ULTRASOUND BIOMICROCOPY
An introduction

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This article is the 1st of a multipart series of articles on the UBM

Introduction

Ultrasound biomicroscopy (UBM) is a recent technique to visualize anterior segment with the help of high frequency ultrasound transducer. The transducer used for posterior segment evaluation (B-Scan) has a frequency of 10 Mhz. 10 MHz frequency probe has a depth of 4 cms and a resolution of 940 microns. Therefore this frequency is ideally suited for the posterior segment as all the structures imaged in the posterior segment have a thickness of more than a millimeter. The anterior segment has a depth of 4-5 mm and the structures are close to each other so we require a higher frequency probe. UBM (anterior segment ultrasonography) is performed with a 50 Mhz probe. The resolution of 50 MHz probe is 40 microns and the depth is 4 mm.

History

Dr. Charles Pavlin & Prof. Stuart Foster developed UBM at the Princess Margaret Hospital at Toronto, Canada in 1989. They developed three probes - 50, 80 & 100 Mhz for clinical trials [1]. 80 & 100 MHz probes were used to see the cornea and the anterior chamber as the depth of penetration is only 2 mm. They reached to a conclusion that a 50 MHz is an ideal compromise between depth and resolution to visualize the entire anterior segment. They published the first papers on UBM in 1990. The first commercially available machine was developed by Zeiss in 1991. It is now available with Paradigm USA. These machines are available with only one probe - 50 MHz.

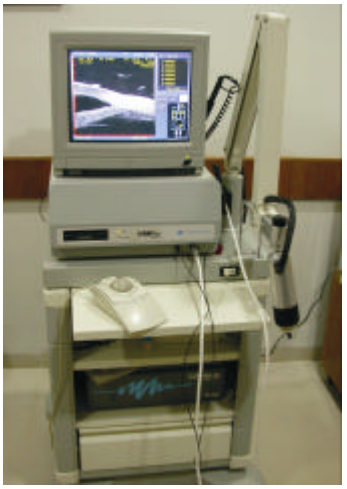


Fig 1a Ultrasound biomicroscopy machine

Instrumentation

There are three main components of the UBM machine.

1. Transducer
2. High-frequency signal processing.
3. Precise motion control

We shall discuss the differences in the three components from the routine B-scan instrument (Fig 1a).

Fig 1b: 50 MHz tranducer

The transducer used in UBM has a frequency of 50 MHz which means that a radiofrequency pulse of 50 MHz is produced by the piezoelectric crystal of the transducer [2]. This radiofrequency travels the body tissue and is reflected back to the transducer. The reflected radio frequency is processed by the signal processing unit. Normal B-scan transducer has oil filled covering with a membrane over the piezoelectric crystals. The penetration of the 50 MHz UBM transducer is poor, hence the transducer has an open crystal and there is no membrane covering the crystal.

The signal processing unit in UBM is specially designed to handle high frequency signals. During normal B-scan the movement of the transducer is over a wide area covering the entire eyeball. In UBM the movements of the transducer have to be subtle to scan adjacent areas in the anterior segment. To enable this subtle movement there is a special motion control device for the transducer. The transducer is mounted on a pulley with the piezoelectric crystal fixed on a large handle (Fig 1b).

Technique

UBM is done with the patient in the supine position and the eye is open. Since the piezoelectric crystal of the transducer is open it should not come in direct contact with the eye to prevent injury to the


Fig 2: Eye cups used for ultrasound

cornea. There is a special cup (fig 2) which fits in between the eyelids, keeping them open (fig 3).
The eye cup is filled with saline or sterile methyl-cellulose. The crystal of the transducer is placed in saline approximately 2 mm. from the eye surface. This distance of 2 mm prevents injury to the cornea and also helps as a fluid standoff.
The eye is scanned in each clock hour from the center of the cornea to the ora serrata [3].

Normal anatomy
Images produced by UBM have a resolution of 40 microns hence they are seen similar to those seen on a low power microscope [4].
The cornea is the first structure seen on ultrasound biomicroscopy. (Fig 4) The corneal layers are well differentiated. The Bowman's membrane is seen as a dense echo below the epithelium. The stroma shows low irregular reflectivity. The endothelium and the Descemet's membrane is seen as a dense highly reflective line. The corneo-scleral junction can be differentiated because of the lower internal reflectivity of the cornea compared to the sclera.

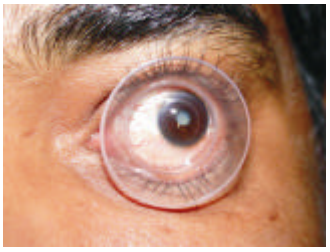


Fig 3: Eye cup fitted in between the eyelids

The anterior chamber is seen as an echo-poor area between the cornea and the iris. The anterior chamber depth can be measured from the posterior surface of the cornea to the anterior capsule. The normal anterior chamber depth is 3128 microns (3.1 mm.)
The iris is seen as a flat uniform echogenic area (Fig 5). The iris and ciliary body converge in the iris recess and insert into the scleral spur. The area under the peripheral iris and above the ciliary processes is defined as the ciliary sulcus. In general the iris profile is straight in contrast to anterior bowing in pupillary block glaucoma and posterior bowing in pigment dispersion glaucoma.
The angle can be studied in a cross section by orienting the probe in a radial fashion at the limbus. The scleral spur is the most important landmark in the angle on UBM. The exact quantification of the angle measurement and structures around the iris will be discussed in the next article on UBM in glaucoma.
The ciliary body can be clearly defined by UBM from the ciliary processes to the pars plana (Fig 6). The ciliary processes vary in appearances and configuration (Fig 7). The axial view of the ciliary processes is seen when taking a section of the angle. The individual processes are better seen in a transverse section through the ciliary processes. The posterior ciliary body tapers off towards the pars plana.
The anterior zonular surface can be consistently imaged by UBM (Fig 8). The zonules are seen as a medium reflective line extending from the ciliary processes to the lens surface.
The posterior chamber is defined as the space between the anterior vitreous face and the posterior surface of the iris The posterior chamber is always defined over its entire extent with UBM. The posterior zonules and vitreous face can be seen separately in some shallow chambered eyes, but not consistently in eyes with chambers of average or greater depth.
The peripheral retina and pars plana region can be visualized as far peripherally as the probe can be moved before eye cup prevents the movement of the transducer. The retina in this region is thin and generally is imaged as a single line that cannot be differentiated from the retinal pigment epithelium unless detached.

Indications for UBM

1. Glaucoma : UBM helps to study the angle in great detail. The exact configuration of the iris, ciliary body & processes can be defined. These structures can be seen in the presence of an opaque media. The angle can be quantified and the values can be followed up after treatment [5].
2. Uveitis : UBM is helpful in the study of anterior uveitis. The presence of pars planitis, supra-ciliary effusion, cyclitic membranes and ciliary body detachments can be visualized on UBM.
3. Trauma : Anterior segment trauma is usually associated with hyphema. In presence of hyphema it is difficult to visualize the iris and lens. UBM is helpful to study the position of the lens the status of the iris, ciliary body and the configuration of the angle. Angle recession and Cyclodialysis cleft can be evaluated on UBM.
4. Opaque media: In presence of dense

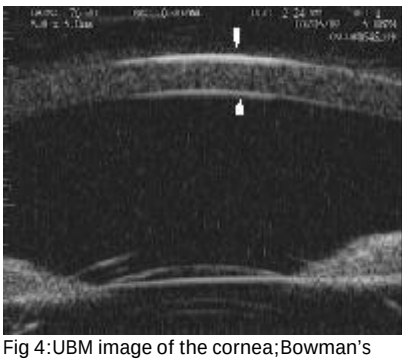


Fig 4:UBM image of the cornea;Bowman's membrane(downward arrow),Descemet's membrane(upward arrow)

Fig 5:UBM image at the limbus: scleral spur(blackarrow),iris(downward arrow) and ciliary sulcus(thick left pointing arow)

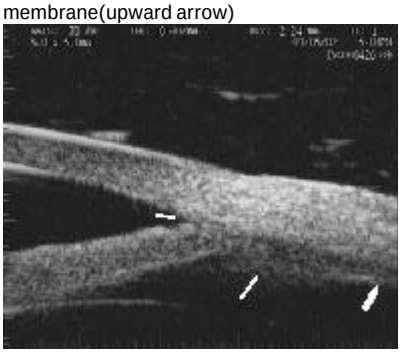


Fig 6: UBM image at the ciliary body: Angle (horizontal white arrow), pars plicata (thin upward arow) and pars plana (thick upward arow)

Fig 7: Axial view of the ciliary processes

Fig 8:UBM image of zonules(upward arrow)

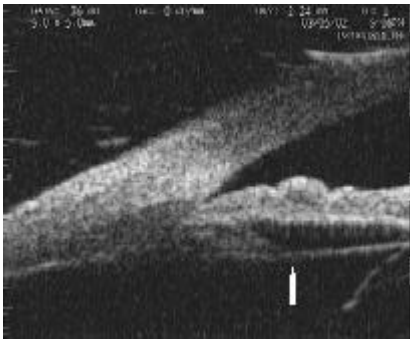
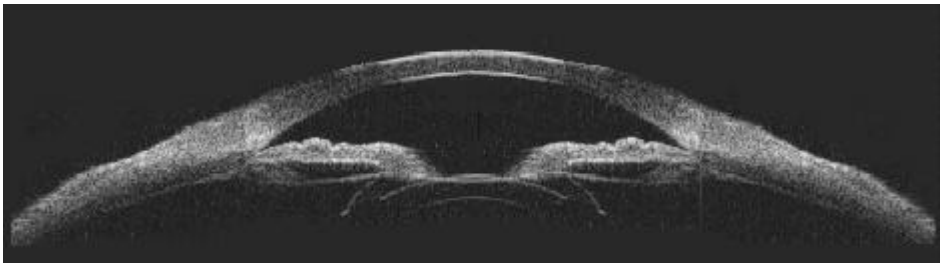


Fig 9:Composite image of the anterior segment on UBM



corneal opacity UBM is helpful to study the anatomy of the anterior segment before surgical intervention.

5. Tumours: UBM is helpful to quantify the characterize tumours in the anterior segment and to study the entire extend of the tumour.
6. Scleritis: UBM helps to differentiate scleritis from episcleritis and also helps to differentiate the various types of scleritis. It is also helpful to study the extent of scleritis and to rule out the involvement of the ciliary body and choroid.

Limitations

The most important limitation of UBM is depth. UBM cannot visualize structures deeper more that 4 mm from the surface. The other limitation is that UBM cannot be performed in presence of an open corneal or scleral wound.

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