Coll. Antropol. **24** (2000) 1: 205–210
UDC 617.7-006:616-073
Original scientific paper

Value of Color-Doppler Imaging in Diagnosis of Intrabulbar and Intraorbital Tumors

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A B S T R A C T

Patients with intrabulbar and intraorbital tumours have been investigated by colour Doppler imaging. In the first group there were 20 patients with malignant melanoma of the uvea and in the second group there were 19 patients with cavernous hemangioma. The third group was a control group represented by 20 healthy individuals. In the group of patients with uveal melanoma it has been established that every patient, except one, has a blood flow inside of tumour tissue. Internal blood flow of intraorbital hemangioma was slower than inside the melanoma and the resistance index was lower. Comparison of blood flow in all patients has shown that there is no statistically significant difference between ophthalmic artery, central retinal artery and posterior ciliary arteries except in maximal blood flow in central retinal artery and posterior ciliary arteries.

Introduction

Color Doppler Flow Imaging (CFDI) is one of the techniques that is 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 the 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]. Lumens of blood vessels in the orbit and eye are too small to be precisely visualised; therefore they are 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 the differences in the blood flow velocity in the central retinal artery, as well as in the posterior ciliary arteries and ophthalmic artery in the patients with uveal mel-

Received for publication September 8, 1999.

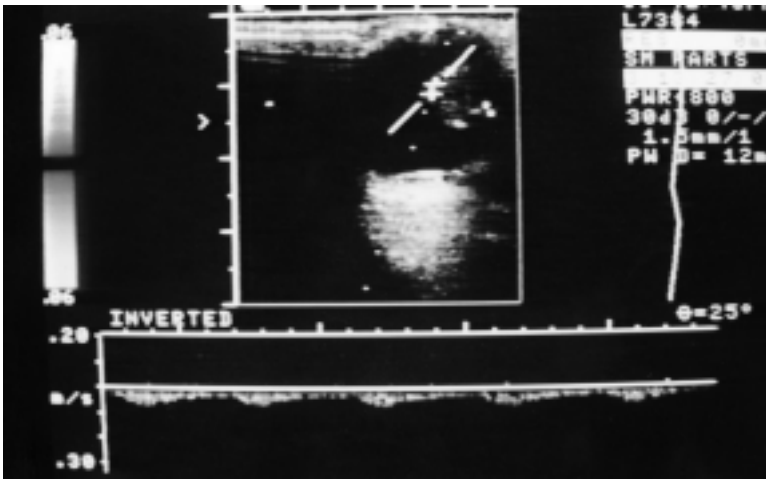

Fig. 1. Color-Doppler flow imaging of choroidal melanoma (the colored dots indicate tumor vessels) and velocity curve of vessels between markers.

anoma, orbital hemangioma and healthy individuals (Figure 1).

Patients and Methods

Twenty patients with uveal melanoma were examined during the period from January 1995 till January 1998. All of them underwent enucleation and pathohistological analysis. Clinical examination, conventional sonography, fluorescein angiography, computed tomography (CT) and CDFI made the diagnosis of uveal melanoma. In the second group, there were 19 patients with intraorbital cavernous hemangioma. After the CT and ophthalmic examinations the orbitotomy was performed and the clinical diagnosis was confirmed by the pathohistological analysis. Data of patients from these two groups were compared with measurements of twenty individuals from the control group.

Transpalpebral CDFI of the eye and orbit was used in the measurements of blood flow in vessels of uveal melanoma, central retinal artery, ophthalmic artery and posterior ciliary arteries. In all individuals the Color Doppler sonography of carotid arteries was performed. Carotid vessels were examined using standard procedure assessing common carotid artery, bifurcation, external carotid and internal carotid artery from the proximal to the distal part. The individuals with pathological findings in the blood flow in carotid arteries were excluded from this study because of the possibility to influence the blood flow inside of orbit.

All examinations were performed on a Color-coded Doppler sonography unit (Acuson 128XP, Mountain View, California) using a linear phased array transducer (5/10 MHz). The ultrasound transducer was applied on closed eyelids using steril ophthalmic methylcellulose as a coupling gel. The patients were in the supine position during the examination. Special attention was paid to the probe pressure on the eye to avoid artefacts. The blood flow was measured in vessels inside tumors, in ophthalmic artery on crossing over the optic nerve, in central artery within 2 mm of optic nerve shadow and in posterior ciliary arteries lateral from optic nerve. The blood flow direction

is displayed in either red or blue, depending on the direction of the flow to the transducer. In this study, the flow toward the transducer was displayed in blue and the one away from transducer in red. Doppler spectral analysis was used to distinguish between pulsatile arterial flow and the more continuos or minimally pulsatile venous flow. Quantification of data was performed by frequency spectrum analysis. The parameters of pulsatile index (PI) and resistance index or Pourcelot's ratio (RI) were calculated in the central retinal artery, ophthalmic artery and posterior ciliary arteries, as:

$$PI \quad \frac{V_{max} \quad V_{min}}{V_{mean}} \qquad RI \quad \frac{V_{max} \quad V_{min}}{V_{max}}$$

(V_{max} – maximal velocity of blood flow in the vessel, V_{min} – minimal velocity of blood flow in the vessel, V_{mean} – mean velocity blood flow in the vessel).

Data of RI and PI were compared between three analysed groups. Statistical analysis was made by Kruskal-Wallis or Mann Whitney tests[11]. Statistically significant were considered the results if p was lower than 0.05.

Results

The mean age of the patients in group with melanoma was 55.7 8.6, in the group with orbital hemangioma 51.53 13.3 and in the control group mean age was 59.9 10.6 years. There is no significant difference in the age of patients because p = 0.064 (p > 0.05).

In Table 1 results of measurements of blood velocity in the group with uveal melanoma have been presented. Inside all tumors we have detected Doppler signals, except in one uveal melanoma. The average maximum systolic blood flow velocity of these tumors was 0.201 0.164 m/s. The average minimum blood flow velocity was 0.083 0.062 m/s. There was no statistically significant correlation between velocity of blood flow inside of melanoma with prominence of tumor.

In Table 2 the results of measurements of blood velocity inside of orbital hemangioma are presented. The average maximum systolic blood velocity measured inside tumor tissue was 0.024 0.039 m/s and the minimum blood flow was 0.020 0.036 m/s. There was statistically significant difference in the blood flow velocity, RI or PI in vessels inside uveal melanoma and orbital hemangioma.

In the control group, the average maximal blood flow in retinal central artery was 0.121 0.031 m/s and the average minimum blood flow in the same vessels was 0.042 0.018 m/s. In the same group of healthy individuals the average maximal blood flow in ophthalmic artery was 0.376 0.133 m/s and minimum blood flow was 0.119 0.036 m/s. In the posterior ciliary arteries maximal blood flow in the control group was 0.110 0.029 m/s and minimal blood flow was 0.035 0.014 m/s.

In all performed measurements there were no significant differences between groups except in average maximum blood flow velocity in central retinal artery and posterior ciliary arteries (p = 0.000; p = 0.001). There was no statistically significant difference between investigated groups in RI or PI of central retinal artery, ophthalmic artery or posterior ciliary arteries.

Discussion

Real time A-mode and B-mode ultrasonography has been used for the diagnostic evaluation of ophthalmic disorders since the early 1960's[12,13]. Modern digital equipment has improved diagnostic imaging. Ultrasonography is routinely used today, but recently CDFI has found its place in diagnosis of vascular malformations in orbit. As the vasculature is essen-

TABLE 1
BLOOD VELOCITIES IN THE PATIENTS WITH UVEAL MELANOMA

Dg.	Prominence (mm)	Tumor (m/s)		AO (m/s)		ACR (m/s)		AA. cill (m/s)	
		Max	Min	Max	Min	Max	Min	Max	Min
Melanoma choroideae	10	0.08	0.02	0.41	0.12	0.19	0.06	0.20	0.07
Melanoma choroideae	8	0.20	0.10	0.52	0.13	0.15	0.05	0.16	0.04
Melanoma choroideae	9	0.07	0.04	0.42	0.15	0.38	0.16	0.24	0.10
Melanoma choroideae	5	0.76	0.26	0.35	0.18	0.12	0.04	0.13	0.04
Melanoma choroideae	4	0.16	0.06	0.39	0.06	0.14	0.04	0.11	0.03
Melanoma choroideae	14	0.31	0.13	0.39	0.13	0.22	0.08	0.12	0.04
Melanoma choroideae	8	0.09	0.04	0.61	0.21	0.12	0.03	0.12	0.03
Melanoma choroideae	5	0.12	0.04	0.31	0.09	0.14	0.03	0.14	0.04
Melanoma choroideae	5	0.14	0.05	0.29	0.10	0.16	0.05	0.10	0.03
Melanoma choroideae	10	0.17	0.08	0.33	0.07	0.31	0.09	0.23	0.05
Melanoma choroideae	15	0	0	0.35	0.09	0.38	0.11	0.22	0.04
Melanoma choroideae	7	0.29	0.10	0.29	0.11	0.15	0.05	0.15	0.05
Melanoma choroideae	6	0.21	0.11	0.25	0.08	0.12	0.04	0.13	0.04
Melanoma choroideae	15	0.22	0.07	0.28	0.07	0.30	0.09	0.18	0.05
Melanoma choroideae	11	0.31	0.14	0.30	0.09	0.22	0.06	0.18	0.06
Melanoma choroideae	10	0.40	0.19	0.36	0.15	0.11	0.03	0.11	0.03
Melanoma choroideae	9	0.16	0.08	0.52	0.21	0.16	0.06	0.12	0.04
Melanoma choroideae	8	0.10	0.04	0.22	0.03	0.15	0.03	0.15	0.03
Melanoma choroideae	5	0.06	0.04	0.25	0.07	0.16	0.04	0.11	0.03
Melanoma choroideae	7	0.18	0.06	0.22	0.04	0.13	0.02	0.11	0.03

Legend: tumor max – maximal blood velocity in vessels in tumor, tumor min – minimal blood velocity in vessels in tumor, AO max – maximal blood velocity in ophthalmic artery, AO min – minimal blood velocity in ophthalmic artery, ACR max – maximal blood velocity in central retinal artery, ACR min – minimal blood velocity in central retinal artery, AA cill max – maximal blood velocity in posterior ciliary arteries, AA cill min – minimal blood velocity in posterior ciliary arteries.

tial for all tumor growth, the idea of detection and differentiation of tumors from normal tissue inside of bulbus or orbit has been born. In gynaecology, for example, according to the finding of Color-Doppler, it is possible to differ between malignant or benign lesions of ovary[14].

Recently, several authors reported about their results using CDFI in intraocular tumors[15–18]. They have all registered Doppler shifts inside tumors, but according to these results it is impossible to differ between a malignant or a benign tumor. In all these studies there was the low resistance to flow. It is expected, as in most neoplasms the vessels lack normal arteriolar smooth muscle, which is the recognised site of peripheral vascular resistance. Only in one uveal melanoma we were unable to detect Doppler signals inside tumor tissue. A very high intraocular pressure was also noticed in this patient. It is possible that pressure has caused collapse of vessels inside tumor and during the pathohistological analysis after enucleation, many necrotic zones were detected. In this study, we have compared the blood velocity inside two different ty-

TABLE 2
BLOOD VELOCITIES IN THE PATIENTS WITH ORBITAL CAVERNOUS HEMANGIOMA

Dg.	Tumor (m/s)		AO (m/s)		ACR (m/s)		AA. cill (m/s)	
	Max	Min	Max	Min	Max	Min	Max	Min
Haemangioma cavernosum	0.17	0.16	0.48	0.09	0.18	0.04	0.12	0.03
Haemangioma cavernosum	0.02	0.02	0.52	0.16	0.18	0.06	0.13	0.05
Haemangioma cavernosum	0.06	0.04	0.56	0.17	0.21	0.06	0.12	0.04
Haemangioma cavernosum	0.04	0.03	0.48	0.11	0.14	0.03	0.10	0.03
Haemangioma cavernosum	0.02	0.01	0.56	0.20	0.16	0.07	0.14	0.05
Haemangioma cavernosum	0.01	0.01	0.47	0.12	0.16	0.04	0.10	0.02
Haemangioma cavernosum	0	0	0.38	0.11	0.17	0.05	0.11	0.04
Haemangioma cavernosum	0.01	0.01	0.31	0.12	0.14	0.03	0.11	0.03
Haemangioma cavernosum	0	0	0.30	0.11	0.13	0.06	0.13	0.04
Haemangioma cavernosum	0.02	0.02	0.21	0.07	0.13	0.04	0.10	0.05
Haemangioma cavernosum	0	0	0.45	0.15	0.15	0.05	0.08	0.03
Haemangioma cavernosum	0	0	0.37	0.11	0.18	0.04	0.09	0.02
Haemangioma cavernosum	0	0	0.52	0.13	0.17	0.04	0.11	0.03
Haemangioma cavernosum	0.02	0.01	0.40	0.16	0.14	0.05	0.12	0.04
Haemangioma cavernosum	0.02	0.02	0.43	0.09	0.16	0.04	0.08	0.02
Haemangioma cavernosum	0.01	0.01	0.36	0.09	0.14	0.03	0.10	0.03
Haemangioma cavernosum	0.03	0.02	0.30	0.12	0.19	0.07	0.12	0.05
Haemangioma cavernosum	0	0	0.31	0.07	0.22	0.06	0.11	0.04
Haemangioma cavernosum	0.02	0.02	0.44	0.08	0.13	0.05	0.11	0.02

Legend: tumor max – maximal blood velocity in vessels in tumor, tumor min – minimal blood velocity in vessels in tumor, AO max – maximal blood velocity in ophthalmic artery, AO min – minimal blood velocity in ophthalmic artery, ACR max – maximal blood velocity in central retinal artery, ACR min – minimal blood velocity in central retinal artery, AA cill max – maximal blood velocity in posterior ciliary arteries, AA cill min – minimal blood velocity in posterior ciliary arteries.

pes of tumors: malignant uveal melanoma and benign orbital hemangioma. According to the results of measurements there is significant difference in the maximal and minimal blood velocity, RI and PI in vessels inside the analysed tumor tissue.

According to the literature until now nobody has compared blood velocity inside vessels in the eye with intraocular tumor and healthy individuals. It could be expected that patients with intrabulbar malignant neoplasm have higher blood flow inside vessels, because of the fast growth of tumor tissue and very numerous vessels inside the malignant tissue. Our results have proved that there is no significant difference in supply with blood in healthy individuals or patients with malignant melanoma, except in maximal blood velocity in central retinal artery and posterior ciliary arteries.

We are aware that this study has been done in a small number of patients firstly because of a small incidence of uveal melanoma. This study is a prospective study and we are looking forward to our further results in Color-Doppler analysis of ocular and orbital tumors.

Our present results and results of other authors suggest that the differentiation between individuals with uveal me-

lanoma, orbital hemangioma and healthy individuals can not be made according to the blood velocity or RI or PI of central retinal artery, ophthalmic artery or posterior ciliary arteries. The vessels inside tumor tissue could be detected by CDFI and according to this study the differentiation between uveal melanoma and orbital hemangioma is possible, but more investigations and measurements have to be done.

CDFI is a very useful diagnostic method for differentiation between avascular and vascular lesions.

REFERENCES

1. BAXTER, G. M.,T. H. WILLIAMSON, Radiology, 187 (1993) 847. — 2. LIEB,W. E., P. M. FLAHARTY, R. C. SERGOTT, Arch. Ophthalmol., 109 (1991) 527. — 3. LIEB,W. E., D. A. MERTON, J. A. SHIELDS, Br. J. Ophthalmol., 74 (1990) 305. — 4. MENDIVIL, A.,V. CUARTERO, M. P. MENDIVIL, Graefes Archiv. Clin. Exp. Ophthalmol., 233 (1995) 135. — 5. LIEB, W. E., Curr. Opin. Ophthalmol., 4 (1993) 68. — 6. GUTHOFF, R. F., R. W. BERGER, P. WINKLER, Arch. Ophthalmol., 109 (1991) 537. — 7. WOLF-KORMANN, P. G., B. A. KORMANN, K. G. REIDEL, Invest. Ophthalmol. Vis. Sci., 33 (1992) 1928. — 8. GULANI, A. C., H. MORPARIA, S. S. BHATTI, Eye, 8 (1994) 307. — 9. HUISMAN, H.: Doppler-sonographie bei Augenkrankungen. (Verlag W. Kohlhammer, Stuttgart, 1990). — 10. LIEB, W. E., P. M. FLAHARTY, A. HO, R. C. SERGOTT, Acta Ophthalmol., 204 (1992) 50. — 11. IVANKOVIĆ, D.: Basic statistical analyses for medical researchers. In Croat. (University of Zagreb, Zagreb,1989). — 12. OSSOING, K. C., J. Clin. Ultrasound, 2 (1974) 33. — 13. ROMANI, A., L. BALDESCHI, F. GENOVESI-EBERT, E. GREMIGNI, Ophthalmologica, 212 (1998) 44. — 14. KURJAK, A., S. KUPEŠIĆ, M. GRGIĆ, Liječ. Vjesn., 117 (1995) 139. — 15. HAKAN, Ö., Y. CEM, A. CÜNEYET, Clinical Imaging, 21 (1997) 77. — 16. DAMMS, T., H. SCHÄFER, R. GUTHOFF, Graefes Archiv. Clin. Exp. Ophthalmol., 233 (1995) 257. — 17. IVEKOVIĆ, R., T. RUNDEK, Z. MANDIĆ, V. DEMARIN, Acta Clin. Croat., 37 (1998) 27. — 18. ATTA, H. R.: Ophthalmic ultrasound. (Churchill Livingstone, New York, 1996).

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VRIJEDNOST OBOJENOG DOPLERA U DIJAGNOSTICI INTRABULBARNIH I INTRAORBITALNIH TUMORA

SAŽETAK

Obojenim doplerom ispitivani su bolesnici s intrabulabrnim i intraorbitalnim tumorima. U prvoj skupini bilo je 20 bolesnika s melanomom žilnice, a u drugoj skupini 19 bolesnika s kavernoznim hemangiomom. Treća skupina bila je kontrolna skupina od 20 zdravih pojedinaca. U skupini bolesnika s melanomom žilnice utvrđeno je kod svih bolesnika, izuzev kod jednoga, protok krvi unutar tumorskog tkiva. Protok krvi unutar kavernoznih hemangioma bio je sporiji nego li unutar krvnih žila melanoma i indeks rezistencije bio je niži. Usporedbom rezultata kod svih bolesnika nije nađena statistički znatna razlika u protoku krvi unutra oftalmičke arterije, centralne arterije mrežnice i stražnjih cilijarnih arterija izuzev u maksimalnom protoku u centralnoj arteriji

mrežnice i stražnjim cilijarnim arterijama.