

Ultrasound Biomicroscopy and Angle Closure

Differentiating between the various causes of blockage.

BY DOUGLAS J. RHEE, MD; GEORGE L. SPAETH, MD; L. JAY KATZ, MD; AND JONATHAN S. MYERS, MD

Ultrasound biomicroscopy (UBM)—developed by Charles Pavlin, MD; Michael Sherar, PhD; and F. Stuart Foster, PhD—utilizes a high-frequency transducer to deliver high-resolution images of the anterior segment. Commercially available UBM units (Figure 1) operate at 50 MHz, produce a tissue resolution of approximately 50 μ m, and penetrate 4 to 5 mm of tissue. Typical B-mode ultrasonography performs at just 8 to 15 MHz with an approximate resolution of 0.11 mm and penetrates between 30 and 40 mm (ie, a few millimeters posterior to the globe).¹ An increase

in the frequency improves the resolution but decreases the penetration of tissue.

UBM is useful for defining anterior segment anatomy in situations such as anterior segment tumors, suspected occult trauma, and postsurgical evaluations. In glaucoma, UBM can be used to take images of a variety of conditions (eg, angle closure, cyclodialysis clefts) and to assess the placement of posterior chamber IOLs in the evaluation of UGH syndrome. Ophthalmologists must be able to differentiate between the various causes of angle closure, because their treatment varies.



Figure 1. The commercially available Humphrey UBM (Model 840; Carl Zeiss Meditec Inc., Dublin, CA) with the upgrade from Paradigm Medical Industries, Inc. (Salt Lake City, UT) has a hand-held probe mounted on an arm (A). Here, clinician Libba Affel performs the scan while the patient is in a supine position; she uses an eyecup containing methylcellulose or saline solution (B). She places the ultrasound tip into the fluid to obtain an image (C).

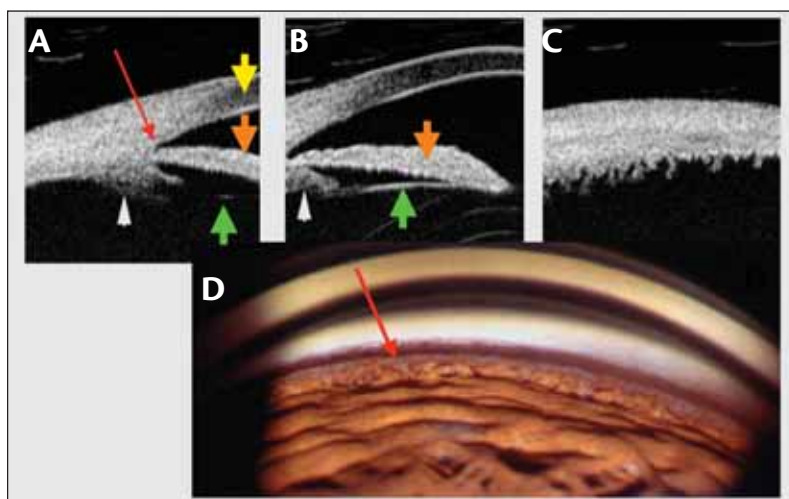


Figure 2. The UBM images show a healthy eye with a wide anterior chamber angle (A through C). The ciliary body (white arrow), lens capsule (green arrow), cornea (yellow arrow), iris (orange arrow), and scleral spur (red arrow) are visible. A cross-section displays normal ciliary processes of normal thickness (C). A gonioscopic photograph of the same eye shows the scleral spur (red arrow) (D).

NORMAL ANATOMY

Aqueous is produced in the ciliary body processes. It then flows through the posterior chamber, behind the lens and iris, through the pupil, and into the anterior chamber. Aqueous drains through the trabecular meshwork and ciliary body face, which are collectively referred to as the *anterior chamber angle* (Figure 2).

In an eye with a clear cornea and an open angle that has some pigmentation of the trabecular meshwork, the angle's structures can be easily examined using gonioscopy. UBM can help the clinician visualize structures behind the iris. It is also of benefit when the anterior chamber structures cannot be clearly seen, such as through a cloudy cornea, with an obstructed view from the iris, or due to a lack of pigmentation in the trabecular meshwork.

PRIMARY ACUTE ANGLE-CLOSURE GLAUCOMA

Overview

Primary acute angle-closure glaucoma occurs when the iris mechanically blocks the trabecular meshwork and ciliary body face, thus causing a rapid elevation of IOP. Specifically, primary acute angle-closure glaucoma occurs from pupillary block or plateau iris syndrome.

Pupillary Block

Primary acute angle-closure glaucoma caused by pupillary block occurs in ana-

tomically predisposed individuals such as persons with narrow angles and a shallow anterior chamber (Figure 3). The prevalence of narrow angles varies by ethnicity and occurs more commonly in Asians than in whites or blacks. The prevalence of narrow angles in whites in the Framingham Study was 3.8%.² In the ethnically mixed black and white population of the Baltimore Eye Study, the prevalence of narrow angles was approximately 2.1%³ versus 8.5% in a Vietnamese population.² Additional risk factors for pupillary block include hyperopia and older age.

The cause of narrow angles is unknown but is related to the anterior-posterior growth of the lens that occurs with age. The crystalline lens grows in all people, but it results in a narrow angle and shallow anterior chamber only in some individuals. When the pupil dilates, the vector forces of the iris' dilatory mus-

cle pull the iris not only centripetally, but posteriorly as well. The subsequently increased apposition between the iris and the lens blocks the flow of aqueous through the pupil. Continuing secretion of aqueous humor creates a pressure differential between the anterior and posterior chambers that bows the iris forward (ie, iris bombe) and obstructs the angle.

UBM images typically show apposition of the peripheral iris against the trabecular meshwork. The ciliary body is angled downward. Moving peripherally from the pupil, the iris has a bowed appearance, but no angulation.

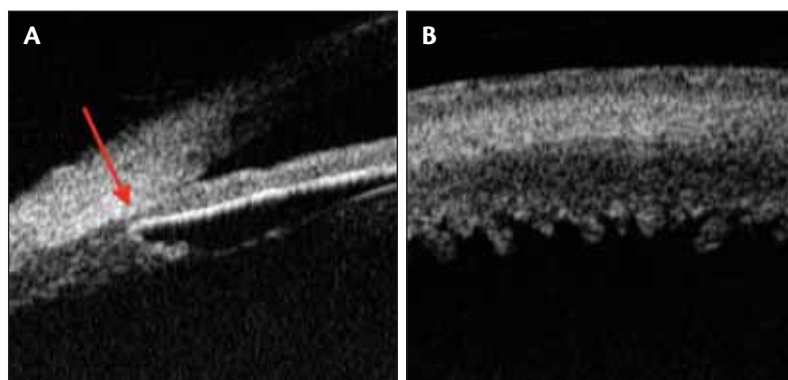


Figure 3. This eye (shown here by UBM) was relieved of an acute angle-closure attack using intravenous mannitol and topical aqueous suppressants. The shallow angle of the anterior chamber without iris bombe indicates that the angle closure has temporarily broken. The red arrow approximates the location of the scleral spur (A). The normal ciliary body thickness is shown in cross-section (B). This patient was successfully treated with laser iridotomy.

Plateau Iris

Plateau iris configuration is a rare condition in which the ciliary processes are anterior and rotated forward. As a result, the far peripheral iris is thrust anteriorly toward the drainage angle. This configuration causes a sharp angulation, with the remainder of the iris planar and the anterior chamber deep (hence the term *plateau iris*) (Figure 4). During dynamic gonioscopy (ie, gentle indentation on the cornea to watch the movement of the peripheral iris roll), the anteriorly rotated ciliary body makes the peripheral iris resistant to posterior bowing. UBM can show the location of the ciliary body and the distinctive angulation of the iris. Mechanical blockage of the drainage angle due to bunching of the peripheral iris during dilation can cause primary acute angle-closure glaucoma. Iris bombe does not occur.

As in cases of pupillary block, physicians perform medical treatment to relieve the attack and clear the cornea. Long-term medical therapy with cholinergic drugs is very effective when patients are willing to take the medication regularly and for an indefinite period. When needed, the initial surgical procedure is a laser iridotomy to relieve any component of relative pupillary block. If the angle does not significantly deepen, then argon laser iridoplasty is indicated. During iridoplasty, the surgeon uses an argon laser to create thermal burns in the peripheral iris to cause contraction of the local iris tissue toward the burn. As the iris pulls away from the angle, the depth of the angle increases.

SECONDARY CAUSES OF ANGLE CLOSURE WITH A SHALLOW CHAMBER

Aqueous Misdirection Syndrome

Aqueous misdirection syndrome, also known as malignant glaucoma, is also associated with elevated IOP and a shallow anterior chamber. Typically, this condition develops following an ophthalmic procedure. The syndrome alters aqueous flow such that the aqueous is directed posteriorly and accumulates in the vitreous. As a result, the ciliary processes, the lens/IOL, and anterior vitreous face move forward, causing the angle to close. UBM can aid clinicians in identifying aqueous misdirection syndrome by allowing them to observe the flattened ciliary processes, which are pathognomonic of the disorder (Figure 5). Occasionally, aqueous misdirection syndrome responds to medical treat-

ment with systemic hyperosmotic agents and aqueous suppressants, which can relieve the immediate rise in IOP, and with cycloplegics to pull the iridolenticular diaphragm posteriorly. If medical management fails, then the physician must break the anterior hyaloid face with either an Nd:YAG laser or a mechanical disruption (ie, vitrectomy) to allow fluid to flow freely between the vitreous cavity and anterior chamber. Typical UBM findings include apposition between the iris and the cornea. The hallmark finding is a flattening of the ciliary body processes.

Swelling of the Ciliary Body

Concentric swelling of the ciliary body can cause its and the iridolenticular diaphragm's forward rotation. Angle-closure glaucoma with a shallow anterior chamber may result.

The ciliary body may swell due to inflammation as an idiosyncratic reaction to a medication (eg, compounds containing sulfamate moieties). Topiramate, an antiseizure med-

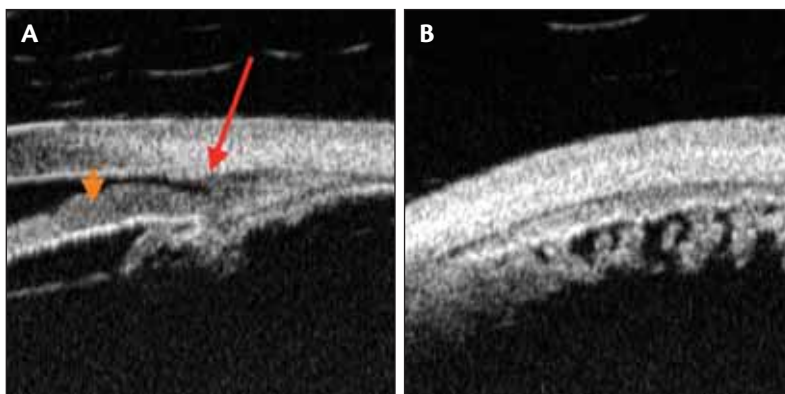


Figure 4. UBM reveals a plateau iris configuration (A and B). Moving peripherally from the pupil, the iris (orange arrow) is planar then angles sharply downward creating a narrow approach and a slit-like space between the trabecular meshwork peripheral iris. The red arrow shows the approximate location of the scleral spur.

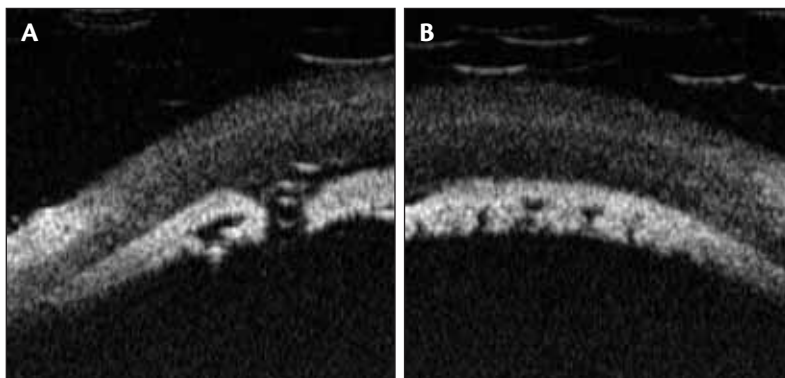


Figure 5. UBM shows aqueous misdirection syndrome following a tube shunt procedure (A). The UBM image of another eye with aqueous misdirection syndrome shows flattened ciliary body processes in cross-section (B).

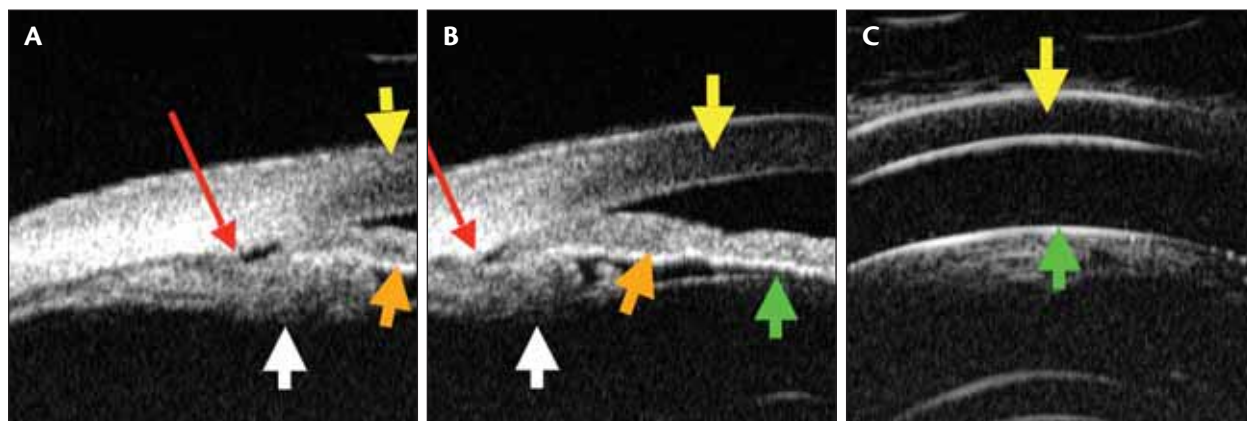


Figure 6. As visible on UBM, topiramate has induced angle-closure glaucoma. The ciliary body process is markedly swollen (white arrow), and there is no iris bombe. The scleral spur (red arrow), cornea (yellow arrow), iris (orange arrow), and lens capsule (green arrow) are also visible (A through C).

ication containing sulfonamide, is gaining wide popularity for preventing migraine headaches. The agent has been associated with swelling of the ciliary body that rotates the iridolenticular diaphragm forward and results in a spectrum of symptoms, ranging from acute myopia to angle-closure glaucoma. UBM is useful in the diagnosis of angle closure induced by sulfonamide, because it shows the swollen ciliary body processes (Figure 6).

The treatment is supportive because the swelling will resolve following discontinuation of the medication. Clinicians may prescribe topical aqueous suppressants to lower IOP while the episode abates but should avoid medications that contain sulfonamide. Peripheral iridotomy is not indicated, because the mechanism is not related to pupillary block.

CONCLUSION

UBM is noninvasive and can provide useful anatomic information on structures hidden by the iris or a cloudy cornea. This information can assist with the differentiation of the various etiologies of narrow or closed angles. □

L. Jay Katz, MD, is Co-Director of the Glaucoma Service at Wills Eye Hospital and Professor of Ophthalmology at Thomas Jefferson School of Medicine in Philadelphia. He stated that he holds no financial interest in the products or companies mentioned herein. Dr. Katz may be reached at (215) 928-3197.



Jonathan S. Myers, MD, is Associate Professor of Ophthalmology at Thomas Jefferson School of Medicine in Philadelphia. He stated that he holds no financial interest in the products or companies mentioned herein. Dr. Myers may be reached at (215) 928-3197.



Douglas J. Rhee, MD, is Director of the Laboratory for Molecular Ophthalmology at Wills Eye Hospital and Assistant Professor of Ophthalmology at Thomas Jefferson School of Medicine in Philadelphia. He stated that he holds no financial interest in the products or companies mentioned herein. Dr. Rhee may be reached at (215) 928-3197; dougrhee@aol.com.



George L. Spaeth, MD, is Director of the Glaucoma Service at Wills Eye Hospital and Professor of Ophthalmology at Thomas Jefferson School of Medicine in Philadelphia. He stated that he holds no financial interest in the products or companies mentioned herein. Dr. Spaeth may be reached at (215) 928-3197.



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For Further Reading

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