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The role of UBM in glaucoma in 2017

Guillaume Besombes - La Louvière Private Hospital (Lille) and Lille Regional University Hospital

Very high-frequency ultrasound or UBM methods, and role in glaucoma

UBM, or very high-frequency ultrasound, uses transducers, the frequency of which is higher than 20 MHz, whereas the usual standard in ocular ultrasound uses probes of 10 MHz. Charles Pavlin first described the use of ultrasound for the anterior segment in the early 1990s [1].

Very high frequency probes (> 20 MHz) provide a very clear improvement in image resolution (around 30 to 50 microns), and there is no tissue penetration limit (especially in pigmented tissue like with anterior segment OCT). UBM images can be used to view all components of the iridocorneal angle, and in particular the iris and ciliary structures, and offer the possibility of dynamic analysis in different lighting conditions.

Various types of glaucoma can be analyzed in this way, and it is possible to issue a therapeutic indication (laser, surgery) and to monitor the effects of treatments.

Iridial angle imaging

A cross-section of the iridocorneal angle can be analyzed with respect to various anatomical landmarks, the most stable of which is the scleral spur (remaining fixed regardless of pupil dilation or accommodation). (Figure 1)

The proposed method for analyzing the angle by UBM involves the creation of cross-sections on the 4 main meridians (3 o'clock, 6 o'clock, 9 o'clock and 12 o'clock), in photopic condition, then in scotopic condition, so as to assess the angle dynamics in the event of physiological dilatation. (Figure 2)

The advantage of the ultrasound is that the examination takes place in the dark, in conditions comparable to those of nocturnal angle-closure glaucoma cases, whereas a gonioscopic examination is carried out with the lighting of the slit lamp. The risk of angle closure is assessed on the number of quadrants in which the low reflectivity of the aqueous humor disappears between the cornea and the iris, with contact between the two structures. More than half of the quadrants showing a closed appearance indicate a more or less confirmed risk of angle closure, with the indication for laser iridotomy.

Other assessments have been cited in literature, based on measurement of anterior chamber depth at the periphery [2]. The most widely accepted measurements are values known as AOD 500 or AOD 750, which are the distance...
measured between the posterior face of the cornea and the posterior face of the iris at 500 and 750 microns from the scleral spur. (Figure 3)

However, when the angle is very narrow or even closed, these values are very low, and cannot be used for scalable monitoring or satisfactory reproducibility.

Other criteria have been defined, such as the angle surface, iris thickness etc., but with applications that are less useful in standard practice. All possible measurements are shown in Figure 4, according to Pavlin [1].

Clinical applications in glaucoma

Angle closure and dynamic analysis: iris factor and lens factor

Iris shape and insertion are elements we can analyze. (Figure 5)

Iris thickness, along with anterior insertion of its root is also a risk factor for angle closure. We can see the iris bulging outwards, reflecting blockage of the pupil with increase in pressure in the posterior chamber [3]. (Figure 6)

A phacomorphic part relating to the large lens can be seen in UBM, and lens vault can be measured (distance between the anterior lens capsule and the posterior cornea). (Figures 7 et 8)

Post traumatic angle recession can be seen in UBM, with more or less severe tearing of the iris root. (Figure 9)
Ciliary process, plateau iris mechanism analysis

There is high variability in the position and volume of the ciliary bodies. The scleral spur is a useful landmark for assessing the anterior position of the ciliary processes. Usually, the ciliary body volume is placed behind the scleral spur [4].

The anterior draping of the ciliary processes is one of the first elements of the plateau iris mechanism, along with the absence or narrowing of the ciliary sulcus. (Figures 10 et 11)

In scotopic conditions, we see tipping of the ciliary processes which push the root of the iris towards the cornea, leading to angle closure. (Figure 12)

We can see a pseudo plateau iris mechanism related to the presence of iridociliary cysts. The UBM can be used to identify the sectors containing cysts in order to guide the iridotomy to the optimal position to be performed in a cyst-free area. (Figure 13)

Pigment dispersion and pigmentary glaucoma

Patients presenting with pigment dispersion are at risk of pigment glaucoma, with inversion of the iris curve (which becomes concave) and which can easily be seen in UBM.

Peripheral iridotomy can be useful for preventing reverse pupil block and minimizing the
contacts between the iris and the lens or the zonules which are releasing iris pigments. *(Figure 14)*

### Angle analysis following laser treatment

Preventive and curative treatment of angle closure usually involves peripheral iridotomy, which removes the pupil block and restores a straighter and more horizontal appearance to the iris and its root, in order to open the iridocorneal angle again. *(Figure 15)*

Especially, UBM is used to identify situations at risk of failure or insufficient treatment in the event of plateau iris, iridociliary polycystosis, with too large phacomorphic part, or anterior iris insertion contact. For example in Figure 16, a case of angle closure, despite wide iridotomy, caused by high lens vault, for which lens extraction would be the most effective treatment. *(Figure 16)*

Argon laser iridoplasty also benefits from UBM which can be used to issue the indication and for monitoring. *(Figure 17)*

### Measurements and analysis before ultrasound ciliary body cyclodestruction

Treatment by ultrasound cyclodestruction (HIFU) is reserved for refractory glaucoma and reduces intraocular pressure by targeting the ciliary processes and production of aqueous humour [5]. A preliminary UBM analysis is essential for an anatomical assessment and to perform measurements in order to select the most suitable sensor size for the patient. *(Figure 17)*
Analysis after filtration surgery

Surgery by sclerectomy or trabeculectomy leads to a conjunctival filtration bubble, the functional quality of which can be seen on the cross-section images. Functional bubble appearance is seen in a thickened conjunctiva, acting like a sponge for the aqueous humor (Figure 18).

An atrophic or fibrotic bleb will be less functional. UBM can also be used to view the intrascleral space, the scleral flap, any incarceration of the iris compromising the result of surgery. After non-penetrating deep sclerectomy, the trabecular leaflet left in place can be identified, and a gonipuncture procedure can be offered in the event of a rise in pressure in order to facilitate filtration. UBM can also be used to monitor the position and good tolerance of devices or valves inserted at the surgical site (valves, collagen sponges, implants etc).

Figure 19 (functional) and 20 (non-functional due to iris incarceration and fibrosis)

Choroidal detachment post-filtration surgery can also be clearly seen. (Figure 21).

Conclusion

Angle analysis by cross-sectional UBM imaging can be used in addition to the gonioscopic examination, with a significant advantage due to greater penetration, making it possible to view the structures behind the iris. This analysis can be used to guide and document patients at risk of angle closure, before and after peripheral iridotomy, especially in the case of iridociliary cystic disease and plateau iris. Where applicable, UBM can be used to guide indications for further treatment.

UBM can also be used to control filtration surgery and to understand the causes of failure, by highlighting the mechanisms of dysfunction.

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REFERENCES