Ultrasound biomicroscopy as a tool in the evaluation and management of ocular hypotony in uveitis

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Purpose: Chronic uveitis can lead to hypotony that may result in severe visual impairment. We highlight the use of ultrasound biomicroscopy (UBM) as an imaging tool to decide the modality of therapy and management of uveitic hypotony. Methods: This was a retrospective hospital-based interventional case-series study that included a total of 36 eyes of 25 patients with uveitic hypotony seen between January 1997 and January 2020. Results: Thirty-six eyes of 25 patients with uveitic ocular hypotony were included. Unilateral involvement was seen in 56%. The median age of presentation was 21 years with a median follow-up of 21.5 months. Anterior uveitis was noted in 13.88%, intermediate uveitis in 52.77%, and panuveitis in 33.33% eyes. UBM findings commonly noted were pars plana membranes, supraciliary effusion, blunted ciliary process, and ciliary body traction. Other findings included ciliochoroidal detachment and ciliary body edema. Moreover, 22.2% eyes were managed with medical therapy alone, whereas 77.8% eyes received both medical and surgical intervention based on UBM findings. Furthermore, 66.7% eyes showed improvement in intraocular pressure, 13.9% eyes maintained the same IOP, whereas 19.4% eyes had worsening of IOP at final follow-up. Conclusion: We found UBM as a useful imaging tool in evaluating and judiciously deciding the mode of management of uveitic hypotony.

Key words: Blunting of ciliary process, ciliary body traction, ocular hypotony, pars plana membrane, pars plana vitrectomy, UBM, ultrasound biomicroscopy, uveitis

Ocular hypotony (OH) can be defined both statistically and clinically.\textsuperscript{[1]} The statistical definition of hypotony is intraocular pressure (IOP) less than 6.5 mm Hg, which is a standard deviation (SD) of over 3 below the mean IOP. The clinical definition of hypotony is IOP low enough to result in vision loss. The numerical definition of ocular hypotony suggested by the World Glaucoma Association is less than or equal to 5 mm Hg by tonometry.\textsuperscript{[2]}

Hypotony in uveitis can result due to several mechanisms working in concert to reduce the intraocular pressure.\textsuperscript{[3,5]} Both acute and chronic episodes of ocular inflammation can lead to hypotony. Hyperacute ocular inflammation can induce a significant drop in intraocular pressure, resolving once the inflammatory episode is brought under control.\textsuperscript{[3]} This effect is most likely mediated by increased prostaglandin secretion (prostaglandin E2 and F2 alpha), which in turn increases the uveoscleral outflow.\textsuperscript{[3,6]} However, chronic uveitis can lead to the development of ciliary membranes, which can increase the outflow by placing traction on the ciliary processes; moreover, it can decrease secretion by directly damaging the ciliary epithelium.\textsuperscript{[7]} While mild transient hypotony is of little consequence, chronic hypotony may lead to visual loss and structural changes, altering the function and appearance of the eye.\textsuperscript{[3,5,9]} Ultrasonic biomicroscopy (UBM) is a very helpful diagnostic tool for detecting the underlying structural abnormalities in ocular hypotony and in deciding on a course of treatment.\textsuperscript{[10,11]} In the current study, we have reported the UBM findings of our patients with uveitic hypotony and the mode of management depending on the patient. In this study, we highlight the use of UBM in deciding an individualized mode of treatment for uveitic hypotony and their vision and IOP outcomes over the course of treatment.

Methods

This study was a retrospective hospital-based interventional case-series study done in a tertiary referral eye care hospital in South India that caters to patients coming from all over the country for specialized eye care. The institutional review board and ethical committee approval was obtained prior to the study. A detailed registry of cases is maintained in our institution in the form of electronic medical records and also as paper files in selected cases. This database was used to identify and include the uveitic patients who were clinically diagnosed to have intraocular pressure of 6 mm Hg or less and for whom UBM was done to detect the pathological mechanism for the reduction in eye pressure. Data from records were retrospectively abstracted into a case sheet prepared for the study purpose.

Inclusion criteria for the study:
1. All patients of uveitis with ocular hypotony
2. All the above patients in whom UBM was documented

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Exclusion criteria for the study:
1. Patients with hypotony of non-uveitic cause
2. Patients with hypotony associated with significant ocular trauma
3. Hypotony in uveitis patients with no documented UBM report
4. Hypotony in patients following glaucoma surgery
5. Patients with inadequate follow-up of less than 3 months from the diagnosis of hypotony

All patients fulfilling the abovementioned criteria and who had a complete documented medical history, visual acuity (VA), ophthalmic examination with refraction, slit-lamp biomicroscopy, applanation tonometry, indirect ophthalmoscopy, UBM, ultrasound B-scan, and optical coherence tomography (OCT) were included. The visual acuity and intraocular pressure for the patients were monitored in the follow-up period. Patients with incomplete data were excluded from study analysis.

Data retrieved and analyzed included age at first visit, gender, laterality of uveitis, site of inflammation based on standardization of uveitis nomenclature (SUN) criteria, occurrence of complications, UBM findings, mode of management for hypotony (whether medical or surgical), and duration of follow-up.

The major outcome measures were intraocular pressure by applanation tonometer and best-corrected visual acuity at the first and final visit.

Ocular hypotony was defined as IOP less than or equal to 6 mm Hg.\(^{[1,2]}\)

The SUN criterion was used to diagnose and define the type of uveitis for all the patients.\(^{[14]}\) The details of associated systemic diseases and relevant laboratory investigations were noted. Specific diagnostic tests were also done in selected cases based on history and examination details. In the cases where specific etiology for uveitis could not be identified with laboratory investigations, the term “idiopathic uveitis” was used.

In those patients in whom fundus evaluation was difficult due to small pupil or media haze, B-scan ultrasonography and OCT were obtained to evaluate other factors for vision loss, such as retinal detachment and persistent cystoid macular edema.

UBM was done for all the patients with OH for assessment of inflammatory lesions of the iris, ciliary body, pars plana, and peripheral vitreous to ascertain the pathological mechanism for hypotony. All UBM scans were done by a trained paramedical staff using Humphrey UBM 840 high frequency, high-resolution system (Humphrey Instruments, San Leandro, CA) after informed consent from the patients. Proparacaine HCL 0.5% eyedrops were used for topical anesthesia. A 21-mm-diameter cylindrical eye cup was inserted between the eyelids and placed on the eyeball. Sterile physiological salt solution or methylcellulose solution was used to fill the eyecup. Hourly radial and longitudinal scans were performed around 360° showing the iridocorneal angle, the ciliary body, and the pars plana areas. Based on the UBM finding, an appropriate mode of treatment (medical or surgical) individualized for the patient was decided.

The patients were medically managed with steroids, immunosuppressives, or a combination of both. Steroids were administered either as topical prednisolone acetate 1% eyedrops, oral (tableted prednisolone 1–1.5 mg/kg tapering schedule), or periocular injections in form of posterior subtenon (PST) of 40 mg triamcinolone acetate. An anti-tubercular regime consisting of four drugs for a minimum of 9 months was started for patients with presumed ocular tuberculosis diagnosis. The surgical treatments done were membranectomy, fluid–gas exchange, silicon oil injection, and intravitreal injection triamcinolone acetonide (IVTA). The decision to treat with medical therapy alone or a combination of medical and surgical therapy was made based on the UBM findings and on the discretion of the treating ophthalmologist.

Statistical methods
All statistical analysis was done using SPSS software (SPSS 2005, SPSS for Windows, Version 14.0, Chicago). Distributions were summarized using proportions, means, or medians as appropriate, and 95% confidence intervals were obtained. Survival analysis was conducted, including plotting Kaplan–Meier survival curves to plot the intraocular pressure outcome in patients who underwent treatment for uveitic hypotony.

Results
The study period was from January 1997 to January 2020. We included 36 eyes of 25 patients with uveitic hypotony. The age of patients in our study group ranged from 10 to 41 years, with median age of presentation of 21 years. Unilateral involvement was present in 14 patients (56%) and bilateral involvement in 11 patients (44%). Of the 25 patients included, 10 (40%) were male and 15 were female (60%). The median follow-up duration was 21.5 months. Six eyes (16.7%) had a history of previous surgery; of which, five eyes had undergone cataract surgery with synechiolysis and one eye had membranectomy.

Location and etiology of uveitis
In our study population, we found anterior uveitis (AU) in 13.88% (n = 5), intermediate uveitis (IU) in 52.77% (n = 19), and panuveitis in 33.33% (n = 12) eyes. The specific uveitic entities were diagnosed with the help of ancillary laboratory investigations. HLA B27-related uveitis was seen in six eyes (16.66%), three of which presented as IU and three as AU. Tuberculous uveitis was seen in eight eyes (22.22%), of which six eyes presented as IU and two as panuveitis. Behcet’s disease was seen in two eyes (5.5%). The remaining 20 (55.55%) uveitic hypotony eyes had no definite diagnosis and were labeled as idiopathic uveitis, of which two presented as AU, eight as IU, and ten as panuveitis.

Results of ultrasound biomicroscopy
UBM was done for all 36 eyes with uveitic hypotony in our study group to evaluate the exact pathogenesis of ocular hypotony (OH). Study of UBM helped us to decide on the modality of therapy appropriate for each case. The most common UBM findings seen in this study were post-inflammatory pars-plana membrane (PP membranes), traction on ciliary body (CBT), supraciliary effusion (SE), and blunting or decrease in the number and size of the ciliary process (BCP) suggestive of ciliary body shutdown. Above UBM findings were seen either individually or in combination with each other [Figs. 1 and 2].

Of the 36 eyes, 22 eyes (61.11%) had PP membranes along with SE and BCP. Four eyes (11.11%) had PP membranes with CBT and BCP. Five eyes (13.88%) had PP membranes with CBT, BCP, and SE. One eye (2.7%) had only PP membranes; one eye (2.7%) showed PP membranes with BCP; two eyes (5.5%) had ciliochoroidal detachment and PP membranes; and one eye (2.7%) showed SE, ciliary body edema with normal ciliary processes.

Management
All 36 eyes were managed either medically or surgically or with a combination of both decided based on the UBM findings for each case. Surgical interventions were planned for the eyes in which UBM revealed CBT, pars plana membranes, and traction
and also for eyes in which medical treatment failed to maintain the intraocular pressure.

**Medical management**
Among 36 eyes with uveitic hypotony, eight eyes received medical therapy alone. Of the eight eyes, three eyes received oral steroids with immunosuppressive agents, two eyes received oral steroids with periocular steroid injection (PST), and the remaining three eyes received a combination of oral steroids, immunosuppressive therapy, and PST injection.

**Surgical management**
The remaining 28 eyes had combined medical therapy and surgical intervention. Prior and concomitant medical therapy included combinations of topical, oral, periocular, intravitreal steroids, and immunosuppressive therapy as required based on the decision of the treating ophthalmologist.

Of the nine eyes that had PP membranes with CBT on UBM, eight eyes underwent lensectomy with vitrectomy and membrane removal with additional belt buckle (BB) in two eyes and silicone oil injection (SOI) in two eyes; one patient refused surgical intervention and hence was included in medical management.

In one eye with only PP membranes, lensectomy–vitrectomy with BB, endolaser (EL) was done. In one eye with PP membranes and BCP, lensectomy–vitrectomy with BB was done, whereas in one eye with SE and ciliary body edema, lensectomy–vitrectomy with IVTA was done. The remaining 15 hypotonous uveitic eyes underwent lensectomy and vitrectomy with/without additional procedures such as belt buckle, silicone oil injection, and intravitreal steroids as per the discretion of the treating ophthalmologist.

**Final Intraocular pressure (IOP)**
Out of eight eyes with medical management alone, IOP improved in seven eyes, and in one eye, IOP remained stable.

Of the total 28 eyes managed surgically, eight eyes with CBT were managed surgically, four eyes had improvement in IOP, one eye maintained IOP, while a decrease in IOP was seen in three eyes. In the two eyes with ciliochoroidal detachment, rise in IOP was seen post-surgical intervention. In the remaining eyes with surgical management, rise of IOP was seen in 11 cases and IOP was maintained in three cases. In four cases, worsening of IOP was noted even with best medical and surgical management. The subset analysis between infectious and noninfectious uveitis/idiopathic uveitis showed that an improvement of IOP beyond 6 mm Hg was more likely in noninfectious uveitis (12 eyes out of 26 eyes had improved IOP) than infectious causes (one eye out of ten eyes had final IOP more than 6 mm Hg), suggesting a better outcome in non-infectious/idiopathic uveitis. The Kaplan–Meier survival curve of IOP was plotted. It showed that at the first year, 73.8%

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**Figure 1:** (a) Ultrasound biomicroscopy (UBM) of a patient showing hypodense ciliary body with blunted ciliary processes (blue arrow). (b) UBM of a patient revealing pars plana membrane with ciliary body traction (red arrow). (c) UBM of a patient showing supraciliary effusion (blue arrow) and blunted ciliary processes. (d) UBM of a patient showing blunted ciliary processes, membranes causing ciliary body traction, and supraciliary effusion

**Figure 2:** (a) Ultrasound biomicroscopy (UBM) of a patient showing pars plana membrane with early traction normal ciliary body (white arrow). (b) UBM image of the same patient showing normal ciliary processes in structure and number (yellow arrow). (c) UBM image of another case showing ciliary body traction (white cross) and blunted ciliary processes
of patients had IOP greater than 6 mm Hg and 45.8% had IOP greater than 6 mm Hg at the end of five years [Fig. 3].

**Visual acuity at final follow-up**

Among eyes that were medically managed, VA improved in three eyes, worsened in three eyes, and remained stable in two eyes. Among the surgically managed 28 eyes, all eight eyes with CBT treated surgically showed VA improvement. In two eyes with ciliochoroidal detachment, VA improved post-surgery. In the remaining 18 eyes, 14 eyes had improvement, three eyes had maintained the vision, and in one eye worsening was noted. The visual outcome of the patients before and after treatment is shown in the graph [Fig. 4].

**Discussion**

Ocular hypotony is an important complication of uveitis affecting those with uveitis, especially with younger age of onset and with longer disease duration. OH is associated with impairment of vision. No particular intraocular pressure limit has been approved by the consensus to define OH as all eyes do not respond the same way to low IOP. There has been much advancement for treating raised IOP. However, not much success has been noted toward achieving ocular survival after hypotony. Chronic uveitis can lead to the development of ciliary membranes, which increases aqueous outflow by placing traction on the ciliary processes, and also decrease its secretion by directly damaging the ciliary epithelium. The reported prevalence of hypotony has ranged between 1.2% and 10% in patients with uveitis, and it varies based on the type of uveitis. The UBM is an extremely useful imaging modality in evaluating the etiology of hypotony in uveitis. It provides a clear anatomical image of the ciliary body region that is operator-independent and least affected by external factors such as scleral depression or mechanical distortion. Our study reports the management outcomes of uveitic hypotony with respect to IOP and vision based on UBM findings prior to therapy.

The Multicenter Uveitis Steroid Treatment (MUST) trial by Sen et al. compared uveitic patients with hypotony to uveitic non-hypotony eyes. They noted that younger age of onset with a longer duration of symptoms was associated with hypotony. They found more women in the hypotony group. However, they reported no difference in the anatomical location of uveitis when both groups were compared. In the present study, we too found that hypotony was more common in younger age and predominantly among women. The MUST trial reported that though prior vitrectomy or cataract surgery was associated with a higher risk of hypotony, they may not be individual risk factors. We did not notice any significant association between prior surgical intervention and hypotony. In this study, 16.7% of eyes had a history of cataract surgery but none of the patients had vitrectomy prior to the onset of hypotony.

Daniel et al. reported an increased risk of uveitic hypotony in children with no gender association. They reported more incidence of uveitic hypotony in AU and panuveitis than in IU and posterior uveitis. Another retrospective study done on 442 patients by Aman et al. reported the median age group for uveitic hypotony as 46.8 years with 57% incidence in females and more commonly seen in AU than in non-AU. In our study, the age of most patients with hypotony was between 16 and 30 years with median age of presentation of 21 years. Whether gender is a risk factor with hypotony is unclear; some studies have reported a significant association between gender and structural complications or poor outcomes, whereas others have found no significant difference. Uveitic hypotony, in our study, was seen most commonly in eyes with IU with 52.77% incidence followed by panuveitis and AU. The most common etiology of uveitis causing hypotony in our study was idiopathic in 50% of eyes, followed by tuberculosis-related uveitis having an incidence of 22.22%.

Ragab et al. studied UBM findings in 29 pseudophakic eyes with secondary glaucoma and concluded that UBM can detect changes not seen clinically and is a useful diagnostic tool in pseudophakic glaucoma. A study by Tran et al. reports that UBM is of great value in diagnosing the cause for hypotony with inflammatory process situated in pars plana and retroiridal vitreous areas where clinical examination alone is not sufficient. Hammer et al. reported that UBM provides a clear detailed image of ciliary body undisturbed by scleral depression or other forms of mechanical distortion. In our study as well, UBM findings contributed essential information that aided in the diagnosis and management of uveitic hypotony. Blunting of ciliary processes and supraciliary effusion in UBM were seen most commonly in our study, with a frequency greater than 50% each. In our study, UBM was able to identify the cause of hypotony in the uveitic eyes. The three most common UBM findings seen in this study were post-inflammatory pars plana membranes with CBT, supraciliary chorial effusions, and supraciliary plaques.
and blunting or decrease in the number and size of the ciliary process suggestive of ciliary body shutdown. UBM was able to identify the structures that could not be assessed clinically and thus aided in the management of these eyes.

In our study, eight eyes (22.22%) were treated with medical management alone. The remaining 28 eyes had both medical and surgical intervention based on UBM findings. Smet et al.[27] reported that using anti-inflammatory agents in raised and slow tapering doses was more likely to be effective in hypotony of recent onset and that some response was seen within 2–3 months. Sen et al.[19] reported no significant effect of immunosuppressives on uveitic hypotony. In our study, oral and topical steroids and periciliar steroids were the mainstay in medical management and the eyes responded well with the treatment. However, adjunctive treatment with immunosuppressives was given for few uveitic hypotony eyes, some of which responded well to the adjunctive immunosuppressive agents. The majority of eyes showed minimal response with medical therapy and hence additional surgical intervention was done with the support of UBM studies.

The study by Smet et al.[27] states that the presence of a detached ciliary body due to ciliary body traction and the absence of ciliary processes suggested a better surgical prognosis. Gupta et al.[28] reported that in eyes with normal ciliary processes, removal of ciliary membranes was sufficient to restore IOP and in eyes with ciliary processes atrophy, silicone oil injection can help in maintaining the IOP. In our study, the modality of management for each case was guided by their UBM findings. The majority of eyes in our study showed improvement in VA/IOP. In a few patients, VA/IOP was maintained. In the remaining patients, they failed to show improvement either in VA or IOP [Figs 2 and 3].

We found that uveitic hypotony due to supraciliary effusion can be well managed with medical therapy alone, whereas uveitic hypotony with ciliary body traction requires surgical removal of the traction causing pars plana membrane along with the medical treatment. Blunting of the ciliary processes and ciliary body shutdown can be managed with medical treatment along with surgical procedures such as belt buckle, fluid–gas exchange, and/or silicone oil implantation.

Though our study has the inherent drawbacks of a retrospective study with few eyes, we found that UBM is an extremely useful tool in identifying the cause and mechanism of uveitic hypotony and thus aided in adequate and appropriate management of these eyes.

Conclusion

We found UBM as a very useful diagnostic test in cases of uveitic hypotony. The exact etiology of hypotony like PP membrane, CBT, BCP or combined mechanisms were detected on UBM and addressed either by surgical and/or medical management with a favourable outcome in IOP in the present series.

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Conflicts of interest
There are no conflicts of interest.

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