Color Doppler Flow Imaging of Ocular Tumors

Renata Ivekoviæ, Arijana Lovrenæiæ-Huzjan1, Zdravko Mandiaæ, Jasna Talan-Hranilovicæ2

Departments of Ophthalmology; 1Neurology; and 2Pathology, Sisters of Mercy University Hospital, Zagreb, Croatia

Aim. To analyze the usefulness of color Doppler flow imaging in the differentiation of benign and malignant ocular tumors.

Methods. Blood flow in tumor and ocular blood vessels was assessed by color Doppler flow imaging in 20 patients with malignant melanoma of the uvea and 19 patients with cavernous hemangioma. Blood velocity measurements in orbital vessels in these patients were compared with the same measurements in 20 healthy individuals.

Results. Blood flow inside the tumor tissue was observed in all patients, except in a single case of uveal melanoma. Internal blood flow of intraorbital hemangiomas was slower and their resistance index lower than that of melanomas. Patients with a tumor did not differ from the controls in blood flow velocities in the ophthalmic artery, central retinal artery, and posterior ciliary arteries. Only the patients with uveal melanoma had higher maximal blood flow in central retinal artery and posterior ciliary arteries compared to other patients.

Conclusion. Color Doppler flow imaging of blood flow can be a useful method to assess the vascularization of ophthalmological tumors, and to differentiate uveal melanoma from orbital hemangioma.

Key words: angioma, cavernous; blood flow velocity; Doppler ultrasonography, color; eye neoplasms; hemangioma, cavernous; orbital neoplasms; ultrasonography. Doppler, color; uveal neoplasms

Color Doppler flow imaging is one of the techniques currently available to assess ocular blood flow. It has been used since 1989 for the measurement of pulsatile blood velocities in the eye and orbit in a variety of vascular and neoplastic ophthalmologic abnormalities, including malignant melanoma of the uvea (1-8). A sample window is placed on a vessel of interest, and the velocity profile of the red blood cells moving within that window is captured in real time (9). The lumen of blood vessels in the orbit and eye are too small to be precisely visualized. They are therefore obtained with less precision in location and measurement of real velocities because of incorrect Doppler angle (10).

The aim of our study was to compare blood flow velocity in the central retinal artery, posterior ciliary arteries, and ophthalmic artery in patients with uveal melanoma or orbital hemangioma with that of healthy individuals.

Patients and Methods

From January 1995 until January 1998 we treated 23 patients (12 women and 8 men) with uveal melanoma. Clinical examination, conventional sonography, fluorescein angiography, computed tomography, and color Doppler flow imaging established the diagnosis of uveal melanoma. After diagnosis, enucleation of the eye with the tumor was performed. During the same time, we had 19 patients (5 women and 14 men) with intraorbital cavernous hemangioma. After the computed tomography and ophthalmic examinations, these patients underwent orbitotomy. The clinical diagnoses were confirmed by pathohistological analysis.

Data on the patients from these two groups were compared with the same measurements in 20 individuals (12 women and 8 men) from the control group. The control group was chosen among patients without ocular pathology who came in for an eyesight check-up. Patients with presbyopia were included in the control group. All patients were informed about the study aims and procedures and gave their informed consent. The age (median, range) of the patients with melanoma was 56 (42-71) years, 52 (17-71) years in the group with orbital hemangioma, and 62 (36-78) years in the control group. The age differences among the groups were not significant (p=0.064). Transpalpebral color Doppler flow imaging of the eye and orbit was used in the measurements of blood flow in vessels of tumors, central retinal artery, ophthalmic artery, and posterior ciliary arteries. Color Doppler sonography of carotid arteries was also performed in all individuals. Carotid vessels were examined using standard procedure that assessed common carotid artery, bifurcation, external carotid, and internal carotid artery from the proximal to the distal part. The individuals with pathological findings of the blood flow in carotid arteries were excluded from this study because of the possibility to influence the blood flow inside of orbit (3 patients with uveal melanoma).

All examinations were performed on a color-coded Doppler sonography unit 128XP, (Acuson, Mountain View, CA, USA) using a linear phased array transducer (5/10 MHz). The ultrasound transducer was applied on closed eyelids using sterile ophthalmic methylcellulose as a coupling gel. Individuals were in supine position during the examination. To avoid artifacts special attention was paid to the probe pressure on the eye. Direction of the blood flow was displayed in either red or blue, depending on the direction of the flow to the transducer. Doppler spectral analysis was used to distinguish be-
between pulsatile arterial flow and the more continuous or minimally pulsatile venous flow. Quantification of data was performed by the frequency spectrum analysis. The parameters of pulsatile index (PI) and resistance index or Pourcelot’s ratio (RI) were calculated according to the formulas:

\[ PI = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{mean}}} \]

\[ RI = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{max}}} \]

where \( V_{\text{max}} \) is the maximal velocity of blood flow in a vessel, \( V_{\text{min}} \) minimal velocity of blood flow in a vessel, and \( V_{\text{mean}} \) velocity blood flow in a vessel. The data among the three groups were compared using Kruskal-Wallis or Mann-Whitney tests (11). The results were considered statistically significant if \( p \) was less than 0.05.

### Results

The mean prominence of the uveal melanoma was 8.5±3.3 and the diameter was 12.4±3.8 mm. The dimensions of orbital hemangiomas were: width 10.4±3.2, length 20.9±14.1, and height 9.6±4.9 mm. Doppler signals could be detected in all tumors, except in a single case of uveal melanoma. Orbital hemangioma and uveal melanoma significantly differed in the blood velocity inside the tumor (Table 1). The mean maximal blood flow in melanomas was 0.201±0.164 m/s vs. 0.024±0.039 m/s in hemangiomas (\( p < 0.05 \)). The mean minimal blood flow was also higher in melanomas: 0.083±0.062 m/s vs. 0.020±0.036 m/s in hemangiomas (\( p < 0.001 \)). Pulsatile index and resistance index of the vessels were significantly higher in melanomas than in hemangiomas (Table 2). There was no statistically significant correlation between the velocity of blood flow and the size of the tumors. Blood velocity in the posterior ciliary arteries, ophthalmic artery, and central retinal artery in patients with tumors were compared to the same measurements in normal individuals (Table 1). There were no significant differences among the three groups (\( p \) ranging from 0.109 to 0.494), except in the average maximum blood flow velocity in the central retinal artery and posterior ciliary arteries, which was highest in the patients with uveal melanoma. The three groups did not differ in the resistance index or pulsatile index of the central retinal artery, ophthalmic artery or posterior ciliary arteries (Table 2).

### Discussion

Real time A-mode and B-mode ultrasonography has been used for diagnostic evaluation of ophthalmic disorders since the early 1960’s (12, 13). Ultrasonography is routinely used today, but recently color Doppler flow imaging has found its place in the diagnosis of vascular malformations in the orbit. As the vasculature is essential for tumor growth, it has been proposed that color-Doppler imaging may be useful in detecting and
differentiating tumors from normal tissue inside the bulbus or orbit. In gynecology, for example, color-Doppler imaging may differentiate between a malignant and a benign lesion of the ovary (14).

Recently, several authors reported their results with color Doppler flow imaging of intraocular tumors (15-18). They registered Doppler shifts inside tumors but it was impossible to differentiate between malignant or benign tumors. These studies also recorded low resistance to blood flow. This was expected because, as in most neoplasms, the vessels in ocular tumors lack normal arteriolar smooth muscle, the site of peripheral vascular resistance (19). In our case series, we were unable to detect Doppler signals inside tumor tissue only in a single case. This patient had very high intraocular pressure, which may have caused the collapse of vessels inside the tumor. Pathohistological analysis after excision revealed many necrotic zones in the tumor tissue.

Our study found significant differences between uveal melanoma and orbital hemangioma in the maximal and minimal blood flow, resistance index and pulsatile index in the tumor vessels. The differences can be explained by the histopathological profile of hemangiomas, which are mostly made of cavities with slow blood flow velocity (19).

To our knowledge, this is the first report that compared blood flow velocity inside the vessels in patients with intraocular tumor and healthy individuals. We hypothesized that patients with intrabulbar malignant neoplasm would have higher blood flow inside vessels, because of the fast growth of tumor tissue and abundant vessels inside the malignant tissue. Our results showed that the only significant difference was higher maximal blood velocity in central retinal artery and posterior ciliary arteries in uveal melanoma, compared to normal patients and those with orbital hemangioma. We are aware that the limitation of this study is a small number of patients, which does not allow conclusions on these differences. The incidence of uveal melanoma is small (20), and we are continuing this case series to increase the sample.

In conclusion, our study showed that ocular or orbital tumors could be detected by color Doppler flow imaging, and that this method could differentiate between uveal melanoma and orbital hemangioma. Further investigation on a large sample is needed to confirm the diagnostic and prognostic value of color Doppler imaging of blood flow in ocular arteries to differentiate between different types of ocular tumors.

### References


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Correspondence to:
Renata Ivekoviæ
Department of Ophthalmology
Sisters of Mercy University Hospital
Vinogradarska 29
10000 Zagreb, Croatia
renata.ivekovic@zg.tel.hr

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