Ultrasound Evaluation of the Posterior Segment of the Eye – A Ready Reckoner

Ultrasound Principles

Ultrasound is an acoustic wave that consists of an oscillation of particles in a medium. Ophthalmic ultrasound uses 8-10 MHz probes (1 MHz is 1000000 cycles per second). Ultrasound used in other medical specialties uses 1-5 MHz. When the frequency decreases the wave length increases and penetration increases. Longer wavelength also reduces the resolution. UBM uses higher frequencies like 50-100MHz resulting in less penetration and better resolution. Ultrasound wave is propagated as a longitudinal wave of alternating compressions and rarefactions of molecules. This wave can be refracted and reflected as light. It is the reflected wave or echo that is utilized in ultrasound evaluation. It depends on the acoustic impedance of the media and the difference in acoustic impedance at an interface called acoustic interface. Also the angle of incidence determines the amount of echo returning. Perpendicular incident waves produce maximum echoes.

Ophthalmic ultrasound uses a pulse echo system which is a piezo electric element which undergoes mechanical vibration when stimulated by electrical energy producing a longitudinal ultrasound wave. The parts of ultrasound system include a pulser, transducer, receiver and a display screen. Amplification plays an important role in ophthalmic ultrasound. It determines the ability of the system to display range of echo intensities. This dynamic range is displayed in units of decibels.

Terminologies

Linear amplification - is on a small range and can display minor differences in echo strength between two echo sources but the range of intensities that can be displayed is limited.

Logarithmic amplification - Large dynamic range can be displayed but the small differences between two echo signals cannot be displayed.

S amplification – developed by Ossoinig – Combines the wide range of logarithmic amplifiers and great sensitivity of linear amplifiers

Gain measured in decibels represents relative units of ultrasound intensity. By adjusting the gain, amplification of echo signals displayed in the screen can be changed. It is just like adjusting the volume of radio where we can control the signals received by the radio. The higher the gain the greater the ability of the machine to detect weaker signals. When gain is reduced only stronger echoes will be displayed.

Time gain compensation (TGC): To enhance weaker signals from deeper tissues. Allows selective amplification of weaker distant echoes compared to stronger nearer echoes.

Standardized echography: Combined use of standardized A scan and contact B scan developed by Ossoinig.

Indications for Ultrasound Examination

1. Posterior segment evaluation in the presence of
**Few classic ultrasound findings**

Fig. 1. 10 MHz ophthalmic ultrasound B/A scan machine with probes and display units

Fig. 2. Point like echoes in vitreous haemorrhage, membrane like lesion in retinal detachment and mass like lesion

Fig. 3. To differentiate RD and PVD. RD has 100% reflective membranous echo with attachment to optic disc and reduced after movement. PVD has variable spike height with good after movements and if complete no attachment at the disc.

Fig. 4 (a & b) Shifting fluid in exudative retinal detachment. The figure on the left shows membranous echo inserting at the disc with high reflectivity and good after movements. To the left is the same retinal detachment in sitting position showing shifting fluid. There is significant choroidal thickening and T sign.

Fig. 5. Dislocated cataractous crystalline lens. Lens capsule is not intact. Point like and membrane like echoes are present in the vitreous cavity. There will be mobility of the lesion on eye movements.

**Ultrasound findings in Diabetic retinopathy**

Fig. 6. Plenty of point like echoes in the vitreous cavity suggestive of vitreous haemorrhage

Fig. 7. Vitreous haemorrhage with incomplete posterior vitreous detachment. There are multiple point like echoes in the gel.

Fig. 8. Vitreous haemorrhage with schisis cavity inside and complete PVD. The after movements will be very good in presence of complete PVD.
Fig. 9. Membranous echo attached to the disc which is incomplete PVD. There are point like echoes beneath the membrane suggestive of subhyaloid haemorrhage. Also there are multiple echoes in the pre-papillary area due to adherent fibrous proliferation and peripapillary tractional retinal detachment.

Fig. 10. Membranous echo inserting at the disc with moderate after movements. This is PVD. There is point like echoes beneath this layer suggestive of sub vitreal or subhyaloid haemorrhage.

Fig. 11. Membranous echo in the lower part with plenty of point echoes beneath suggestive of Incomplete PVD of lower part with sub vitreal haemorrhage. There is intragel haemorrhage also.

Fig. 12. Two membranous attachment pulling the retina in a tent like fashion. This is tractional retinal detachment. There is no PVD between the TRD along the arcades. This is called table top TRD.

Fig. 13. Two membranous attachment pulling the retina in a tent like fashion. There is PVD between the TRD.

Fig. 14. Multiple membranous lesions attaching to the disc area with vitreoschisis. There is subvitreal haemorrhage as well as subretinal haemorrhage. In the lower part there is retinal detachment.

**Ultrasound findings in Trauma**

Fig. 15. High reflective (100% spike height) intraocular foreign body with shadowing behind. Low gain examination will help in the better delineation.

Fig. 16. High reflective point like echo with shadowing suggestive of radio opaque retained intraocular foreign body. Also there is a shallow retinal detachment seen as membranous high reflective echo with not much after movements.
opaque ocular media like corneal opacity, hyphema, cataract or vitreous haemorrhage

2. In clear ocular media – Tumors, choroidal detachment, optic disc anomalies like drusen

3. Intra ocular foreign body

**Examination Techniques** - It is usually done with the eye lid closed and other eye kept open fixing at a target. Coupling medium like methylcellulose is applied on the B-scan probe. In case of trauma or recent ocular surgery, probe has to be cleaned before use.

**B-scan Probe Orientation:**

1. Transverse scan – The Probe is kept at the limbus with the axis of marker circumferential at limbus. The area of the marker is displayed in the upper part of screen. This can be horizontal, vertical and or oblique transverse scans.

2. Longitudinal scan – The marker is perpendicular to the limbus.

3. Axial Scan - Is done with the patient fixing in primary gaze and probe centered in the cornea. It displays lens

and optic nerve in the center of the echogram. This is useful for evaluation of macula.

**Basic B-scan screening protocol**

1. Transverse scan of 4 major quadrants at high gain.

2. Longitudinal scan in 4 major meridians

3. Axial scan.
After using high gain to detect vitreous opacities and gross fundus lesions low gain with improved resolution is used to detect flatter fundus elevations and to detect the topography of large lesions.

**Special examination techniques**

1. **Topography** - Location, extension and shape. *Lesion types can be point like, membrane like, band like and mass like.*

2. **Quantitative** – Reflectivity, internal structure and sound attenuation.

**Quantitative Echography type-I**

*Reflectivity* – Spike height in A-scan (0-100%) and signal brightness in B-scan.

*Internal structure* – Architecture inside a mass like lesion – regular and irregular.

*Sound attenuation* - When sound energy is scattered, reflected or absorbed. On A-scan decrease in the spike height is called angle Kappa which is determined by drawing a line through peaks or lesion spikes. The steeper the angle, the greater the sound attenuation.

**Quantitative Echography type II**

To differentiate retinal detachment from vitreous membrane.

3. **Kinetic** – After movements and vascularity. Kinetic Echography is used to dynamically assess the motion of or within the lesion. This includes 1. After movement on stopping the eye movement suddenly 2. Vascularity which is fast spontaneous motion best seen in standardized A-scan with eye steady 3. Convection movements are slow, spontaneous movements seen in longstanding intraocular haemorrhage or cholesterol debri.

2. **Anterior segment evaluation** using immersion techniques with scleral shells is mostly replaced by ultrasound biomicroscopy.

**Reference**


(Ultrasound pictures from Giridhar eye Institute Archives. Authors have no financial interest in any product or machine shown)