Four-dimensional ultrasound imaging in neuro-ophthalmology

Ekaterina Titianova\textsuperscript{a,b,*}, Sylvia Cherninkova\textsuperscript{c}, Sonja Karakaneva\textsuperscript{a}, Boyko Stamenov\textsuperscript{d}

\textsuperscript{a} Clinic of Functional Diagnostics of Nervous System, Military Medical Academy, 3 Georgi Sofiiski str., 1606 Sofia, Bulgaria
\textsuperscript{b} Medical Faculty, Sofia University, 1 Kozhak str., 1407, Sofia, Bulgaria
\textsuperscript{c} Clinic of Neurology, University Hospital "Alexandrovska", 1 Georgi Sofiiski str., 1431 Sofia, Bulgaria
\textsuperscript{d} Department of Neurology, Pleven Medical University, 8 G. Kochev str., 5800 Pleven, Bulgaria

**KEYWORDS**
4D ultrasound imaging; Optic disc swelling; Optic nerve edema; Retinal detachment; Macular degeneration

**Summary**

**Purpose:** To demonstrate diagnostic abilities of space–time (4D) ultrasound imaging in patients with eye pathology and some neuro-ophthalmic syndromes.

**Methods:** Fifteen healthy controls and 15 patients with eye pathology (papilledema, retinal detachment, macular degeneration and intraocular metastasis) were studied by multimodal (color duplex, B-flow and 3D/4D imaging) sonography.

**Results:** Normal optic disc resulted in a smooth and sharp contour without swelling. Papilledema was presented as a hyperechoic prominence into the vitreous. On its side the optic sheath diameter was increased in association with the degree of optic disc swelling. The retinal detachment was imaged as a hyperchoic undulating membrane, the neovascular macular degeneration — as a hyperchoic membrane behind the retina, and the intraocular metastasis — as irregular unifocal formation into the vitreous.

**Conclusions:** The 4D neuro-ophthalmo-sonology helps for the quick and non-invasive volume imaging of the type, size, location and severity of optic disc and optic nerve edema and its differentiation from other types of eye lesions.

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**Introduction**

The conventional ultrasound methods are widely used in ophthalmology for evaluating the eye structures (lens, vitreous, chambers, retina, optic discs and optic nerves) and eye circulation (ophthalmic arteries and veins) mainly in the presence of cataract or other processes, hindering the ophthalmoscopy [1–3]. Recently the volume 3D/4D eye ultrasound imaging in adults has been introduced [4] which provides additional information for the structural and functional eye changes in normal and pathological conditions.

The aim of the study was to demonstrate the diagnostic abilities of 4D ultrasound imaging in patients with eye pathology and neuro-ophthalmic syndromes.
Materials and methods

Fifteen healthy controls (10 women and 5 men, mean age 47 ± 10 years, age range 21–69 years) and 15 patients (9 women and 6 men, mean age 45 ± 17 years, age range 21–84 years) with visual problems were studied: 10 patients with papilledema, 3 patients with retinal detachment, 1 man with macular degeneration and 1 man with right intraocular choroidal metastasis. Multimodal sonography (color duplex, B-flow and 3D/4D imaging) was used for the evaluation of eye morphology and circulation (Logic 7, GE). The optic nerve sheath was measured 3 mm distal to the optic disc [5].

Results

The normal eye had a typical circular hypoechoic B-mode image with well seen structures inside: a thin hypoechoic cornea (parallel to the eyelid), anechoic anterior and posterior chambers (filled with liquid), anechoic lens, hyperechoic iris and ciliary body (linear structures extending from the peripheral globe towards lens) and relatively echolucent vitreous. The normal retina was not able to be differentiated from the choroidal layers. The optic nerve caused a hypoechoic shadow away from the globe. The same structures had also a typical 4D ultrasound image — the optic disc had a sharp contour without swelling into the vitreous and...
the optic nerves were with relatively symmetrical sheath diameters on both sides (Fig. 1).

In the presence of optic nerve head pathology we found relatively specific 4D images. Papilledema was presented as a contoured hyperechoic prominence into the vitreous. Its degree correlated with the severity of edema, measured by ophthalmoscopy. On the same side the optic sheath diameter was increased in association with the degree of optic disc swelling (Fig. 2).

The space—time imaging contributed for the quick distinguish of neuro-ophthalmic syndromes from other ophthalmic lesions. Retinal detachment was seen as a hyperechoic undulating membrane in the posterior to lateral globe. Blood vessels had grown up from the choroid behind the retina in the case of wet macular (neovascular) degeneration producing hyperechoic membrane into the vitreous. The choroidal metastasis was imaged as a heterogenic irregular unifocal formation within the lateral part of the affected vitreous with a feeding vessel connecting the formation with the choroidea (Fig. 3).

Discussion

Our study shows that space—time ultrasound imaging gives additional information for the type, location and severity of the eye structures and allows their real time volume assessment in normal and disease conditions. All available 4D ultrasound data in the literature are for studying fetal behavior and prenatal eye movements during pregnancy [6], therefore we could not compare our findings with other volume ultrasound ophthalmic studies in adults.

Conclusions

The 4D neuro-ophthalmic-sonology helps for the quick volume imaging of the type, size, location and severity of optic disc and optic nerve edema and its differentiation from other ophthalmic lesions. It may be helpful in avoiding the need from lumbar puncture, CT or MRI.

References