Ultrasonography of the eye and orbit

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Abstract

Ultrasonography (US) is, quite often, the first imaging modality used in eye and orbit assessment. The indications of ophthalmic US cover a wide range of disease where direct clinical assessment is impossible or of little value. Doppler US enhances the ability to assess blood flow in the main arteries and veins. In order to take full advantage of all the possibilities US has to offer the examiner thorough knowledge of the examination technique and normal US anatomy of the eye and orbit is required. This paper reviews the basics of the examination technique and ultrasound anatomy of the eye and orbit.

Keywords: ultrasonography, eye, orbit,

Due to its noninvasiveness, ease of access, quick and reliable information and real-time character, ultrasonography (US) is, quite often, the first imaging modality used in eye and orbit assessment. The indications of ophthalmic US cover a wide range of disease where direct clinical assessment is impossible or of little value: foreign bodies and trauma, intraocular hemorrhage, retinal or choroid detachment, congenital or acquired structural anomalies and tumors. Retroocular orbital diseases such as optic neuritis, abscess, foreign bodies or tumor also benefit from US. Doppler US enhances the ability to diagnose orbital vascular anomalies or tumors and to assess blood flow in the main arteries and veins.

In order to take full advantage of all the possibilities US has to offer the examiner thorough knowledge of the examination technique and normal US anatomy of the eye and orbit is required. The goal of this paper is to review the examination technique and ultrasound anatomy of the eye and orbit.

Examination technique

US of the orbit can be achieved either with general purpose machines or with dedicated “ophthalmology only” scanners that allow for zonal speed error correction and A-mode scanning. As for general use scanners, any US machine that accepts linear, 7.5 to 10 MHz small footprint transducers is suitable for this purpose. Higher frequency transducers are required to assess structures of the anterior pole.
The patient lies supine, head slightly rotated to the opposite side, to prevent gel pouring. A paper or drapery isolation field around the orbit may further prevent gel slippage. The eye is kept closed during the examination. After placing a generous amount of gel on the closed eyelid, transverse and sagittal scans through the orbit are obtained. Assessment of the side structures, mainly extrinsic muscles, is difficult with conventional, linear transducers. In this instance, the divergent or trapezoid emission of US available on some machines is very useful.

Real-time assessment implies on-command eye movement while scanning. Doppler parameters need to be adjusted for low flow. While power or color Doppler quickly identify the presence of blood flow and depict even tiny vessels such as the central retinal ones, spectral Doppler is used to assess flow patterns.

**Ultrasound anatomy**

At the anterior pole of the eyeball, the eyelids and the conjunctiva abutting the cornea produce a moderate echogenic structure which outlines the ventral part of the anterior chamber. With high resolution transducers, the cornea appears as a convex echofree thin line bounded posteriorly by an echogenic interface. The anterior chamber is echofree and is delineated posteriorly by the strong reflecting line of the iris. The pupil appears as a translucent disruption of iris continuity. Posterior to it lies the anechoic lens. The anterior margin of the lens is not apparent, and neither is the posterior chamber, which is too thin to be visible. The lens diameter is 10 mm with a maximal thickness of 3-4 mm. The posterior margin of the lens is convex towards the vitreous cavity and, due to variable spatial relationship with the ultrasonic beam, is only partly apparent. The ciliary body produces a focal thickening of the eye wall, next to the margins of the lens. The vitreous humor is echofree, homogenous and occupies more than two thirds of the eyeball volume. Since it only adheres to the posterior wall in a few points, movement of the vitreous humor relative to the wall can be observed during real time scanning (fig 1).

The posterior wall of the eyeball is echogenic, often with no inner layers. With high frequency transducers and lowering of distal gain compensation, the choroid appears less echogenic than neighboring retina or sclera.

Behind the eyeball, the intraconal fat pad is hypoechoic, mainly due to acoustic enhancement in the vitreous humor. The optic nerve appears as a sagittal hypoechoic structure, 4.5 – 5 mm thick, than runs from the outer part of the eyeball to the tip of the orbit. The length of the optic nerve is approximately 2.5 cm (fig 2).

The extrinsic muscles that form the intraorbital muscular cone appear as hypoechoic bands with typical longitudinal striations. The oblique muscles are almost never seen, due to their close relation to the rectus muscles and thin belly. The rectus muscles can always be assessed, especially if trapezoid emission of ultrasound at the surface of the transducer is used. They are oriented in a sagittal plane and occupy the four cardinal points in the orbit (superior, inferior, medial and lateral). The medial rectus muscle, which is best seen, has the maximal thickness of 4 mm. The inferior rectus muscle is the most difficult to assess (fig 3).

Normal orbital vessels (ophthalmic, ciliary, and retinal) are not seen on grayscale scans. Color or power

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**Fig 1.** The anterior pole of the eye. C = cornea; P = pupil; I = iris; CB = ciliary body; L = lens; VH = vitreous humor.
Fig 2. The retroocular space. ON = optic nerve; VH = vitreous humor

Fig 3. Extrinsic eye muscles. LRM = lateral rectus muscle; MRM = medial rectus muscle

Fig 4. Eyeball vessels. CR = central retinal vessels; ChB = choroid blush
Doppler adjusted for low flow is the method of choice for vessel detection while spectral display is used to analyze flow velocity and patterns. Typically, central retinal and ciliary arteries display low resistance flow (fig 4).

The lachrymal glands occupy the upper outer angle of the anterior orbit. They are almond shaped, echogenic with the long axis below 1 cm. Quite often, they cannot be differentiated from neighboring fatty tissue (fig 5).

**Conclusion**

Ultrasonography of the eye and orbit is not difficult to perform. However, thorough knowledge of ultrasound anatomy and scanning technique is mandatory for proper usage of the technique in the appropriate clinical setting.

**Selective references**