Ultrasound Biomicroscopy (UBM) in Glaucoma Filtering Surgery: An Image Walkthrough

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INTRODUCTION

Ultrasound biomicroscopy is a diagnostic tool based on high-resolution B-mode ultrasonography. Introduced by Charles Pavlin and coworkers,\(^1^-^3\) it is nowadays widely available in different devices and models. The most frequently used carry a polymeric, 50 Mhz transducer with a resolution of 50 mm. As penetration is the reverse of resolution, UBM reaches specific areas of the eye such as the anterior segment including the lens, ciliary body with vitreous processes and pars plana, peripheral retina and superficial vitreous body.

It is an immersion method and the patient lies in supine position.

The published literature on UBM and glaucoma filtering surgery and its complications is relatively scarce.

UBM has been usefully employed in diverse aspects and conditions related with glaucoma: for assessing angle configuration in suspects of angle closure and closed-angle glaucoma,\(^4^-^8\) for the evaluation of the effect of laser iridotomy in narrow angles\(^9^-^10\) for the recognition of angle structures and of angle and anterior segment anomalies in congenital glaucomas,\(^11^-^12\) of angle recession and other lesions in traumatics glaucoma,\(^13\) pigmentary dispersion and pigmentary glaucoma,\(^14^-^15\) in silicone oil-filled eyes with glaucoma\(^16\) and in eyes with opaque grafts with post-penetrating keratoplasty glaucomaa.\(^17\)

Of the published literature on UBM and glaucoma filtering surgery, a group of papers deal with non-penetrating surgery,\(^17^-^21\) other with trabeculectomy,\(^23^-^24\) and another one with the follow-up of glaucoma surgery complications.\(^25^-^30\)

The purpose of this communication is to provide some comments highlighting the utility of UBM in different aspects of glaucoma filtering surgery and, to a certain extent, to let images speak for themselves.

ANTERIOR SEGMENT OCT AND UBM: DO THEY REALLY COMPETE WITH EACH OTHER?

Anterior segment OCT,\(^31^-^32\) being a noncontact device, may be applied in cases with a positive Seidel and also brings a wider image of the anterior segment than UBM but it does not provide a satisfactory view of the posterior chamber and of the ciliary body. Furthermore, anterior segment OCT is used in the seated position and, in eyes prone to be submitted to surgical procedures, an examination in the supine position is more convenient. This is particularly important in glaucoma-related conditions in which changes in the anterior segment occur in the surgical position, such as lens luxation (Fig. 1) and silicone oil in the anterior chamber (Fig. 2).

TRABECULECTOMY

UBM scanning should not be performed in eyes with conjunctival buttonholes, conjunctival flap recession and/or a positive Seidel’s test, so as to avoid risk of infection.

Evaluation of the Bleb and of the Trabeculectomy Site

Even though a seemingly functioning bleb by UBM standards is not necessarily functioning,\(^23\) the presence of hypoechoic areas within a diffuse, extense bleb are positive signs of good filtration (Figs 3 and 4). These “dark” areas do not need to be uniform nor “black”.\(^23\) Other structures to be checked are the ostium, the iridectomy, the condition and situation of the ciliary processes and the intrascleral space under the flap. The ostium must be open and the presence of a tract under the flap should be evident by careful radial scans. Absence of a dark area inside the bleb, a flat or encapsulated bleb, a narrow incomplete or blocked ostium and failure to demonstrate patency of the tract under the scleral flap are the relevant negative signs.

Retrospective Diagnosis of the Cause of Failure

This method allows to determine, in a nonfunctioning trabeculectomy, an occlusion of its internal portion. The ostium may be occluded by the iris, by an incomplete excision of the trabecula, or by an incomplete iridectomy (Fig. 5), malposition of the ostium (too posteriorly placed), scarring of the flap, excessive adjustment of the flap sutures or occlusion of the ostium by proliferative tissue. It is usually difficult to distinguish between the three latter. It is also not possible to know whether
the closure of the flap is primary or secondary to bleb scarring. But when bleb flattening occurs in the presence of normality of all the other sectors including the subscleral tract, it is likely that a primary bleb scarring has occurred (Fig. 6) and therefore a needling procedure, a surgical revision or a new operation may be indicated.

**NONPENETRATING GLAUCOMA SURGERY (NPGS)**

UBM imaging in nonpenetrating deep sclerectomy/viscocanalostomy clearly shows a trabecular-descemetic membrane, an intrascleral chamber with anechoic contents, and a hypoechoic area, posterior to the latter, corresponding to the zone of the excised deep scleral flap\textsuperscript{18-22} (Figs 7 and 8). There is usually no visible bleb in viscocanalostomy, while in NPDS, as obtaining external filtration is one of the aims of the procedure, a bleb should be looked for. It is not uncommon to observe a widened supraciliary space (Fig. 9) which has led to speculations about its role: Increased uveoscleral aqueous drainage? Some intrascleral implants are not visible to ultrasound but others, like the T-Flux, are clearly outlined (Fig. 10). Goniopuncture has been described as an integral part of nonpenetrating glaucoma surgery, which should be timely performed. Goniopunctures are usually detected with UBM, preferably with transversal scans (Fig. 11).
Fig. 5: An incomplete iridectomy blocking the ostium of a trabeculectomy

Fig. 6: Primary bleb scarring: a patent ostium and a subscleral tract with a flat bleb

Fig. 7: Viscocanalostomy showing the trabecular-descemetic membrane and an intrascleral chamber with an anechoic anterior portion

Fig. 8: The same area in transversal scan. Note the width of the intrascral chamber

Fig. 9: Deep sclerectomy with an external bleb containing a hypoechoic area and an apparently widened supraciliary space

Fig. 10: Intrasceral implant (T-Flux) in a deep sclerectomy procedure
The size of the intrascleral space is highly variable. It cannot be estimated by means of radial scans only. Both radial and transversal slices should be made (Fig. 10). There seems not to be a relationship between intrascleral chamber size and IOP reduction. The case in Figure 12 had an enormous intrascleral chamber with IOP in the low teens.

**GLAUCOMA DRAINAGE DEVICES (GDD)**

It is possible, in cases with corneal opacity, to determine the tube’s position in relation to the sclera, to the iris/lens plane and also the tube’s opening and the position of its bevel.

UBM is also necessary for the location of the tube when it has been introduced via pars plana. The relationship of the tube with the posterior surface of the ciliary processes and of the iris should be examined (Fig. 13).

The anterior part of the plate and the bleb area of GDDs can be scanned in most of the patients unless the valve is placed too posteriorly and/or the eyelid opening is too small. A central scan of the plate must be made in the same plane as that of the tube. This allows to assess the state of the plate surface and the presence of an aqueous chamber above the plate, to measure this chamber and to check the thickness of the bleb wall (Fig. 14).

**FOLLOW-UP OF COMPLICATIONS**

UBM is particularly useful for the follow-up and management of complications such as choroidal detachment, anterior chamber flattening and malignant glaucoma.

**Choroidal Detachment**

A serous choroidal detachment may be present even with a normal-size anterior chamber. The typical UBM image shows the retinal profile separated from the sclera and a series of parallel, membrane-like lines occupying this space (Fig. 15). When the choroidal is very small, it may be flat and peripherally located. Therefore it may remain undetected by conventional ultrasonography. UBM may in such cases shed light on unexplained hypotonies: minimal remnants of the choroidal, overlooked by conventional ultrasound, indicate when detected by UBM that IOP recovery is still under way.

**Reduced Anterior Chamber Depth**

When an important serous choroidal detachment with anterior chamber flattening occurs, the angle width and the iridocorneal distance are reduced concurrently with the bulging of the ciliary processes. The axis of this “rotation” movement is the scleral spur (Fig. 16). UBM allows, by means of its built-in caliper, to follow the evolution of a postoperatively reduced anterior chamber. It is of paramount importance to obtain analogue central scans at the maximal pupillary diameter in order to perform an adequate comparison.
Malignant Glaucoma

Malignant or ciliary block glaucoma is a complication of filtering and non-filtering surgeries. Aqueous misdirection produces accumulation of aqueous in the vitreous chamber and a forward displacement of the iris/lens complex with flattening of the anterior chamber and an IOP raise. There may be two mechanisms involved: primary misdirection (triggered by postsurgical apposition of the vitreous against the anterior surface of the ciliary processes) and a ciliary effusion causing rotation of the ciliary processes and contact between the processes and the lens equator leading to misdirection. This second mechanism was highlighted by Trope and coworkers who found ciliary effusions in two cases of confirmed malignant glaucoma, and by other observations in which annular effusions coexisted with moderately elevated IOP and a high prevalence of minimal choroidal effusions and forward rotation of the ciliary body in the early postoperative period. It is easy to presume that, once malignant glaucoma is established, elevated IOP causes the disappearance of the triggering effusion. The typical UBM image in established malignant glaucoma is a flat anterior chamber with flattened and rotated ciliary processes (Fig. 17).

NPGS Complications

Complications with non-penetrating deep sclerectomy/viscocanalostomy are less frequent than with trabeculectomy. A progressive reduction in the intrascleral chamber and its eventual collapse are signs of failure in non-penetrating surgery. Concavity of the trabecular-descemetic membrane has been described as an early sign of failure. It can be observed gonioscopically and also detected by UBM (Fig. 18). Timely applied goniopuncture restores the shape of the trabecular-descemet and lowers IOP (Fig. 19).

Some cases with a narrow angle may suffer peripheral synechiae (Fig. 20) which, when not timely managed, may lead to filtration failure.
Choroidal effusions, a rare complication of NPGS can occasionally be detected (Fig. 21).

**GDD Complications**
Apart from the already mentioned complications, the conditions requiring postoperative UBM examination in GDDs basically comprise opaque media and tube occlusions. Additionally, failure of IOP control may lead to UBM examination of the plate and of the bleb wall.

**CONCLUSION**
Ultrasound biomicroscopy holds various possible applications in glaucoma filtering surgery. Some of them are still not fully studied, developed and/or published. In spite of their common areas, anterior segment OCT and UBM do not fully compete with each other in this topic since UBM has limitations in its indications (need of an intact, non-leaking filtration area) and OCT has limitations in its capacity for reaching some anterior segment structures (ciliary body and posterior chamber).

UBM is a valuable addition to the diagnostic and follow-up armamentarium in the area of glaucoma filtering surgery.

**ACKNOWLEDGEMENTS**
To Dr Jorge Acosta and Dr Ignacio Negri-Aranguren for allowing me to scan some of their NPGS patients.
REFERENCES