Research Article

Ultrasound biomicroscopy versus anterior segment optical coherence tomography in glaucoma

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Abstract
Introduction: Ultrasound biomicroscopy (UBM) is a type of ultrasound that makes a more detailed image than B-scan ultrasound. **Physics:** The enormous potential of ultrasound imaging of tissue is in the frequency range from 40 to 100 MHz. AS. OCT, based on the principle of low coherence interferometry. **Physics:** Anterior Segment Optical Coherence Tomography (AS-OCT). Anterior Segment Optical Coherence Tomography (AS-OCT) is a non-contact, non-invasive technique that provides cross-sectional, three-dimensional, high-resolution images using low coherence interferometry to achieve axial resolution in the range of 3-20 µm. **Clear Scan cover technique. Glaucoma:** Glaucoma is a set of ocular disorders often defined by increased intraocular pressures leading to optic neuropathy and vision loss if untreated. The commonly accepted range for intraocular pressure is 10-22 mm Hg. Three factors affect intraocular pressure: the rate of production of aqueous humor by the ciliary body, the resistance to aqueous outflow through the trabecular meshwork and Schlemm's canal, and the episcleral venous pressure. **Clinical applications of Ultrasound biomicroscopy in glaucoma:** Ultrasound biomicroscopy has been used in the evaluation of anterior chamber and also can measure anterior chamber depth, angle aperture and differentiation betwteen primary or secondary open angle and closed angle glaucoma. **Summary:** Glaucoma is a group of eye disorders with optic nerve damage and vision loss if un treated, the commonly accepted range for intraocular pressure is 10-22 mmHg. Screening for glaucoma is usually performed as a part of standard eye examination, can be assessed with imaging techniques as Anterior Segment Optical Coherence Tomography (AS – OCT), Scanning Laser Polarimetry and/or Scanning Ophthalmoscope and Ultrasound Biomicroscopy (UBM).

Kay Words:
AS-OCT: Anterior Segment Optical Coherence Tomography
OPD: Optical Path difference

Introduction
Ultrasound biomicroscopy (UBM) is a type of ultrasound that makes a more detailed image than B-scan ultrasound. High-frequency sound waves about 50 to 100 mHz are bounced off the inside of the eye to enables the examiner to view the anterior segment of the eye and the echo patterns are shown on a screen. This makes a picture called a sonogram. It is useful in ocular disorders as glaucoma, cysts and neoplasms of the eye, as well as the evaluation of trauma effects and foreign bodies of the eye (Silverman, 2009).

UBM can determine anterior segment morphology in cases of plateau iris in patients with primary angle closure glaucoma (PACG) (Taranum et al., 2015). It can be also used to differentiate between types of narrow anterior chamber (AC) angles (Radhakrishnan et al., 2005).

UBM can be used to investigate the appearance of the anterior chamber in infants with congenital corneal opacity (Yoshikawa et al., 2015). Optical Coherence Tomography (OCT) is a non-invasive, non-contact optical scanning method, for cross-sectional imaging of the internal retinal structure (Michael et al., 1995).

Optical coherence tomography (OCT), Time domain optical coherence

tomography (TD-OCT), (Frequency domain optical coherence tomography (Schmitt, 1995) and spatially spectral domain or encoded frequency domain OCT (also Fourier Domain or Swept Source OCT) (SS- OCT) (Fercher et al., 1995).

Anterior segment OCT (ASOCT) imaging was first described in n1994, using the same wavelength of light as retinal OCT, namely 830nm. This wavelength is suboptimal for imaging the angle due to limited penetration through scattering tissue such as the sclera. OCT imaging of the anterior segment with a longer wavelength of 1310 nm was developed later on and had the advantages of better penet-ration through sclera and also to assess the accuracy and classification of narrow anterior chamber (AC) angles. AS-OCT can be used in quantitative AC angle measurement and detection of narrow angles (Radhakrishnan et al., 2005).

Glaucoma is a group of eye diseases characterized by damage to the optic nerve (optic neuropathy); usually associated with increased intraocular pressure (IOP) (Robert et al., 2012).

Physics

The Acoustic Spectrum

Sound occupies the range from 10 Hz to 20 KHz (fig.1) (Pavlin and Foster, 2012). The medical applications occupy only a tiny sliver of the spectrum between 1 and 10 MHz. Frequencies between 3.5 and 5 MHz are used in body imaging applications where significant penet-ration of the tissues is needed, the choice of frequency is closely tied to the intended application. As the frequency increases, the ultrasound is more strongly attenuated (Pavlin and Foster, 2012).

Although, the vast majority of clinical ultrasound imaging is performed between 1 and 10 MHz, new appli-cations are beginning to emerge in the high frequency range between 10 and 40 MHz (Altmeyer et al., 1992).

Physics

Anterior Segment Optical Coherence Tomography (AS-OCT)

Anterior Segment Optical Coherence Tomography (AS-OCT) is a non-contact, non-invasive technique that provides cross-sectional, three-dimen-sional, high-resolution images using low coherence interferometry to achieve axial resolution in the range of 3-20 µm (Huang et al., 1991).

Anterior segment imaging using OCT was first demonstrated in 1994 by Izatt and colleagues (Izatt et al., 1994). Using light with a wavelength of 830 µm. Huang and Izatt in 2001 first demonstrated the modern version of anterior segment OCT using 1310 nm wavelength light and a scan speed of 4000 A-scans/sec, with telecentric transverse scanning and rapid scanning optical delay technology in a reference arm yielding an axial resolution of 17 µm (Sharma et al., 2013).

Glaucoma

Glaucoma is a set of ocular disorders often defined by increased intraocular pressures leading to optic neuropathy and vision loss if untreated. The commonly accepted range for intraocular pressure is 10-22 mm Hg. Three factors affect intraocular pressure: the rate of production of aqueous humor by the ciliary body, the resistance to aqueous outflow through the trabecular meshwork and Schlemm's canal, and the episcleral venous pressure (Babak and Leila, 2017).

Risk factors

Being black

Having a family history of the condition

Certain medical conditions, such as diabetes, heart disease, high blood pressure and sickle cell anemia. Certain eye conditions, such as nearsightedness

Had an eye injury or certain types of eye surgery. Early estrogen deficiency, such as can occur after removal of both ovaries (bilateral oophorectomy) before age 43.

Taking corticosteroid medications, especially eye drops, for a long time. High internal eye pressure (intraocular pressure). Being over age 60 (SooHoo et al., 2014).

Some people may have high eye pressure for years and never develop optic n. damage. About 11 to 67 million people have glaucoma globally. The disease affects about 2 million people in the United States. It occurs more commonly among older people, closed-angle glaucoma is more common in women (Mantravadiet al., 2015).

Clinical applications of Ultrasound biomicroscopy in glaucoma

Ultrasound biomicroscopy has been used in the evaluation of anterior chamber and also can measure anterior chamber depth, angle aperture and differentiation betwteen primary or secondary open angle and closed angle glaucoma (Giuseppe et al., 2016).

Ultrasound Biomicroscopy also can examine pseudoexfoliation syndrome and shows a flattened anterior chamber thicker crystalline lens in affected eyes, most probably due to zonular defects which are shown by UBM as zonular remnants attached to the lens capsule (Unsal et al., 2015).

It shows iris concavity in pigmentary glaucoma involving difficulty in trabecular outflow due to dispersion of pigment from the iris. In patients with pseudophakia, UBM can help to determine the mechanism of pupillary block In plateau iris syndrome, UBM shows a generally thick, flat, slightly anterior bowing iris which abruptly ascends after its insertion on the ciliary body's anterior surface assuming a "square root" appearance. UBM may reveal the double- hump sign. The most peripheral hump covers over the rigid, anteriorly positioned ciliary body and central rests over along extension on the anterior lens surface (Scuderi et al., 2015).

Summary

Glaucoma is a group of eye disorders with optic nerve damage and vision loss if un treated, the commonly accepted range for intraocular pressure is 10-22 mmHg. Screening for glaucoma is usually performed as a part of standard eye examination, can be assessed with imaging techniques as

Anterior Segment Optical Coherence Tomography (AS – OCT), Scanning Laser Polarimetry and/or Scanning Ophthalmo-scope and Ultrasound Bio-microscopy (UBM).

UBM is a type of ultrasound that makes a more detailed image than B-Scan ultrasound and use sound waves with high frequency (50 - 100 mmHg), and probe during performing. UBM can determine anterior segment morphology in cases of plateau iris in patient with primary angle closure glaucoma (PAGG), can help to determine the mechanism of pupillary block glaucoma, can be used to differentiate between types of narrow anterior chamber (AC) angle and to investigate the appearance of anterior chamber in infant with congenital corneal opacity, also can examine pseudoexfoliation syndrome and is able to detect angle recession glaucoma, iridodialysis, lens sublu-xation, ciliary body detachment and demonstrate cyclodialysis.

The second device is used in diagnosis of glaucoma called Anterior Segment Optical Coherence Tomography (AS-OCT) which is a non-invasive non-contact optical scanning method for cross-sectional imaging of the internal retinal structure, OCT time domain optical coherence tomography, frequ-ency domain OCT, fourier domain OCT are three types of optical coherence tomography.

AS-OCT uses the same wave length of light as retinal OCT, can used in examination of anterior chamber angle as a quantitative data that can determine the mechanism of elevated intra ocular pressure by revealing the relation between peripheral iris and trabecular meshwork also can assess the configuration of peripheral iris,

identify its level of insertion and in eyes with angle closure it can identify the presence and extent of peripheral anterior synechiae, used to diagnose and grade various secondary glaucoma and also to evaluate iris, angle abnormalities in post traumatic eyes, and can identify and quantify angle recession, iridodialysis, and cyclo-dialysis, and lens induced glaucoma can be diagnosed, secondary angle closure glaucoma from a subluxed lens and phacomorphic glaucoma can be diagnosed. Also it was used for detailed assessment of eye with aniridia. Also used for assessment of degree and other causes of angle closure. AS-OCT is one of the effective biometric descriptor to accurately diagnose angle occludability and predict angle closure glaucoma probability, and enables the anterior chamber width measurement to select the best ring diameter for direct use on the ciliary body.

AS-OCT main advantages are no contact with the globe, image acquisition, time is rapid, easy to operate, real time cross-sectional view of the anterior chamber and angle structure much more comfortable for the patient and acceptable when compared with UBM.

Quantitative and qualitative data can be collected and analyzed in an objective way that is much observer dependent and more reproducible than UBM.

And in the diagnosis and management of angle closure (particularly residual angle closure post-iridotomy), this is an advantage that UBM has over AS-OCT in determining non-pupil block mechanism such as an anteriorly rotated ciliary body or ciliary body cyst.

Pathology includes cyclodialysis clefts and ciliary body tumers which may not be detectable using AS-OCT. This limitation seems to be more of a problem with darkly pigmented brown eyes rather than blue eyes where more of the light can be transmitted posteriorly. However in some cases, AS-OCT can visualize iris cysts, iris melanoma, or ciliary effusion.

Other limitations still exist with adva-ncing technology. AS-OCT cannot completely beyond the pigmented epithelium of the iris and its poor ability to show details of the ciliary body and posterior surface of the iris. The posterior pigmented iris and ciliary epithelium block the passage of infra-red light, so preventing a good view of these structures due to light absorption by this layers, but the changes in the anatomical relationship between the iris, trabecular meshwork, and lens under light and dark conditions are more easily seen in the cross sectional images of the anterior chamber that are obtained with the AS-OCT.

Comparatively, UBM can clearly image the ciliary body, lens and zonules. However, AS-OCT can image the crystalline lens, posterior chamber intraocular implant or phakic implantable lens. Both these factors probably result in less distortion of resting angle anatomy. In populations been developed, such as the RTV ue FD-OCT and the cirrus HD-OCT.

The other application of AS-OCT is in evaluating the effects of laser iridotomy and other interventions on angle anatomy. And a significant number of angle-closure patients demonstrate no widening of the angle following laser iridotomy and may benefit from additional treatment such as iridoplasty or lens extraction.
Both these angle-imaging devices produce cross-sectional images of the anterior segment of the eye with different limitations. While the UBM remains the only reliable non-invasive technology that determine ciliary body anatomy, AS-OCT gives higher resolution of the iris and angle with greater ease of scanning.

Furthermore, anterior chamber imaging between the two devices have shown no significant differences, however, the scleral spur appears more easily identifiable with AS-OCT.

Last but not least, ophthalmologists have found that no one can do without the Ultrasound Biomicroscopy and Anterior Segment Coherence Tomo-graphy in diagnosis of glaucoma as they are

complementary to each other , but each device is used and choosed according to the case suitable for.

Conclusion

There are several imaging technologies used in diagnosis of glaucoma. One of the most important two devices used in imaging are Ultrasound Biomicroscopy and Anterior Segment Optical Coherence Tomography.

Ultrasound bionmicroscopy is a high frequency imaging technique using frequency ranging from 50-100 mHz using for imaging the anterior segment of the eye, imaging Anterior Chamber Angle, diagnosis of different types of glaucoma, the main disadvantages of this device are contact with the globe by a liquid and coupling medium, slower acquisition time, smaller field of view although ultrasound biomicro-scopy can image through opaque cornea. On the other hand, there is another device is ASOCT.

The most non-invasive device is Anterior segment optical coherence Tomography (ASOCT), it is non contact method for imaging anterior chamber angle, measurement of Anterior Chamber depth, angle width, Anterior chamber angle parameters including Angle opening distance (AOD), Anterior chamber width (ACW), Iris thickness (IT), Trabecular Iris Space Area (TISA), So the main uses of ASOCT is detection of the angle but there are other indications of ASOCT in glaucoma.

The main disadvantages of ASOCT has a poor ability to image the ciliary body, AS-OCT cannot completely image beyond the iris pigmented epithelium. On the other hand, there is ultrasound biomicroscopy which is used in determination of details of the ciliary body and Posterior surface of the iris.

Last but not least, ophthalmologists have found that no one can do without the Ultrasound Biomicroscopy and Anterior Segment Optical Coherence Tomography in diagnosis of glaucoma as they are complementary to each other. But in my openion.

The main work of Anterior segment optical coherence Tomography only on imaging anterior chamber angle. Ultrasound biomicroscopy is better than Anterior segment optical coher-ence tomography in diagnosis of glaucoma because of less disadvan-tages of ultrasound Biomicroscopy.

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