The usefulness of ocular ultrasound

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Learning objectives

The aims of this exhibit were:

- To know the indications and the proper technique for performing the ocular ultrasound.
- To review the ultrasonographic anatomy of the ocular globe.
- To review echographic signs of the most common ocular pathology through different cases example.
Background

Ultrasound examination of the ocular globe is an accessible, easy, non-invasive and useful technique, in situations that prevent a normal eye examination, or when examination findings suggest particular pathology of the eye.

However, there is certain ignorance in this area among radiologists, as long as ophthalmologists are responsible for making the diagnosis without resorting to ultrasound imaging technique, or by using more invasive or expensive imaging methods.

Indications of ocular ultrasound:

- Situations that prevent a normal eye examination due to the opacity of anterior segment structures (leucoma, corneal edema, hypopyon, hyphema, cataract) or posterior segment structures (hemovitreous, vitritis).

- To provide useful information when examination findings suggest particular pathology of the eye (identification and monitoring tumors, evaluation of choroidal detachment, retinal detachment).

Contraindications and limitations of ocular ultrasound:

Ultrasound examination should not be performed in cases of suspected diagnosis of post-traumatic or postoperative ocular perforation.

Ocular ultrasound is not useful in evaluating bony orbital walls and posterior orbit. At the present time the anterior segment evaluation has practically no indications because of development of ultrabiomicroscopy.

Proper technique of performing ocular US

A high-resolution 7.5-10 Mhz linear array ultrasound transducer is used to perform an ocular examination.
B-mode ultrasound should be performed in a supine patient with closed eyes, taking transverse and sagittal views. Eye movements in different directions and colour Doppler help us to get more info.

It is important to adjust the device controls and settings: gain and focus. The gain manage is very important in mode-B ocular ultrasound. The study starts with a medium gain, that shows the view of medium and high echogenicity structures, and then it is maximized to visualize very low-echogenicity structures (early vitreous or subvitreous hemorrhage, hyphema, vitreous floaters, etc).

**Normal sonographic anatomy of ocular globe**

The eye ball is divided by the lens into two segments:

- **Anterior segment:** subdivided by the iris in anterior and posterior chamber. It includes the cornea, iris, ciliary body and lens. It contains a fluid called aqueous humor.
- **Posterior segment:** also contains more consistent fluid called vitreous humor.

Ciliary body, aqueous humor, vitreous humor and the cornea are the transparent structures of the eye.

The eyeball wall is composed by three layers:

- **The external layer:** a fibrous layer that is very resistant and keep the shape of the eye. It is formed by the sclera at the back and the cornea in the anterior part.
- **The intermediate layer:** the uveal tract is a vascular layer, divided in anterior part (iris and ciliary body) and posterior part (choroid).
- **The internal layer:** a neural layer, the retina, which contains different structures in its surface: macula, fovea and papilla or optic disk.

The structures of the eye are easily visible on ultrasound. The previous structure is the cornea, shown as a thin line, it can sometimes be unidentifiable. The anterior segment comprises two anechoic areas: the anterior chamber (between the cornea and the iris) and the lens, an anechoic structure with thin anterior and posterior capsules. Ciliary bodies are on both sides of the lens shown as hypoechoic structures. The vitreous is seen
as an anechoic region posterior to the lens. The posterior wall (three layers) appears as a concave echogenic line, interrupted by the optical disk.

Ultrasonographic semiology of the ocular diseases

1. Morphologic features of the ocular lesions

- **Point-like echoes:** small lesions with a variable echogenicity according to their composition. Low-echogenicity echoes may be due to degenerative conditions like early vitreous hemorrhage or hyalitis, and high or medium-echogenicity echoes may be caused by evolving vitreous hemorrhage and endophthalmitis evolved.
- **Membrane-like echoes:** linear images, with a variable length, thickness and echogenicity according to their etiology. For instance, the posterior vitreous detachment shows a low-echogenicity membrane while the retinal detachment exhibits a higher echogenicity and thicker membrane.
- **Solid echoes:** bigger images than point-like echoes. They can be focal or diffuse.

2. Kinetic-mobility of ocular lesions

After evaluating the morphology of the lesion, proceed to ask the patient to do eye movements in all axes. It is important to show hidden membranes on the posterior wall in the rest position.

The movement that membranes do to return to its position is called after-movement. After-movement can be fluid (degenerative posterior vitreous detachment), rigid (early retinal detachment) or be absent (choroidal detachment).
Findings and procedure details

OCULAR PATHOLOGY

ANTERIOR SEGMENT

CRYSTALLINE LENS

Cataract

It can be seen as opacity in lens material with echoes inside the lens or increased anteroposterior diameter of the lens with a high echogenicity of the posterior capsule. Also can be seen both images. (Fig. 1)

Lens dislocation

The lens can be moved from its normal position, normally to posterior segment. Lens dislocation is caused by damage to the zonular fibers (suspensory ligament) that keep the lens in place, and can be seen in ocular trauma and Marfan syndrome.

POSTERIOR SEGMENT

VITREOUS

• OPACITIES

Degenerative condition

It occurs in 50% of patients over age 50, more frequently and earlier in subjects with myopia.

B-scan reveals point-like and membrane-like echoes, with a rapid initial movement and a fluid after-movements. This is not specific for degenerative condition, we can see similar images in hemovitreous or hyalitis.
Asteroid hyalosis

It has been associated with diabetes mellitus, hypertension and hypercholesterolemia.

We can see calcium particles like little focal or diffuse opacities with high echogenicity, without any posterior acoustic shadowing and fluid characteristic movements.

- **VITREOUS HEMORRHAGE**

The most frequent causes are the rupture of sclerotic vessels, trauma, choroidal neovascularization, diabetic retinopathy or tumors.

There are several stages of hemorrhage showing different morphological characteristics.

In early stages B-scan reveals very low echogenicity thin echoes, with considerable movements. (Fig. 2)

In its evolution, opacities acquire medium echogenicity, with the same fluid movements.

Then forming high echogenicity fibrin clots, and may be formed thick membranes which moving fluidly with eye movements at beginning, and after become rigid and fixed to posterior wall, being able to cause a retinal detachment.

- **PERSISTENT HYPERPLASTIC PRIMARY VITREOUS**

It is a rare congenital developmental anomaly of the eye, a failure of normal primary vitreous regression (formed by the hyaloid artery) that is not replaced by the secondary or adult vitreous. It is important to use colour Doppler for the differential diagnosis with retinoblastoma and other leucocoria.

Ultrasound reveals a little eye ball (microphthalmia), an hiperechogenic mass behind the lens, and an echogenic band extending from posterior surface of the lens to the optic nerve head. On colour Doppler, this band shows an arterial blood flow, due to the persistence of the hialoid artery. (Fig. 3)

- **POSTERIOR VITREOUS DETACHMENT**
The detachment may be complete or incomplete. Incomplete detachment may present fixation areas to the posterior wall, being able to observe retinal traction. In complete detachment there is no relationship with the posterior wall.

B-scan shows a thin membrane with very low echogenicity and sometimes it is necessary increasing the gain to see it. This membrane has a concave shape parallel to the posterior wall.

On movement, the vitreous shows increased after movements.

With colour Doppler there is absence of flow, which differentiates it from retinal detachment. (Fig. 4)

**RETINAL DETACHMENT**

Accumulation of fluid between the neuroepithelium and retinal pigment epithelium in the "subretinal" space.

It can be seen like a high echogenicity thick membrane, from the optic disc to the ora serrata when the detachment is complete. It takes morphology in "V" in its early stages; "Y" or "T" when it evolves without treatment. May be mobile in the acute phase, becoming more rigid in cases of chronic detachments. Vascularization is detected with Doppler (arteriovenous flow). (Fig. 5)

**CHOROIDAL DETACHMENT**

High echogenicity thick membrane with a convex configuration. It forms an obtuse angle with the posterior wall not detached. Movements are scarce or absent. Colour Doppler reveals arterial flow.

**CHOROIDAL MELANOMA**

They are tumors that affect the uveal tract (iris, ciliary body and choroid). Small tumors show middle and homogeneous echogenicity, a biconvex lens appearance and they have usually a regular outline.
Larger tumors are lower-echogenicity lesions and can present cystic areas representing areas of necrosis or hemorrhage. They are usually mushroom-shaped and they have an irregular outline.

These tumors present smooth attenuation.

Colour doppler examination of these tumors will show evidence of perfusion in most instances. (Fig. 6)

It is frequently associated with retinal detachment, and vitreous hemorrhage occasionally.

**CHOROIDAL METASTASIS**

They are difficult to differentiate from melanoma. They are usually more irregular, more echogenic and vascularized and may be multiple. (Fig. 7)

The most frequent metastasis are usually from breast and lung cancer.
Fig. 2: VITREOUS HEMORRHAGE. Patient with suspected diagnosis of vitreous hemorrhage and cataract that prevent a normal eye examination. Ultrasound reveals multiple medium echogenicity thin echoes with significant movements. Also the examination shows a retinal detachment, which is the cause of the hemorrhage.

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Fig. 3: PERSISTENT HYPERPLASTIC PRIMARY VITREOUS. A. The comparison of the eyes reveals a smaller left eye (microphthalmia). B. Hyperchoegenic mass behind the lens. C. Echogenic band extending from posterior surface of the lens to the optic nerve head. D. On colour Doppler, this band shows an arterial blood flow, due to the persistence of the hialoid artery.

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Fig. 4: POSTERIOR VITREOUS DETACHMENT. Inside the vitreous we can see an hyperechogenic image, well bounded by a posterior thin membrane (arrows), with increased after-movements.

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**Fig. 5: RETINAL DETACHMENT**
A. Same patient as in Fig 2. Ultrasound reveals "V"-shaped membranes (blue dashed lines), with the vertex in the optic disk (acute retinal detachment). B. Patient with a history of retinal detachment surgery due to ocular trauma, which presents eye pain and amaurosis. The ultrasound examination shows a thick "Y"-shaped membranes (chronic retinal detachment; arrows) and anechoic rounded images in the subretinal space (asterisk) due to previous surgery.

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**Fig. 6: CHOROIDAL MELANOMA**
A. Mushroom-shaped mass in the posterior eyeball wall, with a 1 cm diameter, and an irregular outline. B. Colour Doppler reveals perfusion inside the mass. C. The choroidal melanoma causes a retinal detachment.

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**Fig. 7:** CHOROIDAL METASTASIS Small mass (2 mm) in the posterior eyeball wall (arrow), with a lenticular morphology (A) and perfusion in colour Doppler examination (B).

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**Fig. 1:** CATARACT. A. Echoes inside the lens, that shows an increased echogenicity. B. Increased anteroposterior diameter of the lens and high echogenicity of the posterior capsule.

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Conclusion

Ultrasonography is a useful, accessible and easy exploration for the diagnosis of the ocular pathology. All radiologists should properly know the ocular anatomy and semiology for the right interpretation of the US exploration thereof.
References


