High frequency ultrasound imaging in pupillary block glaucoma

Ioannis M Aslanides, Peter E Libre, Ronald H Silverman, Dan Z Reinstein, Douglas R Lazzaro, Mark J Rondeau, Gregory K Harmon, D Jackson Coleman

Abstract

Background—The diagnosis of pupillary block glaucoma requires sufficient clarity of the ocular media. This is particularly important for assessment of both the presence and patency of an iridotomy, and the determination of central anterior chamber depth.

Methods—High frequency ultrasonography was used in three patients with suspected pupillary block to determine iris configuration, posterior chamber volume, and ciliary body configuration.

Results—All patients demonstrated high frequency ultrasonographic findings consistent with pupillary block: iris bombe, a formed posterior chamber, and a lack of anterior rotation of the ciliary processes.

Conclusion—High frequency ultrasound imaging appears to be a valuable adjunct in making or corroborating the diagnosis of pupillary block glaucoma.

Methods

We use an HFU scanning system of our own design which has been described elsewhere.10-14 We use both polymer and ceramic transducers of 50 MHz nominal centre frequency with bandwidths extending up to 70 MHz. The transducer is moved by a pair of computer controlled perpendicularly mounted motors (Newport-Kinger Inc, Garden City, NY, USA) that enable consecutive parallel B-scans to be obtained. The scan width is user defined. For this study, a scan width of 19-2 mm was used in order to encompass a full anterior segment cross section, and was reduced to 10-2 mm to produce more detailed images of the angle. Each examination consisted of a number of scan sequences in either the transverse or sagittal plane, focusing on the angle structures at different clock hours. Each sequence consisted of 16 consecutive scans separated by 0-25 mm intervals.

For scanning, the patient is supine. An adhesive plastic drape supported by a ring stand forms a watertight seal around the eye. After instillation of a topical anaesthetic (proxymetacaine (proparacaine) hydrochloride 0-5%, Alcon, Puerto Rico), a lid speculum is inserted and normal saline is then added to form a waterbath. The transducer is coupled to the eye through this saline standoff medium thus allowing non-contact anterior segment scanning without deformation of the globe.
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Figure 1 Wide angle view of anterior segment of case 1. Left: iris bombé (B) and intraocular lens (IOL) with multiple echoes due to reverberation of the ultrasonic signal, are well illustrated. Right: haptics (H) of the IOL, posterior to the iris, in a sequential series of adjacent scans, and posterior synechiae (ps) are also shown. Totally closed angle bilaterally is seen.

Results

CASE 1

A 73-year-old woman with pseudoexfoliation glaucoma underwent extracapsular cataract extraction with a polymethylmethacrylate posterior chamber IOL without peripheral iridectomy. The procedure was complicated by a perioperative total hyphaema which caused postoperative corneal blood staining. During the second postoperative month, the peripheral anterior chamber gradually became more shallow and intraocular pressure (IOP) rose up to 40 mm Hg despite timolol maleate 0.5% twice a day and acetazolamide 250 mg four times a day. The blood stained cornea prevented the referring physicians from differentiating aqueous misdirection from pseudophakic pupillary block. The patient was referred to our institution for diagnostic evaluation and treatment.

On examination, vision was hand movements. The IOP was 40 mm Hg. Slit-lamp examination revealed dense corneal staining extending to within 2 mm of the limbus. A blood clot was adherent to the endothelium superotemporally. The anterior chamber appeared peripherally shallow, but central depth could not be assessed.

HFU showed loculated fluid filled spaces posterior to the iris. Prominent iris bombé was seen. Extensive adhesions between the pupillary sphincter and IOL could be discerned. Central anterior chamber depth was normal (Fig 1) and the ciliary processes were not anteriorly rotated (Fig 2). The iris bombé, the loculated fluid posterior to the iris, and the non-rotated ciliary processes were felt to be incompatible with aqueous misdirection, yet supported a diagnosis of pupillary block glaucoma.

With a working diagnosis of pupillary block, an Nd:YAG iridotomy was performed. The anterior chamber did deepen slightly peripherally, but the pressure (38 mm Hg) was nearly unchanged as peripheral anterior synechiae had already formed over a significant portion of the angle. An uncomplicated trabeculectomy with mitomycin C 0.4 mg/ml for 4 minutes was performed. All flap sutures were cut by argon laser within 1 week postoperatively, and a functioning filtering bleb was present superonasally. 5-Fluorouracil was injected subconjunctivally on four occasions in the first 2 weeks for a cumulative dose of 40 mg.

Although the bleb remained flat postoperatively, the IOP remained in the teens without medications for 2 months. Between the third and seventh postoperative months, timolol maleate 0.5%, pilocarpine hydrochloride 4%, and apraclonidine hydrochloride 1% were begun as pressure began to rise. On this regimen, pressure remained in the mid teens during the follow up period.

Figure 2 A close up view of the lower angle. Haptics of the intraocular lens (arrow), non-rotated ciliary processes (Pr), and a formed posterior chamber (PC) are shown. Loculated aqueous humour between the iris and capsule-zonule-ciliary body diaphragm can be seen.
CASE 2

An 85-year-old woman with pseudoexfoliation underwent extracapsular cataract extraction. Owing to an intraoperative rent in the posterior capsule associated with vitreous loss, an anterior vitrectomy with peripheral iridectomy and anterior chamber IOL implantation were performed.

Three months postoperatively, iris bombe was found in the superior and temporal quadrants with a pressure of 20 mm Hg. The central anterior chamber was normal. A clinical diagnosis of relative pseudophakic pupillary block was made. HFU scanning was performed and confirmed the diagnosis of pupillary block glaucoma by revealing non-anteriorly rotated ciliary processes and a normal anterior chamber depth centrally. It also revealed a space between the iris and the ciliary body although the zonular fibres and capsule were not seen individually. Figure 3 shows a scan where a zonular-capsular remnant complex is present.

An Nd:YAG iridotomy was performed which resolved the sectoral iris bombe. IOP remained within the normal range (12 mm Hg) as most of the angle remained unaffected.

CASE 3

A 57-year-old man presented with pain caused by angle closure glaucoma in an eye which, to his knowledge, had never perceived light. The cause of blindness was unknown, but B-scan ultrasonography at the time of presentation showed an intumescent lens and a total retinal detachment. The central anterior chamber depth was less than 1 mm, and the peripheral anterior chamber was flat. Moderate rubecosis, a synechially secluded 2 mm pupil and a dense cataract were apparent.

Two Nd:YAG laser iridotomies that were initially performed were not patent, but after enhancement with an argon laser, the pressure fell from 48 mm Hg to 13 mm Hg. Two weeks later the patient returned with recurrent angle closure, an intraocular pressure of 32 mm Hg and apparently occluded iridotomies. Revision of the original two iridotomies and the creation of a third iridotomy reversed the angle closure, and the IOP dropped to 12 mm Hg. One week later, the angle closure recurred for a second time with an IOP rise to 60 mm Hg. Two of the former iridotomies were occluded, but the cataract was visible through the third iridotomy.
The response to iridotomy suggested pupillary block. The closure of the iridotomy was attributed to the underlying rubecosis. However, the markedly shallow anterior chamber and recurrence of angle closure despite one patient iridotomy suggested that either phacomorphic glaucoma or aqueous misdirection were present.

The patient was then referred to our institution for HFU scanning. A cataractous intumescent lens, a secluded pupil, as well as peripheral anterior synchiae were seen (Fig 4). Iris bombe, an anterior chamber formed only in the vertical meridian, a formed posterior chamber, and ciliary processes which were not anteriorly rotated were also clearly visible (Fig 5). On this basis, aqueous misdirection was excluded as a diagnostic possibility. The angle closure may have been partially due to lens intumescence, but the improvement after iridotomy showed that an element of pupillary block was also present.

**Discussion**

Clinical diagnosis and differentiation between pupillary block glaucoma and aqueous misdirection is difficult, the latter being merely a diagnosis of exclusion.\(^{15}\) In each of the three cases presented here, HFU demonstrated three findings which we believe are consistent with pupillary block and exclude the diagnosis of aqueous misdirection. The pupillary block findings comprise:

1. a formed (non-collapsed) posterior chamber. An aqueous humour filled space, between the iris and the lens-zonule-ciliary body diaphragm,
2. absence of anterior rotation of the ciliary processes, and
3. iris bombe which may formally be described as a condition where the peripupillary portion of the iris is posterior to any other region of the iris.

It is hypothesised that the pathophysiology of aqueous misdirection lies in the altered anatomical relation and/or dysfunctional aqueous dynamics occurring behind the iris plane. This results in aqueous humour misdirection that eventually accumulates in the vitreous as opposed to the posterior chamber.\(^{16,17}\) Anatomical access for aqueous flow between anterior and posterior chamber should be present to facilitate this diagnosis.\(^{17}\) Once aqueous humour is sequestered within the vitreous, it is apparently difficult for fluid to pass through the anterior hyaloid to the posterior chamber. Consequently the volume and pressure within the vitreous increases significantly; this would be expected to cause collapse of the posterior chamber, anterior rotation of the ciliary processes, and central shallowing of the anterior chamber. Known risk factors for aqueous misdirection include miotics, chronic angle closure, and filtering surgery.

To date there have been two publications describing HFU findings in aqueous misdirection.\(^{9,18}\) Both report that the ciliary body is so anteriorly rotated that the ciliary processes were in apposition to the iris. In each case shown here, it is clear that the ciliary processes were far from apposition with the iris. Trope and co-workers\(^ {10,18}\) also noted a small choroidal effusion in two of 14 cases of aqueous misdirection. In case 3 of our series, a supraciliary effusion was also seen, suggesting that the presence of an effusion does not exclude pupillary block.

Pupillary block hinders escape of aqueous humour from the posterior chamber to the anterior chamber. Since the pressure would be higher in the posterior chamber than in the anterior chamber (and presumably in the vitreous as well), a formed posterior chamber, a non-anteriorly rotated ciliary body, and iris bombe would be expected only in pupillary block. All three of the cases presented in this paper clearly demonstrated these characteristics.

We believe that the findings discussed in this report enabled pupillary block to be reliably diagnosed using HFU. High frequency ultrasound scanning will often be of use in corroborating clinical findings, but in certain cases, it provides a unique tool for non-invasive assessment and diagnosis where the clarity of ocular media is compromised.

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Figure 5 A close up view of the angle of case 3. A formed posterior chamber (PC), intumescent lens (L), totally occluded angle, non-anteriorly rotated processes (Pr), and a suprachoroidal effusion (Ef) are seen. Finally, corneal epithelium-Bowman's membrane (double line) can be seen.
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