High-Frequency UBM

As the need for precise, high-resolution imaging of anterior segment structures continues to grow, ultrasound biomicroscopy may prove to be a valuable diagnostic tool.

BY NICHOLAS P. BELL, MD, AND KUNDANDEEP S. NAGI, MD

High-frequency ultrasound biomicroscopy (UBM) is a noninvasive diagnostic tool for in vivo imaging of the anterior segment.[1] In ultrasonic imaging, a transducer emits a short acoustic pulse that generates echoes as it propagates through various anatomic tissue structures, each with a specific acoustic density. The echoes are translated into voltages, amplified, and converted into pixel intensity to create a two-dimensional cross-sectional image.[1]

Among glaucoma, cornea, and refractive specialists as well as comprehensive ophthalmologists, there is a growing need for precise, high-resolution anterior segment imaging for diagnostic purposes and surgical planning, especially in patients with narrow anterior chamber angles and refractive surgery candidates. The cost of UBM technology was long prohibitive for physicians not in large academic practices. As the price of equipment decreases, however, high-frequency UBM is finding its way into more and more private clinical offices.

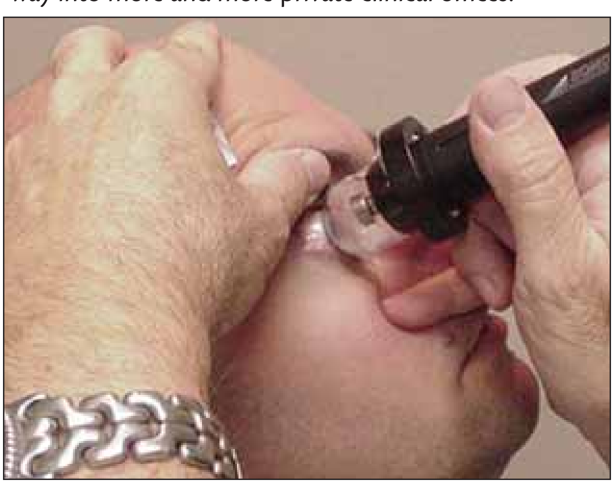

Figure 1. A single-use, water-filled bag/balloon probe cover (ClearScan) provides enough standoff to overcome the near-field artifact and also allows for a safe, comfortable UBM examination while the patient is supine.

"One of the most useful roles of high-frequency UBM is in differentiating the causes of angle closure."

UBM VERSUS OTHER MODALITIES

Most ophthalmologists are familiar with ultrasonography of the posterior segment using a 10-MHz transducer probe. Unfortunately, the low resolution of the 10-MHz system is inadequate for diagnostic utility in the anterior segment. UBM uses a higher frequency (20-80 MHz), which allows for better image resolution and increased magnification.[1]

Although slit-lamp biomicroscopy and gonioscopy can be used to visualize the anterior segment, structures that are posterior to the iris cannot be viewed using such conventional methods. Anterior segment optical coherence tomography provides excellent views of the anterior chamber, but the technology cannot acquire images behind the heavily pigmented posterior surface of the iris, because the coherent light is absorbed by the iris pigment epithelium. Sound waves, however, are not obstructed and thus can be used to image not only the anterior chamber angle but also structures that are posterior to the iris such as the ciliary body, ciliary sulcus, peripheral lens, zonules, IOL's haptics, and posterior chamber.[1-3]

Whereas optical coherence tomography is a noncontact method of imaging the eye, ultrasonography requires a liquid or gel interface with the ocular surface. Furthermore, an acoustic "dead zone" exists between the probe and the focal point of the emitted sound waves. The traditional UBM examination uses an open

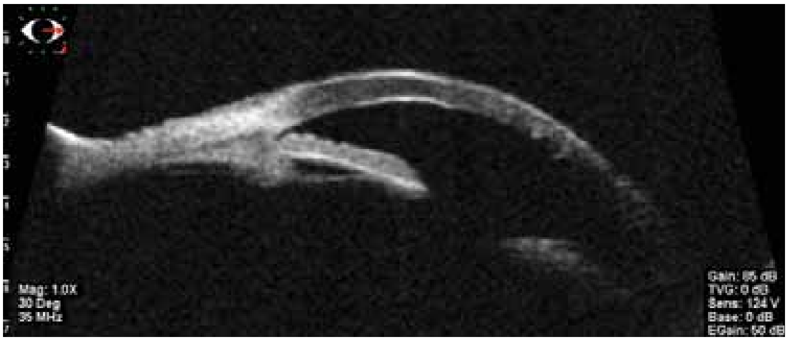

Figure 2. In this 35-MHz image of an eye with plateau iris configuration, anterior rotation of the ciliary body is visible, but the iris is not bowed.

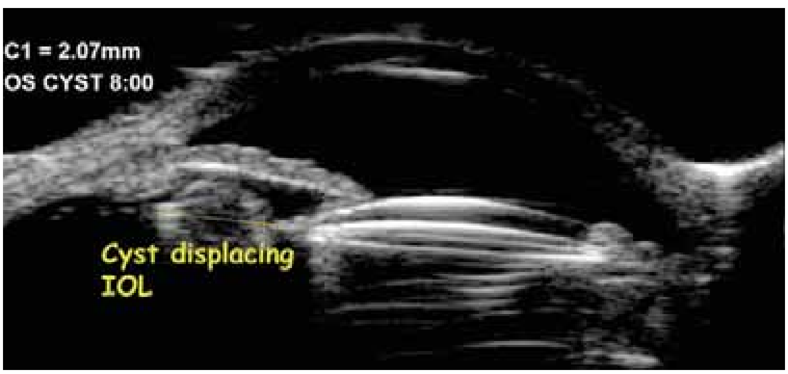

Figure 3. A large ciliary body cyst is causing dislocation of the IOL.

plastic shell to contain the coupling fluid and provide the standoff needed to overcome the near-field artifact. The patient must be in the supine position to prevent the fluid from spilling out of its well. This examination requires a skilled technician to obtain quality images and also to take care not to abrade the cornea or conjunctiva with the edge of the plastic shell or the moving nub of the UBM probe. When the clinician is attempting to examine structures posterior to the limbus, the patient must move his or her eye, and abrasions are more likely.

A recently developed bag/balloon cover (ClearScan; ESI, Inc., Plymouth, MN) is a single-use, sterile bag with a plastic ring that fits over the distal end of the ultrasound probe to form a watertight seal. Pushing the cover against the eye generates positive pressure to maintain space between the ultrasound transducer (inside the bag) and the ocular surface (outside the bag), thus overcoming near-field artifact (Figure 1). A distinct advantage of the bag/balloon device over the traditional gel/shell method is that the UBM assessment can be performed with the patient either seated or supine.[2] As with B-scan ultrasound of the posterior segment, the full value of ultrasound is realized with dynamic testing.

UTILITY

UBM has demonstrated usefulness for evaluating the anterior segment of eyes with narrowing of the iridocorneal angles[4] and primary angle-closure glaucoma.[3,5] The modality also offers mechanistic insights regarding malignant glaucoma and pigmentary glaucoma.[3] Because pathology posterior to the iris is undetected by anterior segment optical coherence tomography, UBM is the ideal imaging modality for evaluating abnormalities in the ciliary body's position, as can occur with plateau iris configuration and syndrome, malignant glaucoma, and anteriorly located annular choroidal effusions.[1]

One of the most useful roles of high-frequency UBM is in differentiating the causes of angle closure. In primary angle closure, forward bowing of the iris is typically evident. Posterior synechiae may even be detectable. With plateau iris, UBM generally demonstrates an anteriorly rotated ciliary body with obliteration of the ciliary sulcus and a flat central iris plane[1,3,6] (Figure 2). If a narrow angle is identified and UBM reveals the absence of any iris bowing and ciliary processes consistent with plateau iris configuration, the ophthalmologist could consider performing iridoplasty without first having a peripheral iridotomy "fail." Interestingly, some patients have been noted to have findings of both plateau iris and pupillary block. If their angles do not open sufficiently after only iridotomy, clinicians can reexamine these patients with UBM to help decide if they also need an iridoplasty to prevent an angle-closure attack.

Changes in ambient lighting cause identifiable anatomical alterations in the iridocorneal angle. As expected, imaging with UBM has revealed a narrowing of the angle in scotopic compared to photopic conditions.[7] Thus, when evaluating patients who are at risk for angle closure, imaging of the anterior segment should be done in low-level, mesopic lighting conditions so that the angle may be assessed at its narrowest.

Iris cysts are commonly discovered with UBM. They are usually insignificant but sometimes may narrow the anterior chamber angle or displace the crystalline lens or an IOL (Figure 3). Malignant glaucoma is characterized by a forward movement of the iris-lens diaphragm, absence of iris bowing, a very shallow anterior chamber,

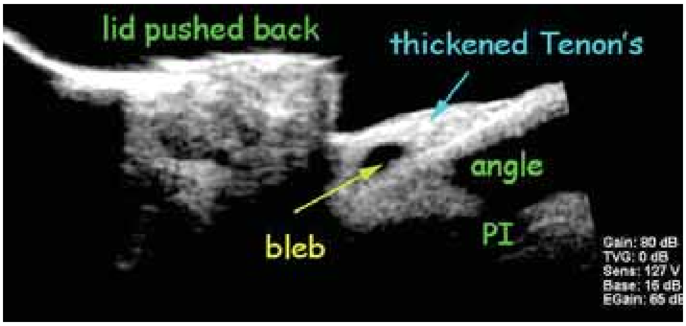

Figure 4. A thickened wall of a conjunctival filtering bleb in an eye with clinically elevated IOP 3 months after trabeculectomy.

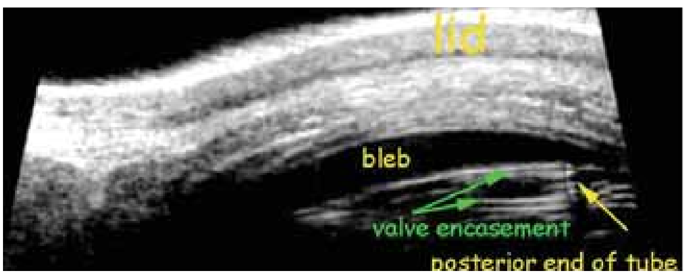

Figure 5. Reservoir plate of functioning valved glaucoma drainage device and overlying bleb. This 35-MHz UBM image was obtained using a bag/balloon probe over a closed eyelid while the patient was supine.

and possible contact between the ciliary processes and the lens equator. A dynamic scan with UBM can be quite useful for diagnosing cyclodialysis clefts, which are not always visible on gonioscopy.

Anterior suprachoroidal effusions may be difficult to identify by indirect ophthalmoscopy. They can easily be found with UBM, however, especially when the bag/balloon technology is used, which allows for the comfortable placement of the handpiece posterior to the limbus. Additionally, because the water-filled probe cover is so well tolerated by patients, it can be used to image the fragile tissue of a filtering bleb or the posterior end of a tube shunt[2] (Figures 4 and 5).

With UBM, the cornea surgeon can look behind a densely opaque or edematous cornea to evaluate if penetrating keratoplasty will benefit the patient. The refractive surgeon can use UBM to assist with surgical planning prior to implanting phakic IOLs. If zonular dehiscence is suspected in an eye with a visually significant cataract, UBM allows the surgeon to identify the extent of zonular loss preoperatively. Evaluating malpositioned or dislocated IOLs with UBM assists the planning of surgical revision.

Finally, UBM can help ophthalmologists evaluate and manage ocular and even adnexal tumors. Detecting and measuring the extent of iris and ciliary body melanomas can be difficult with a clinical examination alone. With UBM, the ophthalmologist can measure the tumor's size and plan surgical excision more precisely. In addition, because the bag/balloon probe cover can mold to irregularly shaped surfaces, there is the potential to measure the size and extent of basal cell carcinomas on the eyelid, cheek, or side of the nose.

CONCLUSION

UBM can be beneficial in the practices of glaucoma, cornea, refractive, and even oculoplastic subspecialists. As this clinical diagnostic tool becomes more affordable, the examination becomes increasingly comfortable for patients, and practitioners gain greater familiarity with its potential applications, UBM will likely become more and more popular in comprehensive ophthalmology offices. ❑

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