ULTRASOUND BIOMICROSCOPY IN DIAGNOSIS OF ANTERIOR SEGMENT PATHOLOGY

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ULTRASOUND BIOMICROSCOPY (UBM)

UBM is a noninvasive method that uses high frequency ultrasound (25 - 60 MHz) for qualitative and quantitative evaluation of structures of anterior segment of the eye.
Advantages of UBM

- Visualization of all structures of anterior segment of the eye to the depth of 16 mm with 35 microns resolution in real time mode

- Performing both qualitative and quantitative examination of structures of anterior segment of the eye

- Performing UBM examination independently from the condition of optical media of the eye
UBM imaging

- Cornea
- Anterior chamber
- Lens and zonule

- Iridociliary complex: iris, ciliary body, the anterior chamber angle (ACA)

- Posterior chamber

- The peripheries of vitreous and retina
Conventional B-scan “window”

Transducer

30-40mm

Lateral resolution = 600 microns
Axial resolution = 187 microns
Technique of UBM

- Transducer 40 - 60 MHz

- Diagnostic window: 15 × 16 mm

- Scanning angle: 30°

- Resolution: 15 - 35 microns
UBM Technique

- Patient in supine position with topical anesthesia
- Eye cup between eyelids filled with normal saline
- Probe placed into eye cup
- Real-time image is displayed on a video monitor
UBM of anterior segment Imaging

Basic positioning of scans

Axial (panoramic) scans

Longitudinal scans

Transverse scans
The panoramic UBM imaging of anterior segment (axial scan)

- Direct gaze
- The probe perpendicular to the cornea directly over the pupil

**UBM assessment**
- Cornea (thickness, transparency)
- Anterior chamber (depth, aqueous humor)
- Iris (position, structure)
- Lens (transparency, position)
- Intraocular lens position
Longitudinal (meridional) sections

- The probe perpendicular to the limbus with the marker towards the pupil according to meridian clock

- **UBM assessment**
  - Anterior chamber angle (ACA)
  - Iris (thickness, convexity, insertion)
  - Ciliary body (thickness, structure)
  - Lens (zonule, capsule)
  - Intraocular lens haptic
  - Peripheries of vitreous and retina
Transverse (cross meridian) sections

- The probe parallel to the limbus over the central iris at the clock hour of interest

UBM assessment:
- Iris (thickness, convexity, structure)
- Ciliary body (thickness, structure, processes, pars plana)
- Peripheries of vitreous and retina (ora)
Transverse Section

ciliary processes

Sclera
Scleral spur is located where the trabecular meshwork meets the interface line between the sclera and CB

**AOD 500** = Angle opening distance at 500 μm from scleral spur

**! AOD 500**  Emmetropia -0,30 mm, Myopia–0,34 mm, Hypermetropia–0,17 mm
Echographic parameters of anterior segment structures in healthy subjects

<table>
<thead>
<tr>
<th>Structure</th>
<th>Reflectivity</th>
<th>Structure</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornea</td>
<td>Low</td>
<td>Regular</td>
<td>0.55 – 0.59 mm</td>
</tr>
<tr>
<td>AC</td>
<td>Anechoic</td>
<td>-</td>
<td>3.0 – 3.6 mm</td>
</tr>
<tr>
<td>Iris</td>
<td>Medium</td>
<td>Irregular</td>
<td>0.2 – 0.4 mm</td>
</tr>
<tr>
<td>CB</td>
<td>Medium</td>
<td>Regular</td>
<td>0.7 – 0.73 mm</td>
</tr>
<tr>
<td>Lens</td>
<td>Low</td>
<td>Regular</td>
<td>3.5 – 4.7 mm</td>
</tr>
<tr>
<td>Zonule</td>
<td>Medium</td>
<td>Regular</td>
<td>1.0 – 1.3 mm</td>
</tr>
<tr>
<td>ACA</td>
<td>-</td>
<td>-</td>
<td>20° - 40°</td>
</tr>
<tr>
<td>Sclera</td>
<td>High</td>
<td>Regular</td>
<td>0.6 – 0.8 mm</td>
</tr>
</tbody>
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UBM and Glaucoma

Anatomo-topographic relationships among the structures of ACA

Mechanisms in development of glaucoma

Approaches in the treatment of glaucoma

Following up the patients after treatment

Morphological changes of ciliary body

Topography of newly created outflow tracts during glaucoma surgery

Location of the drainage devices
Pigmentary glaucoma (pigment dispersion syndrome)

**Mechanism:** dissemination of pigment granules from the posterior iris

- Widely open angle
- Iris configuration (concave)
- Reverse pupillary block
- Amount of iridozonular contact
Pigment dispersion syndrome
Papillary block glaucoma

**Mechanism**: at the iridolenticular contact, resistance to aqueous flow from the PC to the AC creates an unbalanced relative pressure gradient between two chambers.

- Anterior iris bowing, narrowing of the angle.
- Iris-lens contact is relatively small – “dotted”
- LI eliminated the pressure differential between PC & AC and release the iris convexity and the iridocorneal angle wideness.
Malignant glaucoma (ciliary block)

- Angle closure is caused by pressure differential between the vitreous and aqueous compartment.
- Swelling or anterior rotation of the ciliary body with formal rotation of the lens-iris diaphragm and relation of the zonular apparatus may cause anterior lens displacement.
Plateau iris syndrome

**Mechanism**: narrowing of the ACA due to insertion of the iris anteriorly on the CB or displacement of CB anteriorly

- Iris thickness
- Iris profile is straight
- Ciliary processes are moved forward, closing the ciliary sulcus and supporting the peripheral iris
- Peripheral angle is narrow
Pseudoexfoliative glaucoma

**Mechanism**: the occlusion of the trabecular meshwork from the material and pigment

- **Stages of changes**
  - Small high reflective areas which are limited to the pupillary margin, on the anterior surface of the lens, in the ACA
  - Various lengths of zonule with partial lysis
  - Lens displacement with zonule laxity
UBM in the assessment of efficacy of treatment for glaucoma

**Laser iridotomy**

**Iridotomy** – defect of iris

- Location: peripheral iris
- Diameter: more than 0.2 mm
UBM in the assessment of efficacy of glaucoma surgery

Normal filtering bleb – subconjunctival fluid collection and low to moderate intrableb reflectivity

Filtering cystic bleb – hyporeflective areas filled with multiple fluid collections of varying size and intensity
Glaucoma drainage devices

Drainage device in AC, tube lumen is free

Drainage device in PC, tube lumen is free

Drainage device in sclera and doesn’t reach the AC
UBM in cataract surgery

Anatomo-topographic relationships among the structures of iridolenticular diaphragm

Location of lens, the condition of lens substance and zonule

Approaches to cataract surgery

Following up the patients after cataract surgery

Position of IOL, haptics and optical elements

Capsular bag status
Lens anomalies

- Central corneal lenticular adhesion
- Spherophakia, cataract, ectopic lens
- Thinning of iris (dystrophy)
- Iridocorneal adhesion

Microphakia

- Abnormally small lens
- Thinning of iris and CB (dystrophy)
Cataract

Hyperechoic areas of lens, their shape, number and placement depend on the type of the cataract.
Post-traumatic changes of lens

**Immature cataract:**
- Thickness and high reflectivity of cornea
- Shallow AC
- Iris bombe
- Enlargement and “vacuoles type” high reflectivity of lens
- Anterior chamber angle closed

**Subluxation (3rd degree):**
- Displacement of lens into vitreous
- High reflectivity of lens - “layered type”
- Slit-like ciliary body detachment
Zonular rupture

Cyst-like hernia of vitreous body with low reflectivity of its contents

✓ Displacement of lens
✓ Equator lens-ciliary process distance > 1.3 mm
Intraocular lens position

Assessment:

- Location of optical part of IOL according to optical axis
- Position of haptic elements of IOL
IOL Haptic Position

“In the bag”

“In the sulcus”
Intraocular lens dislocation
UBM in ocular oncology

The visualization of tumors

- Conjunctiva
- Limbus
- Iris
- Ciliary body
- Periphery of choroid

Purpose: to determine size, structure, interaction with surrounding tissues, degree of invasion

Development of treatment and assessment of efficacy of treatment
Benign epibulbar tumors

Scleral cyst

lipodermoid
Malignant epibulbar tumors

Conjunctival melanoma

Conjunctival melanoma
Benign iris tumors. Iris nevus

**UBM:** hypoechoic, hyperechoic or uniform reflectivity of local thickness of iris

Progressive nevus
Iris melanoma

- **Local thickness of iris** with changes of anterior and/or posterior surface, low reflectivity in comparison to intact tissues.
Ciliary body melanoma

- Low reflectivity of local thickness of CB in comparison to intact tissues
- During the interaction with equator of lens local cataract can be formed

Local cataract in zone of contact of tumor with lens
Invasion of the ACA, contact with the cornea

Iridociliary melanoma
Iridociliary melanoma

Displacement of lens

Choroid involved
Iris cysts

**UBM appearance:** thin-walled cysts with no internal reflectivity
Ciliary body cysts
UBM and ocular trauma

Anatomo-topographic relationships among the structures of anterior segment

- Cornea
- Anterior chamber
- Iridociliary zone (ICZ)
- Posterior chamber
- Lens
- Zonule

Following up the patients after treatment
Ocular blunt trauma

- Hyphema
- Blood clot in the AC
- ACA recession and prolapse of iris root
- ACA recession and rupture of iris root
Ocular blunt trauma. Changes of ICZ

1–2 – slit-like fistula between AC and suprachoroidal space (cyclodialysis cleft)

3–4 – shallow, uneven AC + exposure of the scleral spur + displacement of iris and CB + CB detachment
Ocular blunt trauma. Changes of ICZ

- Reverse profile of IR
- ACA recession + reverse profile of IR
- ACA recession + tear of IR
- ACA recession
- Tear of the inner layers of sclera
Complications of penetrating trauma

1. Conglomerate of cornea, iris and IOL

2. Iridocorneal synechiae

3. Iridocorneal synechiae
Complications of penetrating trauma: clinical cases

Chamber cysts

AC

Chamber cysts

AC
Foreign bodies in the anterior chamber

- **Metal**
- **Glass**
- **Wound channel**
Outcomes of ocular burns

- Retrocorneal membrane
- Iridocorneal synechiae
- Keratoprosthesis
Episcleritis

- Thickness of conjunctiva
- Sclera is not involved
Scleritis

Marked thickening of conjunctiva

Thickness of sclera
Outcome of scleritis in rheumatoid arthritis

Penetrating defect of sclera, with iris tamponade effect
Outcome of fungal keratitis

- Transparent lens
- Cornea
- "Wrong" AC
- Autologous covering
Outcome of pars planitis

fibrosis of zonule and capsule lens
Acute anterior uveitis

- Marked thickening of CB
- High reflectivity floaters in the AC and vitreous
- CB detachment
Chronic anterior uveitis

Outcome of pars planitis

Outcome of pars planitis, fibrosis of zonule and capsule lens

Cataract
Current Limitation

• Immersion “water bath” technique
• Cost & Availability
• Limited penetration
• Narrow field
• Resolution ?
• No “tissue diagnosis”
Contraindication to UBM

- Open eye injury
- Recent eye surgery
- Corneal ulcer
- Infective surface eye disease
- Uncooperative patient
Conclusion

UBM is…
- New innovation in ultrasound
- In vivo imaging of anterior seg.
- Near microscopic resolution
- Wide & expanding applications
- Further modifications needed
Thank you for attention!
BIOMETRIC PARAMETERS OF ANTERIOR SEGMENT

- a – trabecular meshwork
- 6 – scleral spur (SS)
- 1 – central anterior chamber depth (CACD; mm);
- 2 – iris root (IR, mm);
- 3–4 – angle opening distance at 250 µm and 500 µm from scleral spur (AOD 250, 500; mm);
- 5–6– trabecular–ciliary process distance at 250 µm and 500 µm from scleral spur (TCPD 250, 500; mm);
- 7–8 – iris-ciliary process distance at 250 µm and 500 µm from scleral spur (ICPD 250; 500; mm);
- 9 – posterior chamber depth (PCD, mm);
- 10 – central corneal thickness (CCT; mm);
- 11 – paracentral anterior chamber depth (PaACD; mm);
- 12 – maximum ciliary body thickness (CBTmax; mm);
- 13 – anterior chamber angle (ACA; °).