focus on keeping the rim of this hard plastic shell off the cornea. It's very easy to remove epithelium cells or microtoming the cornea such that it's going to be very irritating to the patient and may take a while to heal, especially in a diabetic patient.

I ask the patient to direct their gaze downward. "Looking down at your feet, look way, way down, now open both eyes look up to the top of your head." Note that my hand is resting on the forehead. I'm actually reducing the shell's downward force. Having minimal pressure on the eye, will be appreciated by the patient. It is very instructional for you, the health professional performing this test, to have this procedure performed on you at least once to experience what

it's like from the patient's point of view. I'm going to move the Kleenex to the temporal side of the shell in case any water dribbles out. I am filling the shell to cover the bottom of the probe by slowly squeezing the BSS bottle. Have the patient look straight forward and depress the foot switch. It just takes several seconds to acquire ten readings, thus the advantage of the fixed immersion shell. To remove the shell, have the patient look up, look way up on top of their head. Gently pull down the lower lid and rotate the shell out and away from the eye. Mop up any residual water and concludes the examination.

Always measure both eyes as they should be within 0.3 mm of one another. A one mm mistake results in a 3 dioper error. Inspect the acquired waveforms to be sure they are of equal height, not stair stepped and that you see spikes behind the retina.