Clinical Applications of Color Doppler Imaging in Orbital Diseases

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Background: Color Doppler imaging (CDI) has been used in ophthalmology to study vascular disorders including various orbital diseases. We report our experience with CDI in orbital diseases and review the literature.

Patients and Methods: CDI was performed in selected patients with orbital diseases such as carotid cavernous fistula, Graves’ ophthalmopathy, ocular melanoma, and orbital tumors.

Results: Twenty-five patients underwent CDI. Seven had carotid cavernous fistula, four had choroidal melanoma, eight had Graves’ ophthalmopathy, and six had orbital tumors. In patients with carotid cavernous fistula, CDI revealed a prominent dilated superior ophthalmic vein and spectral wave-form analysis showed high-velocity arterialized blood flow in all cases. Patients with choroidal melanoma had an arterial signal with flow. In patients with Graves’ ophthalmopathy, flow velocities in the ophthalmic and central retinal arteries were not significantly different from those in normal subjects. No blood flow signal was noted in patients with cavernous hemangioma, lymphoid hyperplasia, or meningioma, while one patient with hemangiopericytoma had multiple blood flow signals.

Conclusion: CDI offers several advantages over computed tomography and magnetic resonance imaging in the evaluation of different orbital diseases. Safe, dynamic, and cost-effective, CDI provides a convenient way to not only diagnose and differentiate orbital tumors, but to monitor treatment efficacy as well.


KEY WORDS: • color Doppler imaging • carotid cavernous fistula • choroidal melanoma • Graves’ ophthalmopathy

INTRODUCTION

Color Doppler imaging (CDI) is a popular diagnostic imaging method for studying vascular disorders and is an alternative to invasive vascular techniques such as venography and arteriography [1–3]. It enables simultaneous bidimensional imaging and Doppler evaluation of blood flow in orbital vessels such as the ophthalmic artery, central retinal artery, posterior ciliary artery, and superior ophthalmic vein (SOV). CDI has been used in ophthalmology to study vascular disorders such as central retinal vein occlusion, ocular ischemic syndrome, anterior ischemic optic neuropathy, and glaucoma [4–8]. Recently, it has been
used to evaluate and diagnose different orbital diseases [9–11].

In this report, we present our experience with CDI in orbital diseases and review the literature.

**Patients and Methods**

CDI was performed in selected patients with carotid cavernous fistula (CCF), Graves’ ophthalmopathy, ocular melanoma, and orbital tumors. All examinations were performed using a Hewlett Packard Image Point HX Doppler unit with a 7.5-MHz curvilinear transducer (L1038, Andover, MA, USA). With the patient in a supine position, the ultrasound transducer was applied to closed eyelids using sterile ophthalmic methylcellulose as a coupling gel. The SOV, ophthalmic artery, and central retinal artery were found. Flow velocity was measured in the SOV, ophthalmic artery, and central retinal artery and/or the artery inside the tumor. The physical principles and technique of CDI have been reported [12].

**Results**

Of the 25 patients who underwent CDI, seven had CCF, four had choroidal melanoma, eight had Graves’ ophthalmopathy, and six had orbital tumors (including cavernous hemangioma, hemangiopericytoma, lymphoid hyperplasia, and meningioma). In patients with CCF, CDI revealed a prominent dilated SOV and spectral wave-form analysis showed high-velocity arterialized blood flow. CDI showed an arterial signal with flow velocity inside the tumor in patients with choroidal melanoma. In patients with Graves’ ophthalmopathy, the flow velocities in the ophthalmic and central retinal arteries (mean peak systolic velocity, 34.7 ± 11.6 and 8.8 ± 2.1 cm/s, respectively) were not significantly different from those in normal subjects (33.7 ± 8.3 and 9.6 ± 2.4 cm/s, respectively). In addition, no SOV signal or velocity was detected. Among patients with orbital tumors, no blood flow signals were noted in those with cavernous hemangioma, lymphoid hyperplasia, or meningioma. However, one patient with hemangiopericytoma showed multiple blood flow signals on CDI.

**Case reports**

Case 1: a 22-year-old male with a history of trauma complained of progressive proptosis and orbital pain in the right eye for 6 months. Ocular examination showed dilated corkscrew-like vessels on the conjunctiva of the right eye (Fig. 1A). Best-corrected visual acuity was 20/40 (right eye, OD) with a positive relative afferent pupillary defect and 20/20 (left eye, OS). Exophthalmometric readings were 27 mm (OD) and 17 mm (OS). CDI revealed a prominent dilated SOV. Spectral wave-form analysis showed high-velocity arterIALIZED blood flow (systolic velocity, 18.4 cm/s; diastolic velocity, 10.7 cm/s) (Fig. 1B). Magnetic resonance imaging (MRI) showed a dilated SOV and communication between the internal carotid artery and cavernous sinus (Fig. 1C). Selective carotid angiography showed a high-flow fistula between the intracavernous position of the internal carotid artery and the cavernous sinus. The patient underwent embolization. CDI 1 month later revealed normal laminar blood flow. The symptoms and signs resolved and the best-corrected visual acuity improved to 20/20 (OD). Exophthalmos disappeared within 1 month.

Case 2: a 55-year-old man complained of blurred vision and a curtain-like sensation in the right eye for several months. Best-corrected visual acuity was 10/200 (OD) and 20/25 (OS). Fundus examination showed a choroidal mass over the posterior retina. CDI of the right eye revealed a mushroom-like choroidal mass with an internal feeding artery. The systolic flow velocity in this artery was 15.9 cm/s (Fig. 2). The patient underwent enucleation and reconstruction of the orbital socket with a hydroxyapatite implant. The pathology proved to be choroidal melanoma.

Case 3: a 46-year-old woman complained of proptosis and changes in her refractive status in the left eye for 6 months. The visual acuity was 20/20 with myopic correction (OD) and 20/20 with bare eye (OS). Exophthalmometric readings were 16 mm (OD) and 18 mm (OS). MRI revealed a well-defined intraconal mass with indentation of the posterior pole of the left eye (Fig. 3A). CDI of the left orbit revealed a retrobulbar mass without any artery signal within the tumor (Fig. 3B). The patient underwent orbital tumor removal and histology showed a cavernous hemangioma.

**Discussion**

CDI is a sonographic imaging technique that permits noninvasive assessment of blood flow velocity in orbital vessels; normal ocular circulation has been reported [13–16]. CDI has also been used to
investigate alterations in blood flow parameters in various disorders such as central retinal artery occlusion, central retinal vein occlusion, glaucoma, diabetes mellitus, ocular ischemic syndrome, uveitis, and endophthalmitis [5,6,15,17,18]. The advantage of CDI over other imaging modalities is its ability to detect blood flow within a lesion. Previous series have demonstrated the utility of CDI in identifying vascular lesions of the orbit, including CCFs, orbital arteriovenous malformations/varices, and superior orbital vein thrombosis [18–20]. Although CDI has proved useful in studying tumors in the eye and throughout the body, less is known about its potential role in evaluating tumors located within the orbit.

**CDI and carotid cavernous fistula**
Several studies have used CDI to diagnose and monitor CCFs. Erickson et al reported the use of CDI to study normal orbits and some orbital disorders such as a presumed dural shunt [21]. Flaharty et al described the use of CDI, showing dilated SOV with reversed blood flow, to diagnose CCFs in three cases [20]. Costa et al reported four cases in which CDI was used to diagnose and monitor CCFs [22]. They also suggested that patients with direct CCFs had higher blood flow velocity than those with dural shunts.

In our experience, all cases with direct or indirect CCF showed a dilated arterialized SOV on CDI. Color imaging can differentiate the flow pattern toward or against the probe and all cases in our study showed reversal of blood flow from the orbital apex to the globe in the SOV due to increased blood pressure inside the cavernous sinus. All hemodynamic changes disappeared in cases with resolution of the fistulas, either spontaneously or following embolization. Compared to repeated carotid angiography, CDI can be a useful tool for monitoring the clinical course of CCFs, without additional risks and at a lower cost.

**CDI and Graves’ ophthalmopathy**
To our knowledge, few reports of CDI of the orbital vasculature in patients with Graves’ disease have been published. Somer et al evaluated SOV flow velocity in relation to various clinical and computed tomography (CT) manifestations of thyroid eye disease [10]. They reported that CT showed apical crowding and horizontal plus vertical extraocular muscle enlargement with significant decreases in

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**Fig. 1.** Case 1: a 22-year-old male with cavernous carotid fistula. (A) Dilated corkscrew-like vessels on the conjunctiva of the right eye. (B) Color Doppler imaging shows high-velocity arterialized blood flow with systolic velocity of 18.4 cm/s and diastolic velocity of 10.7 cm/s. (C) Magnetic resonance imaging shows a dilated superior ophthalmic vein and communication between the internal carotid artery and cavernous sinus.
SOV blood flow velocity. In 18 orbits with thyroid eye disease, SOV could not be detected with CDI. The clinical and CT signs associated with a significant decrease in SOV blood flow velocity and the common findings among the orbits in which the SOV could not be detected with CDI study suggest that external compression of the SOV may contribute to a decrease in SOV blood flow in orbits affected by thyroid eye disease.

Alp et al reported that some orbital blood flow parameters are significantly changed in patients with Graves’ ophthalmopathy compared with patients with Graves’ disease without ophthalmopathy and normal subjects [11]. They found that alterations in blood flow parameters in the orbital vasculature in patients with Graves’ disease may be due to Graves’ ophthalmopathy rather than Graves’ disease itself. Moreover, they found that alterations in orbital arterial blood flow velocities correlate with the degree of extraocular muscle enlargement. They concluded that orbital arterial blood flow velocities are increased in patients with Graves’ ophthalmopathy as a result of orbital inflammation.

In our limited experience, no SOV signal or velocity was detected by CDI in patients with Graves’ ophthalmopathy. The findings were compatible with previous studies.

**CDI and orbital tumors**

Hatton et al used CDI to study different kinds of orbital diseases [9]. They found that the presence of flow reversal when patients rotated their heads while in the supine position supports the diagnosis of a filling varix in a dependent position. Their findings suggest that the absence of flow is more consistent with benign lesions, whereas the presence of intralesional flow may indicate malignancy or malignant potential [10].

Several case series have also demonstrated low flow in benign orbital tumors, including cavernous hemangioma [23–25] and lacrimal gland adenoma [23], and high flow in malignant lesions such as fibrosarcoma [26]. In our experience, the absence
of flow in CDI examination may be associated with benign lesions and favors observation.

**CDI and choroidal melanoma**

Histologic data indicate the importance of tumor vascularization as a determinant of the biologic behavior and response to radiotherapy in choroidal melanoma. Several studies have examined the role of CDI in diagnosis and management of choroidal melanoma [26–28]. Wolff-Kormann et al used CDI to quantitatively measure neovascular blood flow in 31 patients with choroidal melanoma, and blood flow within the tumor was detected in 30 melanomas [27]. Of the 20 patients in whom CDI was performed to investigate the change in tumor blood flow after radiotherapy, 19 showed a significant decrease in peak systolic frequency. This occurred with and in advance of a decrease in tumor size. In one patient, an increasing maximum systolic frequency after radiotherapy marked recurrent tumor growth. The authors concluded that CDI might be a new diagnostic modality for monitoring the effectiveness of radiotherapy in choroidal melanoma.

It is now commonly accepted that choroidal melanomas and metastases are associated with higher flow than benign choroidal lesions [26–28]. Additionally, CDI can demonstrate a reduction in flow within uveal melanomas after radiation treatment, suggesting that it may be useful in monitoring treatment efficacy [26–28]. In this study, we found blood flow signals within the tumor in all patients with choroidal melanoma. Because all patients underwent enucleation of the eyeball, we could not demonstrate changes in tumor blood flow after radiotherapy.

**CONCLUSION**

CDI offers several advantages over CT and MRI in the evaluation of different kinds of orbital diseases. In addition to being safe, dynamic, and cost-effective, and providing a convenient way to diagnose and differentiate orbital tumors, CDI can be a useful tool for monitoring treatment efficacy as well.

**REFERENCES**

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