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Evaluation of the filtering bleb and its relation to an intrascleral aqueous drainage route after trabeculectomy using ultrasound biomicroscopy
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Received 12 November 2015
Accepted 10 February 2016
Journal of the Egyptian Ophthalmological Society 2016, 109:50–53

Purpose
The aim of this study was to evaluate the relationship between filtering bleb parameters (height, extent) and the wideness of the aqueous drainage route beneath the scleral flap using ultrasound biomicroscopy (UBM) in patients who have undergone trabeculectomy with and without mitomycin-C (MMC).

Design
This was a prospective interventional observation uncontrolled study.

Patients and methods
A total of 30 patients undergoing 30 glaucoma filtering surgeries were assessed for at least 6 months using UBM to evaluate the bleb reflectivity, the visibility of the route under the scleral flap, the bleb height, and the extent in correlation with the mean intraocular pressure. Patients were divided into two groups: group A included 15 eyes in which trabeculectomy was performed without MMC and group B included 15 eyes in which trabeculectomy was performed with MMC (0.4%) applied for 2 min.

Results
The reflectivity inside the filtering bleb showed a significant correlation with the maximal width of the aqueous drainage route and the maximal height and the extent of the bleb. Furthermore, the bleb function was significantly associated with its UBM image in eyes trabeculectomized with adjunctive MMC.

Conclusion
The study concluded that the internal structure of the bleb can be a more sensitive predictor of the outcome of filtering surgery.

Keywords:
bleb dimension, filtering bleb, glaucoma, intraocular pressure, trabeculectomy, ultrasound biomicroscopy

Introduction
Trabeculectomy has been the standard surgical treatment for glaucoma since 1960 [1]. The surgical outcome depends mostly on the resulting intraocular pressure (IOP). The description of the morphology and the function of the bleb are usually essential to a favorable outcome [2] Bleb grading systems identified and incorporated a graded assessment of various bleb parameters such as vascularity, height, width, microcystic changes, and diffuse demarcated zones with reference to clinical and photographic standards [3]. The preservation of the aqueous drainage route beneath the trabeculectomy scleral flap cannot be evaluated by conventional slit-lamp examination [4].

The recent development of the ultrasound biomicroscopy (UBM) device has made it possible to observe the detailed structure of the anterior segment of the eye with a noninvasive procedure [5]. Qualitative assessment of the bleb by UBM found that the bleb type was associated with IOP control. Using UBM, four categories were described: low, high, flattened, and encapsulated [6]. In the present study, images of the filtering bleb using UBM (Dicon P545 UBM plus); were taken to assess the utility of UBM in providing images of the internal bleb structure and to correlate the UBM bleb dimension and the internal ostium extent with the success rate after trabeculectomy with and without mitomycin-C (MMC).

Patients and methods
This study was approved by the Review Boards/Ethics Committe of the Benha University of Medicine, informed surgical consent, including indication, risks and complications of the surgical procedure, was provided by all patient. A total of 30 eyes of 30 patients with chronic glaucoma underwent primary trabeculectomy at the Ophthalmology Department.
of Benha University Hospital. Patients were divided into two groups: group A consisted of 15 eyes in which trabeculectomy was performed without MMC and group B consisted of 15 eyes in which trabeculectomy was performed with MMC.

Informed surgical consent, including indications, risks, and postoperative complications of the surgical procedure, was provided by all patients.

In group A, the eyes included 10 eyes with chronic angle closure and five eyes with primary open-angle glaucoma. Group B included eight eyes with chronic angle closure and seven eyes with primary open-angle glaucoma. Tables 1 and 2 show the demographic parameters of the selected cases.

During surgery, the scleral flap of trabeculectomy was 4×4 mm², and the sclerostomy opening measured 1×2.5 mm. The flap was closed with two sutures of 10/0 nylon thread. MMC (0.04%) was applied intraoperatively in eyes of group B under the conjunctiva using a cellulose sponge for 2 min. All patients were followed up for 6 months for IOP control and UBM to study the bleb parameters.

According to Singh et al. [7] a successful bleb was defined as a bleb with an IOP less than or equal to 18 mmHg without topical glaucoma medication.

**UBM examination**

**Instrument and measurement**

For UBM examination, the instrument (Dicon P545 UBM plus, paradigm; Paradigm Instruments, Salt Lake City, Utah, USA) was set at 5.0×5.0 mm field of view with 90 decibels of gain, and 2.24 mm delay. The patient was under topical anesthesia in the supine position, using an eye cup filled with physiological saline as the coupling medium, and the probe scanned over the entire region of the filtering bleb. The bleb morphology was evaluated, including the maximum height of the subconjunctival filtering bleb, the width, the intrabeb reflectivity, and the route under the scleral flap, with the evaluation of the patency of the internal ostium. Just before each UBM examination, the IOP was measured using an applanation tonometer. The correlation between the maximal height, the width of the filtering bleb, and the thickness of the aqueous drainage routes in both groups (A and B) was evaluated by Pearson’s correlation coefficient. A level of \( P \) less than 0.05 was accepted as statistically significant. The study also determined the relationship between bleb parameters taken with UBM and the IOP in both groups.

**Results**

The study was carried out on 30 eyes of 30 patients of chronic glaucoma, which were divided into two groups. Group A consisted of 15 eyes in which trabeculectomy was performed without MMC, and in group B, trabeculectomy was performed with MMC. Tables 1 and 2 show the distribution of selected cases according to the sex, the age, and the type of glaucoma.

**Postoperative evaluation**

All patients were followed up at days 1, 7, 15, 30, and then every month for a total period of 6 months for IOP control and UBM (performed after 2 and 6 months) to measure the bleb height, extent, and width (patency) of the drainage route.

The variation in the bleb dimension was assessed, and their correlation to the IOP was determined as shown in Tables 3–4.

Regarding success, the mean IOP decreased significantly in group B, with complete success in 11 eyes (73.3%) in relation to group A, where complete success was achieved in five eyes (33.3%).

The maximal height of the filtering bleb showed a significant positive correlation with the maximal width of the aqueous drainage route (Fig. 1, 2).

In general, the IOP was correlated inversely with the maximal height and the extent of the filtering bleb as well as the width of the drainage route.

Most of the functioning blebs had low reflective lacunae of different shapes beneath the conjunctiva.
Nonfunctioning blebs that showed high reflectivity usually exhibited adhesions between the conjunctiva and the scleral flap, with an occluded internal ostium (Fig. 2).

**Discussion**

In normal eyes, the main outflow resistance appears to occur at the juxta canalicular connective tissue layer of the trabecular meshwork. This area is by-passed by the surgical procedure, allowing the passage of fluid from the anterior chamber to the intrascleral space [8]. In eyes that had undergone trabeculectomy, the development of a filtering bleb was correlated with the efficiency of filtrations beneath the scleral flap. It has long been believed that the development of a filtering bleb and the micro-architecture of the connective tissue in the bleb influence the IOP during the long-term postoperative follow-up [9]. The use of UBM permits the detailed noninvasive observation of the inner architecture of the bleb after trabeculectomy. Thus, the preservation of the aqueous drainage route beneath the scleral flap probably influenced the development of a filtering bleb after a trabeculectomy [10]. The present study was performed on 30 eyes of 30 patients, which were divided into two groups: group A in which trabeculectomy was performed without MMC and group B in which trabeculectomy was performed with MMC.

Group B had a complete success rate of 73.3%, with a significantly lower IOP than group A, which had a complete success rate of 33.3%, and it was considered to be statistically highly significant \( P < 0.05 \).

**Table 3** The mean values of bleb height and the width of aqueous drainage route as measured by UBM after 2 months in correlation to the IOP

<table>
<thead>
<tr>
<th>Group parameter</th>
<th>Group A</th>
<th>Group B</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of bleb (mm)</td>
<td>0.353 (0.207–0.840)</td>
<td>0.811 (0.450–1.090)</td>
<td>0.001</td>
</tr>
<tr>
<td>Width of aqueous drainage route (mm)</td>
<td>0.311 (0.241–0.320)</td>
<td>0.482 (0.320–0.583)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>IOP (mmHg)</td>
<td>18.7 (12–27)</td>
<td>12.9 (6–18)</td>
<td>3.7 (0.001)</td>
</tr>
</tbody>
</table>

**Table 4** Comparison between IOP (mmHg) and the bleb parameters of UBM after 6 months post operative

<table>
<thead>
<tr>
<th>Group parameter</th>
<th>Group A</th>
<th>Group B</th>
<th>( t )</th>
<th>( P )</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOP (mmHg)</td>
<td>18.7 (4.8)</td>
<td>12.9 (3.6)</td>
<td>3.7</td>
<td>0.001</td>
<td>2.6–8.9</td>
</tr>
<tr>
<td>Reflectivity (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>5–33.3%</td>
<td>1–6.7%</td>
<td>−1.51</td>
<td>&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>8–53.3%</td>
<td>5–33.3%</td>
<td>&lt;0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2–13.3%</td>
<td>9–60%</td>
<td>&lt;0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of bleb (mm)</td>
<td>0.353 (0.227)</td>
<td>0.126 (0.811)</td>
<td>−3.9</td>
<td>&lt;0.01</td>
<td>0.32–1.2</td>
</tr>
<tr>
<td>Breadth of bleb (mm)</td>
<td>1.771 (0.553)</td>
<td>2.472 (0.618)</td>
<td>−2.8</td>
<td>&lt;0.01</td>
<td>0.18–1.2</td>
</tr>
<tr>
<td>Aqueous drainage route assessment (mm)</td>
<td>0.311 (0.257)</td>
<td>0.482 (0.226)</td>
<td>−0.41</td>
<td>&lt;0.01</td>
<td>−0.34–0.23</td>
</tr>
</tbody>
</table>

CI, confidence interval; IOP, intraocular pressure; UBM, ultrasound biomicroscopy.

**Figure 1**

A representation of the poor development of filtering and the aqueous drainage route

**Figure 2**

(a, b) Ultrasound biomicroscopic image sclerostomy opening, the aqueous drainage route, and a well-developed filtering bleb are observed.
In addition, we used UBM in an attempt to determine the correlation between internal bleb structures represented by the bleb reflectivity, height, extent, and the width of the drainage route and the IOP after filtering surgery.

The present study identified a low reflective region adjacent to the scleral flap of the two groups with a positive linear relationship: the lower the IOP, the lower the reflectivity of the bleb and the more the breadth and the maintenance of the aqueous drainage route. It has been believed that bleb scarring is the principle problem after filtering surgery, and that it reduces the filtration. Bleb scarring is reportedly induced by an excessive repopulation of the fibroblast and subsequent over-production of the component of the extracellular matrix [10–12]. The effect of mitomycin in influencing the internal structure of the bleb could explain the low reflectivity of its bleb.

In our study, the visibility of the aqueous drainage route using the UBM with SD was 0.311±0.257 in group A and 0.482±0.226 mm in group B. Hence, the mean and the SD of the aqueous drainage route measurements of both groups were found to be higher in group B than in group A, which is considered to be statistically significant (P<0.01). There are no published data regarding the correlation between the aqueous drainage route extent and the level of IOP. However, Yamamoto et al. [6] found that the UBM images of mitomycin blebs associated with poor IOP control are characterized by lesser visibility of the aqueous drainage route under the scleral flap and a higher reflectivity inside the bleb. However, the study did not provide a numerical assessment of the bleb parameters; it evaluated only the bleb morphology.

Conclusion
The aqueous drainage route was correlated directly to the percentage decrease in the IOP. The study showed that not only was the bleb height correlated to the reduction in the IOP, but also that the lower the IOP was, the wider was the aqueous drainage route.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References
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