Role of B-scan ocular ultrasound as adjuvant for the clinical assessment of eyeball diseases

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Learning objectives

The study focuses on the contribution of ocular ultrasonography when the clinical examination proves to be difficult, mainly due to the existence of intraocular opacities or diagnostic doubts. In these cases, the implementation of an ultrasound examination can streamline or modify the clinical management of their conditions.

Our aims were:

- to illustrate the spectrum of faculties of the ocular ultrasound in detecting and confirming the existence of eye lesions
- to outline the advantages and limits of this technique
- to describe the best indications and results of the method based on a series of 52 patients evaluated in the period 2006-2012.
Background

Although clinical examination and ophthalmoscopy are the basis of diagnosis in most patients with eye disease, in many cases, especially when the clinical examination of the ocular fundus is difficult, other techniques will be required, being ultrasound one of them.

In addition to its specific role in selected cases, ultrasound is a safe technique, cheaper and more affordable compared to other techniques that would also provide good data (such as optical coherence tomography, CT, MRI,...). Ultrasonography does not involve the contraindications that may have other techniques more expensive and less accessible as MRI (presence of metallic items, claustrophobia, etc. ...) or optical coherence tomography (although it has some specific indications, especially in the optic nerve diseases for its high spatial resolution, it is also less more affordable than ultrasound).

Contraindications for ocular US are rare; the main contraindication is suspected ocular globe rupture in patients with trauma or who recently underwent surgery because it may cause extrusion of ocular contents.
MATERIALS, METHODS AND PROCEDURE DETAILS:

Since 2006 until December 2012, 52 patients attended in the consulting room of Ophthalmology of our hospital, were then translated to the Radiology ward to be submitted to an ultrasound scan.

We used linear high-frequency (7.5-13.0 MHz) transducers, a HD11XE Philips and GE Logiq 500.

The examinations were performed in B mode and in color Doppler imaging with patients in the supine decubitus and eyes closed (Fig.1), slightly resting the transducer on both eyelids, after application of coupling gel.

Axial images are obtained from the upper to the lower poles of the entire globe.

Sagittal images are obtained from the temporal to the nasal side.

Oblique views and dynamic images are also performed with eye movements from right to left and up to down. Dynamic imaging is unavoidable; it improves visualization of the entire eye and depicts movement of vitreous echoes or lines.

Color Doppler US easily visualizes the central retinal artery and the short posterior ciliary arteries, and can also depict the retinal layer and the central retinal vein.

RESULTS:

We assessed a total of 79 ocular diseases over the 52 patients examined by ultrasound in our Department. They revealed to be:

- 16 complete cataracts.
- 9 cases of lesions of the anterior chamber: 7 of them bleeding (hyphema) and 2 due to pus deposit (hypopyon).
- 12 cases of hemovitreous.
- 5 neoplastic lesions: 3 choroidal melanomas (including one amelanotic melanoma), one nevus and one melanocytoma.
- 8 macular degenerations (drusen).
- 4 cases of congenital diseases (juxtapapillary colobomas).
- 5 inflammatory pathologies, including one Vogt Koyanagi Harada syndrome.
- 20 cases of lesions in the posterior parietal layers of the eyeball: 8 retinal detachments, 2 choroidal detachments, 6 mixed retinal and choroidal detachment, 4 vitreous detachments.

DISCUSSION AND IMAGING FINDINGS:

In our experience the disorders of the posterior layers of the eyeball were the diseases detected with greater frequency (20 cases), but sonography revealed to be an important adjuvant in detecting also other groups of ocular diseases as cataracts, lesions of the anterior chamber, hemovitreous, neoplastic lesions, macular degenerations, congenital diseases and inflammatory pathologies. Each group revealed to have specific B-scan sonographic features, below sorted out:

- **Cataract** is a degenerative disease of the lens that is usually seen in the older age-groups. It can sometimes be secondary to trauma, when the lens becomes opaque due to deposition of reflective material beneath the lens capsule. An immature cataract shows scattered opacities separated by clear zones. In a complete cataract, the lens has a completely opaque cortex and is seen as a very dense structure (Fig.2).

- **Hyphema** is represented by the presence of blood in the anterior chamber. The ultrasound image shows small echogenic areas anteriorly due to the bleeding (Fig.3).

- **Hypopyon** (pus in the anterior chamber) is represented as an echogenic band in the anterior chamber due to the collection of purulent debris (Fig.4).

- **Vitreous hemorrhage** can result from tearing due to vitreoretinal traction, diabetic retinopathy, vasculitis, subarachnoid hemorrhage, and blunt trauma to the eye. Later, the hemorrhage may organize and develop fibrinous membranes. B-scan reveals widespread low-intensity echoes in the vitreous chamber, which show marked aftermovement on dynamic scanning (Fig.5).

- **Choroidal melanoma**, the commonest primary intraocular tumor in adults, arises from the choroid and ciliary body. Most of these lesions arise posterior to the equator of the eyeball. On B-scan, it is seen as a lenticular-shaped mass arising from the choroid. USG is used to assess scleral erosions and extraocular extension into orbital fat. Some tumors have a collar-button or mushroom shape. Blood flow within the tumor is seen on color Doppler as pulsating channels or lakes of color. Choroidal melanoma may be associated with retinal detachment. The tumor has a bilobed or ‘cottage-loaf’ appearance, which is caused by waisting as it breaks through Bruch’s membrane (Fig. 6).

The pigmentation can range from deep brown(melanotic) to no pigmentation (amelanotic) (Fig. 7).
An area of excavation under a small posterior wall mass is indicative of melanoma, although this feature is not always present.

- **Benign melanocytic tumors** include nevi and melanocytomas. Like a melanoma, the pigmentation of a nevus can range from no pigmentation (amelanotic) to a deep brown pigmentation (melanotic). A melanocytoma typically is heavily pigmented. They, too, have a dome-shaped configuration but, in contrast to melanoma, are highly reflective and do not have internal vascularity (Fig. 8). Unfortunately, small melanomas may show an absence of low internal reflectivity, and, consequently, it may be difficult to differentiate a small benign lesion from a similar sized malignant one.

- **Drusen** (calcified plaques within the optic disc) are usually bilateral and asymptomatic, but they may cause atrophy of the optic nerve. Hyperechoic lesions at the papilla with acoustic shadowing are seen at US. The presence of calcifications and their location are the clues to the diagnosis (Fig. 9). Although the presence of drusen is common in older people, in our experience we detected this disease preferably in young people (75%).

- A **coloboma of the optic nerve head** involves a congenital defect in its structure occurring as a result of malclosure of the ocular fissure. At US, a defect in the optic disc and a papillary excavation are seen (Fig. 10). It may be mild, in which case there is a defect in the optic nerve substance, usually inferiorly. This defect may be more extensive and involve the juxtapapillary choroid and retina. It may be associated with a pit deformity and with a juxtapapillary staphyloma. This latter term refers to an outpouching of the ocular wall around the optic nerve head. In our study 4 juxtapapillary colobomas were demonstrated, one of them not known. In the other three cases, US helped to quantify the level of excavation.

- **Inflammatory pathology:** one of them, with granulomatous appearance, revealed as Vogt Koyanagi Harada syndrome. Vogt-Koyanagi-Harada (VKH) disease is a rare multisystem disorder that affects the eye, inner ear, skin and meninges. The characteristic ocular manifestations are severe bilateral panuveitis with iridocyclitis, serous retinal detachment, diffuse choroidal swelling and optic disc hyperemia. These findings are typically bilateral, but the severity may be asymmetric. Ultrasonographic image displays the lobular nodular thickening of the posterior ocular wall and the mixed detachments of the ocular membranes due to the inflammatory granulomatous lesions (Fig.11, a-b). Angiography shows the typical a retinal nodular enhancement (Fig.11 c).

- **Retinal detachment** (RD) is usually due to a break or tear in the retina; it may also be caused by vitreoretinal traction due to contracting membranes or because of subretinal exudates. The detached retina is usually attached to the firm anchoring points of the ora serrata anteriorly and the optic nerve head posteriorly and, consequently, a total RD shows a funnel (V) shape (Fig.12). Dynamic scan may reveal an undulating motion of the retinal membrane, particularly in a recent RD. RD can be acute or chronic, total or partial (Fig.13). In acute RD the membrane is thin and mobile. Over time the membranes become thicker and echogenic, and with eye movements become rigid. Arterial and
venous flows can be seen inside. There are three types of RD, depending on the underlying mechanism: rhegmatogenous, or retinal tearing; tractional, or separation of the retinal layer due to tugging by vitreous membranes; and exudative, in which blood, fluid, or a lesion is present in the subretinal space. In the presence of RD, the subretinal space and vitreous should always be examined because they may contain blood, exudative fluid, or tumor, thus providing the cause of the detachment, a determination that is usually not possible at ophthalmoscopy. In some patients with partial RD, the request for US was to rule out a neoplasm causing detachment.

- **Choroidal detachment** is caused by accumulation of fluid in the potential suprachoroidal space, which is located between the choroid and sclera and extends from the ora serrata to the optic disc, but the choroid is fixed to the sclera by vortex veins. At US, the bands visible in the choroidal detachment are typically thick and rigid, convex (in obtuse angle), and not "anchored" on the optic disc but at the level of vortex veins. Arterial flow can be seen in the thickness of these membranes (Fig.14). In our experience most cases (75%) of choroidal detachment were observed to be associated to retinal detachment (Fig. 15).

- **Vitreous detachment** is seen in elderly individuals. It results from gel liquefaction and collection of fluid in the subvitreal space, which in turn, results in vitreous detachment. It is seen frequently in cataractous eyes on B-scan. The posterior vitreous detachment or hyaloid detachment appear as avascular membranes and reduced volume of vitreous gel (Fig.16, a and b) with very low echogenicity that also exhibit a typical fluid movement when the patient performs eye movement (Fig. 16c). Vitreous detachment can be observed either associated or not with hemovitreous.
Fig. 1: B-scan ocular ultrasound technique. 1.a: Ultrasound image in "B mode" of the normal eyeball, visualizing the anterior chamber and lens above, and the anechoic vitreous and the posterior wall behind. Deeply, the hypoechoic band of the optic nerve is observed. 1.b: Doppler ultrasound of the left ophthalmic artery, with its velocimetric curve.

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**Fig. 2:** Complete cataract. 2.a: Eye with complete cataract. 2.b: Ultrasound image of the eyeball with increasing thickness of the lens due to complete cataract (arrow).

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Fig. 3: Hyphema (blood in the anterior chamber). 3.a Eye with hyphema. 3.b: Ultrasound image of the same patient observing the presence of small echogenic areas due to the bleeding (arrow).

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Fig. 4: Hypopyon (pus in the anterior chamber). 4.a: Eye with hypopyon 4.b: Ultrasound of the same patient observing the presence of an echogenic band in the anterior chamber due to the collection of purulent debris (arrow).

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**Fig. 5:** Hemovitreous. Increased echogenicity of vitreous due to hemorrhage.

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Fig. 6: Choroidal typical melanoma. 6.a: A minimally raised lesion of approximately 5 mm in the posterior wall of the right eye, which corresponds to a melanoma (arrow). 6.b: Retinography of the same patient: the irregularly pigmented lesion corresponds to the melanoma. 6.c: Angiography shows some areas of contrast enhancement corresponding to the melanoma. 6.d: Optical coherence tomography showing a raised lesion developing minimal retinal detachment.

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Fig. 7: Amelanotic melanoma. 7.a: Raised polypoid lesion of about 6 mm proved to be an amelanotic melanoma. 7.b: Retinography of the patient shows the mass, round and shiny. 7.c: Angiographic study shows a strong contrast enhancement of the mass.

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Fig. 8: Melanocytoma. 8.a: A raised lesion corresponded to a melanocytoma (arrow). 8.b: Retinography showing a dark lesion typically in the optic nerve head.

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**Fig. 9:** Bilateral drusen. 9.a: Bright echoes in the right optic disc due to drusen. 9.b: Drusen in the left eye of the same patient.

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Fig. 10: Colobomatous papillary fossete. 10.a: Ultrasound image showing a small defect in the ocular posterior wall (arrow), corresponding to a colobomatous papillary fossete. 10.b: Papillary defect detail.

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Fig. 11: Vogt-Koyanagi-Harada syndrome. 11.a: Ultrasonographic image displaying the lobular nodular thickening of the posterior ocular wall (arrow). 11.b: Inflammatory granulomatous lesions lead to mixed detachments of the ocular membranes. 11.c: Angiography showing a retinal nodular enhancement in Vogt-Koyanagi-Harada syndrome.

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**Fig. 12:** Complete retinal detachment. Typical V shaped, with thick echogenic rigid bands.

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**Fig. 13:** Partial retinal detachment. 13.a: Thick echogenic band due to partial retinal detachment, with hemovitreous. 13.b: Retinogram of the patient observing on the left a diffuse erasing due to the raising of the retinal layer. 13.c: Ultrasound shows an echogenic image below the thick band of the retinal detachment due to subretinal hemorrhage (arrow).

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Fig. 14: Choroidal detachment. 14.a: Ultrasound image of a patient with choroidal detachment, visualizing a convex and rigid thick band. 14.b: Doppler study revealed arterial flow in the membrane

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**Fig. 15:** Mixed retinal and choroidal detachment. Multiple membranes suggesting mixed detachment, retinal and choroidal.

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**Fig. 16:** Vitreous detachment. 16.a: The posterior vitreous detachment (hyaloid detachment) appears as avascular membranes and reduced volume of vitreous gel with very low echogenicity. 16.b: Dynamic ultrasound of the same patient: when he looks at right and at left, the membranes show complete mobility. 16 c: Posterior vitreous detachment with similar curve as the posterior ocular wall. It is associated to hemovitreous.

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Conclusion

We consider the scan ophthalmic ultrasonography as an important adjuvant for the clinical assessment of various ocular and orbital diseases. With understanding of the indications for ultrasonography and proper examination technique, one can gather a vast amount of information not possible with clinical examination alone.
References


