B-scan ultrasonography of the anterior segment of the eye

MALCOLM LEMAY

From the University of Glasgow, Tennent Institute of Ophthalmology, Western Infirmary, Glasgow

SUMMARY B-scan ultrasonograms of the anterior segment were performed on selected patients. The difficulties in imaging the anterior segment are discussed and the value of this technique is demonstrated by illustration of B-scans in different pathological conditions. This technique can often provide important information and allow an early and accurate prognosis.

B-scan ultrasonography is now widely used in ophthalmology for investigation of orbital lesions and posterior segment lesions when direct visualisation is prevented by opacity in the ocular media. Most authors have concentrated on ultrasonic demonstration of posterior segment lesions, but the separation of diseases of anterior and posterior segments is largely artificial. The present study has perpetuated this division, but in an attempt to demonstrate the diagnostic value of ultrasound in involvement of the anterior segment.

The normal practice of this laboratory has been to include the cornea, iris, and lens on ultrasonograms to aid orientation of B-scan pictures by clinicians. This has led to an increasing demand for information on anterior segment lesions alone.

The difficulties of ultrasonic visualisation of the anterior segment will be considered. The demand for anterior segment ultrasound led to an appraisal of the problems, and the experience gained in the examination of the first 500 patients has led to the development of a satisfactory routine. Cases are presented to illustrate the use of conventional ultrasonic equipment in the management of patients with anterior segment disease.

Materials and methods

Approximately 500 patients have been examined in the first 2 years of a recently established diagnostic ultrasonography clinic, and of these 7 patients will be used to illustrate the most common diagnostic problems. The clinic is one in which both ophthalmologists and radiologists experienced in ultrasonic imaging techniques participate.

Ultrasonic examination is with the Sonometrics 100 Ophthalmoscan (Coleman *et al.*, 1969), a purpose-built scanner assembled for high resolution ophthalmic application. It is possible to image the anterior segment with this equipment. The acoustic coupling is by the waterbath technique previously described by Coleman *et al.* (1969). The contact B-scanner (Bronson and Turner, 1973) does not image the anterior segment unless a waterbath is used.

After light topical anaesthesia a Barraquer type wire speculum is inserted to keep the eye open. It has been found that resolution is improved if the transmitted and reflected impulses do not pass through the closed eyelids. Probes of nominal frequencies of 15 and 20 MHz are used for the study of the anterior segment and the highest available magnification of $\times 5$ is used. Comparable values for posterior segment work would be 8 or 10 MHz at a magnification of $\times 3$. The scans are photographed from an oscilloscope display to produce Polaroid prints. Total examination time is less than 30 minutes.

NORMAL ULTRASONIC ANATOMY

An ultrasonogram of a normal anterior segment produced in the manner described is shown in Fig. 1. This defines the anterior and posterior corneal surfaces, and small echoes are seen within the corneal stroma. The depth of the anterior chamber and the configuration of the iris are clearly seen, and both corneal thickness and anterior chamber depth are demonstrated. These measurements can be made with a high degree of accuracy by the facility of simultaneous A- and B-scan display provided by the Sonometrics 100 apparatus. The anterior lens surface is not shown in this view in which the pupil has been demonstrated. The interior of the lens is echo free.

Address for reprints: Dr M. LeMay, Tennent Institute of Ophthalmology, Western Infirmary, Glasgow G11 6NT

Fig. 1 B-scan ultrasonogram of normal anterior segment

Fig. 2 Normal eye to show lateral side of anterior segment

The region of the ciliary body can also be explored (Fig. 2) and ciliary processes are occasionally identified. Tumour masses can be visualised and their extent defined before local excision.

CASE REPORTS

A. Corneal opacity

Case 1. A 57-year-old man presented with a 10-year history of recurrent episodes of discomfort in his left eye. The vision had been poor since an injury in 1948, and at the time of examination the vision in the left eye was hand movements. An opaque cornea prevented further clinical examination. Ultrasonic examination showed an anatomically normal lens and iris and a cornea with a relatively normal periphery. A 7-mm penetrating keratoplasty was undertaken, and the patient attained a corrected acuity of 6/9 after an uneventful post-

operative course. Pathological examination showed keratinoid corneal degeneration (Garner, 1970) in the excised disc. The abnormal area appears in the ultrasonogram as a dense, echo-rich area in the anterior stroma.

Case 2. A 47-year-old woman with postherpetic scarring of the cornea was examined. Two previous penetrating grafts and a lens extraction had been performed. The ultrasonogram showed an aphakic eye with a thin iris. The most normal echo pattern was in the centre. The cornea was otherwise extensively thickened. In view of the predicted technical difficulties of grafting into a greatly thickened cornea further surgery was postponed.

Case 3. A 13-year-old boy with postherpetic corneal scarring developed secondary bacterial infection and ulceration of the central cornea. He presented with central corneal perforation, and an emergency penetrating keratoplasty was performed.

Fig. 3 Longstanding traumatic cataract from central corneal penetrating wound (Case 4)

Fig. 4 Ultrasonic appearance of senile cataract

Postoperatively the anterior chamber was slow to form owing to leakage of aqueous at the suture line, and vascularisation of the wound from the iris occurred. There was retrograft membrane formation, and the graft became opaque obscuring the anterior chamber. Ultrasonic examination showed a thickened donor graft with a shallow anterior chamber, and adhesions between iris and suture line were demonstrated. More recently a further graft has been performed. With the information available from the ultrasound examination care was taken during surgery to trephine into the formed part of the anterior chamber, avoiding the lens. The recent graft has been successful and reasonable vision has been achieved.

B. Opacities in the lens

Case 4. A patient aged 23 had a totally opaque lens following a penetrating corneal wound in childhood. A narrow strand of iris was adherent to the

corneal scar. The patient was referred for ultrasound to exclude posterior segment abnormality before extracapsular extraction. The anterior segment views (Fig. 3) showed a shrunken lens with almost total absorption of lens matter. It was suggested that capsulotomy would be the more appropriate operation, but surgery has not yet been performed. The appearance of a senile cataract is shown in Fig. 4 for comparison.

C. The traumatically disorganised eye

Case 5. A young man was examined after a blunt injury to 1 eye. A total hyphaema prevented any detailed examination of the injured eye. Ultrasound in the acute phase (Fig. 5) showed subluxation of the lens and an artificially deep anterior chamber, suggesting the likelihood of angle recession. The patient was given a poor prognosis immediately after injury, when the only apparent defect was a total hyphaema.

Fig. 5 Case of total hyphaema. Demonstration of subluxation of the lens (Case 5)

Fig. 6 Extensive anterior vitreous organisation following trauma (Case 6)

Fig. 7 Showing separate nature of fibrosis in the vitreous unlikely to complicate lens extraction (Case 7)

Case 6. Figure 6 shows the eye of a 4-year-old boy after traumatic corneal perforation by a stone. The clinical appearance at this stage was of traumatic cataract; a folded anterior lens capsule was visible through a miotic and adherent pupil. Ultrasonography during general anaesthesia showed extensive involvement of anterior vitreous and lens in what is presumed to be fibrotic process following rupture of the lens capsule. Anterior vitrectomy was considered but was not carried out at this time. A different decision would probably now be made with the availability of a suction/infusion cutter. The patient retains his eye, although useful vision is absent.

Case 7. A situation essentially similar to that in the previous patient is seen in Fig. 7. This patient also has a small and adherent pupil and an opaque lens, but vitreous fibrosis is separate from lens and is unlikely to complicate successful surgery.

Discussion

Ultrasonography is a useful method of visualising the structure of a diseased or opaque eye. Conventional ultrasonograms often include imaging of the anterior segment as part of the completed picture, and early illustrations by Baum and Greenwood (1958, 1960, 1961) include some easily recognisable anterior segments. Coleman and colleagues (Coleman *et al.*, 1969; Coleman, 1972; Coleman *et al.*, 1973a, b) have improved ultrasonic apparatus and techniques and have illustrated a normal anterior segment in early papers. Coleman *et al.* (1969) and Vanysek *et al.* (1969) reported a series of 25 normal and aphakic eyes in which imaging of the anterior segment was attempted.

The reasons for the paucity of reports of anterior segment appearances are worth consideration. Disease of the anterior segment is frequently visible by conventional examination, and further information is often not required. The current case reports have attempted to show examples from patients in whom ultrasound has contributed further useful information. For example, more extensive pathology can be concealed by an opaque cornea or hyphaema (Coleman, 1973a, b). Ultrasonography is probably essential prior to vitrectomy (Coleman, 1972; Jack *et al.*, 1974), and even negative results are reassuring when surgery is being contemplated.

Ultrasonic visualisation of the anterior segment can be technically difficult. Some apparatus is designed to be in contact with the eyelid, and echoes from the cornea are indistinguishable from those of the posterior surface of the eyelids. There would also appear to be considerable absorption and scattering of sound waves during transmission

through the eyelids, particularly with the higher frequencies used in ophthalmology, and this contributes further to poor imaging.

Ultrasonic probes may give poor resolution of detail in the anterior segment. Probes are designed to give maximum lateral resolution near the focal length, which is often designed to coincide with the posterior coats of the eye, and anterior segment detail is again poor. The probe is engineered to both transmit and receive the ultrasonic impulses and if situated close to the cornea is still refractory or 'ringing' from the transmitted pulse when the first reflected waves are received. Echoes from parts of the anterior segment therefore fail to show.

These problems have been overcome to a large extent by improved design of probes. It is possible to narrow the beam width by focusing sound in much the same fashion as light is focused, and to reduce 'ringing' by damping the crystal with a backing usually consisting of epoxy resin and powdered tungsten. Excessive damping of the crystal may further reduce the sensitivity of the device, and so a 'near field' is usually left in which imaging is not satisfactory. The anterior surface of the lens is usually difficult to image owing partly to dispersal of the sound beam by the convex anterior surface and partial concealment by the iris. With a dilated pupil the lens is easily imaged (Posakony, 1969; Gordon, 1969).

Many of these problems are overcome if the waterbath technique is used (Coleman *et al.*, 1969) and the eye is kept open during the examination. In practice the distance of the probe from the cornea is usually 10 to 20 mm, and the problem of the focal length being posterior to the eye does not appear to be of great importance.

Using a frequency higher than 10 MHz improves resolution, perhaps because less damping is required in a high frequency probe (Posakony, 1969) rather than an improvement due to frequency alone. The use of purpose-designed ophthalmic ultrasound apparatus is recommended. The magnification which can be obtained improves resolution rather than merely increasing the size of the image. As recently as 1971 Sokollu (1971) thought equipment design to be the main cause of poor imaging of the anterior segment. Most problems seem to have been overcome in the Sonometric apparatus.

Finally the patient's eyes must be immobile during the few seconds necessary for the recording of each scan to improve resolution further. This can be assured only with a relaxed patient, and the confidence and skill of the operator contribute much to the patient's mental state.

The indications for ultrasonography have been listed by Coleman *et al.* (1973b), and their criteria

may be applied to patients with anterior segment disease as follows: (1) Opaque cornea; (2) opaque anterior chamber (hyphaema, etc); (3) opaque lens, but not *senile* cataract if other tests of function are normal; (4) small pupil $\pm$ opaque lens; (5) anterior vitreous pathology; (6) tumours of the iris or ciliary body.

Ultrasound is generally used to complement existing techniques of examination. In the opaque eye for example a combination of ultrasonography and electrophysiology is valuable (Kennerdell, 1973). The improving quality of ophthalmic B-scans using conventional purpose-designed equipment can give valuable information in deciding the management of selected patients.

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